Instructions

Geospatial Analysis of Sea Level Rise for Rhode Island Municipalities

Analysis of Roads and Structures

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Software Requirements and Data layers

Instructions:

Individuals with ArcGIS software can use this guide to reproduce the results of the Sea Level Rise Analysis completed for Warren, Barrington, and Bristol, RI.

Software Requirements:

ESRI ArcGIS Version 10.6 or greater

Extensions-

Spatial Analysis Extension

Data Layers required:

Rhode Island Municipalities:	https://www.rigis.org/datasets/municipalities-1997/explore?location=41.582723%2C-71.506456%2C10.11
RIDOT Roads:	https://www.rigis.org/datasets/ridot-roads-2016/explore?location=41.583417%2C-71.491586%2C10.12
RIDOT Bike Path:	https://www.rigis.org/datasets/ridot-bike-paths/explore?location=41.678370%2C-71.464210%2C10.54
Sea Level Rise Data: SLR0, SLR1, SLR2, SLR3, SLR5, SLR7, SLR10	Available from URI Environmental Data Center (https://www.edc.uri.edu/)
Structures: (Stormtools CERI outputs) *Municipality*_Risk_100yr_SLR0_agol, *Municipality*_Risk_100yr_SLR2_agol *Municipality*_Risk_100yr_SLR5_agol	Available from URI Environmental Data Center (https://www.edc.uri.edu/)

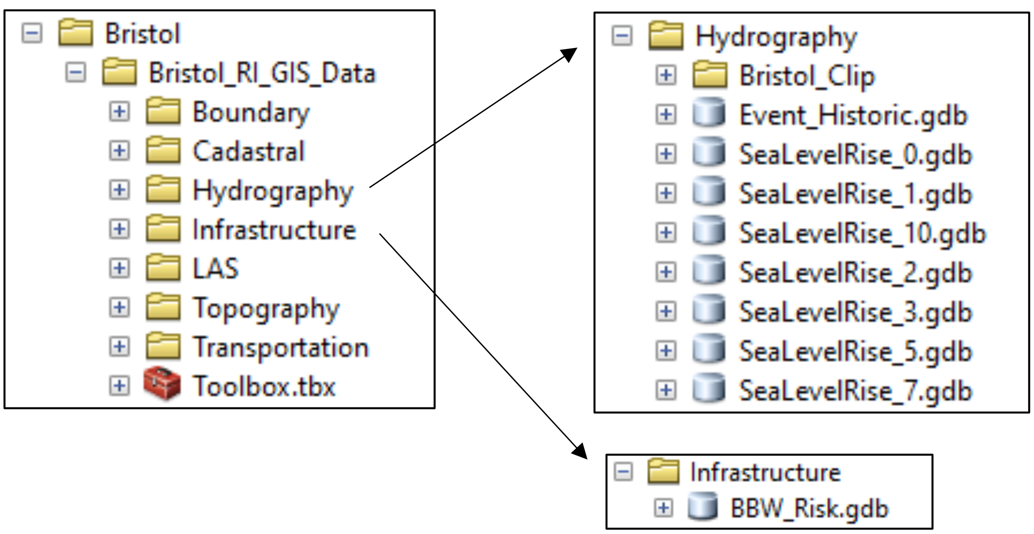
Introduction

This analysis of sea level rise for Rhode Island municipalities focuses on two areas: roads and structures. Following the steps outlined here, a GIS analyst will be able to identify roads that will be impacted by sea level rise, the flood water depth on the road surface, and the linear length of affected roads, using publicly available datasets. Additionally, the structure analysis can be used to identify which structures will be affected by sea level rise, and the percentage of damage to each impacted structure.

Step 1: Download the data layers

Download the data layers (listed in front material) to a project folder, separating them into individual sub-folders. Some of the later steps in this analysis process require the data layers to be stored in file geodatabases. Store data in a similar file structure as shown below:

*Note – not all the files listed below are necessary for this analysis. Some, such as "LAS," "Topography," and "Cadastral" are datasets that were used for advanced visualization of map products. This analysis can be completed without these datasets.

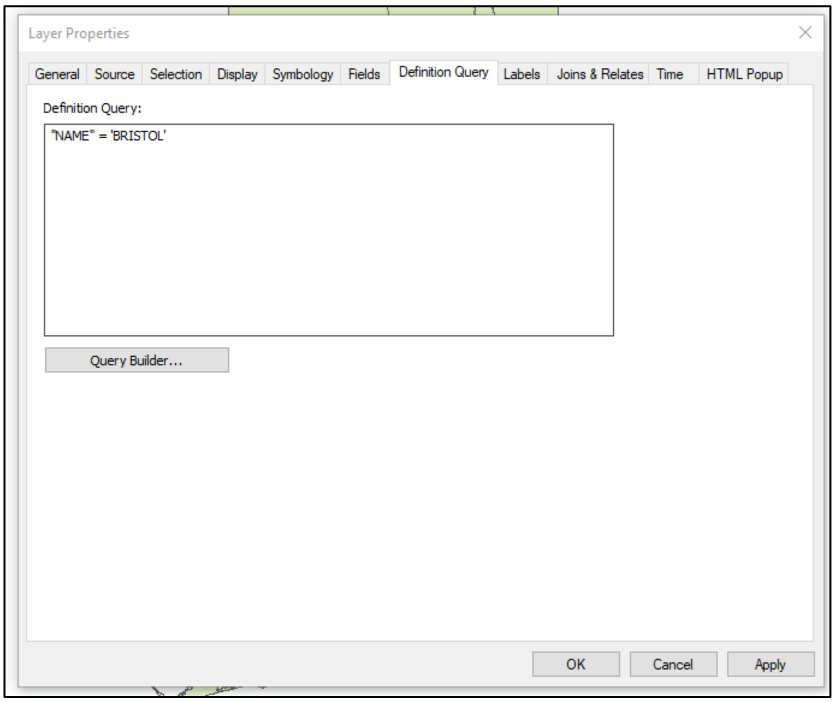


Sea Level Rise data (titled "Hydrography" in this example) and **Structure** data (titled "BBW_Risk") should both be stored as <u>file geodatabases</u> for each sea level rise scenario. Later analysis steps require that data are stored in this format.

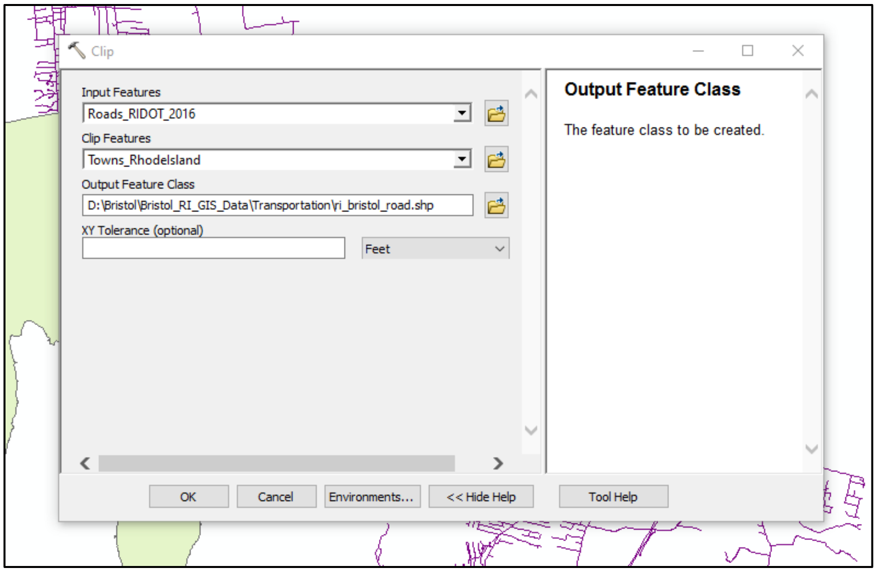
Step 2: Clip data to Area of Interest

All of the datasets in this example extend state-wide, so the data should be clipped to an area of interest to avoid long processing times and/or software crashes. In this example, the area of interest is a municipality.

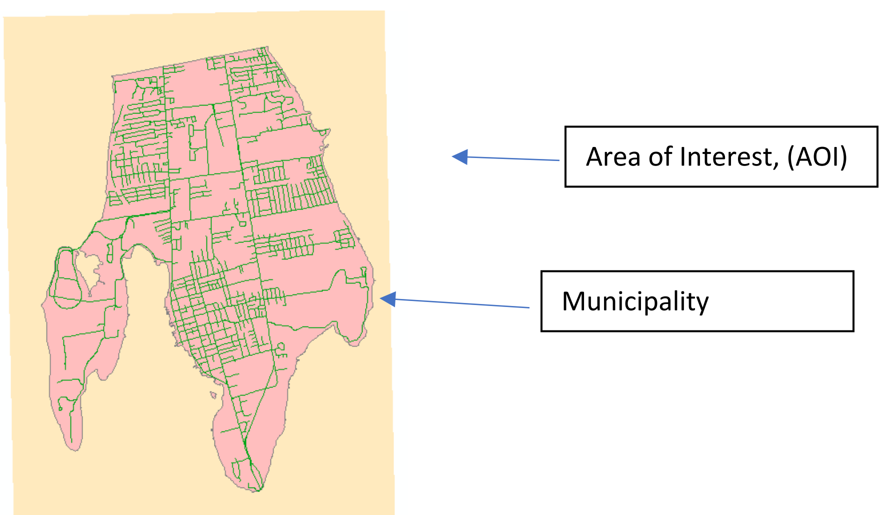
Begin by applying a definition query to the Rhode Island Municipalities layer



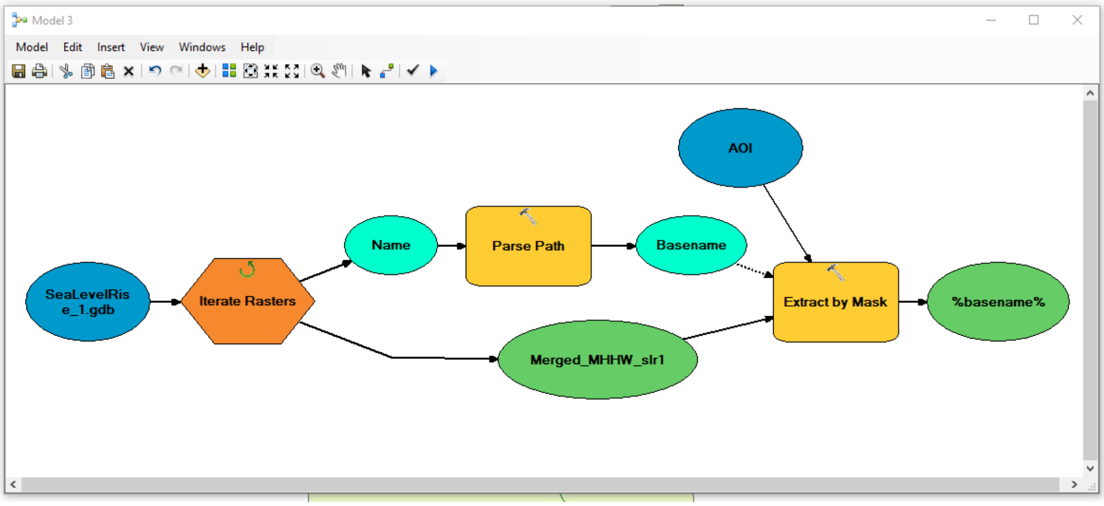
Next, use the *Clip* tool to clip roads to the municipality.



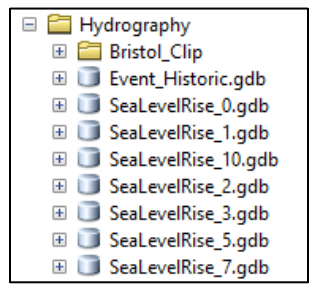
Next, create a new shapefile called "AOI" (for Area of Interest) and extend the AOI layer just beyond the extent of the municipality. This AOI will serve as a processing extent for clipping the Sea Level Rise raster layers.



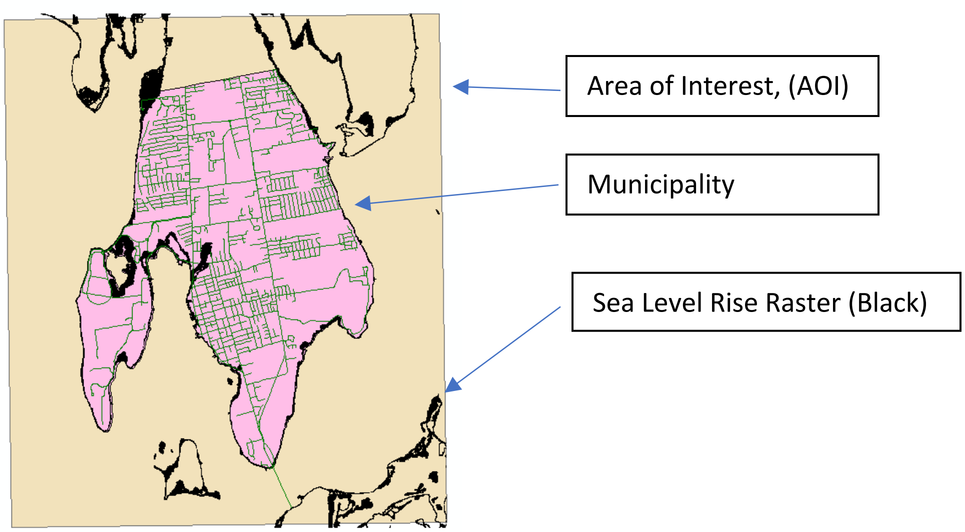
Next, use the *Extract by Mask* tool to clip the sea level rise data to the AOI layer. This can be accomplished for all feature classes within a file geodatabase by using an iterator in model builder. The model builder screen below shows an example of this analysis for "SeaLevelRise_1.gdb."



Repeat this step for each of the Sea Level Rise geodatabases.



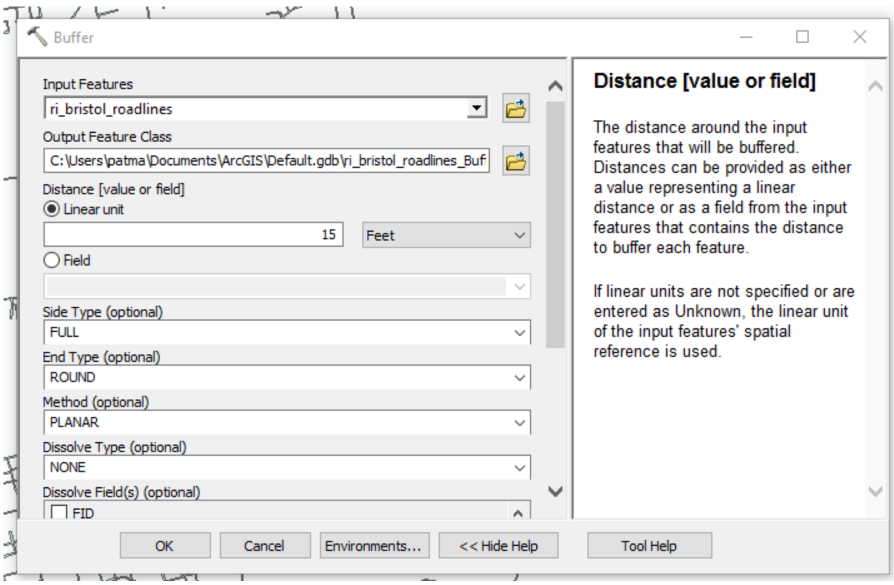
Once completed, the sea level rise raster data will be clipped to the AOI, just beyond the boundaries of the municipality.



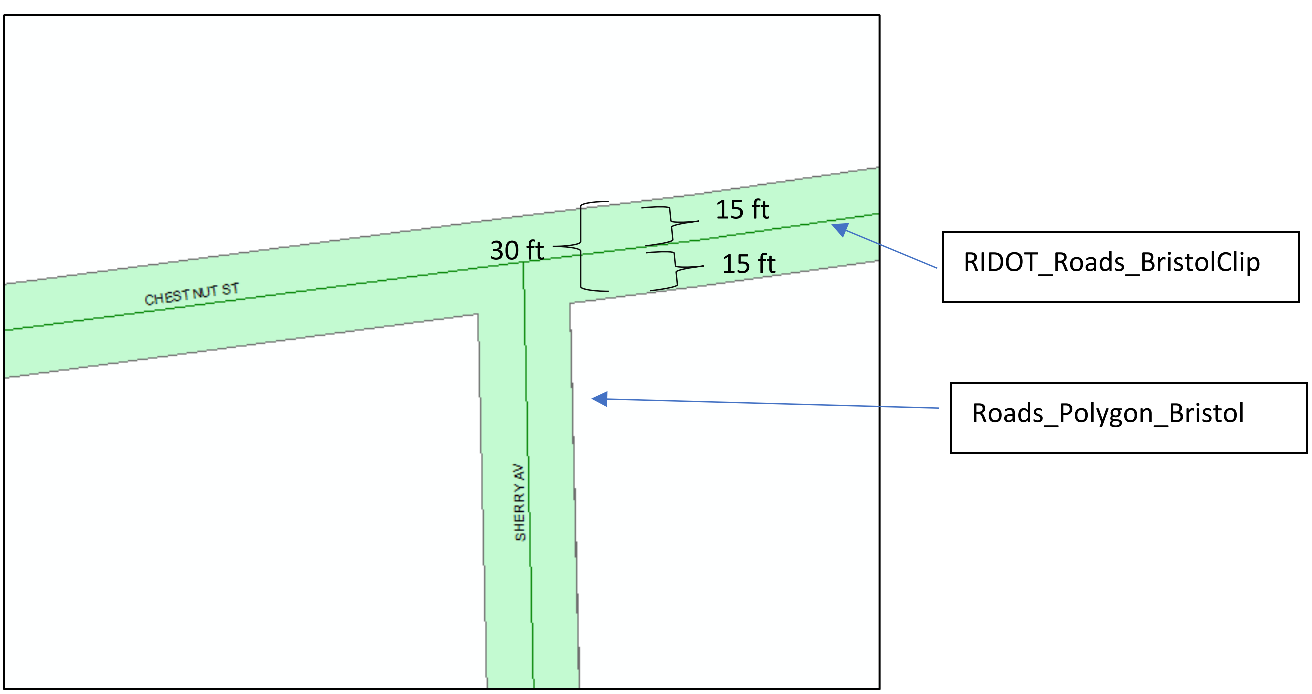
Step 3: Buffer Roads

The next step is to extract the sea level rise raster data to the footprint of the road network. However, the roads are frequently line features, meaning they have no area. Some municipalities have road layers as polygons, particularly those who use an outside GIS consultant to manage the town's data (such as MainStreet GIS). If the municipalities roads are available as polygons from another source, this step can be skipped. Otherwise, follow the steps below to create a "Roads_Polygon" layer.

Open the *Buffer* tool

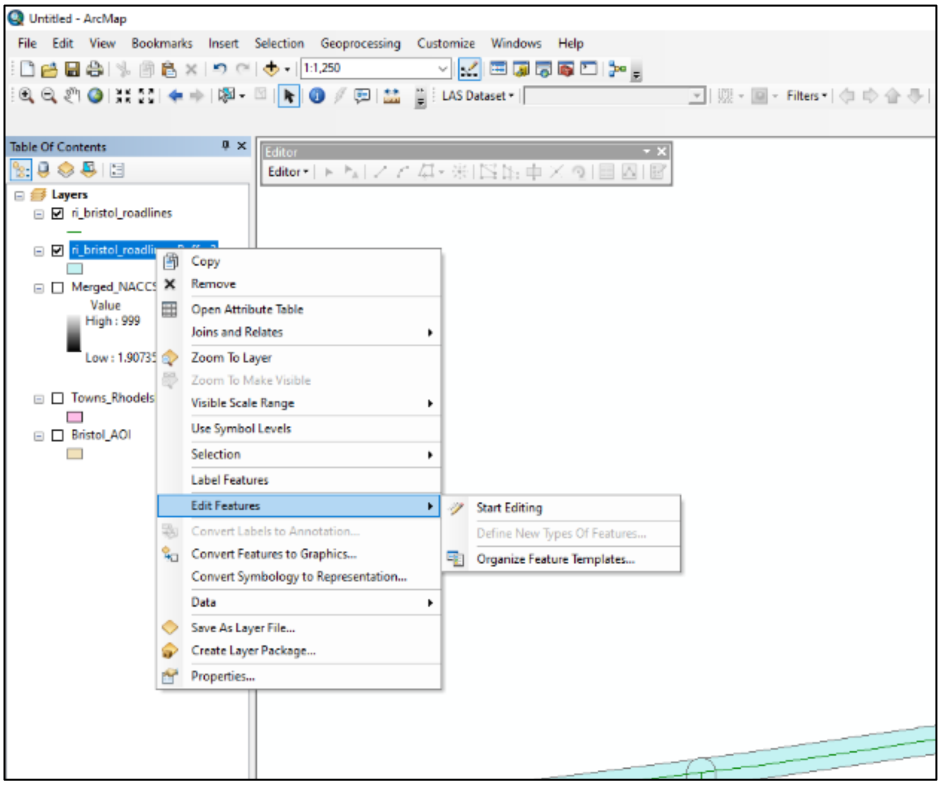


Select the roads (clipped to municipality in Step 2) as the input feature, and select a distance to buffer the roads in the Distance field. The *Buffer* tool will create a buffer on both sides of the input feature, so a 15 foot buffer will create a 30 foot wide road polygon.

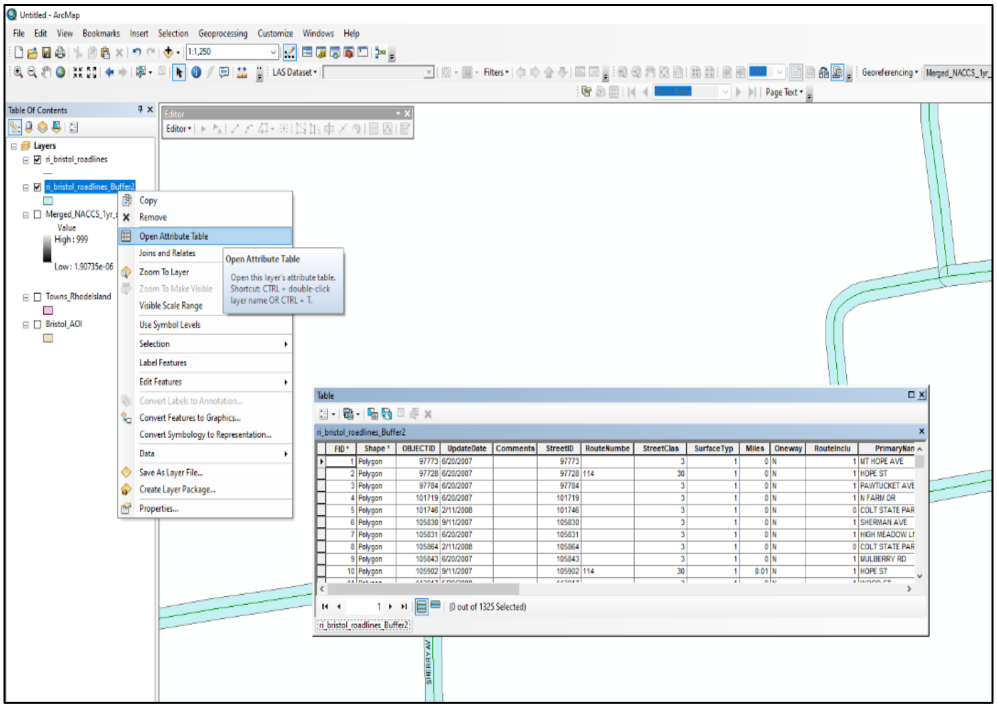


After the buffer tool is used, each road segment will have an individual road polygon. (If, for example, there are 1,325 road segments in the dataset, there will be 1,325 road polygons.) This will cause problems in the next step, when you are extracting the sea level rise data to the "Roads_Polygon" layer.

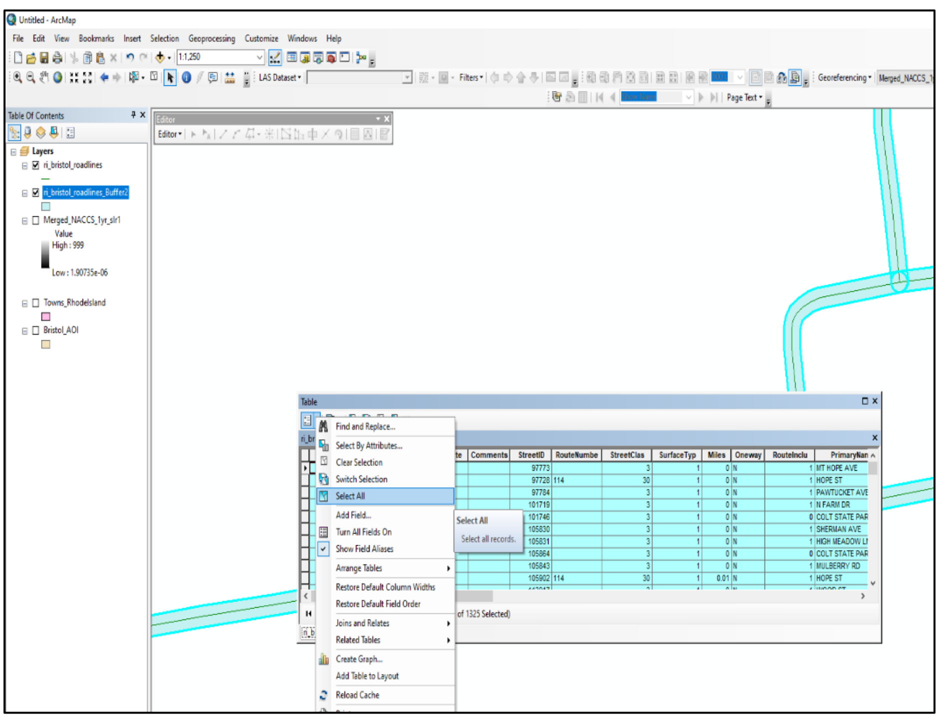
To fix this issue, 1) edit the "Roads_Polygon" layer, 2) open the attributes table, 3) select all features, and 4) merge all features to create one "Roads_Polygon" feature. Save Edits.



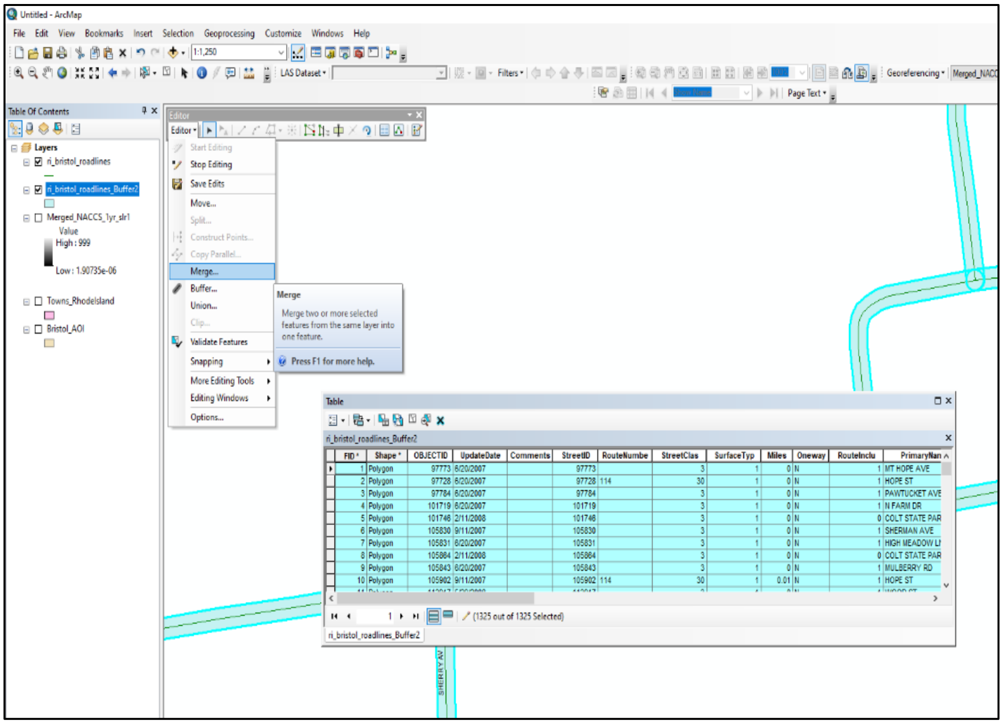
1) Edit Features

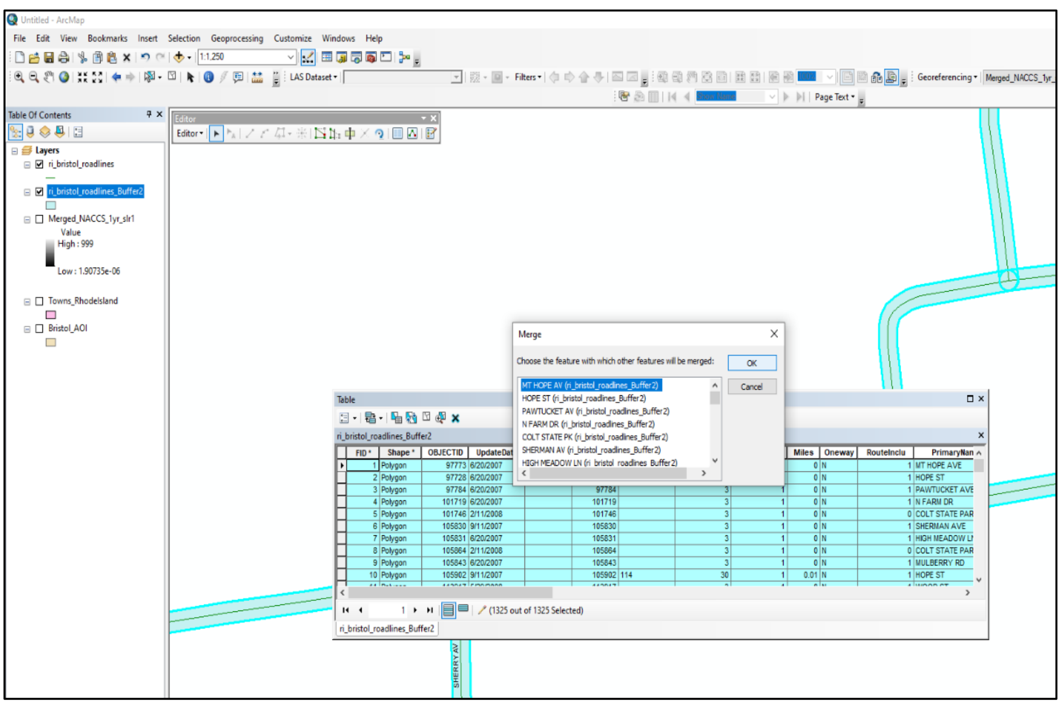


2) Open Attributes Table



3) Select all features

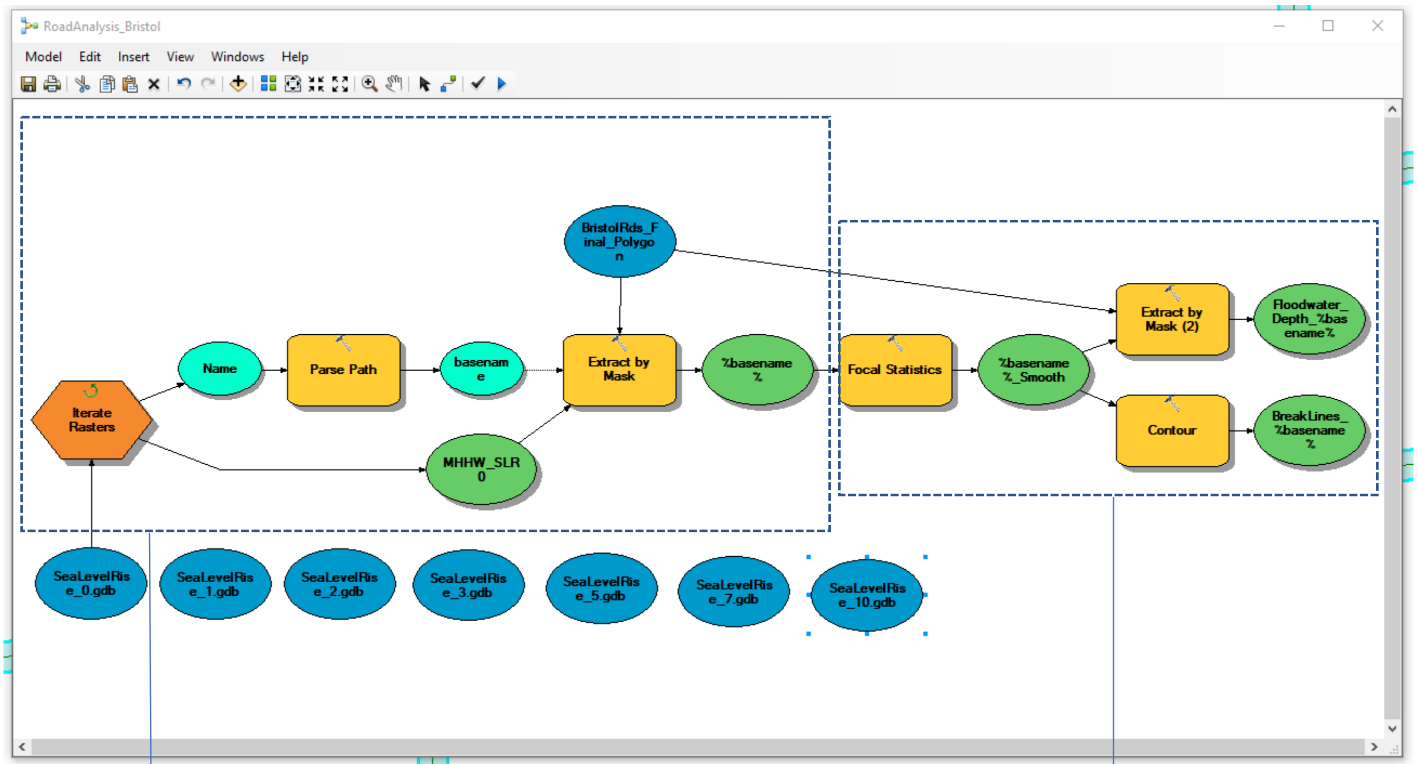




4) Merge- select any road and click ok. Now all the individual polygons should be one single feature.

Step 6: Extract Sea Level Rise rasters to Roads_Polygon

This step takes the Sea Level Rise scenarios and extracts the areas where floodwater intersects the roads polygons. These data can be used to understand the impact and extent of sea level rise on the town's road infrastructure. Similar methods can be used to analyze the impact of sea level rise on other town infrastructure or town owned/managed lands such as parks, bike paths, parking lots, etc. Due to the large number of sea level rise scenarios, it is recommended that model builder is used with an iteration tool to automate the analysis process.



Here, the model extracts the sea level rise scenario to the extent of "Roads_Polygons," however the data may be choppy and peppered.

The second part of the model smooths the choppy and peppered data. Additionally, the *Focal Statistics* operation extends the footprint of the raster beyond "Roads_Polygon" so a second *Extract by Mask* operation is used to clip the raster to the extent of the road surface. The *Contour* operation creates break lines at 0.2-ft interval to help visualize the different floodwater depths.

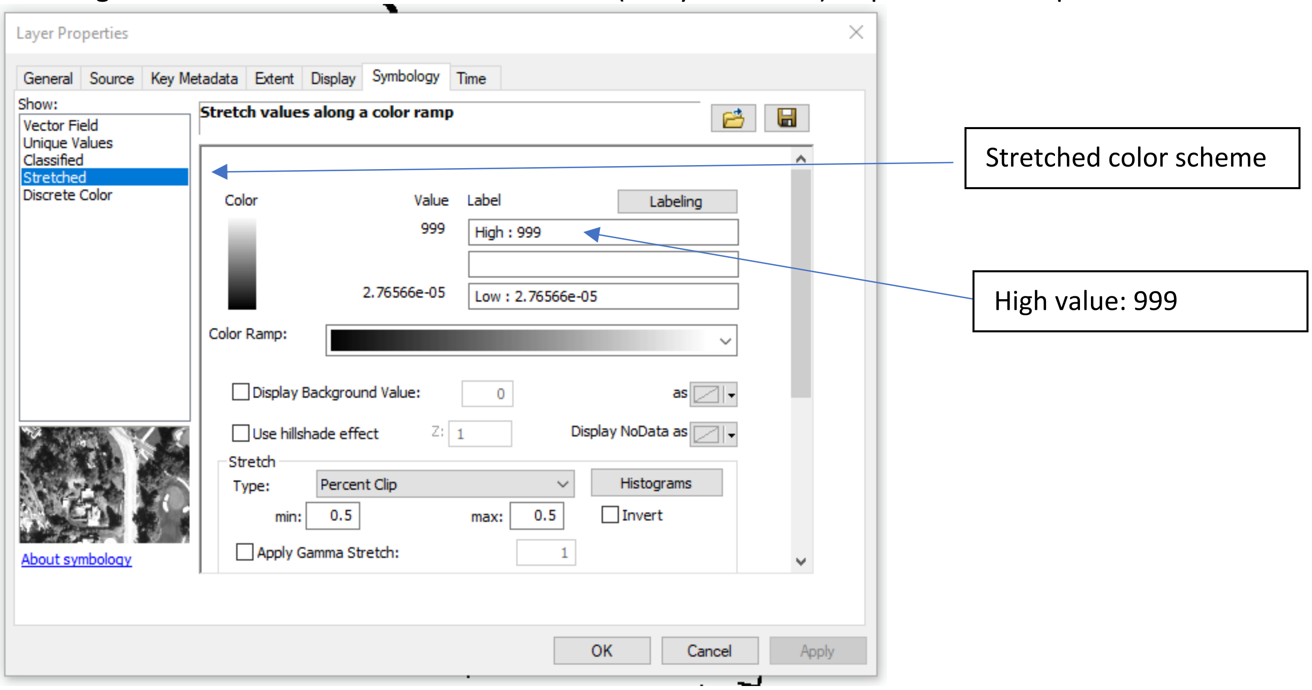
The output of this modeling routine is two datasets. The first are rasters displaying the extent and depth of floodwater on the road surface for a given sea level rise/ storm return period combination. This dataset is clipped to the extent of the road footprint, the same footprint created in the previous step- **Step 3: Buffer Roads.**

The second dataset created from this modeling routine is a series of polylines displaying floodwater depth-intervals. This dataset is used for increased visualization of mapping products.

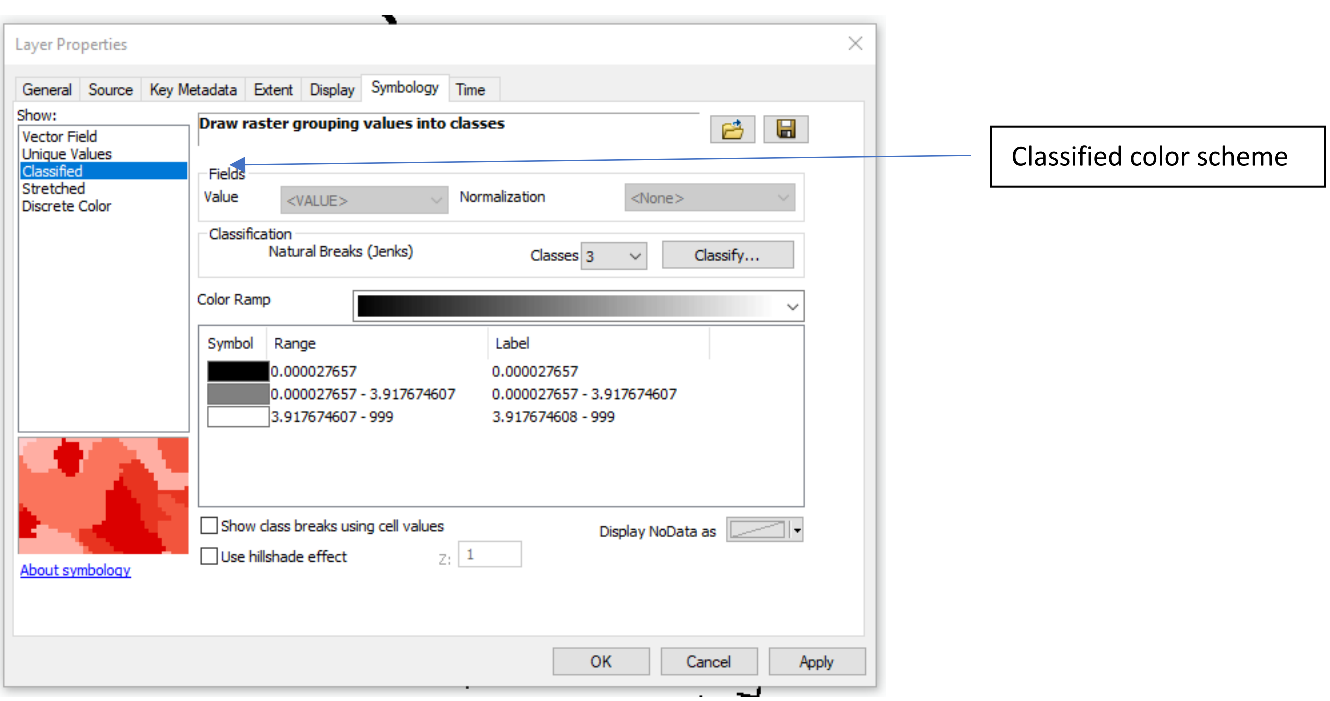
Step 6A: Symbology

For each of the newly created road flooding rasters from the model above, open the layer properties and select the symbology tab. These data will automatically display in a stretched color scheme. The high value may be 999 meaning the pixels corresponding to these locations have an unknown value.

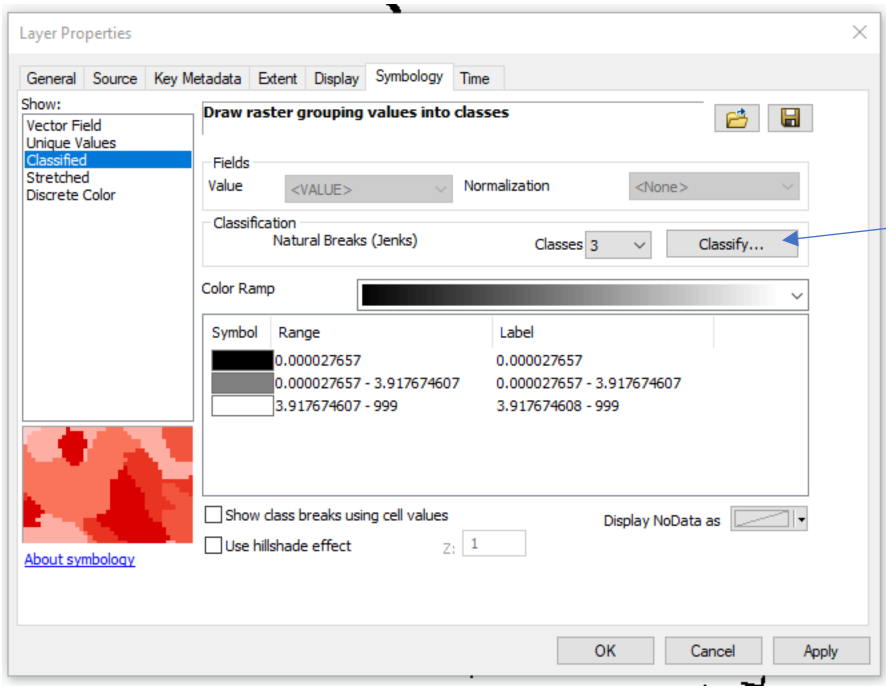
*If the high value is some other value below 999 (likely below 50) skip ahead to step 6B.



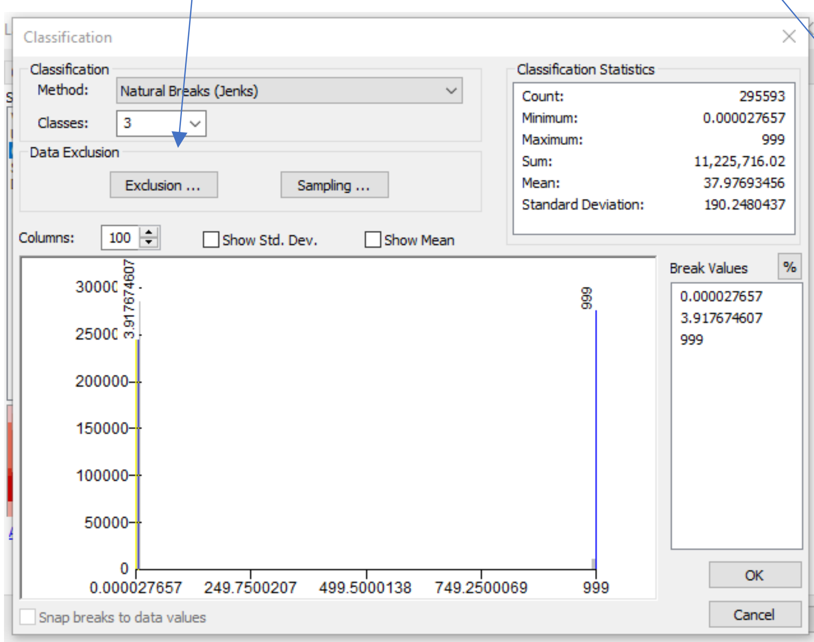
Change the color scheme to classified

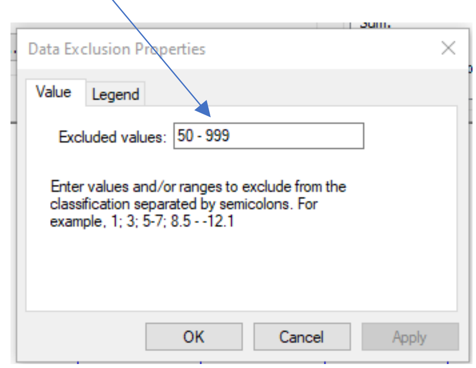


Click on Classify…



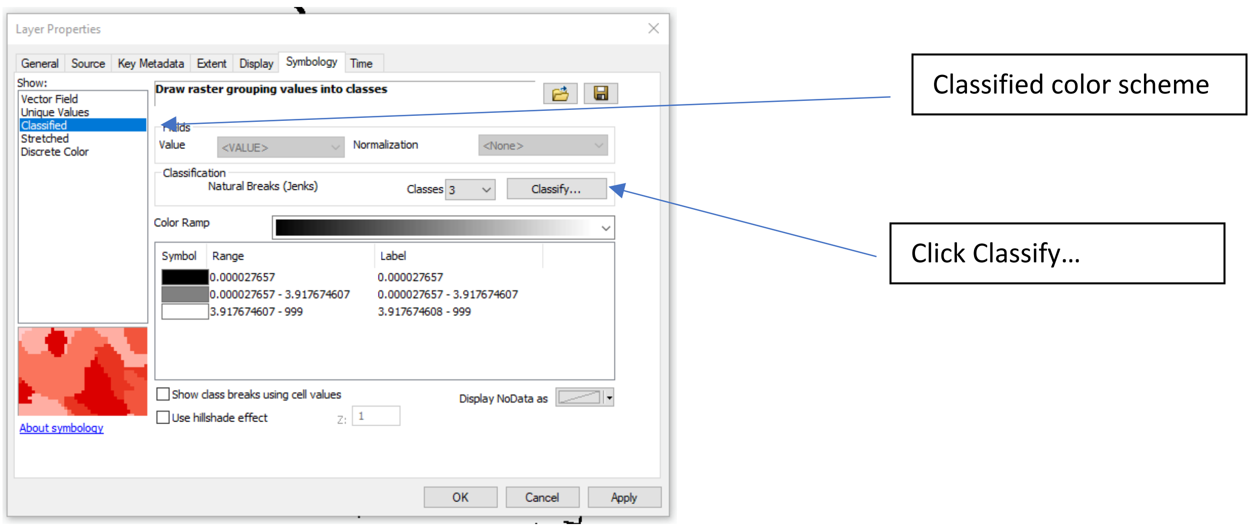
Click on Exclusion… and exclude values between 50-999

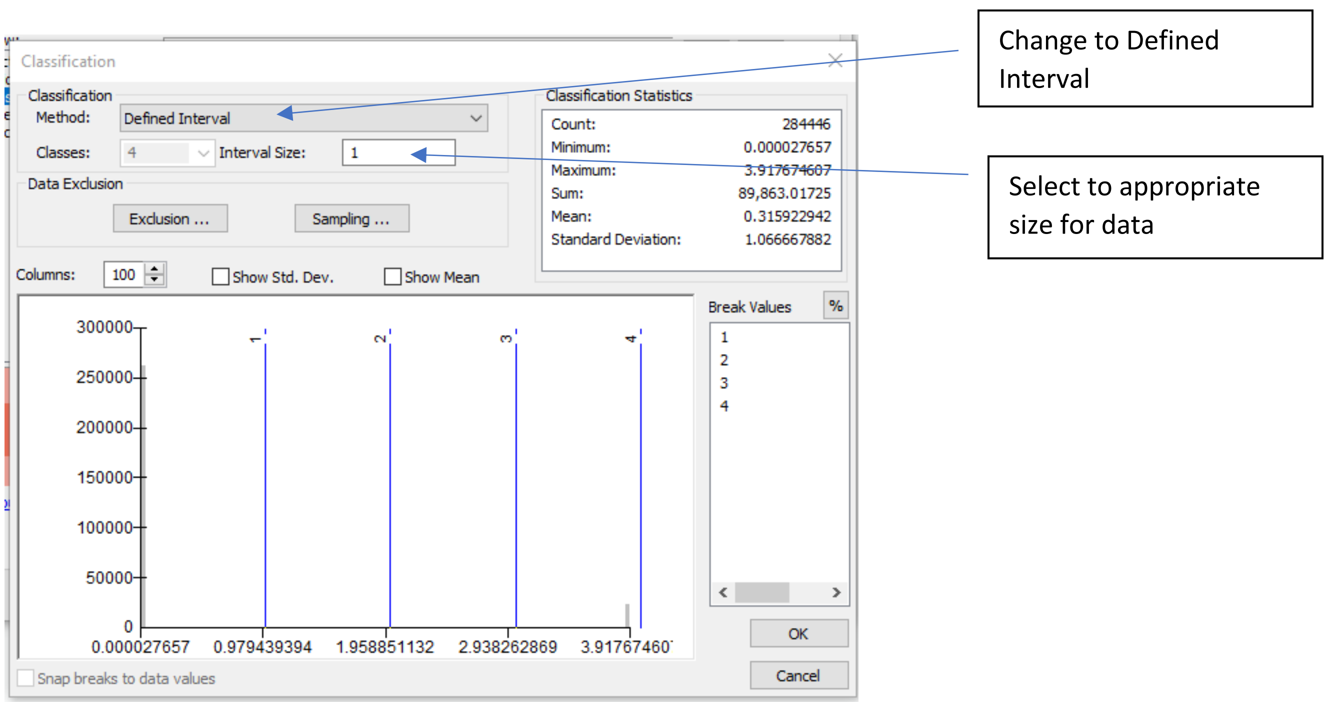




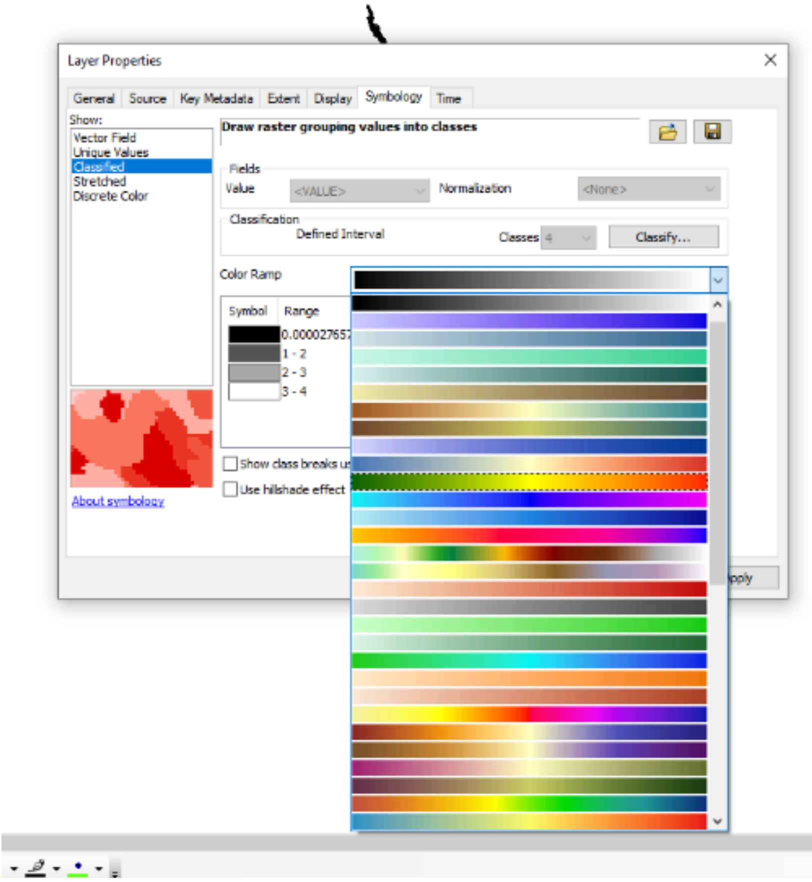
Step 6B: Symbology

In the classified color scheme, click Classify and change the classification method to *Defined Interval*. Select an interval size appropriate for your data (common sizes are: 1, 2, 4 or 5).



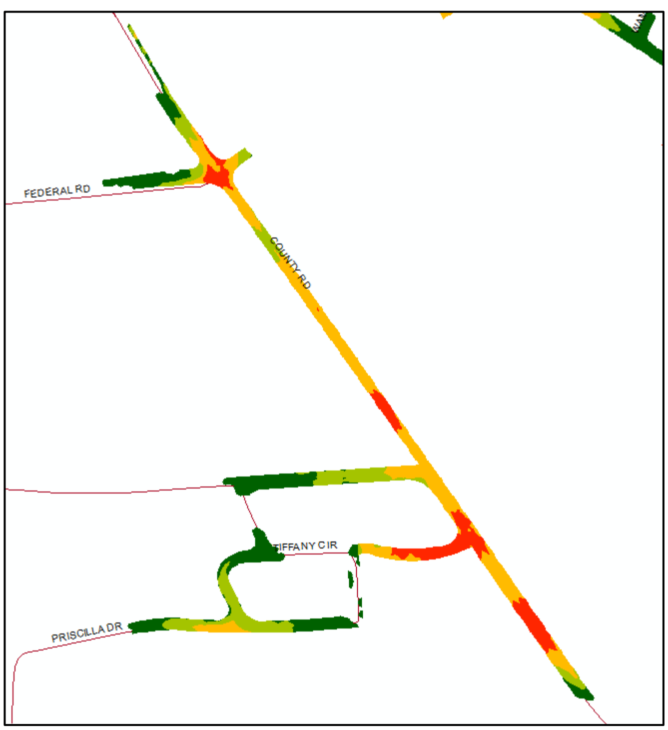


Click OK.



Select a suitable color ramp.

Click OK and close Layer Properties. At this point the ArcMap project should look similar to this:



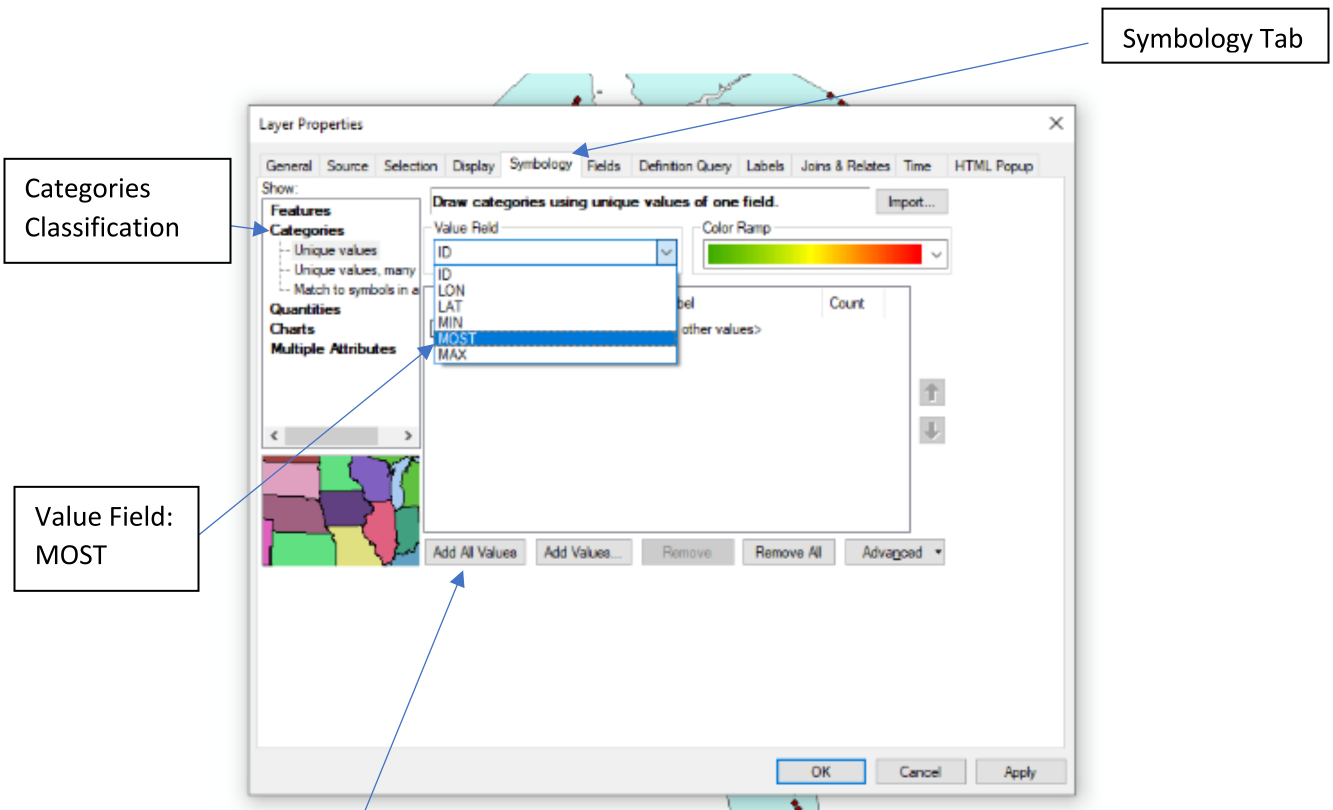
Green colors indicate shallow floodwater, red colors indicate deep floodwater

Step 7: Structure analysis

Begin the Structure Analysis by clipping the three Stormtools CERI output layers to the municipality (in this example the Stormtools layers are named: “BBW_Risk_100yr_SLR0_agol,” “BBW_Risk_100yr_SLR2_agol,” and “BBW_Risk_100yr_SLR5_agol”).

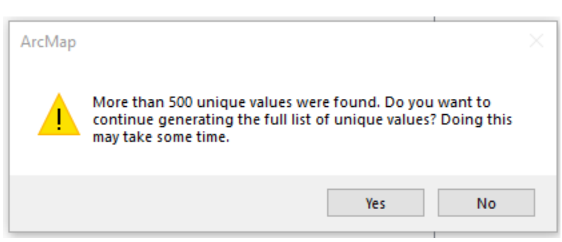
After these data have been clipped, open layer properties, select the Symbology tab, select the Categories classification, and change the value field to MOST.

The MOST value corresponds to the expected damage percentage of a structure, so a structure with a MOST value of 25, means 25% of the structure is expected to be damaged for a given sea level rise event.



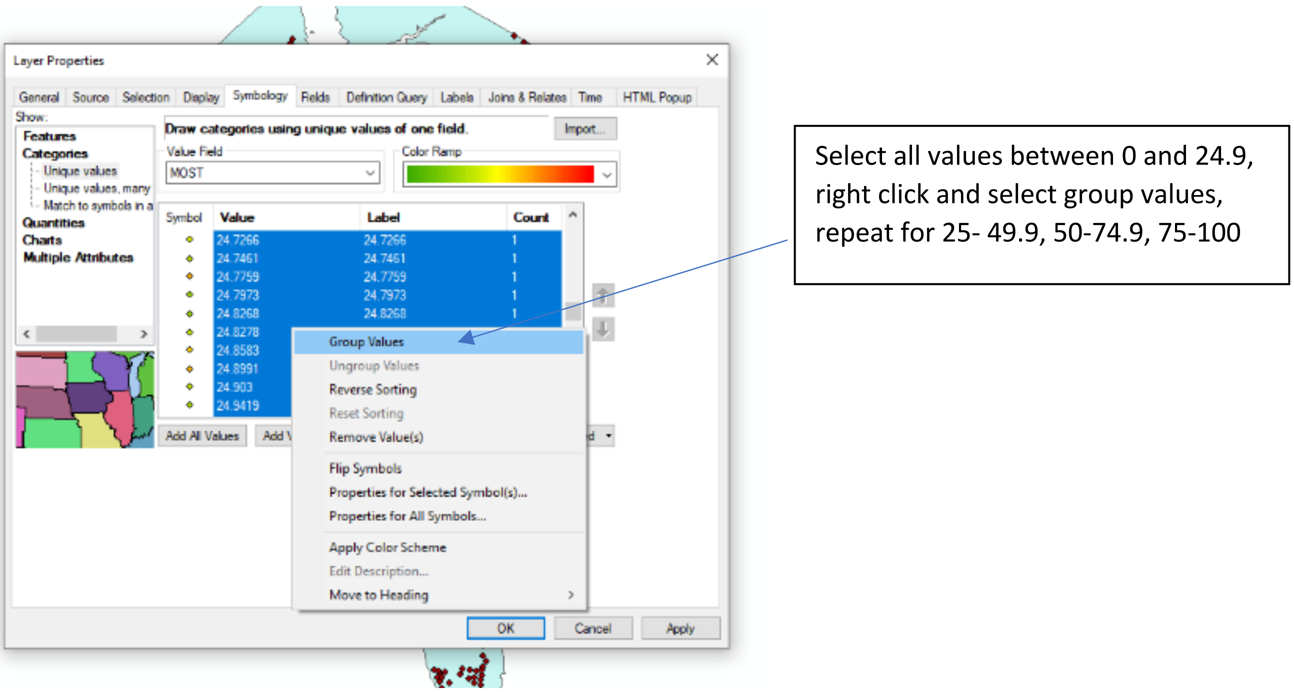
Next Click Add All Values

This warning message may appear, click Yes.

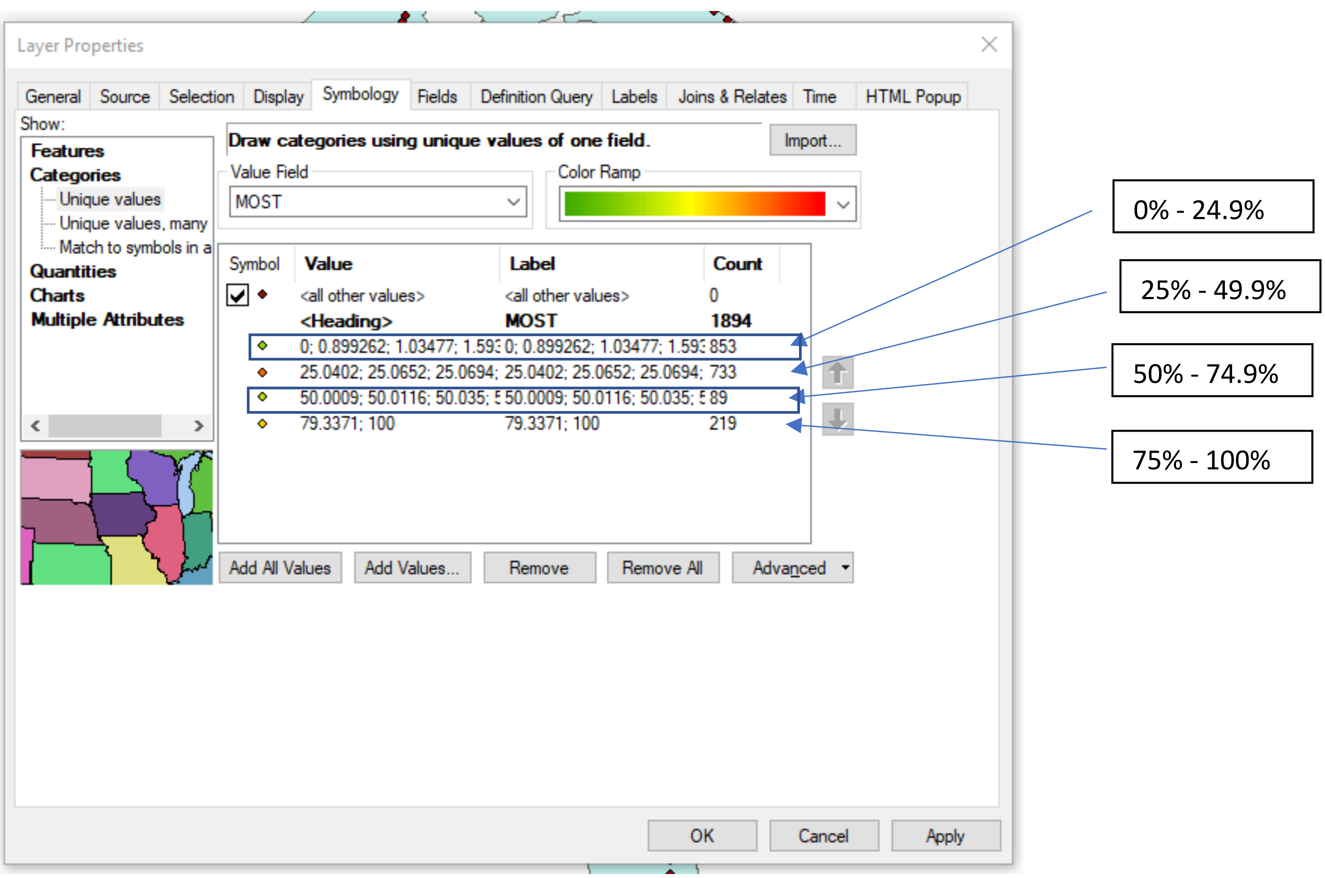


Next, group values into intervals of 25%

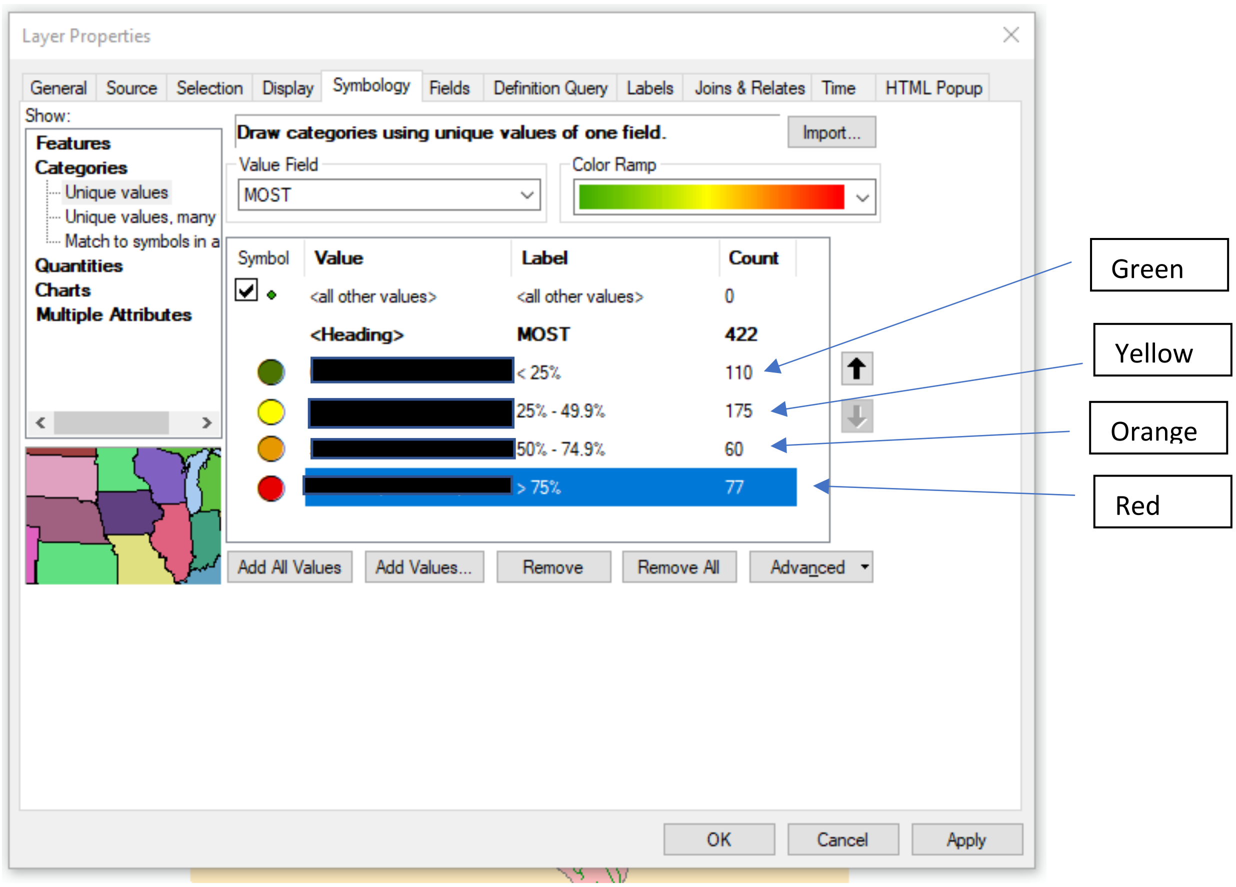
(0%- 24.9%, 25%- 49.9%, 50%-74.9% and 75%-100%)



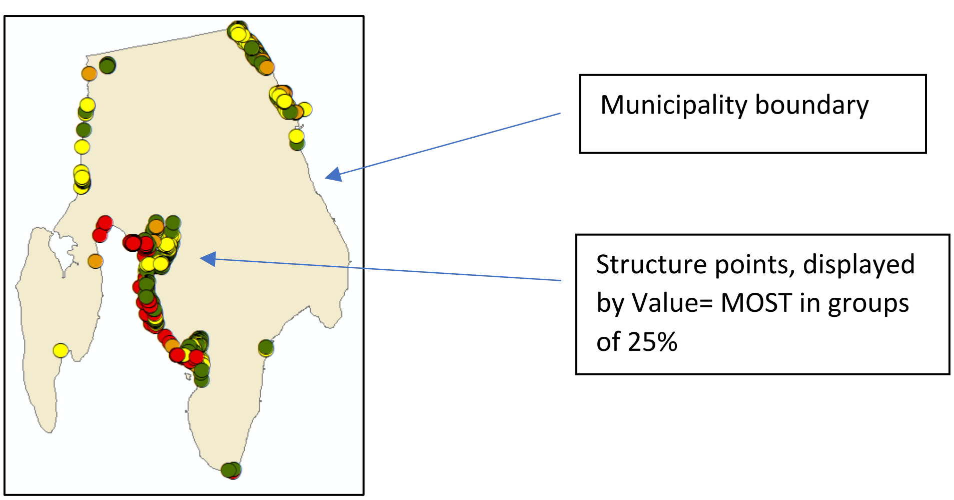
There should now be 4 groupings corresponding to these ranges:



Next change the point colors to a color scheme that makes sense for the desired map products. A common color scheme is:



Click OK, and close layer properties. The ArcMap project should look similar to this:

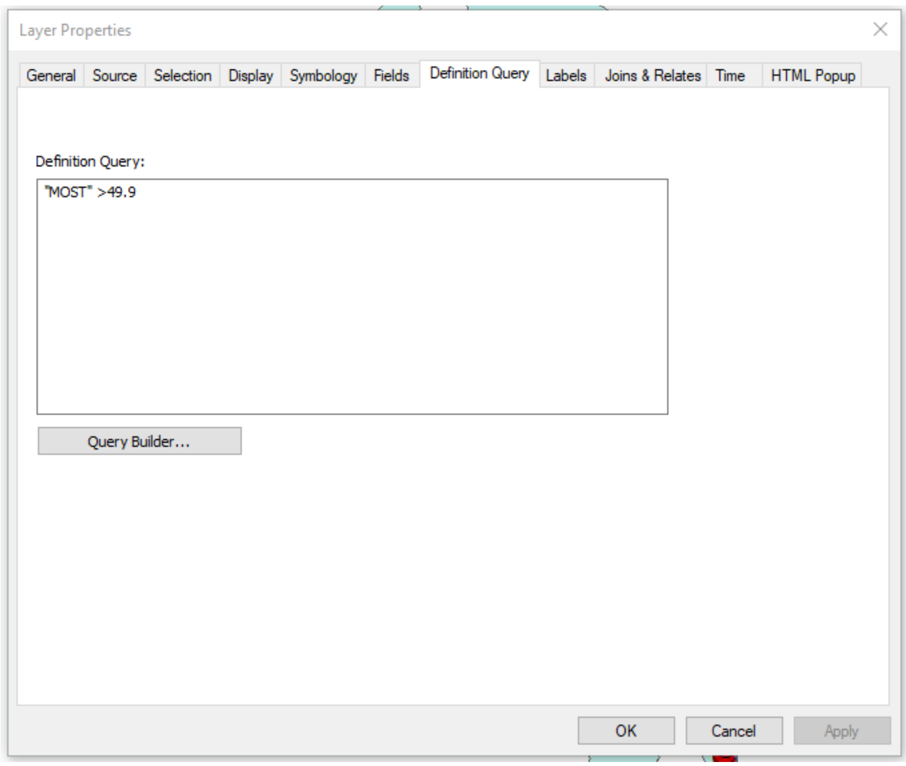


Step 8: Density analysis

The last analysis process is a density analysis using the *Kernel Density* tool. The density analysis examines the spatial density of structures with greater than 50% damage (where damage value=MOST).

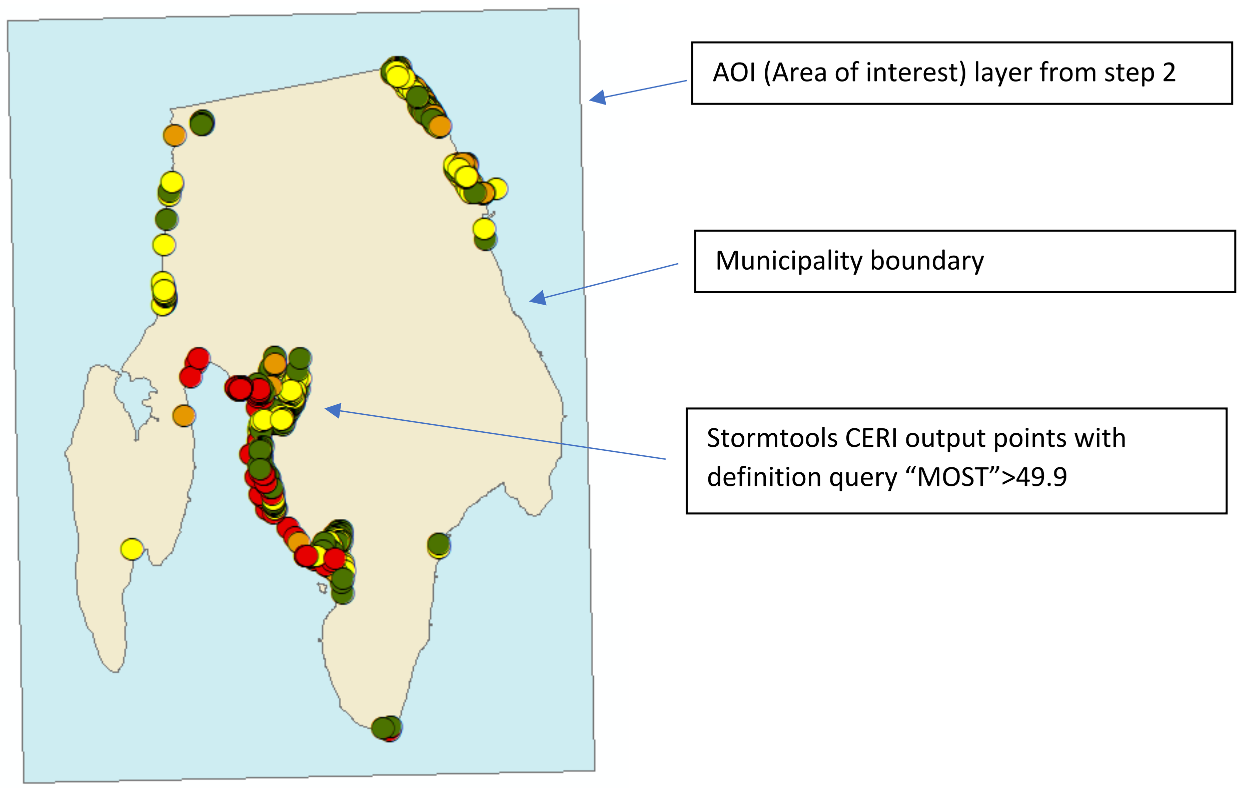
Begin by applying a Definition Query to the Stormtools CERI structure point layers created in the previous step.

Open layer properties, select the definition query tab and apply the query: "MOST" >49.9.

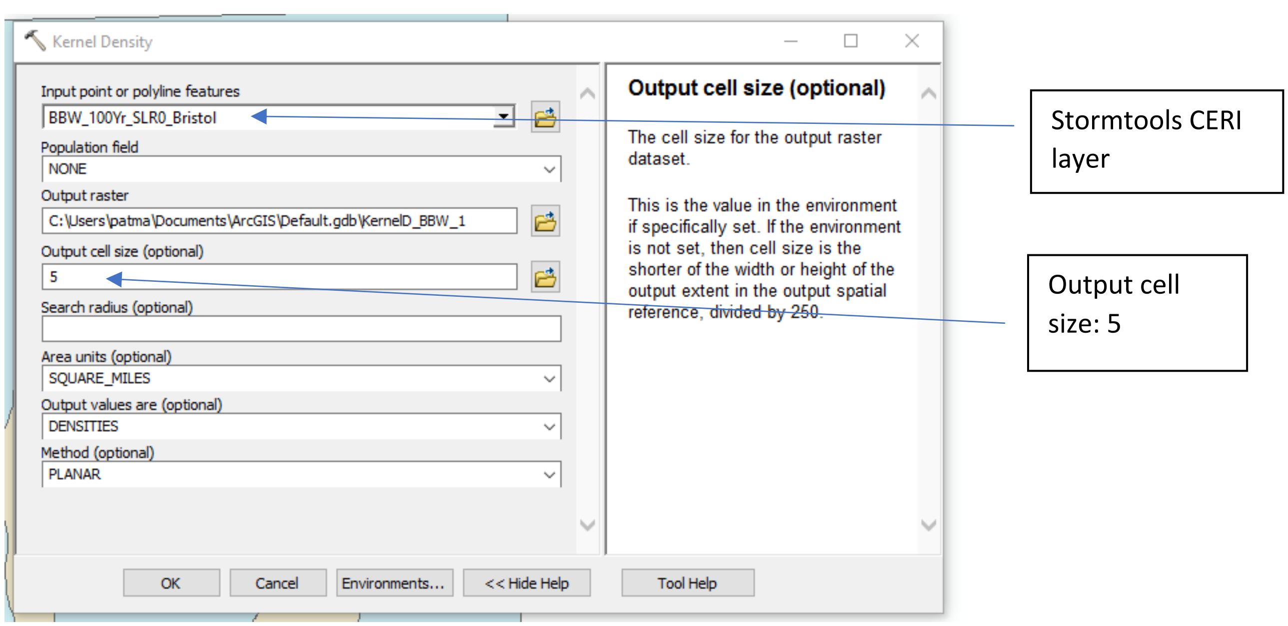


Select OK to close layer properties.

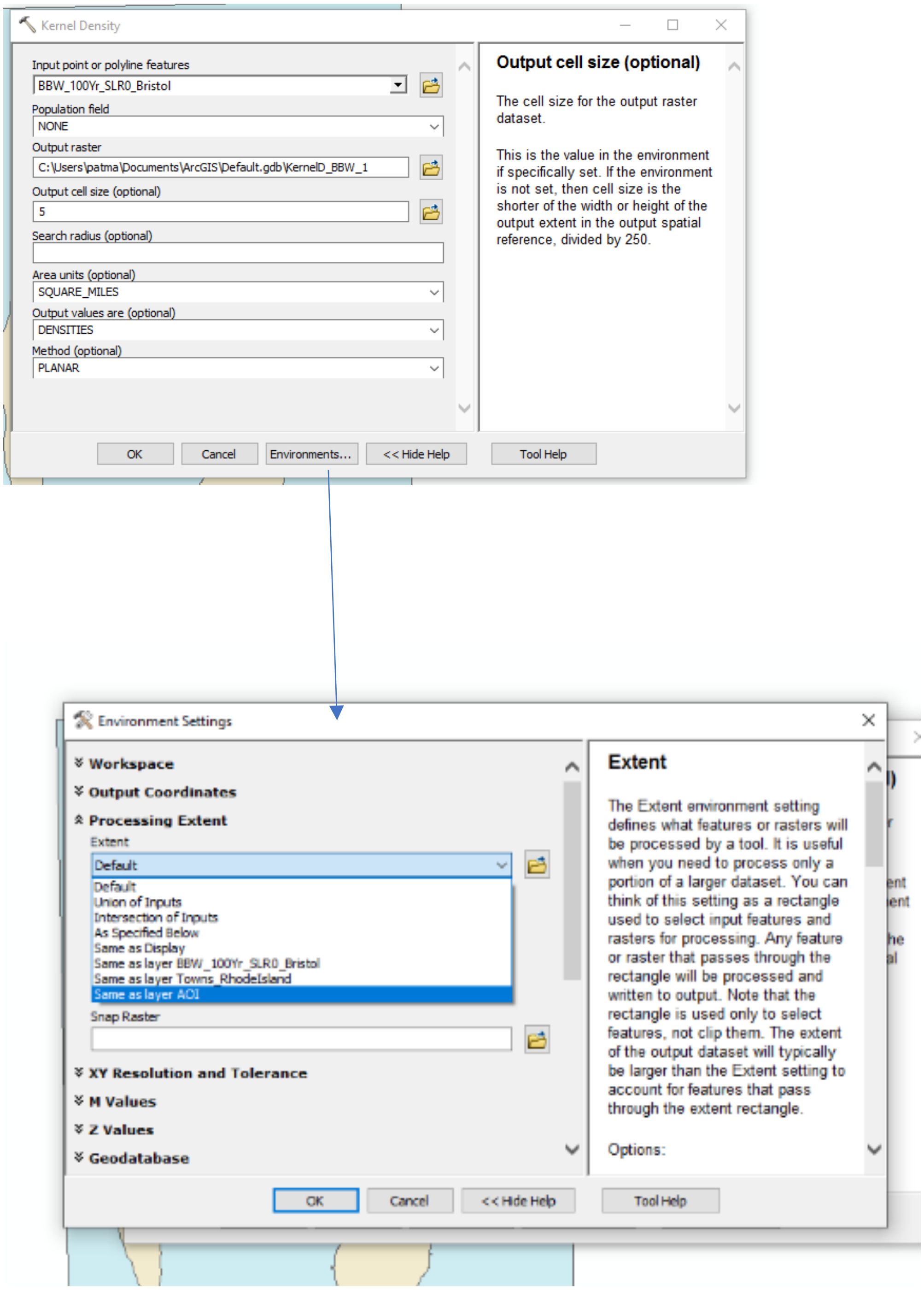
Make sure to add the AOI layer from **step 2** of this analysis.



Open the *Kernel Density* Tool and select the Stormtools CERI (point) layer as the input feature. Change the output cell size to 5

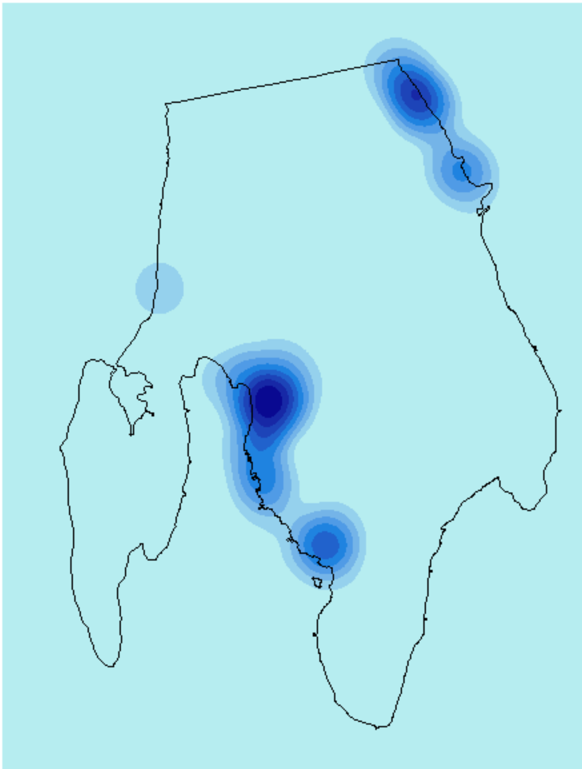


Next, select the Environments… menu in the *Kernel Density* Tool

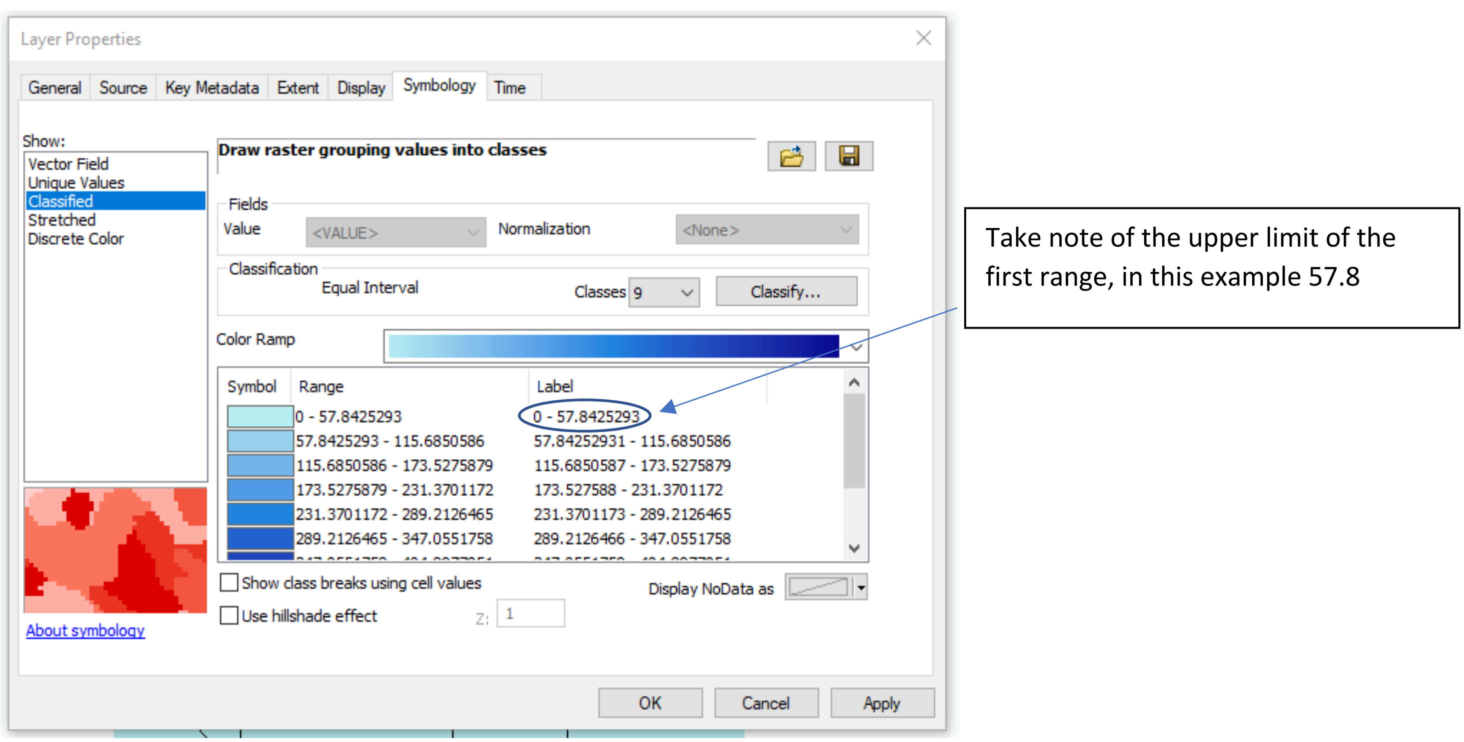


Select the Processing Extent option and change the extent to “Same as layer AOI.” Select OK to close the Environment Settings and run the *Kernel Density* tool.

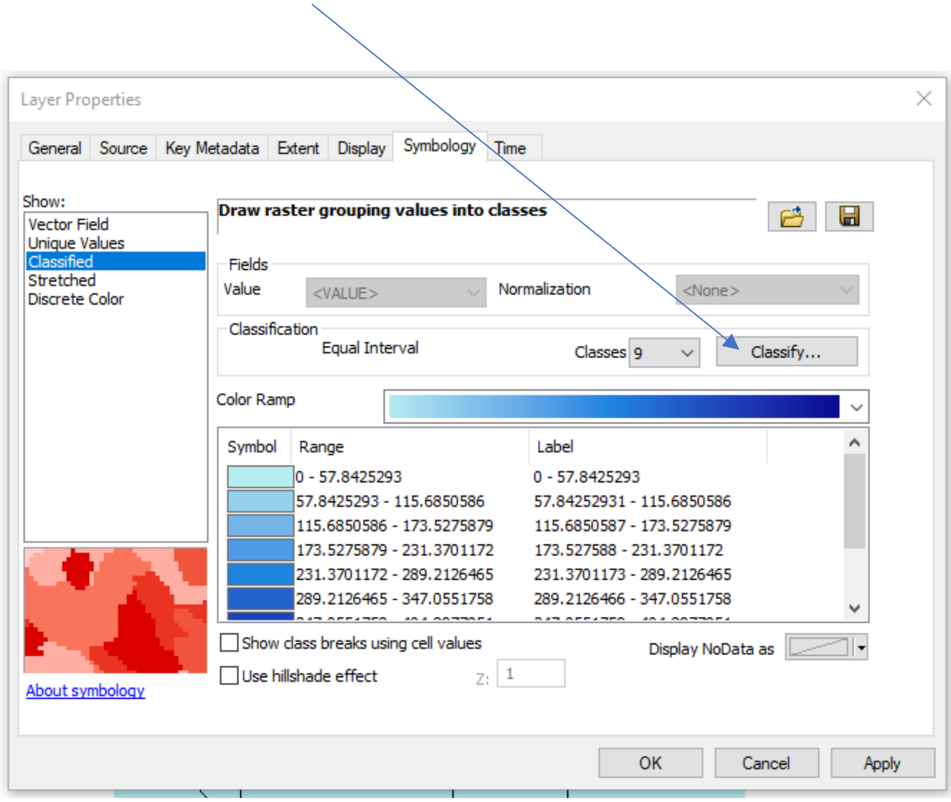
The output raster should look similar to this:



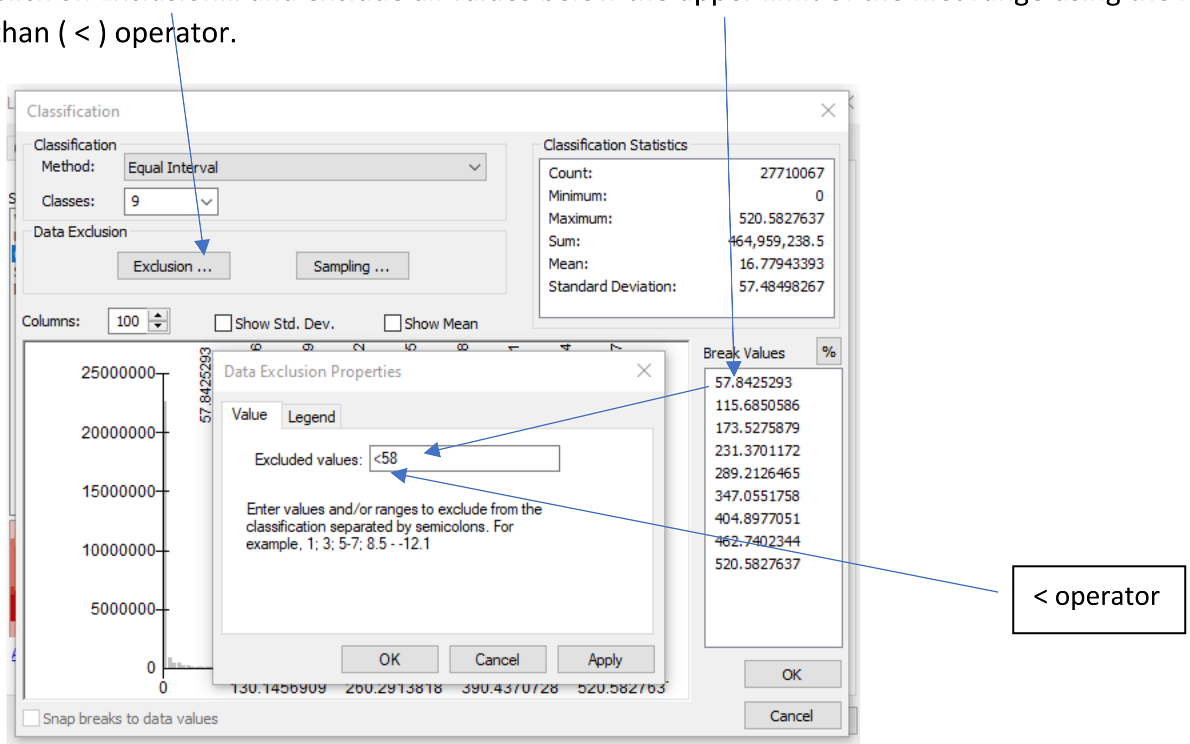
To clean up the symbology, open the Layer Properties for the newly created kernel density layer. Take note of the upper limit of the first range.



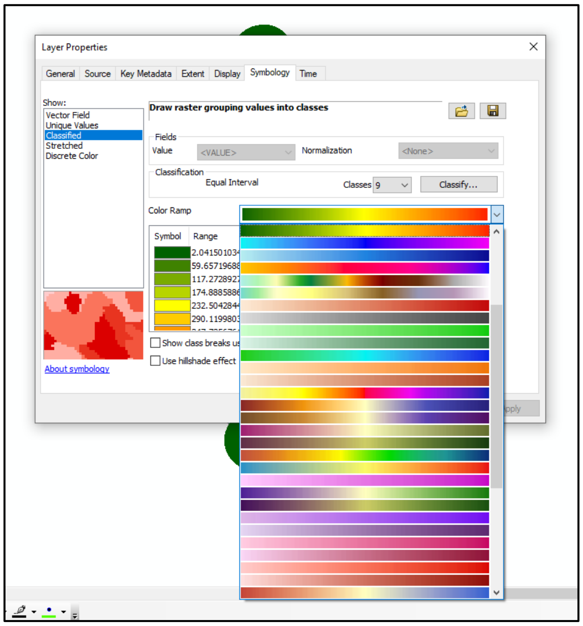
Next, click on the Classify… button.



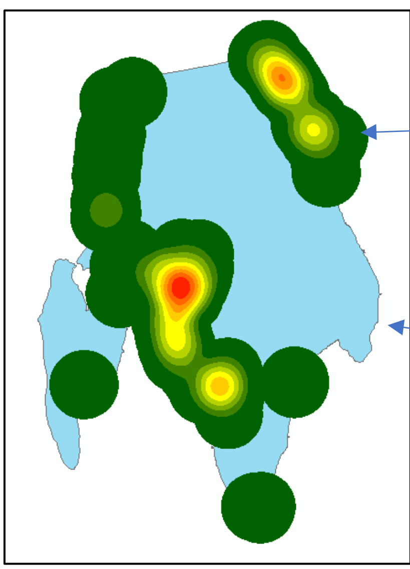
Click on Exclusion… and exclude all values below the upper limit of the first range using the less than (<) operator.



Click OK to close the classification menu. In the Symbology tab, select suitable color ramp and click OK to close layer properties.



The ArcMap project should look similar to this:



Kernel Density raster displaying the density of structures sustaining greater than 50% damage. Green colors indicate lower density of damaged structures; red colors show higher density.

Municipality boundary

These instructions can be used to analyze sea level rise impacts for individual municipalities in Rhode Island. For additional information on this analysis process, see the document titled: *Geospatial Analysis of Sea Level Rise in Warren, Rhode Island. (https://ci.uri.edu/files/Geospatial-Analysis-of-Sea-Level-Rise-in-Warren-Rhode-Island.pdf)*