Analysis of Rising Sea Level at Tourist Spot Waikiki Beach, Oahu, HI

Bianca Valdez, GIS 327G

4/30/18

Introduction

Waikiki is an area on the south shore of the island of Oahu in Hawaii that is recognized as a major tourism destination in Hawaii. This area is characterized by high-rise hotels that line the shore, a world renowned beach, and this location a very popular destination for vacation travelers. The Waikiki beach spans for about 2 miles and it fronts a number of major hotels. Given the popular and economic importance of Waikiki, the effects of climate change are seen as a potential threat to this area of Oahu, and Hawaii's overall economy. Rising sea levels, coupled with high water levels caused by tropical storms is incrementally increasing coastal flooding and erosion, and is impacting infrastructure and tourism. It will cause serious detriment to Hawaii's number one economic engine: tourism ,with an estimated loss of $2 billion every year. The objective of this report is to assess the percentage of hotels and land area that will be affected by rising sea level in Waikiki Beach, Oahu, HI.

Problem

Question: What percent of hotels and land area will be under water due to various rises of sea level in the Waikiki area of Oahu?

I am essentially assessing the flood hazards associated with the Waikiki Beach area due to rising sea level. I want to calculate the percent of hotels, specifically in the Waikiki area of Honolulu, that would be affected by various changes in sea level rise. I want to look at what percent of hotels are affected at 3ft, 4ft,5ft, and 6ft of sea level rise. I hypothesize that a greater amount of hotels and businesses will be affected by 5 or 6ft of sea level rise, and that 3ft or 4ft of sea level rise will only affect a small percentage of hotels and businesses. I also want to find the area of land that would be underwater due to sea level rise, specifically in a fixed area of Waikiki. I will gather DEM data of Oahu, and use the Aspect tool to gain perspective on elevations in order to support my hypothesis. I will then use a TIFF image of the Waikiki area and form it into a shape file. I will then clip the hotels to the Waikiki shape file, and clip the various forms of sea level rise to that polygon. I will also calculate the percent of land that will be underwater due to various sea level rises.

Data Collection

1. From the National Oceanic and Atmospheric Administration (NOAA) I downloaded feature classes for sea level rise https://coast.noaa.gov/slrdata/
    - **HI_Oahu_slr_data_dist.zip** (NAD 83 UTM Zone 4)
2. From the state of Hawaii office planning I downloaded a hotel point shapefile (which was created by the Hospitality advisors LLC) http://files.hawaii.gov/dbedt/op/gis/data/hotels.pdf a LANDSAT image (which was created by Earthstar Geographics LLC) http://files.hawaii.gov/dbedt/op/gis/data/landsat_oahu_15m.txt
    - **hotels.shp.zip** (NAD 83 HARN UTM Zone 4)
    - **landsat_oahu_15m.zip** (NAD 83 UTM Zone 4)
3. From the University of Hawaii Manoa I downloaded a TIFF raster image of Waikiki (which was created by the Coastal Geology Group of the university) http://www.soest.hawaii.edu/coasts/erosion/oahu/mosaics.php and a Digital Elevation Model (created by the NOAA) ftp://soest.hawaii.edu/coastal/webftp/8main_hawaiin_islands_dem_metadata.txt
    - **Oahu_DEM.zip** (NAD 83 UTM Zone 4)
    - **Waikiki_2005_mos.zip** (NAD 83 UTM Zone 4)

Pre-Processing and Data Processing

1. First, I made sure to set the data frame's coordinate system to NAD_1983_UTM_Zone_4N.
2. I then dowloaded the DEM raster of Oahu into ArcMap.
3. I created a Hillshade of the the DEM raster in order to get elevation as seen in *Figure 1*.

Figure 1: Screen Capture of Hillside tool. I created a Hillside out of

4. After the Hillshade was created, I ran the Hillside under the Aspect tool to clearly see the elevations as seen in *Figure 2*.

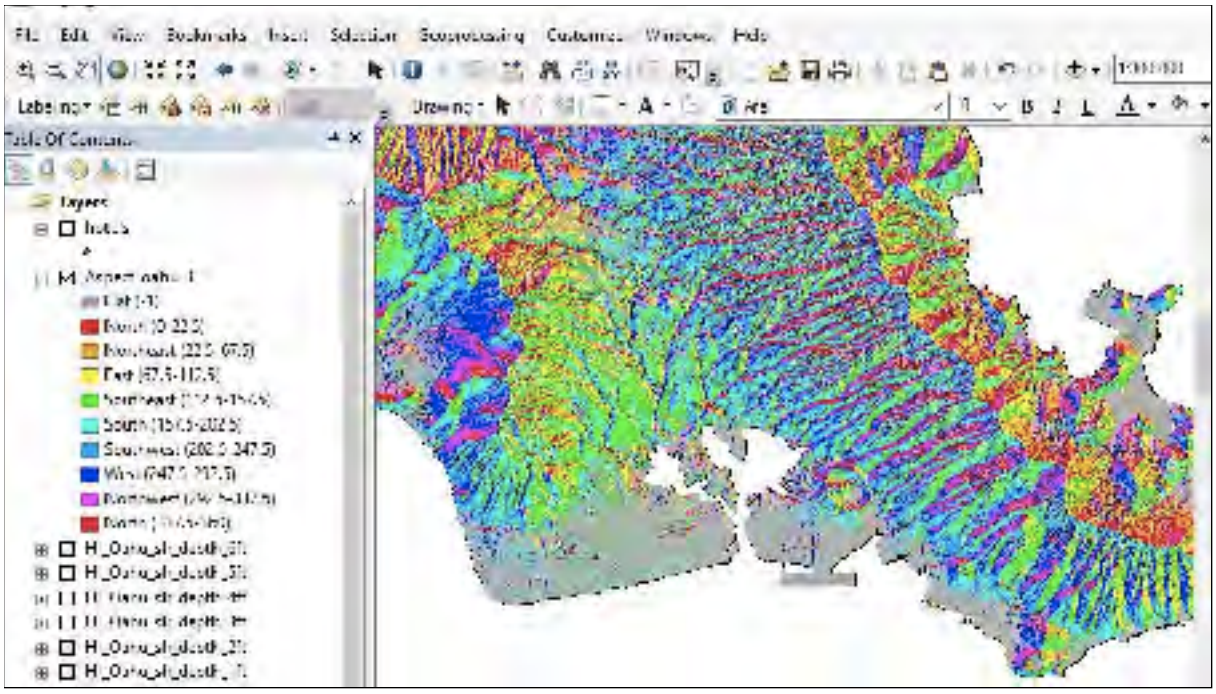


Figure 2: Screen Capture of Aspect map of Oahu.

5. Next, I needed to create a shape file of my TIFF image raster. (I did not use the 'Raster to Polygon' tool because the raster was too big and it would not work)
6. I created my own personal geodatabase in order to create polygon feature classes of the outline of my area of interest. Within the geodatabase I created a dataset called 'waikiki' which held my shape files. This can be seen in *Figure 3*

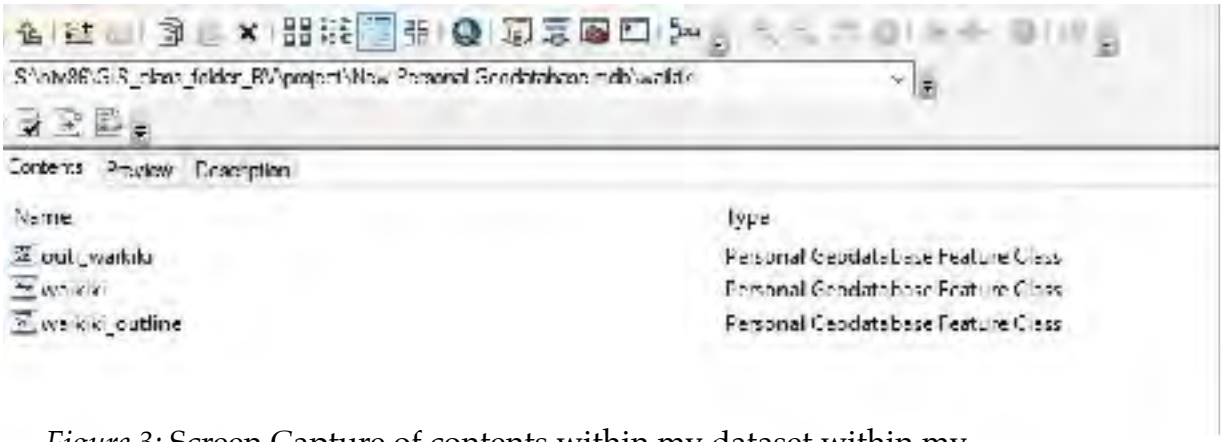


Figure 3: Screen Capture of contents within my dataset within my Personal Geodatabase.

7. I then used the Editor tool and traced along the outline of the TIFF image of Waikiki as seen in *Figure 4*. I saved my edits, turned the editor off and got a polygon of the this area. The image was already under the same spatial reference as the rest of my data, so my polygon that I created was spatially correct as well. I also created a separate polygon that only outline the land portion and did not take any of the ocean part of the image into account. I did this so I could later figure out how much of this particular area would be underwater.

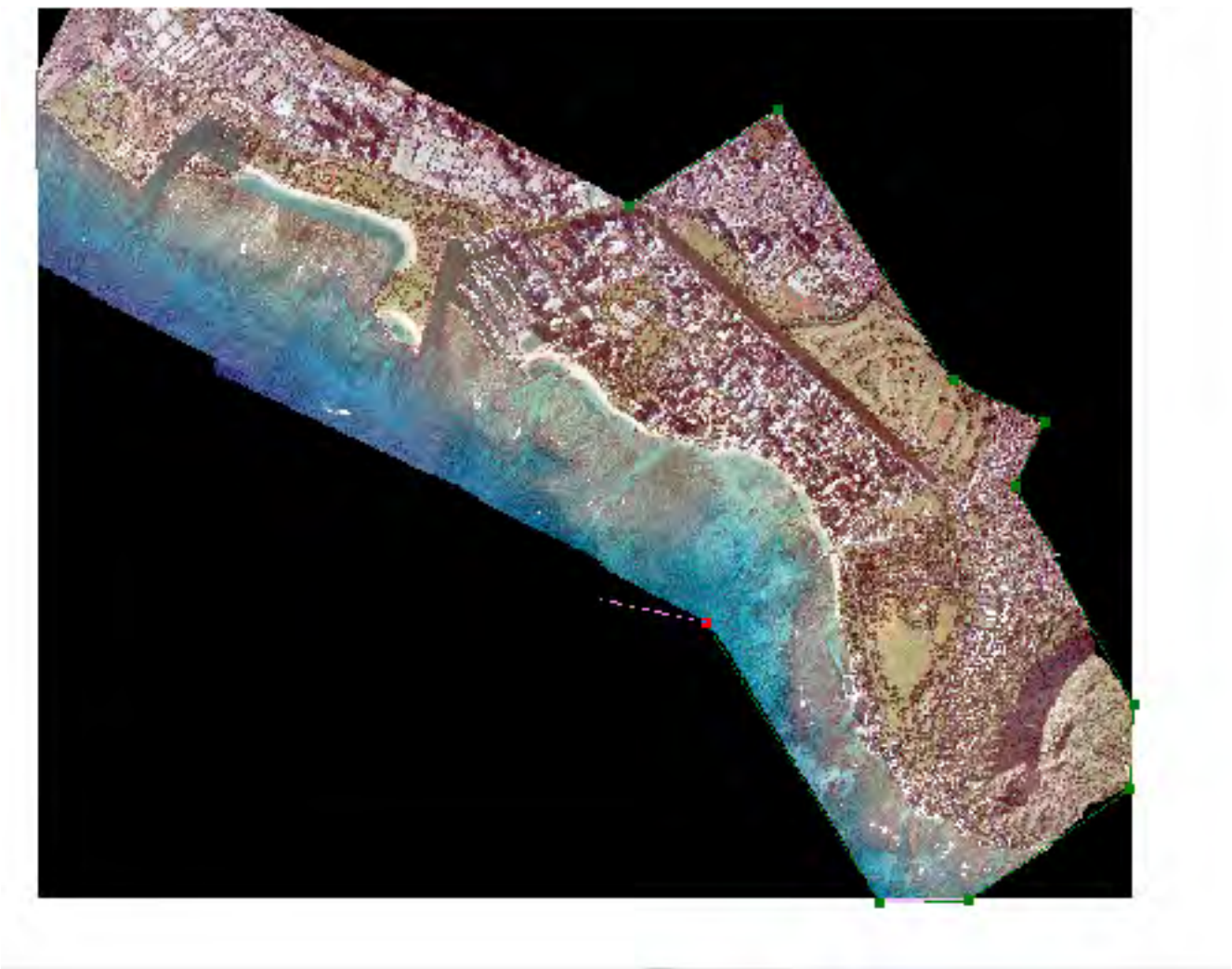


Figure 4: Screen Capture of the process of snapping vertices to create a polygon.

8. After I successfully create a polygon of the Waikiki area, I used the 'Clip' tool to clip the hotel shape file and the various rises in sea levels to the polygon as can be seen in *Figure 5* and *Figure 6*. I also used this tool to clip the rises in sea level to only the land polygon. I also clipped the hotels to the rising sea levels to later see which hotels were affected by 3ft, 4ft, 5ft and 6ft of water.

Figure 5: Screen Capture of the process of clipping hotels to the Waikiki polygon.

Figure 6: Screen Capture of the process clipping 1ft of sea level rise to the Waikiki polygon

9. From the clipped shape files I was able to use the ‘Select by Location’ button to find out how many hotels were affected by 3ft of water for example as seen in *Figure 7*. I looked at the attribute table of each level of sea water change.

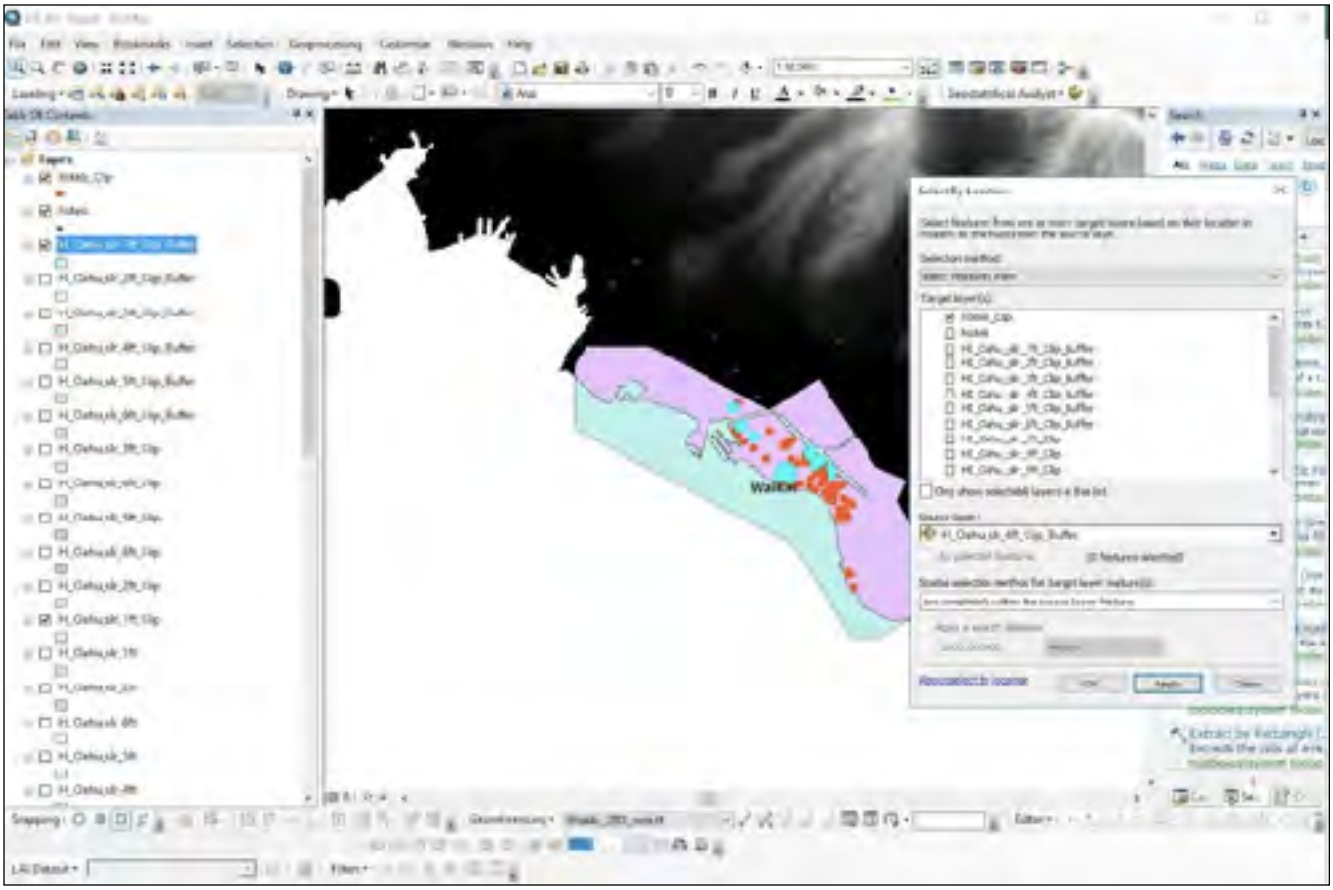


Figure 7: Screen Capture of the process of selecting by location of hotels in 4ft of water.

10. I also wanted to find the area of this particular section of land that would be affected by rising sea level. I order to do this I opened the attribute table, added a field for Area under long integer, and calculated the geometry for the land polygon shapefile. I then looked at the statistics of the file to find the total area as seen in *Figure 8.* I then did the same exact process for my clipped sea levels for the different rises in sea level (3ft, 4ft, etc.). I then found the percentage of what land would be covered by water. I also found the percentage of hotels by opening the attribute table and looking at the selected amount of hotels out of the total about of hotels.

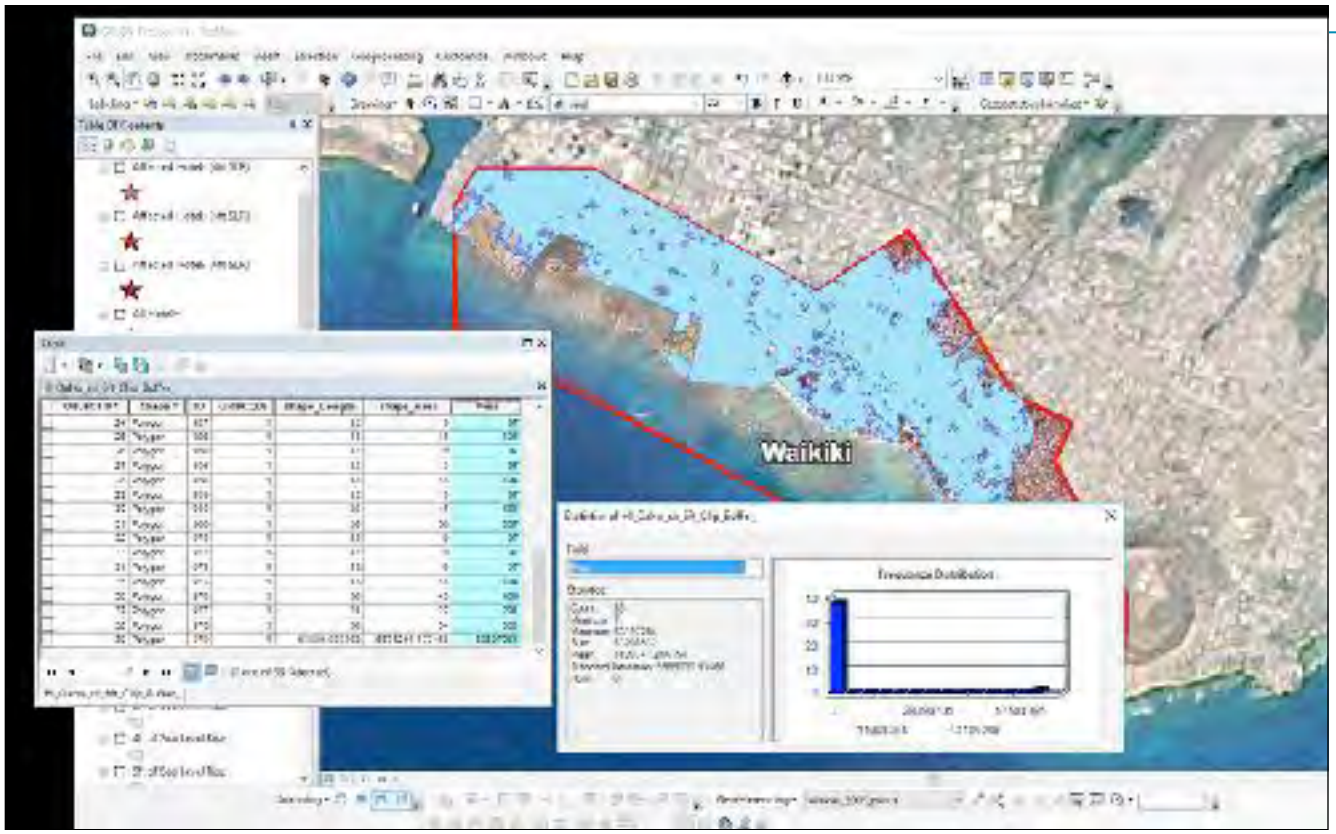


Figure 8: Screen Capture of the attribute table and statistics of the total area of rise of 6ft of sea water.

Analysis/Discussion

I wanted to find out what percent of hotels in the Waikiki area would be affected by different levels of sea level rise. According to the attribute table there was a total of 91 hotels in my area of interest. When I used the 'Select by Location' function I was able to see how many hotels were affected by different sea level rises. Table 1 shows the different sea level rise and the corresponding hotels affected, as well as the calculated percentage that would be underwater. I also attached Table 3 in order to see the qualitative results as well. The table provides the hotels name affected by 4ft of sea level rise. With 1 or 2 ft of water no hotels would be affected. A 3ft of sea level results in 1.09% hotels affected, a 4ft sea level rise results in 23.07% hotels affected, a 5ft sea level rise results in 65.9% hotels affected, and a rise in 6ft would result in 84.6% hotels affected.

ft of SLR	hotels affected	% out of total
1	0	0
2	0	0
3	1	1.098901099
4	21	23.07692308
5	60	65.93406593
6	77	84.61538462

Table 1: Percent Results of Hotels affected per sea level increase

I also wanted to find out the percent of land that would be underwater in my area of interest. I was able to calculate the areas through ArcMap by using the 'calculate geometry' feature in the attribute table. All the of areas I calculated are in square feet. Table 2 shows the calculated total percent of land affected by seawater. For 3ft of sea level rise, about 9.66% of the land in the Waikiki area would be underwater. For 4ft of sea level rise, about 26.45% of the land in the Waikiki area would be underwater. For 5ft of sea level rise, about 50.61% of the land would be underwater. Finally, for 6ft of sea level rise, about 64.7% of the land would be underwater.

ft of SLR	sq ft affected	% out of total
3	9,432,644	9.65850634
4	25,834,691	26.4532963
5	49,429,504	50.6130813
6	63,208,932	64.7224543

Table 2: Percent Results of land affected per sea level increase in the area of interest (Waikiki area)

Name	address	Zipcode	Type	Units	year_built
Central YMCA	401 Atkinson Drive	96814	HOTEL	114	1951
Aloha Towers - Royal Aloha Vacation Club	2215 Aloha Drive	96815	TIMESHARE	41	1976
Aqua Aloha Surf & Spa	444 Kanekapolei Street	96815	CONDOMINIUM/HOTEL	170	1958
Aqua Coconut Plaza	450 Lewers Street	96815	CONDOMINIUM/HOTEL	80	1963
Aqua Palms at Waikiki	1850 Ala Moana Boulevard	96815	CONDOMINIUM/HOTEL	229	1968
Big Surf	1690 Ala Moana Boulevard	96815	CONDOMINIUM/HOTEL	45	1971
Embassy Suites - Waikiki Beach Walk	201 Beach Walk	96815	HOTEL	369	2008
Fairway Villa	2345 Ala Wai Boulevard	96815	TIMESHARE	24	1974
Island Colony	445 Seaside Avenue	96815	CONDOMINIUM/HOTEL	174	1978
Kai Aloha Hotel	235 Saratoga Road	96815	APARTMENT/HOTEL	18	1955
Ohana Islander Waikiki	270 Lewers Street	96815	HOTEL	264	1964
Outrigger Reef on the Beach	2169 Kalia Road	96815	HOTEL	529	1955
Outrigger Regency on Beach Walk	255 Beach Walk	96815	CONDOMINIUM/HOTEL	45	1961
Ramada Plaza Waikiki	1850 Ala Moana Boulevard	96815	HOTEL	158	1965
Seaside Hawaiian Hostel	419 Seaside Avenue	96815	HOSTEL	57	1990
The Breakers Hotel	250 Beach Walk	96815	HOTEL	63	1953
The Equus	1696 Ala Moana Boulevard	96815	CONDOMINIUM/HOTEL	67	1963
Trump International Hotel & Tower	223 Saratoga Road	96815	CONDOMINIUM/HOTEL	301	2005
Waikiki Marina Hotel	1700 Ala Moana Boulevard	96815	CONDOMINIUM/HOTEL	60	1975
Waikiki Parc Hotel	2233 Helumoa Road	96815	HOTEL	297	1987
Waikiki Shore	2161 Kalia Road	96815	CONDOMINIUM/HOTEL	127	1961

Table 3: List of the 21 hotels affected by a rise in 4ft of sea level.

Conclusion

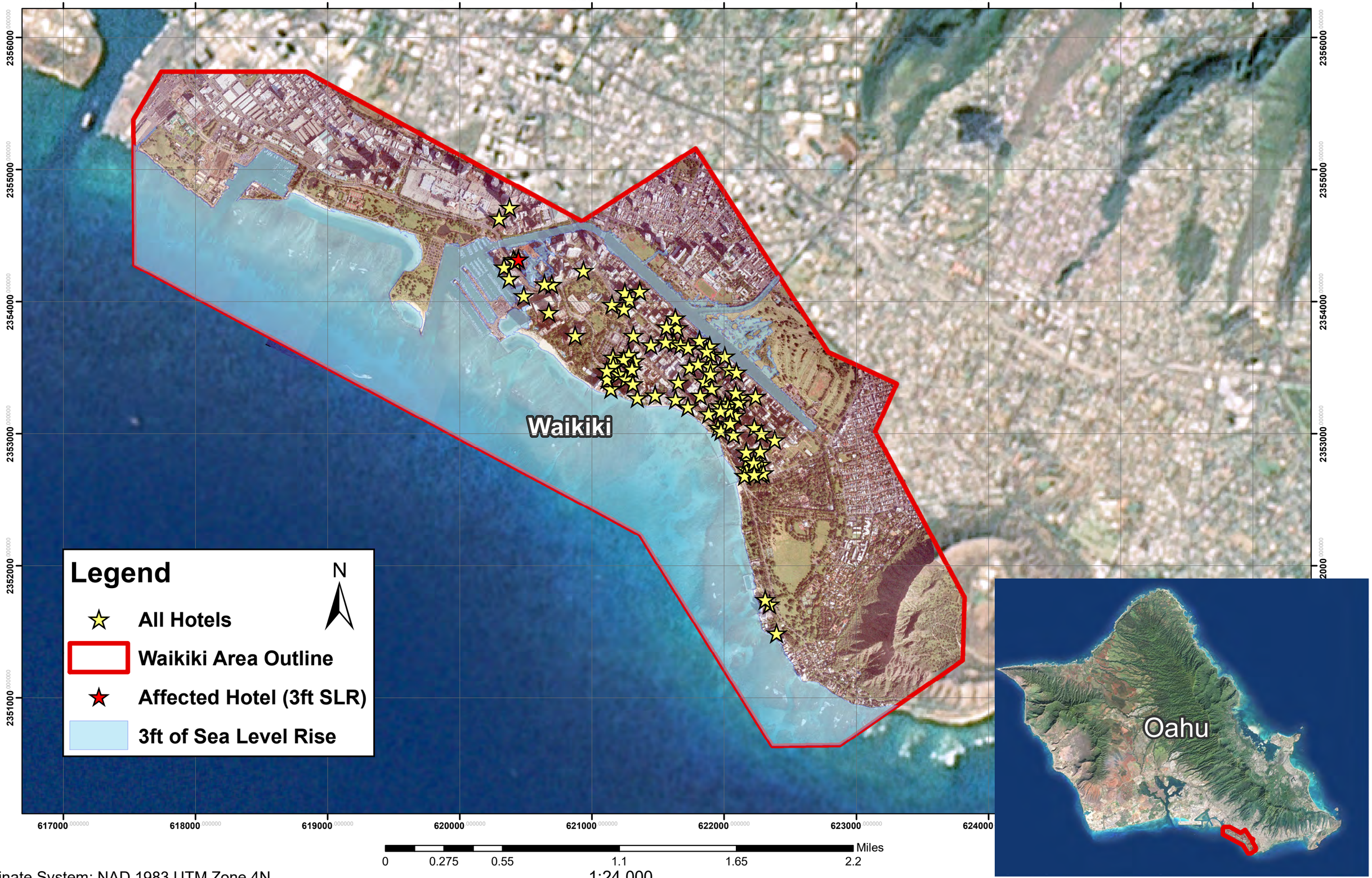
I essentially wanted to find the percent amount of hotels that would be affected by rising sea level in Waikiki, Oahu, HI. I also wanted to find the percent of land that would be affected by rising sea level explicitly in the area of interest I was working with. After calculating these numbers and mapping the results, the data shows that rising sea level will have big impacts on the future of Waikiki. I have attached the maps at the end of this report.

Future Work

Further research into this project can include finding annual revenue data of the hotels in order to calculate the economic loss if Waikiki were to go under feet of water. This could be important data for the State of Hawaii to gauge just how much they could lose, and to begin thinking about where they should build in areas that would not be underwater, or to build some kind of mechanism to keep waters at bay.

Waikiki Affected Area due to 3ft of Sea Level Rise

Bianca Valdez

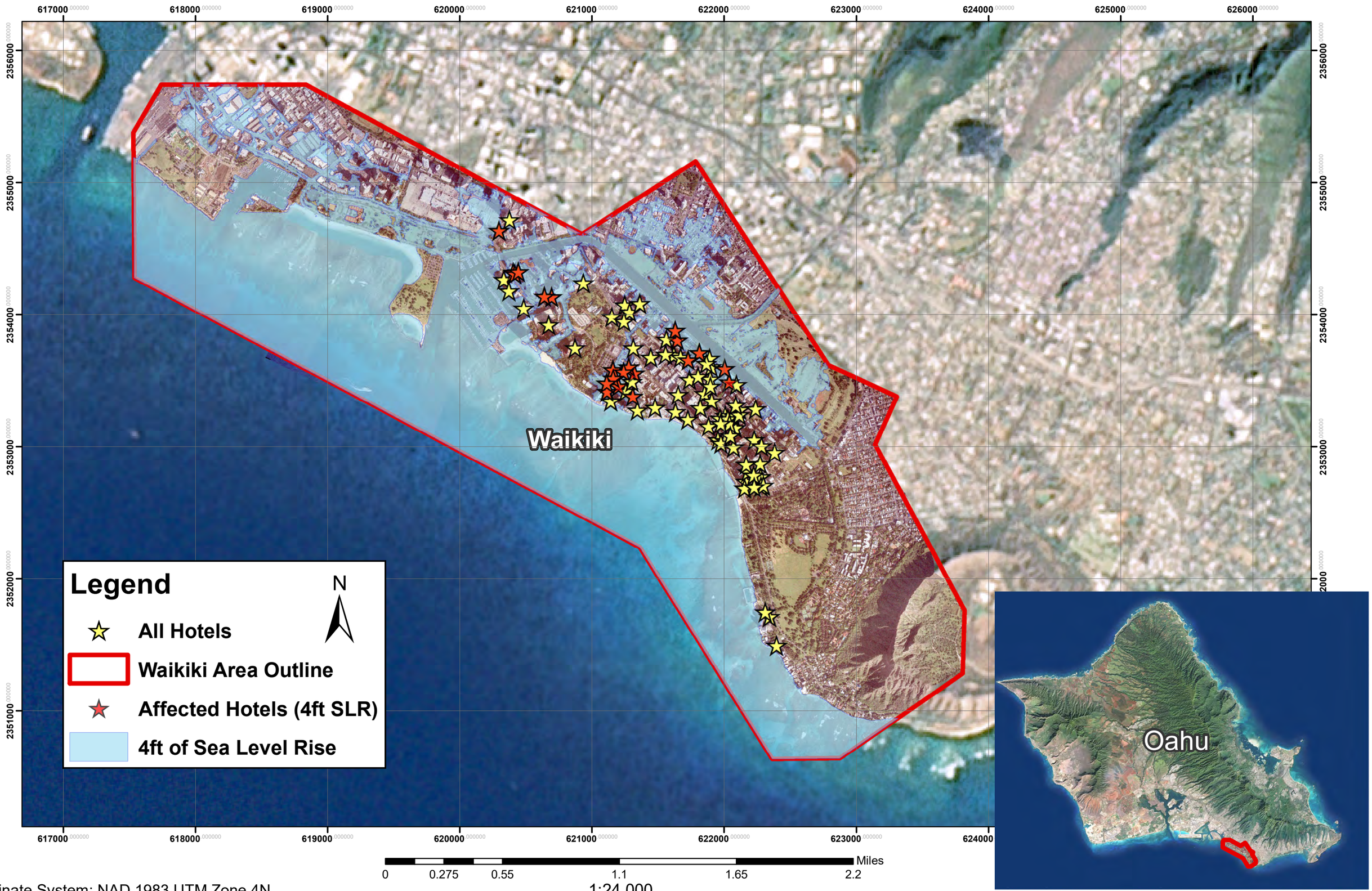


Coordinate System: NAD 1983 UTM Zone 4N

1:24,000

Waikiki Affected Area due to 4ft of Sea Level Rise

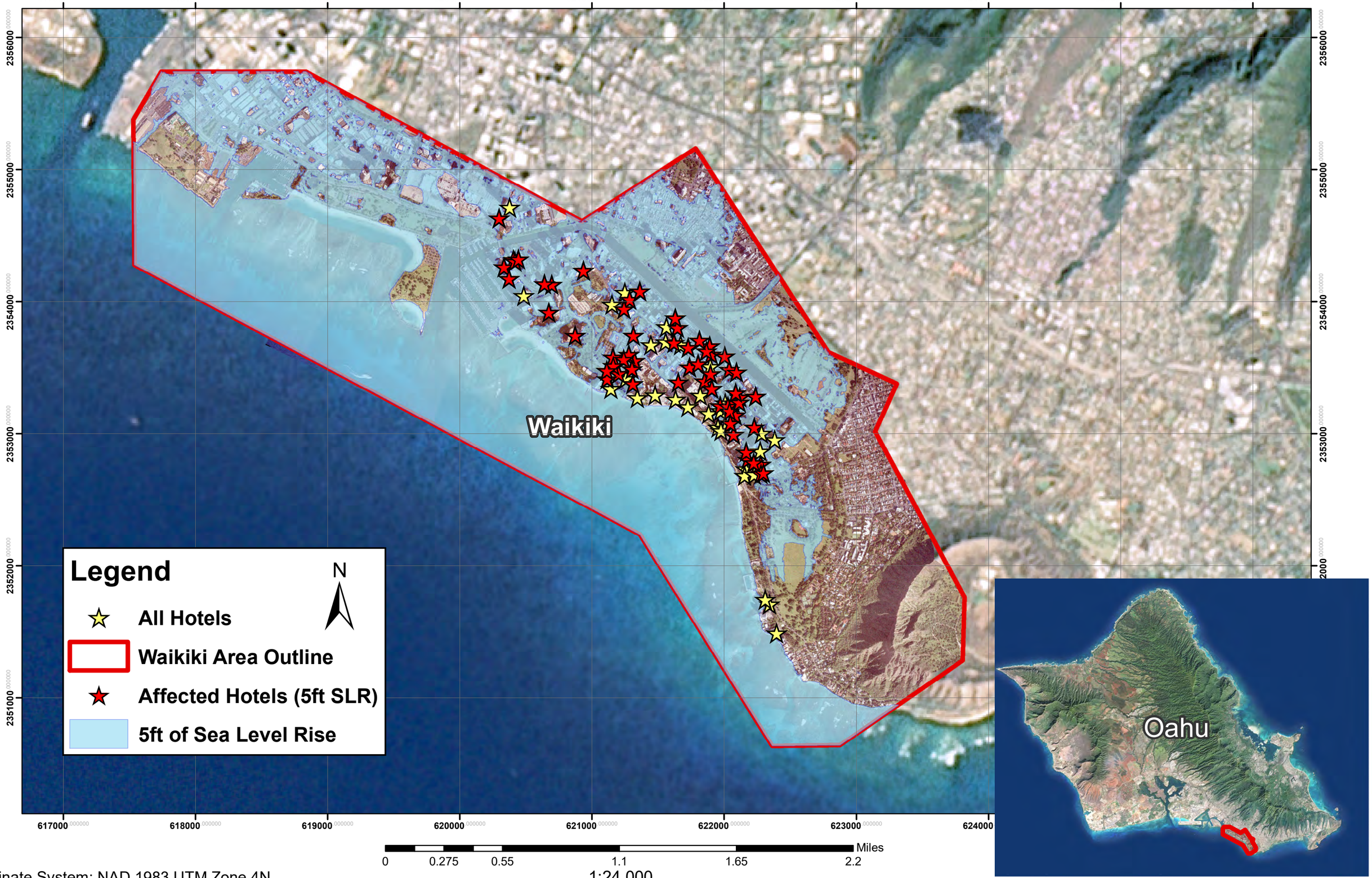
Bianca Valdez



Coordinate System: NAD 1983 UTM Zone 4N

Waikiki Affected Area due to 5ft of Sea Level Rise

Bianca Valdez



Coordinate System: NAD 1983 UTM Zone 4N

Waikiki Affected Area due to 6ft of Sea Level Rise

Bianca Valdez