That “Sinking” Feeling: Subsidence in the Orleans Parish, Louisiana

Introduction

In August 2005, Hurricane Katrina, one of the most devastating storms in recent history struck the United States’ Gulf Coast. Katrina’s high winds and heavy rains quickly proved too much for the city’s aged infrastructure; levees and retaining walls designed to keep the city (much of which rests below sea level) dry were breached, and water rushed into many of New Orleans’ neighborhoods.

Although 125mph winds and 1.5 inches of rain per hour are devastating in almost <u>any</u> environment, New Orleans felt a stronger effect due to its geologic setting. Located in the Orleans parish of Louisiana, New Orleans sits atop the delta of the Mississippi River, a terrain consisting of fine, unconsolidated sediment and resting at sea level. These factors contribute to subsidence, the sinking of the land surface due largely to low-angle faulting, dewatering, and compaction of deposited sediment.

This study used ArcGIS software to take a look at subsidence in the Orleans Parish, the center of much of the damage caused by Hurricane Katrina. By utilizing predicted subsidence rates (Ivins et al. 2007) and combining these with high resolution LiDAR Digital Elevation Models (DEMs), new DEM’s were created which predict the land surface elevation after 25, 50, 100, and 500 years, if subsidence is treated as the sole factor governing elevation change.

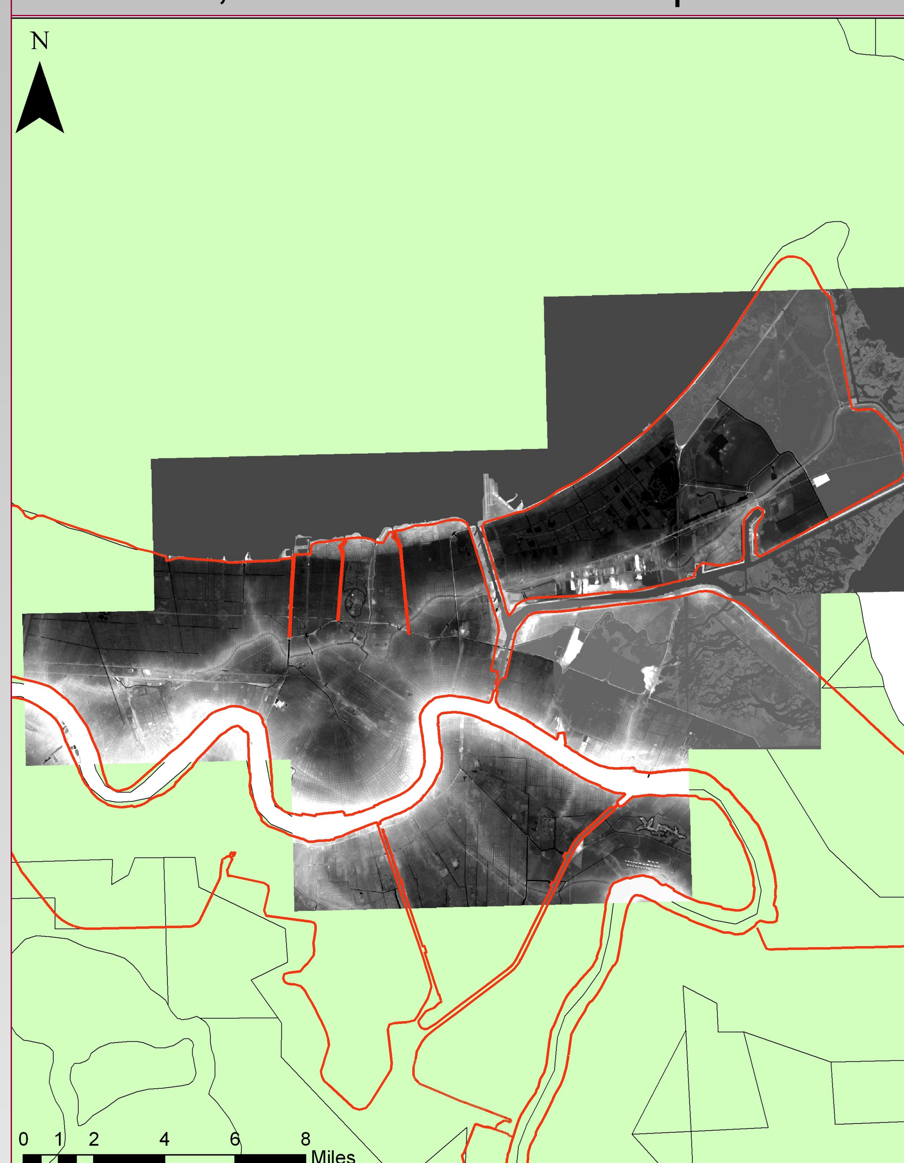

Figure 1 (at left): Digital Elevation Map of the Orleans Parish, with levees outlined in red. Lake Pontchartrain sits to the North and the Mississippi River winds through the center of the parish. High elevations are shown as light, while low elevations are dark.

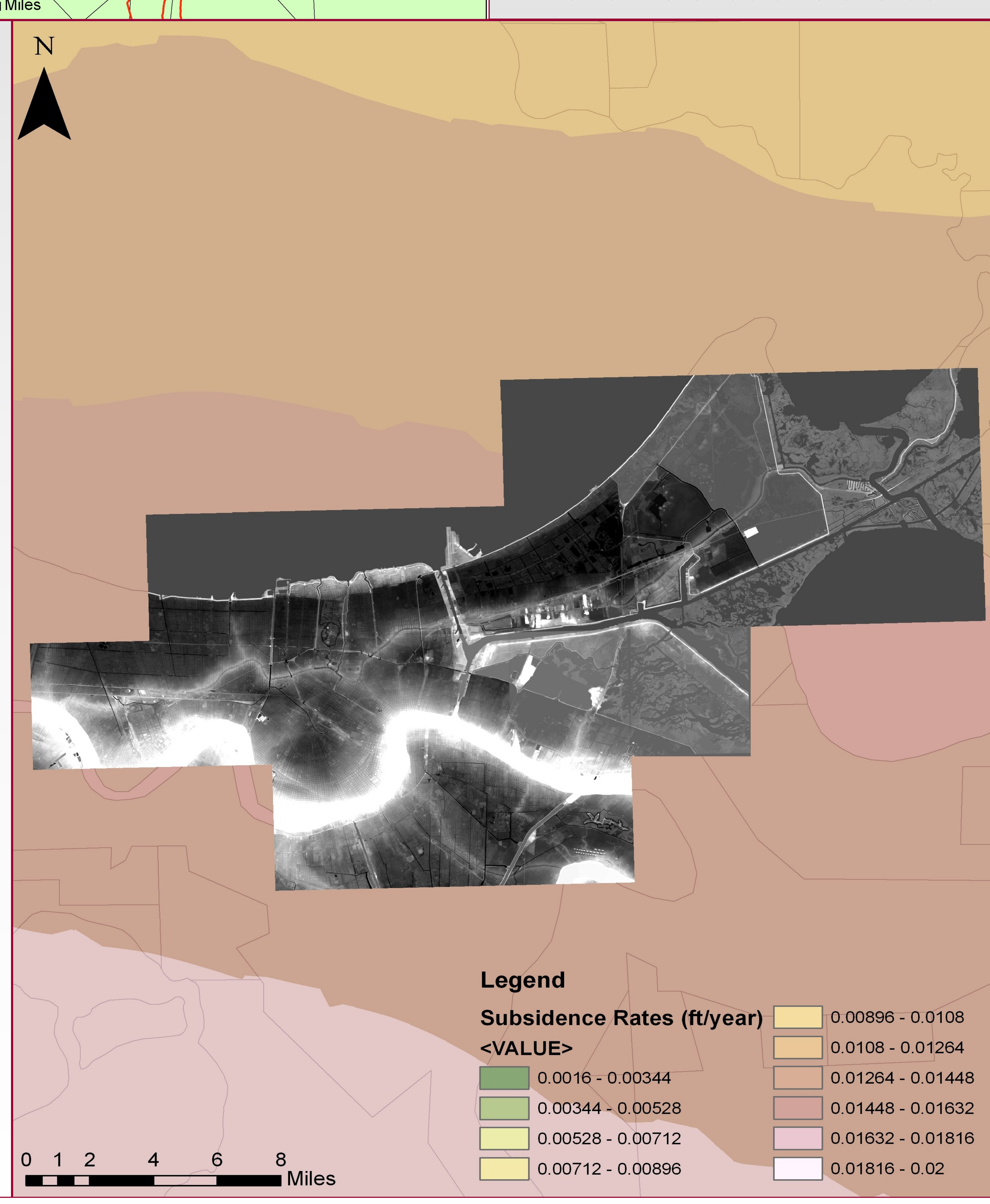

Figure 2 (At right): Orleans Parish DEM Overlain on the Subsidence Rate raster. The legend gives the rate of land subsidence in feet per year.

Methods

In order to have a useful representation of subsidence rates, a digital image showing Gulf Coast subsidence contours from Ivins’ 2007 study was digitized into both polyline and point files, created with equally-spaced control points across the contours from the original image. After mosaicking together LIDAR data (LSU Atlas GIS) covering Orleans Parish, the subsidence contours were georeferenced and overlain (see Figure 2). From this, one can see just how fast the land is subsiding across the parish in ft/yr (about .015 ft (~4.6 mm) on average throughout the parish).

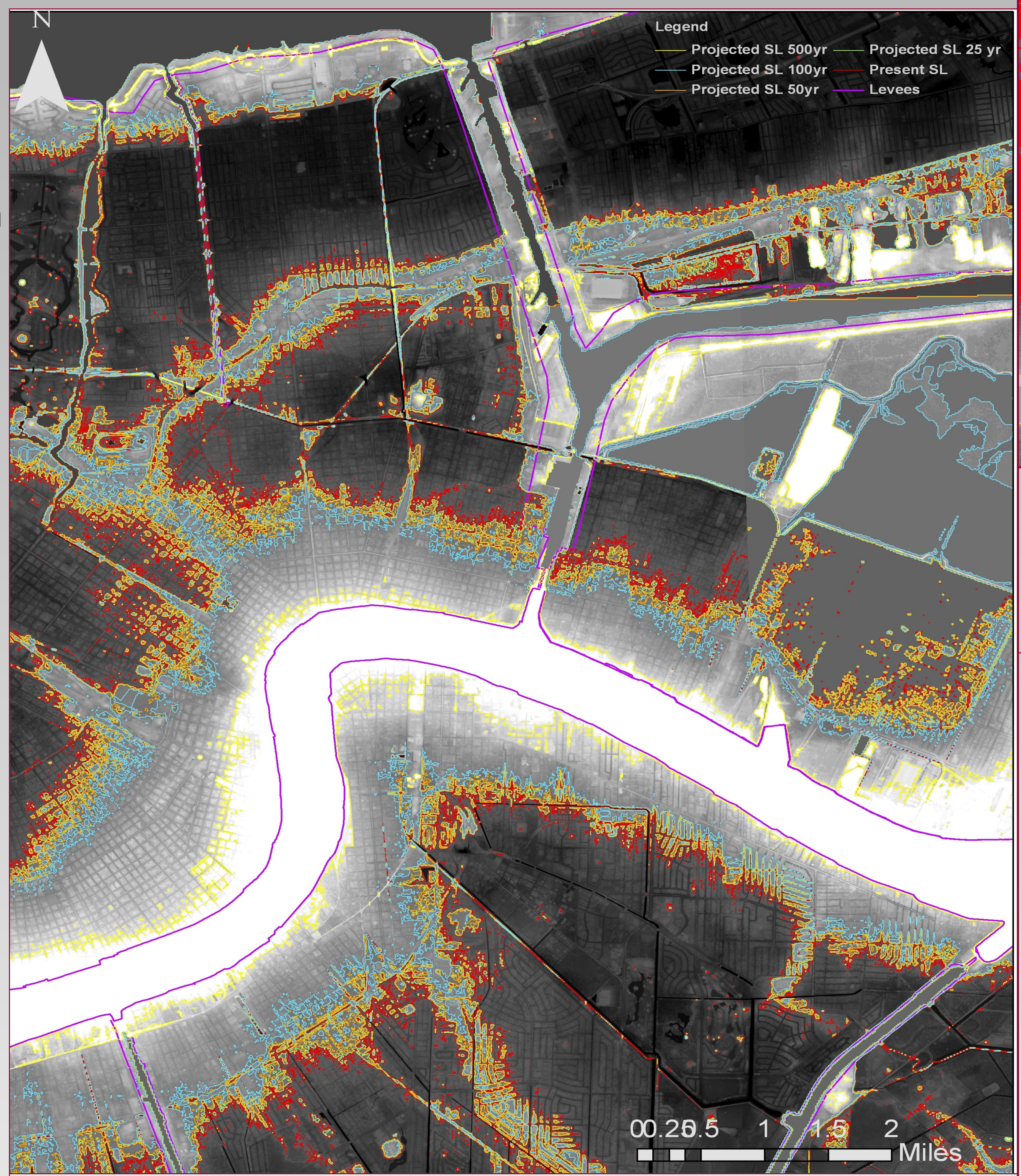

Figure 3 (Above): DEM of Central New Orleans showing zero-elevation contour migration over time. Present-day sea level is shown in red, green corresponds to sea level after 25 yr, orange after 50 yr, blue after 100 yr, and yellow after 500. Levees are shown here in purple.

Next, this subsidence vector data was converted to raster format using the Inverse Distance Weighted method of interpolation via the Spatial Analyst extension. This created a raster layer showing a continuous gradient of subsidence rate values. Raster calculator was then used to create a new raster showing predicted elevation after given amounts of time, using the input:

[LIDAR DEM image]-[x years]*[Subsidence Rate Raster] = Y(New Land Surf. Elevation)

This calculation was completed for x = 25, 50, 100, and 500. A zero-elevation (sea level) contour was then created for each ’x’ value and overlain over the original DEM to provide an illustration of elevation change due to subsidence.

Results

As one can see from Figure 3, which shows zero-elevation contour migration over time, subsidence alone may lower much more of Orleans Parish below sea level in the coming years. In just 500 years (almost no time at all, geologically speaking), the entire city will sit below sea level **due to subsidence alone**; that is, not taking into account sea level rise, which is known to be accelerating in recent years.

Figure 4 (Above): DEM projections of central New Orleans, with areas below sea level colored red. The image at left depicts present conditions, while the image at left shows the city after 500 years of land subsidence (continued at its present rate). Levees are shown in yellow.

Figure 4 (above) shows the central New Orleans DEM with the areas below sea level shown in red. On the left, a present day image is shown; certainly there is a sizable portion on the city already below sea level. On the right, the areas projected to be below sea level in 500 years is in red.

Conclusions

As one can see, the implications of land subsidence on the study area are serious. With nearly the entire city below sea level, will another disaster lead to even greater devastation than Katrina? Surely, the upcoming engineering challenges are vast. Levees must be raised with time, and retaining walls must be reinforced. Although many levees were not actually **overtopped** during Katrina, weaknesses in the structures allowed floodwater to breach through the structures’ interiors. It is entirely possible that subsidence is a factor in levee destabilization, and if/when new levees are built, this should be examined.

No study is perfect, and room always exists for expansion/improvement. In the creation of the subsidence raster overlay (shown in Figure 2), the program was not able resolve the new layer to the cell-size of the high-resolution DEM, and this decreased resolution in the final output by a factor of 5. In addition, due to the scope of the assignment, this study focuses solely on subsidence in projecting elevation changes. In reality, other factors such as eustatic sea level change play a role in defining the elevation of a given area. It should also be noted that this study assumed one constant subsidence rate (a calculated rate from a 2007 Ivins study on crustal loading in the Gulf of Mexico), in reality, subsidence rates are known to fluctuate over time in a given area.

Sources Cited: -FEMA, Katrina GIS Database
-Ivins et al, Post-glacial sediment load and subsidence in coastal Louisiana, 2007
-LSU Atlas—Louisiana Statewide GIS Database

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