The Social and Scientific Misconception of Floodplains

An Integrated Look into the Re-evaluation of the “100-year” and “500-year” Flood Determinants

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Suggested Citation: Roberts, McKenzie, 2019. The Social and Scientific Misconception of Floodplains: An Integrated Look into the Re-evaluation of the “100-year” and “500-year” Flood Determinants. Southern Climate Impacts Planning Program, 31 pp. [Available online at http://www.southernclimate.org/documents/Floodplains_Misconceptions.pdf].

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An Integrated Look into the Re-evaluation of the "100-year" and "500-year" Flood Determinants

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July 2019

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Abstract

The "100-year" and "500-year" flooding events are an under researched facet of environmental and hydrological science, that are used to evaluate numerous factors on city, county and state levels including the creation and determination of floodplains. Houston, Texas, is a prime area that exhibits the impacts that that "100-year" and "500-year" floods can cause and therefore, was used to determine the social and scientific misconception with these recurrence intervals.

Analyzing both the risk perception via survey data and historical climate and meteorological data in the Houston area allowed creation of a new floodplain map to showcase more updated values and become more adaptable to changing ones. Survey data provided insights into how risk is perceived by Houstonians and spatially distributed. Implementing maps that are based on accurate information and data will provide better guidelines for risk assessment and decision making. This research and implementation can help mitigate and prevent further impacts caused by the misinterpretation and miscommunication of these "100-year" and "500-year" flood terms.

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Introduction

When it comes to natural disasters, one of the key components in mitigating detrimental impacts is communicating risks effectively to the public. Communities defer to their city, county and state officials to provide accurate, meaningful information that can help them evaluate the risk presented to them by several different natural disasters and environmental hazards. Wildfires, floods, earthquakes, and hurricanes, are just a few of the natural disasters that afflict the United States yearly. So, when these disasters occur, it is crucial for up to date, well-communicated, information to be provided to the public to help mitigate impacts.

This is true for Houston, Texas, a prime example of a coastal area that is consistently influenced by flooding events. Houston is a bustling, diverse community comprised of numerous different counties, that encompass an area of 669 square miles ("City of Houston", 2017). As of 2017, Houston had a population of around 2,312,717 people and was the fourth largest city in the United States ("City of Houston", 2017). Houston is a sprawling, economically rich place dealing with, agriculture, oil and gas, as well as numerous other jobs due to its location to the port and topological diversity. This makes it a prime area of relocation for people and businesses looking to harness these opportunities and therefore Houston is constantly growing in population.

However, being a "Houstonian", isn't just defined by the city's boundaries. Houston's influence extends far outside of its' physical city limits, to an entire metropolitan area aptly named "Greater-Houston". This wide spatial extent is a testament to the unique, intrinsic and extrinsic values with which people identify Houston. Houston and the Greater-Houston Metropolitan Statistical Area (MSA), are composed of eight different counties ("City of Houston", 2017). Harris County, the county in which Houston is primarily located, has a population just slightly over two times of Houston's at 4,989,618 people (United States Census Bureau, 2018). Though, not all of these occupants are located in the city of Houston, these communities still consider themselves very much a part of Houston's culture, riches and unfortunately, their environmental impacts, especially by means of flooding.

Flooding is the most commonly occurring natural disaster in the United States and it affects millions of people nationwide regardless of location (FEMA, 2004). Coastal communities, like Houston, are increasingly vulnerable to intensive mass, seasonal flooding events due to the proximity to the Gulf of Mexico. This proximity to the Gulf promotes thunderstorms and mesoscale convective systems (MCSs) due to enhanced convection and the delivery of moist air to the area during the spring and summer months (U.S. Geological Survey, n.d). The location near the Gulf, also puts Houston in a prime spot to experience tropical storms and hurricanes which intensely promotes widescale flooding. With the size and extent of Houston (this term now includes, the Greater-Houston area) and its being prone to flooding events, it is easy to see why effective flood mitigation, planning and communication is so important to this area.

One of the ways Houston tries to mitigate impacts due to floods is by the implementation of floodplain maps. In 1981, Houston joined the National Flood Insurance Program, or *NFIP,* and, in tandem with FEMA, began to create their floodplain maps. These floodplain maps were established using old, outdated rainfall data, that didn't provide an accurate depiction, even at that time, of actual floodplain areas (Houston Public Works, 2018). Though FEMA defines a floodplain as, "an area adjacent to a body of water", this doesn't even begin to articulate the actual magnitude of what a floodplain means to Houstonians (Houston Public Works, 2018). This is particularly true for the "100-year" and "500 year" terms since these are the basis for our guidelines.

These terms are laden with a large scientific and social misconception. In simple terms, the floodplains represent areas that would be affected during a "100-year" or "500-year" flooding event. The problem with these seemingly simple definitions is, defining and communicating what these events are. The "100-year" and "500-year" terms can be openly misinterpreted and often are. A "100-year flood", is assigned to a flood event that has a 1% statistical probability of occurrence in an area within a given year. Respectively, the "500-year flood" term is assigned to an event that has a .02% statistical probability within a given year of occurring in area or location (Crowell, et al., 2010).

The Social Misconception

The social portion of this large misconception primarily comes from the misinterpretation of these terms and the depth of their meaning. The "100-year" term is thought to mean: a flooding event of a certain magnitude only occurs once every 100 years. Similarly, the "500-year" term is thought to mean a flood, usually of greater magnitude, only occurring once every 500 years (U.S. Geological Survey, 2010). According to the Global Facility for Disaster Reduction and Recovery, the likelihood of experiencing a "100-year" flood event by age 40, is around 33% ("A "100-Year Flood" Doesn't Only Happen Once Every 100 Years", n.d). If someone expects to only experience this type of flood around once in their lifetime, it can be shocking when they experience it a multitude of times.

When the public believes this misinterpretation as truth, it can inhibit them to aptly assess and react to the risk presented to them. This is because the information they are given is applied incorrectly during these flood events and could cause them to under- or overreact in a given situation. An adverse reaction in either direction can also lead to greater impacts and mistrust of officials, media outlets and other outlets and platforms of information. How people perceive risk is based on several things such as, beliefs, past exposure to risk, judgement and attitudes (Wang, Wang, Huang, Kang & Han, 2018). Given that from 2015-2017, Houston has experienced three "500-year" flooding events, including Hurricane Harvey, their perception of risk may be significantly altered

(Global Facility for Disaster Reduction and Recovery, n.d.). However, if the actual definition of these terms were communicated effectively, the perception might become more accurate because it is based on the understanding of the actual events.

The Scientific Misconception

The scientific portion of the misconception comes from the assumption of understanding by the public in addition to the discrepancy and altering usage of different terms to define these flood events and their respective floodplains. When providing these terms to the public as an explanation of the need of flood insurance or even an evacuation, it is unfair to assume that the community understands the full extent of these phrases. The portion of city, county and state officials who deal with determining floodplains, only deal with the scientific aspect of the floodplain data, and seemingly spend little time focusing on how the information is received.

There is also disagreement in how these terms are communicated verbally. Hydrologists prefer using the phrase "recurrence interval" to describe the value of these events. A recurrence interval, sometimes referred to as a return period is, "…based on the probability that the given event will be equaled or exceeded in any given year" (Robinson, Hazell & Young, 1998). Even though recurrence interval may seem like a more general, broader term, it encompasses more information. It also leaves room for numerical variability which helps account for environmental and atmospheric changes in response to climate change (USGS Water Science School, n.d.). Hydrologists used recurrence intervals, coupled with annual exceedance probabilities or *AEP*s to showcase the different types of flooding events well as their likelihood of occurring in a given year. AEPs simply represent the probability or chance of recurrence within the time interval. (USGS Water Science School, n.d.). By using both of these terms in tandem, it can help people understand that the probability of a flooding event remains the same even if it has happened previously.

As one can see, there is a lot of ambiguity surrounding the true meaning of the "100-year" and "500-year" terms. These terms are muddled with inconsistencies and assumptions that make it hard for the Houston community to perceive and analyze risks associated with flooding events. It is also difficult for Houstonians to assess risks based on their proximity to a floodplain, when the floodplain information isn't updated using valid, available data. The motivation behind this research is witnessing the numerous detrimental impacts of flooding events that could have been abated if a new understanding of floods and floodplains were implemented.

The true definition of the "100-year" and "500-year" terms needs to be a multi-faceted one, that integrates both the social and scientific aspects. By bridging the gap between these misconceptions, communities will have less room for incorrect interpretations and error is risk assessment. A way for these terms to be redefined in both social and scientific terms, is through the implementation of a new, integrative floodplain map that uses new rainfall data, past flooding hazards, and the risk perception of people and officials, all to be cumulatively shown. This could help various Houston communities understand the risks associated with living in a vulnerable, evolving city. It would also help officials better plan and understand how the public views their risk and how the community should be approached the next time one of these flooding events occurs. Ultimately, this adjustment would serve to reorient how we look at floods and floodplains. By establishing a new system that promotes confidence in the information provided and can show how floodplains change, we can mitigate intrinsic and monetary damages that impact the Houston community.

Research Context

In order to understand the complexity of each aspect and how to explore each relation objectively, many different types of literature and reports had to be examined. These examined pieces of literature serve as the foundation of why and how we can bridge the gap between the scientific and social approach to floodplain management.

Initially, Repetitive Loss Properties, or *RLPs,* were analyzed in hopes of understanding why people keep rebuilding and purchasing homes that have been destroyed by intensive flooding events and hurricanes. However, King (2005) reported that a large share of RLPs are outside of designated floodplains and called into question the accuracy of floodplain maps. Floodplains can be affected by climatic variations and topographical changes which aren't readily shown in the maps (Larson & Plasencia, 2001). This helps explain why people aren't deterred from buying repetitive loss properties or properties within a floodplain. Due to the lack of knowledge regarding floodplains, people can't evaluate risk correctly. The rebuilding of these homes exhibits the lack of risk felt by people regarding flood hazards.

Pryce, Chen and Galster (2011), further explain that the rational way of thinking can be hindered by numerous factors. The rational mindset would be to move away from a problem area and relocate to one that had less risk. However, the perception and evaluation of risk isn't so simplistic and is based on someone's own interpretation of events. According to Main (2004), risk assessment consists of four fundamental phases: identifying hazards, assessing risk, reducing risk, and documenting results. Nonetheless, the evaluation of the severity of risk is associated with gender, age, socio-economic background and past exposure to events. Past exposure to risk is especially relatable, regarding how the Houston community evaluates risk. Considering Houston has had various flooding events, whether or not a person has been directly affected before can skew their perceived risk for an event and can render a false sense of security (Houston et al., 2017).

This hinderance of risk emphasizes the importance of having a visual tool, like a floodplain map to ensure that better, sound decisions can be made. However, as discussed in by Dransch, Rotzoll, & Poser (2010), risk communication via maps is increasingly difficult. The most useful maps for understanding risk are ones that are interactive and user friendly. Ensuring that the audience understands the context of the information being communicated is crucial to their attitude and trust towards further risk communication produced by officials (Dransch, Rotzoll, & Poser, 2010). Unfortunately, Harris County falls short in their visual production of an interactive flood map. It provides no explanation of what variables the map is showcasing and is a prime example of an ineffective map.

In order to understand a floodplain map, one must first understand the terms associated with the actual distribution of floodplain guidelines. Though they are given their definitions, a common misconception, as discussed before, is that these events occur at a magnitude that only happens once in 100- or 500-years (Costa, 1978). However, a more apt way to understand "100-year" floods (and respectively 500-year floods) is described by Highfield, Norman and Brody (2013) as, "An understudied, but central aspect in understanding flood impacts is the way we conceptualize, identify, and delineate risk. The 100-year floodplain is the longstanding metric in the United States for determining and acting upon the possibility of an area being inundated". However, even this definition falls short of truly describing how these terms are evaluated and produced.

This misconception led to further analyzing how these recurrence intervals are evaluated and transposed onto floodplain maps. According to Criss and Winston (2008), initially the recurrence intervals were calculated and implemented by FEMA and NFIP to set insurance requirements and rates and were not used for flood mitigation purposes. The meaning of these terms, have expanded in their use for flood mitigation and now can be and are used to determine the risk of experiencing an exceedance event with both stationary and nonstationary parameters (Read & Vogel, 2015).

Though, when it comes to analyzing rainfall events that produce these recurrence events, a static approach is not an appropriate one. Considering climatic and meteorological variability, intensity and frequency of rainfall events can change and result in differing magnitudes of flooding (Kwon, Brown & Lall, 2008). Due to the warming of the climate, this climatic and meteorological variability has been shown in increasing rainfall intensity across the United states, especially in coastal areas (Meehl, Arblaster, & Tebaldi, 2005). More specifically, the Houston area receives around 50 inches of rainfall annually, with a regional increase of 10-15% in annual rainfall in comparison to 1901-1960 baseline estimates (Smith, 2015). With these increasing rainfall intensities, floodplain maps should be redrawn and distributed in accordance with the new, available data (Jones, Haluska, Williamson, & Erwin, 1998).

For the qualitative part of this research, different methods and approaches that were used to analyze risk perception by communities were examined in specific areas. A unique way to analyze people's understanding of floods, suggested by Pielke (1990) is by use of the Nine Fallacies of Floods. These nine fallacies are broken up in three sub-groups to help surmise the "systematic definition of the nation's flood problem" (Pielke, 1990). Brilly and Polic (2005) implemented their own form of flood fallacy evaluation in the form of surveying people about their perception of flood risks. The survey showed that participants' risks were largely based on their location and vulnerability which further supports how communities and people asses their risk.

Flood mitigation was the overarching term that was associated with the multiple aspects discussed. Effective flood mitigation is shown through risk communication (Bubeck, Botzen, & Aerts, 2012) and usage of data correctly communicated by floodplain maps (Meyer et al., 2012). Flood mitigation, by implementing a system that relays risk to the public without causing confusion or panic, is one that is necessary in a place like Houston (Terpstra, 2011). Displaying data well, is just as an important as having accurate data. Mitigation cannot occur without the intervening of the public. So, educating the public and communicating to the public, should be prioritized in order for flood mitigation to be effective and impactful (Dufty, 2008).

Data and Methods

The project sought to do an integrative analysis that allowed for both the scientific and social aspects of floods and floodplains to be showcased and combined to produce a multifaceted assessment. Because of this, a three-method approach consisting of historical weather and climate data, a survey given to the public, and a new flood map which would show the redistribution or extension of different floodplains, was used.

Historical Weather and Climate Data

In order to show that floods in the Houston area were reoccurring in larger magnitudes, it was necessary to show that changes in topography and urban development weren't the only factors promoting large, intensive flooding. To do this, daily rainfall totals were collected from WBAN and COOP stations in Harris County using SC ACIS (State Climatologists Applied Climate Information System). Next, the values were averaged to produce yearly averages from 1950-2018. Lastly, a graph shown in *Figure 1* and the yearly averages produced were used to identify if there is a trend in increasing rainfall intensity or not.

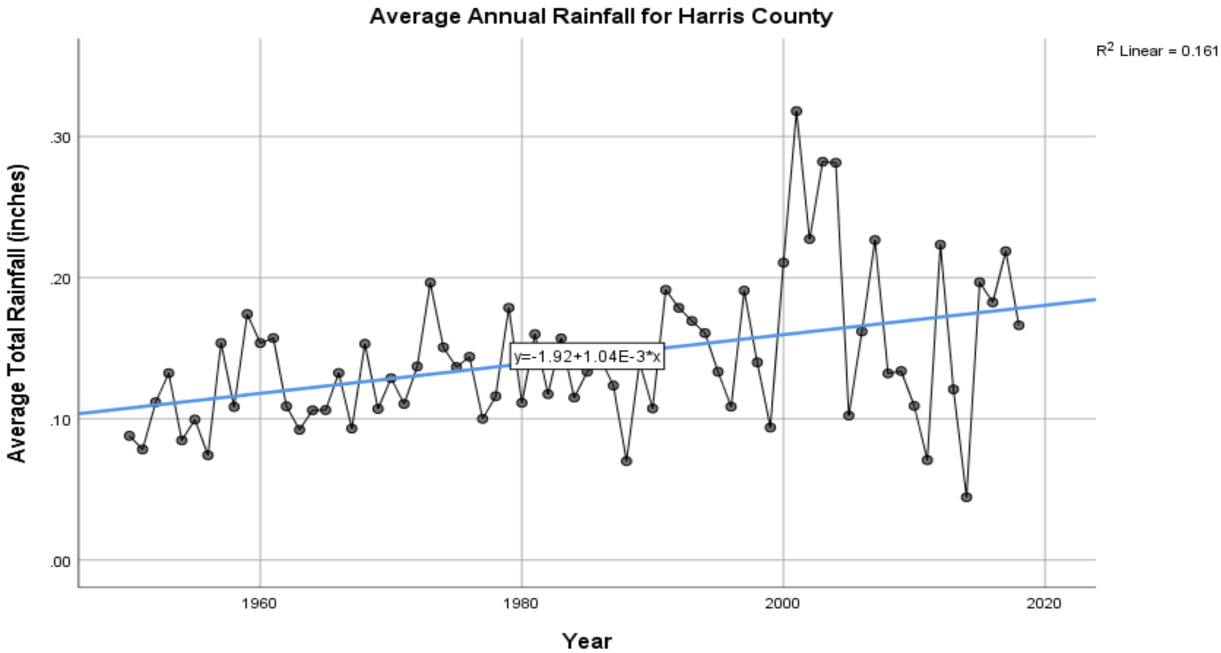

Figure 1. Average annual rainfall for Harris County based on available weather stations from SC-ACIS. Dots show annual value blue line shows best-fit trend line.

The trendline in *Figure 1* was found highly unlikely to be random with a p value = .001 (*Table 1*). This shows that it is highly likely that rainfall intensity is increasing in the Houston area and that it is a primary contributor to the magnitude of these flooding events.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.030	1	.030	12.845	.001[b]
	Residual	.154	67	.002		
	Total	.184	68			

a. Dependent Variable: AnnualAvgRainfall

b. Predictors: (Constant), Year

Table 1. Significance test for increasing average annual rainfall for Harris County.

Survey

To understand the social aspect of the interpretation of floods and floodplains, a 15-question survey was distributed to the Houston and Greater-Houston community. This survey was used to interpret a participant's knowledge regarding floods, floodplains, and related topics like flood insurance. A sample size of 331 respondents was obtained. Answers were analyzed using SPSS to get a better understanding of how the Houston community perceives flood and floodplain information. Survey questions also examined if there were any underlying causes or other misconceptions that could inhibit the accurate assessment of risk.

A key portion of the survey was aimed at comparing expected rainfall values over a 24-hour period for different recurrence intervals. These values were compared between three groups to analyze their difference or similarities. The first group values are based on Harris County calculated expected rainfall values using the IDF (Intensity-Duration-Frequency) equation shown in *Figure 2.* The IDF values are calculated using Harris County specific parameters and are the basis for the current floodplain distribution (Texas Department of Transportation, n.d.).

$$I = \frac{b}{(t_c + d)^e}$$

Equation 4-21.

Where:

I = design rainfall intensity (in./hr.)

tc = time of concentration (min) as discussed in Section 11

e, b, d = coefficients for specific frequencies listed by county

Figure 2. Intensity-Duration-Frequency equation used by Harris County to calculate recurrence values for rainfall. (Texas Department of Transportation, n.d.)

The second group of values were produced by NOAA, in the recent update of Texas rainfall values published in NOAA Atlas 14. These values are precipitation frequency estimates with 90% confidence based on partial duration series for precipitation depth (NOAA, 2018). The last group of values are based on the average survey response regarding the amount of rain someone thinks it takes to cause a flood.

Integrative Map

Using ArcMap, the current Flood Insurance Rate Map or *FIRM* shapefile provided by FEMA for the Harris County area was used and applied over a topographical map of the Houston and Greater Houston area. Then, through ArcScene, Base Flood Elevation values were adjusted, which ensured that both the topographical map and the FIRM map accounted for the same depths and elevations. Then, the FEMA Modeled Hurricane Harvey Damage Assessments datafile was used to try to get a spatial understanding of the widespread flooding and damages that occurred (FEMA, 2017). This information was used because it is a well-documented "500-year" flooding event that occurred in Houston. Based on the "Major" and "Destroyed" values, flood contours were created that helped to redistribute and redraw a "500-year" floodplain.

Analysis

The analysis consists of two parts: comparison of perceptions from the survey results and differences in flood maps. Most of the results were related to the survey because it provided the most data to compute using different variables.

Survey Results

Table 2 shows respondent choices on definitions for 100-year and 500-year floods. This question was designed to assess whether people understood that such floods can occur at any time versus whether they believed that after experiencing a flood, it was unlikely to occur again for 100 or 500 years. The results indicated that between 16% and 17% of Houstonians don't understand the correct way to define these flood recurrence intervals. This amounts to roughly 390,849 people being adversely impacted because of the misinterpretation of these phrases.

The result that relatively few people chose an incorrect definition of 100-year and 500-year flooding was surprising. This could possibly be explained by the number of respondents with bachelor's degrees or above which would provide the assumption that perhaps the respondents were a little more knowledgeable than your average citizen. Another way this could possibly explained, is that the question offered a binary choice, so there was a 50% chance for a respondent to get this question correct if they were just guessing.

A "100-year flood" is:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A flooding event that occurs every 100 years	56	16.9	16.9	16.9
	A flooding event that has a 1% chance of occuring in a given year	275	83.1	83.1	100.0
	Total	331	100.0	100.0	

A "500-year flood" is:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A flooding event that occurs every 500 years	54	16.3	16.3	16.3
	A flooding event that has a 0.2% chance of occuring in a given year	277	83.7	83.7	100.0
	Total	331	100.0	100.0	

Table 2. The percentage of respondents who correctly identified definitions of 100-year floods (top) and 500-year floods (bottom).

The next set of questions focused upon differences in flood risk perception among age groups and gender. Survey results showed that those 40 years of age or over exhibited greater confidence in awareness and knowledge compared to younger respondents (*Figure 3, Table 3*).

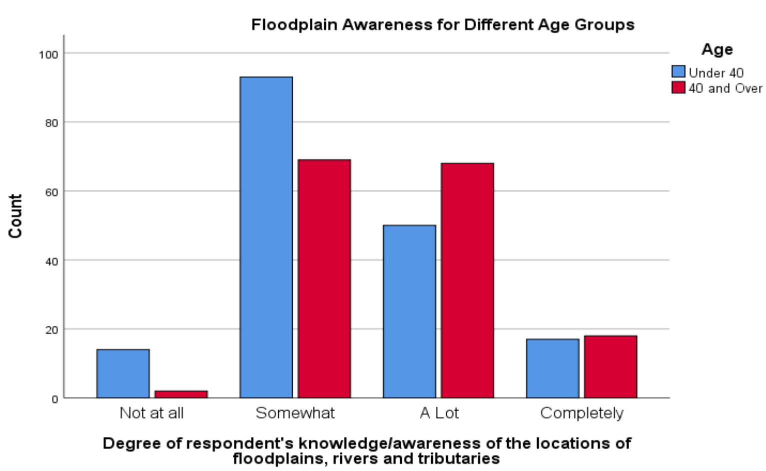

Figure 3. Number of respondents who indicated awareness of floodplain locations based upon age. Those 40 and over (red) were more likely to choose "completely" or "a lot" compared to those under 40 (blue).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.495[a]	3	.002
Likelihood Ratio	15.604	3	.001
Linear-by-Linear Association	9.028	1	.003
N of Valid Cases	331		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.59.

Table 3. Chi-Square Tests show that differences in perception among age groups is statistically significant.

Similarly, survey results showed significant differences in knowledge and awareness of flood plains by gender. Men expressed greater confidence than women in being able to identify flood plains (*Figure 4, Table 4*). Women also felt more at risk from flooding as compared to men (*Figure 5, Table 5).*

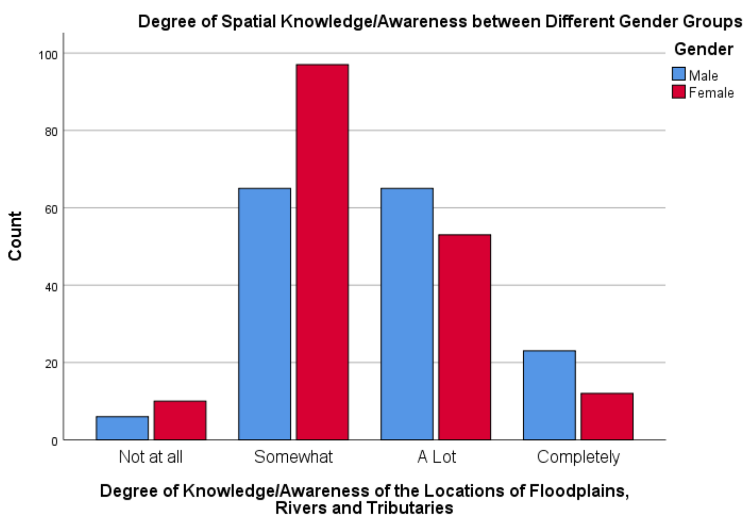

Figure 4. Number of respondents who indicated awareness of floodplain locations based upon gender. Men (blue) were more likely to choose "completely" or "a lot" compared to women (red).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.506[a]	3	.009
Likelihood Ratio	11.602	3	.009
Linear-by-Linear Association	10.833	1	.001
N of Valid Cases	331		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.69.

Table 4. Chi-Square Tests show that differences in perceived knowledge of likely flood locations among gender is statistically significant.

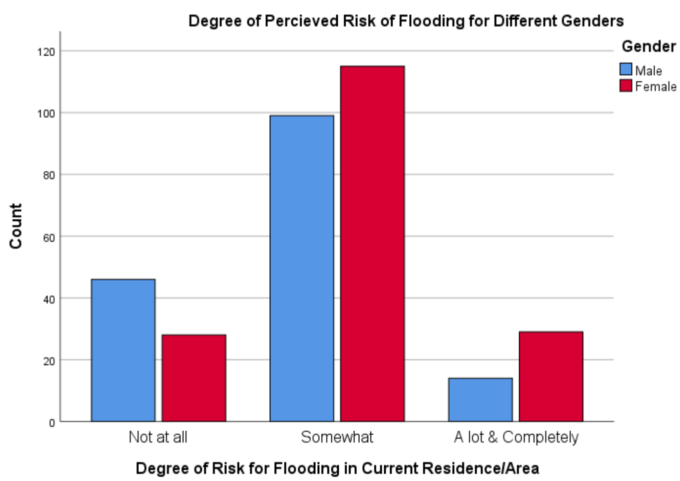

Figure 5. Number of respondents who indicated agreement with the statement "To what degree do you feel at risk for flooding in your current residence / area?". Women (red) were more likely to choose "a lot" or "completely) than men (blue).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.313[a]	2	.006
Likelihood Ratio	10.453	2	.005
Linear-by-Linear Association	10.247	1	.001
N of Valid Cases	331		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 20.66.

Table 5. Chi-Square Tests show that differences in perceived risk among gender is statistically significant.

Rainfall Perceptions

The other portion of the survey related to estimates of amount of rainfall needed to cause flooding. This portion of the analysis compares estimates of 25-, 50-, and 100-year rainfall amounts sufficient to cause flooding between survey respondents, NOAA Atlas 14, and Harris County IDF estimates.

On the survey, respondents were asked "How many inches of rain do you think it takes to flood your area?" The survey did not make a distinction between return frequency, as there were no objective measures of minor, major, or extreme flooding. The mean amount of rainfall estimated by respondents was 18.05 inches.

Comparing this to NOAA Atlas 14 values, the 25-year return-period amount is 11.60 inches, the 50-year amount is 14.20 inches, and the 100-year amount is 17.10 inches (*Figures 6,7 and 8*). Thus, a rainfall on the order of 12 inches should be sufficient to cause at least minor flooding, but citizens perceived amounts such as those to be more routine and did not become concerned until rainfall approached 100-year return period totals.

From the perspective of survey respondents, it could mean that Houstonians perceptions of flood, or how many inches it takes to make a flood within a recurrence interval, is being affected by the flooding they have experienced in recent years. The 18.05-inch average value can be interpreted as indicative of experiencing mass flooding events in their lifetime. This result helps promote the idea of the integration of the Houston community's perception of risk based on past exposure and the new rainfall data values since they seem to coincide so well.

Another interesting finding was the consistent differences between Harris County IDF values and NOAA Atlas 14 values. In all cases, officials using Harris County IDF guidance would become concerned at recurrence intervals more frequent than indicated by the NOAA Atlas 14 analysis. If flood management operations are linked to the Harris County IDF values, it could be that response actions are taken more frequently than necessary. It also may be that NOAA Atlas 14 has been updated more recently than Harris County IDF values, reflecting more recent events that are not accounted for in the Harris County method.

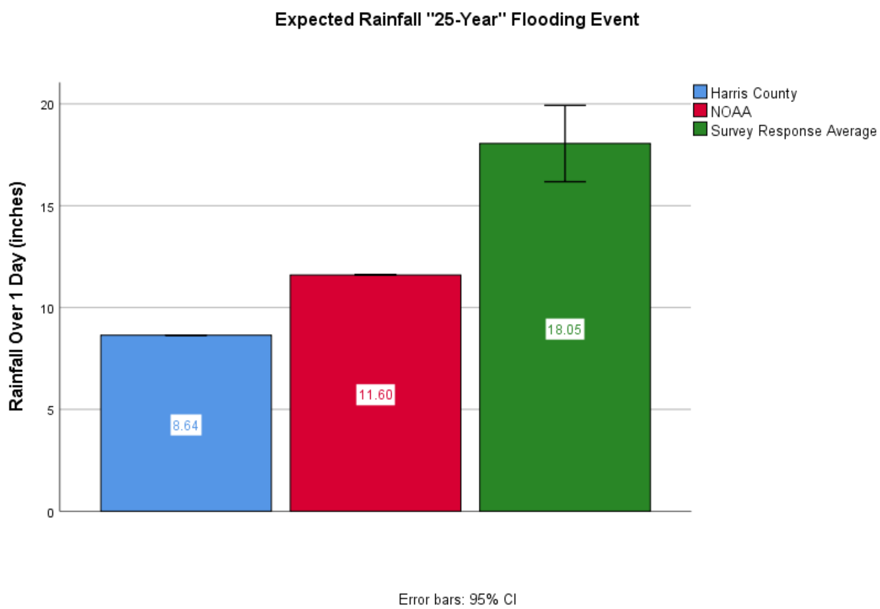

Figure 6. Estimates of rainfall for 25-year return period for Harris County IDF (blue) and NOAA Atlas 14 (red). Survey average amount of rainfall necessary to cause flooding is shown in green. Values are statistically different from each other (sample t-test).

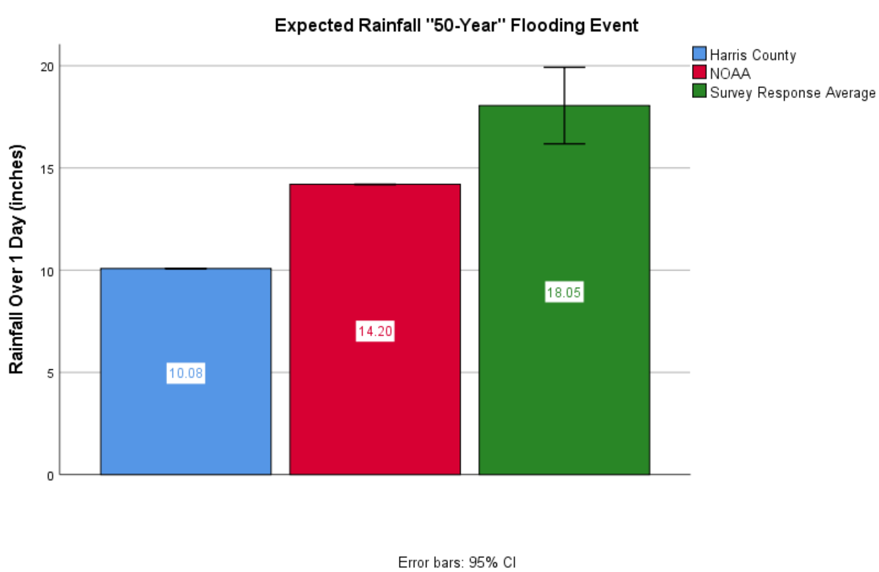

Figure 7. Estimates of rainfall for 50-year return period for Harris County IDF (blue) and NOAA Atlas 14 (red). Survey average amount of rainfall necessary to cause flooding is shown in green. Values are statistically different from each other (sample t-test).

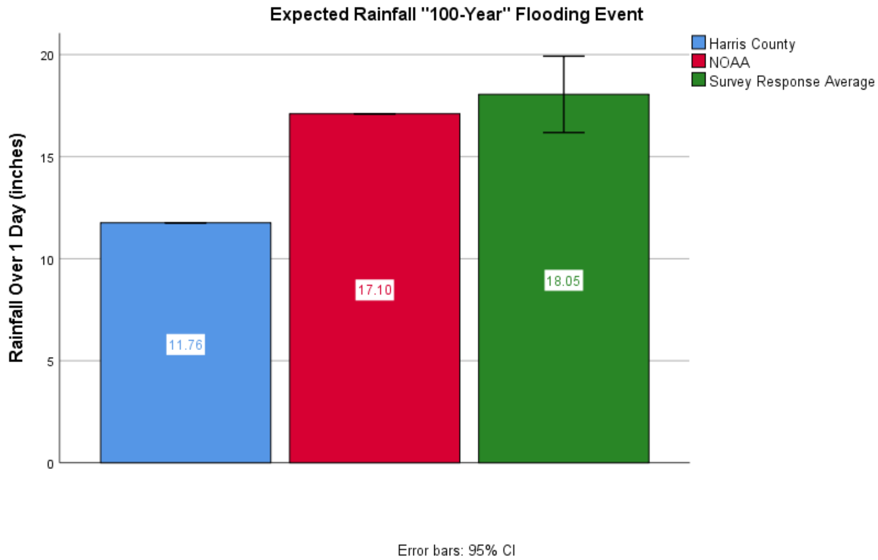

Figure 8. Estimates of rainfall for 100-year return period for Harris County IDF (blue) and NOAA Atlas 14 (red). Survey average amount of rainfall necessary to cause flooding is shown in green. Harris County IDF and NOAA Atlas 14 values are statistically different from each other (sample t-test), however values for NOAA Atlas 14 and Survey Response Average are not statistically different from each other.

Flood Maps

When regarding creating a computational, cumulative analysis on the "500-year" flood events, it was difficult because there is very little information that is documented. Most of the information that is documented about these events come from tropical storm and hurricane data. This may under-estimate the impacts from non-tropical events, which have also caused major flooding in Houston in recent years. Therefore, all data are treated and identified equally regardless of source of actual rainfall.

The analysis began with FEMA's FIRM shapefile, showing the distribution of 100-year and 500-year floodplains across Houston (*Figure 9*). This shows that despite relatively little variation in elevation across the city, there is a patchy area of floodplains, largely concentrated along bayous. Areas outside of these designated floodplains were heavily impacted by Hurricane Harvey, along with other events; therefore it is necessary to identify areas that may be susceptible but are not designated floodplains.

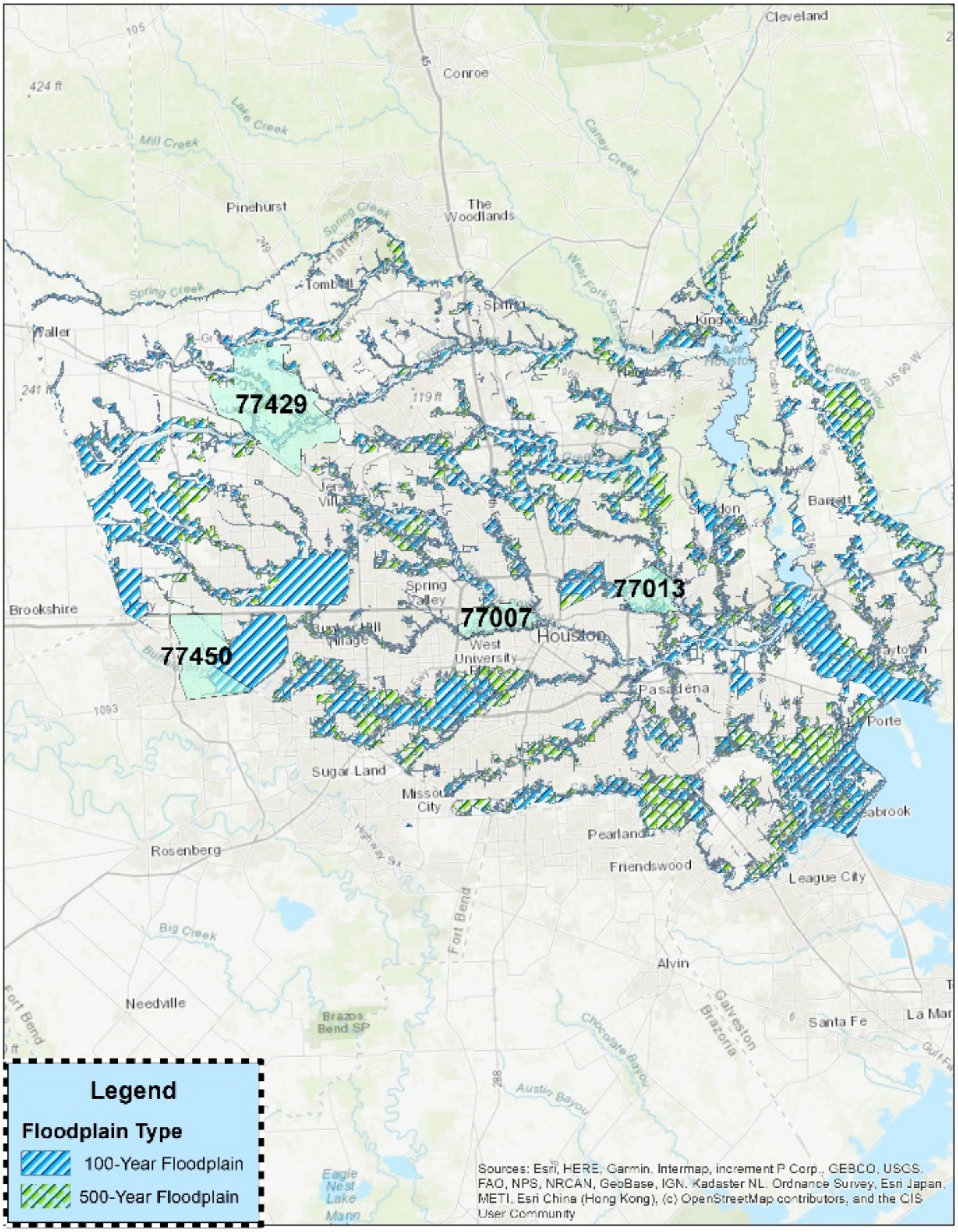

Figure 9. The initial map of Harris County using only the FIRM shapefile provided by FEMA.

Zooming in on one of these areas, the 77429 zip code (*Figure 10*) shows one portion of the area within the designated 100-year floodplain, another within the 500-year floodplain, and a sparsely-developed as well as neighboring heavily-developed area outside of both floodplain designations. Despite these differences, a nearly identical proportion of properties received major damage or were destroyed, regardless of floodplain designation. Using the integrative map model that draws flood contours based upon actual damage, most of the zip code block would be within a floodplain designation (*Figure 11*).

Figure 10. A portion of the 77429 zip-code block that contains a "500-year" floodplain as well as data points showcasing different flood damage levels during the last "500-year" flooding event.

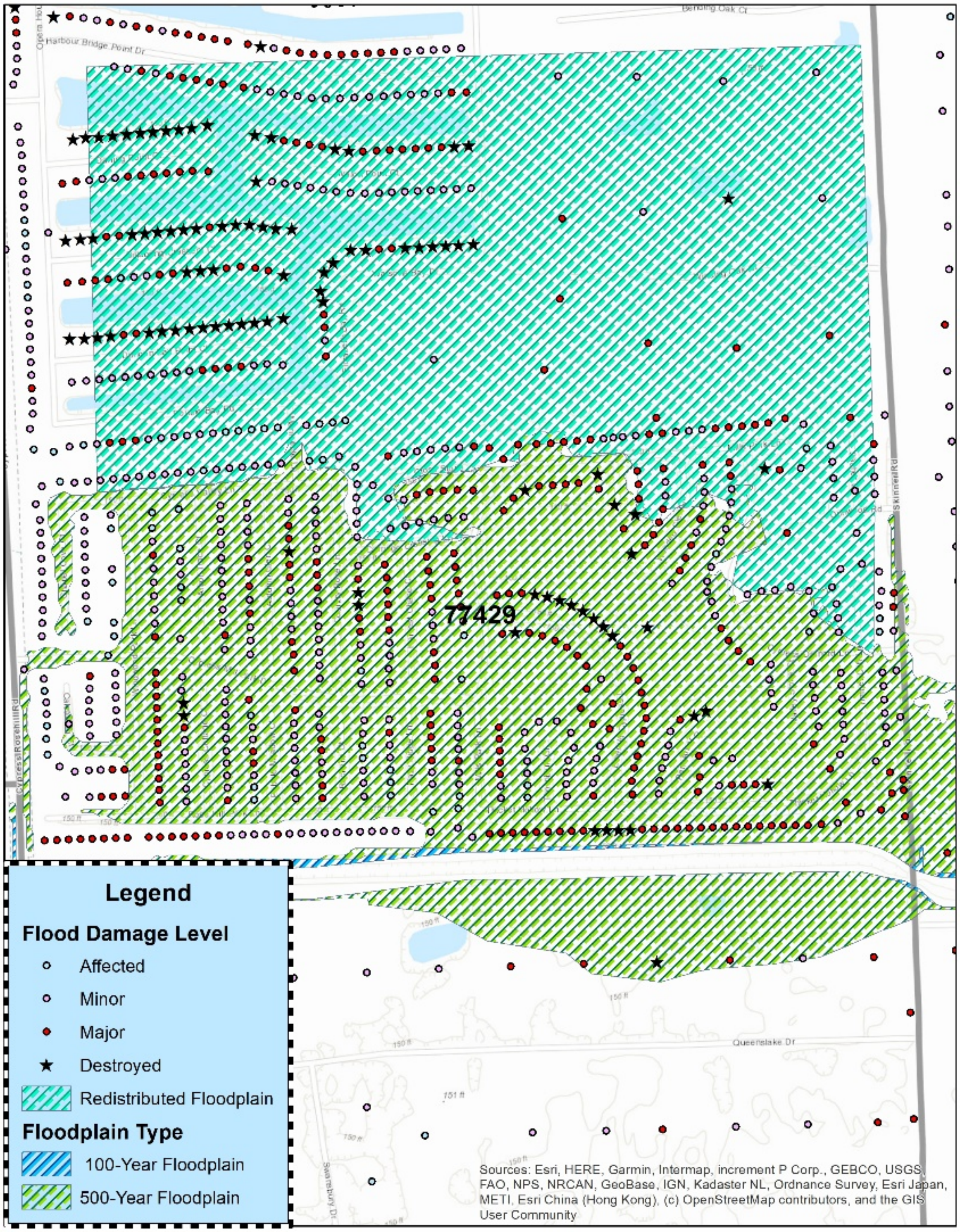

Figure 11. The Integrative Map model of the new redrawn and redistributed floodplain map based on the flood contours produced.

The main hope for the new floodplain map is that is can be implemented in a dynamic way. Because floodplains and risk are not static entities, they should not be treated as such. Actual flooding is dependent upon elevation, proximity to water bodies, land use characteristics, maintenance of channels, and other factors in addition to actual rainfall rates. Therefore, we should endeavor to create new floodplain maps that serve to explain the possibility of a floodplain's evolution and expansion due to rainfall events.

Conclusion

The issue with the "100-year" and "500-year" terms, is that there is no way for them to be simplistically defined yet, we still try to explain them as phrases that have very little impact or variability. When in all actuality, these terms can be adapted and applied to a changing environment and emphasize the severity of risk in an area. However, since in the Houston area, these terms are treated as uniform ones, they are incorrectly relayed to the public by way of floodplain mapping. Trying to identify these recurrence interval flooding events is very difficult because there are many types of floods, varying locations, and other location specific parameters that must be evaluated by city, county, and state officials.

Ultimately, there are these heady scientific and social implications associated with the correct understanding of the "100-year" and "500-year" terms. The treatment and communication of these terms as static entities can result in the misinterpretation and hinderance of risk assessment. Therefore, it should be accurately communicated to the public, based on past meteorological data and social perception, the actuality and vulnerability of these floodplain areas. If this is not done, Houston can expect to see more detrimental impacts caused by floods in the near future, however for now, we can promote a better understanding and analysis of these terms by the community. So, when the next flood occurs, the Houston community will be armed with the knowledge used to lessen these impacts.

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Appendix

Public Awareness of Floods & Floodplains in Harris County

Thank you for participating in this survey. This survey is being conducted to study people's awareness of floodplains for my undergraduate capstone research at the University of Oklahoma. All responses to this survey are anonymous and will only be used for educational purposes.

1. **How long have you resided at your current residence?**

   Less than 1 year   1-5 years   5-10 years   10-20 years   More than 30 years

2. **Do you currently live in a floodplain?**

   Yes   No   I Don't Know

3. **How many times has your residence flooded since you have lived there?** *Please respond with a single number (not a range).*

   Number of times: ____________

4. **A "100-year flood" is:** *Please check an answer box*

   - ☐ A flooding event that occurs every 100 years
   - ☐ A flooding event that has a 1% chance of occurring in a given year

5. **A "500-year flood" is:** *Please check an answer box*

   - ☐ A flooding event that occurs every 500 years
   - ☐ A flooding event that has a 0.02% chance of occurring in a given year

6. **To what degree do you feel at risk for flooding in your current residence/area?**

   N/A   Not at all   Somewhat   A lot   Completely

7. **Would you build or purchase a future home in a floodplain?**

   Yes   No   I Don't Know

8. **To what degree would you rate your knowledge/awareness of the locations of floodplains, rivers and tributaries in your area?**

   Not at all   Somewhat   A lot   Completely

9. **Do you think it is important to have flood insurance while living in Houston?**

   Not at all   Somewhat   A lot   Completely

10. **How many inches of rainfall do you think it takes to flood your area?**

Number in inches: _______________

11. **At what stage do you consider yourself or an area to be in a flood?** *Please check an answer box*

☐ When water starts to enter homes/buildings ☐ When the water level is rising on a street

☐ When you can no longer drive your car safely down a roadway ☐ I don't know

☐ Other: ____

____

12. **What is your age?**

Age: _____________

13. **What gender do you identify as?**

Male Female Other: __________________________

14. **What is your highest level of education?**

Have not completed high school High school degree or equivalent Some College

Associate degree Bachelor degree Graduate degree

15. **What is your zip code?** *This will be used to identify if your area is in or near a floodplain*

Zip Code: ________________

Acknowledgments

I would like to extend a special thanks to Dr. Randy Peppler and Dr. Mark Shafer for their time, contributions and guidance throughout this research process.

This work was conducted as part of a Capstone project in the University of Oklahoma Department of Geography and Environmental Sustainability, under the direction of Dr. Thomas Neeson.

This publication is funded by the Southern Climate Impacts Planning Program (SCIPP) as authorized by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration Co-operative Agreement, NA18OAR4310337.

Copies have not been printed but are available through the SCIPP website.