Understanding Flood Zones in Sugar Land As an Average Homeowner

City of Sugar Land

Zijin Chen[1,3], Erik Schenck[2]

[1] John Foster Dulles High School, Sugar Land, TX
[2] IT Department, City of Sugar Land Office, Sugar Land, TX
[3] Gifted & Talented Mentorship Program, Fort Bend ISD, TX

FBISD
INSPIRE • EQUIP • IMAGINE
GIFTED AND TALENTED

Introduction

According to NASA's 2023 analysis on the change in global surface temperature [1], the 10 most recent years are the warmest on record. In fact, Earth is now 2.45 degrees Fahrenheit warmer in 2023 than in the late 19th-century (before industrialization). Texas is not an exception to the effects of climate change. Along the Gulf Coast, there is a 1000% increase in the number of high tide flooding days when comparing the year 2000 to 2020. Studies found that rising sea levels positively correlate to elevated numbers in severe storms, as seen with Hurricane Harvey, resulting in more intense floods [2].

On a local level, this begs the question: should buyers interested in homes in Sugar Land be worried about increased flood risk? On the City of Sugar Land's official website [3], this city is classified as a generally Low-Flood Hazard Zone (Zone X) since it's protected by levees. However, Sugar Land does have areas that are labeled as a high-flood risk zone according to the Federal Emergency Management Agency (FEMA), and the city participates in the National Flood Insurance Program (NFIP) to make flood insurance available to homebuyers. There is limited information available to the public that analyzes the City of Sugar Land's flood zones to help citizens and potential homebuyers understand the topography of the land. What factors classify the city as a generally low-risk flood zone? What makes certain areas a high-risk flood zone? Most importantly, how can we apply this knowledge on a global level?

This research endeavor serves to understand the mathematical, geographical, and architectural patterns when designing streets in the context of reducing flood risk.

Methodology

This research endeavor took a quantitative approach to analyze current neighborhoods in Sugar Land that are under FEMA's determined flood zones (based on 2023 data) by focusing on the crown of streets since they're the easiest and most common flood infrastructure to collect information on. Using ArcGIS Pro, a software designed for geographic information system (GIS) purposes, four maps (provided by FEMA and the City of Sugar Land's database) are used: flood zones (from 2023), catch basin locations, elevation (from 2021 drone-captured LiDAR data), and a raster image of the entire city.

According to FEMA, Sugar Land is only classified into three out of the six types of flood zones: 1% Annual Chance Flood Hazard, 0.2% Annual Chance Flood Hazard, and Area with Reduced Risk Due to Levee. Using the maps, ArcGIS Pro tools, and Google Spreadsheet tools, multiple streets were selected from each of the zones to analyze the relationship between the elevation of streets, positioning of storm drains, and distance from bodies of water, as well as physical traits of the city's geography. In each zone, if possible, the streets are divided into ones directly next to a large, still body of water, like a lake, and streets that aren't directly near one, to determine if the bodies of water increase flood risk.

Due to the vast amount of data points on the map, ArcGIS Pro's "Summarize Elevation" tool was used to determine the surface elevation for bodies of water with the finest (highest) digital elevation model (DEM) spatial resolution. The resolution refers to the area of land being represented by a single grid cell, and the more grid cells used to represent a piece of land, the better the resolution and the more accurate the summarization of the elevation in that area.

Results

▲ Catch Basin Location ◆ Intersection of Streets

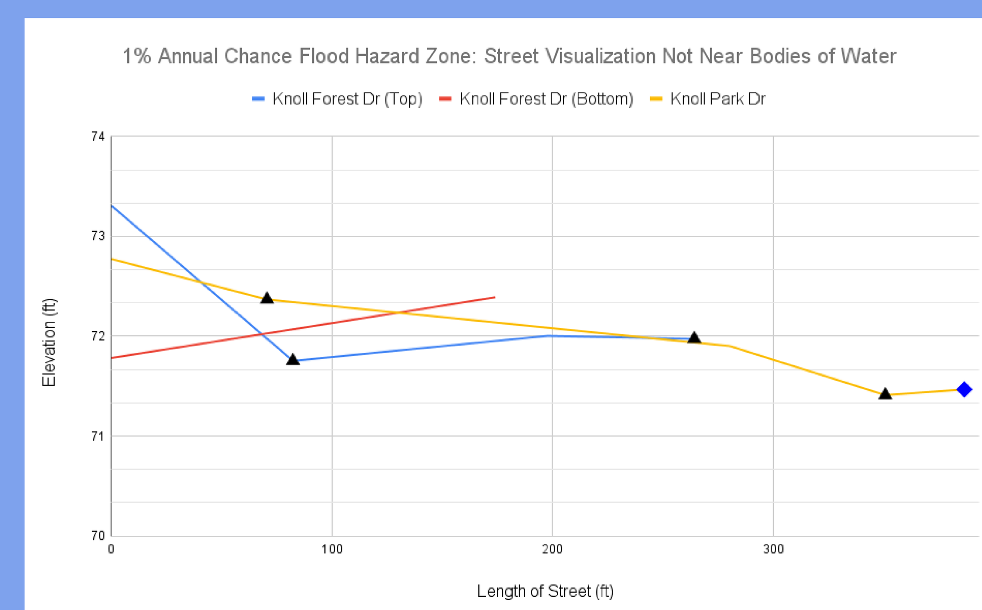

Figure 1

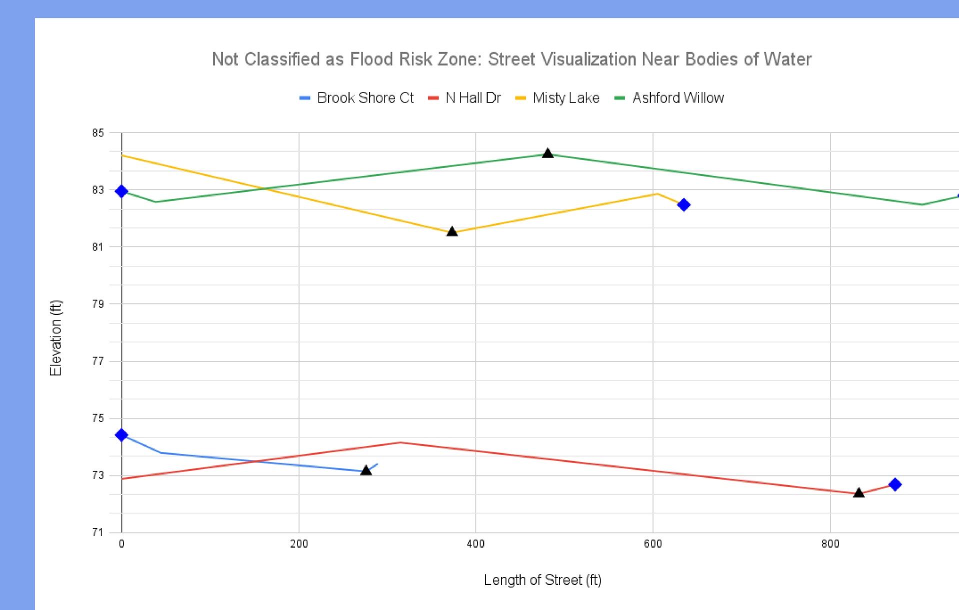

Figure 2

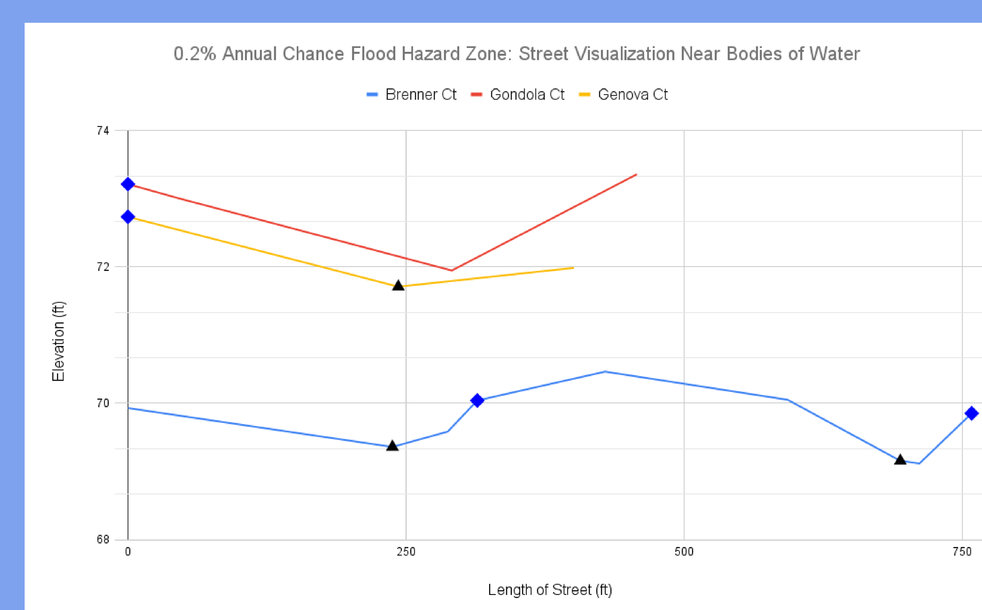

Figure 3

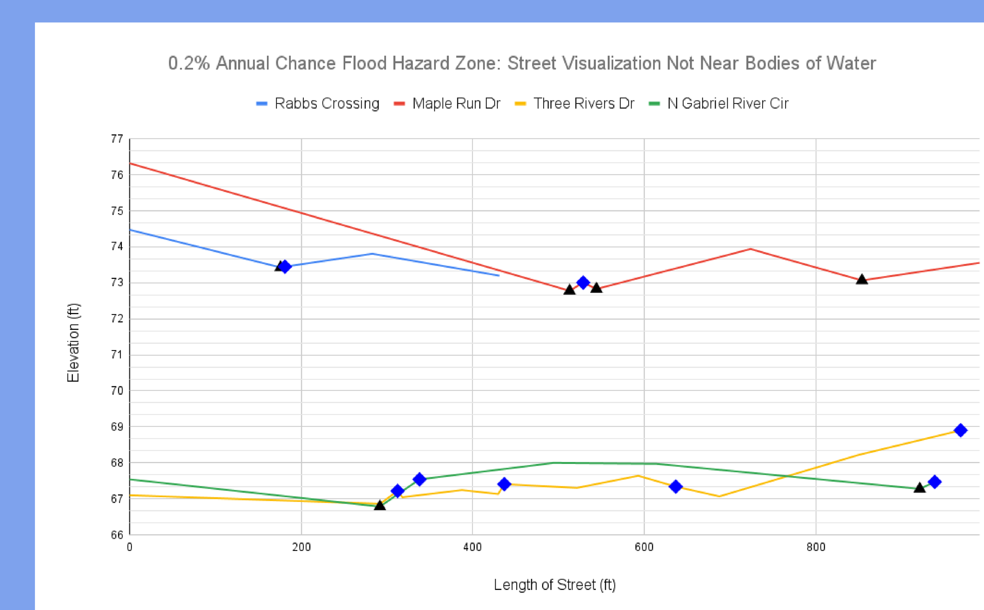

Figure 4

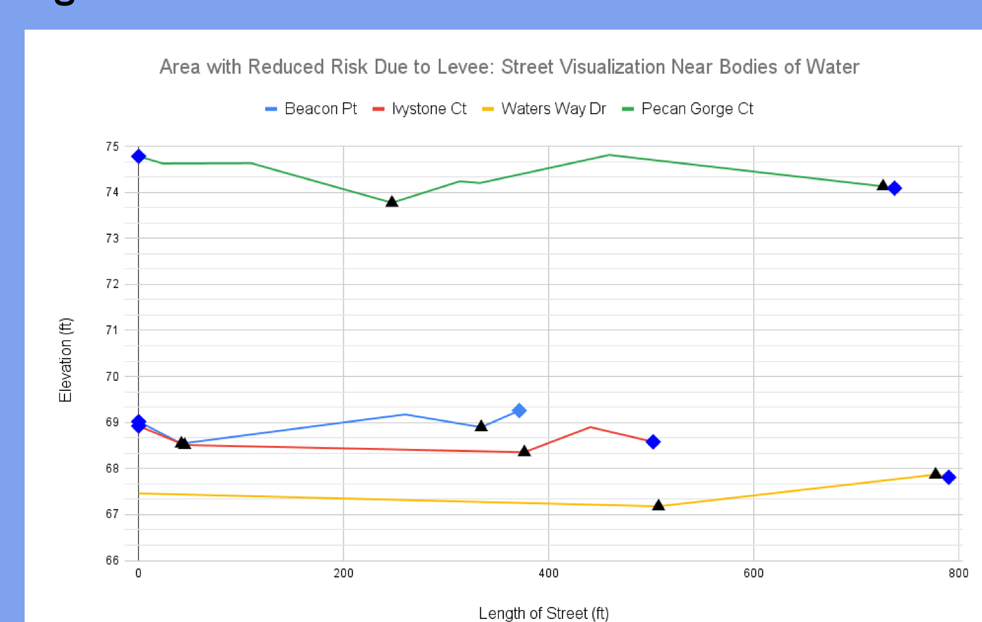

Figure 5

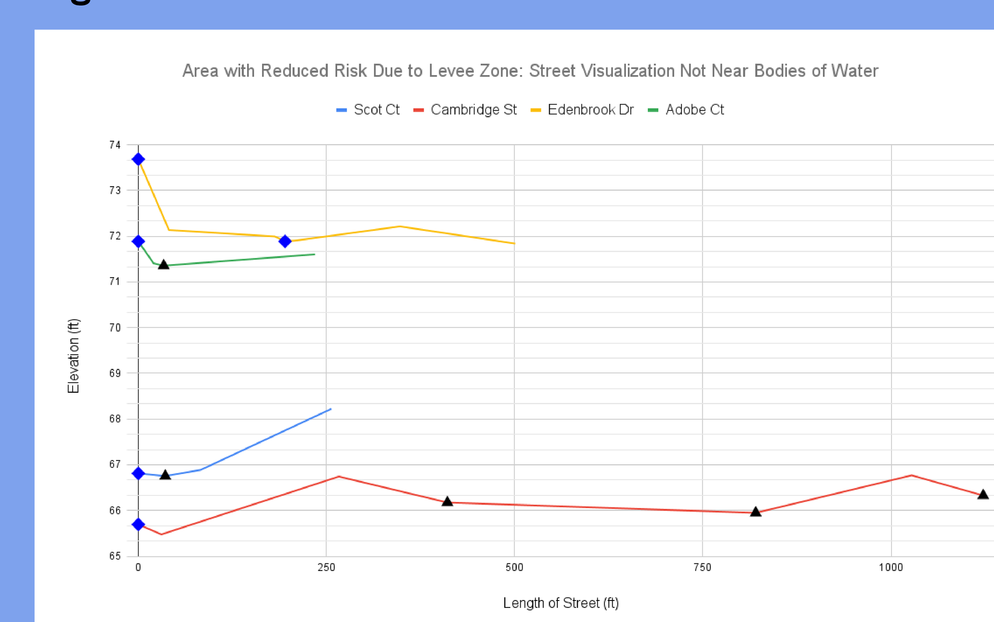

Figure 6

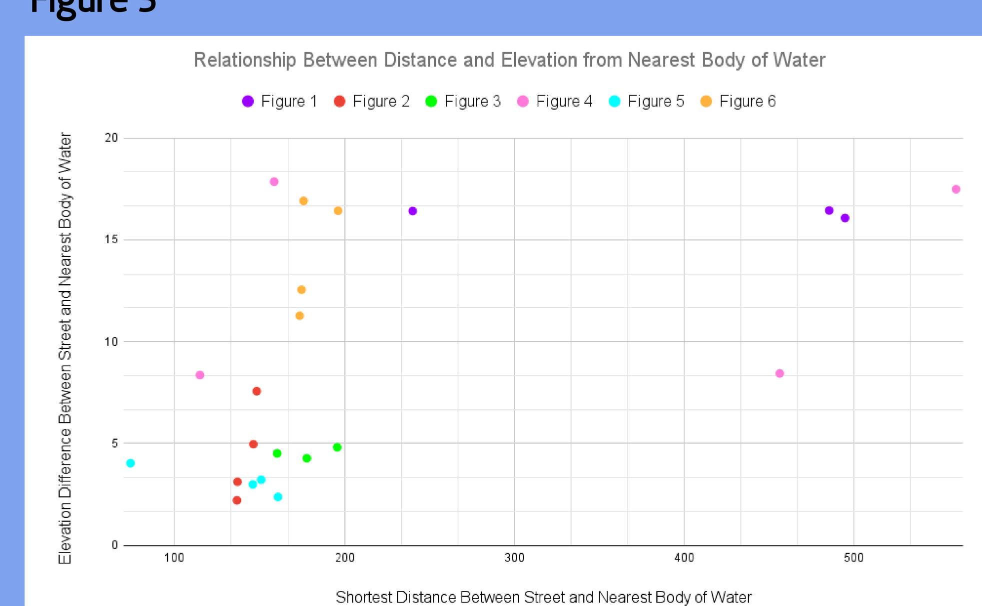

Figure 7

References:

1. "Global Temperature." NASA, 2023, https://climate.nasa.gov/vital-signs/global-temperature/?intent=121.
2. Zuvanich, Adam. "Gulf Coast sea level rising at 'unprecedented' rate, recent studies find." Houston Public Media, 12 Apr. 2023, https://www.houstonpublicmedia.org/articles/climate-change/2023/04/12/449026/gulf-coast-sea-level-rising-at-unprecedented-rate-recent-studies-find/
3. "Flooding." Sugar Land TX, https://www.sugarlandtx.gov/895/Flooding#:~:text=This%20area%20is%20protected%20by,Hazard%20Zone%20(Zone%20X).

Findings & Conclusion

The data indicates that across the first six figures, drains are located towards the ends of streets and near intersections. Looking at the change in elevation, streets slope down towards drains to where the catch basins act as the dip in the "valley" of their relative area, and intersections generally serve as a relative peak in elevation to change the course of water flowing from the intersection into the nearby drain.

The basic assumption for an area classified as a high-risk flood zone (1% Annual Chance Flood Hazard) would have traits of low elevation and close proximity to the nearest body of still water like lakes and ponds. Figure 7 contradicts this information with the majority of Figure 1's streets having the highest elevation difference from the surface of the nearest water channel, Rabbs Bayou. It can be concluded that the streets and houses in this neighborhood were constructed in response to the high flood risk, resulting in a much higher elevation difference and farther distance from the bayou.

Another contradictory observation arises where the streets located in a less flood-risk zone have a smaller elevation difference if they're located near a large body of water, as seen in Figure 3 and Figure 5's streets in Figure 7. A possible conclusion is that streets located in neighborhoods that have artificial lakes, like Beacon Pt and Pecan Gorge Ct, are designed to where the lakes act as a reservoir for water runoff when it rains heavily. It's necessary for these artificial lakes to have a water intake and release system, so it's likely that they're strategically built near drainage channels, as seen with the unnamed drainage channels to the left of Beacon Pt and Pecan Gorge Ct, if the lakes overflow, reducing flooding risk.

Discussion

To analyze the flood risk of an area, there are many other factors beyond elevation and distance that are needed, including understanding the permeability of the land, how much these drains can take in water before backing up, and the volume of lakes. In addition, when collecting the data, the accuracy of distance and elevation are mainly estimates since all the borders and peaks were determined by personal judgment instead of a computer program. In the future, one improvement that can be made while maintaining the simplicity of the project is by using ArcGIS Pro "Summarize Elevation" tool on the streets or converting the map into a 3D visual to better determine data points and locations.

Although these limitations and the extremely small amount of data don't accurately represent flooding patterns in every urban area, there are still clear trends that can be applied on a global level for other cities, helping the average population better understand the geography of their land. For example, the placement of drains and water channels in Sugar Land follows the common pattern of where gravity will pull water towards. Overall, this research can be applied to help city planners and engineers develop stronger infrastructure and street systems in the context of reducing flood risks.