Severe Flooding in the Onion Creek Watershed and Floodplain Housing Buyouts

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I. Introduction

The Onion Creek watershed lies in southeast Austin, Texas—and is prone to a magnitude of flooding problems. Most of these problems are due to the 25-year and 100-year floodplains that encompass a significant area in this watershed. Stretching 211 square miles from southeast Austin in Travis County to the far east end of Blanco County, this large region suffered immense damages from the Halloween flood of 2013, the Memorial flood of 2015, and more from the past. The widespread devastation of families and homes in this watershed in Travis County encouraged the City of Austin, in partnership with the Army Corps of Engineers, to create a program to purchase homes lying in the 25-year and 100-year floodplains. These homes were constructed in the early 1970's, before anyone knew this region was in a dangerous floodplain. The Lower Onion Creek Housing Buyout Program was thus developed in 1999. The City of Austin and US Army Corps of Engineers then worked to get federal funding to purchase properties at risk of structural flooding because of their proximity to Onion Creek and position in the floodplain.

II. Objectives

My main objective for this term project is to learn about the Lower Onion Creek Housing Buyout program from the City of Austin, and learn about their progress, future buyouts, and goals with the properties once the buyouts are completed. I also want to investigate the effects of large flood events on the Onion Creek Watershed in Travis County (Figure 1), and understand how the property buyout neighborhood in the floodplain is affected. After understanding the flood risk, I will investigate the relationship between homes at a higher risk of flooding and the socioeconomic status of the families that live in those homes. More than often, poorer citizens buy homes that lay in the floodplain because they are much cheaper, and then suffer the immense consequences after large flood events such as the Halloween floods of 2013 and the Memorial Day floods of 2015 occur. Lastly, I want to look at the floodplain mapping available for as far back as it goes in the buyout neighborhood—to see how the floodplains have changed over the years as the earth has experienced additional warming and extreme weather conditions due to climate change.

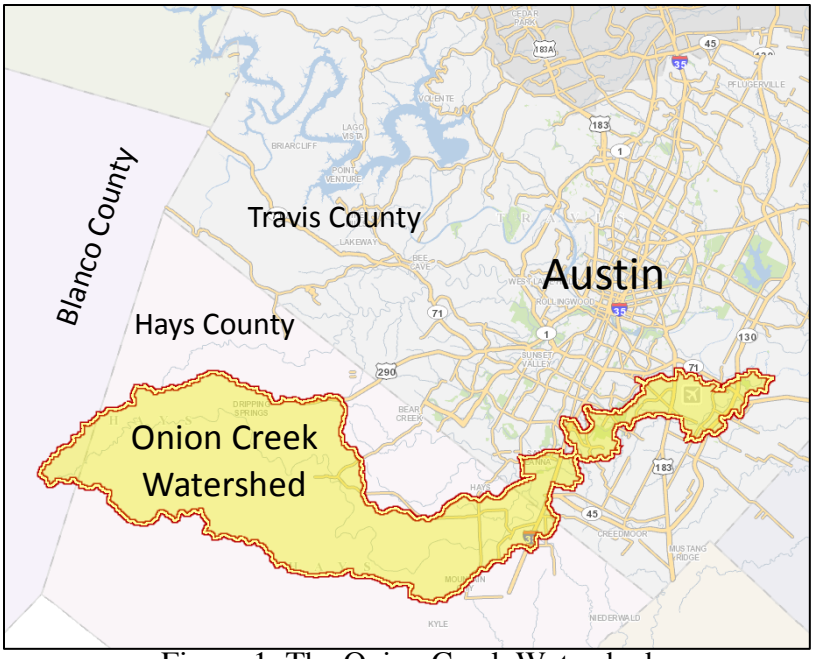


Figure 1: The Onion Creek Watershed

III. Method

In order to understand the housing buyout program, how it works, what progress has been made, and what future plans are in store—I first began at the website of the City of Austin's Watershed Protection Department. Here, the website provides full access to all the project files and details, city council documents, flood mitigation studies, and statistics about the Lower Onion Creek Housing Buyout Program. By navigating this website, all the qualitative information I need can become available with research.

Next, in order to investigate how flooding impacts this buyout neighborhood in southeast Austin, www.austintexas.gov/floodpro was a great resource to access data for floodplain map layers created by The City of Austin's Watershed Protection Department. These layers provide great insight to how susceptible certain neighborhoods are to possible structural flooding during storm events of certain magnitudes (i.e. 25 year, 100 year, 500 year floods). By integrating the National Hydrography Dataset flowlines, subbasins in the watershed, and the watershed outline to the 25-year and 100-year floodplain maps, it becomes clear how the creek interacts with the surrounding landscape, and how some neighborhoods are in more danger than others. I then compared these floodplain maps to FEMA's current National Flood Hazard Layer. Furthermore, I utilized various tools on GIS to investigate the landscape in the property buyout neighborhood, and see how water is conveyed throughout. The tools I used included contour lines, the digital elevation model, flow direction model, percent change in slope, and the height above nearest drainage model.

To properly evaluate the socioeconomic impact on the property buyout neighborhoods, I used the Living Atlas on ArcGIS Online to see how the median household income, social vulnerability, and percent Hispanic population changes based on the neighborhoods in

Onion Creek. I particularly focused on the Lower Onion Creek Housing Buyout neighborhood to see if these three socioeconomic factors could be positively correlated with the homes acquired in these purchases, as well as the homes laying in the 25-year floodplain. I expect a positive correlation for all three factors, since homes lying in any floodplain often have a much lower market value, which means poorer families tend to purchase these homes.

Lastly, after contacting the floodplain office at the City of Austin's Watershed Protection Department, I was able to gain access to the floodplain maps over the years, dating back to 1973. The early maps were digitized from the original drawings. Analyzing these maps helps make sense of how these homes in the Lower Onion Creek Project Buyout neighborhood were constructed in the 1970's, even though they are in the middle of the 25-year floodplain now.

IV. Results and Discussion

i. The Lower Onion Creek Housing Buyouts

The Lower Onion Creek Housing Buyout Program began in 1999, where the US Army Corps of Engineers worked in partnership with the City of Austin to create the idea of acquiring homes at a high risk of flooding in southeast Austin. In particular, this project focused on the southeast corner of William Cannon Drive and S. Pleasant Valley Drive (as seen in Figure 2). Highlighted in pink in Figure 2, all these homes were acquired under the US Army Corps of Engineers Project, and the remaining yellow and green homes were of lower priority—and were left to the City of Austin (without the Corp's federal funding) to complete the property buyouts. All the homes in pink and green are in the 25-year floodplain zone, where the remaining yellow homes are in the 100-year floodplain zone. US Congress passed this US Army Corps of Engineers Project in 2007, it received the remainder of the funding by 2014, and almost all of the buyouts were completed by May 2017. The catastrophic Halloween Floods of 2013 expedited the funding process for the City of Austin, as many of the homes in this buyout region were severely damaged by the flood, as seen in Figure 3.

The 483 Corps Buyouts were completed by May 2017, along with 320 out of 340 additional City of Austin purchases. The City of Austin has spent around $100 million to date for this neighborhood, and has demolished all but one of the homes purchased as of last week. Of the 290 acres purchased, 190 will undergo ecological restoration to ensure that storm water can be conveyed and treated properly and diminish downstream flooding in and around Onion Creek. The Army Corps of Engineers is currently designing the recreational area for the remaining 100 acres of land.

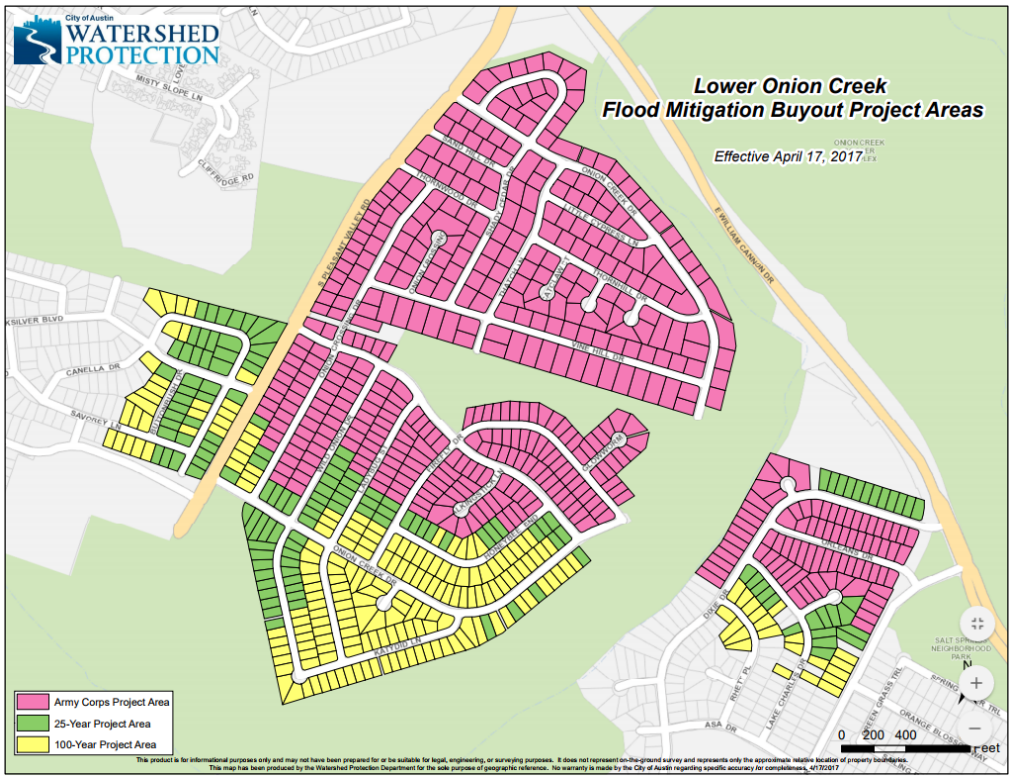


Figure 2: The Lower Onion Creek Flood Mitigation Buyout Project Areas

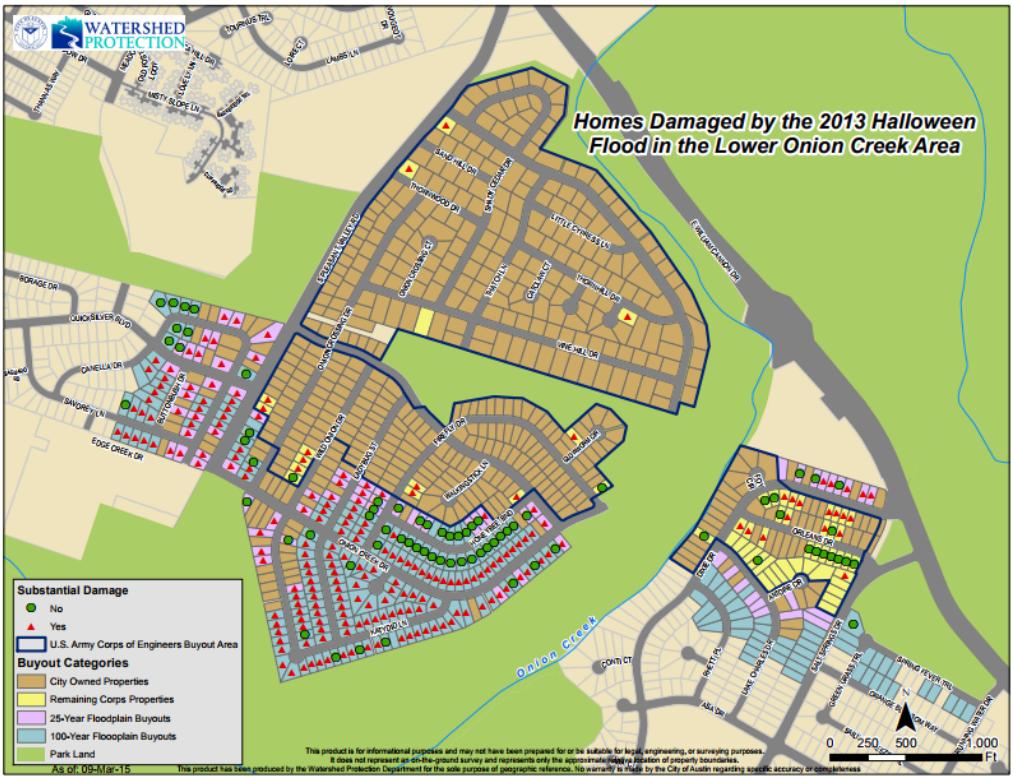


Figure 3: Damage to Homes from Halloween Flood of 2013

The future for the City of Austin's flood mitigation through property buyouts has extended into new neighborhoods—namely the Pinehurst and Wild Dunes neighborhoods further south in Lower Onion Creek from the initial property buyout neighborhood. These two neighborhoods are also at a high risk for structural flooding (as seen in Figures 4 and 5), and have therefore been deemed as high priority for future buyout plans. The legend on the bottom right corner of Figure 4 shows that the potential structural flooding inside these homes can reach as high as 3.7 feet deep. The City of Austin's Watershed Protection Department has pitched a flood mitigation plan to City Council, and plans on getting funding to begin buyouts in this region very soon.

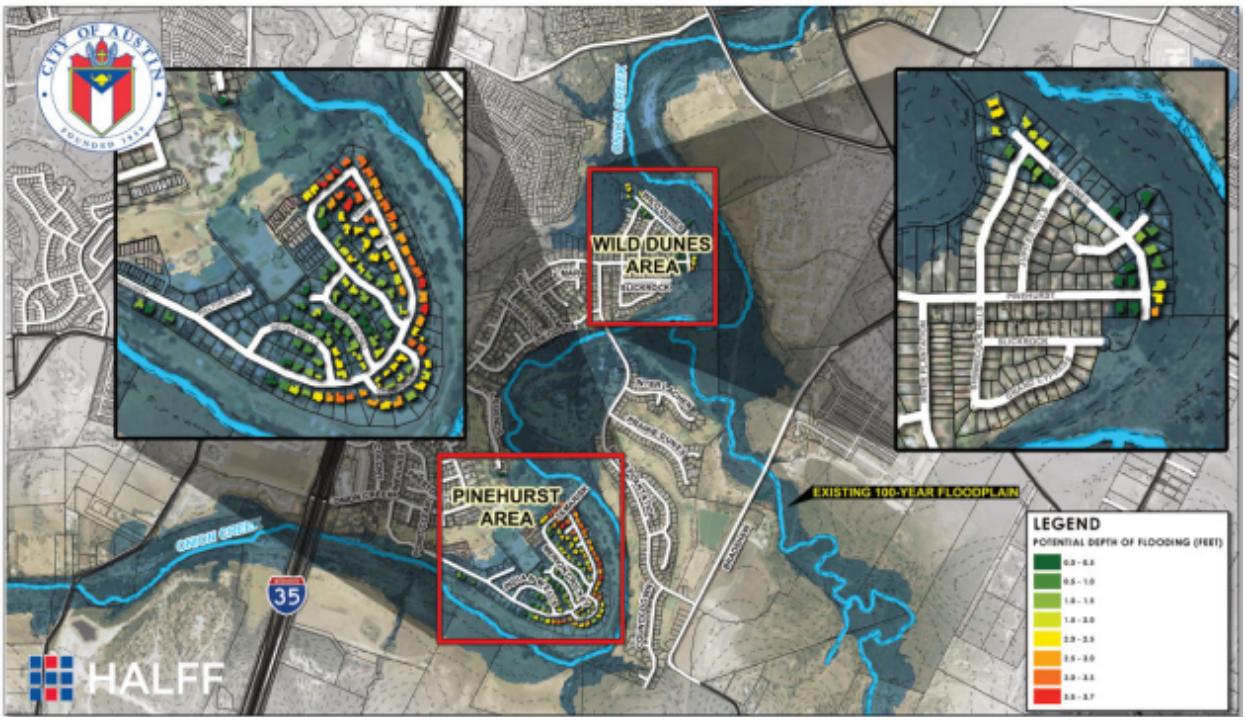


Figure 4: 100-Year Floodplain and Flood Risk in Wild Dunes and Pinehurst Neighborhoods

Figure 5: Close-Up View of Flood Risk in Wild Dunes (left) and Pinehurst (right) Neighborhoods

ii. Flooding Effects on Project Buyout Neighborhood

Figures 6 and 7 are the GIS maps created to show the floodplain models in both Travis and Hays County throughout the Onion Creek watershed. The 25-year floodplain can be seen in bright red, and the 100-year floodplain is shown in bright blue. The floodplain map, as seen in Figure 6, was integrated with the watershed subbasins layers (for both counties), the NHD flowlines layer, and the boundary for the Onion Creek Watershed. Layering the NHD flowlines layer is essential to see how the creek and stream flowlines overlap with the floodplains. Figure 7 more explicitly shows how the 25-year and 100-year floodplains overlap with the flowlines, as well as how it encompasses the entire Lower Onion Creek Housing Buyout Program neighborhood.

To show the consistency between FEMA and the City of Austin's floodplain maps, Figure 8 shows FEMA's National Flood Hazard Layer, which only maps out the 100-year and 500-year floodplains (therefore excluding the 25-year layer seen for the City of Austin's maps). Comparing Figure 7 and Figure 8, the 100-year floodplain is almost identical. Therefore, having two consistent floodplain maps further verifies the risk in these floodplain regions, and also legitimizes the need for housing buyouts or significant flood mitigation techniques employed in these neighborhoods.

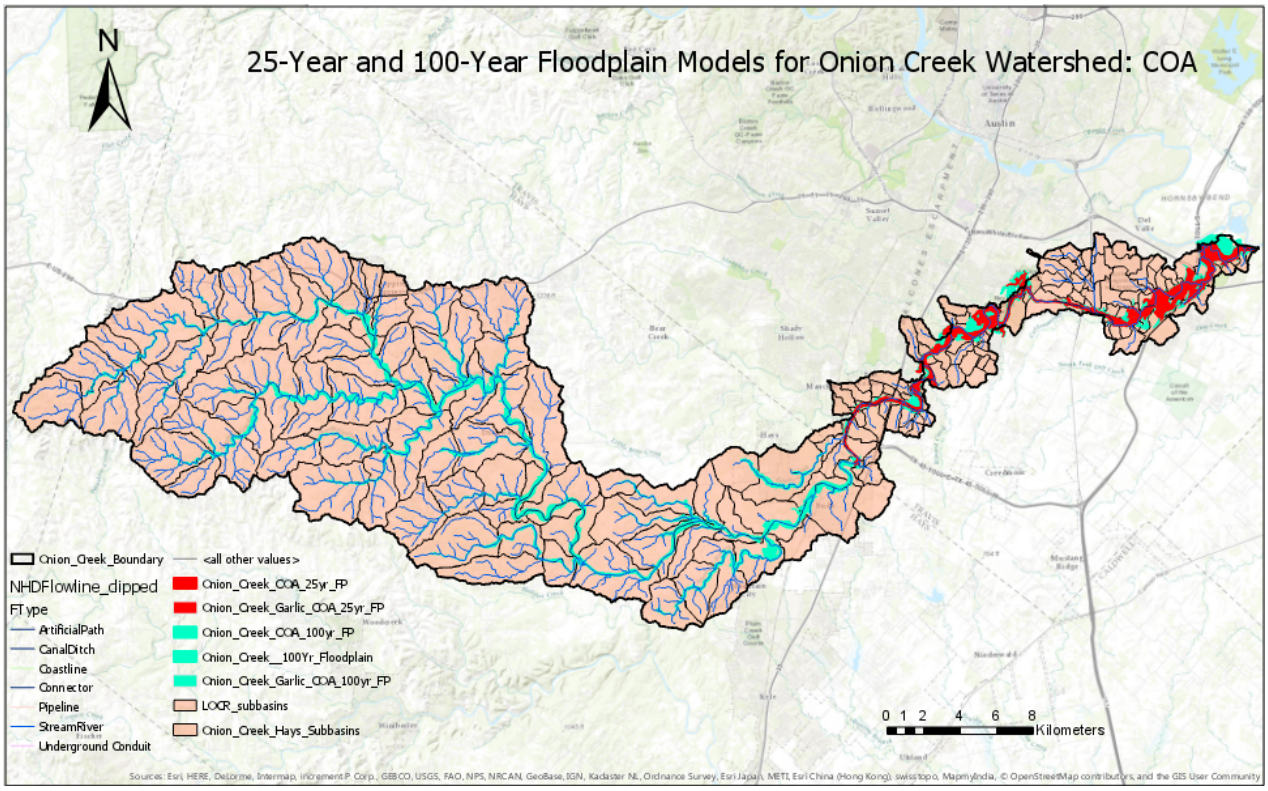


Figure 6: 25-year and 100-year Floodplain Model for Onion Creek Watershed

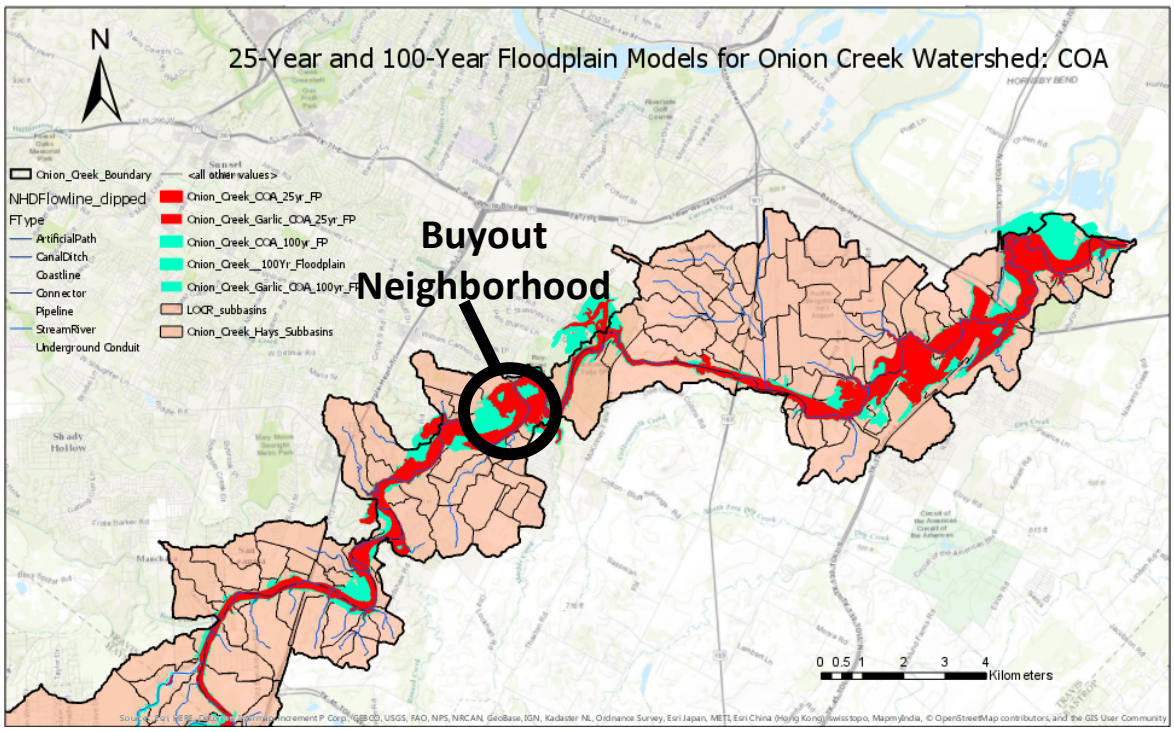


Figure 7: Close-Up View of 25-year and 100-year Floodplains in Onion Creek Watershed

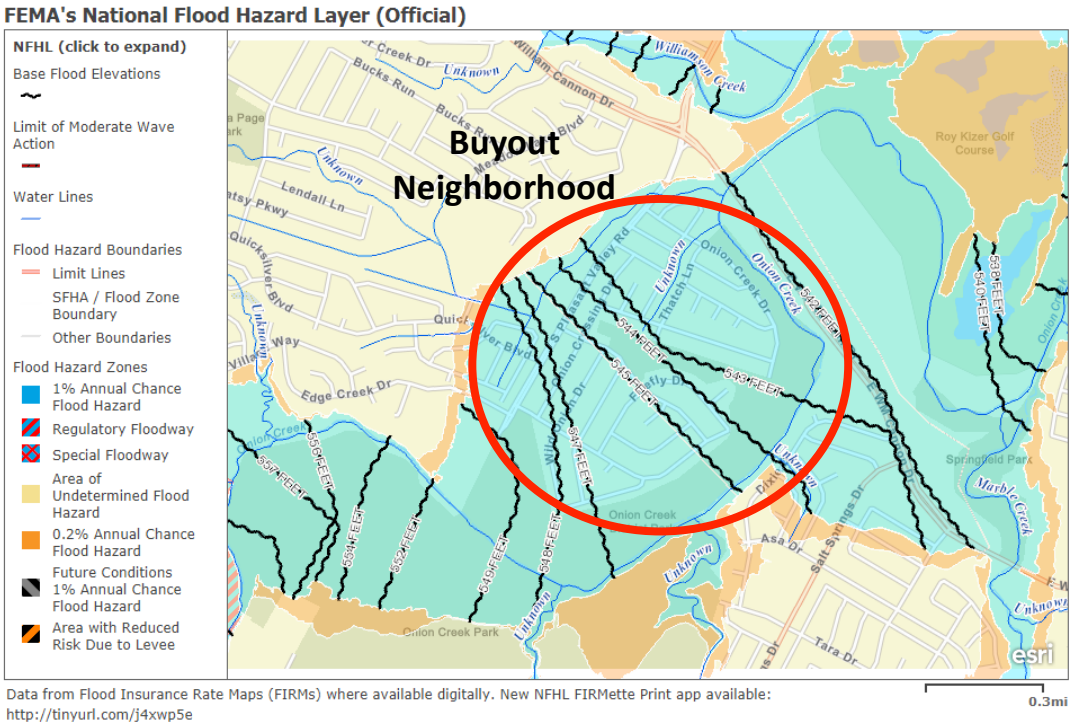


Figure 8: FEMA's National Flood Hazard Layer in Buyout Neighborhood

Next, I utilized numerous GIS tools to analyze the landscape of the housing buyout neighborhood to understand why it is so susceptible to flash floods—and why the floodplain area is so particularly widespread here. The first tool I used was the Contour

tool, where I constricted the analysis area to the watershed boundary—but only focused on the neighborhood of interest. I used 10 meters as my contour interval, and the result in Figure 9 showed that this region is very flat with respect to Onion Creek. Therefore, whenever Onion Creek overflows in a large storm event, the surrounding neighborhoods are highly susceptible to street, yard, and structural flooding. This can also be seen in Figures 10 and 11—where four separate files of the Digital Elevation Model (DEM) were downloaded from the USGS website, joined together (Figure 10), and clipped to fit the Onion Creek Watershed (Figure 11). Figure 10 shows the overall changes in elevation with streams in the watershed, and Figure 11 shows specifically how there is very little elevation change in the buyout neighborhood. This can be seen in the legend; the green color is one small subset of the elevations, but most of this buyout neighborhood is characterized as green.

Next, I utilized the flow direction tool in GIS to see where water tended to flow in the buyout neighborhood in the event of a storm. Figure 12 shows this flow direction model, employing the 8-direction pour model that ESRI uses to demonstrate water movement across a landscape. By looking at the area almost circumscribed by Onion Creek in the buyout neighborhood, it is clear that only the outer area of land right next to the creek flows in the direction of the creek—showing that there is little elevation change that would prevent water from leaving the creek and coming into people's homes. The myriad of flow directions in Figure 12 shows how storm water and creek water could easily become trapped, infiltrate people's yards and homes, and have a difficult time flowing out to its proper conveyance structures.

To convey the same point, Figure 13 shows the percent change of slope in the buyout neighborhood. It is evident that this area does not have proper natural drainage capabilities, which is clear by the fact that a majority of the neighborhood has a percent change of slope less than or equal to 3%.

Lastly, I performed the Height Above Nearest Drainage (HAND) calculation using the CyberGIS TauDEM application from Hydroshare in conjunction with ArcGIS Pro to show flood inundation in the entire Onion Creek Watershed, as well as the property buyout neighborhood (and its specific catchment). Starting with the digital elevation model and NHDFlowline datasets, running a model in the TauDEM application allows the calculation of flow accumulation, and then HAND by using the "D-infinity Distance Down" and "D-infinity Flow Direction" tools. Figure 14 shows a zoomed out view of the HAND map for all the subbasins connected to Onion Creek, where red and yellow colors are the most susceptible to inundation (up to 5 meters in depth). Additionally, using the close-up HAND data and local address points, all the light blue address points in Figure 15 show which properties are predicted to have inundation given the stage height of 11.3 meters (or 37 feet), which is from the Halloween Floods of 2013. These light blue address points in the northern cluster is entirely in the Lower Onion Creek Property Buyout neighborhood. Physical proof of devastation and this model goes to show the need for aggressive methods of flood mitigation in this area. Figures 16 and 17 are the graphs showing flood stage versus time at the stream gauge in Onion Creek at US Highway 183 right next to this neighborhood, provided by the National Oceanic and

Atomospheric Administration (NOAA). Figure 16 shows the stage height of 36 feet at its peak of the storm in 2013, and Figure 17 shows the peak stage height of 23 feet during the Memorial Day floods. Having these values in conjuction with the HAND models provide insight into predicting storm devastation on neightborhoods in the future.

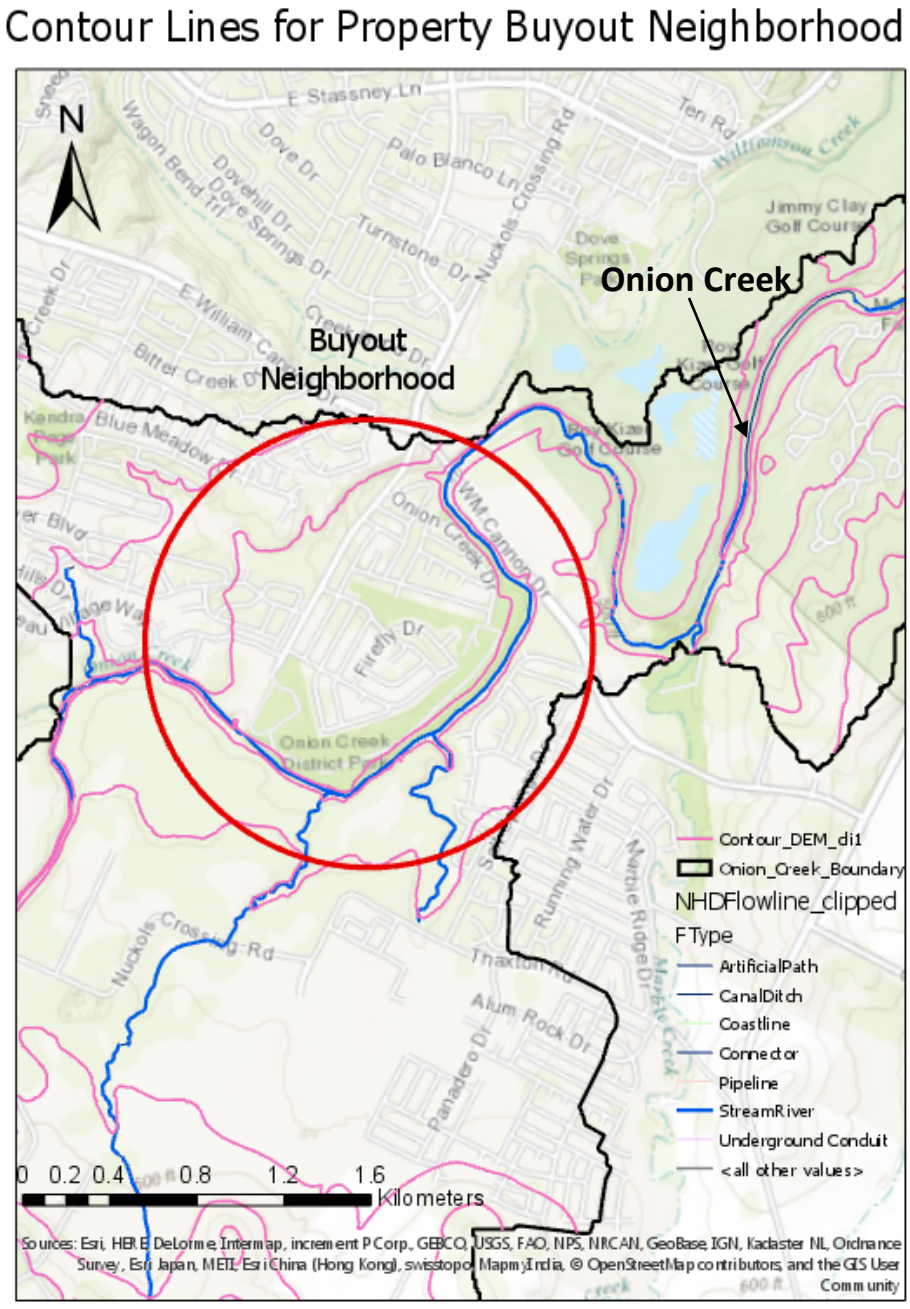


Figure 9: Contour Lines in the Onion Creek Watershed

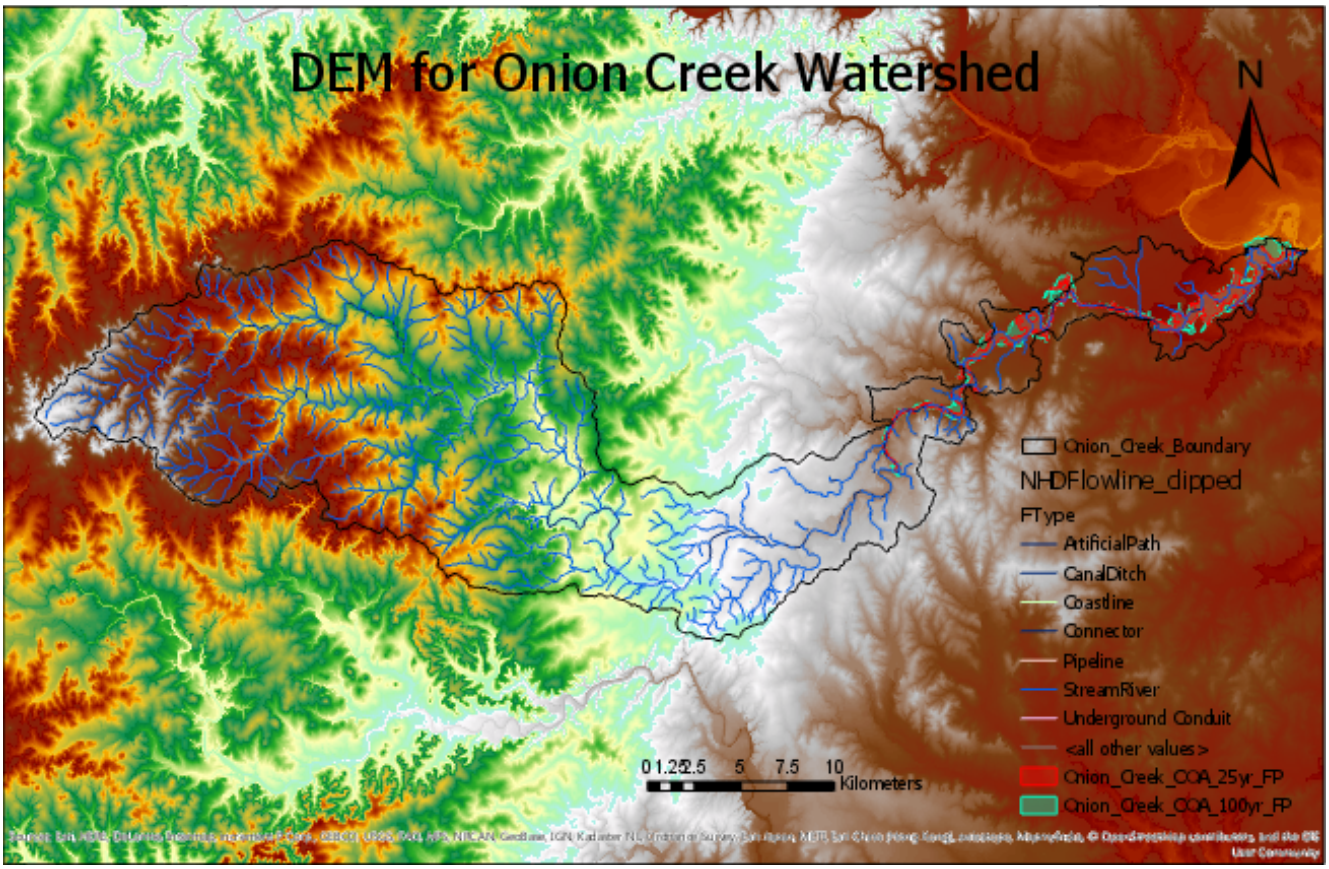


Figure 10: Digital Elevation Model (DEM) for the Onion Creek Watershed

DEM Close-up for Onion Creek Watershed

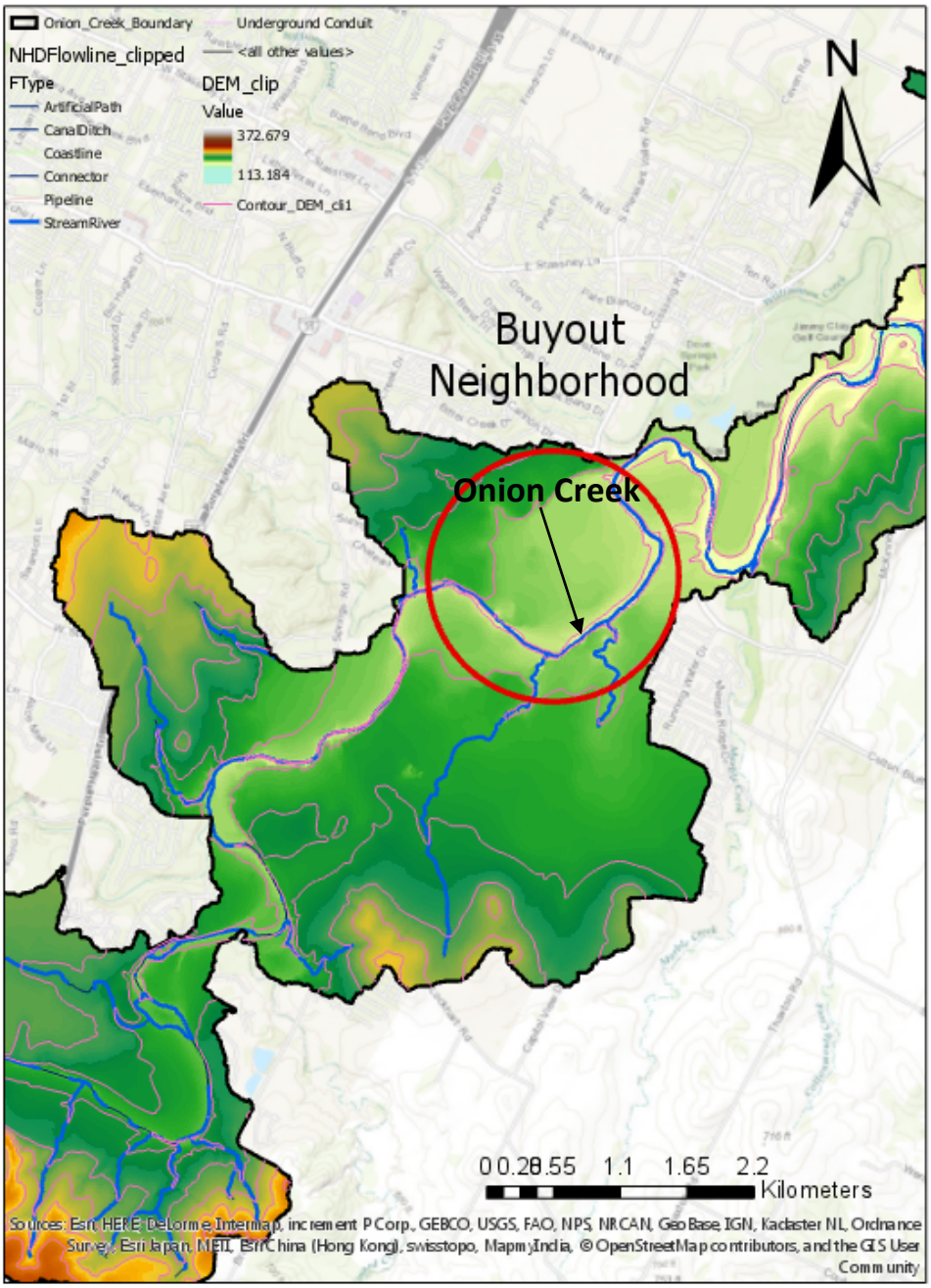
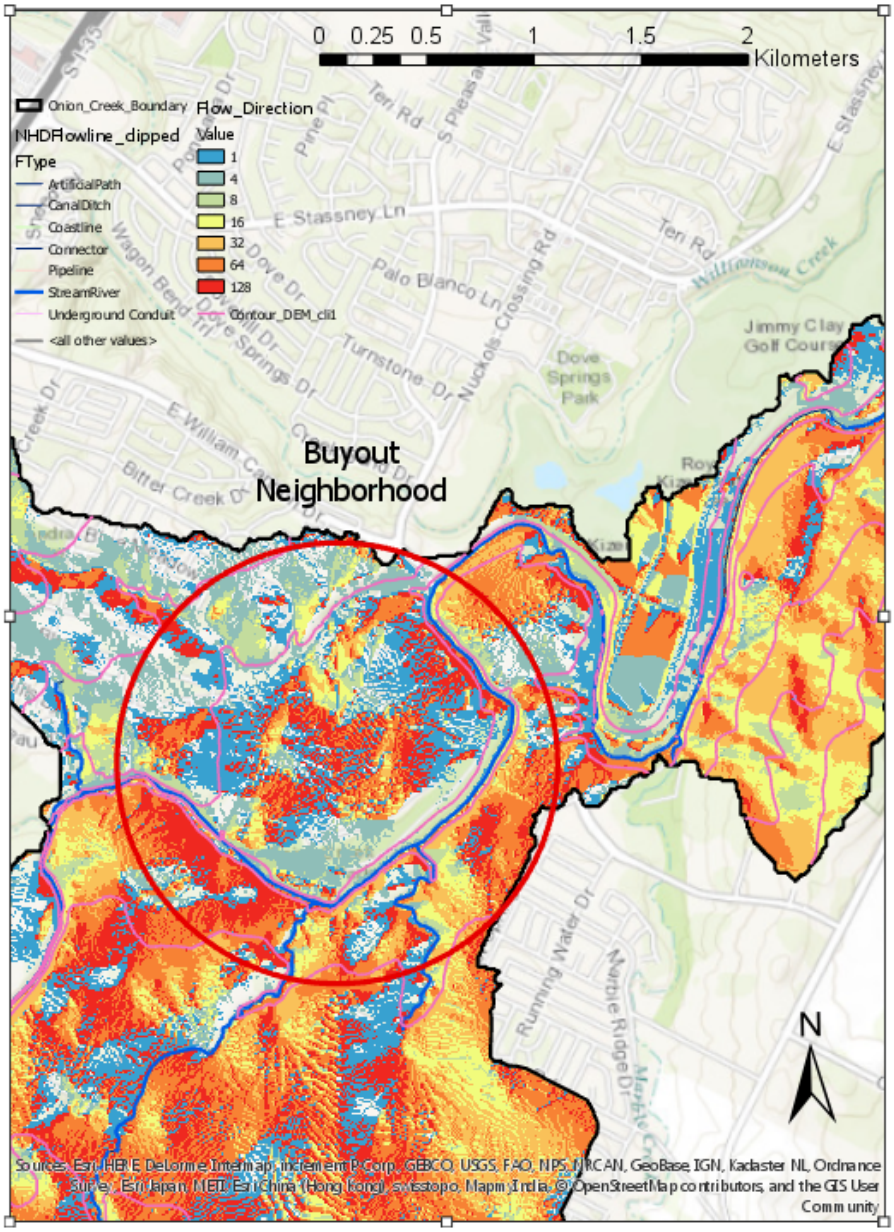
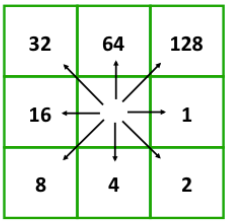


Figure 11: Close-Up View of Digital Elevation Model with Contours in Buyout Neighborhood

Flow Direction in the Property Buyout Neighborhood





ESRI Direction encoding

Figure 12: Flow Direction in Property Buyout Neighborhood (left), 8 Direction Pour Model (right)

Percent Change in Slope in the Property Buyout Region

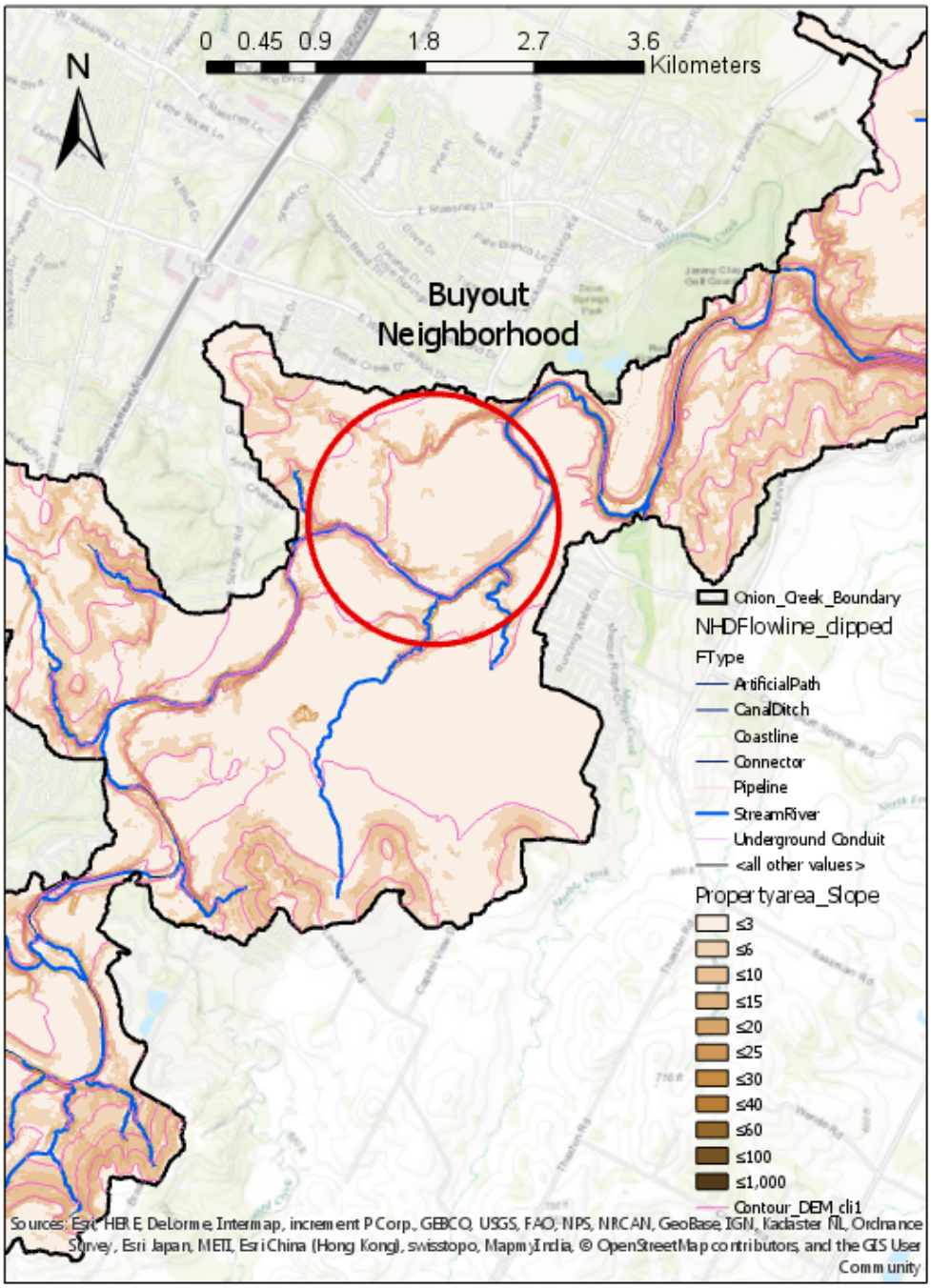


Figure 13: Percent Change in Slope Across Property Buyout Region

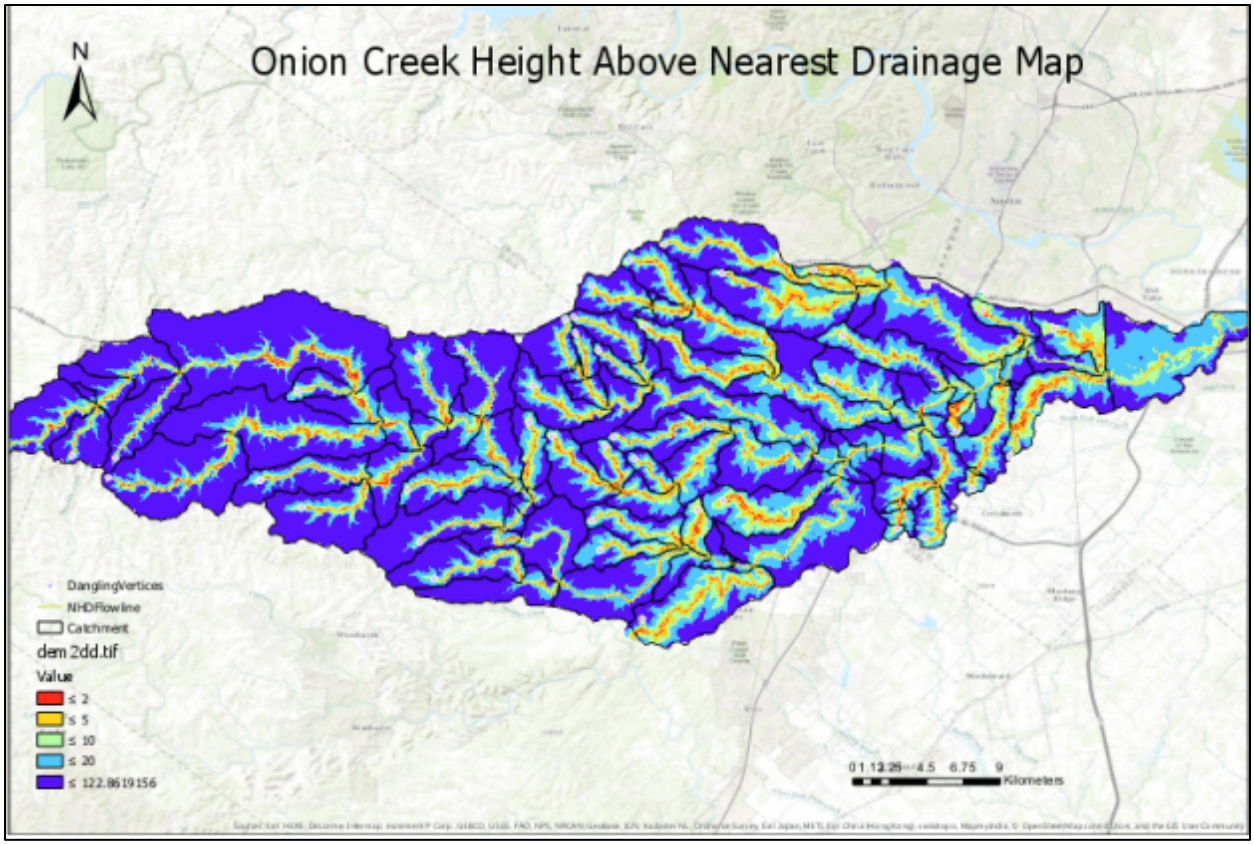


Figure 14: Onion Creek Subbasins Height Above Nearest Drainage Map

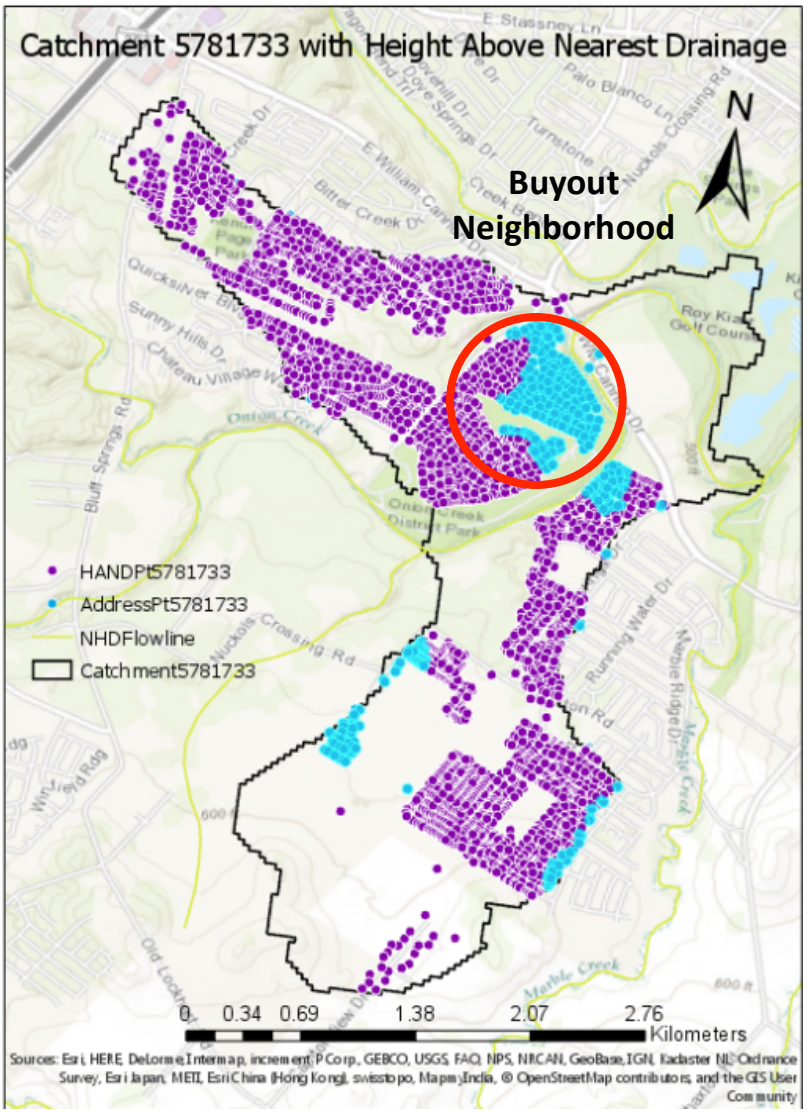


Figure 15: Height Above Nearest Drainage Flooding Catchment with Buyout Neighborhood

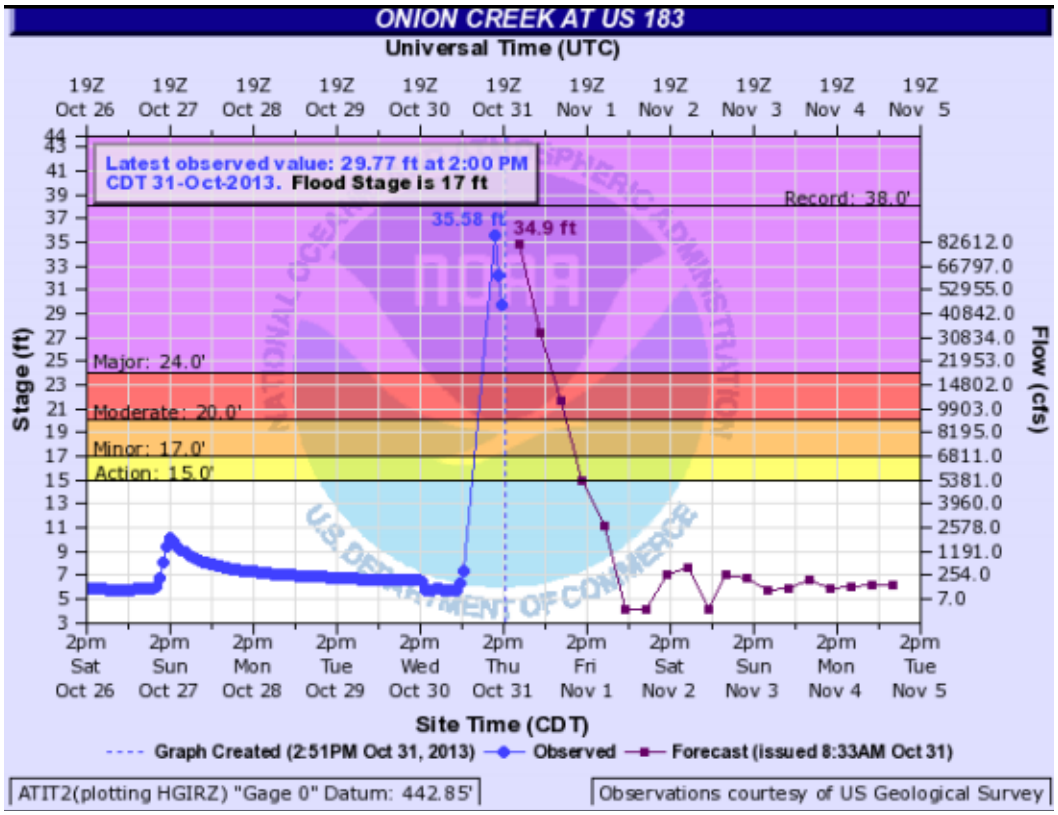


Figure 16: 2013 Halloween Flood Stage Height vs. Time

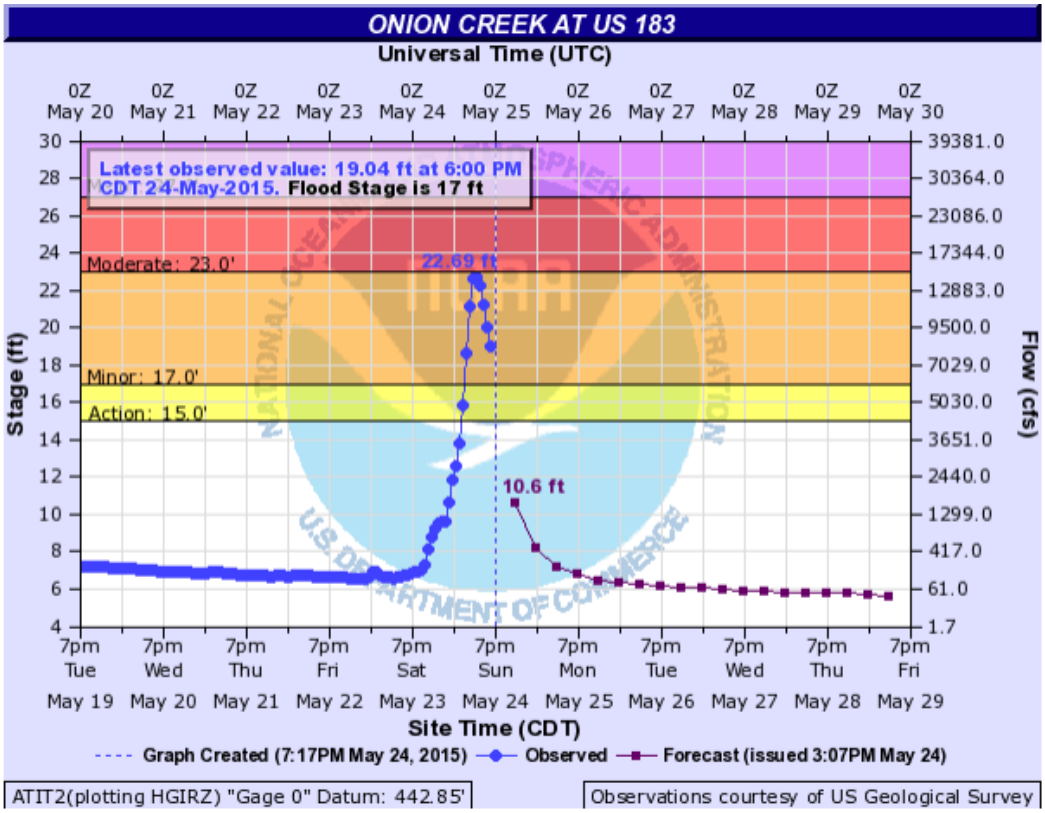


Figure 17: May 2015 Memorial Day Flood Stage Height vs. Time

iii. Socioeconomic Impacts in Property Buyout Neighborhood

Since the buyouts were just completed this year and many properties were purchased after the devastating floods of 2013, I made sure to look at various data from 2010-2012, when many people still lived in this neighborhood prior to being displaced by the program. First, the Median Household Income layer from 2010 data (Figure 18) showed that the exact outline of the buyout neighborhood (seen in light peach color) has the same tract designation, averaging at an income of $24,001 to $39,000 per year. This is compared to the 2010 national average of about $50,000 per year.

Next, the Percent Hispanic by Block Group from 2010 data (Figure 19) showed that this neighborhood has over 30% hispanic population, which is designated in the "very high" category.

Lastly, the Social Vulnerability Score, assessed in 2012, deemed this exact neighborhood to be in the "highest" category for social vulnerability, as seen in Figure 20. This score is based off numerous socioeconomic factors such as median household income, age, disability, home value, women population, minority population, and more.

Prior to the completion of the housing buyouts, there appears to be a strong correlation between median household income, percent hispanic population, and social vulnerability in this particular property buyout neighborhood. There is also a correlation between floodplain zones and these three factors since this neighborhood lies in a dangerous 25-year and 100-year floodplain zone. Homes in the middle of floodplains come with risk, and therefore a much lower price ticket. Families with less disposable income and minority families purchased these homes, and then suffered the consequences once large storm events came through the region. Therefore, there seems to be a disproportionately large effect of structural flooding on neighborhoods comprised of lower income and minority citizens.

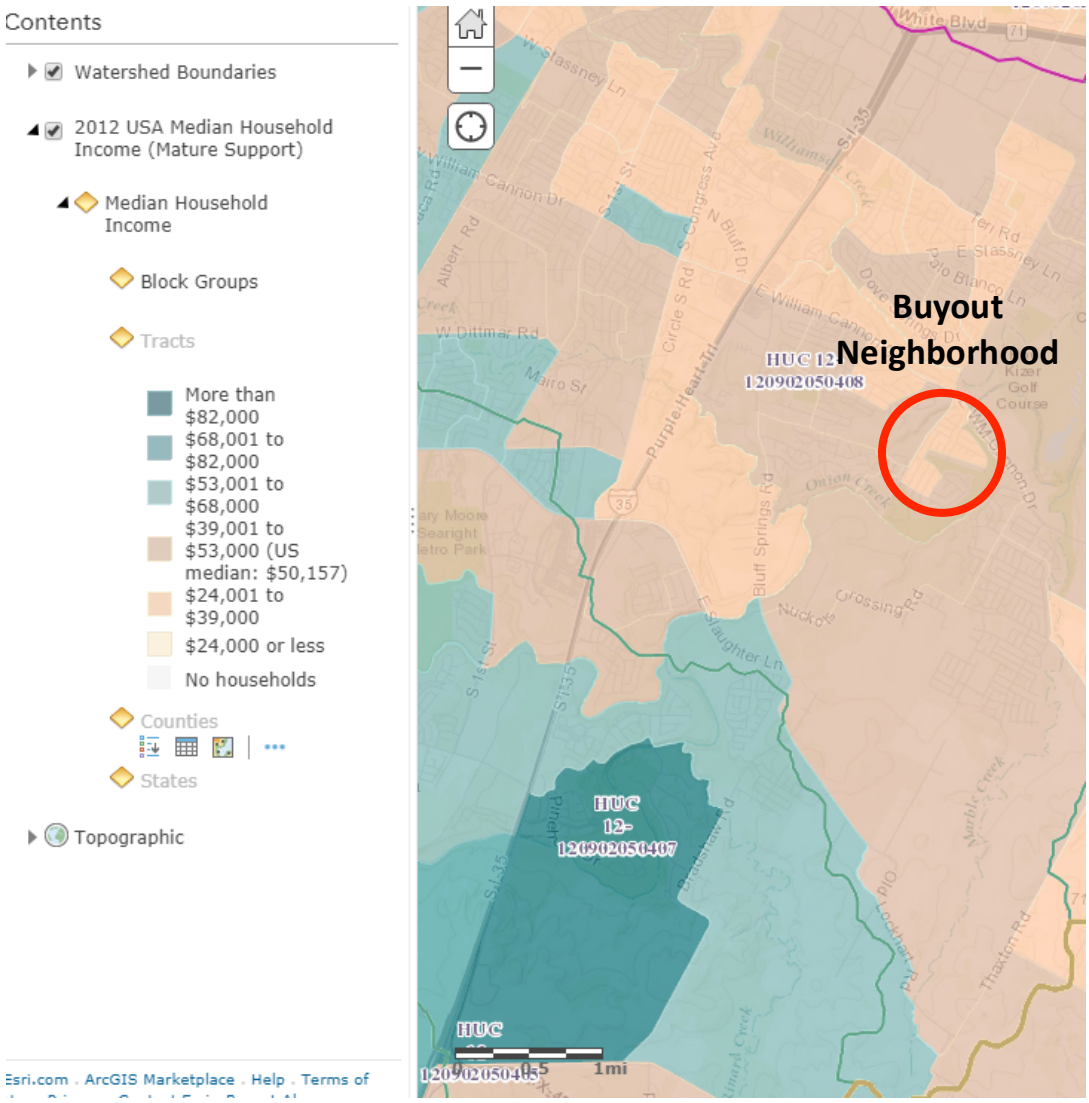


Figure 18: Median Household Income in Buyout Neighborhood and Surroundings (2012)

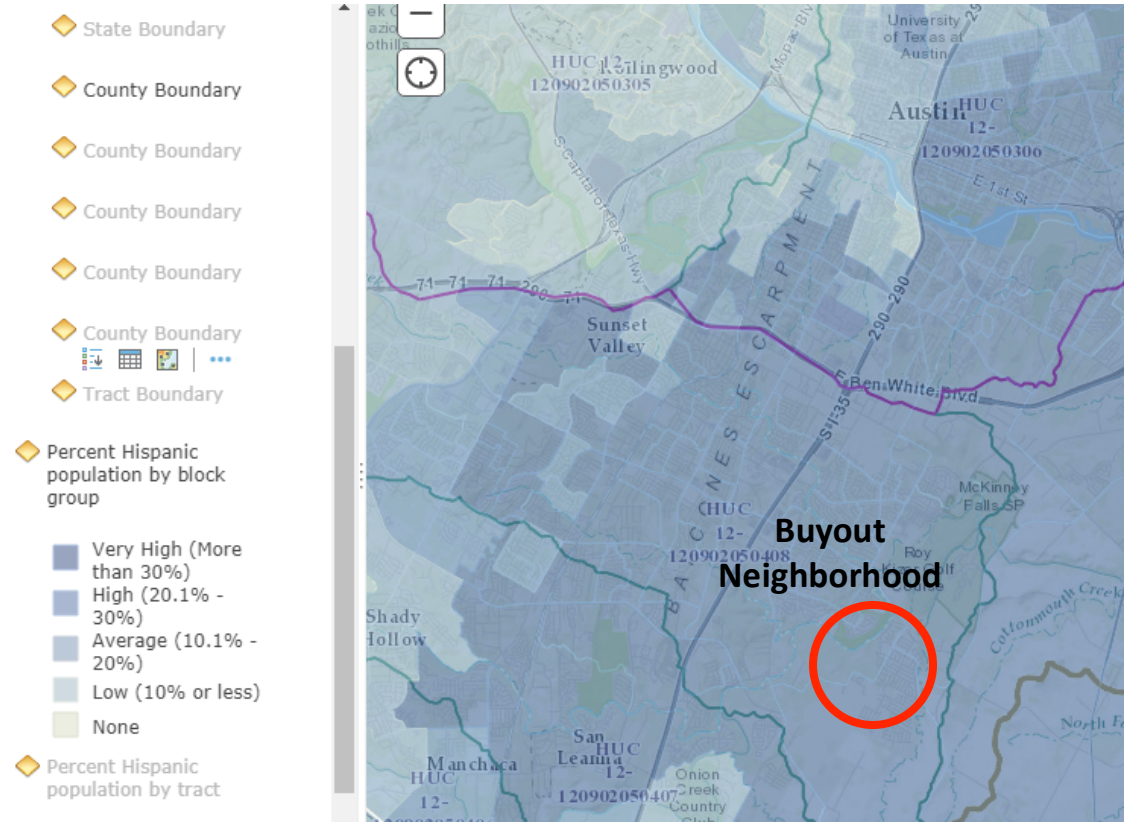


Figure 19: Percent Hispanic Population by Block Group in Buyout Neighborhood (2010)

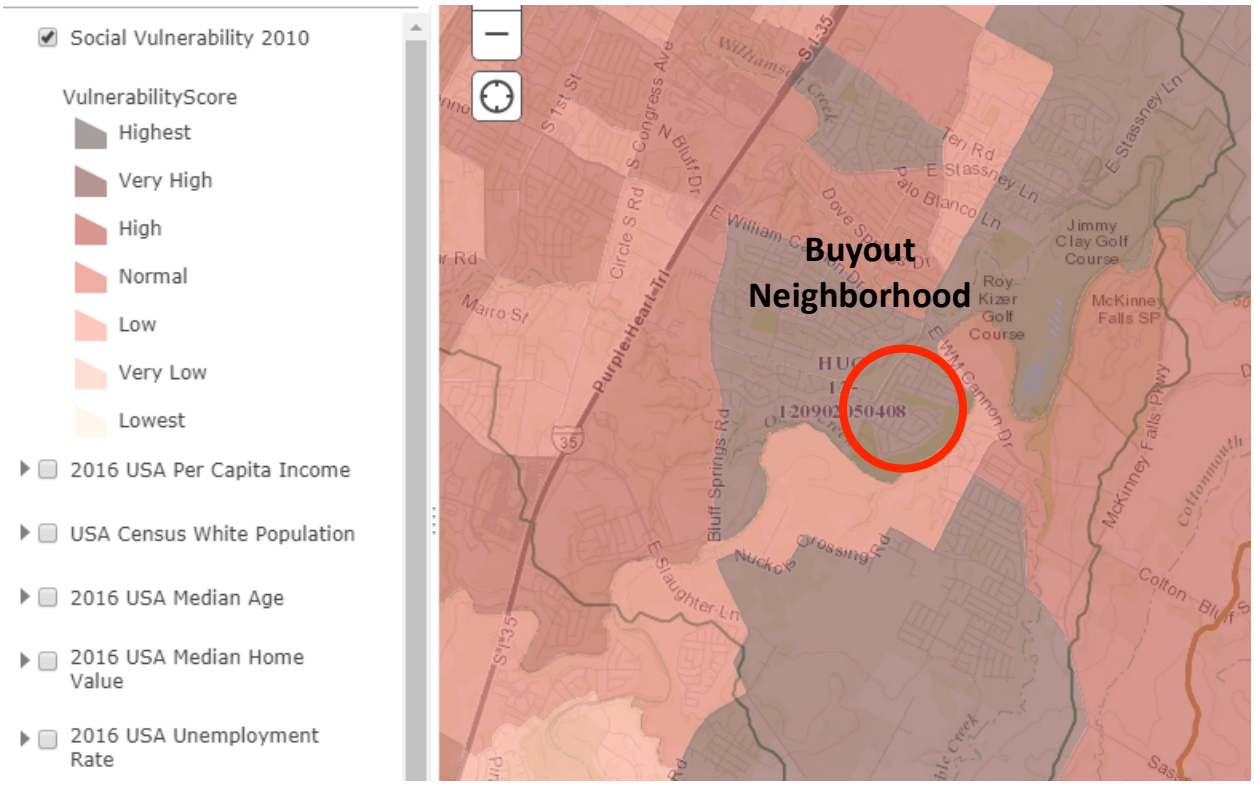


Figure 20: Social Vulnerability Score (2010) in Property Buyout Neighborhood

iv. Floodplain Evolution from 1973 to Now, provided by the City of Austin-Watershed Protection Department.

From 1973 to 2017, there have been substantial changes to floodmaps. This can be attributed to improved engineering techniques and technologies, increased resources spent on LIDAR and surveying, and climate change. Beginning in 1973, the US Army Corps of Engineers Flood Study (Figure 21) that was digitized from a scanned map shows a considerably large 100-year floodplain, shown in dark blue. Next, one of the first FEMA floodplain maps from 1978 (Figure 22) shows an almost identical floodplain to Figure 21, most likely because it had not changed significantly over the course of those 5 years. Next, FEMA's floodplain map from 1982 (Figure 23) differs highly from the previous two—the 100-year floodplain shifts significantly to cover the areas directly next to Onion Creek, and hardly intrudes into the neighborhood. The biggest shift comes next, from that 1982 to the 1993 Flood Insurance Rate Map, as seen in Figure 24. The 1993 map has the 100-year floodplain fully engulfing the property buyout neighborhood, where it only effected a handful of homes only 11 years before. From here on out, the maps after 1993 as seen in Figures 25 and 26 continue to encompass the property buyout neighborhood—showing that it is, and continues to be at a high risk during any 100-year storm event. The floodplain maps for 2000 (Figure 25) and 2008 (Figure 26) get larger every time, showing that this trend can continue indefinitely into the future.

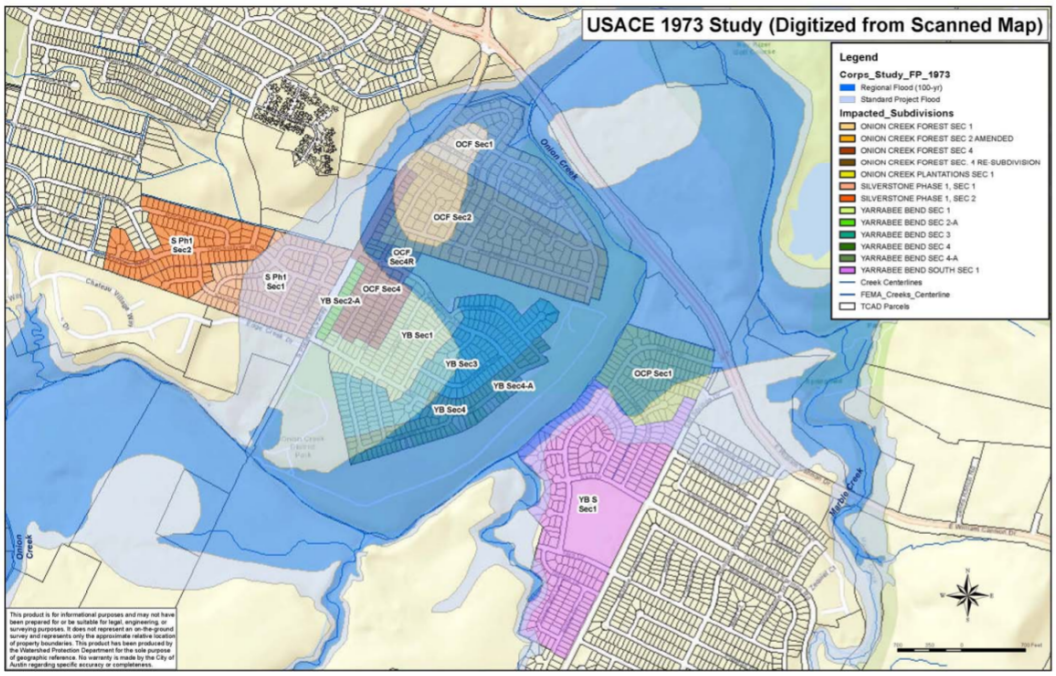


Figure 21: USACE 1973 Flood Study

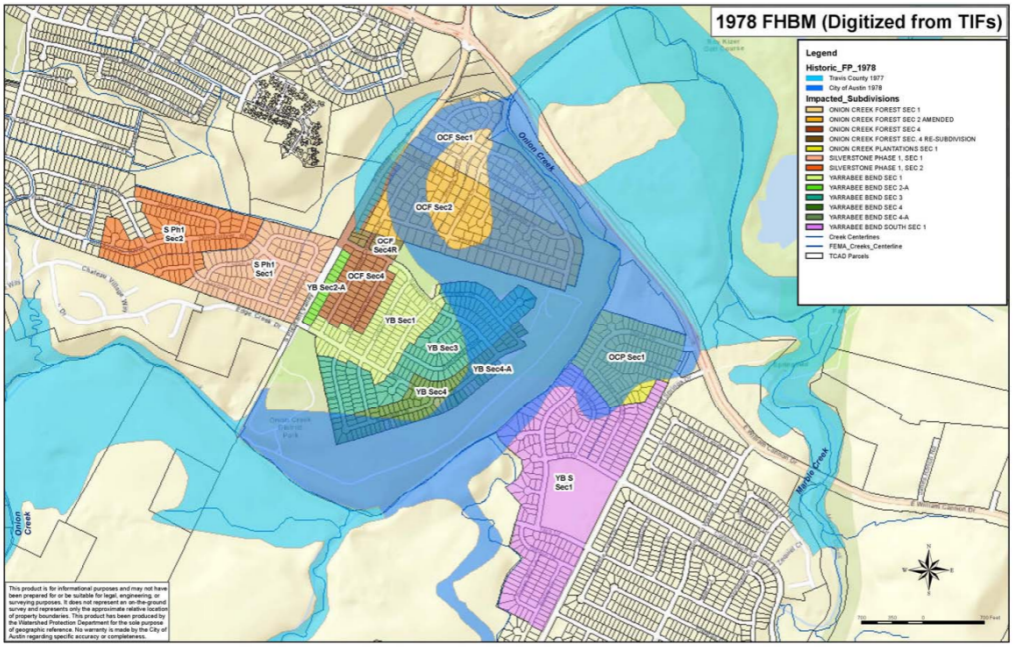


Figure 22: FEMA 1978 Flood Hazard Boundary Map

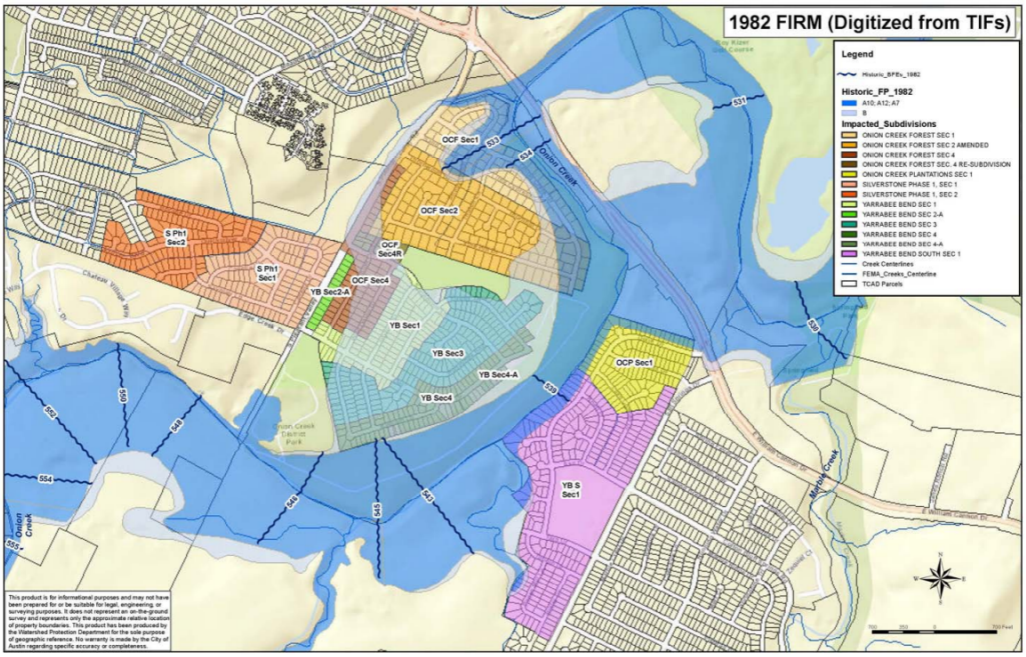


Figure 23: FEMA 1982 Flood Insurance Rate Map

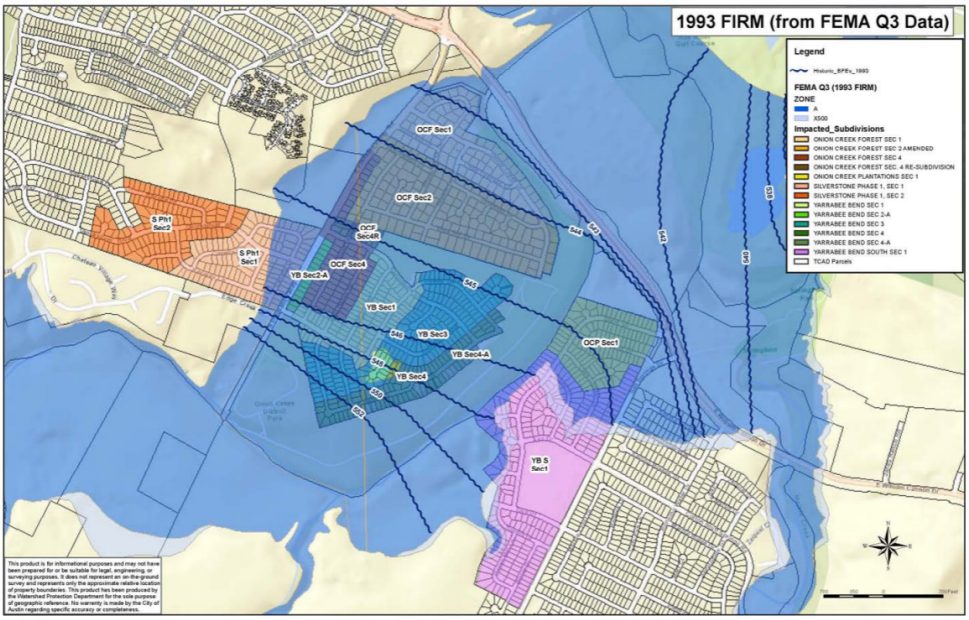


Figure 24: FEMA 1993 Flood Insurance Rate Map

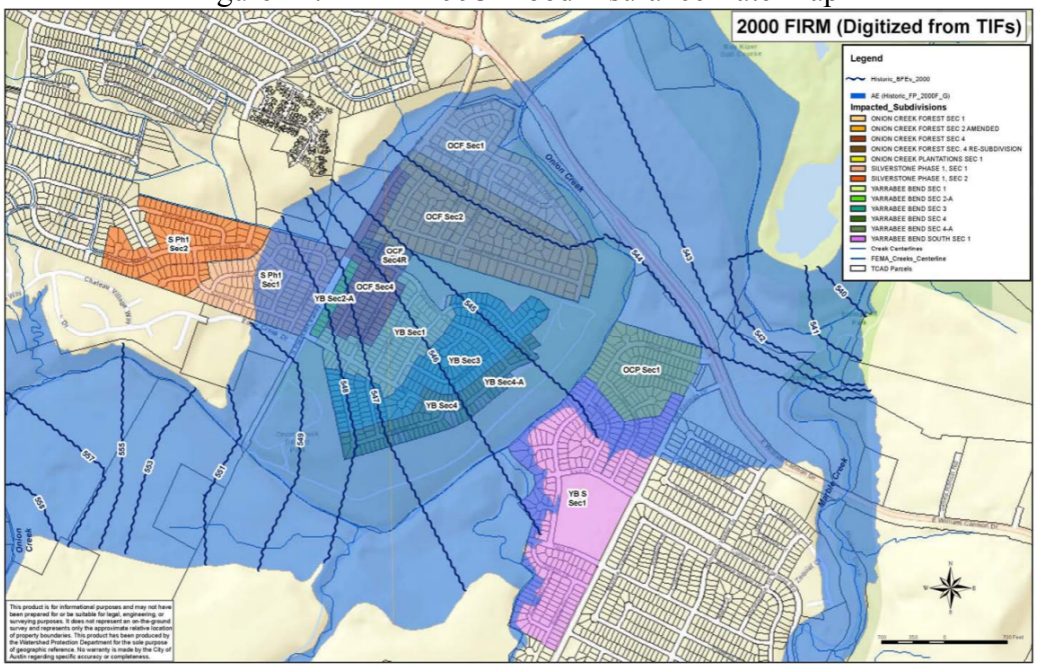


Figure 25: FEMA 2000 Flood Insurance Rate Map

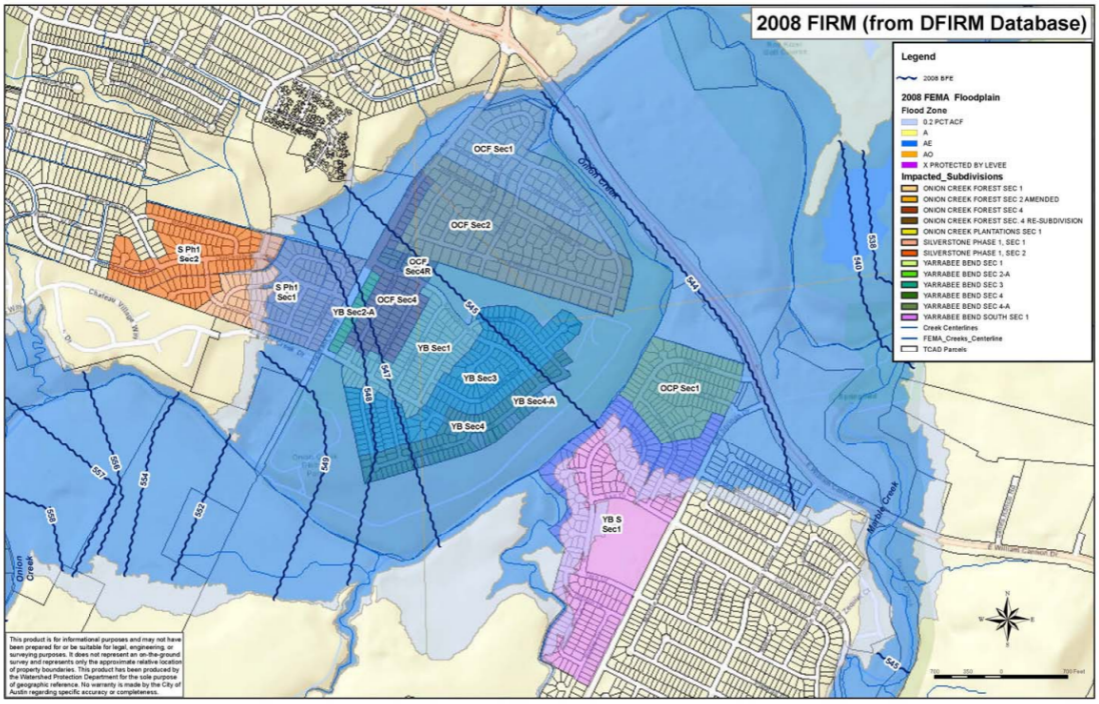


Figure 26: FEMA 2008 (Current) Flood Insurance Rate Map

V. Conclusion

Our society is becoming more urban and less rural, the population is increasing globally, climate change is becoming more severe, water resources are becoming more stringent, weather patterns are becoming less predictable, and aggressive flood mitigation is becoming more important than ever before. With a growing population and a huge migration to cities across the world, ensuring the safety of citizens is of the utmost priority. In Austin, TX, for example, weather severity means a higher frequency of flash floods in this region, and an increasing number of people in danger. The Onion Creek Watershed is one of the worst regions in Austin for flash floods. From past storm events, this region has seen the most extensive damage to people's homes. The City of Austin, in partnership with the United States Army Corps of Engineers, created the Lower Onion Creek Housing Buyout Program to help mitigate the devastating effects of these floods on families. This was accomplished with millions of dollars of federal funding to buy all these homes located in the 25-year and 100-year floodplains, and allow the families to move elsewhere with the money from selling their home at market-price value. This flood mitigation technique is not ideal since it involves displacing families, but was essential to keeping this area and the families in it safe. ArcGIS is an incredibly versatile tool that illustrates the way water moves throughout a region, how some neighborhoods are more susceptible to flooding than others, can quantify the magnitude of flooding across a watershed or even an individual home, and can show who may be the most effected by floods, depending on the region analyzed. Floodplain maps are being constantly updated and our society is becoming increasingly informed through the internet and social media. Future generations can have access to floodplain maps and GIS tool maps to help inform them of potential flood risks and making housing decisions in the future.

Sources:

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