Chapter 1: Planning Region Description

Introduction: The Regional Flood Plan in Context

Origins of the State Flood Planning Process

In Texas, the billion-dollar flood disaster is becoming a regular occurrence. Between 2015 and 2017, flooding alone caused nearly $5 billion in damages to Texas communities. When considered in conjunction with the impact of Hurricane Harvey, the total cost in 2017 approached $200 billion in financial losses ((NOAA), 2021) and nearly 100 deaths. As the state grappled with how to better manage flood risk and reduce loss of life and property from future disasters, the Texas Water Development Board (TWDB) prepared the first ever statewide flood assessment, which described Texas' flood risks, provided an overview of roles and responsibilities, and included an estimate of potential flood mitigation costs and a summary of stakeholder views on the future of flood planning.

This plan was prepared because:

- Flood risks, impacts and mitigation costs had never been assessed at a statewide level
- Flood risks pose a serious threat to lives and livelihoods
- Much of Texas is unmapped or uses out-of-date maps (Peter M. Lake, 2019).

The TWDB presented its findings to the 86th Texas legislative session in 2019. Later that year, the Legislature adopted changes to Texas Water Code §16.061 which established a regional and state flood planning process led by the TWDB. The legislation provided funding to improve the State's floodplain mapping efforts and to develop regional plans to mitigate the impact of future flooding. Regional flood plans for each of the State's 15 major river basins must be submitted to the TWDB by January 10, 2023. An updated version of the regional flood plans will be due every five years thereafter. (TWDB Flood Planning Frequently Asked Questions, 2021)

Overview of the Planning Process

The Lower Brazos Flood Planning Region (also known as Region 8) is one of fifteen (15) Texas river basins preparing a flood plan. Given the diverse geography, culture and population of the state, the planning effort is being carried out at a regional level in each of the State's major river basins. When complete, the TWDB will compile these regional plans into a single statewide flood plan and will present it to the Legislature in 2024. Regional flood plans are required to be based on the best available science, data, models, and flood risk mapping. The Legislature allocated funding to be distributed by the TWDB for the procurement of technical assistance to develop the flood plans.

Who's Preparing the Plan?

The TWDB has appointed Regional Flood Planning Groups (RFPG) for each region and has provided them with funding to hire a technical consultant to prepare their plans. The TWDB administers the regional planning process members through a contract with the planning group's sponsor who is selected by the RFPG. The Lower Brazos Flood Planning Group chose the Brazos River Authority (BRA) to serve as its sponsor. The sponsor's role is to provide support for meetings and communications and to manage the

technical consultant contract. The RFPG selected the Halff Associates Team as their technical consultant to prepare this plan.

The RFPG's responsibilities include directing the work of their technical consultant, soliciting, and considering public input, identifying specific flood risks, and identifying and recommending flood management evaluations, strategies, and projects to reduce risk in their regions. To ensure a diversity of perspectives are included, members represent a wide variety of stakeholders potentially affected by flooding, including:

- Agriculture
- Counties
- Electric Generation Utilities
- Environmental Interests
- Flood Districts
- Industry
- Municipalities
- Public
- River Authorities
- Small Businesses
- Water Districts
- Water Utilities

Even though each basin has a different leadership team, the TWDB provided detailed specifications to guide the preparation of the flood plans for each basin. When complete, the Regional Plans will outline a path forward to reducing existing risk to life and property and improved floodplain management data and practices. They will also identify potential Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs) and Flood Mitigation Projects (FMPs) which may be appropriate for future study and funding.

Data Sources

To ensure that flood plans are based upon consistent and reliable information in every basin, the Texas Water Development Board compiled GIS data resources in the Texas Flood Planning Hub. GIS layers are provided for:

- Critical infrastructure
- Flood infrastructure
- Flood risk
- Hydrology
- Jurisdiction boundaries
- Parks
- Population
- Property
- Terrain
- Transportation

A dedicated GIS team from Halff Associates organized and analyzed this data for the Lower Brazos Flood Planning Region, identified additional data sources needed to meet the TWDB's objectives and used all of the data to prepare the illustrative maps included in this report.

To supplement the data provided by the TWDB, Halff Associates, Inc. also developed a Lower Brazos RFPG - Stakeholder Survey to gather data from individuals with flood related responsibilities. At least two recipients from each community received this detailed survey to increase response rates. The total number of recipients in any given community varied with the size of the community – larger communities had four to five recipients, while smaller communities had two to three. Respondents provided contact information and flood-related responsibilities, verified flood information that had already been collected, responded to questions to support the development of the regional flood plan, and verified and provided geospatial data through data uploads and web maps. An interactive web map

allowed survey respondents to draw in both problem areas and proposed projects that were not included in other information about the region.

Public Outreach

Approximately 688 total stakeholders representing entities with flood related responsibilities received the survey in July by way of 553 emails, which included flood planning basics and the survey link. **Figure 1** illustrates all categories of stakeholders that were included in the data collection effort. **Table 1** describes the various methods used to contact stakeholders and the number of stakeholders reached by each effort.

Figure 1: Outreach Efforts and Contacts Made

To ensure everyone had the opportunity to participate, the Halff Associates team in coordination with BRA followed up via 629 emails a week later, including additional stakeholder contacts identified by responders to the first email. Calls went out to 553 recipients who had not yet responded, and a second round of calls was made to 327 recipients. A third and final round of calls was made to 106 recipients who had not responded to the survey and worked for entities with a population greater than 20,000. The result of this outreach effort was a response rate of approximately 11.3%. Survey results are included throughout Chapter 1, and the Chapters to follow.

Table 1: Outreach Efforts to Region 8 Stakeholders

Method of Outreach	Number of Stakeholders Reached
Email 1	553
Email 2	629
Call 1	573
Call 2	327
Call 3	106

Source: Halff Associates

Funding Sources

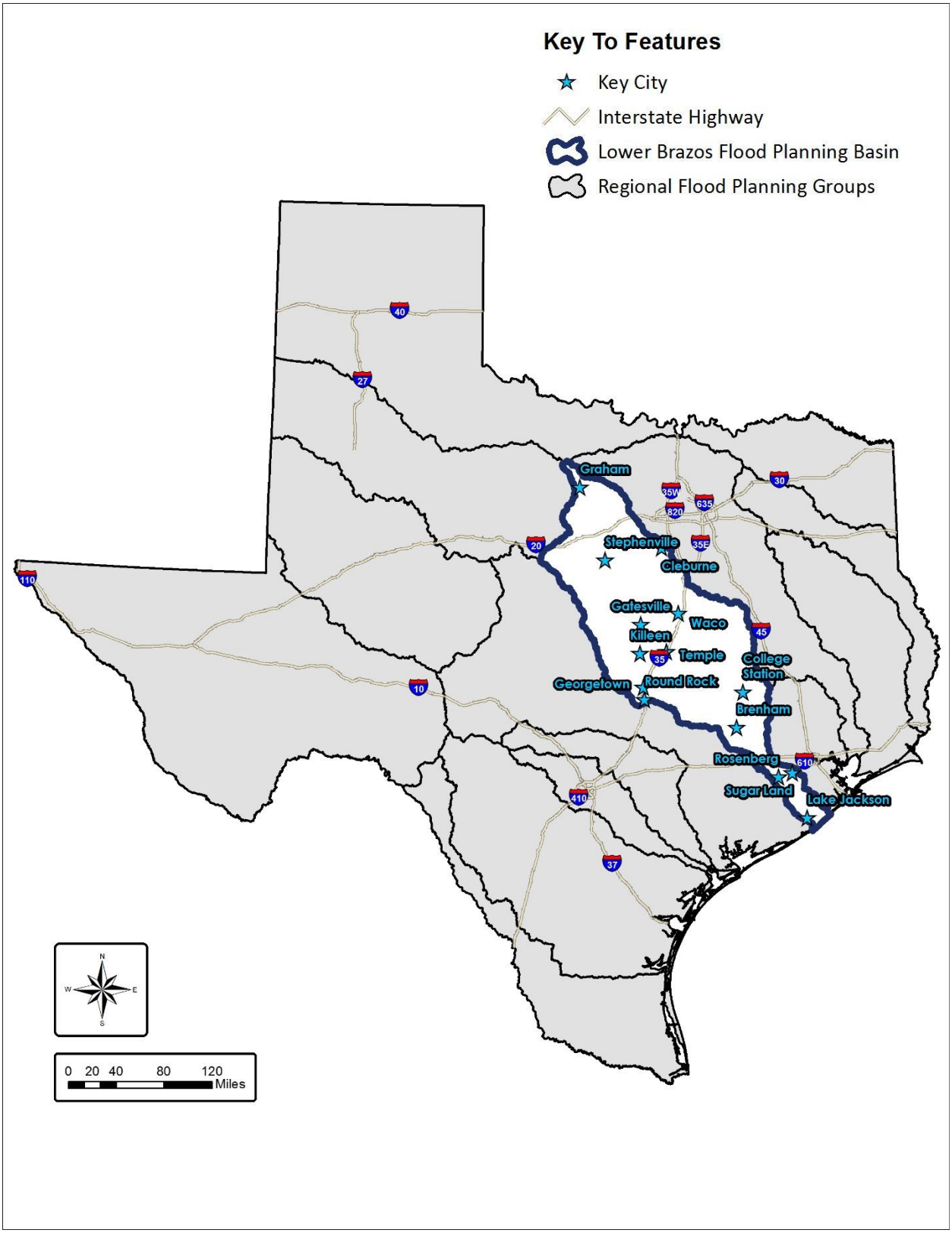
To fund projects identified by these plans, the legislature created a new flood financial assistance fund and charged the TWDB with administering the fund. The Texas Infrastructure Resiliency Fund, as approved by Texas voters in November 2019 is being used to finance the preparation of these plans and will also be used to finance the recommended flood-related studies and projects. Communities who identify future projects aimed at flood mitigation will be eligible for financial assistance in the form of grants and loans from the TWDB. Additional discussion of funding sources available for flood mitigation activities, including federal and state funding, will be discussed in Task 4B of this plan.

1.1 Characterizing the Lower Brazos Regional Flood Planning Region

1.1.a. Social and Economic Character

The Lower Brazos Flood Planning Region (hereinafter Planning Region) covers an area of over 23,000 square miles, 43 counties, and 193 local communities. The Planning Region boundary is determined by the hydrologic characteristics of the Lower Brazos River basin and intersects with several political jurisdictions, including counties, cities, and special districts (refer to **Figure 2**). To better understand the current and future character and conditions of the Planning Region, this section will provide a brief, general description of communities, population, the various types of development, economic activities, and industrial sectors at the greatest risk of flood impacts.

Figure 2: Lower Brazos Flood Planning Region



Municipal Population and Future Growth

Current Population

According population estimates by the Texas Water Development Board, the current population of the Lower Brazos Flood Planning Region is 3,035,000, and constitutes 10 percent of the population for the state of Texas. Of the 193 local communities, there are at least 40 communities with a population greater than 30,000; and 18 communities with a population greater than 50,000, according to the Water User Group Data from Texas Water Development Board (TWDB). The cities with a population between 115,000 and 150,000, include Killeen (Bell County) in the central Lower Brazos River basin, Waco (McLennan County) also in the central area of the basin, Sugar Land (Fort Bend County) in the south of the basin, and Georgetown and Round Rock (Williamson County) on the western boundary of the basin. College Station in Brazos County in the southern area of the Lower Brazos River basin has a population of just over 100,000. **Table 2** details the cities in the Planning Region with a population of over 80,000.

Table 2: Communities in the Planning Region with Population Greater than 80,000

Community	County	Population 2020
Killeen	Bell	144,243
Waco	McLennan	132,512
Sugar Land	Fort Bend	132,098
Round Rock	Williamson	123,598
Georgetown	Williamson	118,763
College Station	Brazos	100,854
Bryan	Brazos	84,196
Temple	Bell	81,736
Cedar Park	Williamson	81,716

Source: Texas Water Development Board

Figure 3 illustrates the total population by census tracts in the Planning Region utilizing 2021 Esri population estimates, which are the most current population estimates for 2021. **Figure 4** describes the 2020 population estimate by Water User Groups for communities in the Planning Region.

Figure 3: **Lower Brazos Flood Planning Region Population by Census Tract**

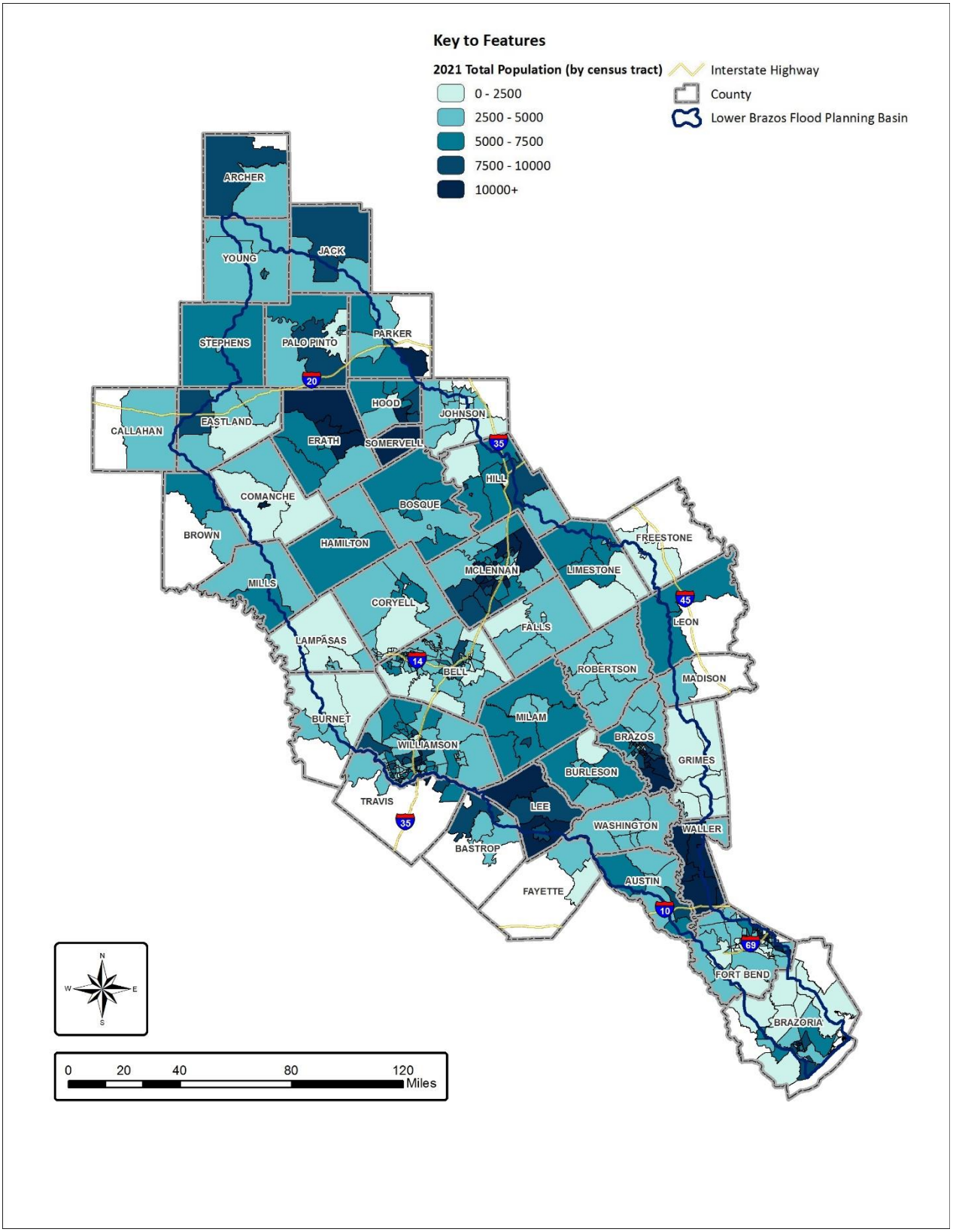
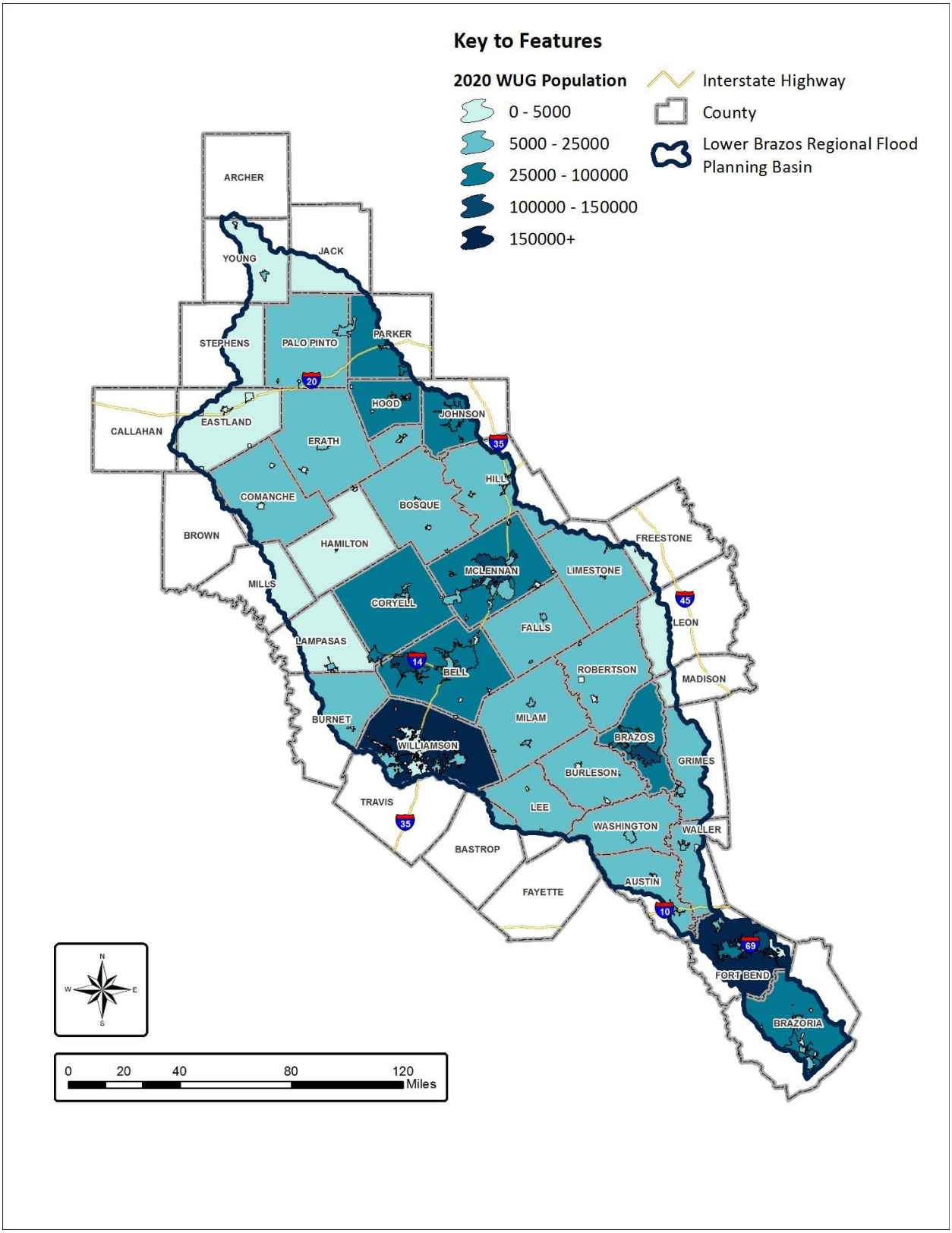


Figure 4: Lower Brazos Flood Planning Region Population by Communities



Projected Growth within the Lower Brazos Flood Planning Region

Based on population projections for Water User Groups by the Texas Water Development Board, the areas within the Lower Brazos Flood Planning Region expected to experience high population growth are primarily the metropolitan areas of Killeen-Temple-Fort Hood in the west central area of the Lower Brazos basin; Waco in the east central area of the basin; Sugar Land-Houston in the south of the basin; and the Round Rock-Austin metropolitan area at the western edge of the basin. By 2050, the total population in Killeen, Round Rock, and Georgetown will exceed 220,000 people each, while the cities of Waco, Sugar Land, and College Station will have a population of greater than 150,000 people each. **Table 3** details the population of the cities with the largest population size in the Planning Region in 2050.

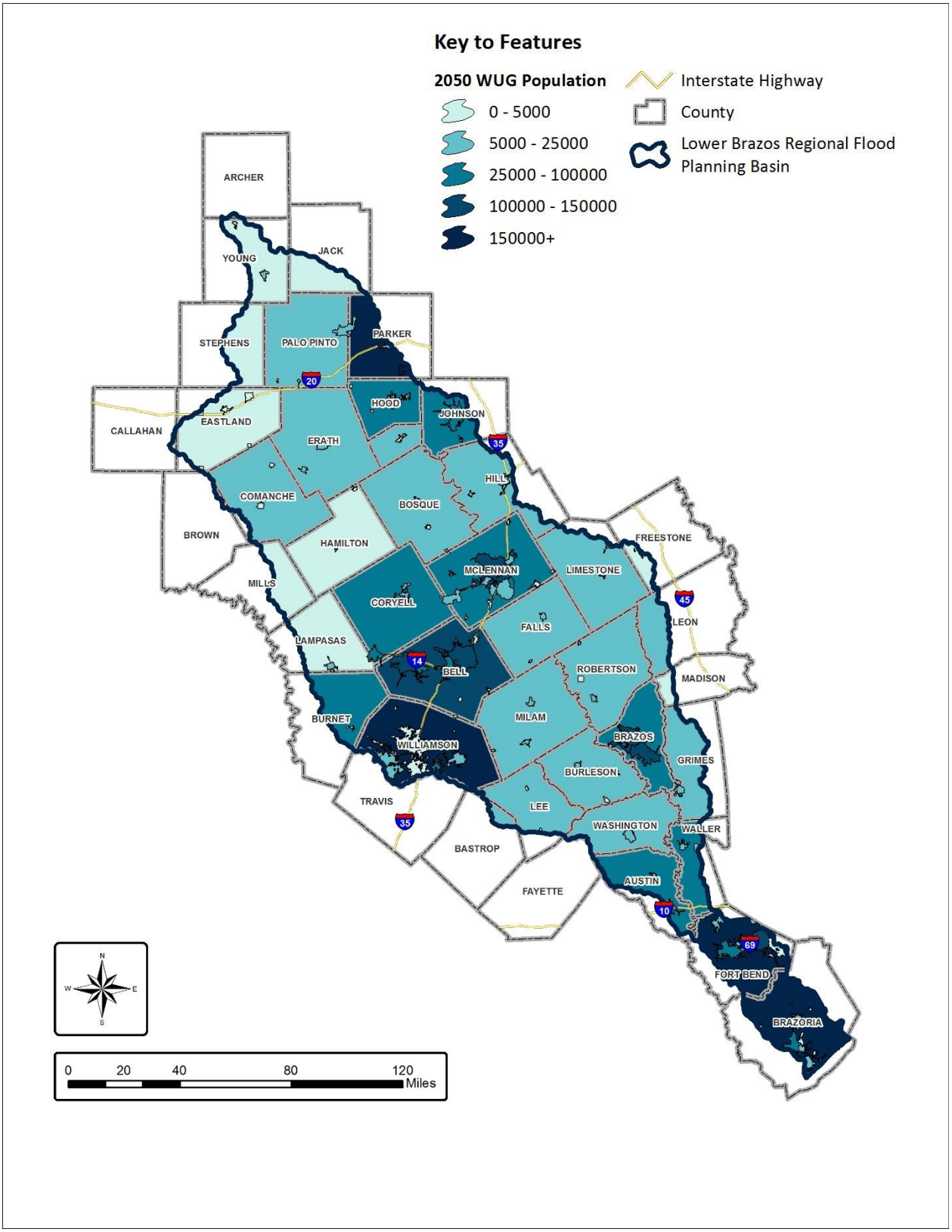
Table 3: Communities in the Lower Brazos Flood Planning Region with Projected Population in 2050 Greater than 100,000

Community	County	Population 2020	Population 2050	Percent Increase
Georgetown	Williamson	118,763	244,043	105%
Round Rock	Williamson	123,598	239,565	94%
Killeen	Bell	144,243	221,697	54%
College Station	Brazos	100,854	195,852	94%
Waco	McLennan	132,512	160,966	21%
Sugar Land	Fort Bend	132,098	156,030	18%
Bryan	Brazos	84,196	140,827	67%
Temple	Bell	81,736	125,626	54%
Leander	Williamson	48,575	121,365	150%

Source: Texas Water Development Board

As described in **Table 3**, by 2050 Bryan in the Bryan-College Station metropolitan area and Sugar Land in the Sugar Land -Houston-The Woodlands metropolitan area will have populations exceeding 140,000. The population for Temple and Leander will also increase to over 110,000 as these cities capture the growth in the Austin metropolitan area. **Figure 5** illustrates the expected increase in population for communities in the Planning Region based on Water User Group Data from TWDB.

Figure 5: Lower Brazos Flood Planning Region Future Population



The cities with the highest population growth rate between 2020 and 2050 will be communities adjacent to or near the metropolitan areas with the largest and most dense pockets of population. These include unincorporated areas of Coryell County (near Killeen), Fort Bend County (near Sugar Land), and Brazoria County (near Lake Jackson); and the cities of Hutto, Leander, and Georgetown in the Austin-Round Rock-San Marcos metropolitan area. **Table 4** details the ten fastest growing cities and unincorporated areas within counties in the Planning Region.

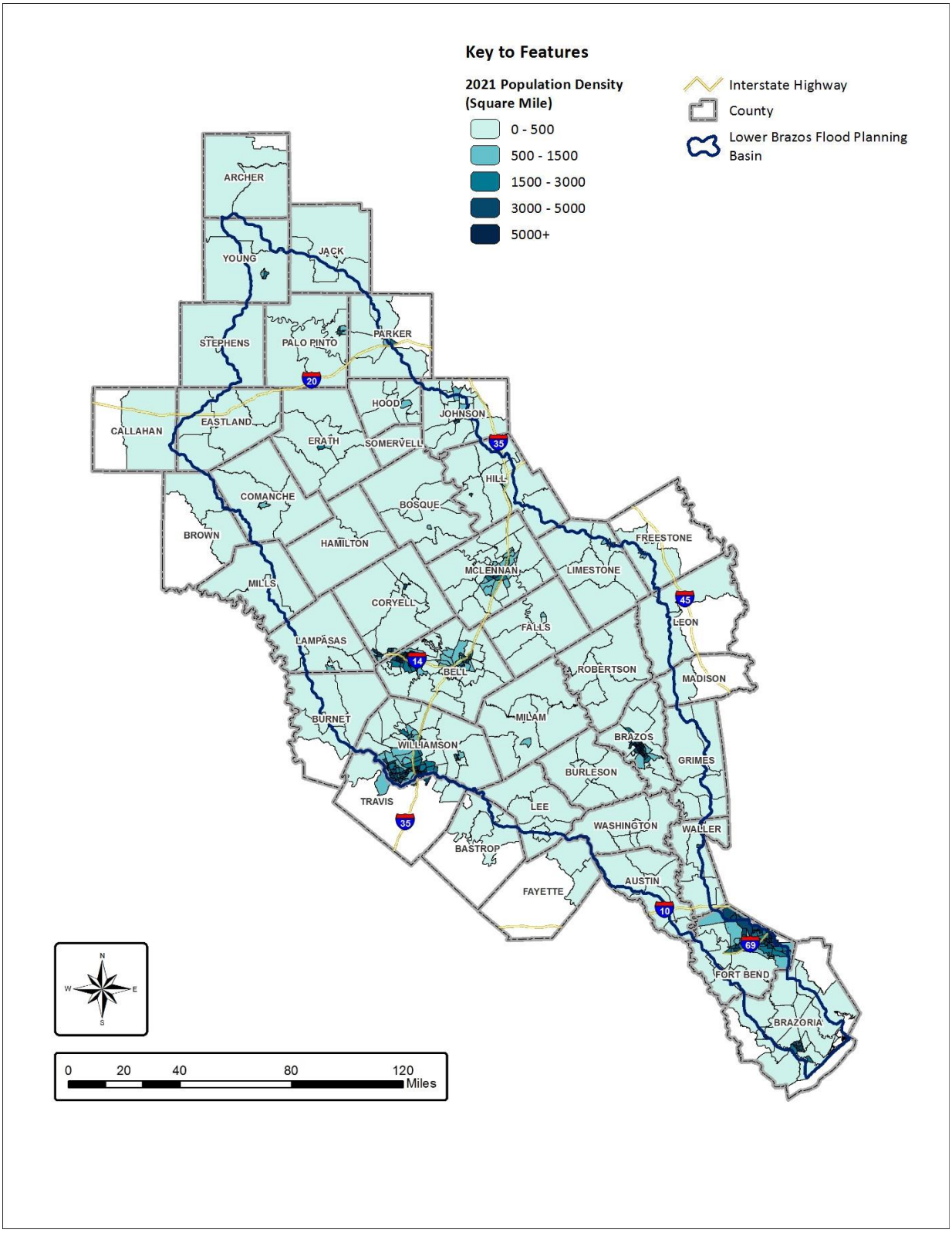
Table 4: Top Ten Fastest Growing Communities 2020 - 2050

Community	Population 2020	Population 2050	Rate of Population Growth
Unincorporated Area in Coryell County, Coryell County	2,474	9,942	302%
Hutto, Williamson County	17,326	56,194	224%
Leander, Travis and Williamson Counties	59,821	151,328	153%
Unincorporated Area in Fort Bend County	107,087	264,898	147%
Unincorporated Area in Williamson County	39,226	93,158	137%
Sienna Plantation, Fort Bend County	21,743	47,894	120%
Prairie View, Waller County	3,400	7,406	118%
Unincorporated Area in Brazoria County	100,247	207,557	107%
Georgetown, Williamson County	118,763	244,043	105%
Copperas Cove, Lampasas and Coryell Counties	36,253	52,061	104%

Source: Texas Water Development Board

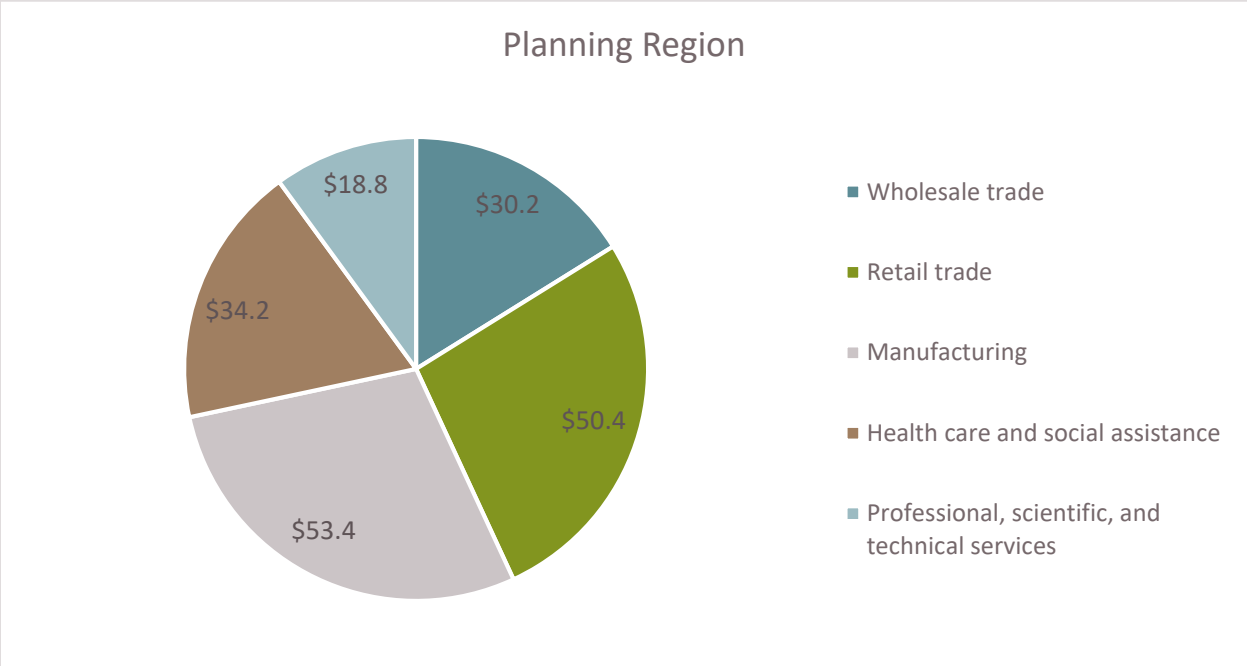
As illustrated further in **Figure 6**, the communities in the Planning Region with the highest population density are Sugar Land and Lake Jackson in Austin-Oyster and Lower Brazos HUC 8; College Station and Bryan in the Navasota HUC8; Round Rock in San Gabriel HUC 8; Killeen and Temple in Leon and Cowhouse HUC 8; and Waco in Middle Brazos-Lake Whitney HUC 8. A HUC or Hydrologic Unit Code is a United States Geological Survey (USGS) watershed delineation or boundary based on surface hydrologic features. Each hydrologic unit is assigned a 2-digit to 12-digit number that uniquely identifies the unit within a classification system consisting of 21 regions (2-digit), 222 subregions (4-digit), 370 basins (6-digit), 2,270 subbasins (8-digit), approximately 20,000 watersheds (10-digit), and approximately 100,000 subwatersheds (12-digit). A HUC 8 represents the subbasin level analogous to medium-sized river basins. There are 14 HUC 8s in the Lower Brazos Planning Region.

Figure 6: Population Density by Census Tract



Economic Activity

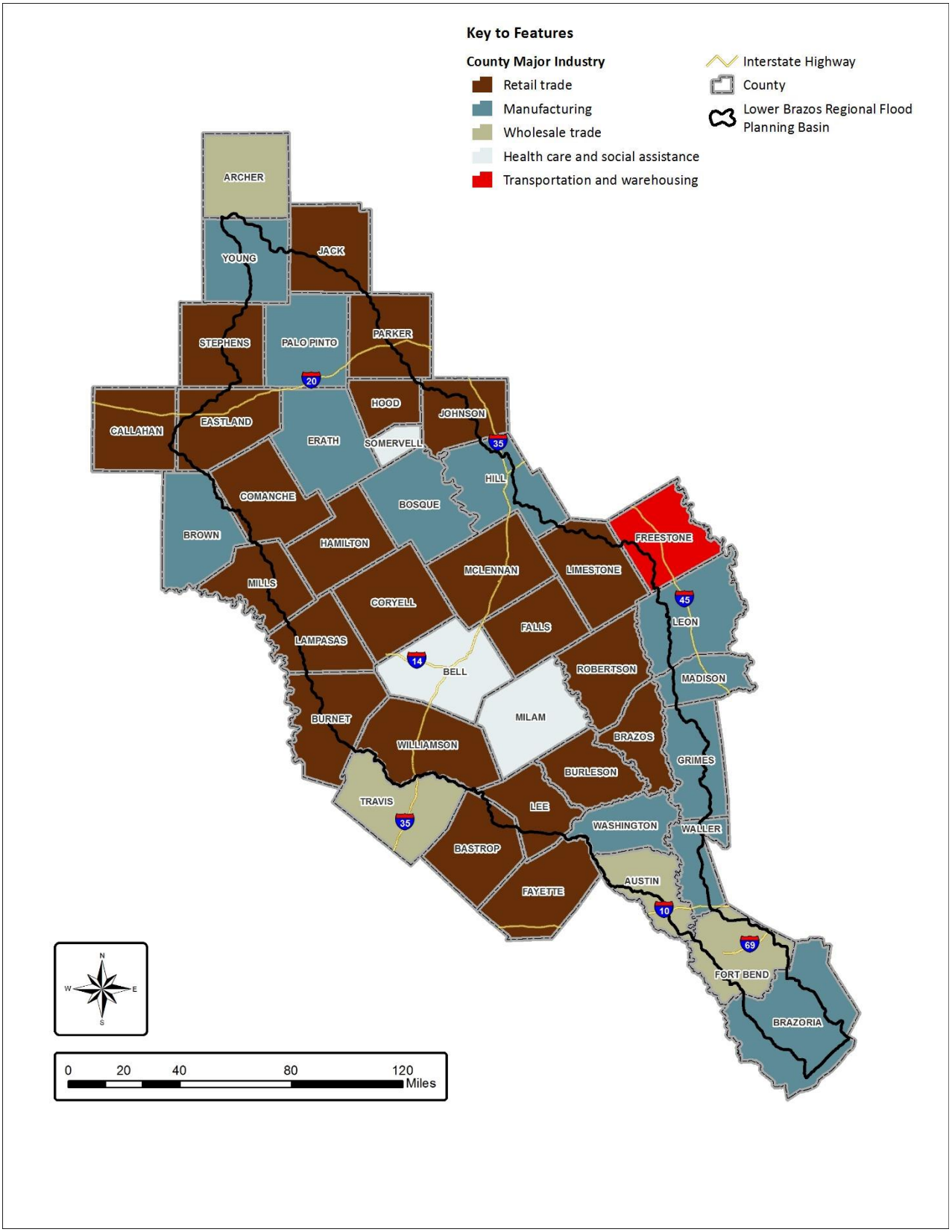
The Lower Brazos Flood Planning Region is home to key industries, such as wholesale and retail trade, manufacturing, and health care and social assistance, which contribute to the gross domestic product of the Planning Region and support the local and state economies. Based on the 2017 Economic Survey, the total value of sales or revenue generated by firms and businesses in the Planning Region amounts to over $215.9 billion. This constitutes approximately 4.5 percent of the total revenue generated by all firms and businesses in Texas. The dominant industry sector or the sector generating the most revenue for the Planning Region is manufacturing, at $53.4 billion, followed closely by retail trade, at $50.4 billion, and health care and social assistance, at $34.2 billion.



Source: U.S. Census Bureau Economic Census

The health care and social assistance sector employs the largest number of people in the Planning Region, at approximately 304,170 employees, followed by the retail trade sector, at approximately 153,116 employees. The industry sector employing with third-largest number of employees is accommodation and food services with approximately 113,133 employees. **Figure 7** illustrates the dominant industry in each county in the Planning Region.

Figure 7: Major Industry by County



Commercial Activity

Within the Planning Region, the county generating the most commercial activity and largest revenue, at $45.9 billion, is Fort Bend, which also has the largest number of firms or businesses (15,663). Its dominant industry sector is wholesale trade. Williamson County has the second largest number of total firms as well as revenue, generating over $29 billion, of which almost $10 billion is in the retail trade industry. Brazoria County, in the south of the Planning Region and bordering Fort Bend County, generates the third largest revenue, at $37 billion, of which $24 billion is generated in the manufacturing industry sector. **Table 5** lists the five counties generating the most sales and revenue in the Planning Region. These counties also have the largest number of firms and businesses; and their dominant industry sectors employ between 90,000 and 215,100 employees.

Table 5: Top Five Counties by Total Revenue, Firms, and Employees

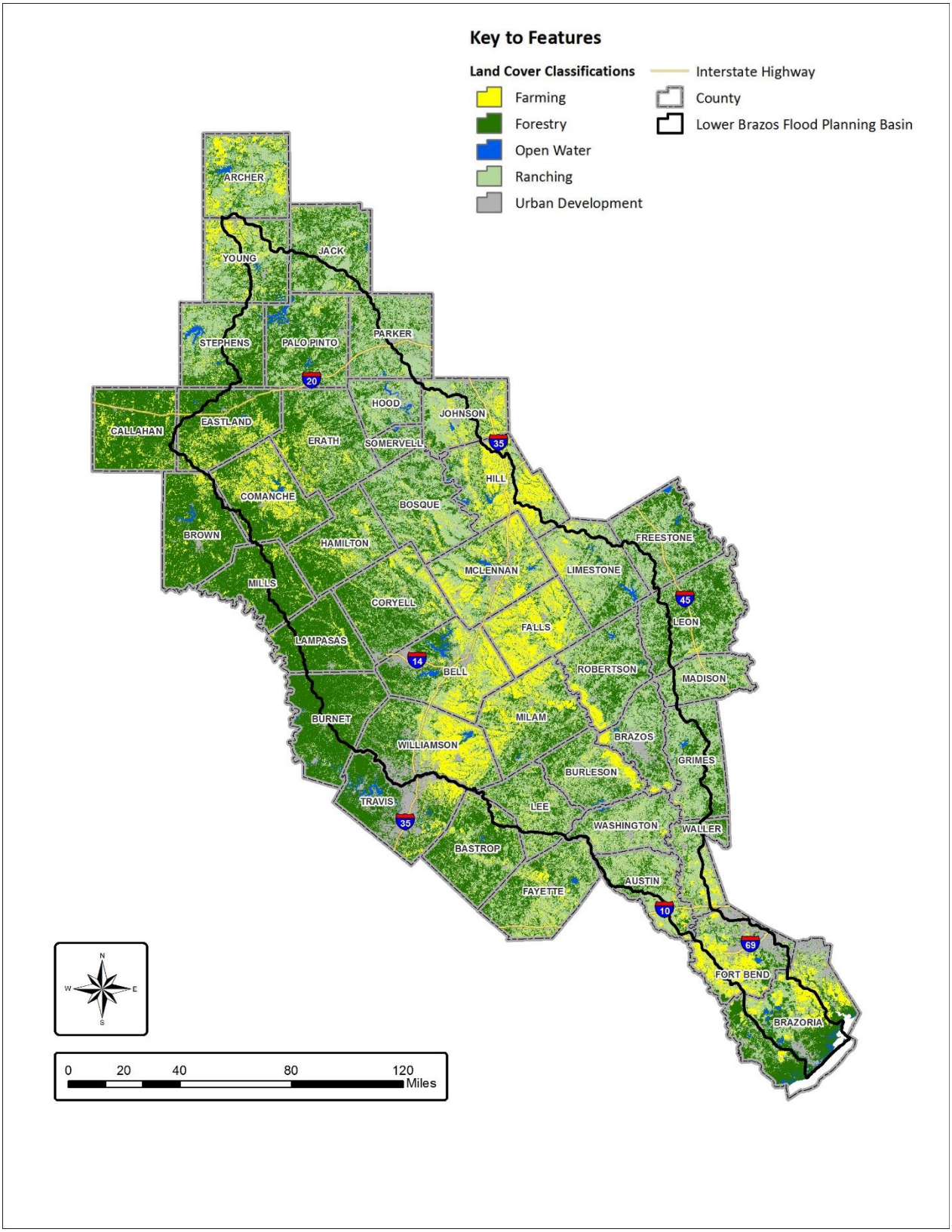
County	Total Revenue (in Billion)	Total Number of Firms and Businesses	Total Number of Employees	Dominant Industry Sector
Fort Bend	$45.9	15,663	213,164	Wholesale Trade
Brazoria	$37.1	5,304	91,045	Manufacturing
Williamson	$29.7	9,751	172,007	Retail Trade
Bell	$22.2	4,670	122,842	Health Care and Social Assistance
Madison	$19.3	4,157	84,856	Manufacturing

Source: U.S. Census Bureau Economic Census

Agricultural Activity

According to the United States Department of Agriculture (USDA) Landcover data, over 13 million acres in the Lower Brazos Planning Region are rural contributing to the economy of the state and the region through farming, ranching, and forestry. Approximately 5.4 million acres of the Planning Region are utilized for ranching, providing critical support to Texas's cattle production, which remains the state's top agricultural commodity in terms of market value (Texas Department of Agriculture, 2021). Similarly, 5.5 million acres of rural lands in the Planning Region are comprised of forestry, which is the sixth top agricultural commodity in the state. Of the 2.2 million acres of farmland in the Planning Region, significant areas of the rural land are producing wheat, sorghum, corn, and oats, which are in the top 10 most important agricultural commodities in terms of market value in Texas. **Figure 8** on the following page illustrates the variety of agricultural uses in the basin (Texas Department of Agriculture, 2021).

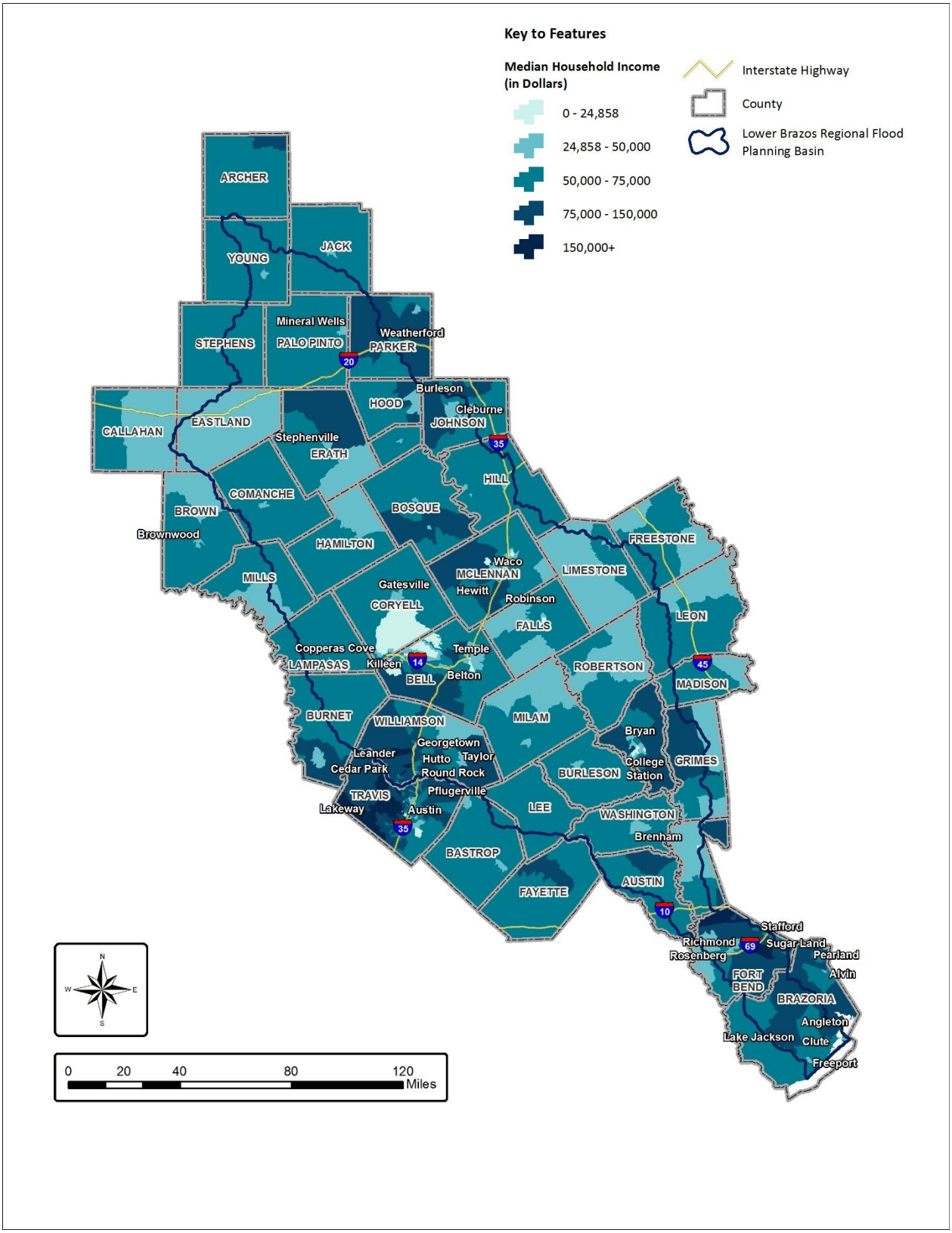
Figure 8: Land Cover



Economic Status of Population

According to the 2019 5-year American Community Survey, the median household income for Texas is $61,874. Over half of all census tracts in the Planning Region, approximately 53 percent, have median household income below the median household income for Texas. As illustrated in **Figure 9**, the census tracts with the lowest median household income (less than $30,000) are primarily in the urban centers of Killeen, Waco, and College Station. The census tracts with median household income greater than $30,000 but less than the state's median household income are primarily in the central area of the basin, namely Limestone, Falls, Robertson, Milam, Coryell, and Lampasas Counties. In the northern area of the basin, census tracts in Bosque, Eastland, and Palo Pinto Counties also have median household income below the median value for Texas. Census tracts with median household income higher than $92,000 are in the suburban areas of Austin and Round Rock in Williamson County, Waco in McLennan County, College Station in Brazos County, Sugar Land in Brazoria County, and Bellville in Austin County.

Figure 9: Median Household Income by Census Tract

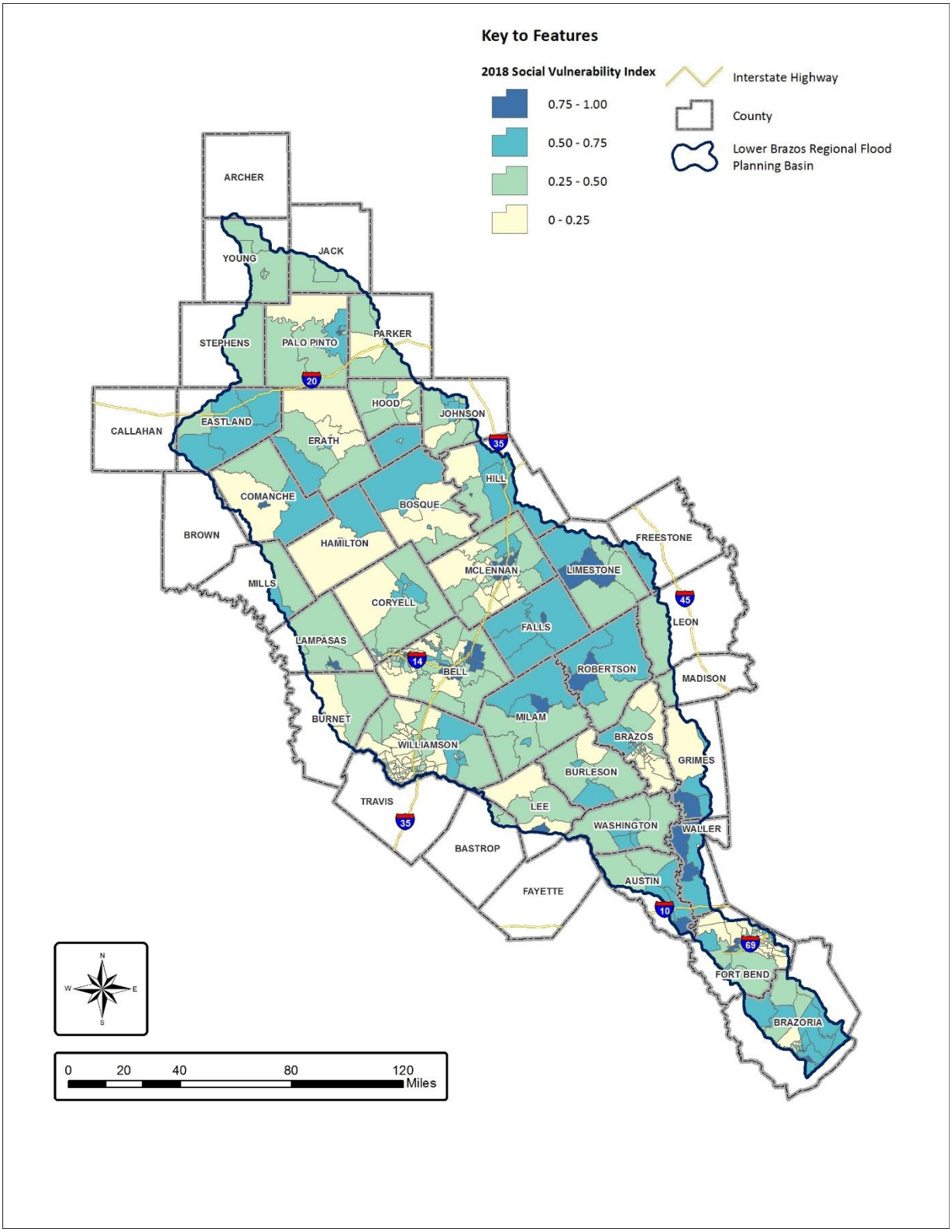


Social Vulnerability in the Planning Region

Social vulnerability refers to the potential negative effects on communities caused by external stresses on human health, according to the Center for Disease Control (CDC). Such stresses include natural or human-caused disasters, such as floods or disease outbreaks. Identifying communities with high social vulnerability in the Lower Brazos Flood Planning Region is critical for flood planning and mitigation, since communities with high social vulnerability are at a greater risk of incurring loss of life and property during a flood event, according to the CDC. Factors that contribute to a community's social vulnerability include the number of residents in poverty, with lack of access to transportation, and living in crowded housing. These conditions reduce residents capacity to withstand and recover from disasters, such as hurricanes. Federal agencies like the Federal Emergency Management Agency (FEMA) and the U.S. Department of Housing and Urban Development (HUD) utilize the Social Vulnerability Index (SVI) to assist communities during and after human-made and natural disasters.

The SVI indicates the relative social vulnerability of every census tract in the United States and ranks each tract based on percentile values between zero and one, with higher values indicating greater vulnerability. The index considers 14 factors: poverty, unemployment, income, education, age, disability, single-parent households, race / minority status, limited English-speaking ability, housing type, crowding, and vehicle ownership. The TWDB has provided SVI values for census tracts in the Planning region. The census tracts with the highest SVI value (census tracts that are in the top quartile of social vulnerability) are primarily in and around the mid-sized communities of Waco and Temple in the central area of the basin and the small-sized communities of Cameron and Calvert in Milam and Robertson Counties (refer to **Figure 10**). Other census tracts that have high social vulnerability include the less-populated communities of Hempstead and Groesbeck. These communities are at a greater risk of incurring loss of life, property, and livelihood due to high social vulnerability attributed to a higher poverty rate, diminished mobility or access to transportation, and unsafe housing conditions.

Figure 10: Social Vulnerability by Census Tract



1.1.b. Flood Prone Areas and Flood Risks to Life and Property

Identification of Flood Prone Areas

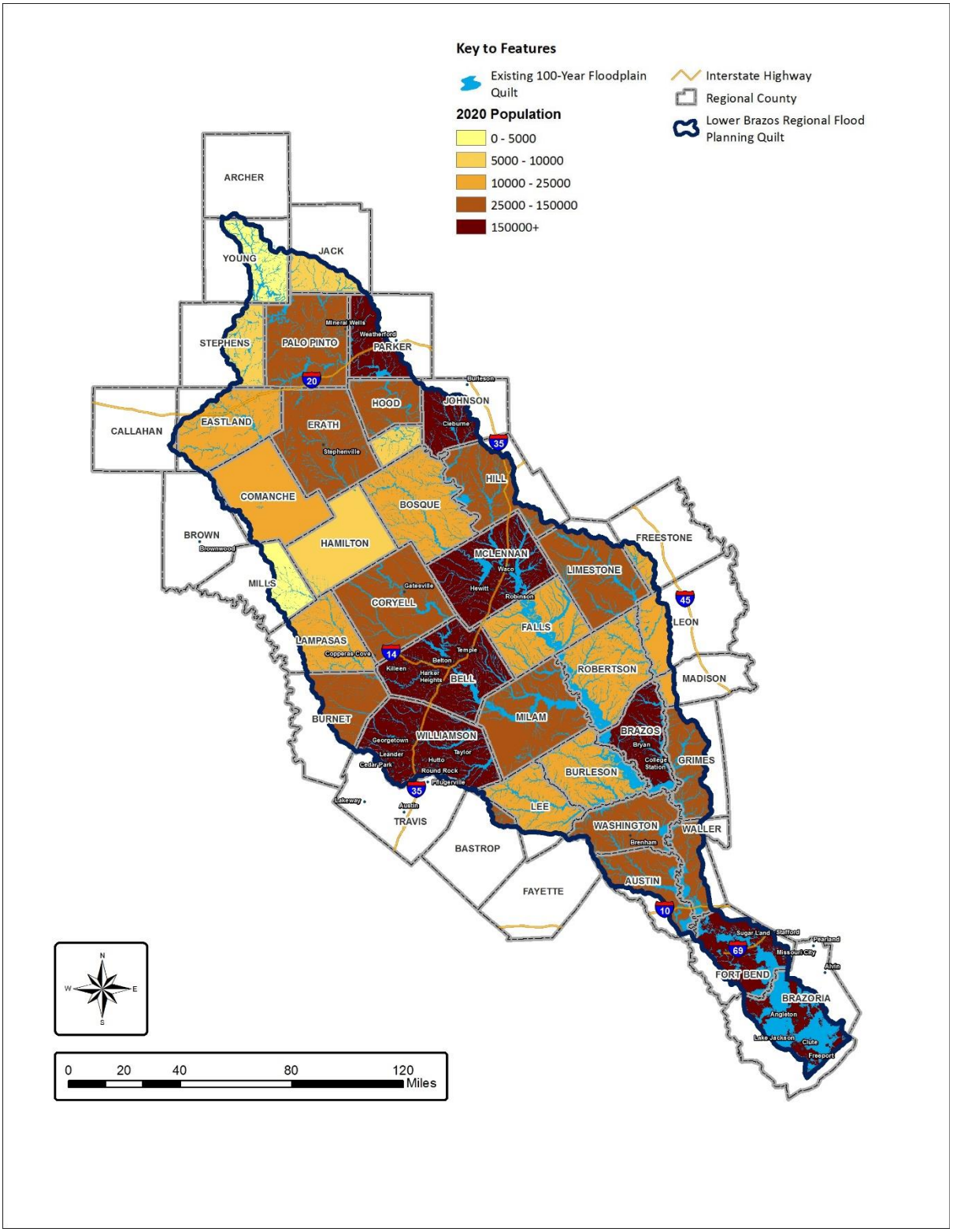
By juxtaposing the floodplain quilt or 1 percent annual chance flood event and the current and expected population in 2050, this flood plan has identified the communities with a high growth rate most at risk of flooding in the future (refer to **Figure 11**). Specifically, there are seven communities completely or partially in the Planning Region that have over one-fourth of their land area in the floodplain quilt and will have a population growth rate of 10 percent or more by 2050. These communities include Richwood, Lake Jackson, Clute, and Danbury in Brazoria County (refer to **Table 6**). Overall, approximately 15 percent of the Lower Brazos Flood Planning Region is in the one percent annual chance flood event.

Table 6: Flood Prone Areas

Community	Percent of Community in 100 Year or 500 Year Floodplain	NFIP Participation	Critical Facilities at Risk	Percent Growth in Population (2020 – 2050)
Richwood	40	Yes	5	13
Lake Jackson	38	Yes	17	9
Clute	32	Yes	12	11
Danbury	30	Yes	5	0
Pleak	14	Yes	1	-
Waco	13	Yes	93	21
Nolanville	11	Yes	4	-
Salado	10	Yes	5	32
Beverly Hills	10	Yes	2	-

Source: Texas Water Development Board, Federal Emergency Management Agency National Flood Hazard Layer

Figure 11: Floodplain Quilt by 2050 Population



Rates of NFIP Participation and Related Flood Planning Activity

There are eighteen (18) communities and two counties within the Lower Brazos Flood Planning Region which do not participate in the National Flood Insurance Program (NFIP) administered by FEMA. As shown in **Figure 12**, these cities and town are primarily located in the central area of the Lower Brazos River basin in McLennan, Hill, Falls, Limestone, Coryell, Parker, Waller, and Williamson Counties. Hamilton and Falls Counties in the west central and central area, respectively, of the Lower Brazos River basin do not participate in the NFIP (refer to **Figure 12**). These counties and communities have portions of their land area intersecting the 100-year floodplain where residents are at risk of incurring life and property loss during a flood event. Flood planning efforts in the Planning Region should consider the increased vulnerability of communities that are within the 100-year floodplain and do not participate in the NFIP, which helps residents recover from the impact of flood damage to their real and personal property.

Figure 12: NFIP Participation

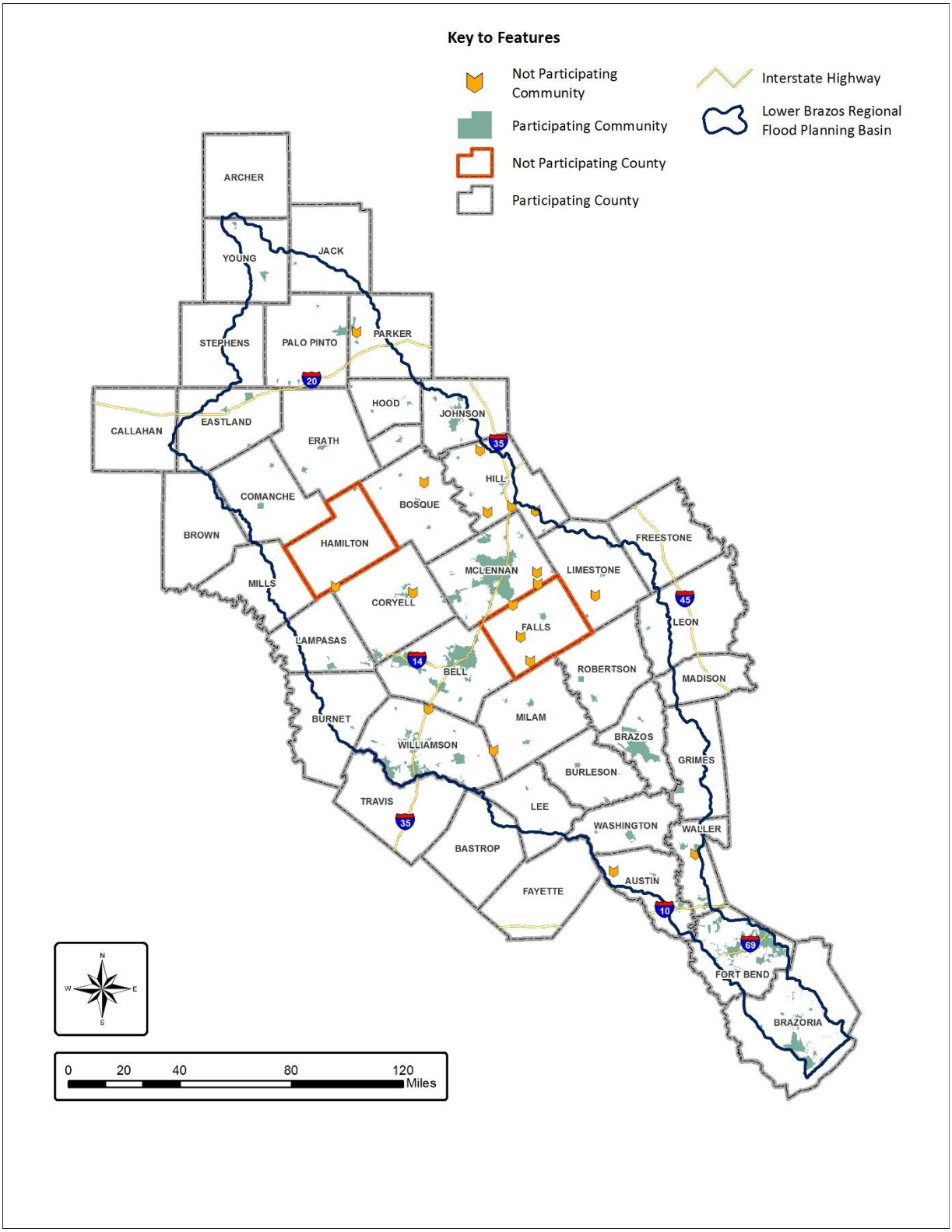
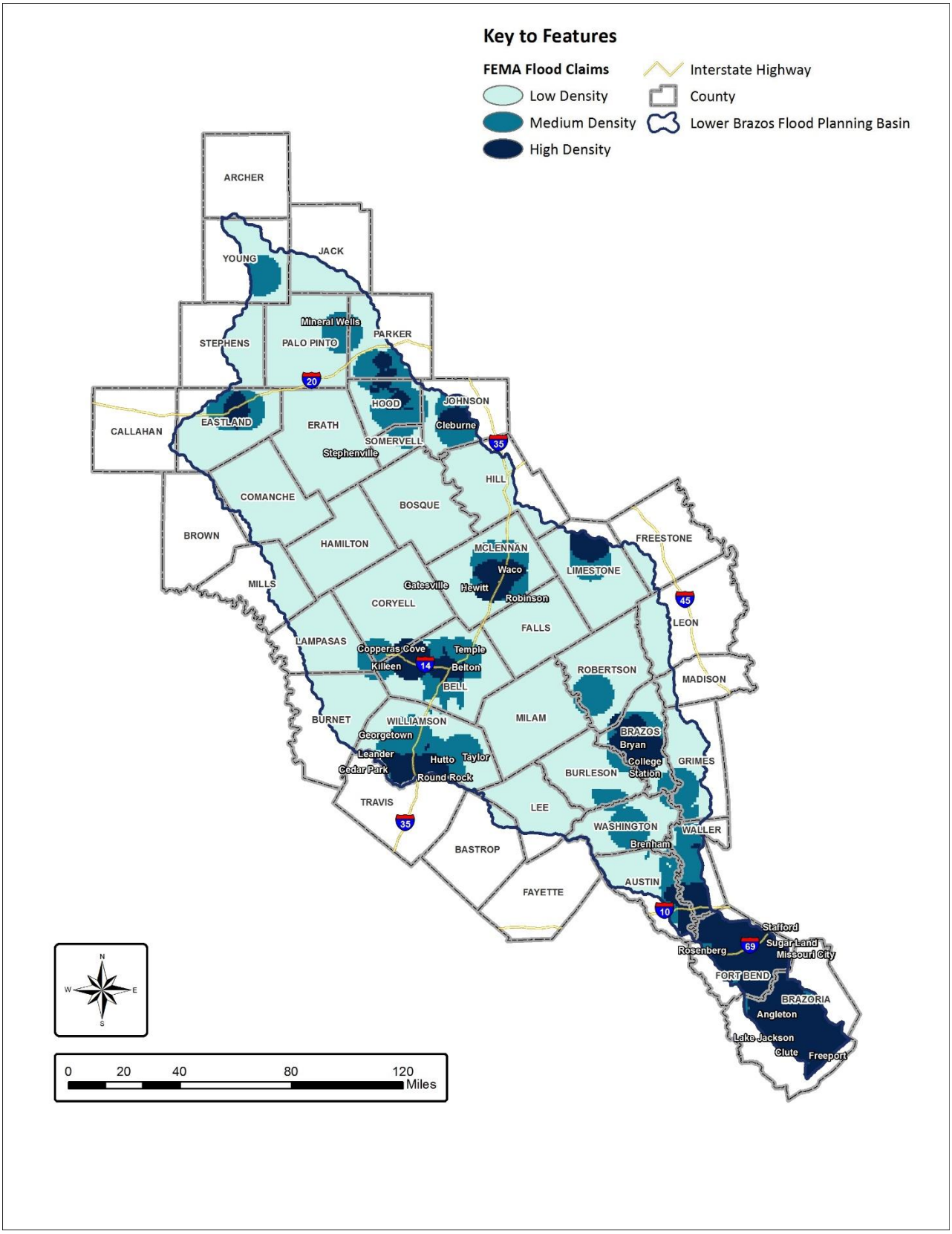


Figure 13 illustrates the density of flood claims filed with FEMA in the Lower Brazos Flood Planning Region boundary indicating areas where both natural and built flood infrastructure is deficient in protecting homes from flooding. The highest density of FEMA flood claims is in Brazoria and Fort Bend Counties in the southern area of the basin, which have high existing and future population growth. The metropolitan areas of Killeen, Waco, Round Rock, and College Town also have a high density of flood claims. In the northern area of the basin, Cleburne and the suburbs of Weatherford have a high density of flood claims.

Figure 13: FEMA Flood Claim Density



Agricultural and Natural Resource Most Impacted by Flooding

The Lower Brazos basin is comprised of five main land uses, which include farming, forestry, ranching, urban areas, and open water. **Table 7** provides the acreage for each land use in the basin. The following section discusses the detrimental impact of flood events the agricultural and natural resources of the Lower Brazos Region.

Table 7: Lower Brazos Land Use Summary

Land Use	Total Area in Lower Brazos Basin (acres)	Total Area in Lower Brazos Basin at Risk of Flooding (acres)
Farming	2,325,760	433,209
Forestry	9,732,480	933,057
Ranching	8,783,360	683,035
Urban Development	1,699,840	135,680

Source: TWDB Floodplain Quilt & USDA Land Use Agriculture

Farming

Flooding or excess precipitation can wash nutrients downstream or result in complete or partial loss of crops. The severity of impact flooding has on farming depends on many factors including what is planted, what time of year the flood event occurs, and wind speed of the storm. Additionally, the stage of growth of a crop influences the susceptibility to damage or loss due to excess water. Different crops have different resiliency to excess precipitation and prolonged standing water. Permanent crops, such as fruit trees, tend to be more resilient to excess precipitation and standing water than row crops, such as cotton. Heavy rain prior to planting could delay planting or prevent planting entirely. Damage can also occur after a crop has been harvested. Crops, such as hay or cotton, that have been harvested but not bailed or processed can be degraded by heavy rainfall in the region. The Lower Brazos Region experienced over $140 Million in crop losses due to flooding, hurricanes, and tropical storms from 1989-2020, according to the United States Department of Agriculture Risk Management Agency.

Forestry

Forestry impacts due to flooding are also multifaceted. Flash flooding can bring swift moving debris that could physically wound a tree creating the conditions for contaminated flood water to introduce diseases to the tree. Sustained flooded conditions can deplete the oxygen supply and cause root damage to trees. Floods that occur during the growing season can kill trees much faster than similar conditions during the dormant season, according to the Texas A&M Forest Service, an agency chartered by the Texas Legislature to manage the interests of forests in Texas. Furthermore, as described in research conducted by the University of Arkansas Agriculture Research & Extension, flooding can positively impact forests by clearing weaker trees, spreading seeds, and stimulating growth of surviving trees.

Ranching

Information from Texas A&M AgriLife Extension illustrates how ranching activities in the region are also impacted by flooding. Livestock can be swept away, drowned, or injured by flash floods. Livestock

exposed to contaminated flood waters can experience health issues such as pneumonia or foot rot. Livestock could also be exposed to disease carrying mosquitoes during flood events. Flood events can cause delays in building back livestock herds. Damages to feed crops can also reduce ranching capabilities.

Natural Resources

The Lower Brazos Region contains many natural resources that can be negatively impacted by flood events. As with livestock, wildlife can be injured or killed by flash floods. Severe flood conditions can degrade stream health and impact ecosystems in the region. Flooding can cause an imbalance of the ecosystem of the Brazos River Estuary. Oil and gas extraction can also be interrupted by flood conditions.

The agricultural land use in the Lower Brazos basin that has the largest acreage within the 100-year floodplain is forestry with over 930,000 acres in the 100-year floodplain. In other words, 17 percent of the entire land area used for forestry is in the 100-year floodplain. The total acreage of land used for ranching in the Lower Brazos basin that is in the 100-year floodplain is over 683,000 acres, which is 13 percent of the entire land area used for ranching in the basin. While the total acres of land used for farming in the 100-year floodplain, at approximately 433,209 acres, are less than the forestry or ranching land acres in the 100-year floodplain, the percentage of the total farming land in the 100-year floodplain is the highest, at 19 percent, compared to other agricultural uses.

The HUC 8s with the largest agricultural land area in the 100-year floodplain are Lower Brazos – Little Brazos and Middle Brazos – Lake Whitney in the northeastern area of the Lower Brazos Planning Region, as detailed in **Table 8**.

Table 8: Land Use Acreage Within 100-Year Floodplain by HUC 8

HUC 8	Farming	Forestry	Ranching	Total
Austin Oyster	33,552	108,738	36,500	178,790
Bosque	4,308	9,680	9,545	23,533
Cowhouse	2,045	15,478	6,950	24,473
Lampasas	6,293	41,903	13,772	61,968
Leon	16,825	52,134	22,995	91,954
Little	55,422	34,092	37,372	126,887
Lower Brazos	38,561	136,259	130,776	305,597
Lower Brazos - Little Brazos	182,840	101,918	131,001	415,759
Middle Brazos - Lake Whitney	39,848	74,575	69,915	184,339
Middle Brazos Palo Pinto	7,954	95,477	59,037	162,468
Navasota	11,466	122,840	76,874	211,181
North Bosque	8,454	31,576	24,562	64,592

HUC 8	Farming	Forestry	Ranching	Total
San Gabriel	18,383	34,170	20,870	73,423
Yegua	7,257	74,217	42,866	124,339
Total	433,209	933,057	683,035	2,049,302

Source: United States Department of Agriculture

1.1.c Key Historical Flood Events

Historic Events Prior to Current Level of Regulation

In December of 1913, a notable flood of record occurred across the Lower Brazos River Watershed (Ellsworth, 1923).After a very wet fall which led to high stages, the watershed received about 3 inches of rainfall on average over 10 days and many levees were damaged. As a result, the confluence of the Brazos River and major tributary Little River at Valley Junction reached a record stage of 55.0 feet on Dec 4, 1913. Four days later, a record stage of 66.2 feet were recorded at the Richmond gage in Fort Bend County, according to the United States Geological Society (USGS), and firsthand accounts note that the floodplains of the Colorado and Brazos rivers merged with each other. At least 174 people were killed as a result of flooding along the Brazos River (Sawyer, 2021).

September 1921 brought heavy rainfall and flooding to central Texas (Ellsworth, 1923). The United States Weather Bureau recorded 16 inches of rainfall in Williamson County on September 9, 1921. As a result, the Little River near Cameron crested at a record gage height of 49.50 feet, and gage height for the Brazos River at Jones Bridge, near Bryan, TX rose to 47.90 feet between Sept 8-12. The Little River Basin, particularly in Williamson and Milam Counties, suffered 159 fatalities, the greatest loss of life across the region. Collectively, $4,000,000 in damages and 224 fatalities were recorded in the Lower Brazos watershed, as reported by United States Geological Society (USGS).

The floods of April-June 1957 followed a period of severe drought in Texas (State of Texas Board of Water Engineers). Palo Pinto County recorded 19 inches of rainfall in May 1957 resulting in the downstream gage at the Brazos River near Glen Rose, TX reaching 33.89 feet, the fifth highest of record. Little River near Cameron reached a gage height of 39.56 feet with a stream flow of 116,000 cfs, the third highest of record. The long duration event generated extensive runoff; 9.3 million acre-feet of total volume passed the Richmond gage. United States Army Corps of Engineers (USACE) estimated statewide flood damages totaling $100,000,000.

These major flood events amongst others, led to the construction of multiple flood control reservoirs to regulate flow on the Brazos River. While major flooding in more recent years has resulted in significant loss of life and property, gages with long periods of record throughout the watershed show that flooding was more severe in the region prior to regulation.

Historic Tropical Flooding Events

Tropical Storm Frances

Tropical Storm Frances made landfall on September 13, 1998, between Corpus Christi and Victoria. While Harris County was among the hardest hit in the coastal region, Brazoria County averaged 10 inches of rainfall in 24-hours. West Columbia received more than 16 inches of rainfall in 24-hours, according to the National Hurricane Center. A major disaster declaration was issued for Brazoria County as a result of inland flooding. One direct fatality connected to flood conditions was reported in Brazoria County, as reported by National Oceanic and Atmospheric Association’s (NOAA) Storm Event Database.

Hurricane Ike

Hurricane Ike made landfall on September 13, 2008 near Galveston as a category 2 hurricane, bringing strong wind and rain to Texas and Louisiana. The NHC reported wind gusts of 80 mph in Rosharon and

83 mph in Danbury, making Hurricane Ike one of the most destructive weather events on record for the Lower Brazos Region. While Hurricane Ike did not bring record setting rainfall to the basin, the storm's wind field stretched 400 miles wide and produced severe storm surge, which ranged from 5 to 10 feet along the coast of Brazoria County, as reported by NHC's Tropical Cyclone Report for Hurricane Ike. As a result, Ike is the second most severe flooding event in the region's history by number of flood claims.

Tropical Storm Hermine

Tropical Storm Hermine made landfall on September 5, 2010, in northeast Mexico before turning towards central Texas. The storm developed into a band of intense rainfall along I-35. The National Hurricane Center (NHC) reported 16 inches of total rainfall for Lake Georgetown between September 7-9, 2010, of which 15 inches fell in a single 24-hour period. As a result, Little River near the city of Little River reached a gage height of 40.58 feet, the second highest of record. Flash flooding in Bell, Johnson, and Williamson Counties resulted in 3 direct fatalities, as reported by NOAA's Storm Event Database.

Hurricane Harvey

Hurricane Harvey made landfall near Rockport, Texas on August 25, 2017, as a Category 4 hurricane. Brazos River recorded the highest gage height since regulation of flows began, with 55.19 feet and 52.65 feet at Richmond and Rosharon, respectively. Rainfall within the Brazos River watershed between August 25 and September 1 ranged from 13-39 inches, the highest of which is comparable to the average annual precipitation for the watershed, according to NOAA. This extreme rainfall resulted in Harvey being the most damaging storm in the region since the NFIP launched in 1968. Flash floods in Fort Bend County resulted in three direct fatalities, as reported by NOAA's Storm Event Database.

Historic Flooding of Non-Tropical Origin

Winter 1991-1992

Winter 1991-1992 brought heavy rainfall and flash flooding to most of the Lower Brazos Region (Halff Associates, 2019). The heaviest rain fell in Coryell County, which received an average depth of seven inches in 12 hours, and Medina, which received 16 inches between December 18-23, 1991, according to USGS. Little River reached a stage of 38.95 feet at Cameron, which remains the highest stage after the 1957 flood at this location. The Brazos River floodplain reached five miles width near Bryan and merged with Oyster Creek downstream of Rosenberg.

Spring 2007

Spring 2007 brought heavy rainfall to the Lower Brazos River region after 18 months of drought conditions (Halff Associates, 2019). Though Marble Falls was the hardest hit area of the storm, the Brazos River watershed upstream of Whitney Reservoir received 13 inches of rainfall in May 2007 raising the Brazos River near Aquilla to a stage of 23.28 feet. The Brazos River reached 46.45 feet with 85,900 cfs streamflow near Bryan, the highest stage recorded since the gage began collecting data in 1994. Flash floods in the Leon and Little River watersheds resulted in at least eight direct flood fatalities, as reported by the NOAA Storm Event Database.

Memorial Day 2015

At the end of an above-normal month of rainfall in central Texas, an intense storm produced flash flooding in the Lower Brazos region on May 23, 2015 (Halff Associates, 2019). The Brazos River near

Hempstead reached a stage of 49.97 feet on July 18, its third highest stage since flood control reservoirs were implemented in the upper watershed. On May 25, 2015, as the system approached Harris County, it merged with a smaller cell in Fort Bend County, resulting in widespread flooding along the lower reach of the Brazos River. A maximum rainfall was recorded at 12 inches over two days near Richmond. Brazos River near Rosharon reached a stage of 51.46 feet on June 5, the sixth highest recorded stage. Flash floods in the Leon River watershed and Fort Bend County resulted in at least five direct flood fatalities, as reported by the NOAA Storm Event Database.

Spring 2016

Widespread heavy rain during Spring 2016 led to elevated stages along the Brazos River and wet antecedent conditions for a higher intensity storm that produced 17 inches of rainfall in 24-hours on May 26 in Brenham. This translated to river stages of 54.89 feet at Hempstead and 54.74 feet at Richmond. These gages recorded stages not seen since the flood of 1913, but the stage at the Richmond gage would be surpassed the following year during Hurricane Harvey in 2017. Flash flooding resulted in at least 15 direct deaths in the Brazos River watershed. Among the fatalities of the Spring 2016 floods were nine soldiers from Fort Hood, as reported by the NOAA Storm Event Database.

FEMA Flood Claims

FEMA flood claim data began with the establishment of the National Flood Insurance Program in 1968. Total NFIP flood claims connected to each major historical flood event are summarized in **Table 9** for Significant Historical Flood Events within the Lower Brazos watershed.

Table 9: FEMA Flood Claims for Significant Historical Flood Events within the Lower Brazos watershed

Flood Event	Year	Number of Flood Claims	Flood Claims Paid
Hurricane Harvey	2017	44,323	$311,463,534
Spring 2016	2016	8,816	$47,200,156
Hurricane Ike	2008	12,750	$22,477,298
Tropical Storm Hermine	2010	3,363	$20,035,360
Memorial Day 2015	2015	3,815	$8,270,617
Tropical Storm Frances	1998	7,621	$6,061,991
May-June 2007	2007	2,362	$5,502,155
September 1979	1979	602	$3,060,896
Winter 91-92	1992	208	$2,622,179

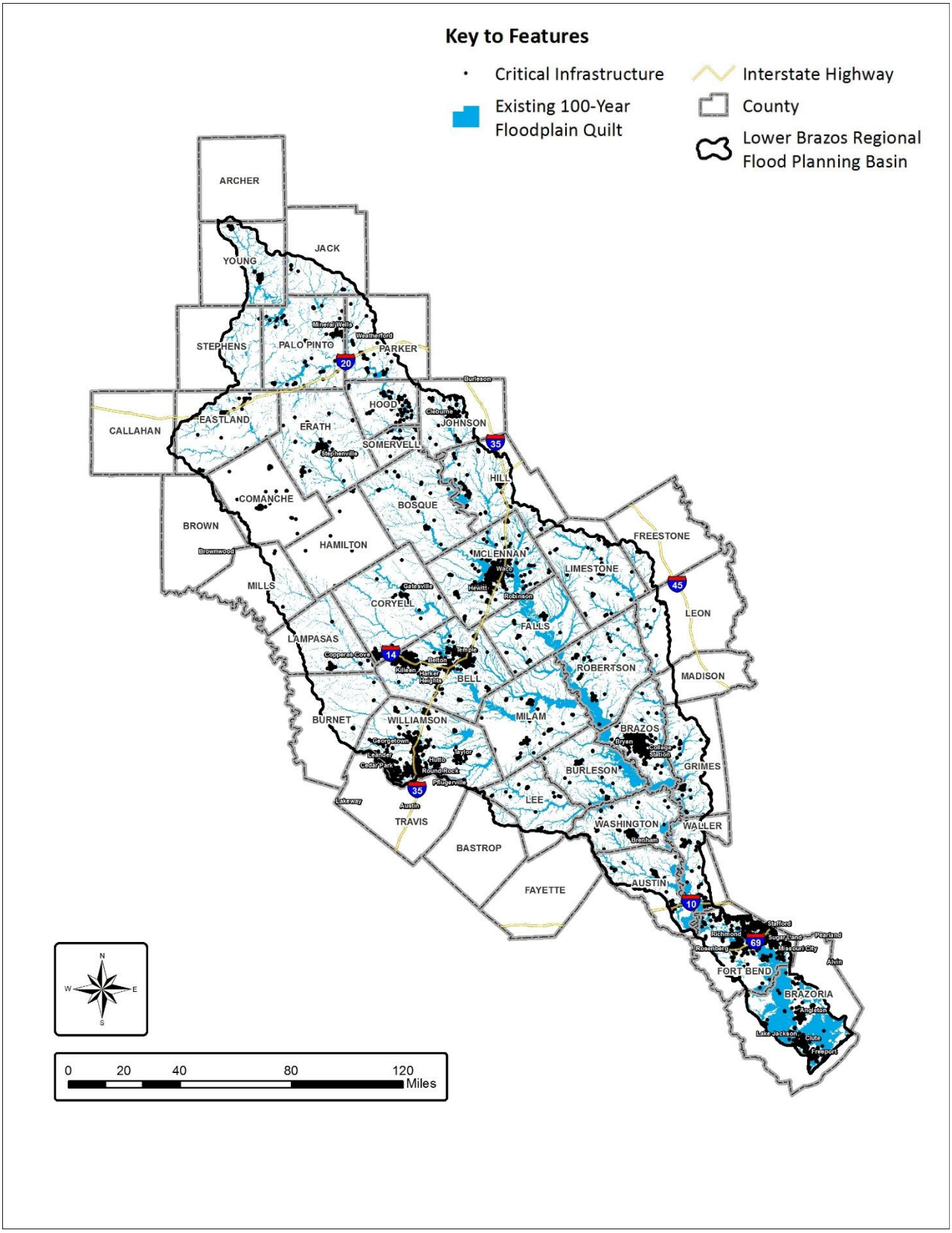
Source: Federal Emergency Management Agency (FMEA)

Location of Critical Facilities

Critical facilities are community assets, such as hospitals, fire stations, police stations, storage of critical records, energy producing facilities, water and wastewater treatment plants, and similar facilities that require special consideration in floodplain management and disaster planning. Critical facilities must

always continue to function and provide services during a flood. In the Lower Brazos Flood Planning Region, critical facilities are located in the communities along the Interstate 35 corridor, such as Waco, Killeen, and Round Rock in the central portion of the Planning Region, as well as the heavily populated areas in Fort Bend and Brazoria Counties in the south of the Planning Region. **Figure 14** illustrates the density of critical facilities in the Planning Region.

Figure 14: Density Map of Critical Facilities



1.1.d Political Entities with Flood-Related Authority

The Halff team has identified all political subdivisions with flood-related authority as stakeholders for the survey distribution in the Lower Brazos Planning Region. These entities include cities, counties, river authorities, soil and water conservation districts, water control and improvement districts, flood control and improvement districts, municipal utility districts, and levee improvement districts among others. **Table 10** details the number of entities with various levels of flood-related regulatory authority in the Lower Brazos basin.

Table 10: Political Entities with Flood-Related Authority

Entity	Number
Cities	178
Counties	44
Municipal Utility District	253
Municipal Water District	2
Water Control and Improvement District	20
Non-Municipal Water District	4
Management District	12
Redevelopment District	1
Drainage District	7
Levee Improvement District	15
Special Utility District	5
Improvement District	5
Fresh Water Supply District	7
Water Sewer Irrigation and Drainage District	1

Source: Texas Water Development Board

Fort Bend and Brazoria Counties at the southern tip of the Lower Brazos basin have among the largest number of water and flood-related entities functioning within the county, including drainage districts, fresh water supply districts, and municipal utility districts. In addition to these entities, Fort Bend County has 12 levee improvement districts. Municipalities in Fort Bend County, such as Fulshear and Sienna, also operate several additional utility districts. The area comprising Williamson County at the western boundary of the basin and nearby communities such as Leander and Round Rock has the next highest number of political entities with several municipal utility districts, water control and improvement districts, and a water, sewer, irrigation, and drainage district. Counties in the north of the Lower Brazos basin have relatively fewer number of flood-related political entities responsible for flood planning, management, and mitigation.

Summary of Existing Flood Planning Documents

The Summary of Existing Flood Planning Documents section provides insight into the regulatory and policy environment governing floodplain management in the various jurisdictions of the Lower Brazos

Flood Planning Region. It summarizes the most common types of regulation, structural controls and planning activities.

Floodplain Ordinances

The regulatory framework guiding floodplain management in the Planning Region is comprised primarily of local floodplain ordinances. Overall, there are over 240 floodplain management and flood prevention ordinances in the Lower Brazos basin. Cumulatively, these ordinances:

- restrict and prohibit land uses that are dangerous
- control alteration of floodplains, channels, and natural protective barriers
- describe permitting and variance procedures for land use regulation in relation to flood prevention
- define the duties of the floodplain administrator
- specify subdivision and construction standards
- prescribe penalties for non-compliance to standards
- define overall rules and regulations for flood control and flood hazard reduction

Some communities, like Killeen and Austin County, have included drainage design manuals and detailed construction standards within their ordinances for flood hazard reduction. Overall, Brazoria County at the southern tip of the basin has the highest number of local flood reduction and floodplain management ordinances, at over 24 ordinances. Counties in the center of the Flood Planning Region, including McLennan, Bell, Williamson, and Hill Counties, have over 13 local flood management ordinances each.

Current Local regulations & development codes

Some of the counties and cities have included flood control measures in the local subdivision regulations for stormwater management using the basis of 50 percent, 10 percent, 4 percent, and 1 percent annual chance events. Similarly, McLennan County in the central area of the Lower Brazos basin has included detailed drainage and flood control requirements within the county's subdivision regulations. Williamson County, close to the western boundary of the Lower Brazos basin, has specified stormwater management controls and infrastructure for subdivision development. The Fort Bend County Drainage District in the south of the basin has conducted detailed hydrology and hydraulics analysis to determine the base flood elevation profile for the watersheds in the county. The City of Fulshear in Fort Bend County in the south of the basin has developed a Downtown Drainage Planning Study that provides recommendations for improving drainage in Fulshear Downtown.

Local and regional flood plans

Several counties and municipalities in the Planning Region have developed hazard mitigation plans. One example is the North Central Texas Council of Governments 2021 Hood County Hazard Mitigation Action Plan. Municipal Utility Districts and Levee Improvement Districts in the basin's southern area have also developed emergency action plans for flood mitigation. The Fort Bend County Drainage District has conducted detailed hydrology and hydraulics analysis to determine the base flood elevations for the watersheds in the county, including the Brazos River. The City of Sugar Land in Fort Bend County has overseen the development of several drainage improvement analyses for various locations in the city. Sienna just south of Sugar Land has created the Sienna South Levee System Master Drainage Plan and a 2021 emergency action plan.

1.2 Assessment of Existing Flood Infrastructure

The assessment of existing flood infrastructure provides an overview of existing flood infrastructure and natural areas that contribute to lowering the flood risk of communities in the Lower Brazos Flood Planning Region. This assessment of existing flood infrastructure, both natural and man-made, is based on data provided by TWDB. This data includes both structural and natural flood protection features and is summarized in this section. Additional information on major public flood infrastructure self-reported by entities who took the Lower Brazos Basin Community Survey is also included.

1.2.a Natural Features

An inventory of the natural features that perform important flood-related functions in the Lower Brazos Flood Planning Region is integral to the flood planning process. This inventory includes wetlands, lakes, reservoirs, parks, and preserves. As detailed in **Table 11**, there are over 249,000 acres of wetland in the Lower Brazos basin. Over 60 percent of the wetlands in the basin are freshwater forested / shrub wetlands, of which the largest wetland acreage is in the Navasota HUC 8 watershed on the central-eastern boundary of the Planning Region. The Lower Brazos HUC 8 watershed, which includes mid-sized cities like Sugar Land, Fulshear, and Rosenberg, has 38,214 acres, or 25 percent of the total freshwater forested / shrub wetlands in the basin.

Table 11: Types of Wetland by HUC 8

HUC 8 Watershed	Estuarine and Marine Wetland (acres)	Freshwater Emergent Wetland (acres)	Freshwater Forested / Shrub Wetland (acres)	Total Wetland (acres)	Total Wetland (percent)
Austin-Oyster	25,463	23,854	16,285	65,602	26%
Bosque	-	405	928	1,333	1%
Cowhouse	-	260	1,750	2,010	1%
Lampasas	-	623	1,559	2,182	1%
Leon	-	2,813	5,582	8,395	3%
Little	-	936	3,311	4,247	2%
Lower Brazos	1,973	17,064	38,214	57,251	23%
Lower Brazos-Little Brazos	-	5,578	15,345	20,923	8%
Middle Brazos-Lake Whitney	-	1,888	9,096	10,984	4%
Middle Brazos-Palo Pinto	-	2,477	4,673	7,150	3%
Navasota	-	8,344	40,606	48,950	20%
North Bosque	-	574	1,987	2,561	1%
San Gabriel	-	1,361	5,683	7,044	3%

HUC 8 Watershed	Estuarine and Marine Wetland (acres)	Freshwater Emergent Wetland (acres)	Freshwater Forested / Shrub Wetland (acres)	Total Wetland (acres)	Total Wetland (percent)
Yegua	-	2,260	8,426	10,686	4%
Total	27,436	68,437	153,445	249,318	100%

Source: United States Fish and Wildlife Service

Overall, the Austin-Oyster HUC 8 watershed at the southern tip of the basin comprises of over one-fourth of the total wetland in the Planning Region performing critical flood-related functions. Approximately, 15 percent of the entire Austin-Oyster HUC 8 watershed land area is covered with wetlands. While Lower Brazos and Navasota HUC 8 watersheds contain over 20 percent each of the total wetland acreage of the Lower Brazos basin, only five and three percent of their land area, respectively, is comprised of wetland. HUC 8 watersheds in central and northern areas of the basin stretching from Graham and Stephenville in the north to Killeen and Bryan in the south comprise of less than five percent of the total wetland acreage of the basin and less than one percent of their land area has wetland coverage. These HUC 8 watersheds, therefore, are lacking the relative protection and flood mitigation functions performed by natural features, such as wetlands.

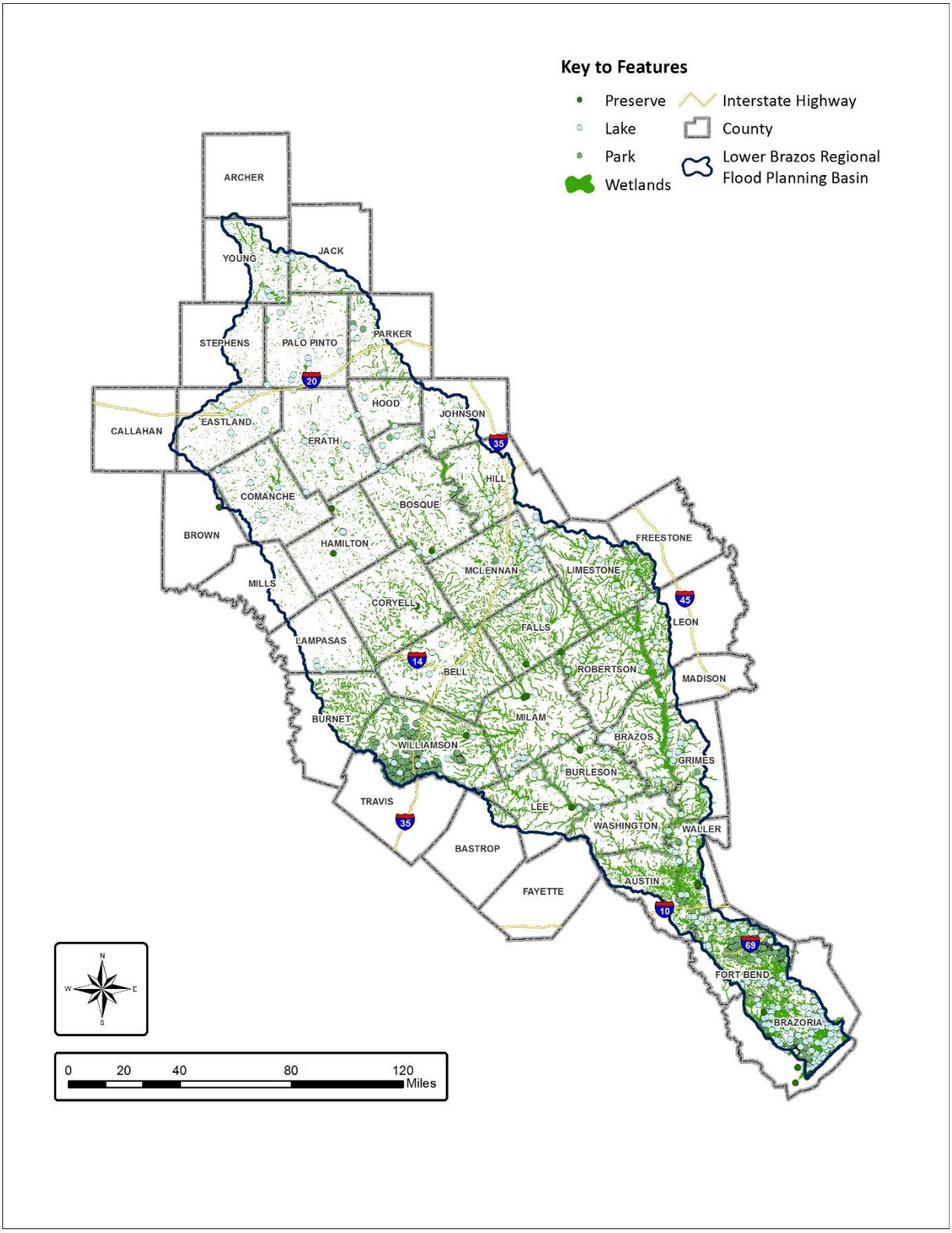
Lakes, reservoirs, parks, and preserves are critical natural infrastructure performing mitigating functions during flood events. **Table 12** details the acreage of each of these natural features and the total land area in the HUC 8 watersheds covered by these natural features. Austin-Oyster HUC 8 watersheds in the southern tip of the basin and San Gabriel at the south western boundary of the Lower Brazos Flood Planning Region have approximately 17 percent of the land area covered with lakes, reservoirs, parks, and preserves. Other HUC 8 watersheds in the Planning Region that have 12 to 13 percent of the land area covered with lakes, reservoirs, parks, and preserves, are Middle Brazos – Palo Pinto and Middle Brazos – Lake Whitney HUC 8 watersheds in the north and north eastern portion of the Planning Region as well as the Lower Brazos HUC 8 watersheds in the south of the Planning Region. HUC 8 watersheds in the central and central northern area of the basin have two percent or less of their land area comprising of food mitigating natural features. **Figure 15** illustrates the location of parks, lakes, preserves, and wetlands in the Planning Region.

Table 12: Lakes, Reservoirs, Parks, and Preserves by HUC 8

HUC 8 Watershed	Lakes (acres)	Reservoirs (acres)	Parks (acres)	Preserves (acres)	Total Lakes, Reservoirs, Parks, Preserves (acres)	Percent of Total HUC 8 Land Area
Austin-Oyster	8,448	3,389	39,169	267	51,273	17%
Bosque	94	6,218	107	145	6,564	2%
Cowhouse		3,305		152	3,457	1%
Lampasas	142	6,356	946	-	7,444	2%
Leon	2,751	13,861	381	580	17,573	6%
Little	184	-	-	918	1,102	0%
Lower Brazos	8,309	5,170	13,464	8,754	35,697	12%
Lower Brazos-Little Brazos	2,098	-	294	2,124	4,516	1%
Middle Brazos-Lake Whitney	8,735	26,598	2,883	-	38,216	12%
Middle Brazos-Palo Pinto	30,623	-	9,016	-	39,639	13%
Navasota	19,950	-	1,469	-	21,419	7%
North Bosque	756	2,338	529	34	3,657	1%
San Gabriel	374	5,540	32,332	13,530	51,776	17%
Yegua	1,895	11,571	9,237	3,148	25,851	8%
Total	84,359	84,346	109,827	29,652	308,184	100%

Source: United States Fish and Wildlife Service, United States Army Corp of Engineers, Texas Parks and Wildlife Department

Figure 15: Natural Features in Lower Brazos Flood Planning Region



1.2.b Constructed Flood Infrastructure/ Structural Protections

The existing major infrastructure features in the Lower Brazos Planning Region includes publicly-owned dams, levees, and weirs. In total, there are 480 public dams in the basin, of which 19 percent are in the Middle Brazos – Lake Whitney HUC 8 in the northeastern area of the basin. Leon HUC 8 watershed has 71 dams, or 15 percent of all dams in the basin. Other HUC 8 watersheds that have close to 10 percent of the dams in the basin are Cowhouse HUC 8 watershed in the central area and San Gabriel in the south western area of the Lower Brazos basin. The San Gabriel HUC 8 also has 36 of the 41 weirs in the basin.

The HUC 8 watersheds with the fewest dams are Bosque, Yegua, Lower Brazos, and Austin-Oyster. However, the Lower Brazos and Austin-Oyster watersheds have a relatively large number of levees, 34 percent each of the total number of levees in the Planning Region. **Table 13** details the dams, levees, and weirs in the Lower Brazos Flood Planning Region.

Table 13: Dams, Reservoirs, Levees & Weirs by HUC 8

HUC 8 Watershed	Publicly-owned Dam	Levee	Weir	Total
Austin-Oyster	8	21	-	29
Bosque	3	-	-	3
Cowhouse	46	-	-	46
Lampasas	16	1	-	17
Leon	71	4	-	75
Little	42	1	-	43
Lower Brazos	6	21	1	28
Lower Brazos-Little Brazos	42	7	-	49
Middle Brazos-Lake Whitney	91	4	-	95
Middle Brazos-Palo Pinto	24	1	4	29
Navasota	31	1	-	32
North Bosque	45	1	-	46
San Gabriel	50	-	36	86
Yegua	5	-	-	5
Total	480	62	41	583

Source: United States Army Corp of Engineers

The two HUC 8 watersheds that abut the Gulf Coast have coastal barriers and revetments that provide structural protection against coastal flooding, as summarized in **Table 14**.

Table 14: Coastal Infrastructure in Austin-Oyster and Lower Brazos HUC 8

HUC 8 Watershed	Coastal Barrier	Sea Wall	Coastal Revetment
Austin-Oyster	29	8	9
Lower Brazos	4	-	-
Total	33	8	9

Source: United States Fish and Wildlife Service, General Land Office

Other types of infrastructure that serve flood protection functions in the Planning Region include high and low water marks. There are 1,513 high water marks and 1,155 low water marks in the Planning Region. As detailed in **Table 15**, San Gabriel HUC 8 watershed in the south western area and Austin-Oyster HUC 8 watershed in the southern area have the largest percentage of high and low water marks in the Lower Brazos Flood Planning Region, at 21 percent and 14 percent, respectively. Leon HUC 8 watershed in the central area of the Planning Region has 312 high and low water marks comprising 12 percent of all flood water marks in the Planning Region. The HUC 8 watersheds in the northern and central area of the basin, such as Bosque, Cowhouse, and Lampasas, as well as Yegua in the southwest have the fewest number of high and low water marks.

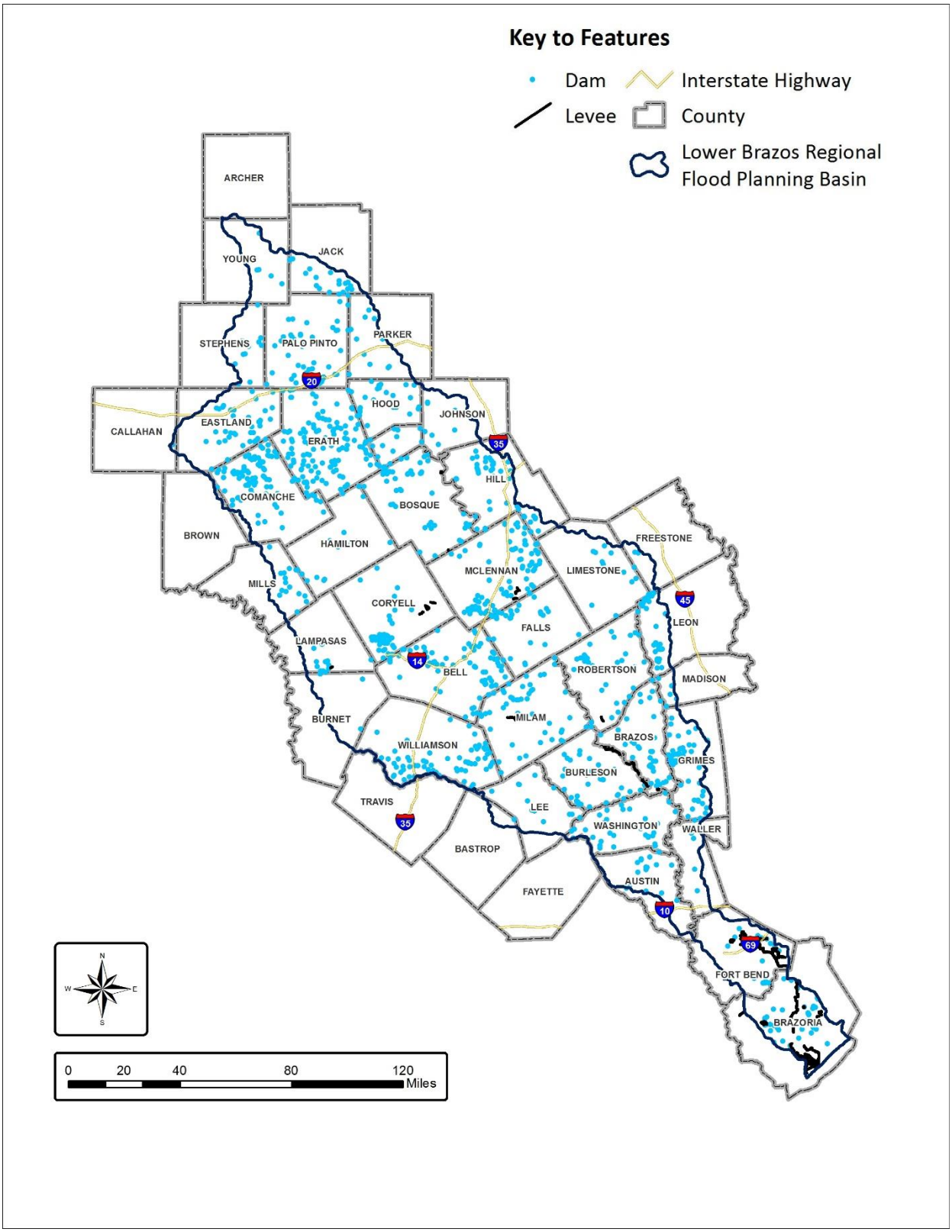
Table 15: High / Low Water Marks by HUC 8

HUC 8 Watershed	High Water Mark	Low Water Mark	Total	Percent
Austin-Oyster	368	1	369	14%
Bosque	6	19	25	1%
Cowhouse	6	8	14	1%
Lampasas	68	103	171	6%
Leon	75	237	312	12%
Little	166	60	226	8%
Lower Brazos	90	27	117	4%
Lower Brazos-Little Brazos	125	98	223	8%
Middle Brazos-Lake Whitney	112	107	219	8%
Middle Brazos-Palo Pinto	52	69	121	5%
Navasota	39	106	145	5%
North Bosque	28	51	79	3%
San Gabriel	353	210	563	21%
Yegua	25	59	84	3%
Total	1,513	1,155	2,668	100%

Source: Texas Water Development Board

Figure 16 on the following page illustrates the location of dams and levees in the Planning Region.

Figure 16: Constructed Flood Infrastructure in Lower Brazos Flood Planning Region


Key to Features
Dam
Levee
Interstate Highway
County
Lower Brazos Regional Flood Planning Basin
ARCHER
YOUNG
JACK
STEPHENS
PALO PINTO
PARKER
HOOD
JOHNSON
CALLAHAN
EASTLAND
ERATH
HILL
COMANCHE
BOSQUE
BROWN
HAMILTON
FREESTONE
MCLENNAN
LIMESTONE
MILLS
CORYELL
LEON
FALLS
LAMPASAS
BELL
ROBERTSON
MADISON
BURNET
MILAM
BRAZOS
WILLIAMSON
GRIMES
BURLESON
TRAVIS
LEE
WASHINGTON
WALLER
BASTROP
AUSTIN
FAYETTE
FORT BEND
BRAZORIA
N
W
E
S
0
20
40
80
120
Miles

1.2.c Non-Functional or Deficient Flood Mitigation Features

This section summarizes information on non-functional or deficient flood mitigation infrastructure in the Lower Brazos Flood Planning Region. This information is based on self-reported data from communities that have responded to Lower Brazos Basin Community Survey and have self-assessed the condition of their infrastructure as Functional, Non-Functional or Deficient. This self-reported data has been augmented by information obtained from Levee Safety Assessments by the Levee Improvement Commission in the Texas Commission on Environmental Quality (TCEQ) and the Soil and Water Conservation Society's (SWCS) Levee Program and Small Watershed Programs to indicate areas where the existing infrastructure is failing to do its job of protecting the population, or is at risk of failure.

The following tables provide information on the level of service (LOS) and functional classification of the dams and levees in the Lower Brazos Flood Planning Region. **Table 16** describes the functional classification of levees in each HUC 8 and **Table 17** provides the total number of levees in each classification.

Table 16: Functional Classification of Levees by HUC 8

HUC 8 Watershed	Levees 100-Year LOS	Levees Not Assessed	Levees In Progress	Levees Functional
Austin-Oyster	11	18	1	1
Bosque	-	-	-	-
Cowhouse	-	-	-	-
Lampasas	-	1	-	-
Leon	-	4	-	-
Little	-	1	-	-
Lower Brazos	18	18	1	2
Lower Brazos-Little Brazos	-	7	-	-
Middle Brazos-Lake Whitney	-	4	-	-
Middle Brazos-Palo Pinto	-	1	-	-
Navasota	-	1	-	-
North Bosque	-	1	-	-
San Gabriel	-	-	-	-
Yegua	-	-	-	-

Source: United States Army Corp of Engineers

Table 17: Functional Classification of Levees in Lower Brazos Flood Planning Region

Functional Classification	Number of Levees
Total Count	54
With 100-Year LOS	22
Levees with 100-Year LOS with overlap in Austin-Oyster and Lower Brazos HUC 8s	7
Functional	2
In Progress	1
Not Assessed	49
Deficient	3
Non-deficient	1

Source: United States Army Corp of Engineers

Of the 480 dams in the Planning Region, the level of service classification is available for 310 dams and is detailed in **Table 18**. More than half, or 51 percent, of the dams for which the level of service classification is available have a 50-year LOS classification and 47 percent have a 100-year LOS.

Table 18: Functional Classification of Dams by HUC 8

HUC 8	25-Year LOS	50-Year LOS	100-Year LOS	Total
Austin-Oyster	-	-	-	-
Bosque	-	-	2	2
Cowhouse	-	-	-	-
Lampasas	-	9	4	13
Leon	-	26	28	54
Little	-	-	40	40
Lower Brazos	-	-	-	-
Lower Brazos-Little Brazos	-	29	-	29
Middle Brazos-Lake Whitney	3	28	39	70
Middle Brazos-Palo Pinto	-	10	3	13
Navasota	-	-	2	2
North Bosque	-	13	29	42
San Gabriel	-	45	-	45
Yegua	-	-	-	-
Total	3	160	147	310

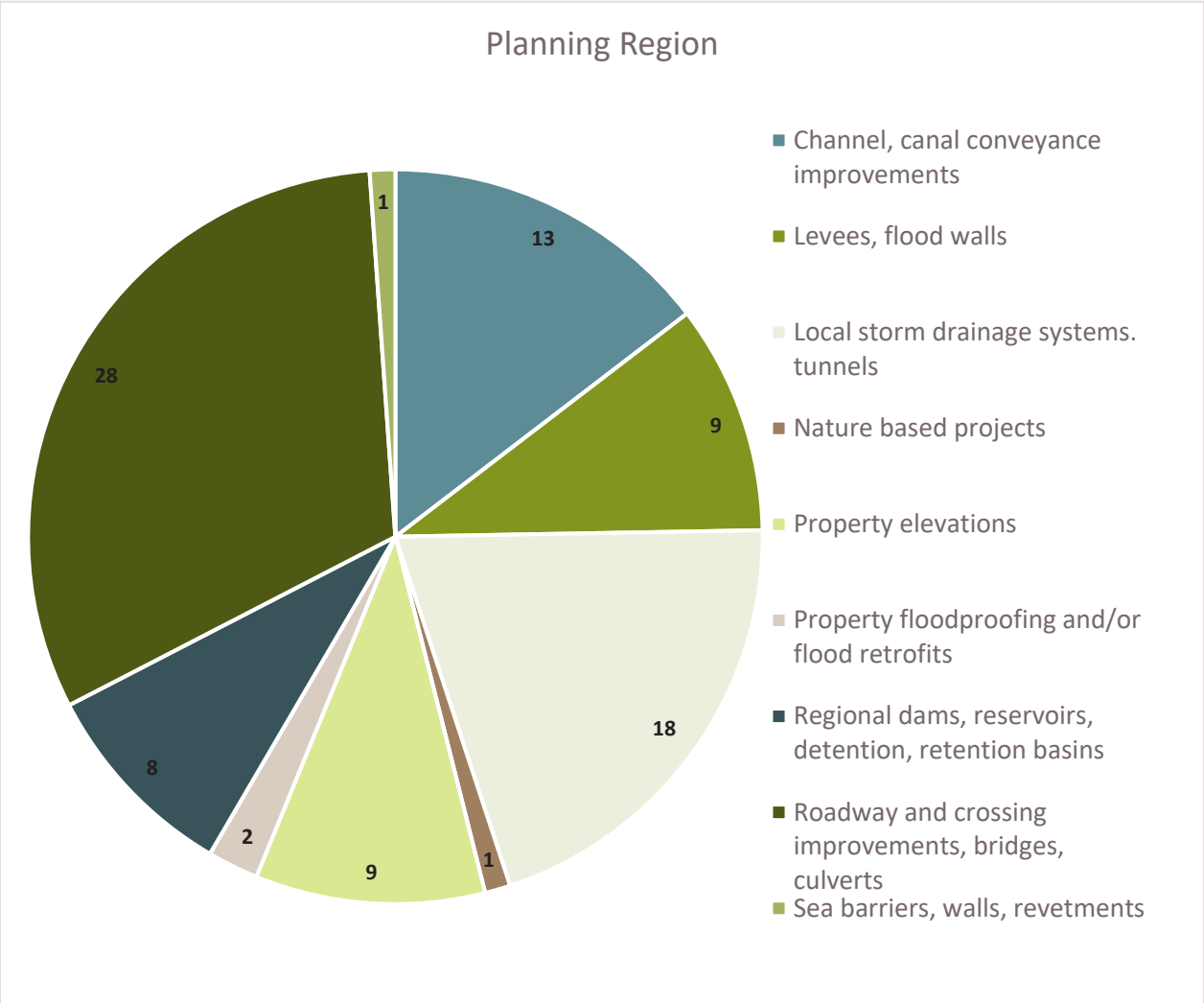
Source: United States Army Corp of Engineers

1.3 Proposed or Ongoing Flood Mitigation Projects

For a thorough flood planning process which takes into account the flood protection policy and regulatory framework at the local level, it is important to document the proposed and ingoing flood mitigation projects in the Planning Region. The data for this section is derived from two primary sources. The first source is the Lower Brazos RFPG - Stakeholder Survey, which was supplemented by direct outreach to stakeholders. More detailed results are available in **Summary of Proposed or Ongoing Flood Mitigation Projects** in **Appendix A**. The second source is existing Hazard Mitigation Plans in the region.

Ongoing or Proposed Projects Identified in Region 8 Data Collection Tool

Over sixty communities indicated in the Data Collection Tool that they planned to undertake flood mitigation projects in the coming years. However, there are a number of gaps in this data set as little data was provided on individual projects. Some communities indicated that they anticipated pursuing a variety of Flood Mitigation Projects (FMPs) in the coming years. Almost all the communities responding to the survey question on ongoing or proposed flood management strategies or projects indicated they did intend to pursue more than one type of flood mitigation projects. These include projects related to local storm drainage systems, roadway improvements, regional dam improvements, reservoirs and detention areas improvements, sea barriers and revetments, and levee improvements.



Source: Lower Brazos Basin Community Survey

Table 19 details the frequency with which communities plan on implementing a particular type of flood mitigation. While several project types, like local storm drainage systems and roadway improvements may be local in nature, many other solutions are more regional in nature, such as regional dams and retention as well as highway improvements that may involve state agencies.

Table 19: Number of Flood Mitigation Projects

Type of Flood Mitigation Project	Number
Channel, canal conveyance improvements	13
Levees, flood walls	9
Local storm drainage systems. tunnels	18
Nature based projects	1
Property elevations	9

Type of Flood Mitigation Project	Number
Property floodproofing and/or flood retrofits	2
Regional dams, reservoirs, detention, retention basins	8
Roadway and crossing improvements, bridges, culverts	28
Sea barriers, walls, revetments	1
Total	89

Source: Lower Brazos Basin Community Survey

These proposed or ongoing flood mitigation projects are derived from survey responses received from communities throughout the basin, including cities, counties, and additional political entities such as levee improvement districts and municipal utility districts. The predominant types of projects being pursued are:

- Local storm drainage systems and tunnels
- Roadway and crossing improvements, bridges, and culverts
- Channel, canal conveyance improvements

The projects with the lowest interest were nature based projects, property floodproofing, and sea barriers, walls, and revetments. It is important to note that there may be more on-going projects than described in the survey, since respondents provided information on projects they were pursuing at the time of the survey but not every on-going project in the entity. Potential funding sources identified for these projects include FEMA, Texas General Land Office, Community Development Block Grant-Mitigation, TWDB, and Texas Department of Emergency Management, as well as local funding sources coming from the general fund, taxes, stormwater utility fees and other fees.

Structural Projects under Construction

Information provided in response stakeholder outreach is insufficient to provide a complete understanding of structural projects under construction within the entities that responded to the Lower Brazos RFPG – Stakeholder Survey. Entities within Fort Bend County are the only survey respondents with information on projects that are under construction. Of the 132 proposed or on-going flood mitigation projects in Fort Bend County, there are currently 73 projects reported in the survey which have completed the design phase and are in the construction phase.

Nonstructural Flood Mitigation Projects Being Implemented

Information provided in response stakeholder outreach is insufficient to describe the nonstructural flood mitigation projects being implemented within the various entities.

Structural & Non-Structural Flood Mitigation Projects with Dedicated Funding & Year

Information provided in response stakeholder outreach is insufficient to describe all of the structural and non-structural flood mitigation projects with dedicated funding. Entities within Fort Bend County are utilizing Hazard Mitigation Grant Program (HMGP- FEMA/TDEM) funds, and FEMA funds.

Projects Identified in Hazard Mitigation Plans

In addition to the projects identified in the Lower Brazos Basin Community Survey, the community Hazard Mitigation Plans developed or adopted by communities in the Lower Brazos Planning Region are an important source of information on future flood mitigation activities. **Table 20** lists all flood mitigation projects identified in the current Hazard Mitigation Plans for each county and community in the Lower Brazos Flood Planning Region.

Table 20: Flood Mitigation Projects in Hazard Mitigation Plan

Flood Mitigation Projects	Number
Buyout/Acquisition	47
Drainage Control & Maintenance	116
Education & Awareness for Citizens	84
Equipment Procurement for Response	82
Erosion Control Measure	7
Flood Insurance Education	24
Flood Study/Assessment	48
Infrastructure Improvement	177
Installation/Procurement of Generators	44
Natural Planning Improvement	13
Outreach and Community Engagement	79
Technology Improvement	24
Urban Planning and Maintenance	127

Source: Lower Brazos Basin Community Survey, Halff Associates Inc

Since these plans are prepared on a five-year cycle, **Table 20** details the types of projects that will need funding in the future. While it is difficult to estimate the total cost of future mitigation projects, it is likely that a significant amount of funding needs for structural improvement remains unmet, given the number of high-cost projects like infrastructure improvement and drainage control and maintenance.

Many non-structural initiatives such as education and citizen awareness, outreach and community engagements, and urban planning and maintenance can be accomplished with lower investment, while an ongoing program of buyouts and acquisitions may be a more longer-term and expensive initiative. It is likely that many of the Flood Mitigation Projects identified by communities have already been completed since the initial Hazard Mitigation Plan was adopted.

Potential Benefits of Planned Mitigation Projects

Although most communities did not provide detailed information about their intended projects, there does appear to be substantial awareness of the value of preparing for future flood events. Both survey responses and a review of Hazard Mitigation Plans indicate that substantial investment is being made in

local drainage, roadway and flood control infrastructure. Without greater detail as to the scale, complexity and location of these projects, it is difficult to quantify the benefit received, but it is anticipated that the inventory of this information will continue to expand in future planning cycles.