Examining Residents' Vulnerability from the Flood Hazard in the Onion Creek Neighborhood of Austin, Texas: Who is At-Risk and Why?

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DEDICATION

To my family and friends who stood by me, encouraged me and pushed me through all my challenges. I am grateful.

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ABSTRACT

Onion Creek is a neighborhood south of downtown Austin that falls within the base floodplains where Base elevations are provided. As a result, it is a high-intensity flood zone. Demographically speaking, the region is occupied by residents of which the majority live above the poverty line and have an average Household Income of over $90,000. The aim of this study is to i) identify and map out relatively low to high flood risk areas of the neighborhood and, ii) understand the social, economic, political and/or cultural factors that influence the residents' decisions to stay in the neighborhood. Flood vulnerability levels will be analyzed and mapped based on the analysis of a Digital Elevation Model (DEM) data and Stream data of the study area. A survey was distributed to residents, analysis were conducted to understand their general background, awareness levels, flood mitigation efforts in the area, and experiences/reflection about flooding. Results from the study show that the residents' decision to continue residing within the area is based off the knowledge their homes are not located within the floodplain, and a sense of familiarity and community that they feel within the neighborhood.

INTRODUCTION

In the 20th century, extreme flood events were the number one natural disaster in the United States in terms of both property damage and loss of lives. Citizens of the U.S. have faced some significant flood disasters. The 1900 Galveston Hurricane produced by 16-foot storm surge that resulted in the deaths of more than 8000 people and over $602 million in damages. The Great Mississippi Flood of 1927 was the most destructive flood on record with 246 deaths and losses of $41.7 billion (Than, 2011). The 1928 South Florida Hurricane and Flood affected the Lake Okeechobee area resulting in 2,500-3,000 fatalities and $1.5 billion in damages. The Johnstown, Pennsylvania Flood of 1889 killed 2,209 people and cost $12.6 billion in damages. The statewide Ohio Regional Flood of 1913 killed 467 people with over $82 billion in damages, the Mississippi River Basin regional flood of 1993 led to the death of 48 people and resulted in $20 billion in damages (Perry, 2000). Hurricane Katrina in 2005 flooded southern Louisiana with 1,833 fatalities and damages over $103 billion (Harrington 2019).

Extreme flood events occur as a result of a combination of environmental factors such as stream and river basin topography and physiography, precipitation and weather patterns, soil moisture conditions, and impervious surfaces all of which determine collectively the magnitude and intensity of a flood event. Flooding impacts for human beings depend on vulnerability levels of the affected populace and degrees of exposure of human communities to floods, which vary across space and time and closely related to social, economic, demographic, ethnic/racial, institutional, and environmental conditions.

Central Texas has the highee potential for flooding than in any other region in the U.S. Between 2011 and 2020, statewide, central Texas experienced three 100-year floods (NCEI/NOAA, n.d.). The Austin metro area has experienced at least six major flood events

throughout the twentieth century, including the 1900 Austin Dam Break, the 1935 Upper Llano River flood event, the 1981 Memorial Day Flood, the 2013 Halloween Floods on Onion Creek, the Memorial Weekend Flood of 2015, and the Hill Country Flood of 2018. As the area becomes more urbanized, the threat of loss of life, property damage, and homes lost to flooding has increased substantially.

The City of Austin lies in the heart of Central Texas and is prone to inland floods characterized by excessive precipitation and high-water runoff volumes within the watershed of river or stream. The area's rocky, clay-rich soil and steep terrain makes it uniquely vulnerable to major flooding. In addition, the geographical location of Austin places the city at a meteorological disadvantage from flooding due to the major storms from west (from the Pacific Ocean) and southeast (from the Gulf of Mexico), and strong frontal boundaries coming in from the Great Plains. At times, such as with the "perfect storm" of 1998—known as, the Great Central Texas flood—more than 20 inches of rain fell too fast, for too long, leading to significant overburdening of streams and rivers (Earl, 2007). Furthermore, new meteorological data, known as Atlas 14 (NCEI/NOAA, n.d.), have now revealed that parts of Austin will experience, on average, three inches more rain in major storm events than the National Oceanic and Atmospheric Administration had calculated with old rainfall data back in 1961 (Brazziell, 2019).

Onion Creek neighbourhood (ONC) south of downtown Austin and is known to be prone to flooding. Much of the development that took place along the lower portion of ONC occurred before a full understanding of the floodplain was established and recent floodplain regulations were put in place. As such, many houses/buildings were located within this flood-prone zone that could lead to serious loss of lives and property in the event of a flood (Watershed Protection Department, 2018). In addition, the new data, mentioned above from Atlas 14 (NCEI/NOAA, n.d.), indicates that much of the Austin area, including many

homeowners in Onion Creek who now reside in a 500-year flood plain, are likely to face revisions of floodplain identification (definition) that locate them in a 100-year flood plain, suggesting that the homeowners are facing increased personal risk from flooding (Brazziell, 2019).

According to FEMA, flood damage is expected to be greater in areas where a base flood can occur. Typically, the base flood is the national standard used by the National Flood Insurance Program (NFIP) alongside all Federal Agencies, necessary for the purchase of flood insurance (and future development within an area). Based on FEMA's flood zone maps, OCN lies within a high-intensity flood zone (ZONE AE). AE Zones are the base floodplains where base elevations are provided (City of Austin, 2017). Within a span of five years, Onion Creek has experienced three significant historical flooding events which were floods in October 2013, May 2015 and October 2015, with most of the affected homes not having flood insurance.

At the national level, socio-economically disadvantaged people reside mostly in flood prone areas. Individuals that fall within this category make such choices for their residence because of the low property prices of homes within flood zones. Looking it at it from a local level, coastal flood zones are more occupied by higher income groups whereas inland flood zones are occupied by the poorer population, signifying a worrying situation where inland communities are less responsive to flood hazards as a result of their lower economic condition (Qiang, 2019). Some other studies on environmental justice have shown that households of lower socioeconomic status experience a higher impact from flooding than those from a higher socioeconomic status. According to Collins et. al (2018), environmental injustice in Miami emerged when socially privileged groups exposed themselves to residential flood risks in a bid to attain certain coastal amenities, whereas the more socially vulnerable groups were pushed to areas prone to inland flood risks and limited access to

protective resources. This could lead to questions such as why residents would intentionally buy homes along the coasts that are at high risk. The risks of living in such areas are compensated by institutionally established access to mitigation resources, which include flood insurance policies with premiums that are lower than the standard costs of flood risks. For instance, in metro Houston, many landscapes that stand a greater risk of flooding, lack water-based amenities for residents, thus causing such regions to be inhabited by more vulnerable groups of those in a lower socio-economic class. With the city of Austin being prone to inland flood, one would anticipate that the socially vulnerable population would reside in the higher risk flood areas of Austin, however, that is not the case with Onion Creek. There exists a wide body of knowledge aimed at tackling flood hazards as it relates to environmental justice issues across major cities in the United States. However, little to no academic research has been carried out to investigate the true extent of flooding and damages in the Onion Creek neighborhood of Austin. Also, a better understanding is needed on the conscious decisions taken by homeowners before and after purchasing a home in the neighborhood.

Demographically, Onion Creek is not a poor neighborhood. According to the U.S. Census Bureau (2011), the median income for households and families within the area is $80,000 and $97,000, respectively. However, about 1.0% of families and 1.2% of the population of Onion Creek live below the poverty line which brings into question the socio-demographic distribution of flood risk within the study area. This poses the question: ‘Why do these residents choose to stay in a flood prone area?’. This situation is unique and does not tally with research and results from previous environmental justice studies, thus creating inconsistency and knowledge gap with a need for a better understanding of the situation with Onion Creek. A few possible answers that come to mind range from relatively lower housing values, incentives being made available to residents of the region, and ties to the community

by virtue of their length of stay. It may also be the case, despite knowledge of the flood risk, that residents desired Onion Creek for its favorable location, amenities and ambiance of the area. We cannot know for sure until more in-depth research is conducted for Onion Creek. This study will seek to answer the research questions below:

1. Where are the high-risk areas for flooding in Onion Creek Neighborhood, Austin?
2. What social, economic, political, or cultural factors might explain why people live in these high-risk areas for flooding in Onion Creek Neighbourhood?

The purpose of this study is to better understand the physical areas of Onion Creek which are subject to high-risk flooding, and then to discover the factors or reasons why households reside in the flood prone region of Onion Creek. This research will also investigate the extent to which the City of Austin's flood mitigation programs have been communicated effectively to the residents of Onion Creek, especially those that live in high impact areas for flooding. The City of Austin has put up mitigation initiatives to tackle flooding events, but just how effective have their plans been? What alternatives might be explored to further curb the effects of flooding? With the results from this study, city planners of the City of Austin might have a better understanding of the efficiency of their mitigation initiatives, while creating room for the proposal of alternate plans to the urban and development planners and policymakers of the city of Austin, geared towards more intense flood mitigation actions.

The first question is answered based on GIS analysis of secondary data. Using DEM data, slope, flood water direction and water flow accumulation will be modelled, in conjunction with streams within the study area. Flood vulnerability/risk levels within the study area will be analyzed and mapped giving a visual representation of high-moderate-low risk parts to the impacts of flooding.

The second question is approached with the help of survey of homeowners of the Onion Creek Neighborhood. The vulnerability level maps serve as a guide towards narrowing down the target group for the survey. A survey instrument (questionnaire) asks respondents the following: a) their considerations made before purchase their home in Onion Creek—ranging from the cost of land and/or houses in the area, to the disclosure of flood insurance premiums to buyers on the part of real estate agents, b) the awareness of buyers to the potential natural hazards known to occur in the area, c) their perceptions of risk concerning extent of the damage that homeowners might have to bear in the event of a future flood, and d) their past experience with flooding: Did flood victims within the study area receive any form of assistance either from the public or individually? Questions on the survey instrument are also designed to find out what efforts has the City of Austin extended towards flood victims in the study area to mitigate the adverse effects of floods?

The city of Austin in the year 2014 set up a buyout program in Onion Creek, with the Watershed Protection Department, to re-acquire properties that fall within the 100-year floodplain and provide consistent relocation benefits to displaced owners. Therefore, the survey also asks homeowners how effective this buyout program has been thus far and if the residents truly benefitted from these programs in any way. Homeowners are asked for their opinions on how effective urban planning has been toward flood hazard management in the city. Some land management activities and urban development projects could be contributing to the neighborhood's disaster. Developmental extensions into floodplains in the United States fall within 1.5 to 2.5 percent annually (Lacewell and McNeely, 1976). According to Liao et al. (2019), flood prevention measures undertaken by cities do not necessarily eradicate the problems of floods, and flood adaptation measure should be the way forward instead with the re-construction/renovation of structures effective for a real flood regime. The

survey includes multiple choice questions, Likert scale questions, and open-end questions for participants to share their thoughts.

This study will delve into obtaining a better understanding of the factors that propel households to live within floodplains and how public/government support (or the lack thereof) has influenced their decisions.

Within subsequent segments of this research, a thorough dissection of previous research centered on flood exposure will be examined based on socio-economic and demographic determinants, flood insurance and property values, and floodplains, urban development and mitigation polices implemented.

LITERATURE REVIEW

This section begins with an overview of previous research on flooding and delves into socioeconomic and demographic factors that explain increases in levels of risk from flood occurrences, the influence of housing values, flood insurance and floodplain development.

2.1 SOCIOECONOMIC FACTORS AFFECTING FLOOD EXPOSURE

The degree or level of flood exposure experienced by communities may be partly founded on the basis social inequity as evidence of significant inequalities exist in patterns of flood risk exposure and its impact (Walker and Kate, 2011). The more vulnerable, less wealthy, minority groups tend to bear most of the losses; both of lives and property, in the event of a flood. Existing literature on the subject matter have tried to identify the major factors attributed to the unequal exposure of communities and people to floods, which include hazard risk perceptions and awareness levels in the decision-making process of moving into an area; the housing values and flood insurance rates (Paganini, 2019; Zhang et al., 2010). These factors can be attributed to demographic variables such as gender, race, age; and socio-economic variables such as income levels, education (Montgomery et al. 2015). Other factors influencing flood exposure include urban development and construction in an area, zoning policies and even flood mitigation procedures put in place.

2.2 DEMOGRAPHIC STATUS

Minority groups and races stand to be at greater risks of exposure to floods as necessary resources needed to aid flood prevention and mitigation are unavailable to those populations. Results from studies of a household survey in Harris County, Texas showed that minorities were the least informed group in the housing market and of the dangers of living in a flood prone area (Zhang, 2010). Examining the unequal exposure to flood after Hurricane Harvey in the Greater Houston Area, Collins et al. (2020) found that the areal extent of

flooding was disproportionately distributed with respect to race. Hispanic, Black and other minority households experienced extensive flooding than White households.

In a bid to examine the influence of hazard characteristics on the relationships between race, nativity, housing tenure and residential hazard exposure, analysis results showed that race/ethnicity minority variables proved to be very significant predictors of greater exposure to floods (Grineski et al.2017). Maantay et al.(2009) demonstrated the need to aggregate population data from U.S. Census tracts to obtain a more realistic population distribution for hazard and vulnerability mapping using New York City as a case study. The results showed that even though city-wide, minority populations do not disproportionately live within floodplains, they are however disproportionately undercounted by traditional methods of population estimation at nearly twice the rate at which it undercounts the white population.

Analysing the racial/ethnic composition of the population residing within both the coastal and inland flood risk zones in Miami, Montgomery (et al.2015) showed that neighborhoods with higher percentages of Non-Hispanic Blacks and Hispanics (making up the minority population) are exposed to inland flood risks in areas that lack water-related amenities, indicating that inequalities in exposure to coastal and inland flood risks are more a function of racial/ethnic minority than social vulnerability. Profiling the leading drivers of social vulnerability to floods, Rufat et. al. (2015) identified demographic characteristics as a leading empirical driver.

Utilizing a questionnaire survey to obtain data from 3 communities in Birmingham and one in Southeast London, Soetanto et. al. (2020) established a relationship between flood experience and the demographic factors of age, gender and ethnicity with results from the analysis showing that age, ethnicity and experience of flooding had a significant effect on the

perceptions of social responsibility towards building community resilience. Chakraborty et. al. (2014) analysed the racial/ethnic inequities in flood risk exposure in the Miami Metropolitan Statistical Area by integrating socio-demographic data with the floodplain maps. The results showed the significance of various socio-demographic flood risk predictors with the Non-Hispanic Black and Hispanic residents that were overrepresented in inland flood zones and underrepresented in the coastal flood zones.

Lindell et. al. (2008) put forth and tested a multi-stage model of household responses to floods in Harris County, Texas. The model proposed a basic casual chain of demographic variables covering hazard proximity, hazard experience, perceived personal risk and expectations of continued residence in the homes/hazard adjustments. Results from the study suggested that gender, age, income, hazard proximity risk information as well as ethnicity affect perceived personal risk.

Subsidized housing with greater flooding extent contained significantly higher percentages of extremely low-income female-headed households (Chakraboty, 2021). Attempting to decipher the differential capacities of social groups to access protective resources for reducing threats to loss while residing within flood-prone environments and flood hazards and water-based benefits, Collins et. al. (2018) implemented a conceptual model with an environmental justice perspective. Findings from Miami show that environmental injustice materialises as socially privileged groups expose themselves to residential flood risks in the search for coastal amenities while the socially vulnerable residents are pushed to areas with air pollution and in-flood risks within a constraint to protective resources. In Houston, the flood zones were disproportionately assigned to the socially vulnerable population.

In Austin, between the years 1990-2000, the number of low-income people living within the floodplains increased rapidly while that of high-income people living in the floodplains decreased sharply (Lee and Jung, 2014).

2.3 SOCIO-ECONOMIC STATUS

Collins et. al. (2020) used primary survey data obtained from 377 representative households to analyse spatial data on 2017 Hurricane Harvey induced flooding. It was shown that houses of lower socio-economic status experienced more flooding than households of higher socio-economic status, indicating a disproportionate distribution of the areal extent of flooding with respect to socio-economic status. Utilizing statistical analysis based on a county-based assessment of socio-economic inequalities of population exposure to flood in the United States, Qiang (2019) was able to reveal national trends and local deviations from trends of exposure. On a national scale, economically disadvantaged people were more likely to reside in flood zones than outside. At the local scale, economically disadvantaged people tended to reside in flood zones in inland areas.

According to Chakraborty et. al. (2014), a clear distinction was made between the different types of flood zones on the basis of probability of flooding and the location of the 100-year floodplain. From the study, it was discovered that coastal flood zones were characterized by significantly higher median income and housing values while the inland flood zones were characterized by much lower median income and housing values. Rufta et. al. (2015) identified socio-economic status as one of the leading factors of social vulnerability to damaging flood events after carrying out a meta-analysis on 67 flood disaster case studies between 1997 and 2013.

Assessing hazard vulnerability in spatial terms using both biophysical (natural and technological) and social indicators comprising of 8 socio-economic factors, Cutter et. al.

(2000) showed a high degree of spatial variability in overall hazard vulnerability in Georgetown County, South Carolina with results suggesting that a combination of medium levels of biophysical vulnerability merged with medium-to-high levels of social vulnerability increases the overall vulnerability of the study area.

2.4 FLOOD INSURANCE AND HOUSING VALUES

An effective compulsory flood insurance program will result in maximum net benefits to the nation by causing rational economic floodplain use (Lacewell and McNeely, 1976). Using a flood insurance case study in Canarsie, Brooklyn, Paganini (2019) showed how the National Flood Insurance Program (NFIP) stands to produce and amplify already existing racial inequalities in the housing market by governing through the mechanism of household finances. Evidence was provided to show that the NFIP plays a role in instigating environmental gentrification, where fostering resilience entails displacement and luxury development. According to Priest et. al. (2005), there are people who have been traditionally excluded from insurance as a result of price and people that live in high-risk areas that might be cost-prohibited through the introduction of risk-related premiums.

Increase in flood risk leads to a statistically significant decrease in housing values for residential properties within the 100-year floodplain (Bartosova et. al. 2000) and a statistically positive influence within the 500-year floodplain (Shultz and Pat, 2001). Property values in the average floodplain are sold for 4.2% less than similar non-floodplain homes (Troy and Jeff, 2004). Observing existential sales records from September 2000 to 2004 from Carteret County, North Carolina, Bin and Jamie (2001) discovered a 5-10% reduction for property values within a flood zone subject to wave action while those vulnerable to wave action are associated with higher property values and price differentials in flood risk inland areas are equivalent to the capitalized value of flood premiums. The market value discount

applied to property values in floodprone areas is less than the present value cost of all future flood insurance premiums (Harrison et. al. 2001). Eves (2002) also analysed and compared residential house sales in flood prone areas and similar houses in immediate adjoining areas not affected by flood over a period of 16 years, including the major flood in Sydney, England in 1990 with findings suggesting that the disadvantageous aspect of flood-liable property will result in a lower initial purchase without an increase in the volatility of annual average capital returns of the property over a long period of time.

Zhang, Seong and Michael (2010) analysed the relationship between hazard proximity and risk perception and its effect on housing values from 321 households in Harris County, Texas. The study indicated that risk perception is a mediating factor between hazard proximity and property value, with mediation being partial rather than complete. Chakraboty (2021) sought to determine whether federally subsidized housing units and residents were disproportionately situated in areas with greater flood extent and if the areal extent of flooding around subsidized housing developments was greater for development in places where higher proportions of socially vulnerable people reside. The study indicated significantly higher percentages of subsidized units and residents in neighbourhoods with greater flood extent.

2.5 FLOODPLAINS, DEVELOPMENT AND MITIGATION

Brody et. al. (2007) unveiled how planning decisions and its effects on the built environment affect property damage caused by floods by observing 383 non-hurricane flood events in Florida counties within a 5-year time span. Results from the study showed that alterations of naturally occurring wetlands significantly increased property damage caused by floods. When compared with historically based regression models for designated flood discharge, rural areas had mainly 25-to-100-year peaks, while gauges in recently urbanized

areas received discharges greater than the modelled 100-year event. Physical development of communities such as the alteration of hydrological systems, the concentration of structures and impervious surfaces, influenced damaging flood events.

With formally adopted city plans and policy-making processes, Burby and Dalton (1994) analysed the influence of land-use plans on limiting development of areas at risk from natural hazards proposing that without state mandates requiring both plans and attention to hazards, local governments will ignore opportunities for risk reduction through planning and development. Contextual frameworks highlight the role of real estate development and continued increase in sea level rise as the dominant drivers of coastal flood (with New York as a case study), describing the social processes governing development in zones namely zoning, resilience planning and related insurance rates (Herreros-Cantis et. al. 2020). Because flood prevention measures do not necessarily eradicate the problem of flood hazards, but rather result in the redistribution of floodwater, subjecting other areas to increased flooding, Liao et. al. (2019), are of the opinion that flood adaptation measures should be considered by government organizations, by making the built environment (buildings, infrastructure, etc.) fit for the actual expected flood regime. This will shift the focus from flood hazard mitigation to flood control engineering and environmental design.

Location-based decisions are critical in mitigating property damage from floods. The effects of built environment measures like impervious surface, wetland alteration, while controlling for biophysical and socio-economic characteristics suggest that the scale/type of human development on naturally occurring wetlands, play a significant role in mitigating flood damage (Brody et. al. 2008).

The distribution of responsibilities in the event of a flood event has grown urgent, and the need for an efficient and effective distribution system is needed. Results from Doorn

(2016) illustrate that fairness and social justice are equally important factors to consider in flood risk management. Fairness in the allocation of responsibilities amongst private individuals and the government can impact the distribution of risk levels. The state also has a responsibility to provide basic flood protection and individuals can only be given roles to play provided they have the capacity and resources to respond. Issues of *recreancy*, environmental justice, and relocation as they relate to flood control infrastructural projects are significant. *Recreancy* is the concept used to describe the relationship between trust and risk where *trust* refers to the public's trust that social institutions will respond to social risks (Freudenburg, 1993). Recreancy was observed in a project in inner city Houston, where community cohesion was intended as the main guideline by the project sponsors, also highlighting issues with the engineering process (Lynn, 2016).With a series of workshops and surveys, it was discovered that residents possessed zero adaptation perspectives nor the knowledge of the availability of resources useful to them in the incident of a flood eventually leading to the feeling of being exempted from the planning process within their communities (Douglas et. al. 2012).

2.6 ONION CREEK AND THE CITY OF AUSTIN

Floodplains have been developed for residential use in Austin between the years 1990 and 2000 (Lee and Jung, 2014). In the Halloween Flood of 2013 according to Earl et. al.(2013), along Onion Creek, flooding occurred over 63 percent of the recently updated FEMA 100-year floodplain. According to the City of Austin's Hazard Mitigation Plan (2016), numerous structures that have experienced one or more floods causing substantial damage, have been acquired and continue to undergo acquisition, in a bid to protect open space adjacent to floodplains. The city is currently engaged in floodplain buyouts in the Onion Creek watershed.

In light of the October 2013 and 2015 flooding events, the Onion Creek Flood Mitigation Analysis enabled the city to re-evaluate flood risk in the Pinehurst and Wild Dunes neighborhoods, to evaluate potential flood mitigation alternatives. Buyouts and regional detections were identified as the most suitable alternatives, with buyouts being less expensive and having the flexibility of being implemented as funding is made available (City of Austin, 2017). The decision-making process behind property buyouts in the floodplain have significant potential social justice implications. Decisions often involve political motivation that may amplify disproportionate movement of low-income or minority communities. Siders (2019) are of the opinion that promoting long term adaptation and equity in the floodplains will need conscious effort to tackle social justice.

About 10% of land in Austin falls within the floodplain, with Onion Creek being Austin's largest watershed and is subject to the dangers of floods. Development within the 25- and 100-year floodplain stand to increase the risk of dangers to people and property and causing changes in floodplain. As such all developers and engineers with the intent of building within the floodplain are mandated to be familiar with the Land Development Code (LDC). According to the Land Development Code, there is a prohibition on the encroachment of buildings and parking areas within the 25-year floodplain. There is also a prohibition on the encroachment of proposed buildings and parking areas beyond the 25-year floodplain but within the 100-year floodplain, with a few exceptions, such as the construction of parking areas less than 5,000 square feet and exceptions in the Central Business Area District providing requirements and conditions for building structures. Foundation floor slabs need to be a minimum of 2 feet above the 100-year floodplain and all development involved in the construction of buildings must compensate for any floodplain volume that is displaced by that construction. The engineers and developers must also show that the development activities and building construction improves the drainage system by exceeding the minimum

requirements non-obstruction of waterways, maintenance of unobstructed waterways and standing water being declared a nuisance (Land Development Code 25-7-92:96).

The Austin City Council approved changes to the land development code putting more homes and businesses within the 100-year floodplain. There will also be a redesignation of the city's 500-year floodplain as the new 100-year floodplain, requiring all structures within its boundary to meet more strict building regulations (City of Austin. 2019). According to Halff Associates (the engineering consulting firm employed by the city of Austin), there are 2 options that will eliminate flooding in Onion Creek which include either the City of purchase of 147 properties worth $91 million, or the City acquisition of 86 properties and construction of flood walls up to 16 feet tall at a cost of $81 million (Andra, 2018).

DATA AND METHODOLOGY

The circumstances behind the floods and the social/behavioral characteristics of the residents of Onion Creek appear to be unique when compared with previous research. Onion Creek falls within a high-intensity flood zone and has experienced three major flooding events within a time span of five years (2013-2017). Looking at the overall socio-economic statistics of the study area, it would not be considered a poor or socially vulnerable neighborhood, which challenges results from existing literature. To get a better understanding and explanation on flooding impacts, social and behavioral processes and mitigation efforts in Onion Creek, the following questions need to be answered:

1. Where are the high-risk areas for flooding in Onion Creek Neighborhood, Austin?
2. What social, economic, political, or cultural factors might explain why people live in high-risk areas for flooding in Onion Creek Neighbourhood?

The following datasets were collected and analyzed for this study using a mixed methods approach.

- Floodplain extent (based off the FEMA FIRM Database) representative of locations and attributes of flood insurance risk zones. Property that falls within the 100-year flood zone have a 26% chance of being flooded and as such are required to purchase flood insurance.
- Onion Creek Property Data obtained from the Travis County Central Appraisal District.
- Digital Elevation Model (DEM) obtained from the USGS.
- Onion Creek Stream Data obtained from FEMA.
- Demographic Variables: Race/Ethnicity, Age, Sex.

- Socio-economic Variables: Household Income, Level of Education.
- Flood Insurance.
- Housing Values.
- Development and Mitigation Efforts.

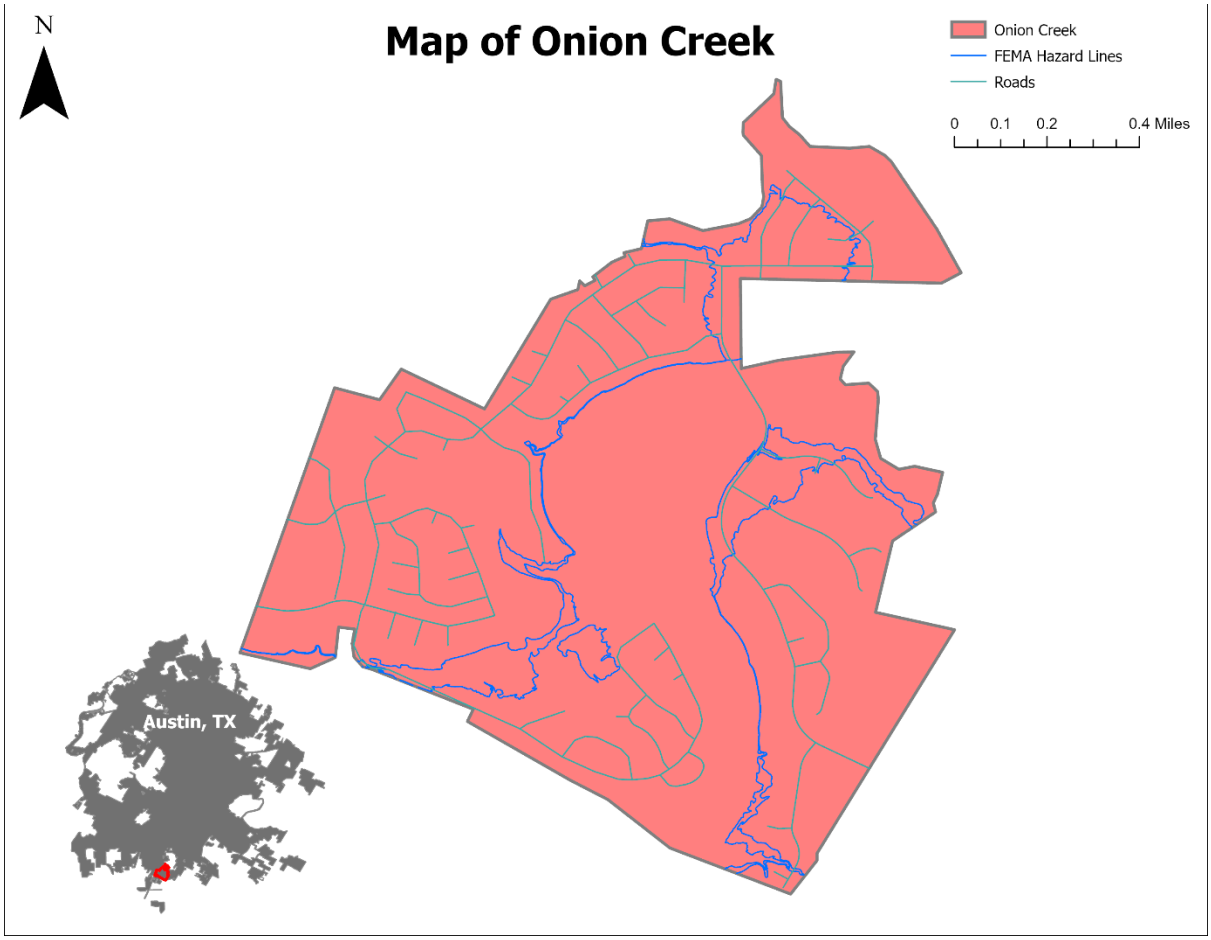
The demographic and socio-economic variables were obtained from the 2020 U.S Census Bureau and Survey questionnaire. Data on flood insurance, housing values, development and mitigation efforts were also obtained from the survey questionnaire.

The analysis includes 2 phases. PHASE 1: A quantitative risk assessment/vulnerability analysis will be performed to identify and map out the high-risk flood areas within the neighborhood using ArcGIS Pro. Floodplain extent and stream data (representative of hydrology within the region) were obtained from the FEMA database. A 30m x 30m resolution 32-bit Digital Elevation Model was obtained from the United States Geological Survey (USGS) Earth Explorer.

PHASE 2: A survey questionnaire was carried out to gain a better understanding of the social, economic, political, and cultural factors that guide the choices residents make to purchase a home and to live in a flood-prone area, as well as their experiences with flood events in OCN. The survey obtained data on the general background of the participants, their flood awareness levels, flood mitigation initiatives put in place to help residents and their experience and reflection. Participants in the survey were recruited in two ways:

- A random selection using Facebook as a medium of survey distribution and recruiting. With Facebook, residents of the neighborhood are delineated/selected based on their zip code/neighborhood name on their profiles.
- Using the Onion Creek Homeowners Association platform, the survey was shared to residents through the E-blast newsletter.

It is also important to note that, prior to recruiting any participants, the survey instrument was subjected to an Institutional Review Board (IRB) scrutiny at Texas State University to ensure that the rights and privacy of all research participant were duly protected.



ANALYSIS AND RESULTS

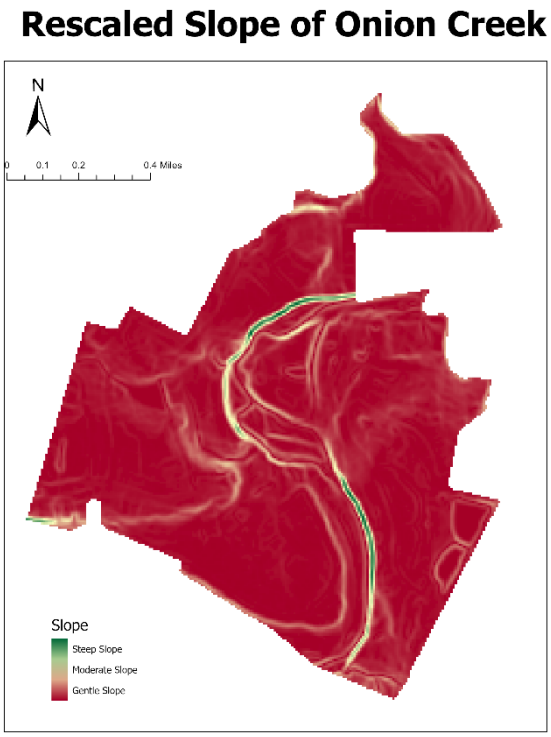
PHASE 1: Where are the high-risk areas for flooding in Onion Creek Neighborhood, Austin?

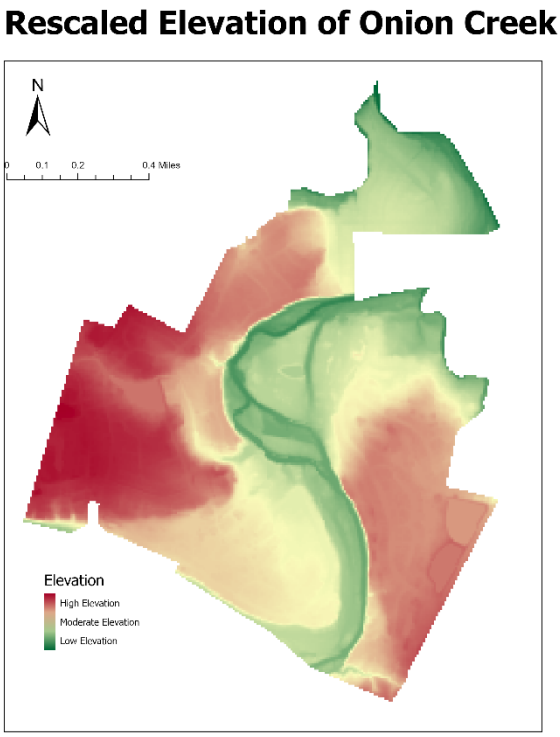
For this analysis, the variables taken into consideration include Slope, Elevation, Flow Accumulation and Euclidean Distance from Streams within the study area. Instead of using a reclassification scheme, a Rescale by function Linear Transformation is used. This process handles continuous input values without having to group them into categories; rather, this process rescales different measurements using a linear function onto a continuous floating point evaluation scale. For each of the input rasters, the minimum value is assigned a Lower Threshold value while the maximum value is assigned as an Upper Threshold value. A three-step evaluation scale is set ranging from 1 to 3 for each variable with 1 representing Higher values, 2 representing medium values and 3 representing Lower values.

Using a 30m-by-30m resolution 32-bit Digital Elevation model obtained from the United States Geological Survey, the steepness of each cell within the raster surface is calculated to generate a slope raster. The slope raster is then rescaled using a linear function resulting in Low slope values representing a flatter terrain while higher slope values signify a steeper terrain (Map 2.).

In order to solve the problem of sinks within the DEM caused by data resolution errors, the sinks are first filled to ensure the proper outline of streams and basins. The resulting raster is then rescaled using a linear transformation and ranked from low-moderate-high elevation (Map 3). To take into consideration the hydrologic characteristics of the surface elevation raster, flow direction is determined from every cell within the raster to its downslope neighbour. A D8 flow method was adopted to model the flow direction from each cell to its steepest downslope neighbour. The resulting flow direction raster is then used to

calculate flow accumulation of water flow which is the accumulated weight of all the cells flowing into each downslope cell in the output raster. The elevation raster (after sinks have been filled) serves as the input raster of the weight applied to each cell. A linear rescaling transformation was applied to the flow accumulation resulting in the 3-step scale. Cells with resulting high flow signify areas of concentrated flow in the event of heavy rainfall and vice-versa (Map 4).





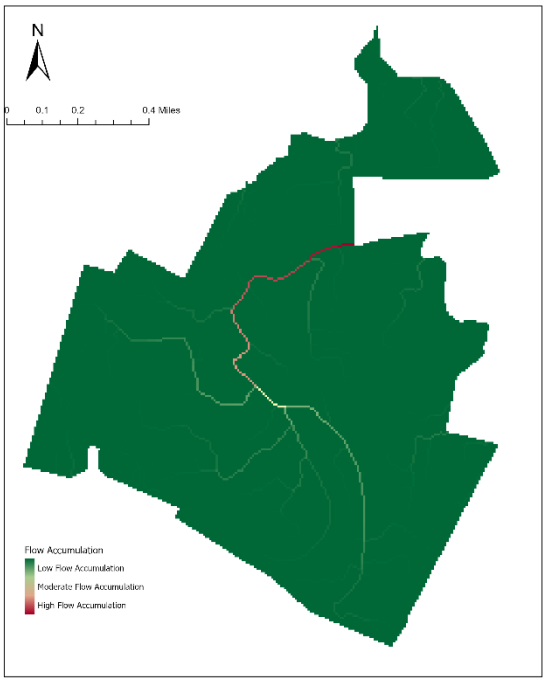
Map 2: Slope of Study Area

Map 3: Elevation of Study Area

The final factor taken into consideration is the straight-line distance from streams within the study area. Thus, the distance from each cell within the raster is calculated in relation to the nearest stream. With the linear rescaling transformation applied to the resulting cells, cells closest to the streams are considered high-risk areas while cells further away from streams are considered low-risk areas (Map 5). All four variables; slope, elevation, flow accumulation and straight-line distance from streams are combined and cell statistics are

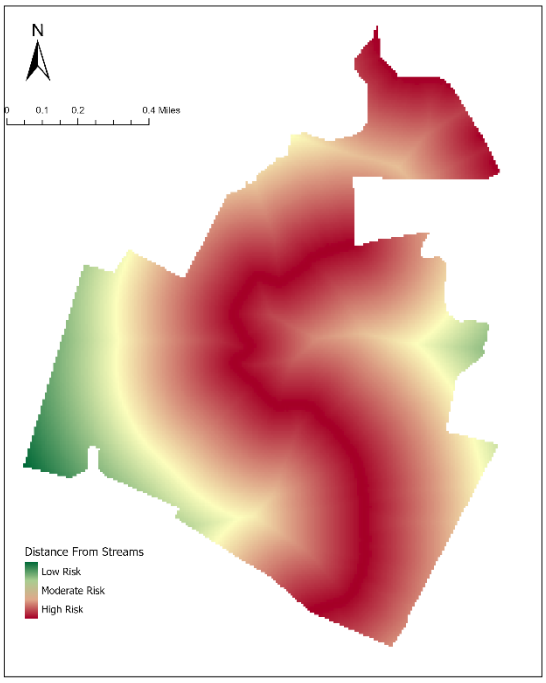
calculated by adding up all the values of the input raster's without assigning weights to variables.

Rescaled Flow Accumulation of Onion Creek



Map 4: Onion Creek Flow Accumulation

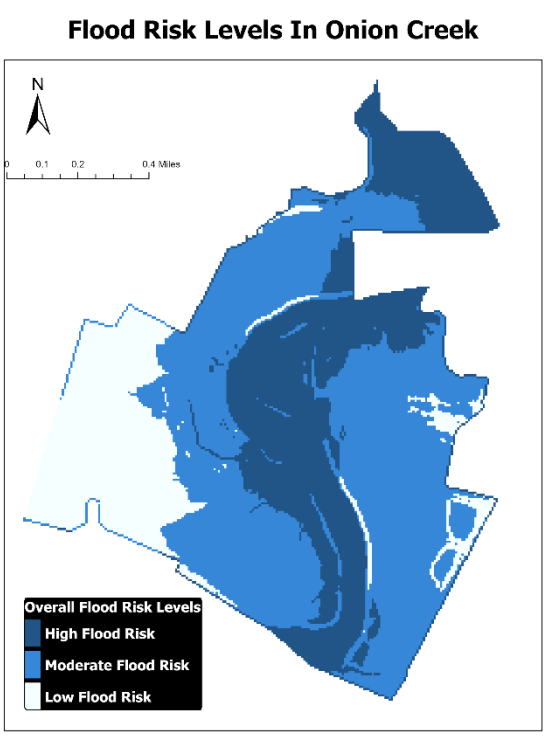
Distance from Streams In Onion Creek

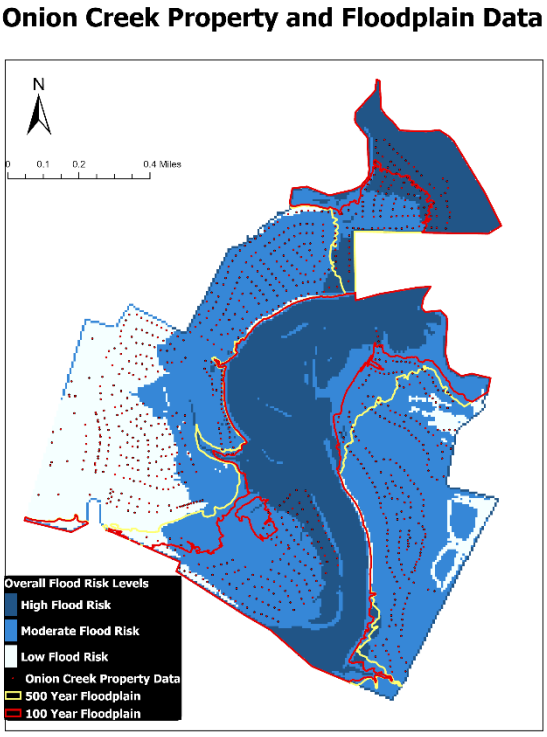


Map 5: Euclidean Distance from Streams

A final map depicting high risk areas, moderate risk areas and low risk areas of the study area (Map 6) is produced. This output of flood-risk map can be used in comparison to the 100- and 500-year floodplain maps produced by FEMA (Map 7). Some variability exists between the 100–500-year floodplain and high-moderate risk areas with respect to home placement in the neighborhood. Also, results from the survey (in-depth discussion in next phase) show that some homes and their households not within the current FEMA floodplain did experience slight-severe damage from flooding events, indicating a need for the revision and update of current FEMA floodplain maps to better delineate homes/property that are at a higher risk. Based on FEMA guidelines, revising floodplain maps involve the collaboration of FEMA and the community. Communities are assigned floodplain administrators to obtain information from the locals that could aid the understanding of water drainage in an area.

Upon completion of data analysis, preliminary flood maps are made, reviewed, and adopted by the community. Considering the results of the vulnerability analysis and survey, the community will need to file and submit a Letter of Map Change (LOMC) to have the flood maps updated.





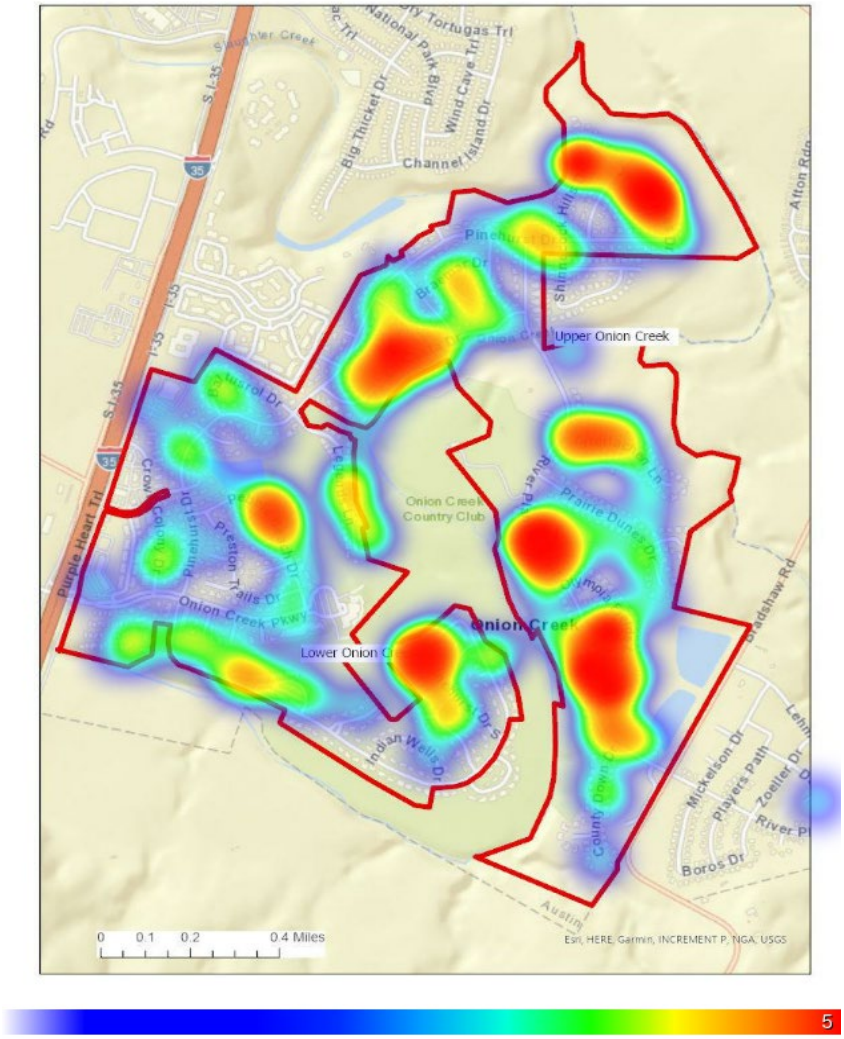
Map 6: Overall Flood Risk Levels

Map 7: ONC Floodplain/Property Data

PHASE 2: What social, economic, political, or cultural factors might explain why people live in high-risk areas for flooding in Onion Creek?

In order to ensure that participants of the survey resided within just the Onion Creek neighborhood, Google Earth was used to identify the boundaries of the neighborhood. Using the StreetMap view within ArcGIS Pro, a feature class of the study area was created to delineate OCN on the map. A map of the outlined study area was then added to the survey as the first question to sieve out participants in such a way that only people who live within the

outlined study area can proceed to take the rest of the survey. The survey was distributed using 2 mediums, namely Facebook and the Onion Creek Homeowners Association (HOA) E-news blast platform. A total of 139 responses were received from residents of the study area. Map 7 is a heatmap showing the locations where the survey participants reside within Onion Creek Neighborhood (Map 8).



Map 8: Heatmap of Survey Participants

With the filtering effect from the first question, a total of 139 responses were gathered that fit the specific criteria for the study being: i) Must reside within the outlined region, ii)

Must be of 18 years or older, iii) Must be a home-owner. The survey questions ts were split into 4 categories and aimed to obtain information on:

- The General Background,
- Flood Awareness Levels,
- Flood Mitigation Efforts within the Region and,
- Experiences and Reflection related to flood and personal experience.

Analysis was carried out on the participants to better analyse and understand their perceptions and knowledge levels related to flood awareness, mitigation efforts and their experiences/reflection. Responses are broken down and coded using **NVivo** (a qualitative analysis tool) to categorize and group the thought angles and levels of understanding/knowledge of the participants.

Table 1: Survey Questions

Category	**Survey Questions**
General Background	i) How long have you lived in your Onion Creek home?
	ii) What gender do you identify as?
	iii) What is your age?
	iv) What ethnicity/race do you identify as?
	v) What is your highest level of education obtained?
	vi) What is your annual household income?
Awareness Level	i) Are you aware that the Onion Creek neighbourhood is a flood-prone area?
	ii) If yes, at what point did you realize it was flood-prone?
	iii) Does your property fall within the floodplain?
	iv) Were you informed by the realtors of the flood risks of the area?

	v) Were you aware of the need/requirement to purchase flood insurance?
	vi) Did you purchase flood insurance for your home?
	vii) If you didn't purchase insurance, why?
	viii) Within what range is the cost of your home?
	ix) During the time lived here, have you experienced a flood?
Mitigation Efforts	i) Have you received any support/help from an individual, public or government Organization, to help with the negative impacts of floods on your home?
	ii) What type of help was received?
	iii) Have you heard of the 'Flood Buyout Program' initiated by the City of Austin?
	iv) Have you participated in this Buyout Project or any other initiatives of the City of Austin to mitigate flood risks/damage?
Experience and Reflection	i) Could you give a summary of your experience with flooding in your home at Onion Creek?
	ii) With your experience in mind, do you plan to move out of Onion Creek?
	iii) If No, please explain why.
	iv) What lessons have you learnt from living in the flood prone area of Onion Creek?

GENERAL BACKGROUND

All the survey respondents were Homeowners of Onion Creek belonging to the Onion Creek Homeowners Association. with 55.4% male participants, 43.9% female participants and 0.7% of other gender. About 22% of the participants have lived in the area for over 20 years while 36% and 31% (the majority) of the participants have lived in the area for 0 -5 years and 5 – 15 years. Onion Creek Neighborhood lies across 3 Travis County block groups (BG0024252, BG0024281 and BG0024282); as such, the demographics of all three groups accumulated are compared against the survey participants. The largest age group in Onion Creek are people 50+ years old with a percentage of 80.43%; 13.04% of the participants falling within 40-50 years of age. The neighbourhood is predominantly white with a percentage of 88.24% accompanied by 9.56% Hispanic population. According to the U.S Census Bureau, median household income in the state of Texas is $31,000; the three block groups encompassing the Onion Creek neighbourhood have a median household income of $92,227.11, indicating financial stability.

Figure 1: Length of Residence of Survey Participants

Table 2: Socio-demographic Status of Study Area (Census vs. Survey Results)

U.S Census Bureau (Three Selected Block Groups in Travis County)			**Survey Results (OCN)**	
Race	% White	**73.07%**	% White	**88.24%**
	% Black/African American	**3.12%**	% Black/African American	**1.47%**
	% American Indian	**0.31%**	% American Indian	**0.00%**
	% Asian	**9.33%**	% Asian	**0.00%**
	% Native Hawaiian	**0.11%**	% Native Hawaiian	**0.00%**
	% Some Other Race	**10.96%**	% Some Other Race	**1.00%**
	% Two or more races	**3.11%**	% Two or more races	**0.00%**
			% Hispanic	**9.56%**
Household Income	Average Household Income	**$92,227.11**	$25,000 - $50,000	**4.92%**
			$50,000 - $100,000	**27.87%**
			$100,000 - $200,000	**48.36%**

			More than $200,000	**18.85%**
Level of Education	Less Than High School Diploma	**9.47%**		
	High School Graduate	**16.90%**	High School Graduate	**5.04%**
	Some College Degree	**19.63%**	Some College Degree	**2.88%**
	Associates Degree	**5.41%**	Associates Degree	**8.63%**
	Bachelor's degree	**29.91%**	Bachelor's Degree	**39.57%**
	Master's degree	**16.26%**	Post-Graduate Degree	**43.88%**
	Professional School Degree	**0.50%**		
	Doctorate Degree	**1.92%**		
Age	% 18 and 19 years	**2.68%**	% 20 to 30 years	**0.00%**
	% 20 to 24 years	**8.09%**	% 30 to 40 years	**6.52%**
	% 25 to 34 years	**16.56%**	% 40 to 50 years	**13.04%**

	% 35 to 44 years	**19.76%**	% Above 50 years	**80.43%**
	% 45 to 54 years	**9.48%**		
	% 55 to 64 years	**20.09%**		
	% 65 years and over	**23.35%**		

The survey data show that more than half of the participants representative of the study area earns above $200,000, indicating a high level of affluence in comparison to surrounding areas. Also, there exists less diversity in terms of race within Onion Creek Neighbourhood when compared to current U.S Census Data. Residents of the study area are also highly educated with 39.57% of participants in possession of a bachelor's degree and 43.88% in possession of a post-graduate degree. Once again, this raises the question 'Why do these individuals/families live here when they have the financial means and resources to relocate?'.

AWARENESS LEVEL

Looking at the residents' flood hazard awareness levels, residents were asked on their knowledge of flooding in Onion Creek. Apparently, 99% of the survey participants are aware that Onion Creek is a flood-prone neighbourhood. In addition, in order to understand the role of realtors in the placement of families in flood-prone areas, participants were asked to indicate at what point they realized the neighbourhood was susceptible to flooding. A little

over half of the participants were aware of flooding in the region before moving into the neighbourhood while 41% were not aware until after purchasing a home in the area (Fig. 2).

Figure 2: Residents Flood Awareness Breakdown Bar

Of the 139 resident participants of the survey, 70% live in property that fall outside the FEMA designated floodplains while 30% reside within the floodplain. Using GIS and property data from the Travis County Central Appraisal District, it was also discovered that 29% of homes/property in the study area are currently located within the floodplain (Table 3). Also, almost half of the participants were not informed by the Real Estate agents of the floods risk of the area (Fig. 3).

Table 3: Onion Creek Neighbourhood Property Distribution within Floodplain

	Survey Sample	**OCN (Travis County Property Distribution)**
Total Number (Households)	**139**	**1243**
Within Floodplain	30%	29%
Outside Floodplain	70%	71%

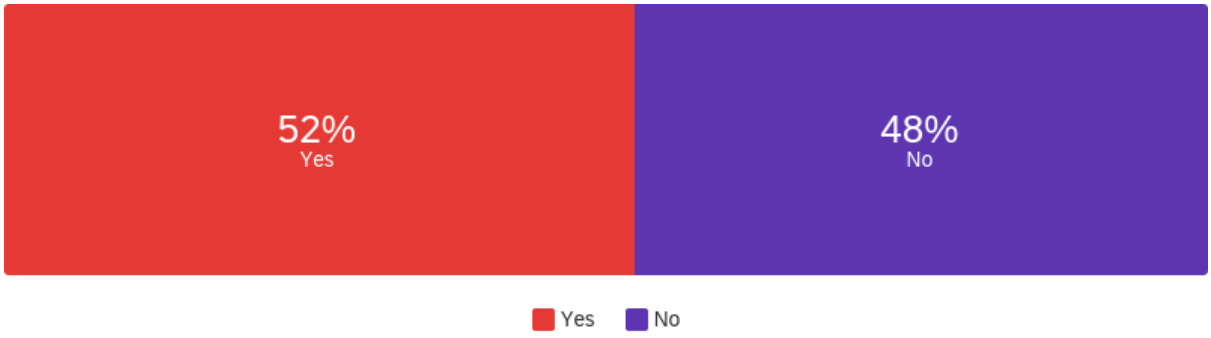


Figure 3: Realtor Disclosure on Flood Risks to Residents

This does not come as a surprise as it was not until the 1st of September 2019 that a new Senate Bill (SB 339) was passed, signed and put in effect by the Governor of Texas requiring disclosure notices of sellers of residential property as it related to floodplains, flood pools, flood ways or reservoirs. Under this new bill, sellers have to disclose the following:

I. whether their home is located wholly or partly in a l00-year flood plain;
II. whether their home is located wholly or partly in a 500-year flood plain;
III. whether their home is located wholly or partly in a flood pool;
IV. whether their home is located wholly or partly in a reservoir;
V. whether the home is located five miles downstream of a reservoir;
VI. whether their home may flood under catastrophic circumstances; and
VII. whether their home has flooded in a flood event.

Unfortunately, this bill had not been implemented after most of the participants have moved into their homes.

Considering the subject of flood insurance, 56% of the respondents were aware of the need/requirement to purchase flood insurance for their homes by virtue of the neighbourhood location, but 44% were not aware of this requirement. Consequently, only 46% (60 respondents) of the total number of respondents purchased flood insurance for their homes. The study was however unable to establish the overlap between those that were aware of the

requirement but did not purchase flood insurance. In a bid to understand why other participants did not purchase flood insurance, the following deductions were made:

Table 4: Inferences on Non-purchased Flood Insurance.

Results	**Survey References**	**Sample Response Descriptions**
Did not see the need (Not required)	10	i) We were in a special area that did not (yet) require flood insurance. ii) Was not required for closing. iii) I did not see a need.
Did not think home would be affected	3	i) Did not know creek would get that high. ii) Onion Creek did not flood prior to the purchase of our home. It started flooding years later due to upstream development and increased impervious cover and downstream failure to clear the channel of natural debris causing back up at the confluence of Onion Creek and Slaughter Creek.
Home is at a high elevation	15	i) House is above upper reach of floods. ii) We are considerably higher in elevation than the flood risk areas. iii) House is located in just about the highest point in neighborhood.
Home is not in flood zone (floodplain)	43	i) I am not in a flood plain therefore I don't see the need to purchase insurance. ii) We are not in the flood plain.

		iii) We are far outside of the flood plain.

Residents with homes outside the designated FEMA floodplains did not purchase flood insurance, along with residents whose homes were at a much higher elevation. On average, residents that did purchase Flood Insurance for their homes paid approximately $886 annually.

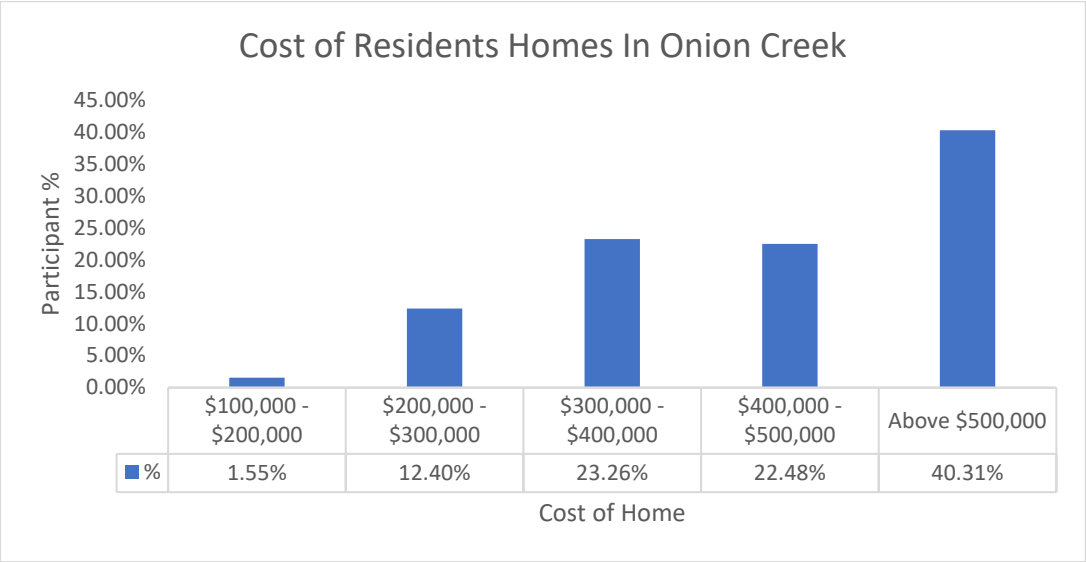


Figure 4: Cost of Homes In Onion Creek

With this in mind, it is also worth noting that of the total number of participants for this survey, only 28% (or 37) had witnessed/experienced a flooding event within the neighbourhood in one form or another. When asked to state the years that these flooding events occurred, the floods of 2013 and 2015 came out on top. Participant's responses were run through the word frequency query in NVivo to find the flood years that occurred the most. The higher the frequency of occurrence, the larger the font size and vice-versa. Some residents did, however, recall major flooding events in the neighbourhood as far back as 1998 and 1981 (Fig. 5).

Figure 5: Most Popular Flood Events in Onion Creek (Year)

MITIGATION EFFORTS

The city of Austin as well as FEMA have put in place relief/mitigation efforts to support flood victims in time of crisis. The essence of this section is to find out just how efficient and beneficial these efforts have been. Of the 37 participants that have experienced a flooding event in the study area, only 9 had received any sort of assistance from the government, FEMA or individuals, leaving the rest to fend for themselves. Results show that the most common type of help received was from FEMA (Fig 6). While some residents were provided with Relief Funds, Temporary Shelter and Food, others were offered buyouts by the city and some had their homes cleaned up after the floods.

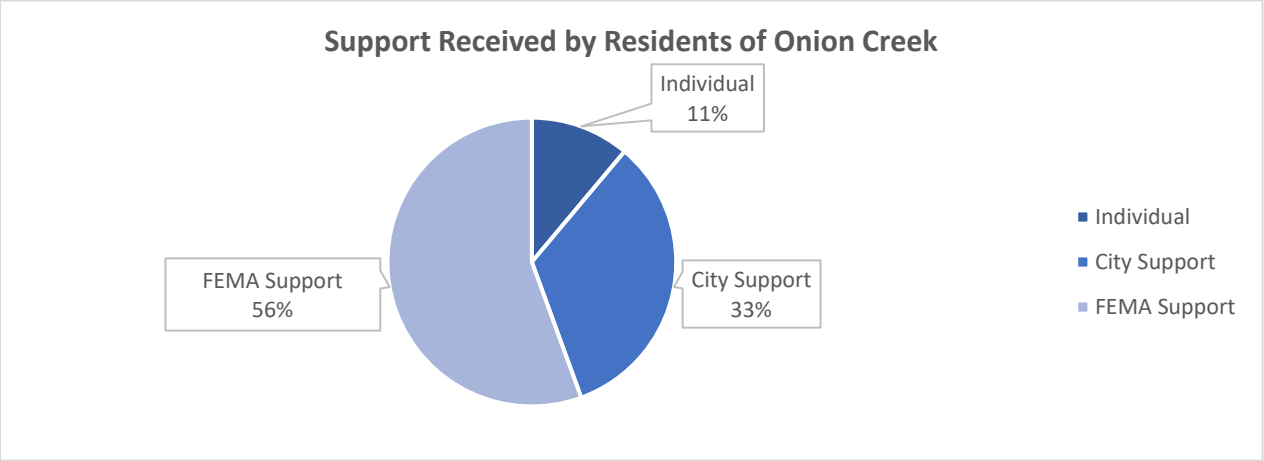


Figure 6: Support Received by Residents from Institutions/Organizations

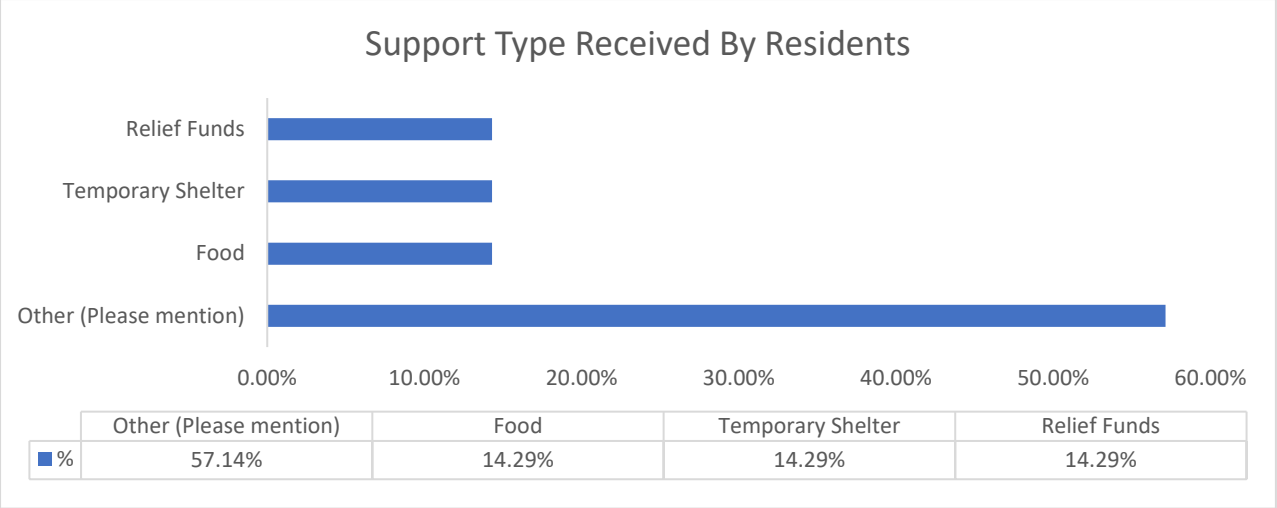


Figure 7: Support Type

The Watershed Protection Department in alliance with the Office of Real Estate Services under the umbrella of the City of Austin, set up a Buyout program to purchase homes in flood prone areas in order to move the residents out. The Buyout program is a scheme set up by the City of Austin to buy homes that fall within the floodplain or that have flooded, at fair market value. The homeowners are given monetary compensation to relocate, and the homes are demolished and turned into parkland. The program is partly funded by the Federal Emergency Management Agency's Hazard Mitigation Grant Program. In 1998, the city of Austin partnered with the U.S. Army Corps of Engineers to evaluate flooding problems in Austin and Travis County. As a result of the depth and extent of the floodplain within the area, it was determined that the best option to solve the flooding problem would be to acquiring the flood-prone properties and relocating the residents. After the Halloween floods of 2013, homeowners in Onion Creek that asked for their homes to be bought out immediately and whose houses had been damaged were ranked based on the depth of flooding. The houses with the highest risk were bought out first up until all buyout requests were attended to.

In a bid to test the knowledge levels of the residents on the Buyout program as it pertains to their neighbourhood, participants were asked to share their thoughts/views on what they consider the buyout program to be.

Table 5: Participants Knowledge on The Buyout Program.

Results	**References**	**Sample Response Descriptions**
Buying Homes in Flood zones (Floodplains)	12	i) Houses in lower OC that experienced flooding that fits risk. ii) If your home is located in a flood prone area that floods year after year, the city will purchase your home and you will move out and live somewhere else that does not flood. iii) The city offers to buy out certain designated homes in the flood area.
Buying Homes that experienced Flooding	10	i) Rather than rebuilding houses repeatedly due to flood damage, the City of Austin buys the property and demolishes the buildings. ii) If your home was flooded twice i.e., 2013 and 2015 you were considered for the buyout program. iii) Applicable to those that had flood waters invade their homes.
Homes Bought at Fair Market Value	6	i) A program set up to purchase the home at fair market value. ii) For homes designated by City, they will purchase at close to market price.

		iii) City pays what they think is market value for purchase of my home.
Monetary relocation compensation	5	i) Pay for your moving to another home. ii) Use the funds to purchase a new home in a non-flooded area. iii) Plus, a stipend for moving and resettlement costs.
Purchased Homes are Demolished and Turned to Parkland	7	i) COA is purchasing homes in my neighborhood and the area will be park land. ii) The city is buying out homes in the flood plain and destroying them. iii) The city then razes the homes purchased and leaves the lots vacant.

Satellite imagery from the years 2018-2021 obtained from Google Earth clearly show the progressive demolition of homes within Onion Creek along Pinehurst Drive (Figures 8&9). Comparing the geography of the homes on Pinehurst Drive that have been bought and demolished with the Overall Flood Risk Levels seen in Map 6, these homes did fall within the High to Moderate Risk levels.

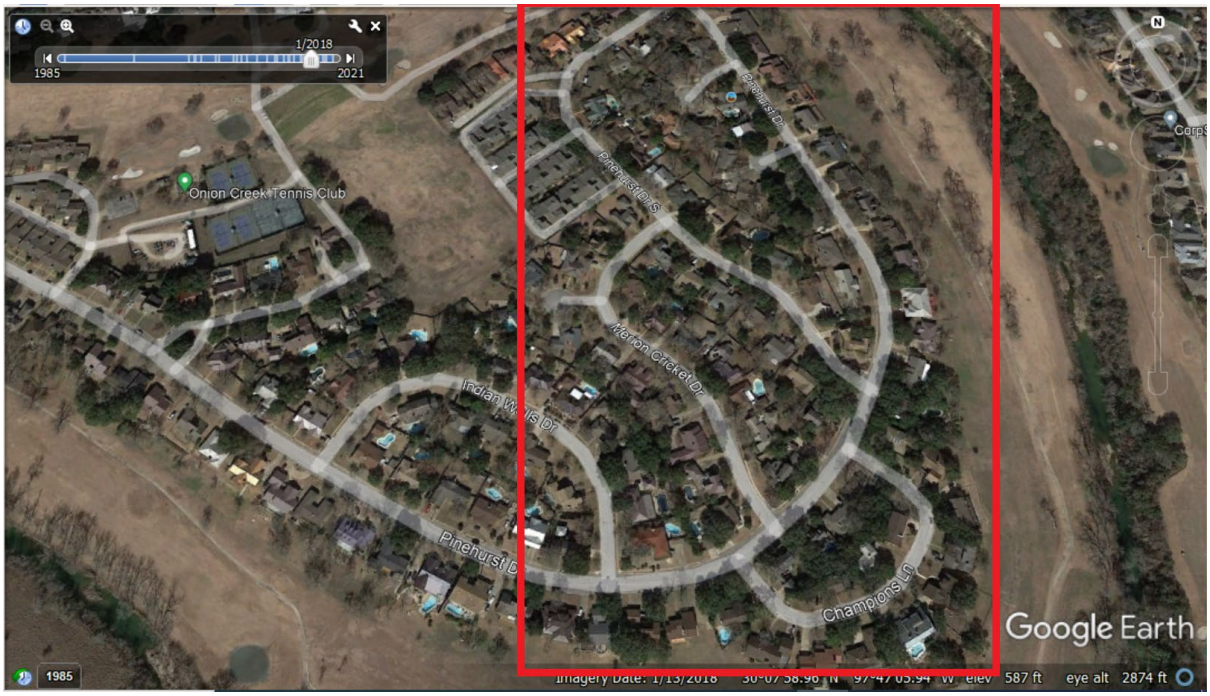


Figure 8: 2018 Satellite Imagery of Upper Onion Creek

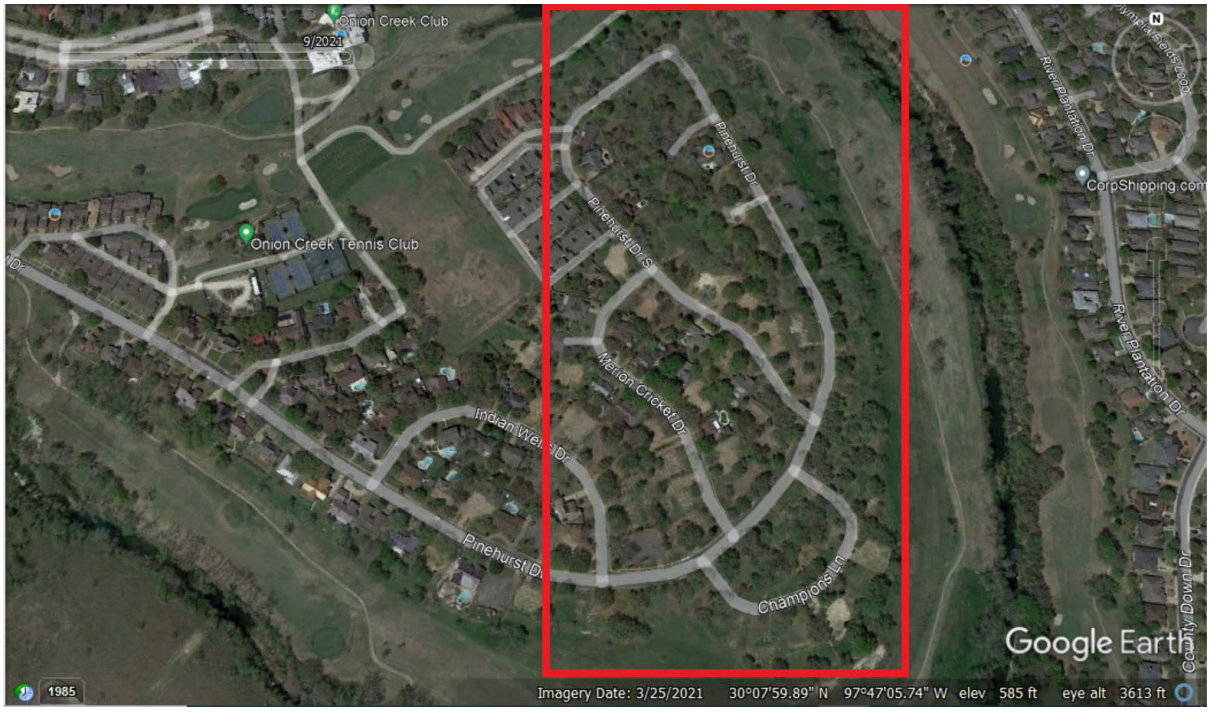


Figure 9: 2021 Satellite Imagery of Upper Onion Creek

EXPERIENCE AND REFLECTION

Working with the data and information obtained from the previous sections, one would anticipate that these residents would be eager to relocate considering that they live within a high-intensity flood zone. As such, residents were asked to summarize the experiences they had with floods in the study area and reflect on how this might affect their decisions moving forward.

Results from the analysis indicate that a large number of residents experienced slight to significant levels of damage to their homes as a result of flooding events, or had the waters get as far up as their lawns, completely covering the surroundings but not getting into the house itself. A small number have never had flood waters come into their homes or property but witnessed the effect the floods had on their neighbours, so much so that some of the residents rallied around to help each other get to safety and save belongings.

Table 6: Summary of Residents experience with Flooding.

Results	**References**	**Sample Response Descriptions**
Experienced slight-significant damage to the home	11	i) Lived here since 1980. Lower always had flooding but not like 13/15. My childhood home was bought out. All my classmates' homes. Gone. In 13 Our metal roof and no gutters caused the flood. The rain came so fast and so much just slid off the roof and water surged through the house. ii) Terrible, never thought that Onion Creek could get this high...With the incompetence of City of Austin environmental policies do not keep the Creek clear, we flooded.

		iii)	Our home at 10106 Pinehurst had water throughout the house that was about 2-4 inches high. We had to remove all the carpeting in the house, remove the sheetrock and insulation about 2 feet up the wall. We did not live in the house for about 6 weeks. We cleaned all the 2x4s with a Clorox mixture to help prevent mildew.
Home has never flooded	5	i) ii) iii)	Home has never flooded. I have not had flooding in my home in the 33 years we have owned the home. My home is at the highest point of Onion Creek subdivision and has not flooded since I purchased it in 1998.
Neighbours were affected	6	i) ii) iii)	Friends' homes experienced 2-6' of water inside in 2013. In 2015, water did not rise as high, but still affected many homes in the flood plain. Friends and relatives in the neighborhood were affected and the damage of bridges and streets affected our ability to travel within the area. The next day we drove to lower OC to help family recover what they could.
Water did not enter home but affected home surroundings	14	i) ii)	Home was not flooded. Live next to creek and Pebble Beech Pond which overflowed and rising water entered our yard close to foundation. We have not experienced actual flooding in our

		structure, but the 2013 flood waters came within 0.25 inches of coming into our garage and on the patio iii) Flood waters in 2013 got into our garage and up on our front porch but never got into our home.

Some of the underlying factors resulting in an increase in flood events raised by the participants include an increase in infrastructural development. The study area is continuously undergoing development as more apartment complexes have been erected over time. One would say that the continuous construction of housing/living units defeats the aim of the Buyout program, thus creating more concern. An increase in infrastructural development results in an increase in impervious cover which does not absorb moisture and increases run-off. Lack of maintenance of drainage channels has also been highlighted as a cause for increased flood events. Some respondents also stated that errors exist in the floodplain maps, hence the need for an updated map that properly/accurately delineates homes at risk within the 100- and 500-year floodplain.

In regard to relocation preferences, a majority of the respondents (about 94%) indicated no interest in relocating outside the neighbourhood (Fig 10); further research is needed to understand why. However, sample bias is present as some of the residents that took advantage of the Buyout program do not stay in the area anymore, and those that still live within the area may not be interested in using the program, hence serving as a limitation of the survey study. It is important to note that the reason behind the majority's decision to stay is the fact that they feel a sense of belonging, community, and safety in the neighbourhood. Some would even say it is a neighbourhood with very distinct and unique features. Over time, the community has grown into a family that can depend on one another in times of crisis and

need. Some others stated the fact that that their homes are not in the flood zone and as such do not see a need to relocate.

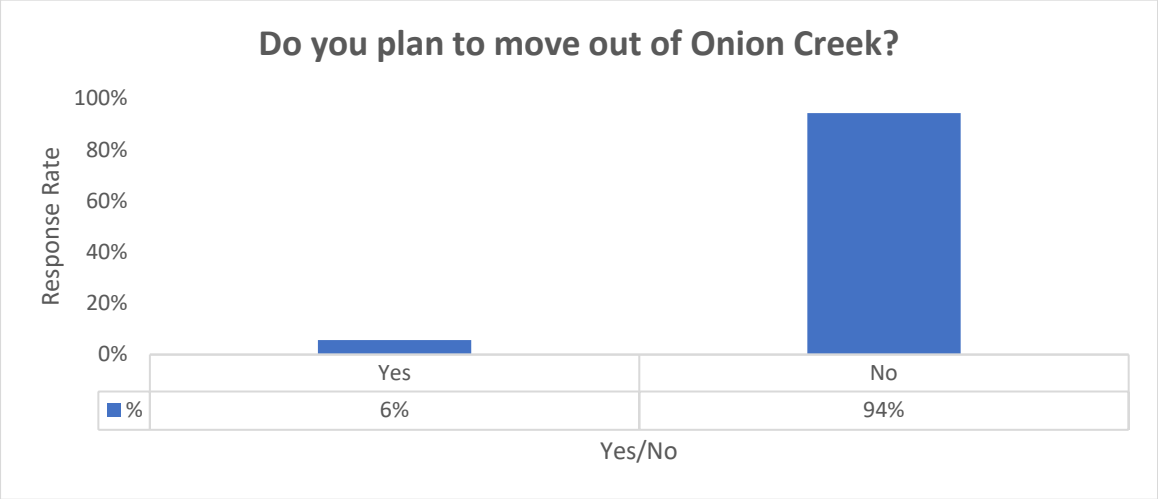


Figure 10: Relocation Response Rates of Residents

Table 7: Participants Relocation Perspective

Code	References	Sample Response Descriptions
Buyout for home is not being offered	1	i) I am not being offered a buyout and Austin property cost is outrageous right now.
Familiarity with neighbourhood, community, scenery	17	i) This is a unique place. Families sell homes and then move down the street. My sister, mom, uncle, cousin & aunt all live here. ii) It is a Diamond in the rough neighborhood with pride of ownership, beautiful surroundings of the golf course and a wonderful community, all within minutes of downtown Austin. iii) We love the neighborhood; my husband is an avid

		golfer; my kids grew up here and love it too, so much that my daughter bought the house next door when she married.
Length of Residence	3	i) However, I am in my eighties and moving away from friends and neighbors does not seem to be urgent at this time of my life. ii) I lived here before it was considered a flood plain. All the construction west of Onion Creek is causing most of the flooding now.
Not in flood zone(floodplain)	8	i) We like our house, and it is outside the flood plain ii) My home is not in danger. iii) Our house is not at threat.

Reflecting on past flood events, participants shared the lessons learned along the way throughout the whole process of preparing for a flood to experiencing it. 4 common opinions/points stood out:

- Always be alert and ready to move when the need arises;
- Properly investigate and ask questions before moving into a neighbourhood;
- Do not underestimate the importance of flood insurance;
- Educate yourself on the matters that affect your surrounding/neighbourhood (in this case, flooding and the environment).

Table 8: Lessons Learned from Flood Events

Code	References	Sample Response Descriptions
Always be Aware and Prepared	9	i) Be prepared and aware of potential flooding. ii) Monitor the weather and be prepared to leave. iii) When you take a risk in living in a floodplain you may have negative results that outweigh whatever rewards you may have perceived in that home. The same general risk/reward concept is pertinent throughout one's life.
Carry out Thorough Investigation before buying a House	7	i) To investigate more thoroughly when purchasing a home near water. ii) Note these details before making a decision to move to an area. iii) Be aware of the flood history of the home you are buying before buying here. Not all home along the creek are subject to flooding. Those further away from the creek have even a less chance of flooding.
Infrastructural Development in the neighbourhood should stop	3	i) Also wishing the amount of infrastructure continuing to go up in surrounding areas would stop, as it adds to the impermeable soil issue, further exacerbating the flooding potential. ii) That all of this development along IH-35 has altered the water runoff. iii) Too many people moving into the area west of

		Onion Creek. The counties and state need to do a better job of building run off areas.
More knowledgeable on Flood Matters and the Environment	7	i) I learned that there was no regulation against allowing debris along Onion Creek and that much of the animal damage and death was due to the debris washed by the flood. I learned that a solution for future flood control was to divert disastrously high Onion Creek flow to the quarry, which already had pumping capability. ii) That the waterways, specifically the Onion and Slaughter Creeks, are not kept free of foliage such as trees, shrubs, grasses et al that deter and even prevent free flow of rainfall. iii) The 2015 flood was different in that the storm hung over Onion Creek itself and the city drainage system could not handle the runoff creating flooding issues in places that did not have them in 2013.
Purchase Flood Insurance	6	i) Buy flood insurance ii) Make sure you have flood insurance. iii) Be sure to have that flood insurance.
Purchase houses on Higher Elevation	3	i) Stay on high ground. ii) Lucky my house is on higher ground. Other homes should never have been built in floodplain.

Tight Knit Community	2	i)	At the time of the floods, Onion Creek residents and staff pulled together and helped each other. I learned that our community was strong.
		ii)	I have learned that I miss my neighbors.

CONCLUSION

Onion Creek has had to experience several major damaging flood events over time especially as it is located within a flood -prone region. Unfortunately, most of the development in the region had begun long before a full understanding of floodplains was established. As a result, families moved in and settled into the neighbourhood. Contrary to a lot of research that show that racial/ethnic minorities and people of a lower socio-economic status tend to stand a higher risk to flood exposure by residing in these flood prone areas because of housing values, the study area and its residents do not fit the norm calling for further investigation to understand the factors behind their decision to continue to reside in the area. Results from the survey show that although the residents are fully aware of the flood risks associated with region, they choose to stay for 2 reasons: i) the familiarity and attachment to the neighbourhood and community; ii) their homes are not within the floodplain. Also, the following have been called out as contributors to the increase in flood within the area: i) Increase in infrastructural development and impervious cover; ii) Failure to clear drainage channels of natural debris; iii) Errors in the new floodplain map as well as the current one.

The vulnerability analysis in conjunction with some survey responses have raised a need for the revision and update of current FEMA floodplain maps to ensure a more up to date and accurate identification of homes/property that are at a higher risk. Some variability exists between the 100/500-year floodplain and Overall Flood risk levels with respect to property distribution. As such, there is the likelihood that homes not within the current floodplains could still be at risk. This creates a bigger cause for concern especially as Austin is growing and developing at a rapid rate as more individuals move into the city. Homes that are currently not within the 100-year floodplain could easily end up in the floodplain within the next few years considering the high rate of development.

The research is also subject to some limitations: i) Rather than working with a linear rescaled transformation for the flood-risk analysis section, future studies can look into obtaining advise from a flood expert on weighting preferences for all 4 variables; ii) Switching up some of the survey question formats from Multiple choice to a Likert scale. This could have helped strengthen some of the quantitative analysis of the survey; iii) Samples bias as they are self-selected.

Lastly, further research should be looked into:

i) The roles realtors play in the selling of homes within this region. The flood disclosure notice was not passed until September 2019, which explains why a good number of respondents were not informed. It would be of interest to understand the reasons behind the actions of real estate companies and their agents considering that they are placing households in flood-risk areas.

ii) What part do development companies and the City have to play regarding the continuous infrastructural development in the area? Who gave the permits? The Buyout program was set-up to purchase and relocate homeowners whose houses were in the floodplain or had experienced flood damage, thereby reducing the damages and casualties likely to occur. However, construction and development appear to be continuous in the neighbourhood as more apartment complexes spring up, ultimately putting people lives at risk. Thus, it is pertinent to understand the motives and relationships between these development companies and the city of Austin.

iii) The relationship between age and hazard perception in Austin using Onion Creek as a case Study. A good number of survey respondents are from 50 years and above. This could serve as grounds to understand the connection between their

age and what they perceive as a hazard to not just themselves but also those around them and how it affects the decisions made.

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