Goodbye Galveston

The Effects of Rising Sea Level on the Coast of Galveston, TX

Maria Reistroffer

GEO 327G

12/3/2015

Problem:

Greenhouse gases contribute to global sea level rise and threaten human life, property, wildlife habitats, and freshwater resources. Coastal cities such as Galveston, TX are at risk of complete submersion as the Polar ice caps continue to melt. Galveston is one of the largest industrial and commercial ports in the U.S., and with a mean sea level rise of 6.34mm per year and an average elevation of a couple meters, it would take over one thousand years for the island to disappear.

Goal:

Create a map of Galveston Island utilizing ArcMap and spatial analysis to observe how high sea level must rise to completely cover the barrier island in Galveston County. I will also utilize raster data and elevation models to analyze how human population is affected by the melting of Antarctica's ice cap.

Data Acquisition:

- County Boundaries
- Galveston Census Data
- City Data
- Galveston Raster Elevation Data
- Mean Sea Level Rise in Galveston, TX

County Boundary Data:

https://tpwd.texas.gov/gis/data/downloads#Boundaries

Census Data:

http://tnris.org/data-download/#!/county/Galveston

City Data:

http://tpwd.texas.gov/gis/data

Elevation Data:

http://tnris.org/data-download/#!/county/Galveston

Mean Sea Level Trend Data:

http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8771450

Methods:

I first opened a blank document in ArcMap and set the coordinate system to NAD 1983 UTM Zone 15N (Figure 1).

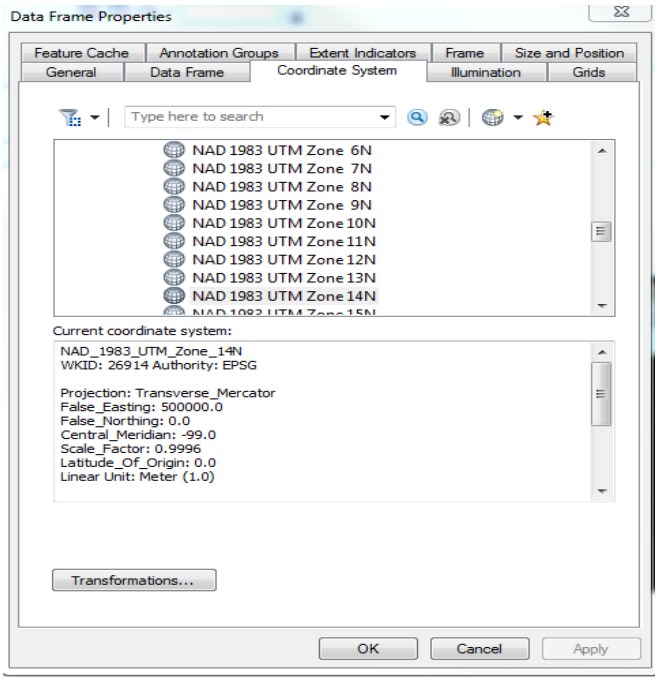

Figure 1: Set Coordinate System to NAD 1983 UTM Zone 15N

I navigated to the TNRIS cite http://tnris.org/data-download/#!/county/Galveston and selected the League City and Bacliff quadrangles. The two quadrangles from the 2013 National Elevation Dataset of the Galveston county region as well as the Census data from the same cite were added to my ArcMap document (Figures 2-4).

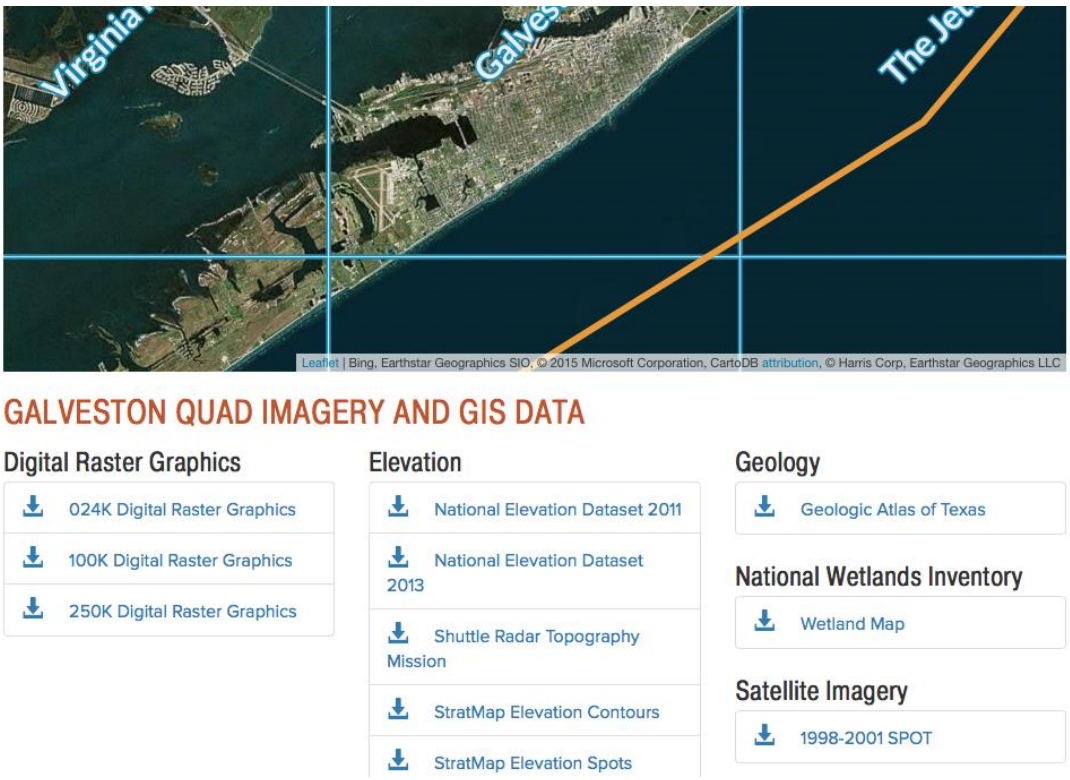

Figure 2: TNRIS elevation and census data downloads

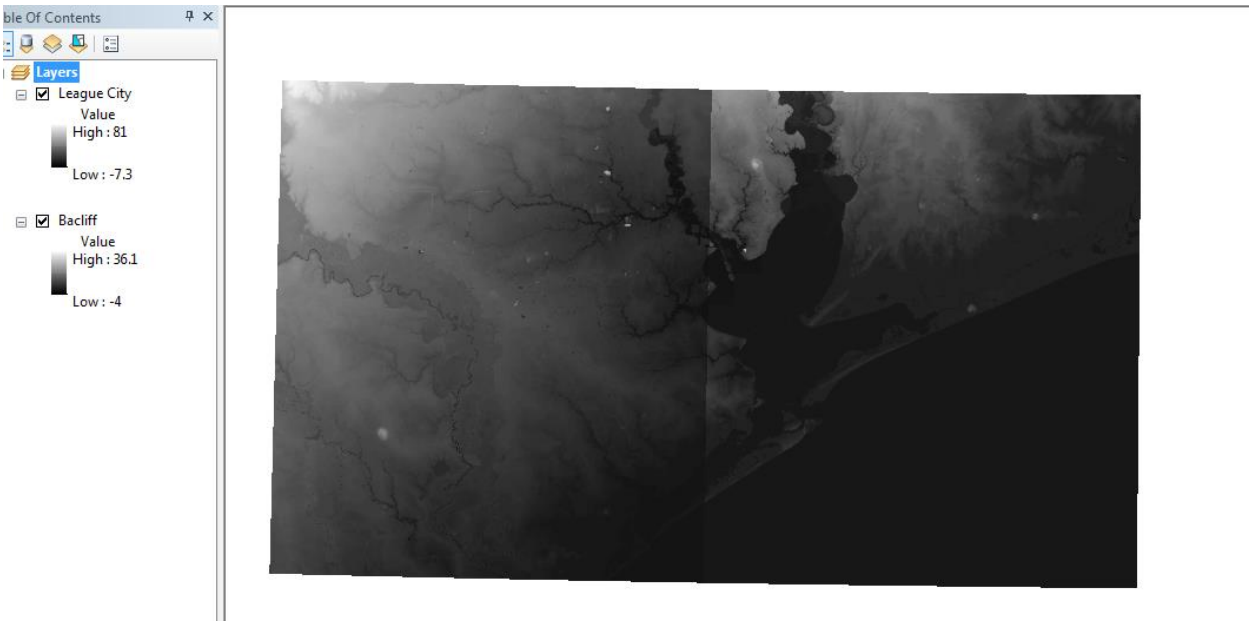

Figure 3: Two quadrangles added to ArcMap

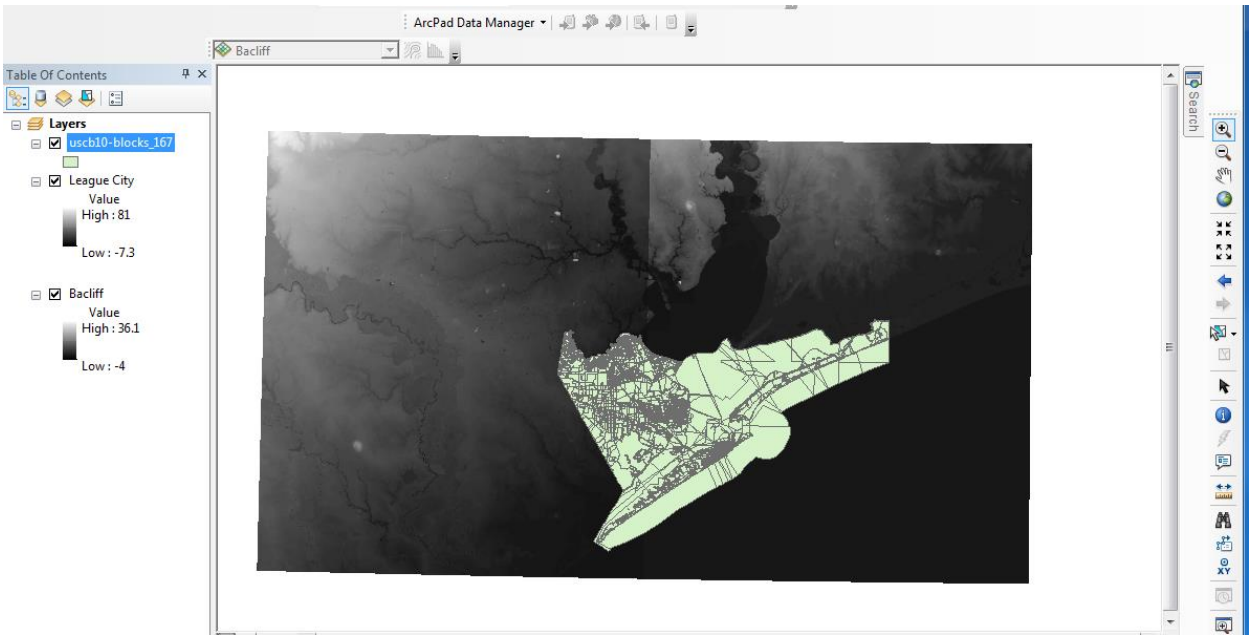

Figure 4: Census data added to ArcMap

Next, the TX counties shapefiles were downloaded from the above cite and added to the Arcmap document. I opened the attributes table and labeled the counties by “Name” with dynamic labeling (Figure 5).

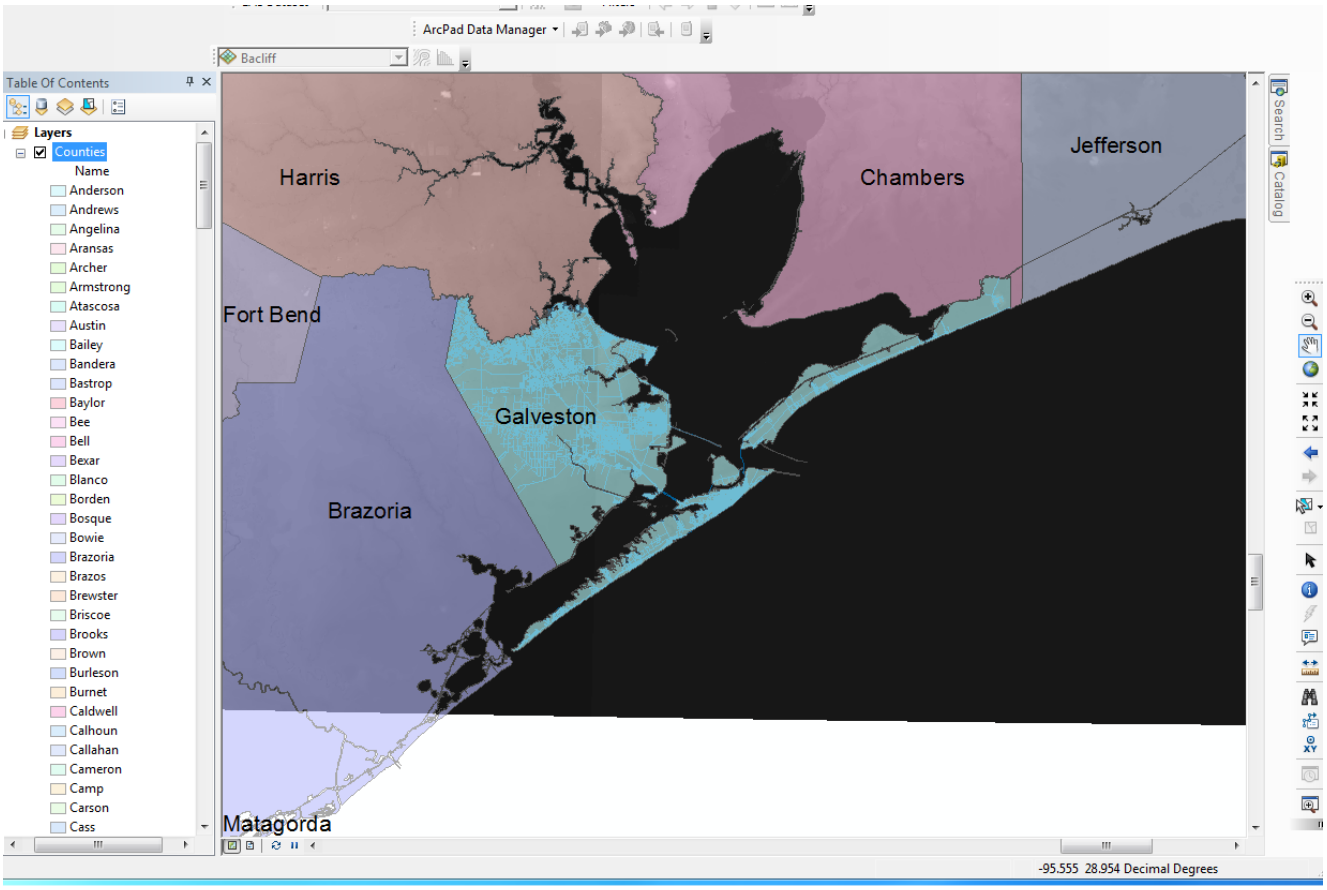

Figure 5: Added and labeled TX counties by “Name”

I changed the symbol of Texas Counties to a hollow fill so that the elevation raster was visible (Figure 6).

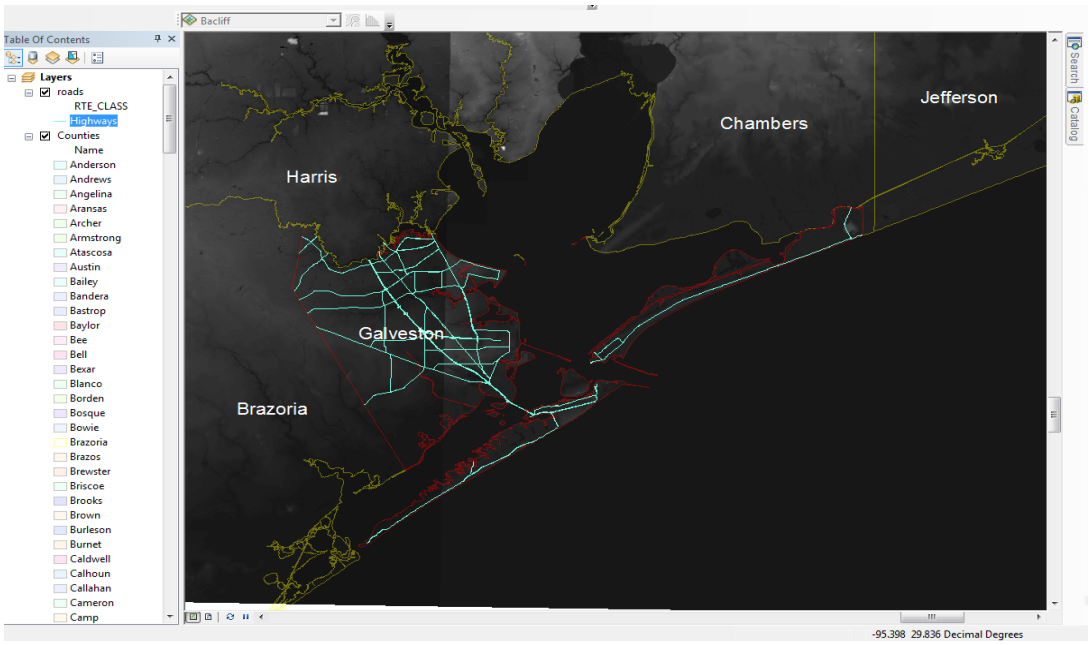

Figure 6: change counties symbol to hollow

I added a shapefile of roads from the TNRIS cite (Figure 7). From the attributes table, I chose to display only the major highways in Galveston to avoid unnecessary clutter.

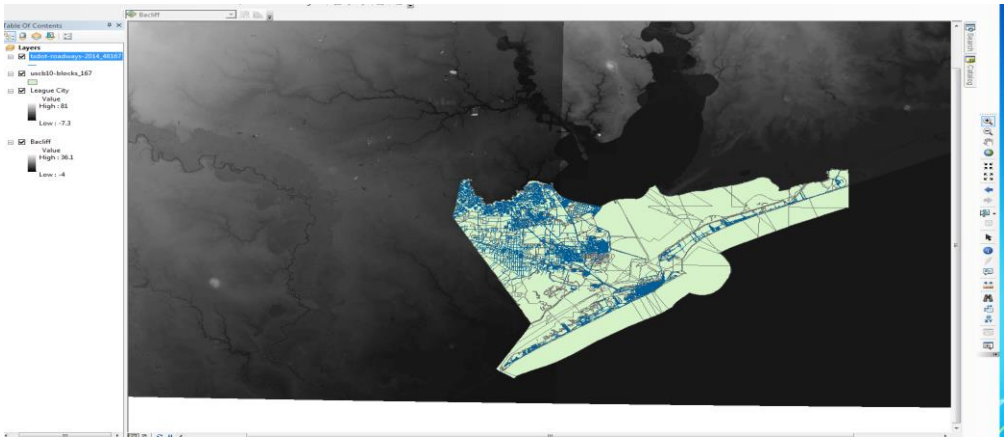

Figure 7: Added Galveston county roads shapefile

The Texas city data was then downloaded and added to the document.

The next step was to stich the two rasters together in order to create a new mosaic. The Mosaic To New Raster tool was used to merge the rasters. I kept he same pixel type as the original two rasters (32 bit float) and used the same number of bands (1) (Figure 8).

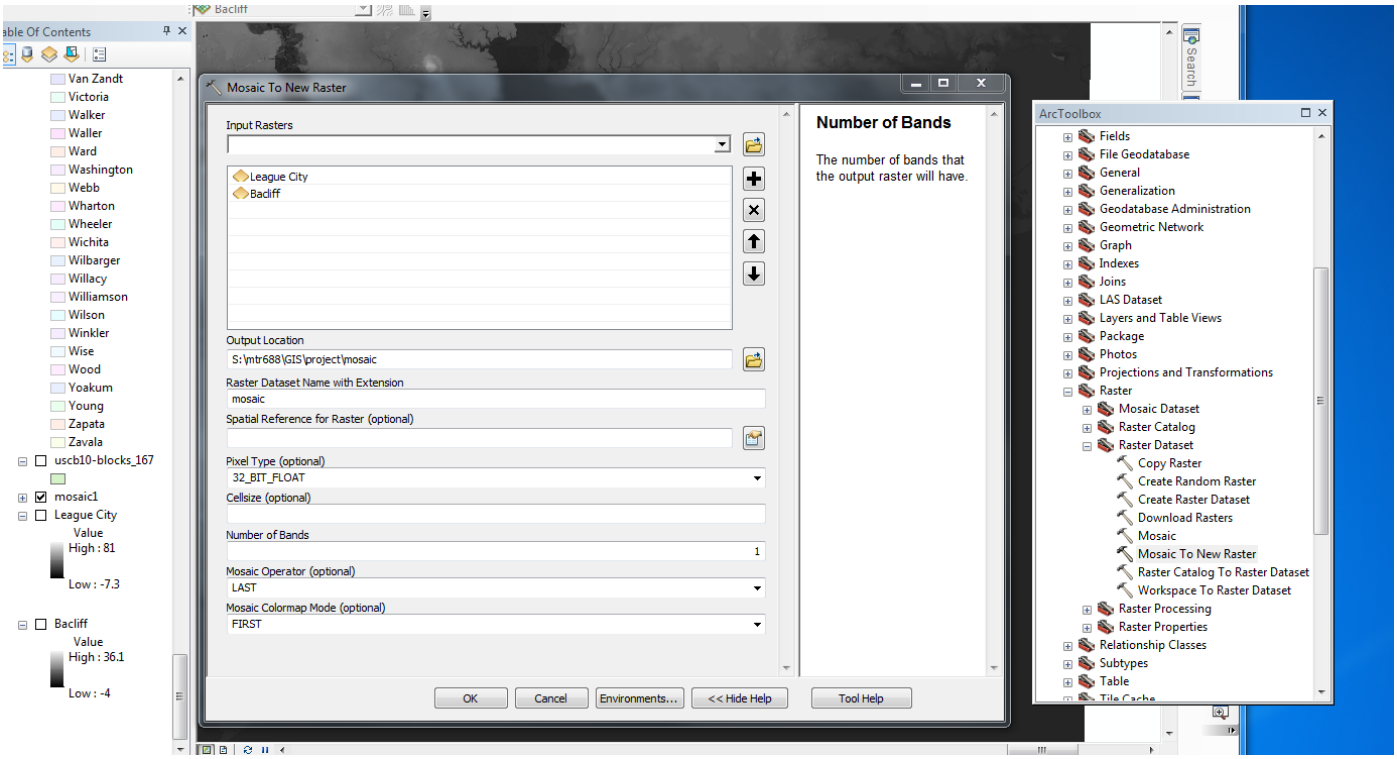

Figure 8: Mosaic To New Raster

At this point, I double-checked the items in my TOC to make sure everything was in the same projection (NAD 1983 UTM Zone 15N), but the data was projected in NAD 1983. I used the Batch Project tool to convert my shapefiles to UTM zone 15N (Figure 9). This tool does not work in converting the mosaic.

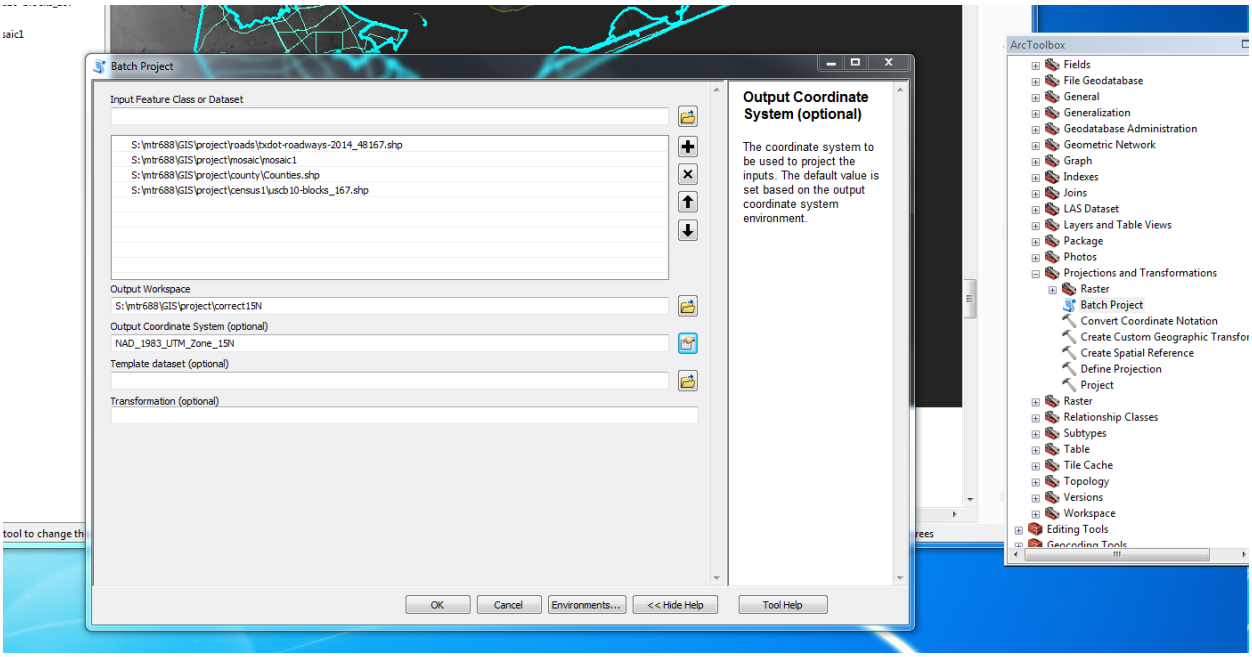

Figure 9: Batch Project Tool

I used the Project Raster tool to convert the mosaic to UTM zone 15N coordinates (Figure 10).

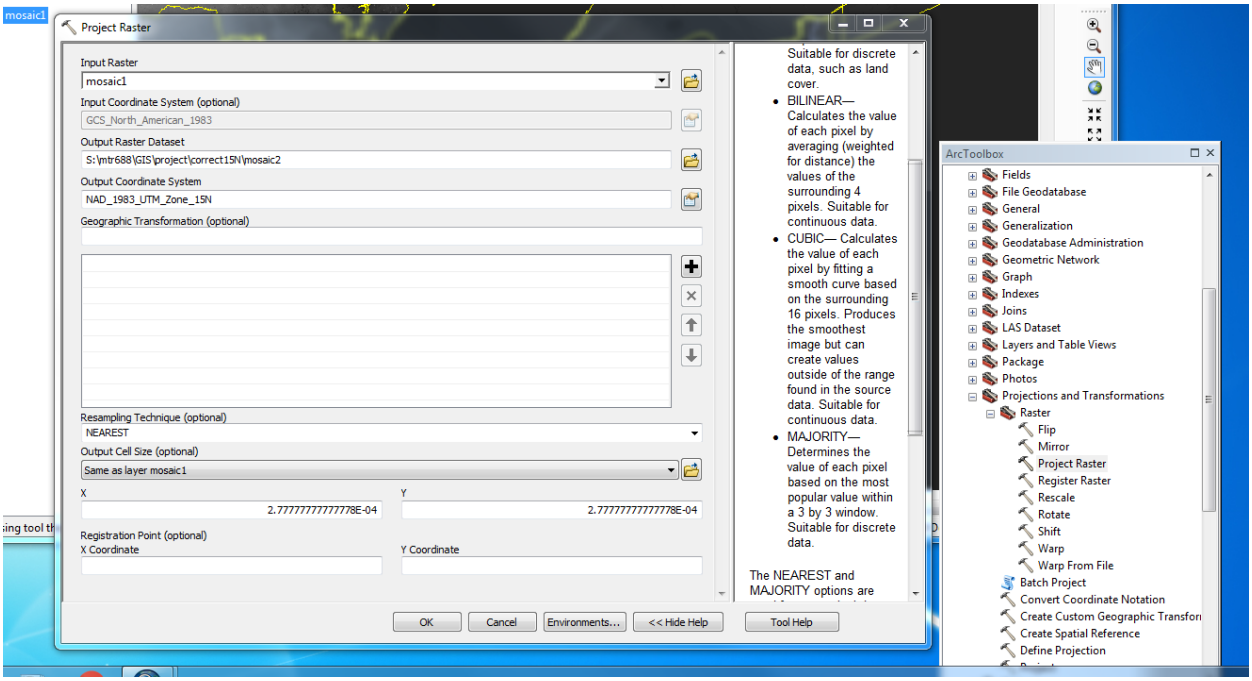

Figure 10: Project Raster Tool

I then created shapefiles of the surrounding counties by using the select features tool by right clicking on the counties file in the TOC>selection>create layer from selected features (Figure 11).

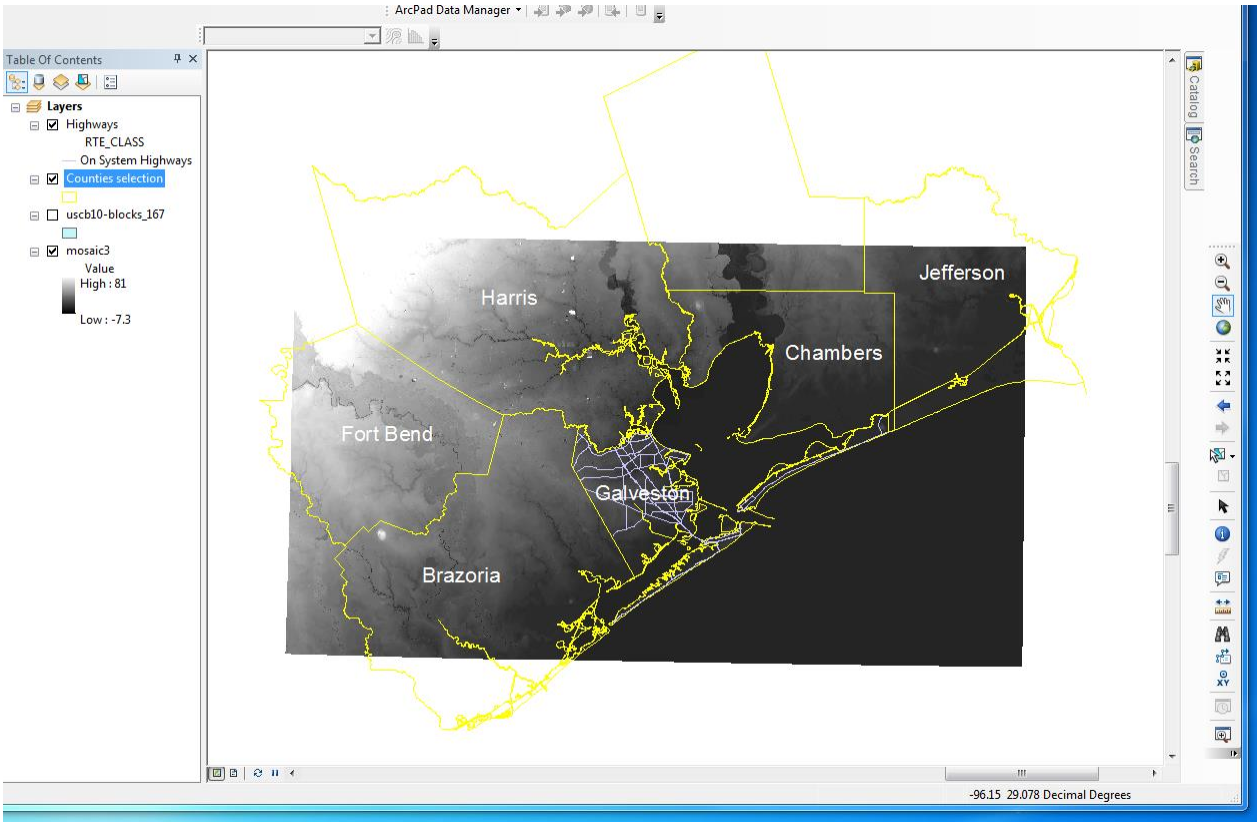

Figure 11: surrounding counties shapefile

I symbolized the elevation raster to classified, changed the color to Elevation #2, clicked classify…>selected equal interval, 30 classes>OK (Figure 12).

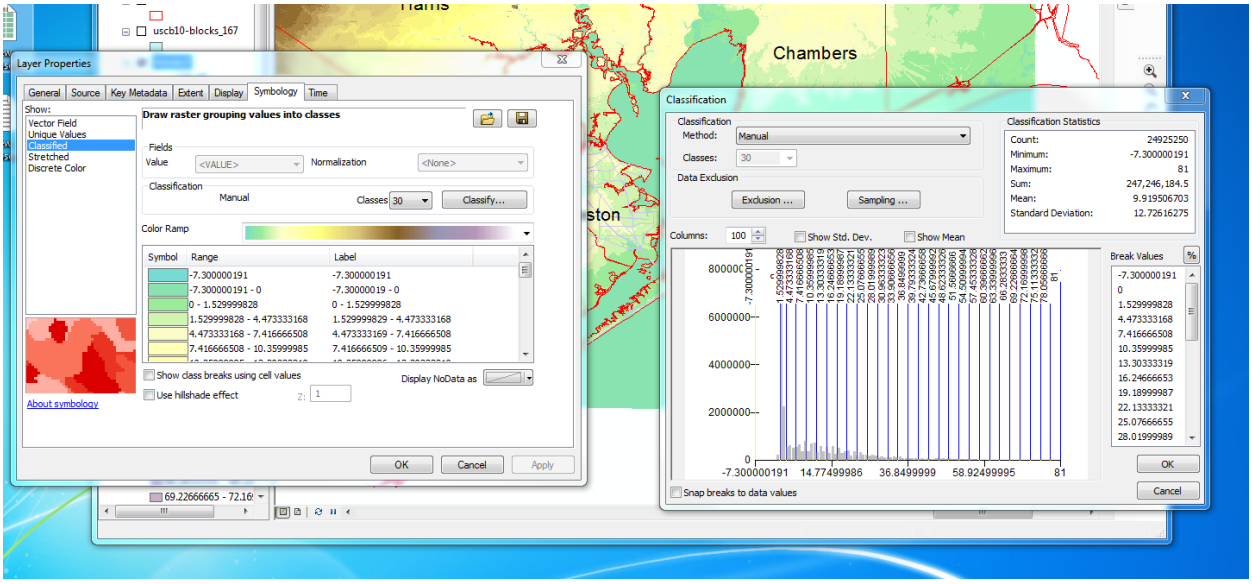

Figure 12: Raster symbology

A contour line was created to illustrate the shoreline using the contour tool and selecting a contour interval of 100 (Figure 13).

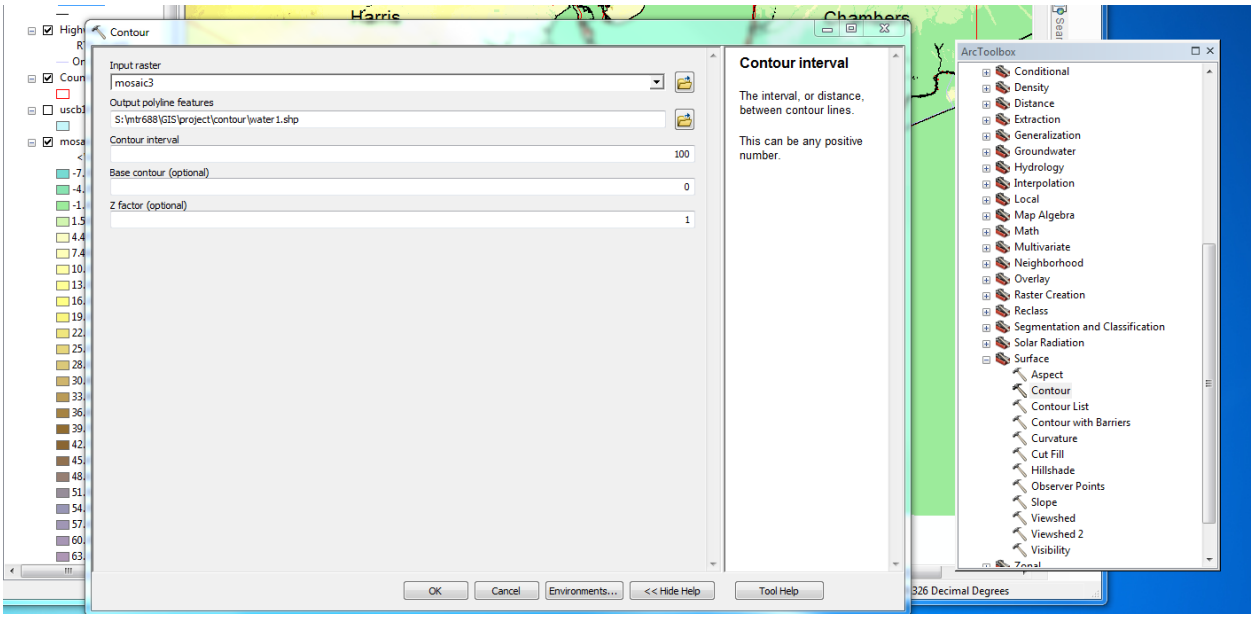

Figure 13: Shoreline contour

The 3D Analyst and Spatial Analyst extensions were turned on in order to use raster calculator and to create a hillshade. Customize > Extensions.

A HillShade was made in order to show difference in elevation of the area (Figure 14).

ArcToolbox > Spatial Analyst Tools > Hillshade

After this step, I noticed that a Hillshade not very useful due to static and low elevations in the locality.

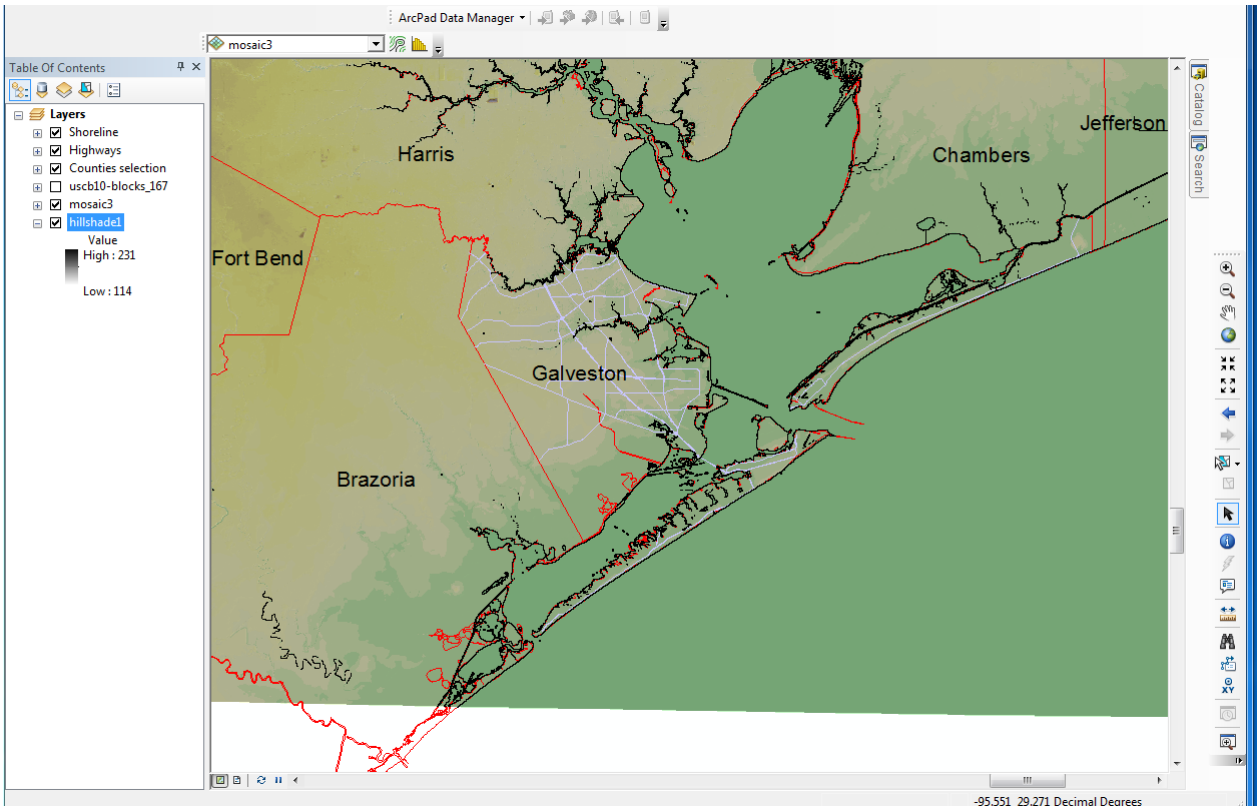

Figure 14: Map with Hillshade

A Binary Raster was created to show what parts of the map are below sea level. I used the search toolbar to find the Raster Calculator. I inputted the conditional statement:

Con("mosaic3" <=0,1) (Figure 15).

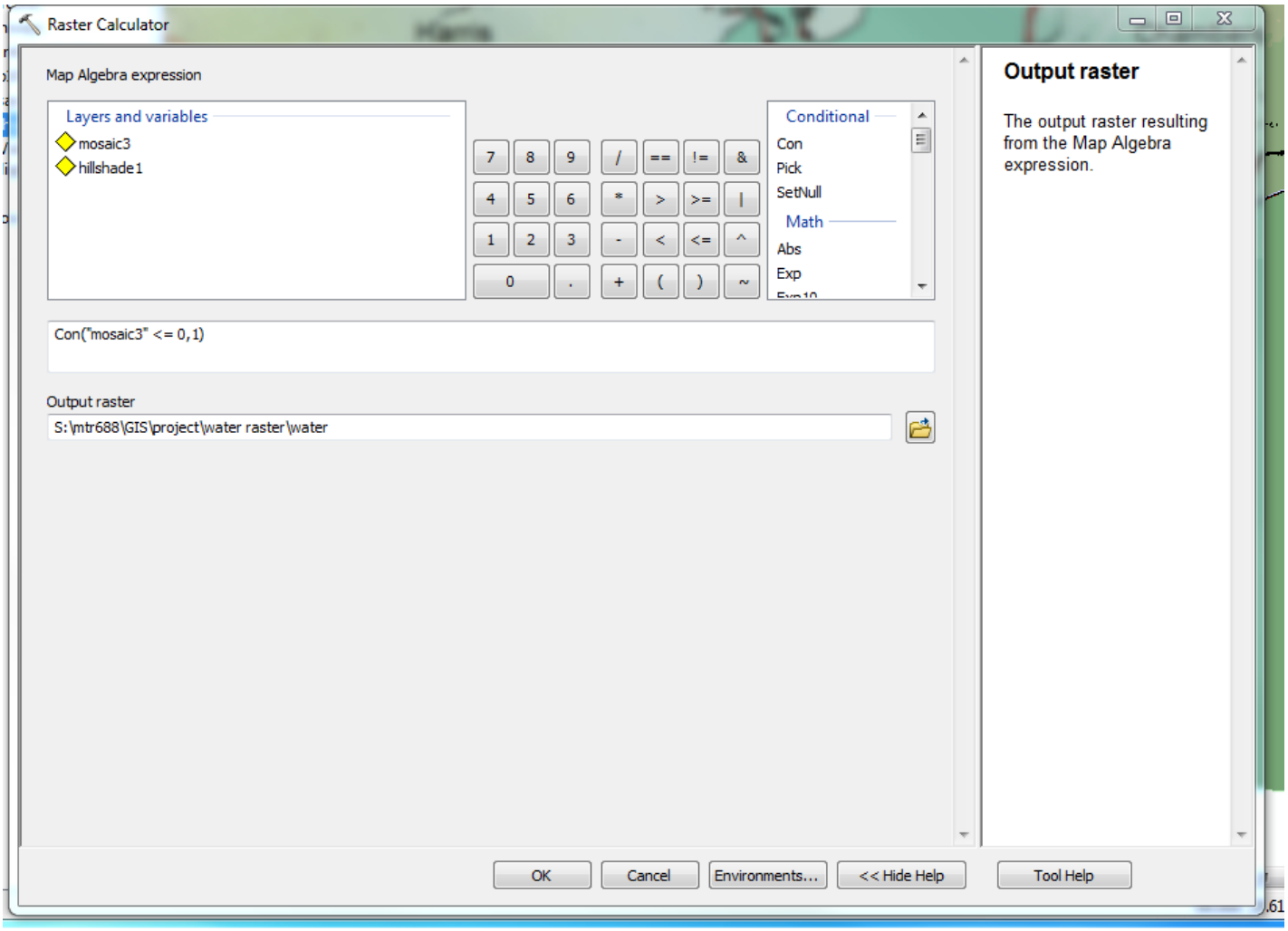

Figure 15: Raster Calculator for binary raster

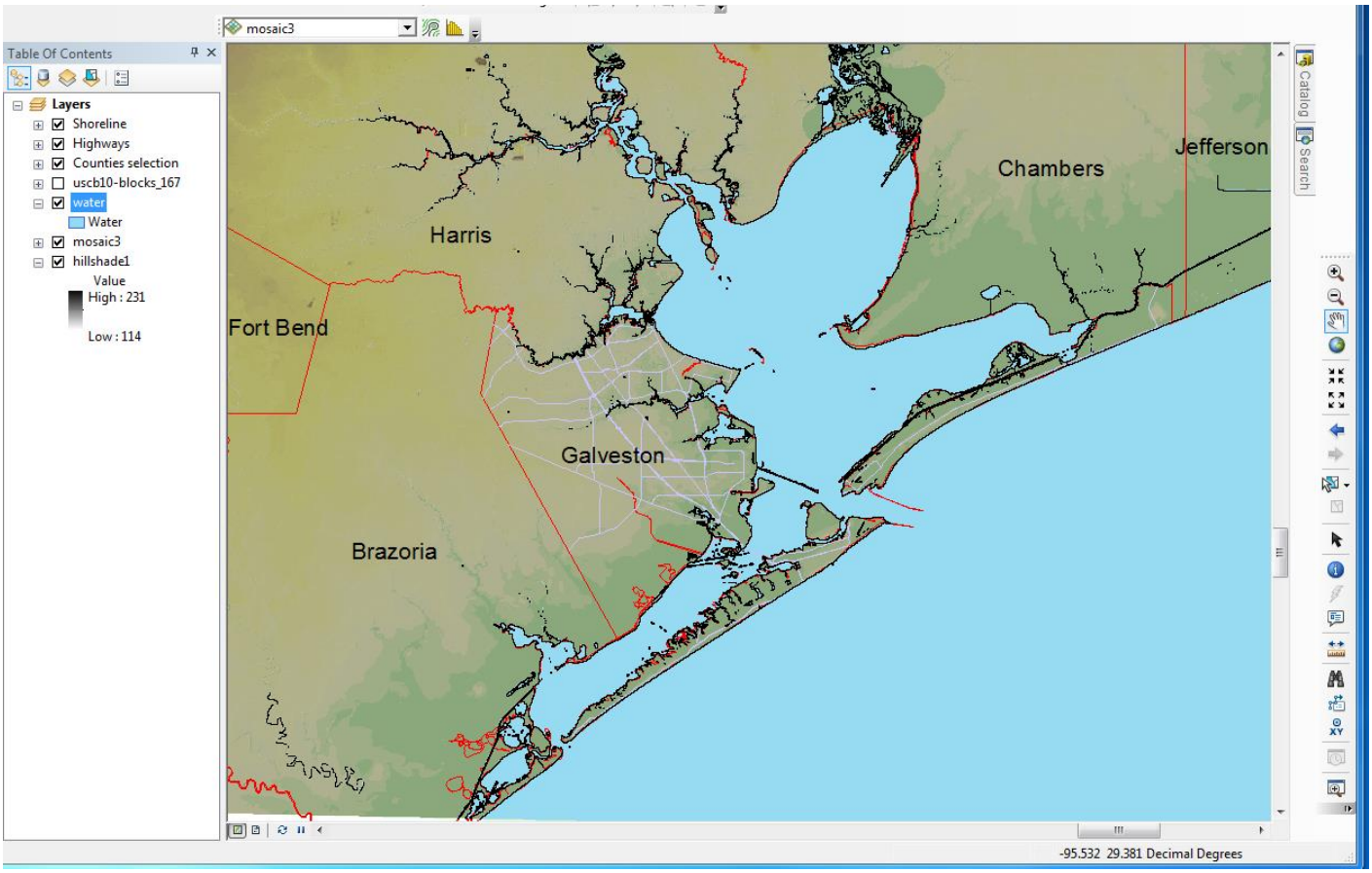

Figure 16: Map showing binary water raster

I changed the transparence of the elevation raster to 40% transparency to display Galveston County as the area of interest.

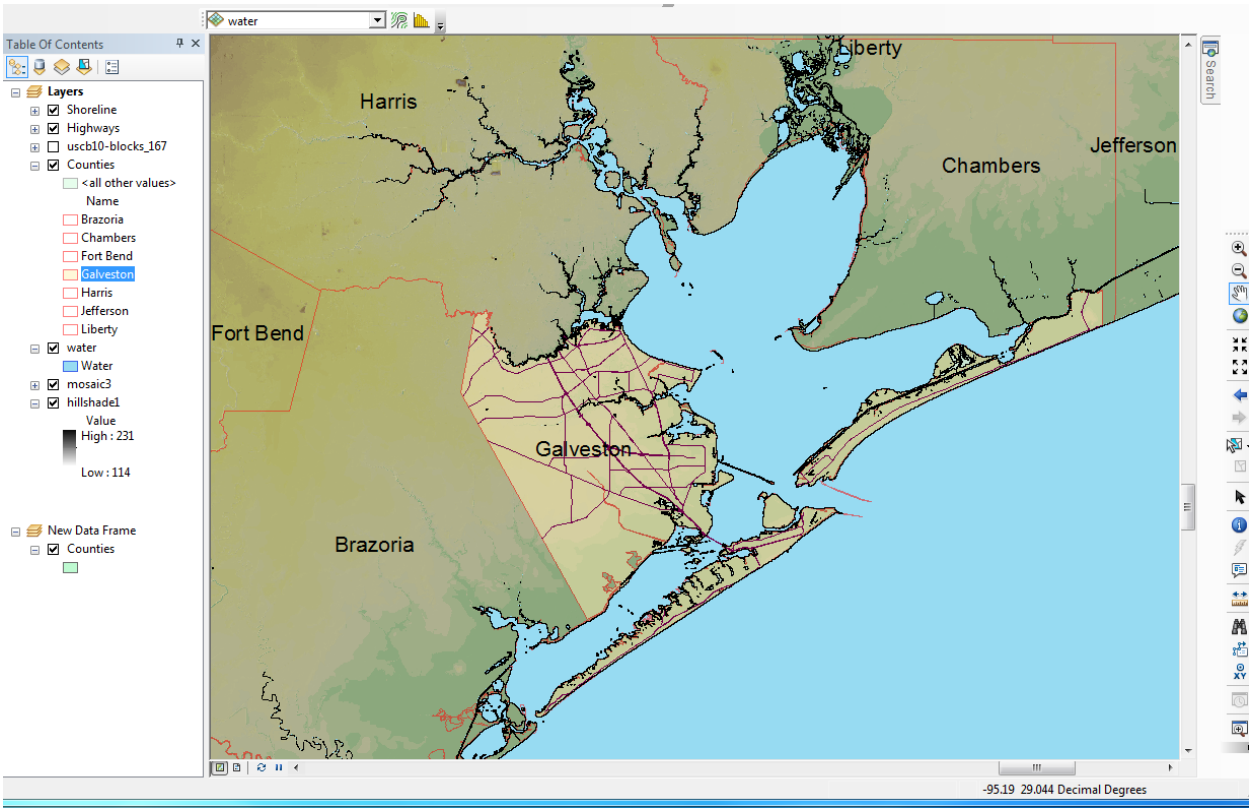

Figure 17: Map showing Galveston County

I used the Select by Location feature to create a new shapefile that includes only the cities within Galveston County (Figure 18).

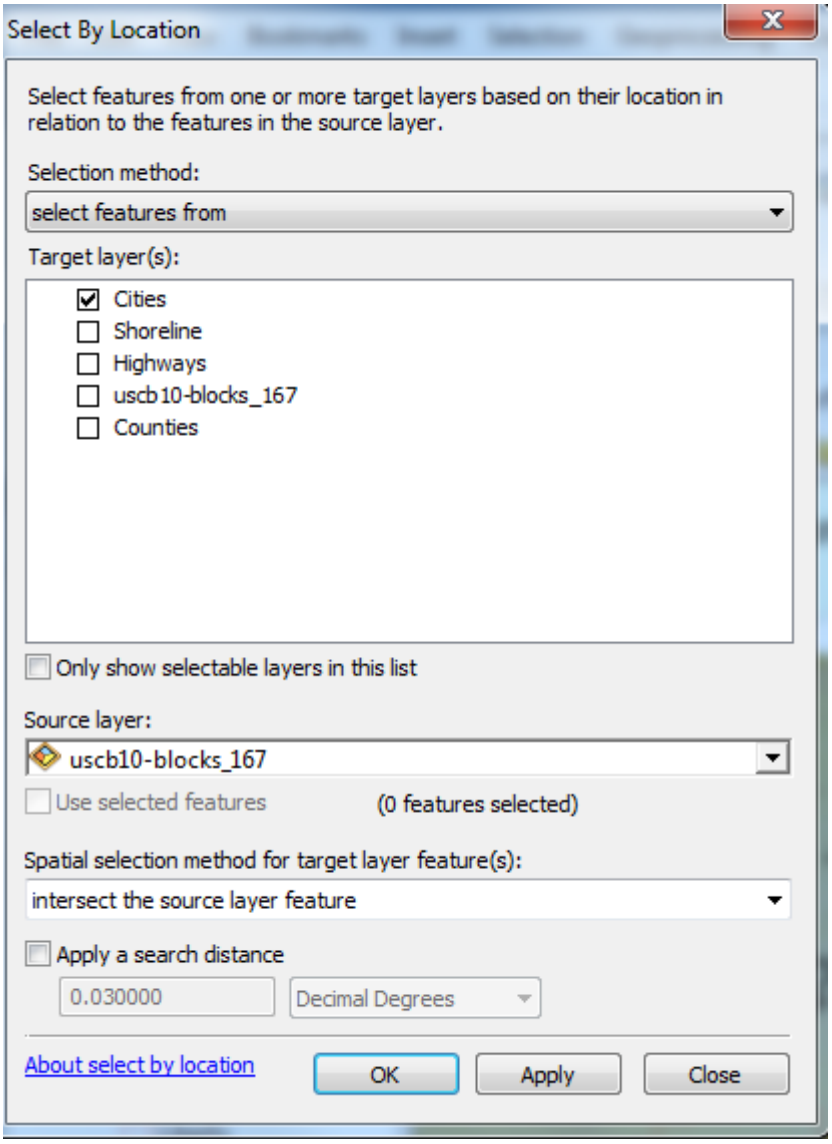

Figure 18: Select By Location tool to display cities in Galveston County

The Census Shapefile only gives population density and not total population, so I used the attribute table within the city points shapefile for my analysis. The Census Shapefile was only used in selecting items specifically within Galveston County.

To calculate the total population in Galveston County, I opened the attribute table of the Cities file and took the sum from the cities (Figure 19):

Select Pop2008Est from attribute table > statistics > sum

Total Population in Galveston County cities: 287,041 people

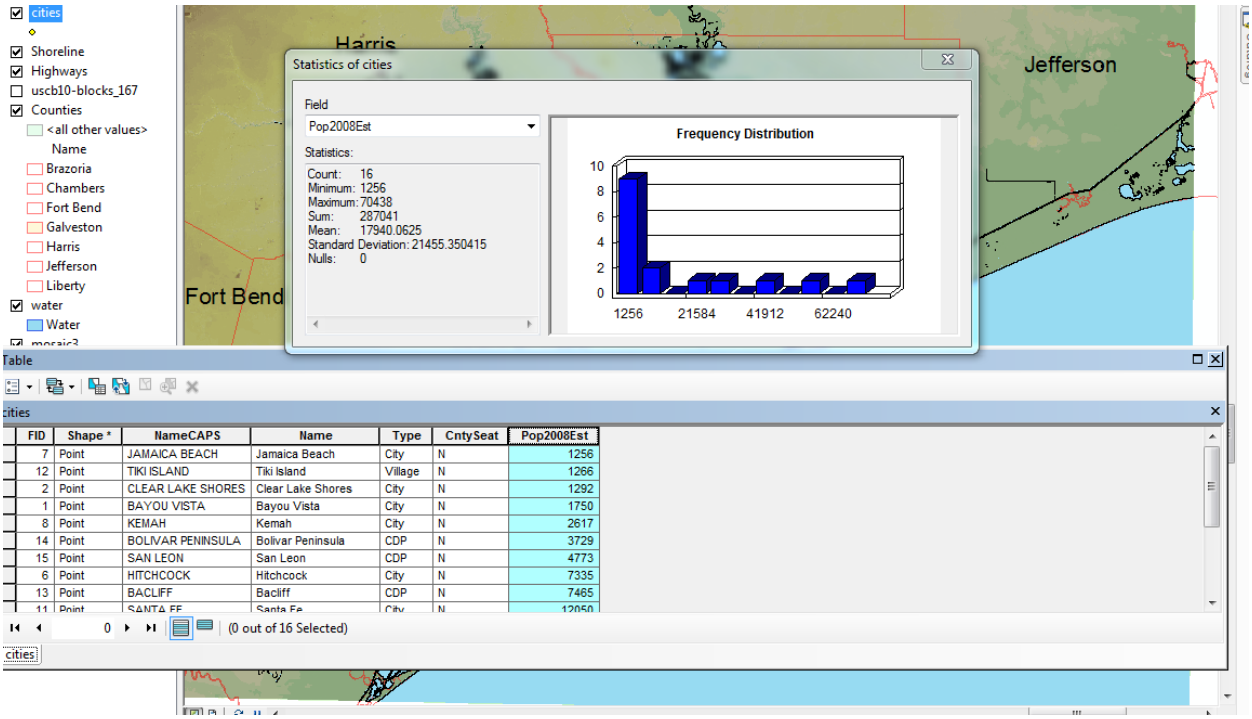

Figure 19: Calculating total population

The cities were labeled one by one as annotations, repositioned, and placed in front of a halo for clarity (Figure 20).

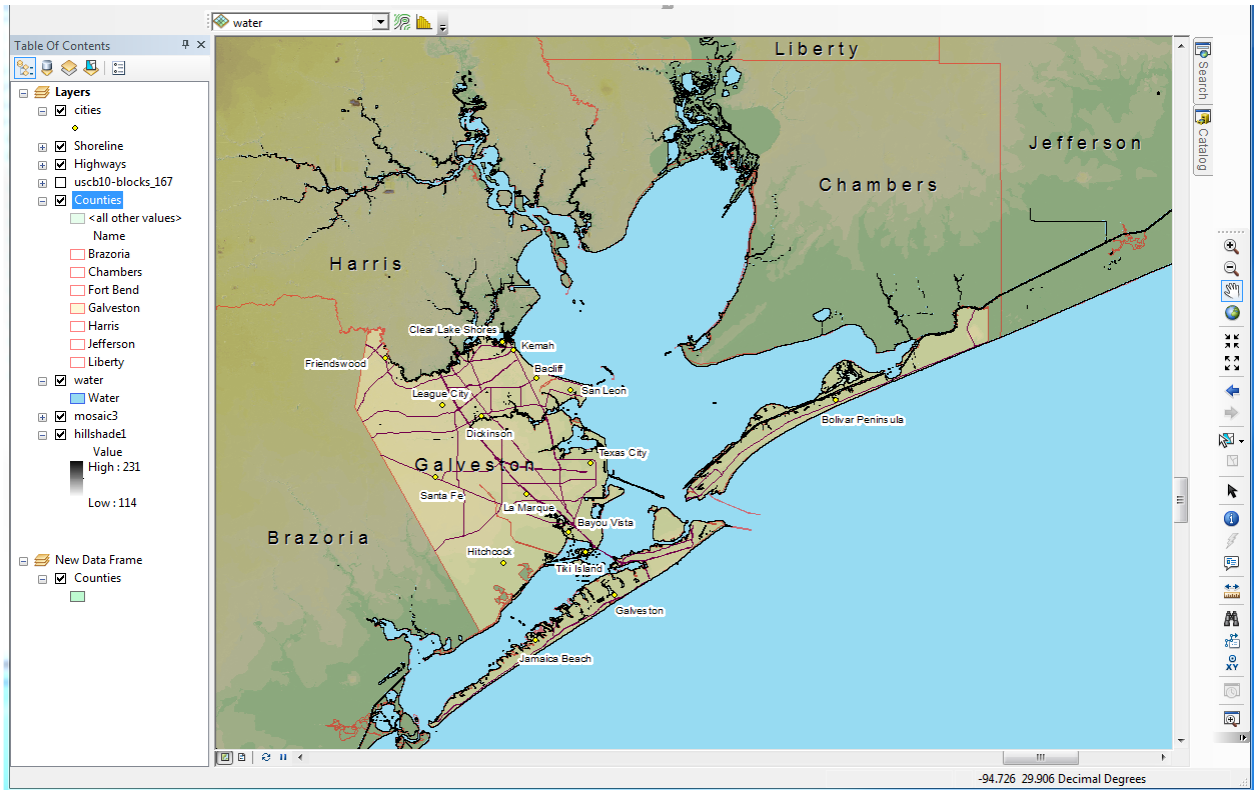

Figure 20: Map showing city labels

After the present day sea level map of Galveston County, TX was complete, I created a new map showing an increase in sea-level one meter at a time until every spec of land on the barrier island of Galveston County was submerged. For each map, a new elevation raster, binary raster, and water contour was created.

To create the new elevation raster, I opened raster calculator and subtracted one meter from the original elevation raster (Figure 21).

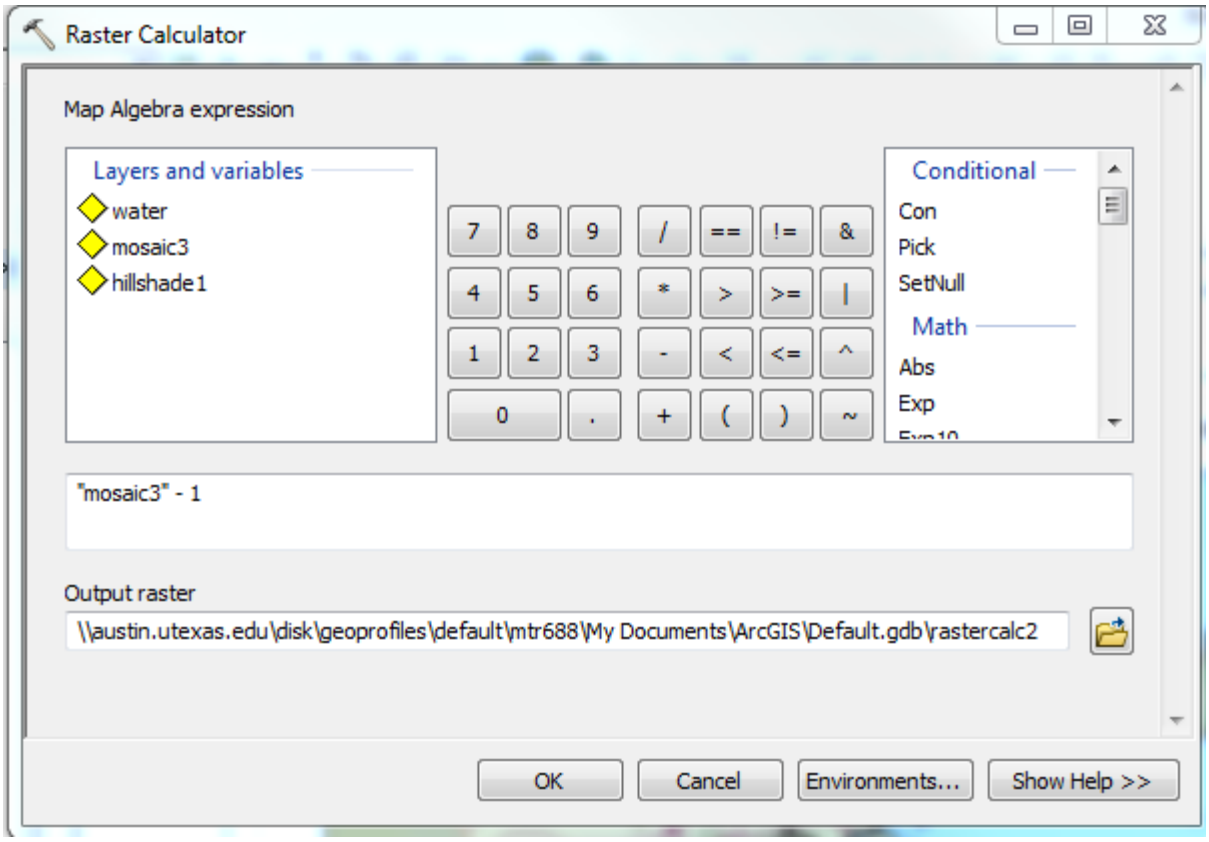

Figure 21: Using raster calculator to create new elevation model

The same steps used to create the first map were followed to construct a binary raster and water contour for the new maps.

A reference scale of 1:400,000 was maintained for all maps in order to compare changes in sea level.

I used the select by Location tool to monitor when Galveston Island was completely submerged once it appeared that all specs of land were below the binary water raster (Figure 22).

Select feature from Galveston County > Source layer: “water11” > Intersect the source layer feature

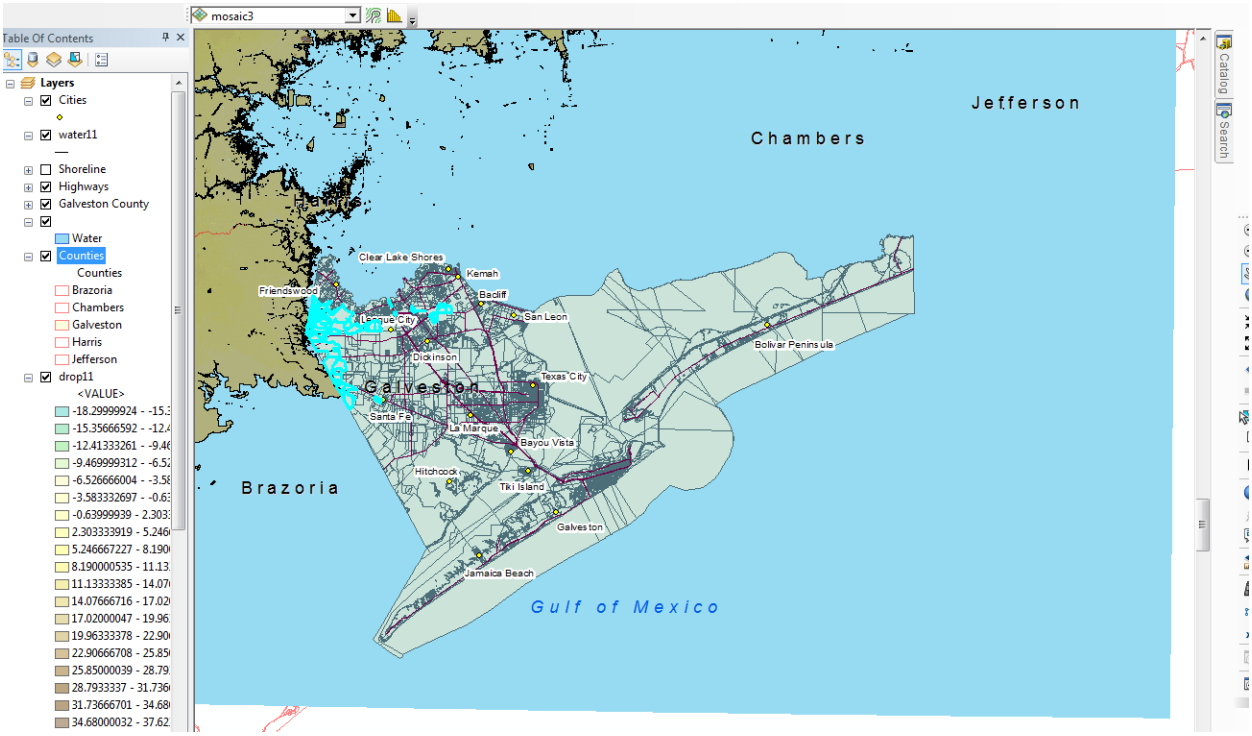

Figure 22: intersection of water and land on Galveston County

It took an elevation of 11 meters to completely submerge the barrier island.

Although my models predict population loss in all cities of Galveston County, I chose to quantify population loss on the three major cities of the Barrier Island alone:

I used the selection tool and opened the attributes table of the cities to calculate the total population on the barrier island (Figure 23).

Total population loss in major cities on Island: 6,3940 people

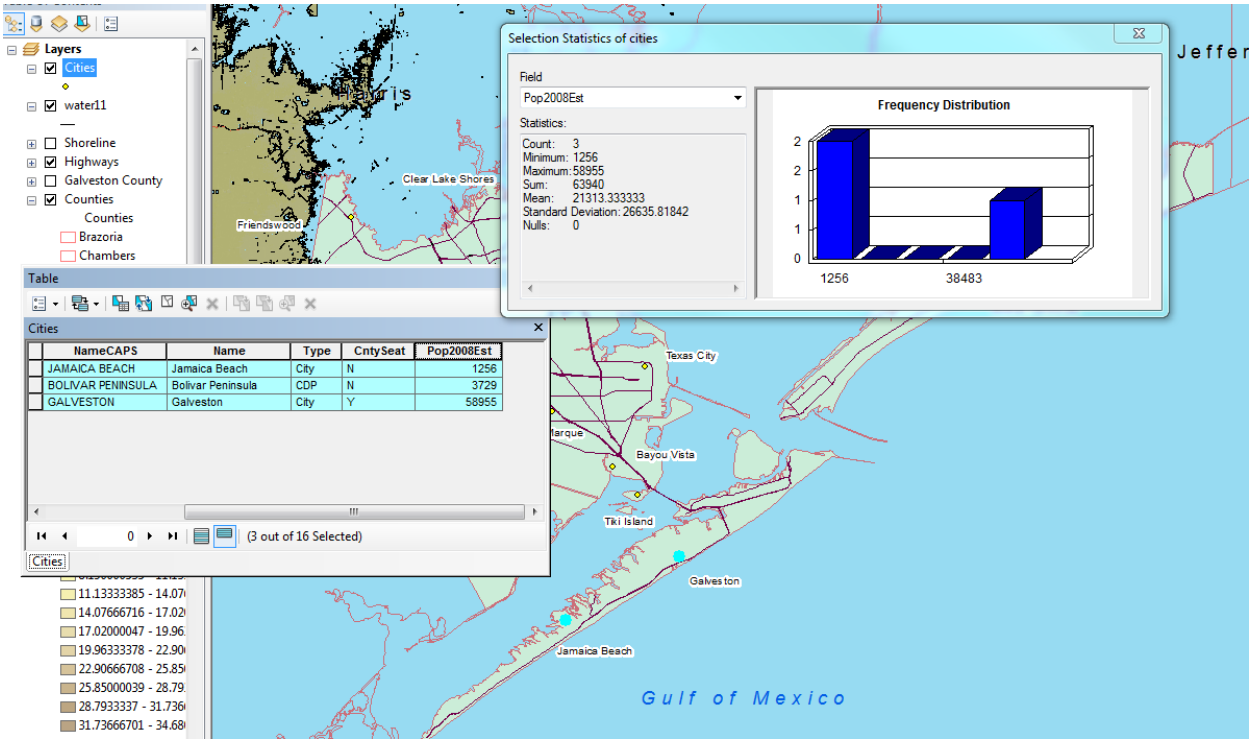

Figure 23: Population displaced by 11 meters of Sea level rise on barrier island of Galveston County

Calculations:

To estimate how long it would take for the Barrier Island of Galveston County to completely submerge, I researched the Mean sea level rise for Galveston (6.34mm/yr).

The following calculation was made to predict when the Barrier Island would disappear under the rising sea level:

11 meters/(.00634 meters/year)=1,735 years

Conclusion:

If the mean sea level continues to rise at present rates, the cities of Galveston, Jamaica Beach, and Bolivar Peninsula will be completely under water in 1,735 years. All 287,041 people presently living in the major cities of Galveston County would be displaced with an 11 meter sea level rise. From this amount, 6,3940 people would have to evacuate from the barrier island. Although sea level rise occurs on a relatively slow timescale, maps created in ArcMap can be used for future city planning purposes, or as a present day model for storm surges in the area. The following maps illustrate the progressive sea level rise in Galveston County.

Present Day Sea Level of Galveston County, TX

Maria Reistroffer
12/1/2015

Legend

Cities
Highways
Water

Counties

Brazoria
Chambers
Galveston
Harris
Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 1 Meter on Galveston County, TX

Maria Reistroffer
12/1/2015

Legend

Cities
Highways
Water

Counties

Brazoria
Chambers
Galveston
Harris
Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 2 Meters on Galveston County, TX

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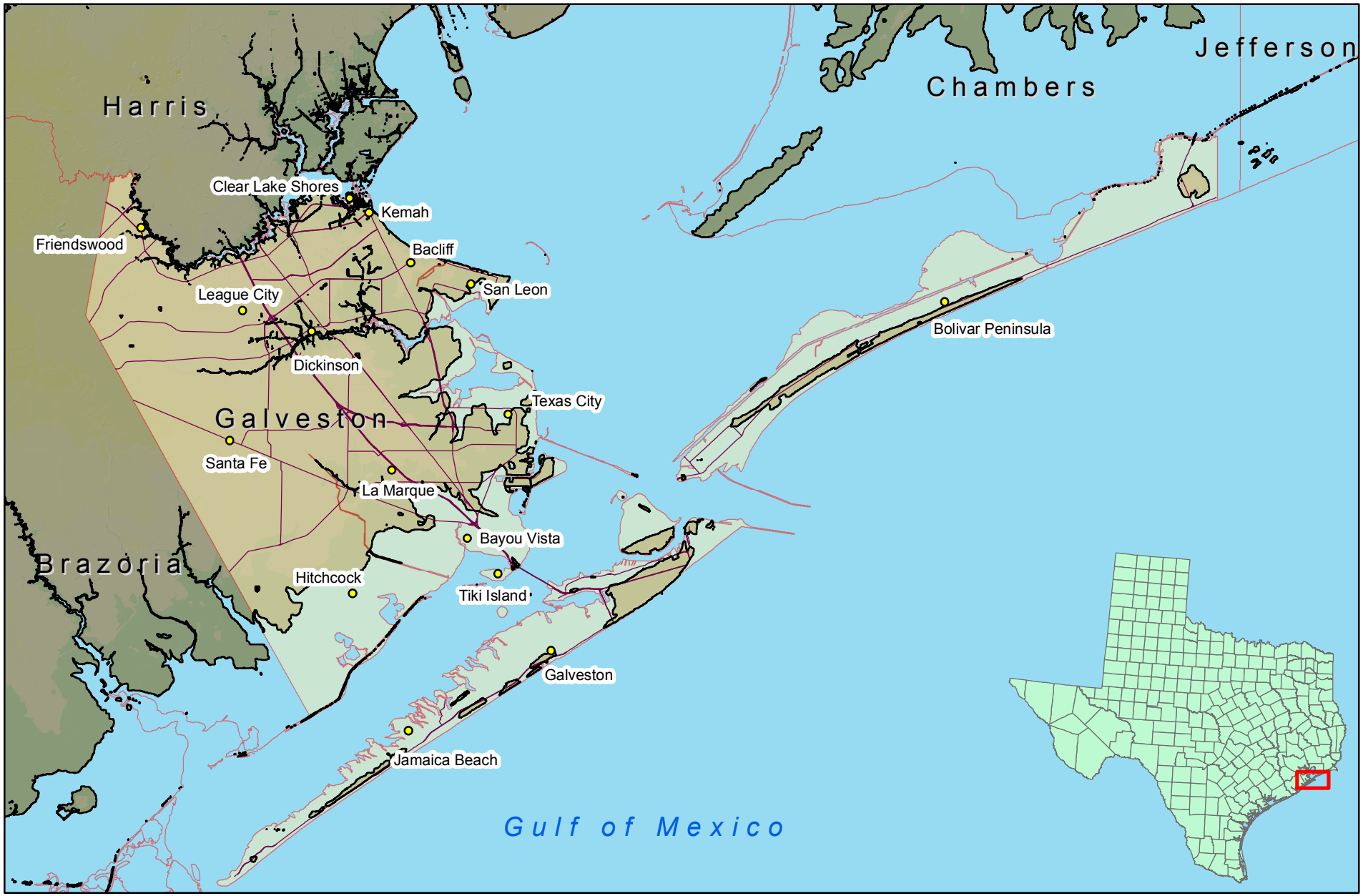
12/1/2015



Legend

- Cities
- Highways
- Water

Counties

- Brazoria
- Chambers
- Galveston
- Harris
- Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 3 Meters on Galveston County, TX

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12/1/2015

Legend

- Cities
- Highways
- Water

Counties

- Brazoria
- Chambers
- Galveston
- Harris
- Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 4 Meters on Galveston County, TX

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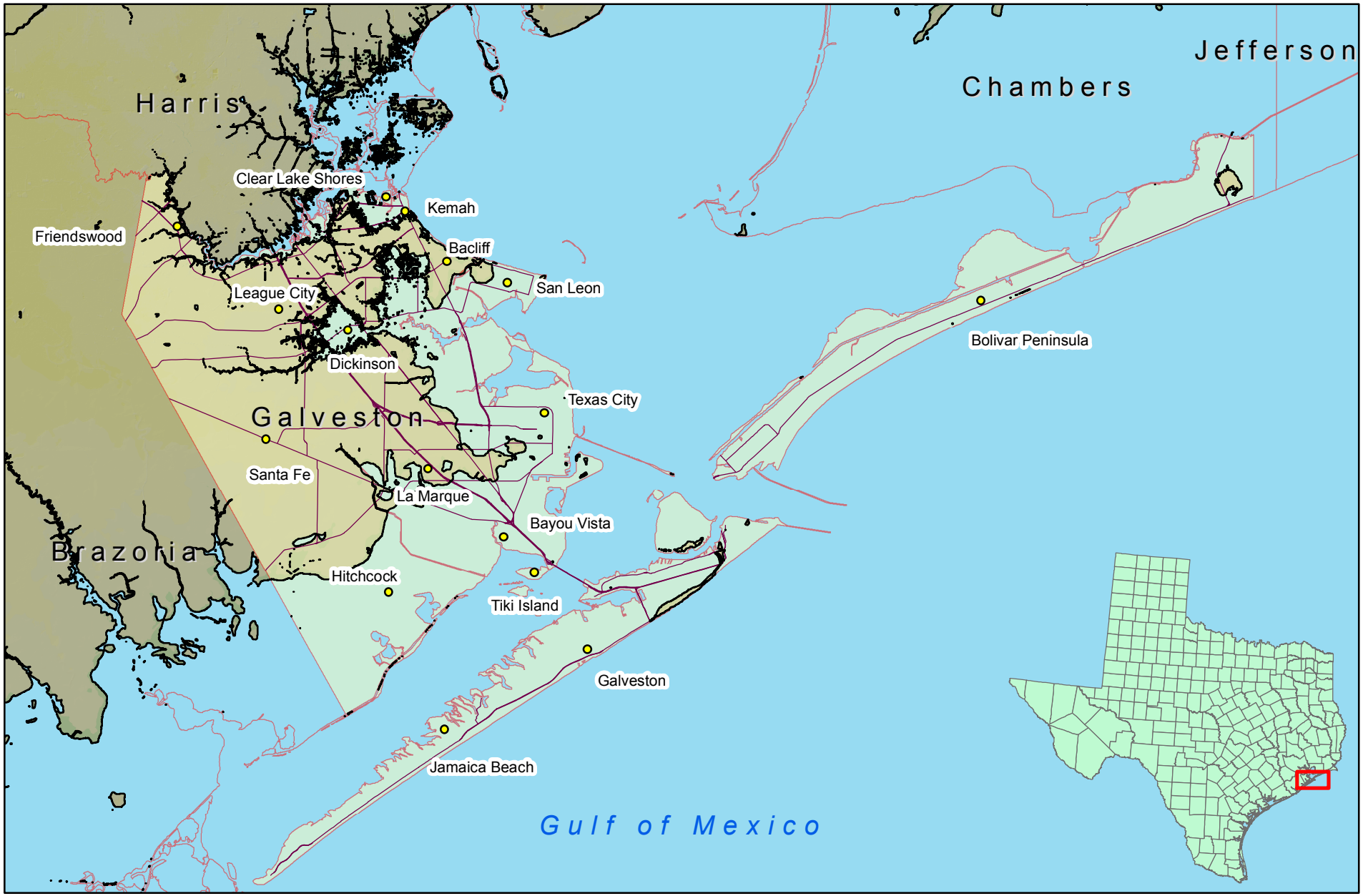

Legend

- Cities
- Highways
- Water
- **Counties**
- Brazoria
- Chambers
- Galveston
- Harris
- Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 5 Meters on Galveston County, TX

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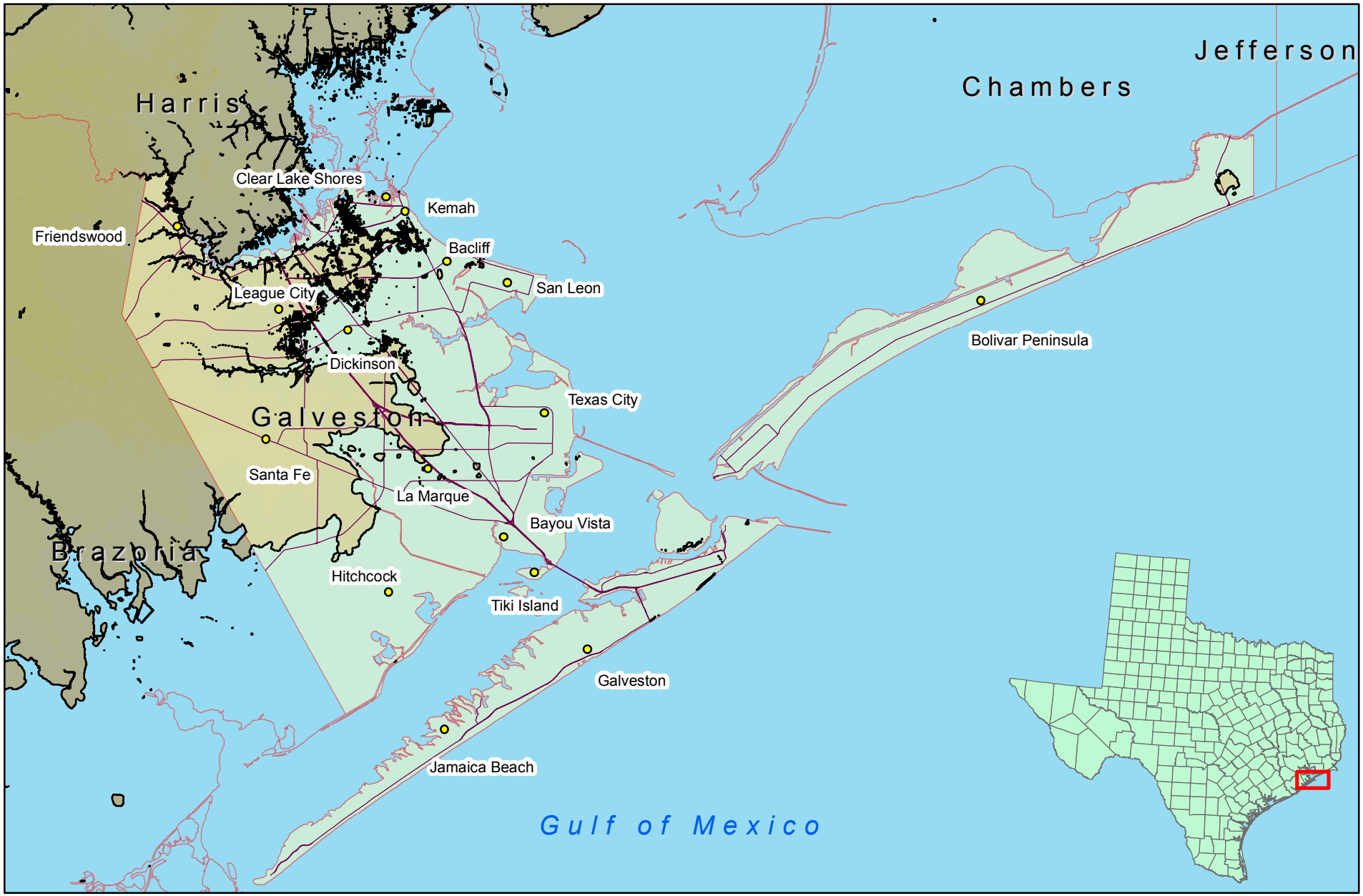

Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 6 Meters on Galveston County, TX

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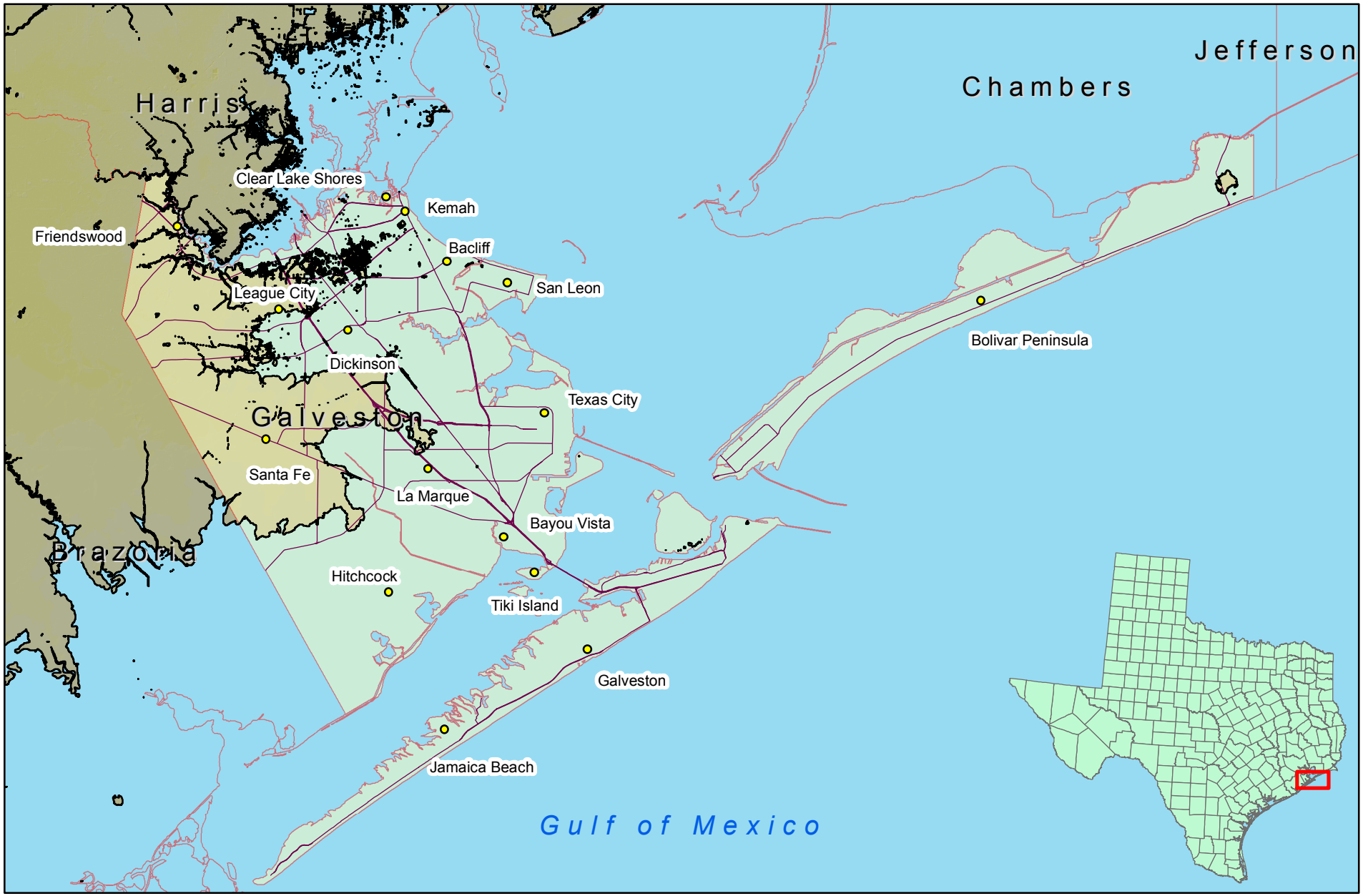
12/1/2015



Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 7 Meters on Galveston County, TX

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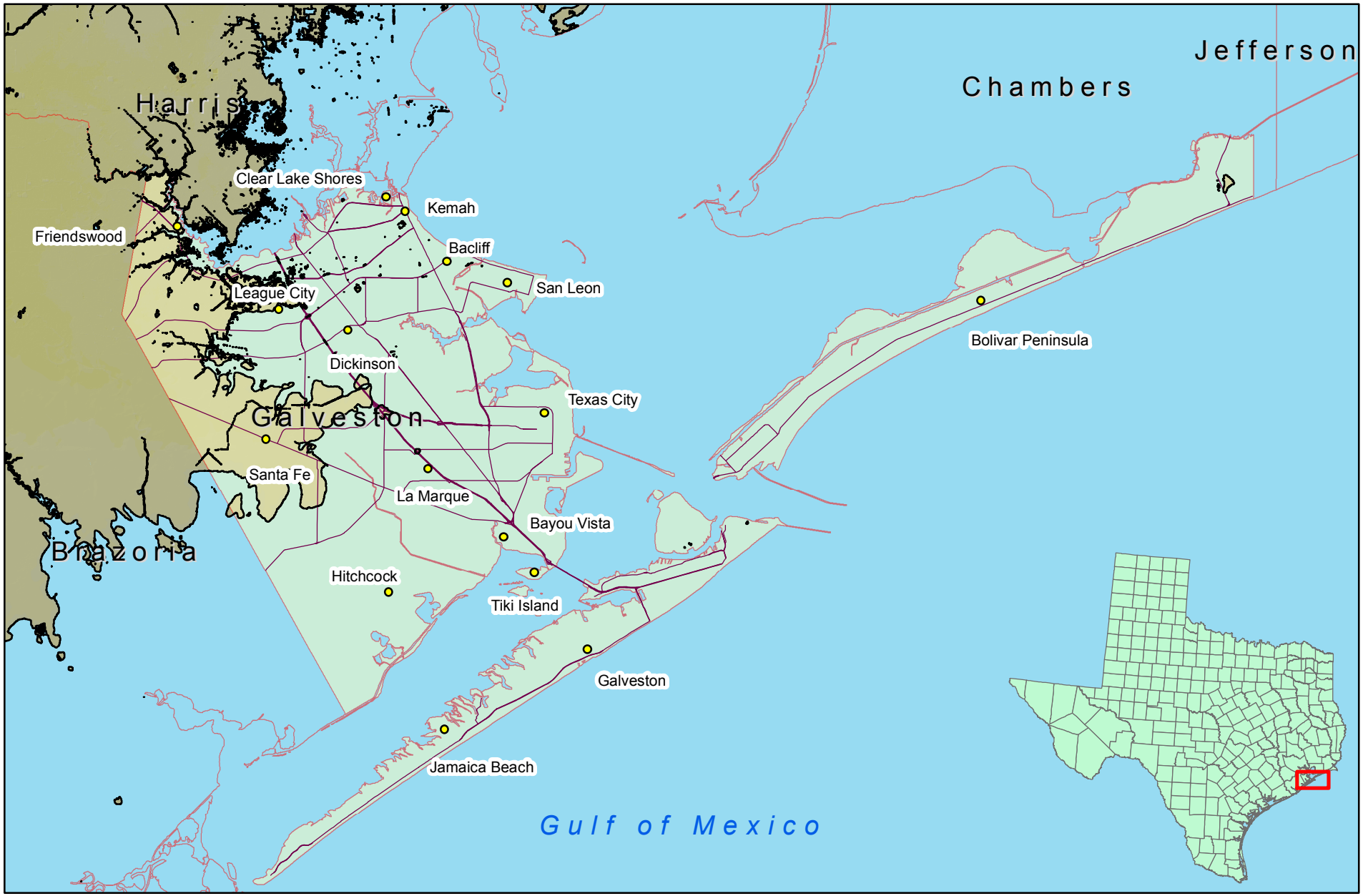


Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

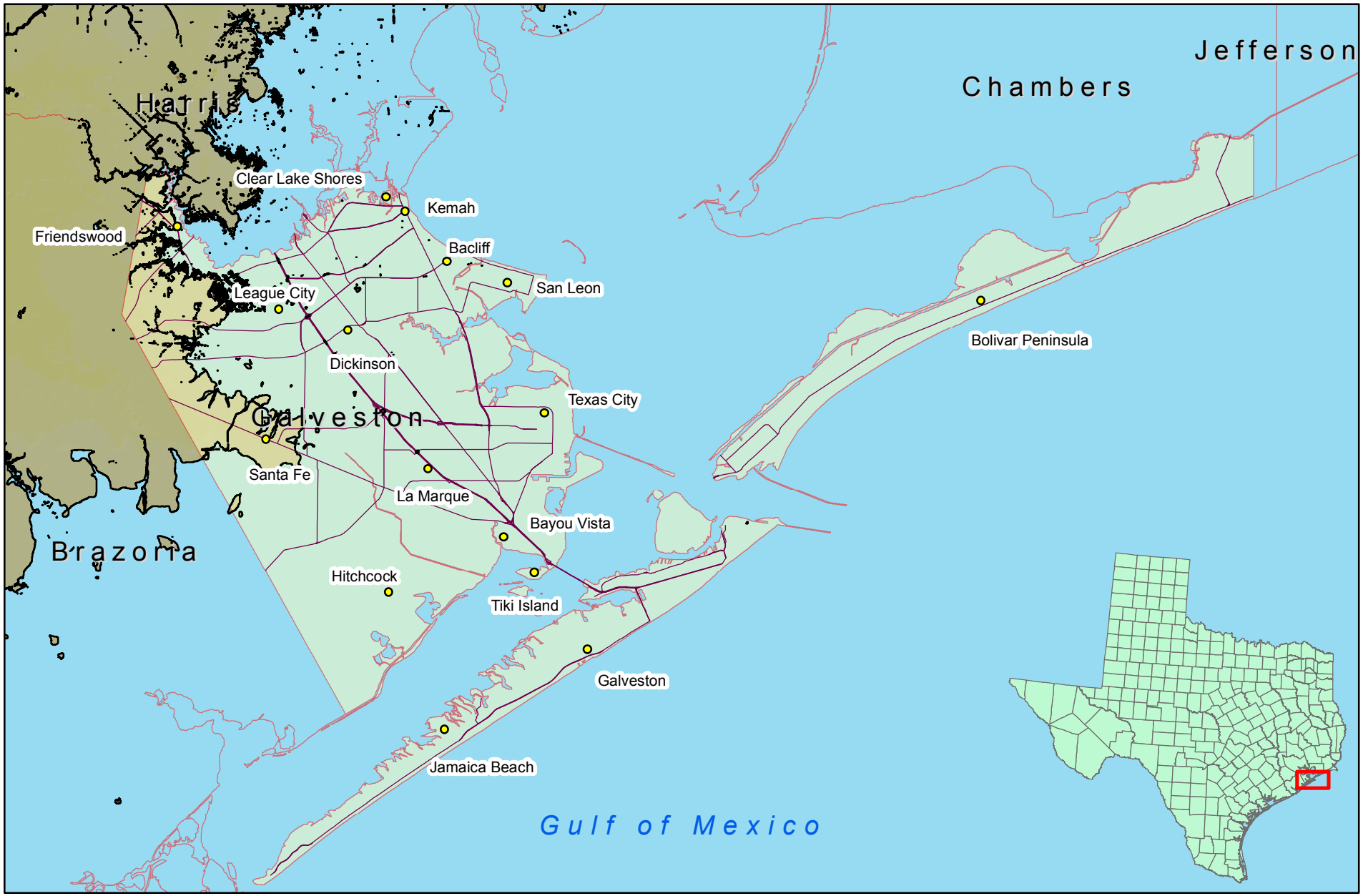
0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 8 Meters on Galveston County, TX

Maria Reistroffer
12/1/2015



Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 9 Meters on Galveston County, TX

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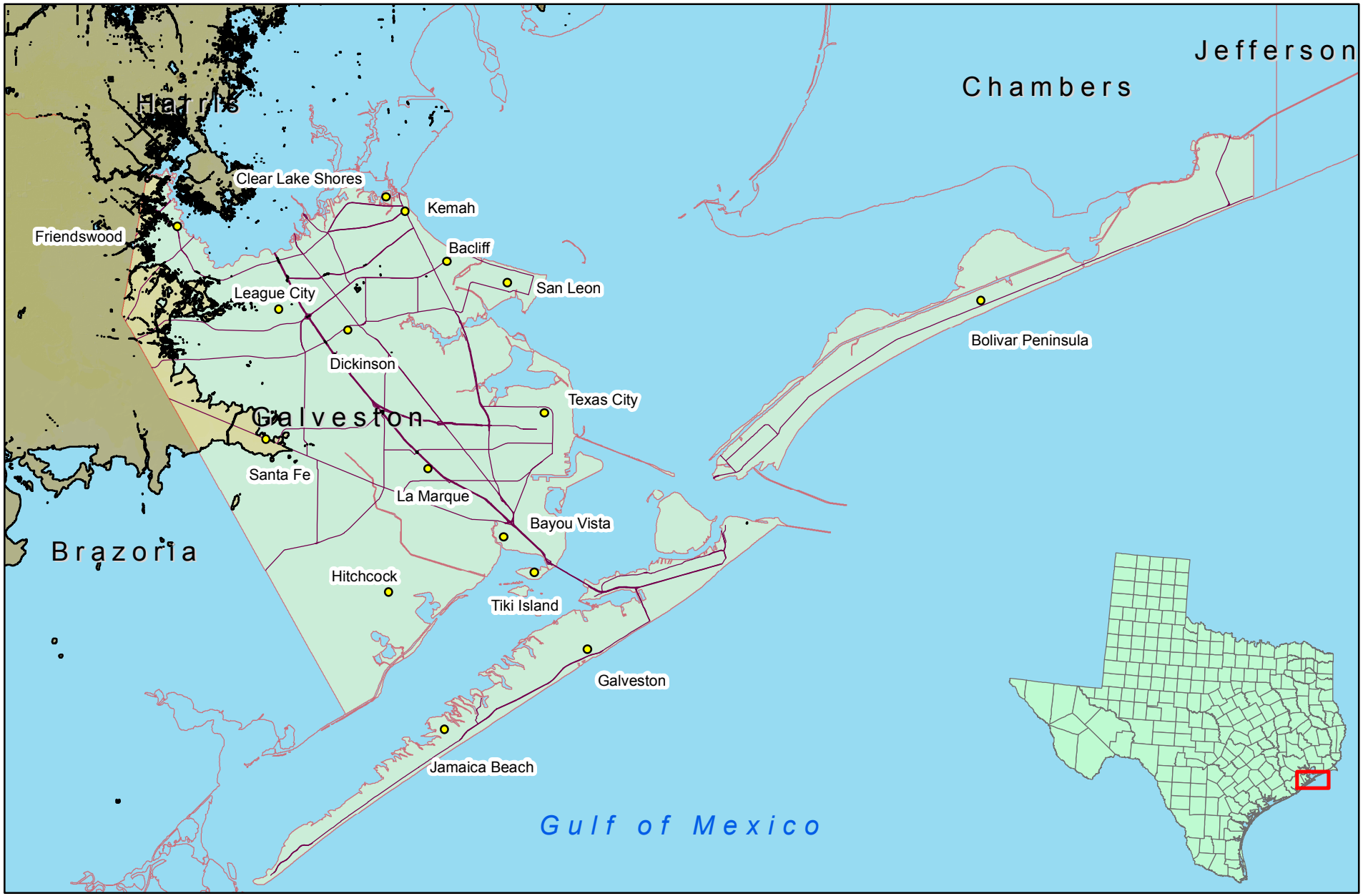

Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 10 Meters on Galveston County, TX

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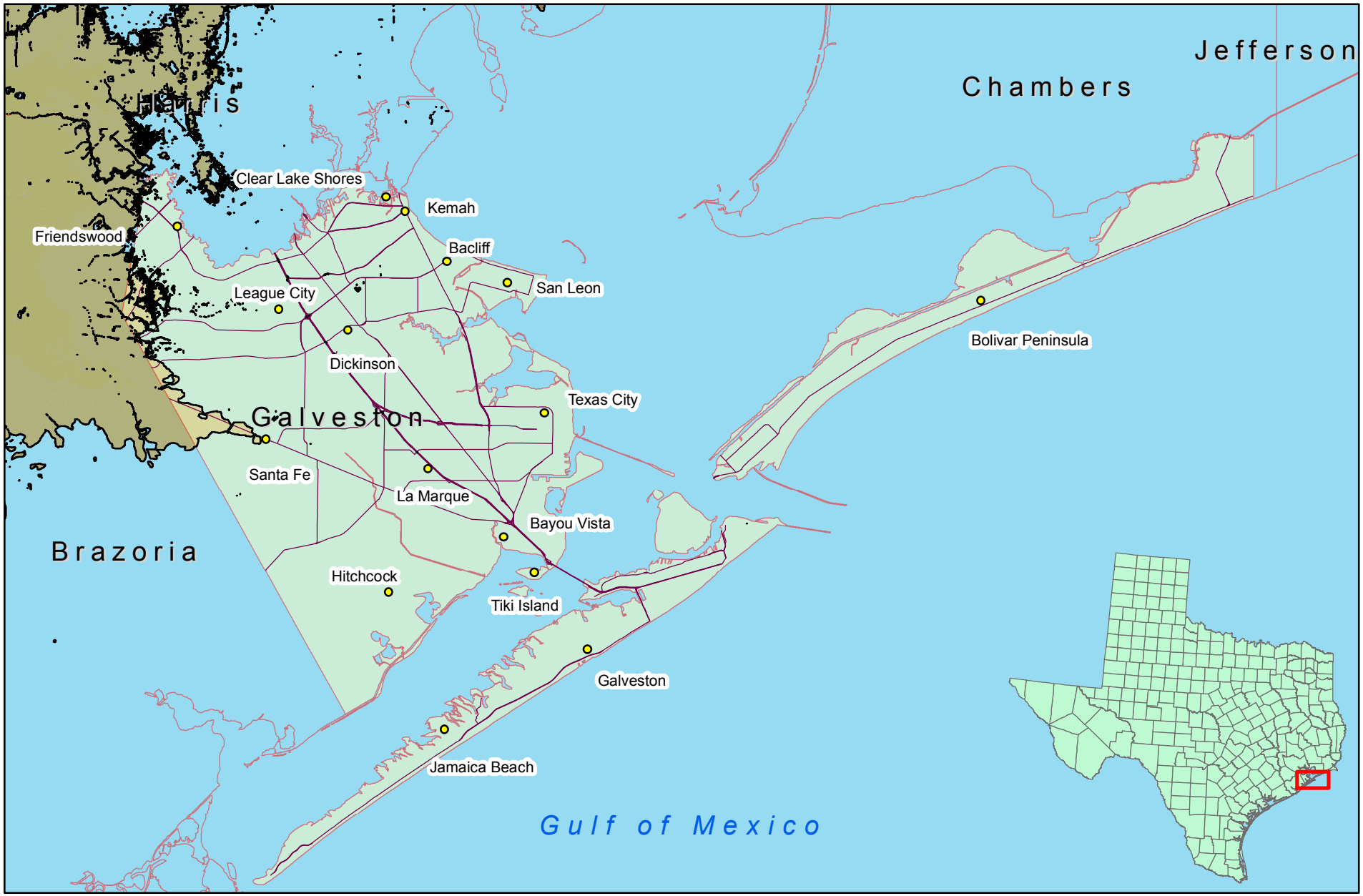
12/1/2015



Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N

Sea Level Rise of 11 Meters on Galveston County, TX

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12/1/2015

Legend

Cities — Highways — Water

Counties

Brazoria — Chambers — Galveston — Harris — Jefferson

0 5 10 20 Kilometers

NAD 1983 UTM Zone 15N

N