

**Hospitals and Libraries in Flood Zones in  
Harris County Texas**

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## **Abstract**

Harris County Texas, which includes the City of Houston, has a history of flooding. The flooding occurs when there are large amounts of rain in a short amount of time, such as during a tropical storm system. The relatively flat topography of the county means that the water does not easily drain off. There is a substantial amount of damage from each flood, and the dollar estimate of the amount of damage increase with each storm. The floods damage buildings, cars, livestock, infrastructure and many other things. This project looks at two building types that have been damaged in floods, hospitals and libraries. Hospitals because they are an important facilities, and libraries because the Houston library system sustained substantial damage from Hurricane Harvey in August 2017. This project lets the user choose which building type they are interested in, either hospitals or libraries. Then the user can choose one of three different geoprocessing functions. They can clip their building choice by the flood zones layer to see which buildings are in the flood zones, they can choose a buffer distance around their building choice to visualize how far away the buildings are from flood zones, or they can create a layer that is the intersection of their buildings choice with the flood layer. Any of the three methods will show that there are buildings in flood zones. It is beyond the scope of this project to be an exhaustive study of the flooding problem. The hospitals and libraries layers are not complete data sets of either of those structures, and many buildings that are not in officially designated flood zones flooded anyway.

## Introduction

Harris County Texas, which includes the city of Houston, has a long history of flooding, as shown in Figure 1 from the Harris County Flood Control District. (HCFCFCD 2021)

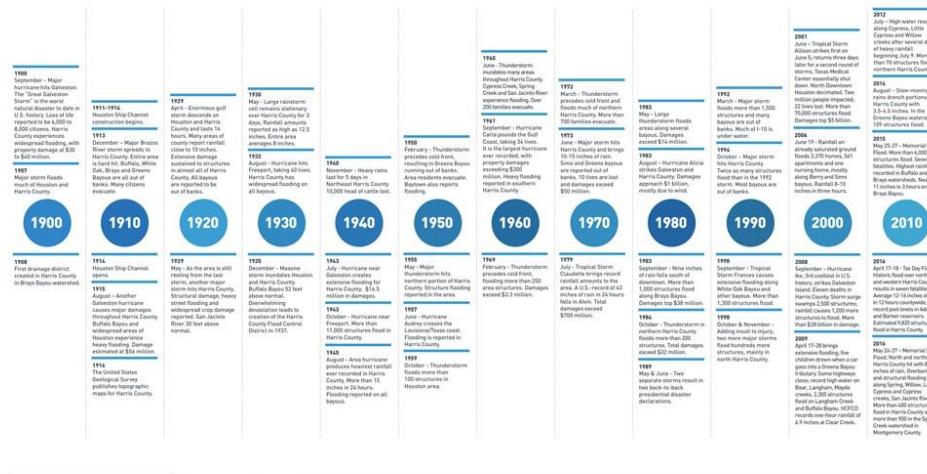


Figure 1 Houston Flood Timeline from Harris County Flood Control District

According to the Harris County Flood Control District, a major flood occurs in the county about every two years (HCFCFCD 2021). There are many reasons why the county floods so frequently; it is on the coast of the Gulf of Mexico so it is vulnerable to tropical storm systems, it is relatively flat, so rainfall is slow to drain off, the elevation ranges from sea level to a few “peaks” at 310’ elevation above sea level, (Peakbagger, 2021) and much of the prairie lands in the west part of the county that used to soak up rainfall have been developed (KPC, 2021). Recent major floods are Tropical Storm Allison June 5-8, 2001 which impacted 2 million people and caused over \$ 5 billion in damages including major damage to the Medical Center, the Memorial Day Flood May

25-27, 2015, the Tax Day Flood April 17-18, 2016 with 12"-16" of rain within 12 hours and almost 10,000 structures flooded, and the Memorial Day Flood May 26-27, 2016 with up to 13" of rain that affected the North and Northwest parts of the county (HCFCD 2021). The most recent devastating flood was Hurricane Harvey, Aug 25-29, 2017 a category 4 hurricane with reported county rainfall amounts over the four days ranging from 27.01" at Hooks Airport in Tomball, to 54" in Bunker Hill Village. (N.O.A.A.2021). The damage estimate for Harvey is \$125 billion. (Lindner & Fitzgerald, 2018). Most of the county was affected in some way, either with direct structure damage, or through being "trapped" because of streets being flooded for days afterwards. One of the many notable destructions, was severe damage to many of the county's libraries. (Ward, 2018). Notable was the damage to the Barbara Bush Library, which had 2' of water in it that destroyed roughly 44,000 books and all of the fixtures and furniture on the first floor (Walker & Wilson, 2018). The purpose of this project is to use GIS to look at libraries and hospitals in Harris County, and let a user explore the data and determine if a library or hospital is in a FEMA designated flood plane, if it is within a certain distance of one, etc. This project could be expanded in the future to include other infrastructure such as roads or airports that might also be in flood zones, or to compare the designated flood zones with the areas that actually flooded.

## **Materials and Methods**

### **Data**

Five different data sets were used for this project. Three data sets were used for the analysis.

Two different point shapefiles, for the libraries (COH, 2019) and hospitals (COH, 2019) were

obtained from the City of Houston GIS (COHGIS) Data Hub (COH). The City of Houston maintains a GIS data hub with accurate GIS data for the city and some parts of the county. The libraries and hospitals are not a complete set of either of those facilities in the county, but they provide enough data points, in a wide enough distribution, to show the functionality of the Python coding used in the project. The third data set is a polygon shapefile showing the FEMA different categories of flood zones for the county was obtained from the Federal Emergency Management Agency (FEMA, 2021). A polygon shapefile of the county boundary and a line shapefile of the county roads were obtained from the Harris County Appraisal District (HCAD, 2021), and were used to provide context on the maps.

## Methods

Arcpy (Esri, 2021) was used to write Python scripts, and ArcGISPro (Esri, 2021) was used to test the scripts and see how the analysis looked on a map. The scripts were divided into logical modules or functions. The functions are in one Python file, and another Python file is the “main” that calls and references the functions.

The function that uses the FEMA flood zones layer selects the flood zone attributes (called FLD\_ZONE) that are defined as flood zone areas, and adds them to the map as a new layer. See Table 1 for the flood zone definitions (Flood Zones, 2021).

Flood Zone	Definition
A	“Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies.”
AE	“Areas subject to inundation by the 1-percent-annual chance-flood event determined by detailed methods.”
AO	“Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet.”
VE	“Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves.”
X	“An area of minimal flood hazard that is determined to be outside the Special Flood Hazard Area and higher than the elevation of the 0.2-percent-annual-chance (or 500-year) flood.”

*Table 1 Flood Zone Definitions (via Flood Partners)*

## Pseudocode for Python code:

### Pseudocode for “Main”

```

Import the modules.
Set the environments.
Call the function to make the flood zone layer.
Call the function to clip the hospital layer by the county layer.
Call function to get user input for task wanted.
Call function to get user input for building type wanted.
Use if/elif/else to call the correct function to perform the task wanted.
    If the task is “intersect”
        # The following two lines should probably be in the intersect function
        #   but this is where I could get everything to work correctly.
        Ask if user wants to print out list of buildings in the intersect.
        Use if/else to assign the correct column name to use when printing.
        Call the intersect function.
    Elif if the task is “clip” call the clip function.
    Else if the task is “buffer” call the buffer function.
Call function to print list of shapefiles.

```

### Pseudocode for “Module”

```

Import modules.
Function to make flood zones layer.
    Construct a query to select flood zone attributes.
    Use the arcpy SelectLayerByAttribute function.
    Copy features to map using arcpy CopyFeatures function.
Function to clip the hospital layer by the county boundary.
    Define the local variables.
    Use the arcpy Clip function.
Function to ask user what task they want to do.
    Use a while loop with a nested if/else statement to make sure a valid
    choice of ‘clip’, ‘buffer’, or ‘intersect’ is input.
    Return the choice.
Function to ask user what building type they want to use.
    Use a while loop with a nested if/else statement to make sure a valid
    choice of ‘library’ or ‘hospital’ is input and assign correct value
    to a building variable.
    Return the choice.
Function to find intersect of building choice with flood zone layer.
    It has a building argument passed to it.
    Set variables.
    Use the arcpy intersect function and add to map as layer.
    Return the intersect layer name.
Function to clip building choice by flood zone layer.
    It has a building argument passed to it.
    Set the local variables.
    Use the arcpy clip function.
Function to buffer building choice by user’s distance choice.
    It gets the building argument passed to it.

```

Ask user for distance in miles and format to a usable buffer variable.

Use the arcpy buffer function.

Function to print list of buildings that might flood.

It takes the building layer name and correct column name as arguments.

Use the arcpy cursor method in a while loop to print out the names of the buildings in flood zones, and add "(might flood)" at end of name.

Delete the cursor.

Function to print list of shapefiles in folder.

Use the os.listdir function to print list of files.

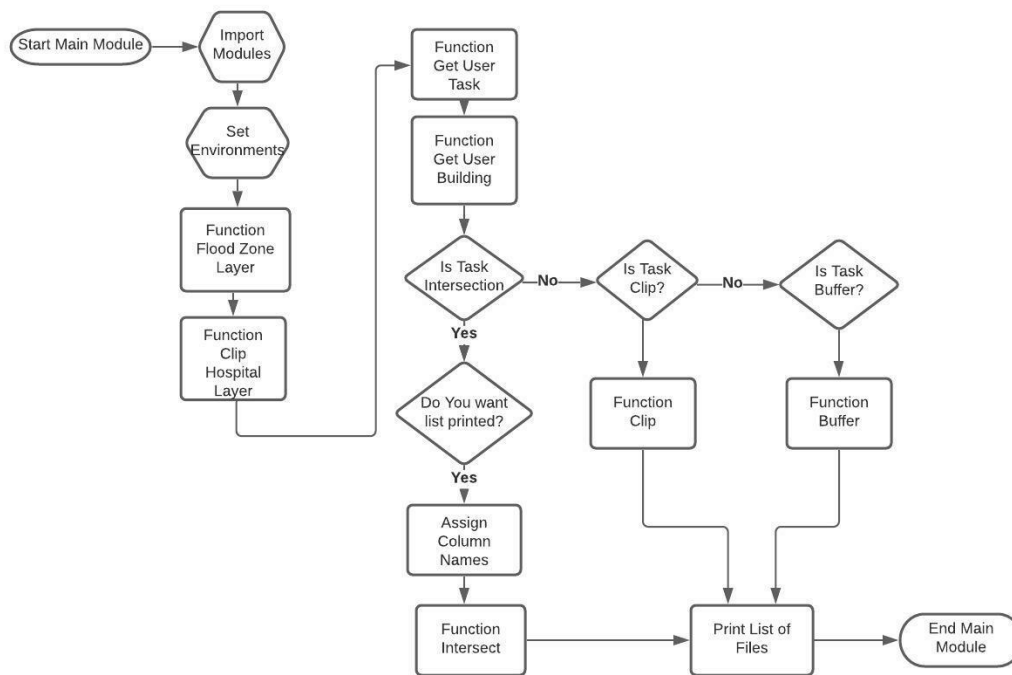
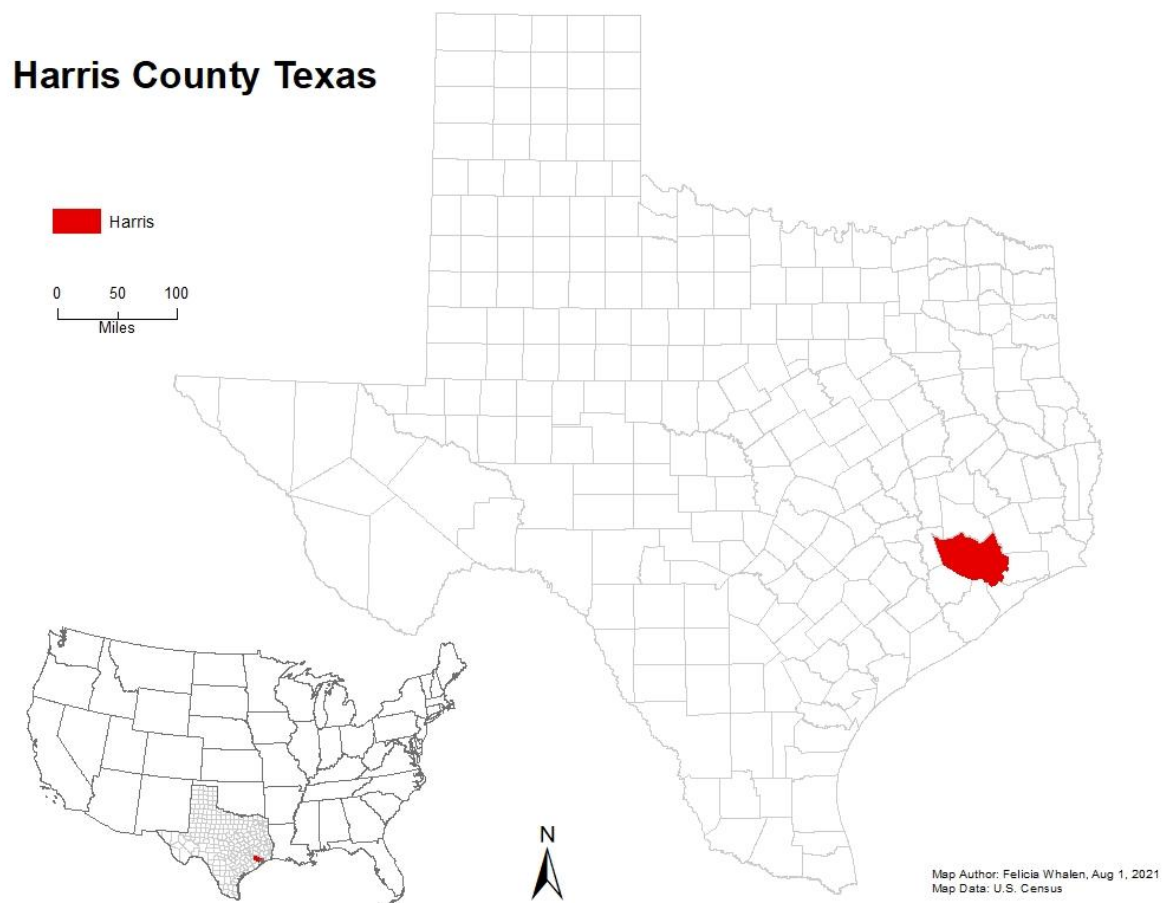


Figure 2 Flowchart of Main Module (Lucidchart, 2021)

## Results

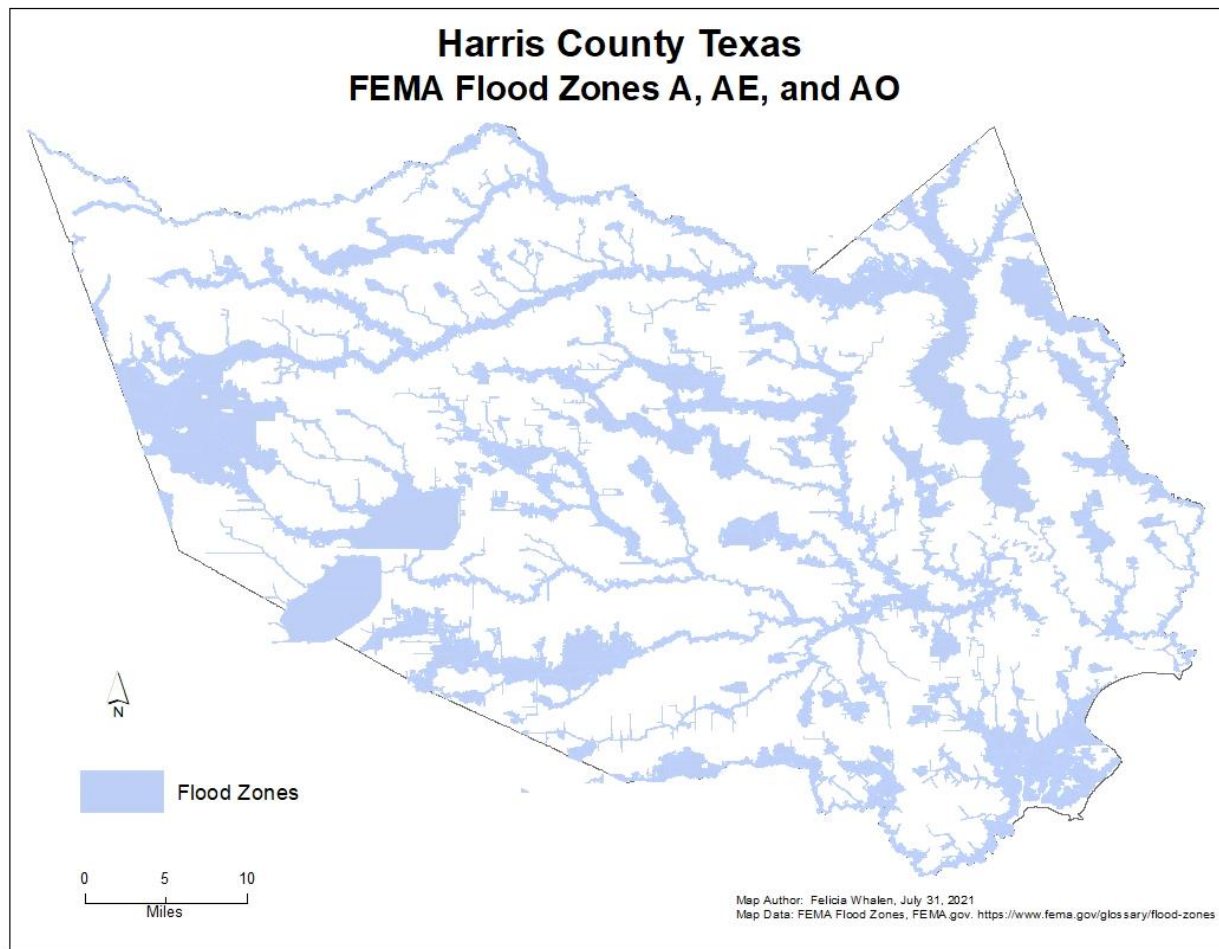
Harris County Texas is located in southeast Texas on the Gulf of Mexico coast.



*Figure 3 Location of Harris County Texas*



The following map shows just how much of the county is in a flood zone. The blue areas are FEMA flood zone designations A, AE, and AO, which are defined earlier in this paper.



*Figure 4 Flood zone areas in Harris County*

The areas talked about in the introduction that had the highest and lowest rainfall amounts during Hurricane Harvey are marked, along with the locations of the hospitals and libraries.

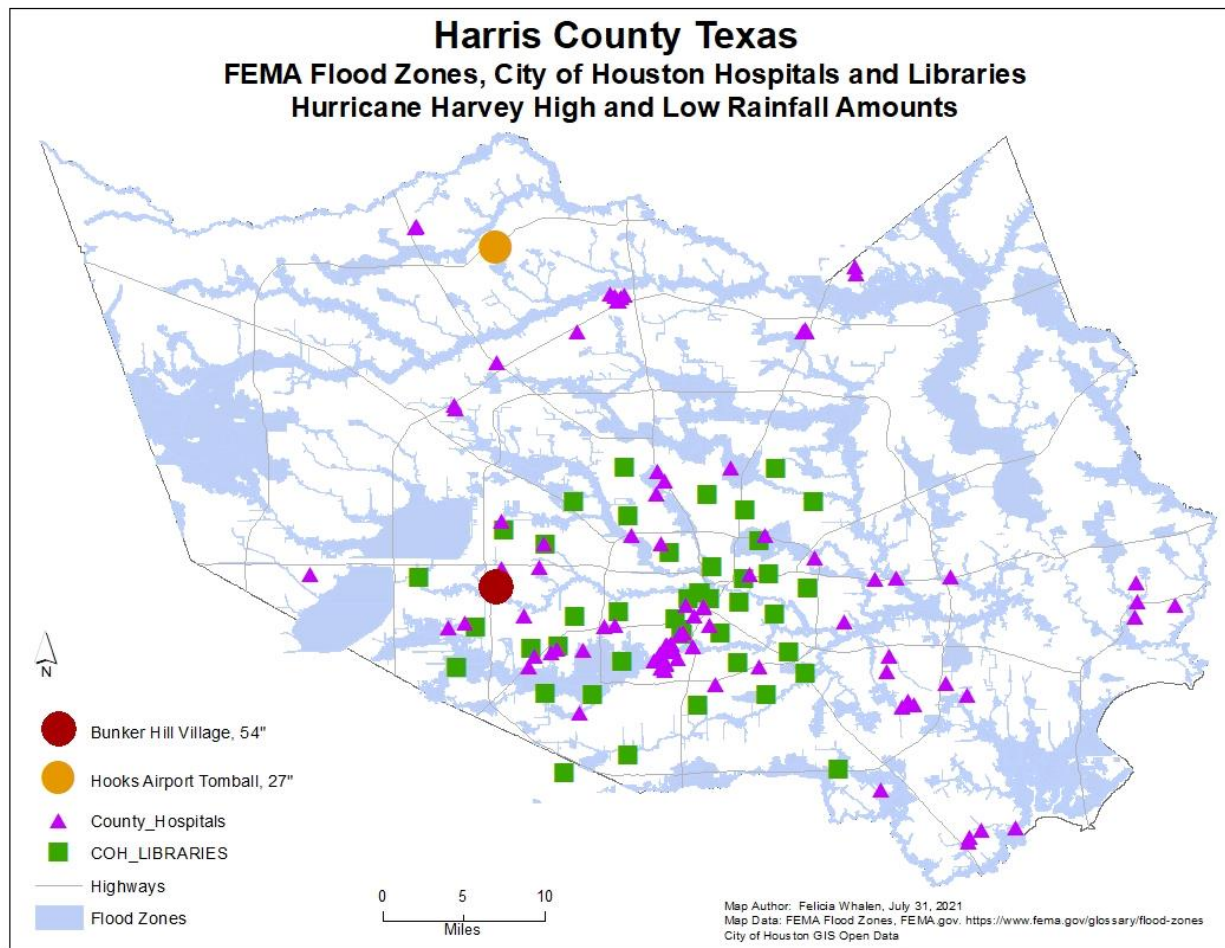


Figure 5 Hospitals, libraries, and Harvey High/Low locations.

The code can be used to find the intersections of either building layer and the flood zone layer.

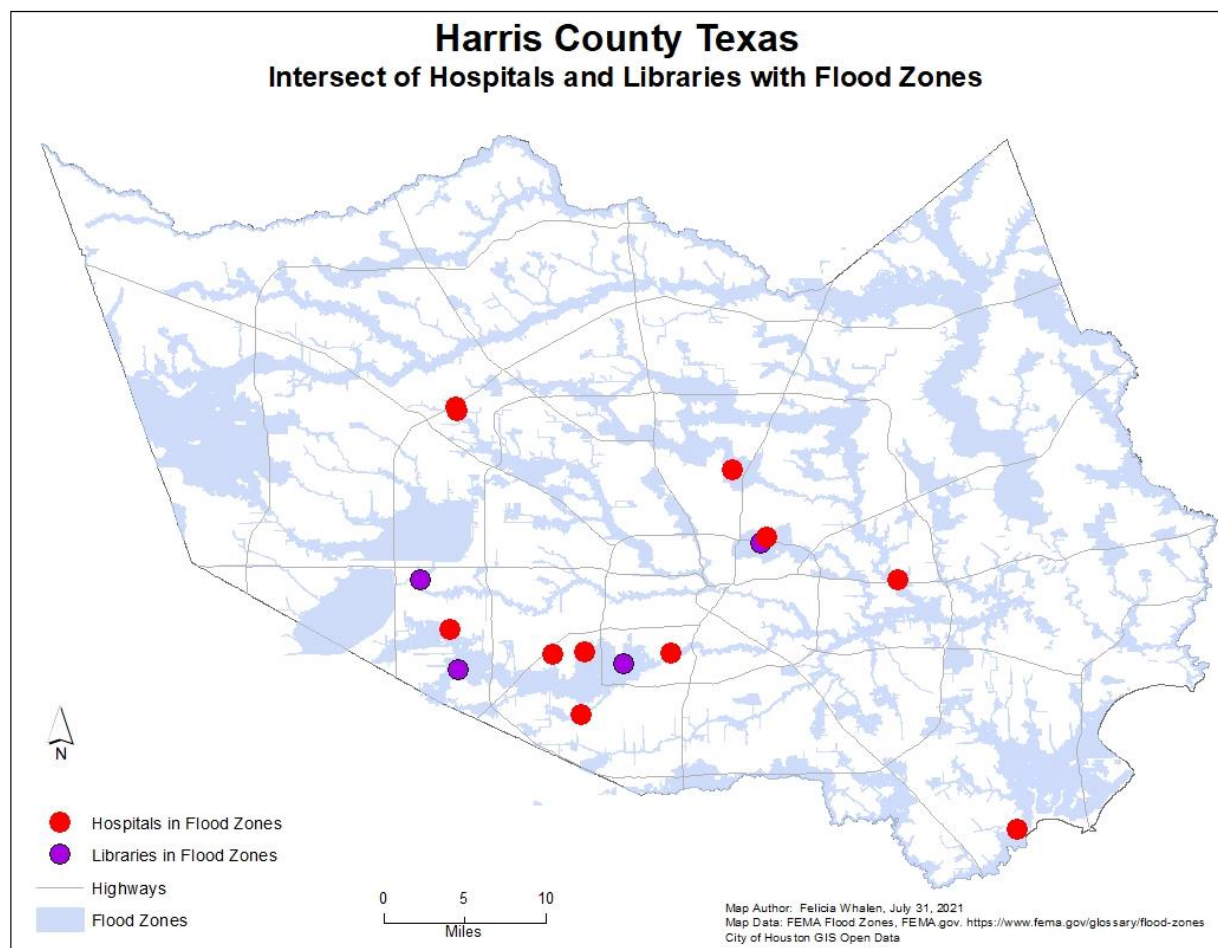
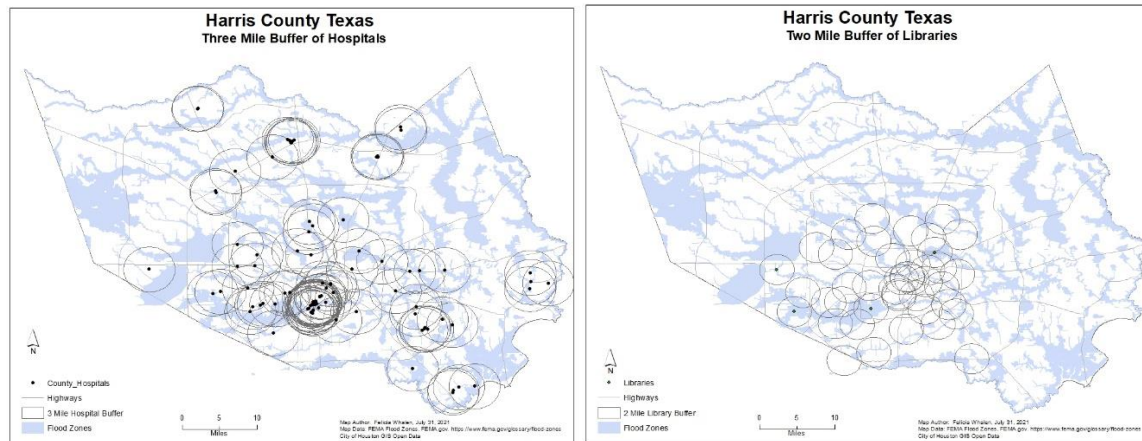


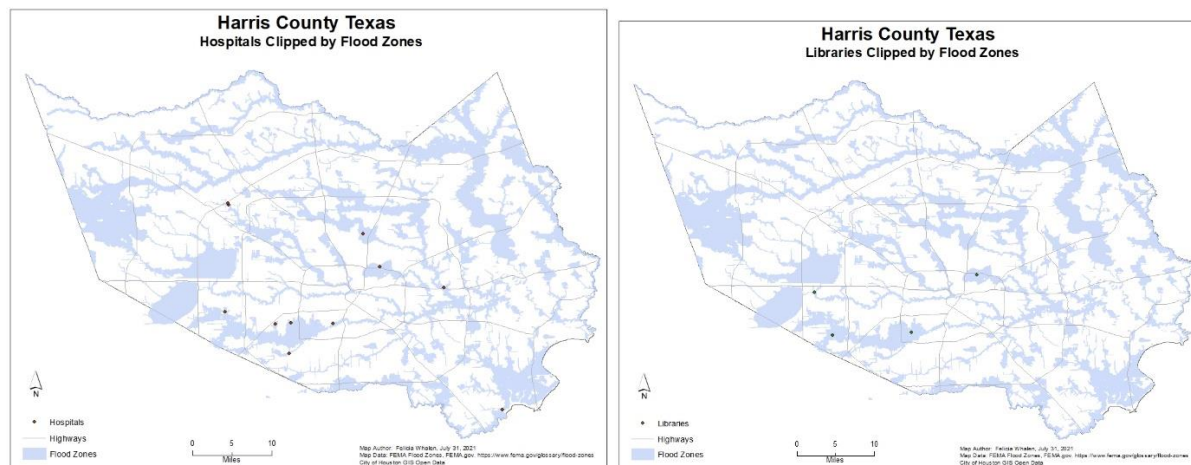
Figure 6 Intersect of Hospitals and Libraries with flood zone layer.

Users can request a buffer for their building choice, and input the number of miles they want the buffer to be. Here are examples of a three mile hospital buffer layer, and a two mile library buffer layer.



*Figures 7 & 8 Buffer examples.*

Users can also request a clip as shown below:



*Figures 9 & 10 Clip examples.*

Output from cursor method. If the user requests it, the program will print out a list of the buildings of their choice that intersect with the flood zone layer, and therefore might flood.

```
CHRISTUS ST. JOHN HOSPITAL (might flood)
SPECIALTY HOSPITAL OF HOUSTON (might flood)
SHARPSTOWN GENERAL HOSPITAL (might flood)
MD ANDERSON CANCER CENTER (might flood)
MEDICAL CENTER HOSPITAL - BELLAIRE (might flood)
HCA W. HOUSTON MEDICAL CENTER (might flood)
EAST HOUSTON REGIONAL MEDICAL CENTER (might flood)
LYNDON B. JOHNSON HOSPITAL (might flood)
HOUSTON COMMUNITY HOSPITAL - NORTHSIDE (might flood)
KINDRED HOSPITAL HOUSTON NORTHWEST (might flood)
CY-FAIR MEDICAL CENTER HOSPITAL (might flood)
```

*Figure 11 Hospital Cursor output.*

```
HENINGTON-ALIEF LIBRARY (might flood)
MCGOVERN - STELLA LINK LIBRARY (might flood)
KENDALL LIBRARY (might flood)
MC CRANE-KASHMERE GARDENS LIBRARY (might flood)
```

*Figure 12 Library Cursor output.*

## **Discussion and Conclusions**

This project was limited in scope for several reasons, including time constraints. It does a good job of illustrating the flooding problems and potential flooding problems in Harris County. As can be seen in the maps, areas that are FEMA designated flood zones cover a large part of the county. There are several hospitals and libraries that are in flood zones. It was not determined if these actually flood or not; they may be build up on stilts or have some other way of making



the lowest level of the building higher. The interactive nature of the project should make it interesting for users.

Unfortunately, many areas in the county that are not in designated flood zones, including my own property, have flooded in recent storms. This project could be expanded in the future to get an accurate map of areas that have flooded in recent flooding events, such as the Hurricane Harvey Flood Inundation Maps from USGS. (USGS, 2018). Recent elevation data along with land use data could also be used to try to determine where flood waters might go. More areas of interest could be used, such as more complete hospital and library lists, or schools, or individual property plots.

All citations created using Chegg website. (Chegg, 2020)

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