Task 1: Planning Area Description

Source: Lower Colorado River Authority Mansfield Dam flood gates

Introduction - The Regional Flood Plan in Context

Overview of Establishing Legislation

In Texas, the billion-dollar disaster is becoming a typical occurrence. Between 2015 and 2017, flooding alone caused almost $5 billion in damages to Texas communities. As the state grappled with how to better manage flood risk and decrease loss of life and property from future disasters, the Texas Water Development Board (TWDB) led the first ever flood assessment, which described Texas' flood risks, provided an overview of roles and responsibilities, and contained an estimate of potential flood mitigation costs and a summary of stakeholder views on the future of flood planning. This assessment was created because:

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- Much of Texas is unmapped, or uses outdated maps (Peter M. Lake, 2019).

The TWDB presented its findings to the Texas Legislature during the 86th 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. A mandate required the TWDB to facilitate the creation of a regional flood plan for each of the State's 15 major river basins by January 10, 2023. Updates are required every five years thereafter (TWDB Flood Planning Frequently Asked Questions, 2021). The overarching intent of the plans are to protect against the loss of life and property to:

1. Identify and reduce the risk and impact to life and property that already exists, and
2. Avoid increasing or creating new flood risk by addressing future development within the areas known to have existing or future flood risk.

Overview of the Planning Process

In 2019, the Texas Legislature passed Senate Bill 8 directing the creation of the first-ever State Flood Plan for Texas—to be prepared by the Texas Water Development Board (TWDB) and to follow a similar region-driven "bottom-up" approach that's been used for water supply planning in Texas for the past 20 years. Fifteen flood planning regions have been established—based on river basins. The first Texas Flood Plan will be delivered from Regional Flood Planning Groups to the TWDB by January 10, 2023.

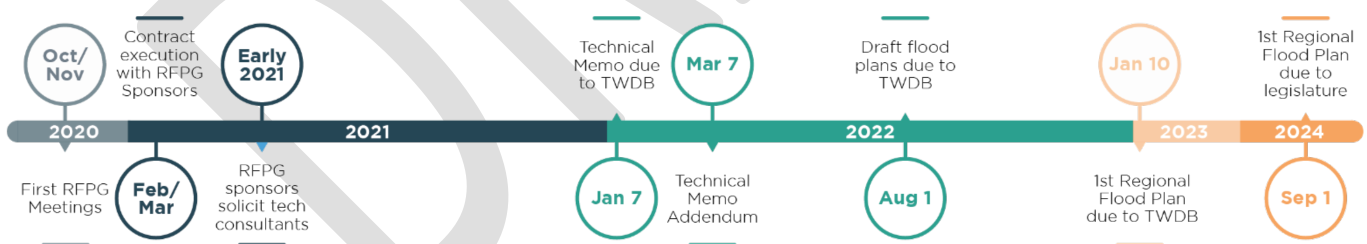
Who Prepared the Plan?

The TWDB has appointed Regional Flood Planning Groups (RFPG) for each region and has provided them with the funds necessary to prepare their plans. The TWDB will administer the regional planning process through a contract with a planning group sponsor who is chosen by the RFPG for their significant role within the river basin. The sponsor will provide support for meetings and communications and manage the contract of the technical consultant once determined by the RFPG. The Lower Colorado River Authority (LCRA) was selected as the project sponsor for Region 10. Halff Associates, Inc. was selected by the RFPG to be the technical consultant to assist with the development of the Lower Colorado-Lavaca Regional Flood 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
- Industry
- Municipalities
- Public
- River Authorities
- Small Businesses
- Water Districts
- Water Utilities

The Lower Colorado-Lavaca RFPG is responsible for developing the regional flood plan for the Lower Colorado, Lavaca River and San Bernard Basins in accordance with TWDB requirements. The TWDB will combine the regional flood plans into a single State Flood Plan to be delivered to the Legislature by September 1, 2024.



Funding Sources

To fund projects identified by these plans, the Legislature created a new flood financial assistance fund and charged the TWDB with managing it. 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 flood-related implementation projects. Communities who identify future projects aimed at flood mitigation will be eligible for financial assistance in the form of grants from the TWDB.

Characterization - The Lower Colorado-Lavaca Region

The Lower Colorado-Lavaca region (Flood Planning Region 10) is comprised of three major river basins, the lower portion of the Colorado River, Lavaca River and the San Bernard River basins. The region extends from the northwest near San Angelo to the southeast to Matagorda and Lavaca Bays and the Gulf of Mexico. Major tributaries within these basins include the Llano, Pedernales, San Saba, Lavaca, San Bernard, and Navidad Rivers and Sandy, Onion, Cummins, and Champions Creeks. Major surface water impoundments, some of which have flood storage, include Lake Coleman, Lake Brownwood, Lake Texana, and the Highland Lakes system.

The central portion of the Lower Colorado-Lavaca region lies within what's known as "Flash Flood Alley," one of the most flood prone areas of the U.S. Major storm and flood events can occur throughout the year but are most common during the spring and fall. Much of the region, particularly the lower coastal areas, are exposed to tropical storms and hurricanes with flooding caused by heavy areawide rainfall and coastal storm surge.

The Austin Metropolitan Area is the major population center in the region with a current population of approximately 2.3 million, the majority of which is in the Lower Colorado-Lavaca region (U.S. Census Bureau, 2020). The region's population is projected to increase by 50% by 2050. In terms of land use, much of the region is rural in nature with small and medium sized towns and cities interspersed throughout. The region also includes several public agencies with flood control and drainage responsibilities including the Lower Colorado and the Lavaca-Navidad river authorities, utility districts, and drainage districts.

Figure 1: Lower Colorado-Lavaca Flood Planning Region

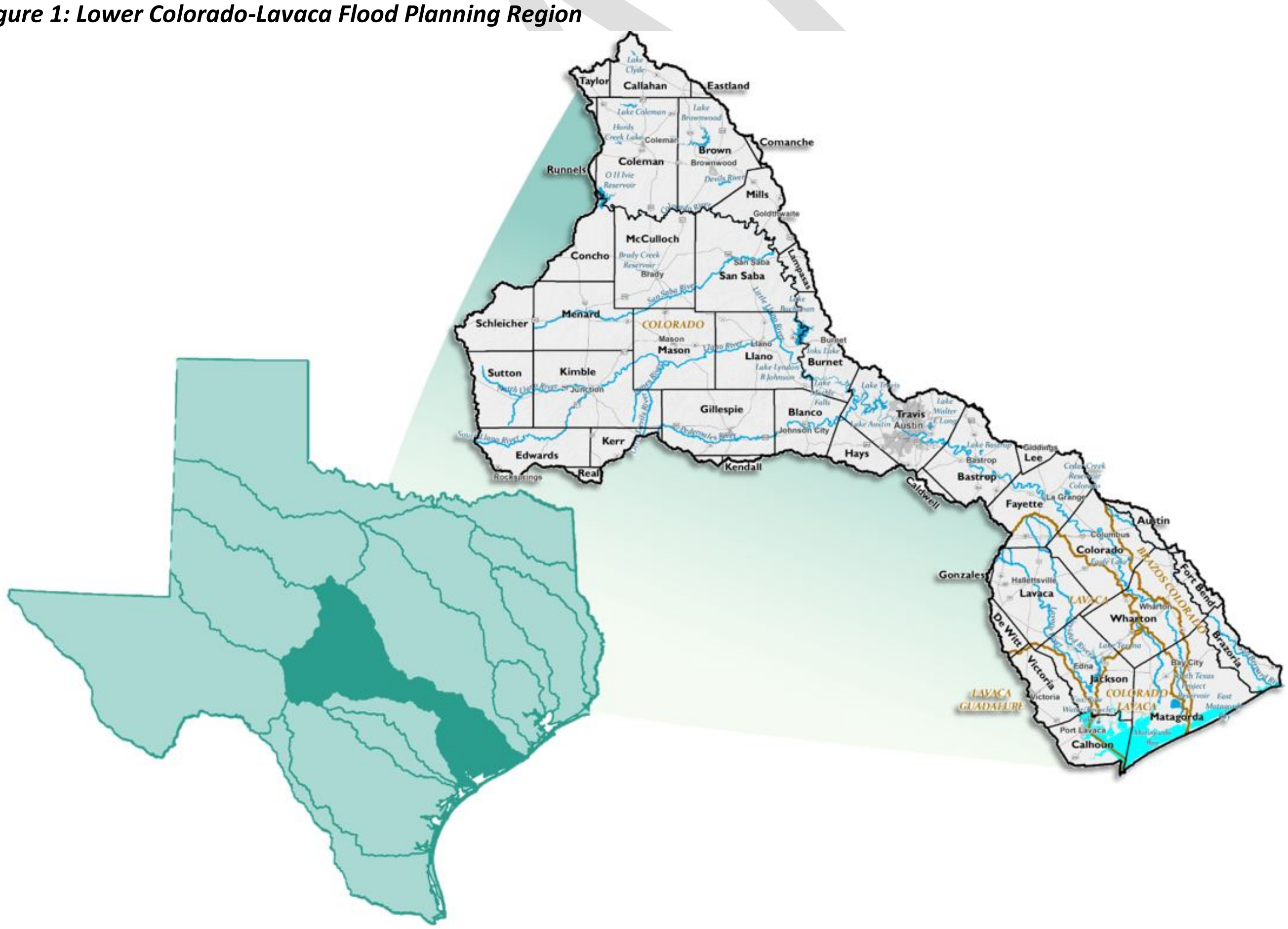


Figure 2: *Region 10 Quick Facts*

43 counties *43 counties, or a portion of each, are included in this basin*	**~10% within 1% ACE** *10 percent of the region is within the FEMA 1% annual chance flood event (100 yr.) floodplain*	**24,380 sq. miles** *Total area of the region*
1,877,786 people *2019 Population* today in the basin	**2,866,025 people** *Population 2050, projected* to be in the basin by 2050; approximately a *50% increase*	**3 river basins** *Three major river basins: the lower portion of the Colorado River, San Bernard and the Lavaca River basin*
Major tributaries *Major tributaries: Llano, Pedernales, San Saba, San Bernard Lavaca & Navidad rivers, Sandy, Onion, Cummins and Champion creeks*	**110 flood events** *110 major flood events have occurred in last 20 year with significant losses to life and property*	**50 flood disasters** *Between 1953-2020: 50 major disaster declarations and 6 emergency declarations*

To better comprehend the nature of that flood risk, this section will cover people, type and location of growth, economic activity, and sectors at highest danger of flood impacts.

Social and Economic Character

As the Lower Colorado-Lavaca Flood Planning Region increases in population, communities are expanding outward to accommodate this growth. Texas grew roughly 15% in the last 10 years. As structures are built on previous farmland and crops are replaced by urban sprawl, the increase in impervious surfaces generally decreases the absorption of precipitation. Urban drainage systems could also tax the capacity of the Lower Colorado and Lavaca River's creeks and tributaries. Population growth and the outward expansion of urban areas into what was previously open space has increased the burden on the region's flood control system and is exposing a rising number of residents to flood risk. Floods and other disasters could affect everyone, but they are unlikely to affect everyone equally.

The Lower Colorado-Lavaca region stretches across an area of 24,380 square miles, 43 counties, and 376 local communities and special districts. It is important to note that the river basins do not neatly follow or conform to county boundaries. This means that the Region 10 planning area includes only portions of many of the 43 counties (Table 1).

Table 1: Region 10 Counties

Region 10 Counties				
Austin*	Coleman*	Gillespie*	Lee*	San Saba
Bastrop*	Colorado	Gonzales*	Llano	Schleicher*
Blanco*	Comanche*	Hays*	Mason	Sutton*
Brazoria*	Concho*	Jackson	Matagorda	Taylor*
Brown*	De Witt*	Kendall*	McCulloch	Travis*
Burnet*	Eastland*	Kerr*	Menard*	Victoria*
Caldwell*	Edwards*	Kimble	Mills*	Wharton*
Calhoun*	Fayette*	Lampasas*	Real*	
Callahan*	Fort Bend*	Lavaca*	Runnels*	

**indicates this county is partially within this RFPG and is also represented by at least one other RFPG.*

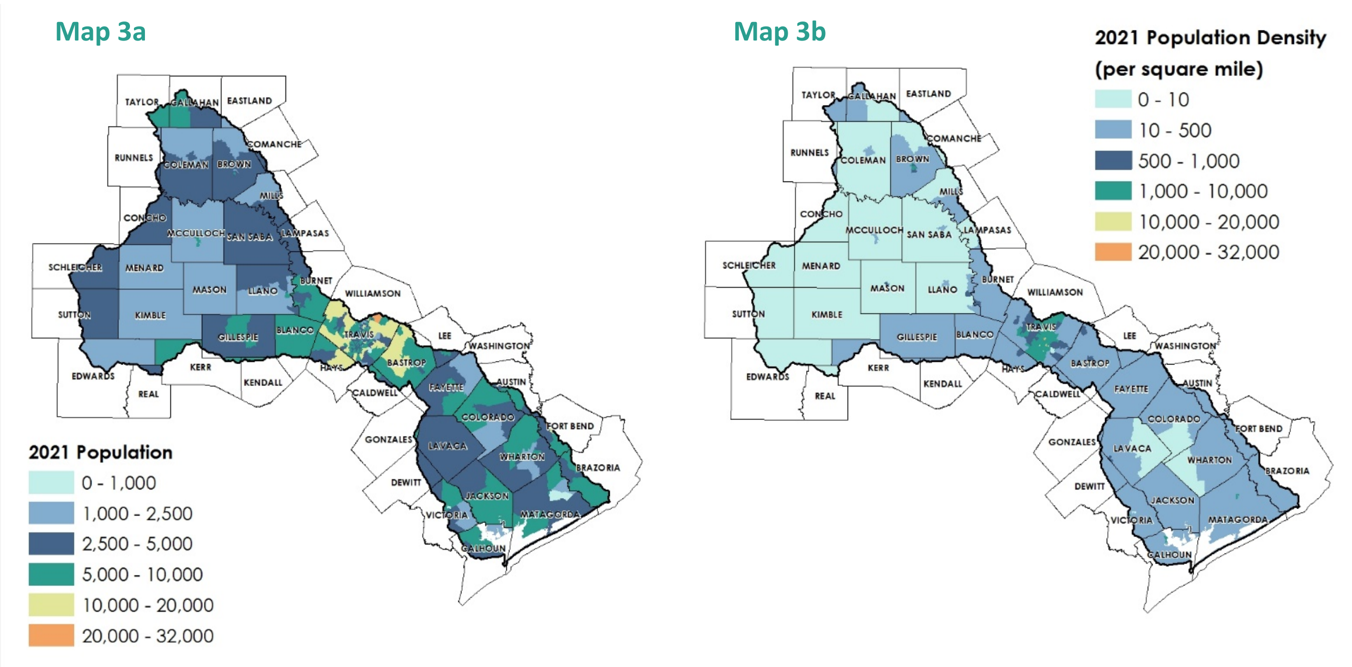
Population and Future Growth

Current Population

The 2020 5-year American Community Survey (U.S. Census Bureau) estimates show that the existing population of the region is 1,916,344, which is over six percent of the population of Texas. As indicated on *Figure 3: 2021 Population by Census Tract*, on the next page, the northern portion of the region is largely embodied within the Texas Hill Country and is characterized by sparsely populated small towns with pockets of populations concentrated in and near downtowns. The largest concentration of residents live in Travis County in the central part of the region. The southern portion of the region is also characterized by smaller population centers embodied within rural counties.

Map 3a (Figure 3, on the next page) also shows that the greatest numbers of people, by census tract, are largely located along the major river corridors. This is indicative of many large cities historically being developed in close proximity to water.

Figure 3: 2021 Population by Census Tract



Source: US Census Bureau 2021

Population Density and Character of Development

Beyond just total population numbers, the concentration of population density as well as form and character of development also varies widely across the region. *Map 3b* (Figure 3), above, shows that northern part of the region has the lowest density of development (i.e., lowest population density per square mile) and the southern portion is slightly denser, but not by much. Various counties show small pockets of denser development, mostly located around the downtown's of cities which serve as the county seats. The central portion of the region, particularly around Austin, has the densest concentration of population.

The form and character of development also changes across the region, including varying areas of rural, suburban, and urban character, and special considerations for those areas along the coast (Figure 4, on the next page). Each of these areas exhibit different characteristics and needs as it relates to flood prevention and mitigation.

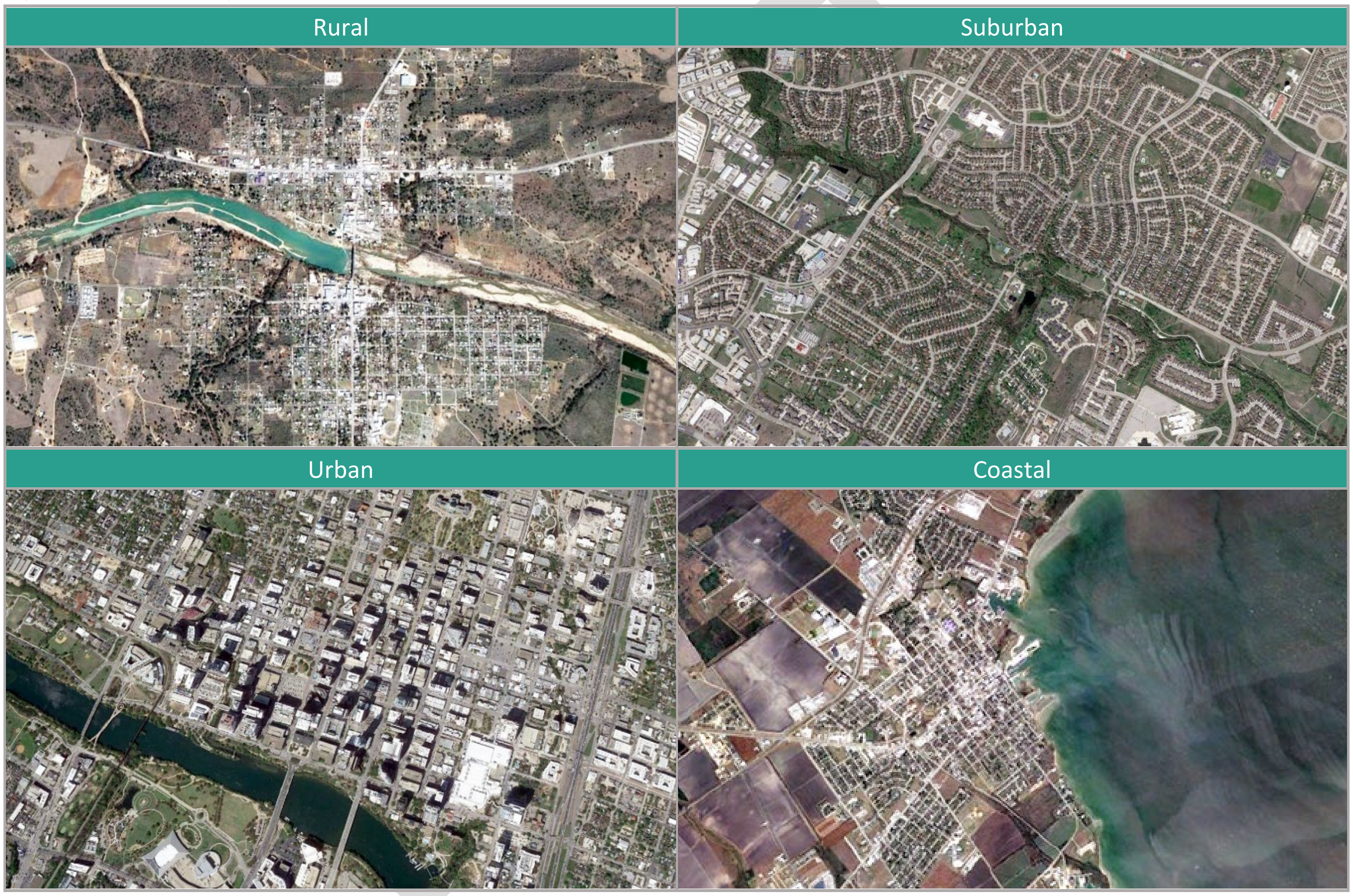
In the sparsely populated rural areas, flooding oftentimes impacts rural roadways, low water crossings, and small downtowns with close proximity to major watercourses (e.g., the City of Llano). Many small towns often struggle to proactively reduce future flood risk due to limited resources such as staffing and funding.

In the rapidly intensifying suburban areas (e.g., on the outer fringe of the Austin Metropolitan Area), new growth develops over open lands and natural areas by increasing impervious surfaces while simultaneously reducing the land's natural ability to absorb flood water. In these areas, increased efforts are needed on flood mitigation to prevent future populations from being placed in areas of increased flood risk. However, since many development decisions are made using data on current site-specific conditions, they oftentimes do not take into consideration that changes in land use, in the aggregate, exacerbate flood problems over time.

In urbanized areas, like downtown Austin and some of the original core areas of our larger cities, past development decisions have already placed citizens in harm's way, particularly for more vulnerable populations. As changes in rainfall intensity and duration continue to worsen over time, these areas will be simultaneously be dealing with efforts to mitigate future problems stemming from new development/redevelopment and adapting to intensifying impacts in areas already developed. Since these areas are also the employment centers and hubs of commerce, disruptions stemming from flood events can cause significant impacts to local and regional economies.

The coastal areas in the region also require special attention. While the character of development in these areas may exhibit rural, suburban, or urban characteristics, they must simultaneously prepare for the intensifying impacts of both riverine and coastal flooding. They are located at the most downstream point of the Lower Colorado-Lavaca River basin, and thus eventually receive the flood waters from all upstream flood events. They also are increasingly subject to intensifying coastal-related impacts like coastal flooding stemming from hurricanes and sea level rise.

Figure ***4: Character of Development and Flood Risk***



Urbanized Areas

Of the 376 local communities in the region (as detailed in the TWDB Water User Group Data), there are eight communities with a population greater than 10,000; and three communities with a population greater than 30,000 (Table 2, on the next page). The cities with the largest population in the northern, central, and southern portions of the basin include Brownwood (Brown County; 39,761) in the northern portion of the region, Austin (Travis County; 1,298,624) in the central portion of the region, and Victoria (Victoria County; 93,857) in the southern portion of the region.

Table 2: Cities in the Lower Colorado-Lavaca River Basin with Population Greater than 10,000

Cities with Population Greater than 10,000			
Austin*	Bay City	El Campo	Pflugerville
Bastrop	Brownwood*	Fredericksburg	Victoria*

**indicates cities with population greater than 30,000*

Source: 2021 Regional Water Plan - Population Projections for 2020-2070

Existing and Projected Growth by HUC 8

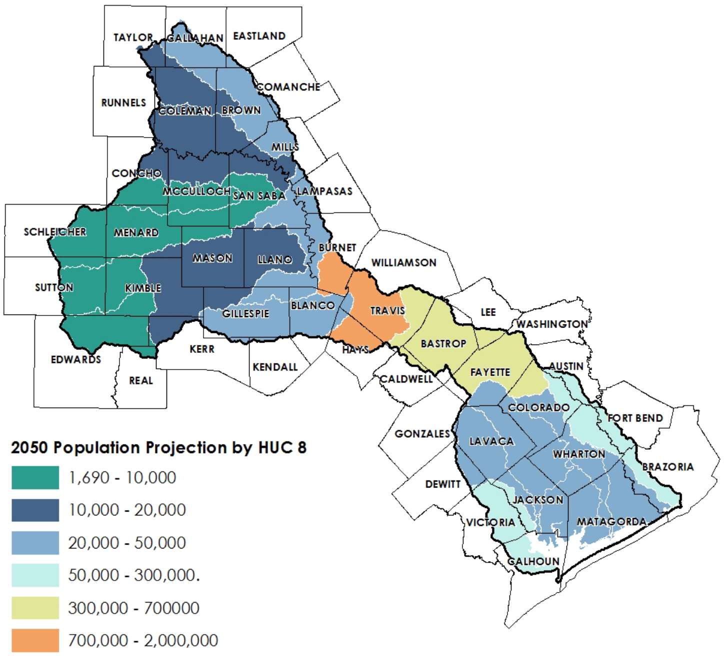
The current growth patterns are generally projected to continue over the next 30 years, with greater concentrations of population being aggregated in urbanized areas, and possible continuation of declining population in more rural areas. The analysis for this section was undertaken using the Water User Groups and HUC 8 watershed population projections provided to each region by the TWDB from the State Water Plan. From 2020 to 2050, the number of communities with populations over 10,000 is projected to increase from eight to 17.

The Austin-Travis Lakes HUC 8 watershed is projected to have the largest concentration of population (almost 1.4 million) by 2050 (State Water Plan). Image Source: Shutterstock.

By 2050, the Austin-Travis Lakes HUC 8 is projected to contain almost 1.8 million people. This is an increase of 34 percent from 2020 to 2050. Within the region, the second largest population is projected to be in the Lower Colorado-Cummins HUC 8 which will contain 567,772 people by 2050 at an increase of 43 percent over the next 30 years (Table 3).

In this timeframe, the entire region is projected to have a population increase of almost 33 percent (Table 3). See *Figure 5: 2050 HUC 8 Watershed Population Projections* on the next page which illustrates the projected growth in population in each HUC 8 watershed.

Figure 5: 2050 HUC 8 Watershed Population Projections



Source: TWDB Population Estimates

Similar to today's general population distribution, the largest concentration of population is expected to remain in the Austin metropolitan area, where by 2050 the total population just within the City of Austin is projected to exceed 1.5 million people. As set out in Table 3, below, the watersheds with the greatest projected population growth in terms of percentage of increase include Lower-Colorado-Cummins (43% or +245,000 people), San Bernard (40% or +35,000 people), and Austin-Travis Lakes (34% or +619,000 people). This means that the region's greatest increases in population between 2020 and 2050 will continue to be in cities next to or adjacent to the metropolitan areas with the largest and most dense pockets of population.

Table 3: Existing and Projected Population by HUC 8 Watershed

HUC 8 Name	HUC 8 ID	2020 Population	2050 Population	Population Change %	2020 Density (People/ Square Mile)
Austin-Travis Lakes	12090205	1,191,244	1,811,099	34.23	963.89
Brady	12090110	8,634	9,076	4.87	10.79
Buchanan-Lyndon B	12090201	26,634	32,427	17.86	21.06
East Matagorda Bay 1	12090402	34,517	41,519	16.86	46.73
East Matagorda Bay 2	12100401	25,547	28,797	11.29	26.70
Jim Ned	12090108	12,662	13,185	3.97	16.22
Lavaca	12100101	29,133	29,944	2.71	32.14
Llano	12090204	15,575	16,291	4.40	5.98
Lower Colorado	12090302	23,269	26,525	12.28	33.08
Lower Colorado-Cummins	12090301	322,686	567,772	43.17	147.50
Middle Colorado	12090106	11,283	11,757	4.03	5.63
Navidad	12100102	21,810	25,783	15.41	15.62
North Llano	12090202	1,658	1,690	1.89	1.81
Pecan Bayou	12090107	42,651	44,913	5.04	30.14
Pedernales	12090206	34,398	42,828	19.68	26.97
San Bernard	12090401	53,018	88,471	40.07	50.16
San Saba	12090109	7,978	8,301	3.89	3.49
South Llano	12090203	3,064	3,080	0.52	3.30
West Matagorda Bay	12100402	50,583	62,567	19.15	60.89
	Region Totals	1,916,344	2,866,025	33.14	78.90

Source: Texas Water Development Board *Flood Data Hub*

2019 Daytime and Nighttime Population Grids

When considering flood risk, preparedness, and mitigation, it is important to know the extent of human exposure to flooding at various times of the day and night. This is critically important in that population density, and thus exposure, changes in geographic location and intensity throughout the day and night. As such, the TWDB provided each planning region with a LandScan™ geodatabase to help identify and prepare for these changing exposures.

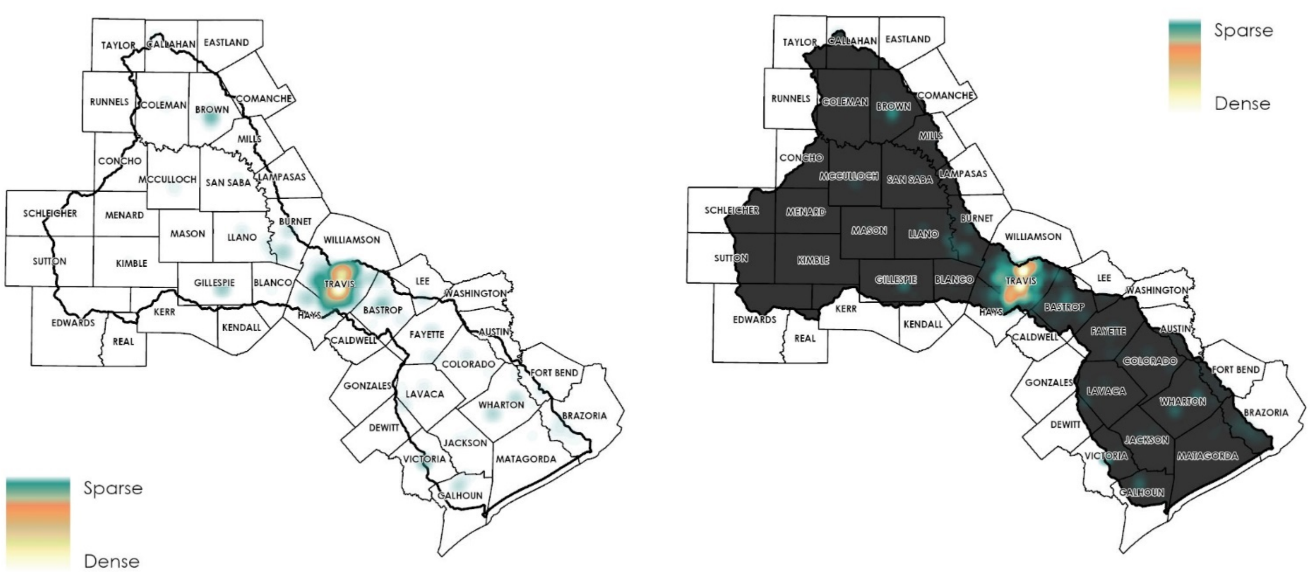
> **LandScan™ Population Projection Geodatabase**
>
> Oak Ridge National Laboratory's (ORNL's) LandScan™ is a community standard for understanding population distribution. It uses geographic information system (GIS) mapping and remote sensing to disaggregate census counts within a specific area to develop day and night population estimates. Since individual population distribution models can account for the differences in spatial data accessibility, quality, scale, and precision as well as the differences in cultural settlement practices, information gathered can determine which properties and structures as well as the number for residents that could be affected by future flood risk.

As seen in *Figure 6: 2019 Daytime / Nighttime Population Grids,* the LandScan™ geodatabase shows that Travis County contains the greatest daytime population in 2019 out of all counties in the region (Map 6a). This indicates that a larger number of individuals either work or spend daytime hours in or around the City of Austin. In 2019, Bastrop County and Hays County contained the second and third largest number of individuals during daytime hours.

Map 6b shows that a larger concentration of individuals spent the nighttime hours in Travis County in 2019 when compared to other counties in the region. Individuals who spend time in Austin during the day disperse to the surrounding suburbs of Pflugerville, Manor, and Del Valle at night.

Figure 6: 2019 Daytime / Nighttime Population Grids

Map 6a: Daytime | **Map 6b: Nighttime**



Source: 2019 LandScan™ USA for day/night populations

2019 Daytime and Nighttime Building Populations

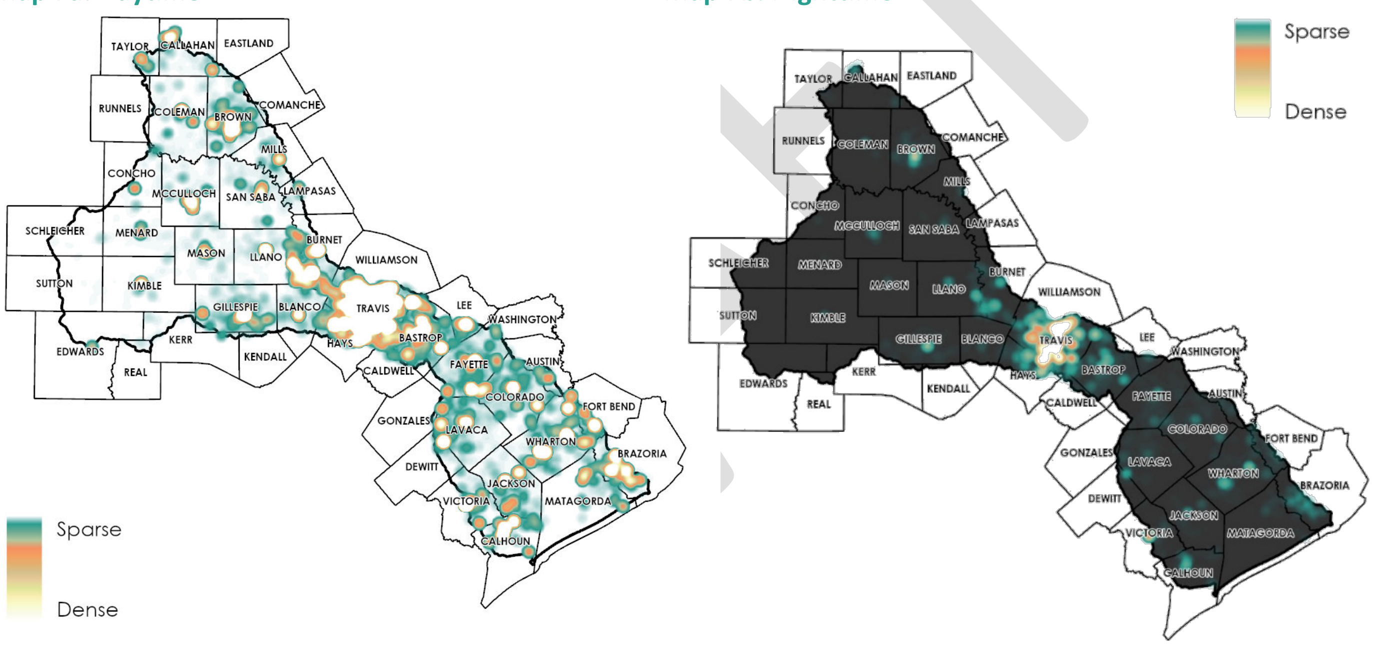
The TWDB also provided building footprints (e.g., homes, structures, etc.) with LandScan™ geodatabase populations to indicate how many people occupy the buildings during the daytime and nighttime hours. As indicated in *Figure 7: 2019 Daytime / Nighttime Building Populations*, below, the yellow areas illustrate the highest concentrations of future population. The brownish to orange areas show the next level of population concentration.

As is evident on *Maps 7a and 7b* (Figure 7), the general population aggregates into higher intensity employment centers during the daytime working hours, with the largest concentration occurring in the Austin metropolitan area. During the nighttime hours, the general population disperses to lower intensity residential areas. Although the Austin metropolitan area still has the greatest concentration of nighttime population, it is more dispersed than during the daytime hours.

Figure 7**: **2019 Daytime / Nighttime Building Populations

Map 7a: Daytime

Map 7b: Nighttime



Source: TWDB Buildings with SVI and Estimated LandScan™ 2019 Populations

Impacts to businesses along Shoal Creek during the 2015 Memorial Day Austin Flood. Source: Unknown.

Economic Activity

To better understand the economic risk the region faces from flood events, this section overviews the most significant industries within the region by three factors:

- Number of establishments
- Annual payroll
- Total annual revenue

Data from the 2017 5-year American Community Survey (U.S. Census Bureau) was utilized to identify the most predominant industries within the basin. Industries were divided in accordance with the North American Industry Classification System (NAICS), which classifies all business establishments to facilitate the publication of statistical data related to the United States economy. The identification of the dominant industries in each category highlights the economic sectors with the highest potential for economic impact in the event of a flood.

Number of Establishments

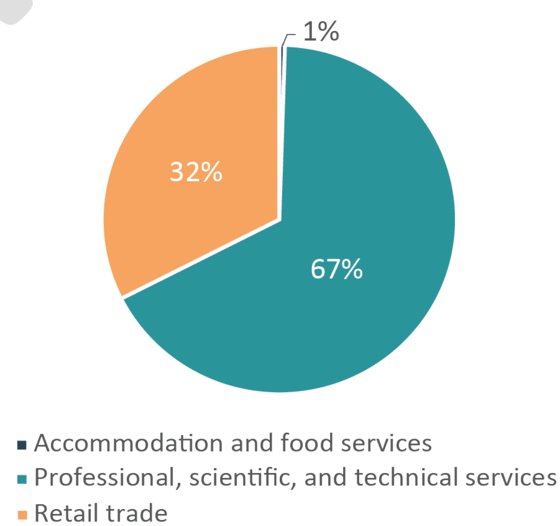
The Lower Colorado-Lavaca Flood Planning Region contains important industries such as accommodation and food services; professional, scientific, and technical services; and retail trade, which contribute to the gross domestic product of the region and support for the local and state economies. Based on the 2017 Economic Survey, the total value of sales or revenue generated by firms and businesses in the region amounts to over $325 billion, which constitutes approximately 13% of the total sales / revenue generated by all firms and businesses in Texas. The main industry in the basin, by the number of establishments (i.e., the number of firms or businesses), is professional, scientific, and technical services at 67%. The retail trade industry makes up an additional 32% and the accommodation and food service industry is only one percent.

Figure 8: Establishment Percentages for Major Industries shows that the professional, scientific, and technical services sector employs approximately 137,884 employees, followed by the retail trade sector, at approximately 487,909 employees. The industry sector employing the third-largest number of employees is accommodation and food services with approximately 178,263 employees.

Annual Payroll

The total annual payroll in the Lower Colorado-Lavaca basin is $58,301,823,000. *Figure 9: Major Industries By Payroll*, on the next page, shows that manufacturing is the largest industry by payroll in the region (28%), followed by transportation and warehousing (27%). Professional, scientific, and technical services and health care and social assistance represent the next largest share of all industries by payroll.

Figure 8: Establishment Percentages for Major Industries

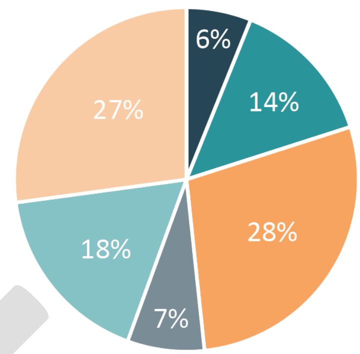


Source: U.S. Census Bureau, 2017 Economic Census - Summary Statistics Table EC1700BASIC, Dataset

With regards to the share of payroll for the entire basin, professional, scientific, and technical services has an annual payroll of $12,357,878,000; followed by health care and social assistance at $8,497,817,000; and manufacturing at $6,218,365,000.

By mitigating the impact of flooding on businesses, communities can make their residents more economically resilient. One factor that will be considered in this plan is social vulnerability, as measured by the Social Vulnerability Index (SVI), which accounts for loss of income as one of the greatest predictors of future vulnerability for individuals and communities. The Index (SVI) uses 15 different census variables to help identify communities that may need support before, during, and after a disaster. A severe flood event which affected income streams in these areas would heavily impact those vulnerable populations.

Figure 9: Major Industries by Payroll



Source: U.S. Census Bureau, 2017 Economic Census - Summary Statistics Table

Total Annual Revenue

Of the three economic activity measures, the total revenue by industry may provide the most useful insight into potential economic disruption of a major flood event by indicating the sectors most likely to be exposed to this risk, as it serves as a good indicator of which industries have the greatest economic impact. Inside the region, the county producing the largest amount of commercial activity and most revenue, at $163.7 billion, is Travis, which also has the greatest number of firms or businesses (26,318)(Table 4). Its main industry sector is wholesale trade. Fort Bend County has the second greatest number of total firms as well as revenue, producing over $45.9 billion, of which almost $10 billion is in the retail trade industry. Brazoria County, in the southeast portion of the region and bordering Fort Bend County, produces the third greatest revenue, at $37.1 billion, of which $24 billion is produced in the manufacturing industry sector. The western side of rural Fort Bend County and Brazoria County are in the Lower Colorado basin and the greater economic activity is in the Lower Brazos Basin. The eastern sides of each of these counties are within the Houston metropolitan area. Table 4: Top Four Counties by Total Revenue, Firms, and Employees lists the four counties producing the most sales and revenue in the region. Travis and Fort Bend counties also have the greatest number of firms and businesses; and their main industry sectors employ between 28,190 and 87,164 employees.

Table 4: Top Four Counties by Total Revenue, Firms, and Employees

County	Total Revenue (in Billions)	Total Number of Firms and Businesses	Total Number of Employees	Dominant Industry Sector
Travis	163.7	26,318	540,055	Wholesale Trade
Fort Bend*	45.9	15,663	213,164	Wholesale Trade
Brazoria*	37.1	5,304	91,045	Manufacturing
Hays*	10.2	3,066	51,798	Retail Trade

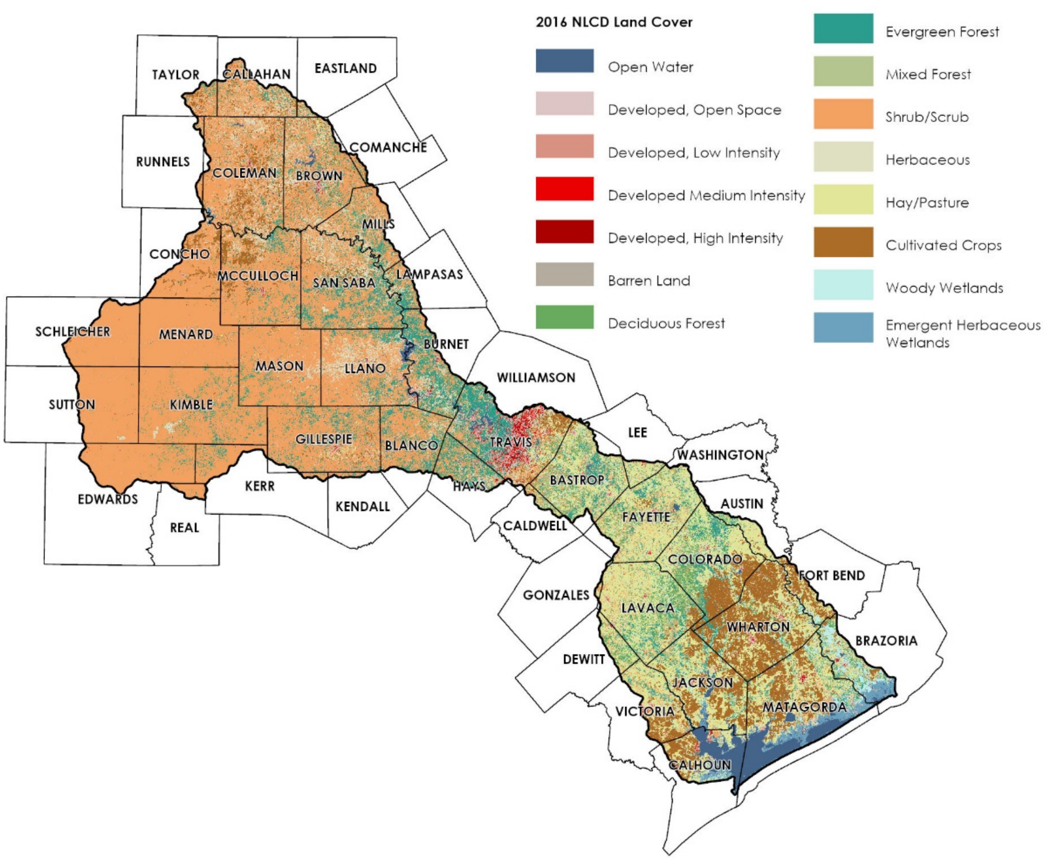
**Theses counites are partially in the region*

Source: US Census (Economic Census Summary Table, 2017, By County)

Land Cover and Use

As shown in *Figure 10: Land Cover*, the most prevalent land cover in the region is shrub/scrub at around 46 percent. It is the predominant land cover for much of the northern portion of the Lower Colorado-Lavaca basin. In the central portion of the region, the most developed area, only about 1.5 percent of the region is developed at a low, medium, or high intensity. It is in these areas, however, where increased impervious surfaces, made up of materials that water cannot penetrate (e.g., roadways, rooftops, and parking), generally increase the potential for flood risk. However, the underlying geology of the Texas Hill Country is already fairly impervious bedrock such that increased development has less of an impact. Over time, the rapid development that is currently occurring in the Austin metropolitan area will continue to increase the amount of impervious surfaces throughout Travis County. Hay/pasture and deciduous, evergreen, or mixed forest both makes up around 14 percent of the region and are predominantly located within the southern portion of the basin.

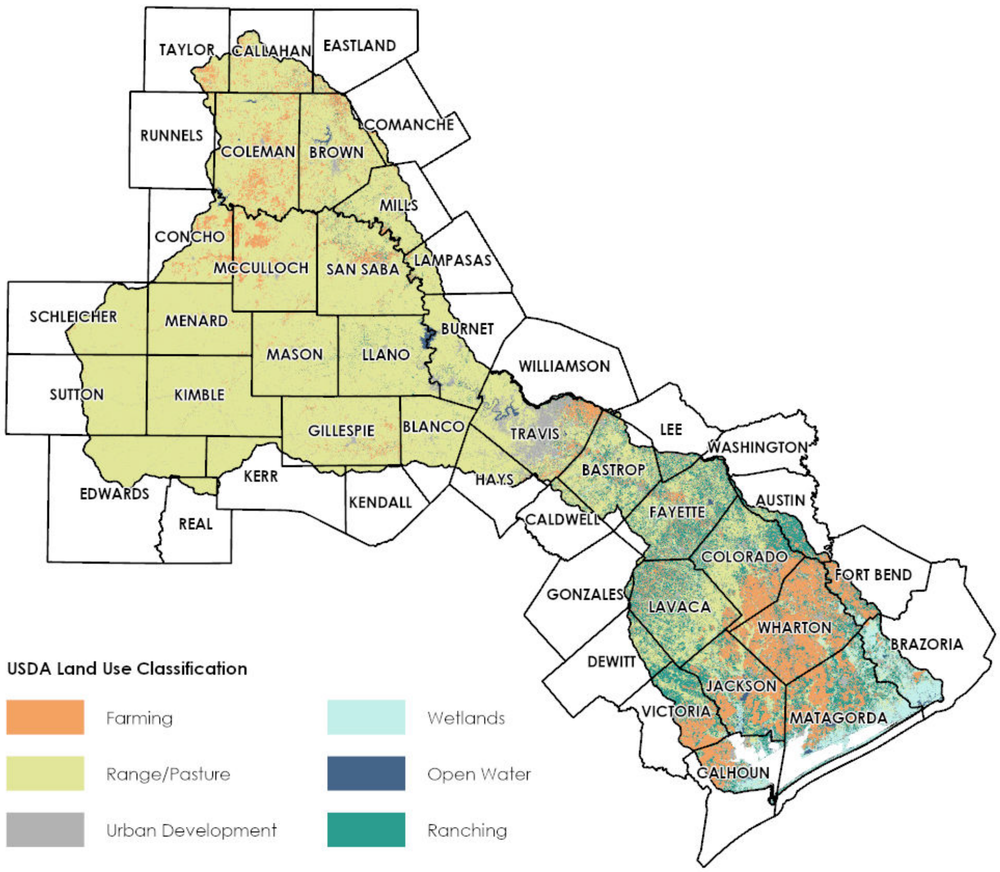
Figure 10: Land Cover



Source: USGS National Land Cover Database 2016 (USGS, 2016)

According to the United States Department of Agriculture (USDA) Land Cover data, the rural areas in the Lower Colorado-Lavaca basin contribute to the economy of the region through farming, ranching, and range/pasture. *Figure 11: Land Use*, on the next page, displays the United States Department of Agriculture (USDA) land use classifications in the region. The largest land use classification is range/pasture at 64 percent of the region, followed by farming at 12%. Only a small portion of the region falls under the urban development land use classification and is comprised of only four percent.

Figure 11: Land Use



Source: *United States Department of Agriculture, National Agriculture Statistics Service*

The Edwards Plateau Ecoregion in Gillespie, Llano, Mason, Menard, Kimble Counties in the northern part of the basin is home to the Texas Hill Country. The largest concentration of urban development is located in the Austin metropolitan area. In the southern part of the basin, farmland is the main use of working lands. As the Colorado River descends south toward the bay, it provides a water source for farming in Wharton County. In Colorado, Lavaca, and Fayette Counties, ranching and rangeland are the predominate uses. Large landholdings in these counties could also be reflected in socioeconomic data, where census tracts in these rural areas have a very high median income.

Agricultural & Ranching Activity

The Colorado River is one of the main rivers which traverses the region. It passes through extremely productive agricultural areas with rich farming and ranching heritage. Although fewer individuals are exposed to flood hazards in these areas than compared to our urbanized areas, the impact of flooding on agriculture, ranching and range/pasture can be severe and have serious local and regional economic consequences.

Flooding on farm and ranchland, like this flood near La Grange in Fayette County, can have significant impacts on local and regional economies. Source: Shutterstock.

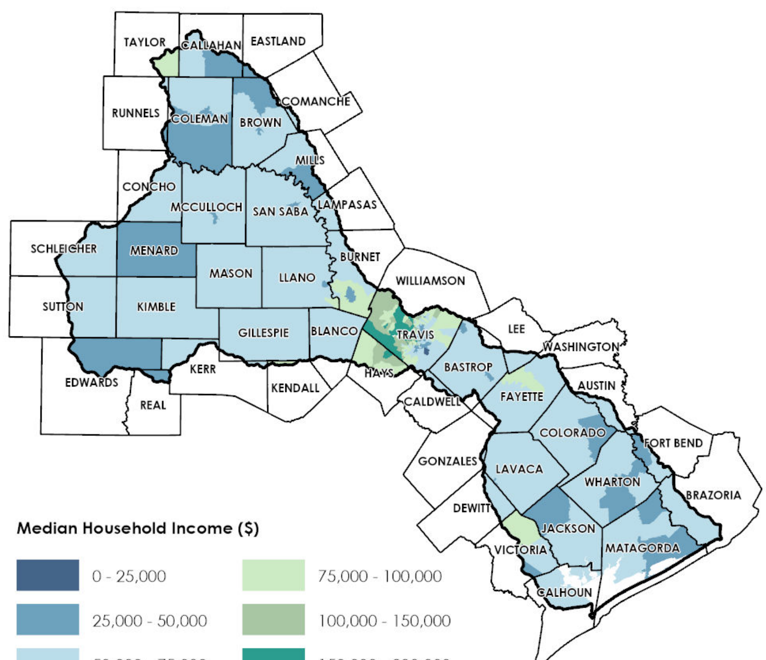
Floods can delay the planting season, as they immerse the fields and make them impassable for heavy equipment. This can lead to decreased crop size, lower yields, and reduced profits. When floods occur as crops grow in the fields, they can destroy an entire season's work and investment. Floods at harvest time can make it impossible for farmers to harvest mature crops and get them to market. Livestock could drown in floodwaters if they do not have access to a higher elevation where they can escape. Even if the livestock is safe, damage could occur to barns and other buildings, and cleanup of muck and debris can affect their feeding grounds. Forestry or orchard operations can lose trees to fast moving waters and erosion, wiping out years of growth instantaneously.

Economic Status of Population

Median Household Incomes can be affected by many factors, including education levels, opportunity of employment, and location. The Median Household Income (MHI) measure divides the data in two equal halves and provides a good comparison for income levels across the basin.

Figure 12: Median Household Income displays the median household income in the region and *Table 5: Median Income per County*, on the next page, displays the average median household income of all counties in the region. The highest median household income in this area is between $85,580 and $100,795 in Travis and Hays Counties. The lowest median household income in the region is in the northwest and southeast areas. The counties located in the southeast portion of the region are disproportionally affected by the projected increased rainfall from NOAA Atlas 14.

Figure 12: Median Household Income



Source: U.S. Census

Table 5: Median Income per County

County	Average of Median Household Income (in dollars)	County	Average of Median Household Income (in dollars)
Hays County	100,795	Sutton County	57,014
Travis County	85,580	Gonzales County	56,346
Taylor County	84,459	Colorado County	54,198
Kendall County	84,239	Schleicher County	53,753
Blanco County	66,195	Matagorda County	52,941
Burnet County	65,858	Victoria County	52,190
Jackson County	65,194	Mills County	52,000
Comanche County	64,425	Concho County	51,325
Austin County	64,045	Coleman County	51,118
Brazoria County	63,331	Runnels County	50,969
Lampasas County	62,920	McCulloch County	50,417
Fayette County	61,845	Callahan County	49,922
De Witt County	61,810	Brown County	48,673
Fort Bend County	61,414	San Saba County	48,448
Llano County	61,098	Edwards County	48,163
Washington County	60,859	Wharton County	48,153
Calhoun County	60,122	Mason County	47,570
Lavaca County	59,932	Kimble County	44,825
Gillespie County	59,304	Eastland County	40,128
Kerr County	58,952	Menard County	38,828
Lee County	58,261	Real County	36,673
Bastrop County	57,905		

Source: US Census

Social Vulnerability Analysis

When anticipating the likely extent of damages to a community from catastrophic floods, it is important to first consider "exposure" based on the geographic location of people and property. It is also important to consider the "vulnerability" of populations from flooding impacts. Vulnerability is the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long term as well as the short term. "Vulnerability depends upon many factors such as land use, extent and type of construction, contents and use, the nature of populations (mobility, age, health), and warning of an impending hazardous event and willingness and ability to take responsive actions" (Wright, 2007).

Disasters affect different people or groups in different ways, which range from their ability to leave an area in harm's way, to the possibility of damage to their homes and properties, to their capacity to gather the financial resources required to recover and rebuild after a storm. These factors are known as Social Vulnerability, or an individual's or group's "capacity to anticipate, cope with, resist and recover from the impacts of a natural hazard" based on their relative vulnerability. Determining communities with high social vulnerability in the Lower Colorado-Lavaca Flood Planning Region is important for both flood planning and mitigation. Communities with high social vulnerability are at increased risk of experiencing loss of life and property in a flood event. Federal agencies like the Centers for Disease Control and Prevention (CDC), Federal Emergency Management Agency (FEMA), and the U.S. Department of Housing and Urban Development (HUD) use the Social Vulnerability Index (SVI) to help communities during and after human-made and natural disasters.

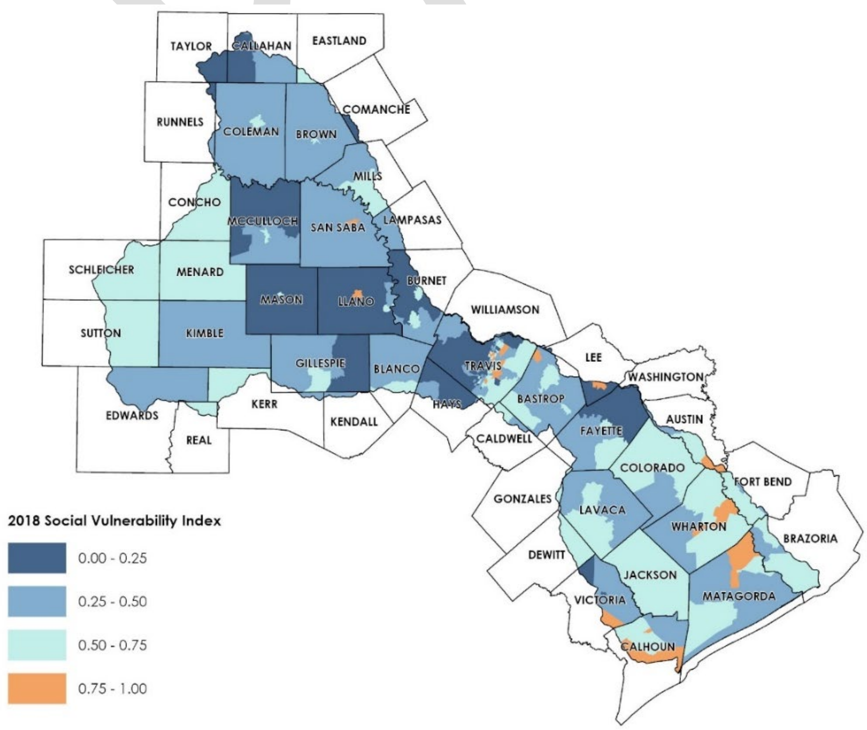
The assessment of social vulnerability is based upon an analysis using the Social Vulnerability Index (SVI) from the Centers for Disease Control and Prevention (CDC). Measures of vulnerability are on a scale of 0-1, with 1 being the highest level of vulnerability, and are used to map social vulnerability in the region at various scales. The index focuses on a series of 15 demographic indicators (Jaimie Hicks Masterson, 2014). These include:

- Below poverty
- Unemployed
- Low Income
- No vehicle
- No high school diploma
- Aged 65 or older
- Aged 17 or younger
- Civilian with a disability
- Single-parent households
- Minority status
- Multi-unit structures
- Mobile homes
- Crowding
- Group quarters
- Language barriers

The presence of several factors above in a population, or even an individual household, have proven to be a consistent indicator of the lasting impact of a disaster. Decreasing social vulnerability can reduce both human suffering and financial damage. The SVI variables are used to help local officials identify communities that could require support before, during, or after disasters. This plan will consider the location of highly socially vulnerable populations with respect to future need for protecting critical facilities and investing in flood mitigation projects.

Figure 13: Social Vulnerability Index (SVI) shows the counties with the highest SVI in the region. They include Matagorda County (Bay City), Calhoun County (Seadrift and Port O'Connor), and Wharton County (El Campo, Wharton, and Hungerford). Identifying the locations of social vulnerability clusters helps inform where changes to flood mitigation programs, policies, and interventions can help lessen their social vulnerability. Interventions to reduce flood impacts in socially vulnerable areas can occur at all phases of a disaster, including pre-disaster mitigation and preparedness, response, and recovery. By focusing just on reducing the physical exposure to flooding, it may fail to adequately protect those that are most vulnerable and have the least ability to prepare, respond, and recover from flood impacts.

Figure 13: Social Vulnerability Index (SVI)



Source: Center for Disease Control (CDC) via TWDB

Flood Prone Areas and Flood Risks to Life and Property

A strong baseline understanding of exposure and vulnerability is needed for Texas to better manage flood risk to mitigate loss of life and property from flooding. This is a critical step in decreasing the vulnerability of the Lower Colorado-Lavaca region's people and places to future flooding.

Currently, a patchwork quilt of plans, regulations and infrastructure protect Texans from flood exposure. This planning mainly occurs at a local level, with varying standards that makes it very difficult to quantify risk throughout the region. However, flood prevention efforts in the region, like most areas, largely just focuses on implementing the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) requirements. FEMA's NFIP is a federal program which provides flood insurance to property owners, renters and businesses as a means to recover faster after a flood occurs. While is does help reduce the socio-economic impact of floods, its primary focus is not on flood prevention.

FEMA's NFIP uses Flood Insurance Rate Maps (FIRMs) to identify special flood hazard areas to help mortgage lenders determine insurance requirements and to help communities develop strategies for reducing risk. The average age of the regions FIRMs is 10 years with an average date of January 1, 2014. Currently (2021), there are 6,564 flood insurance policies in the region and 5,103 flood insurance claims with a total value of $142.9 million. This is good news, as it improves their prospects for economic recovery in the event of a major flood. It is also bad news in that many communities are using maps that are decades old and may only tell part of the story, including accounting for flooding that occurs outside floodplains. They may not reflect changing patterns of development and frequently fail to identify flood risks associated with changes in the topography, environment, and increasingly climate change.

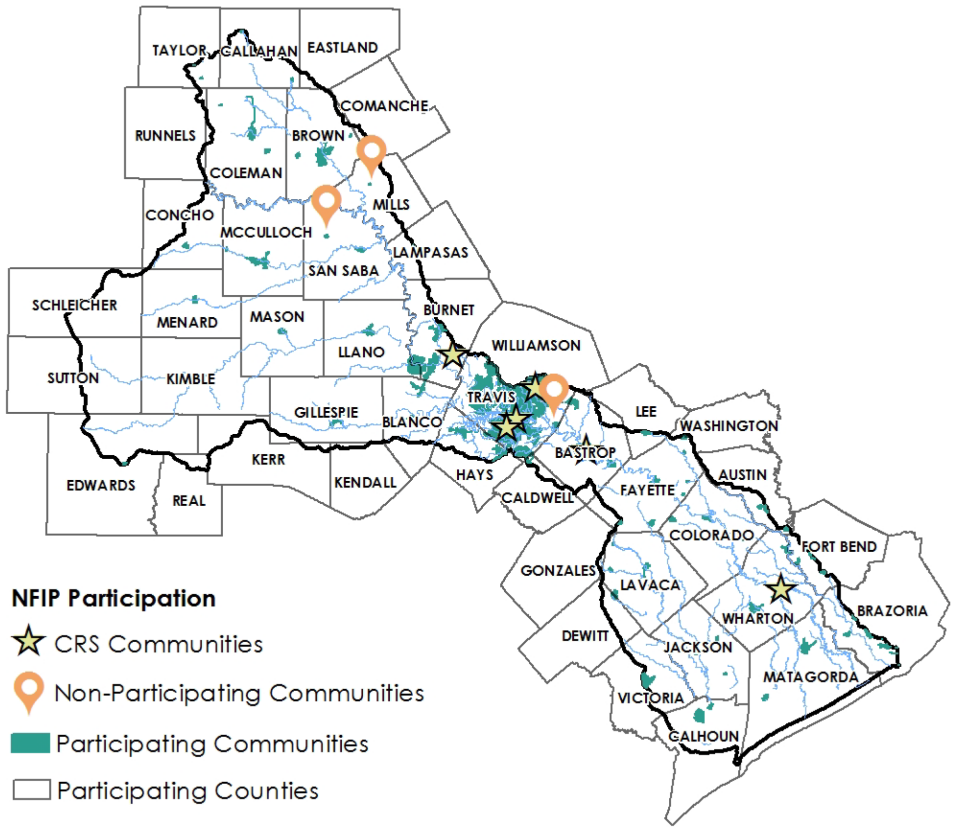
Figure 14: National Flood Insurance Program Participation, on the next page, displays the communities in the region who are participating in the NFIP. The map also shows the communities that are participating in the Community Rating System (CRS), which is a voluntary incentive program that identifies and encourages community floodplain management practices that exceed the minimum requirements of the NFIP. The CRS uses a class rating system that is similar to the Fire Insurance Services Office (ISO) rating that helps to identify how prepared a community is for fires. Similarly, the CRS helps to identify how prepared a community is for floods.

Under the CRS, flood insurance rate premiums are discounted to reward community actions which meet the three goals of the CRS, including:

1. Reduce flood damage to insurable property
2. Strengthen and support the insurance aspects of the NFIP
3. Encourage a comprehensive approach to floodplain management (FEMA).

In the Lower Colorado-Lavaca region, only five communities are CRS participants. These include Austin, Pflugerville, Sunset Valley, and Wharton. Participating counties include Bastrop and Burnet. All counties and all but three municipalities (Mullin, Richland Springs, and Webberville) are NFIP participants.

Figure 14: National Flood Insurance Program Participation



Source: FEMA National Flood Insurance Program Community Rating System (FEMA, NFIP, CRS) 2020

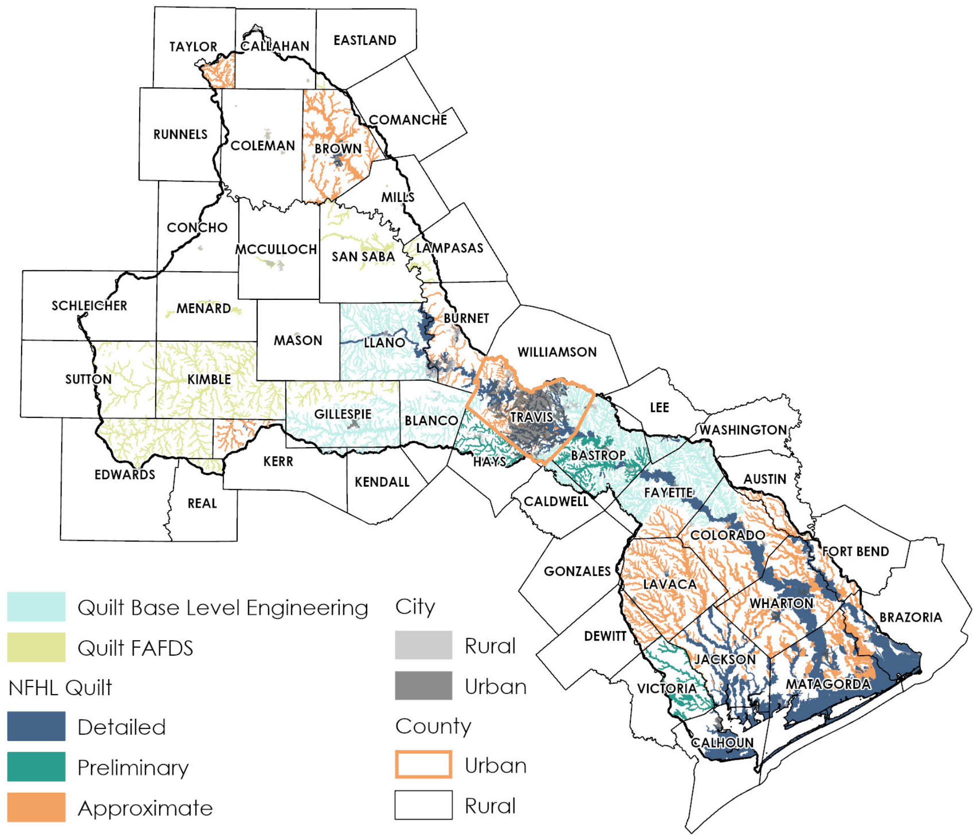
Identification of Flood Prone Areas

According to current NFIP mapping, *TBD (with new floodplain quilt)* percent of the total area in the region is within the 1 percent to 0.2 percent annual chance event (ACE) which can otherwise be described as facing between a 1% or and 0.2% annual risk of loss. But this does not provide a comprehensive accounting for all flood risk, as not all of the floodplains within the Lower Colorado-Lavaca region have been modeled and mapped. While developing a comprehensive flood risk model of the region is beyond the scope of this planning effort, the TWDB floodplain quilt used in this plan is "sewn" together from various sources of data (e.g., National Flood Hazard Layer, Base Level Engineering, Local Studies, etc.) to provide a comprehensive coverage of all known existing statewide flood hazard information.

In the absence of a unified flood map that applies throughout the region, the subsequent chapters of this assessment will piece together an intricate flood quilt, combining numerous data layers from FEMA, including effective maps, preliminary maps, base level elevation (BLE) maps, data from other federal agencies, local and regional studies, and commercial data from Fathom. Chapter 2 provides additional details regarding these datasets.

Types of Flood Risk

Figure 15: Initial Floodplain Quilt versus Urban Areas



Source: TWDB Floodplain Quilt with TxDOT Urban Areas

Figure 15: Initial Floodplain Quilt versus Urban Areas, shows the initial floodplain quilt information provided by the TWDB that serves as Region 10's starting point, providing an approximation of region-wide flood risk currently available data. This data was provided by TWDB to provide the RFPGs with a common starting point for their own compilation of flood risk data in their regions. In subsequent chapters, this "quilt" will be confirmed, updated, and otherwise enhanced as appropriate to prepare a larger flood risk assessment (TWDB, 2021). When complete, this regional floodplain quilt will identify gaps in information and more accurately approximate the distribution of flood risk across the region.

A general definition of flood is an overflow of land not normally covered by water and which has three general characteristics: 1) the inundation is temporary; 2) the land is adjacent to and inundated by overflow from a river, stream, or creek, or an ocean, sea, lake or other body of standing water; and 3) damages or destruction of property and loss of life can occur. Adverse effects include damages to buildings, bridges, and other man-made structures, potential loss of life, inundation of roadways, backwater in sewers or local drainage channels, creation of unsanitary conditions, streambank erosion and deposition of materials during recession, rise of ground water coincident with the increased streamflow and other related problems. Due to the varying ecoregions and topography, the Lower Colorado-Lavaca region experiences multiple types of flood risk as described below.

- **Local (Urban) Floods**: Local floodplains are those flood prone areas that are located outside of mapped effective FEMA flood zones, designated Special Flood Hazard Areas (SFHA), shown on FIRMs. Typically, urban communities identify local flooding as being roadways, subsurface infrastructure, and areas conveyed upstream of storm drainage inlets.

  Nationwide, these flood zones have several names, including "urban floodplains," "residual floodplains," and "local floodplains," and are in developed or developing areas. Because local drainage floodplains are not mapped on FIRMs, some communities have begun taking steps to better define and understand local flooding risks in their community using strategies such as local knowledge, historical events, and approximate or detailed local flood modeling studies, drainage master planning, local neighborhood analysis, and large scale 2-dimensional hydraulic modeling. Although not regulated by the FEMA criteria, these areas often represent a significant portion of known flood hazards within the city and account for in inordinate proportion of federal flood insurance claims.

- **Riverine Floods**: Riverine flooding is very common in the region as many communities have developed near rivers or streams to take advantage of the aesthetic and recreational benefits they provide. Riverine flooding occurs when excessive rainfall over an extended period causes a river, stream, or creek to exceed its channel capacity. Overbank flooding occurs when water rises and overflows over the edges of a river or stream. This is the most common and can occur in any size channel, from small creeks to huge rivers. One specific form of flooding is the "Flash Flood," which is characterized by an intense, high velocity torrent of water that occurs in an existing river channel with little or no warning time. Flash floods are very dangerous and destructive because of the force of the water, and the debris that is often swept up in the flow. Floods on larger river basins are as destructive and dangerous, but normally develop over a long period of time and allow for significant warning and preparation (such as evacuation of flood prone areas).

  The severity of a riverine flood is determined by the amount of precipitation in an area, how long it takes for precipitation to accumulate, previous saturation of local soils, and the terrain that exists in the watershed or catchment area. In flatter areas, floodwater tends to rise more slowly and are generally shallow and may remain longer. In hilly areas, floods can occur within minutes after a heavy rain/flash flood event. To determine the probability of river flooding, hydrologic and hydraulic models consider past precipitation, forecasted precipitation, current river levels, effectiveness of flood control structures, and other related factors. Riverine flooding depicted on the community's FIRM are intended to show the extent of riverine floodplains in a community. Thus, updating FIRMs that are outdated, modeling areas that have never been mapped, and performing detailed studies where there currently are not detailed studies would improve the definition of riverine flood risk.

- **Coastal Floods**: Coastal surge flooding occurs in the southern portion of the region along the Gulf coast. It is typically the result of extreme tidal conditions caused by severe weather. Storm surge, produced when high winds from hurricanes and other storms push water onshore, is the leading cause of coastal flooding and often the greatest threat associated with a tropical storm. In this type of flood, water overwhelms low-lying land and often causes devastating loss of life and property.

  The severity of a coastal flood is determined by several factors, including the strength, size, speed, and direction of the storm. The onshore and offshore topography also plays an important role. To determine the probability and magnitude of a storm surge, coastal flood models consider this information in addition to data from historical storms that have affected the area, as well as the density of nearby development.

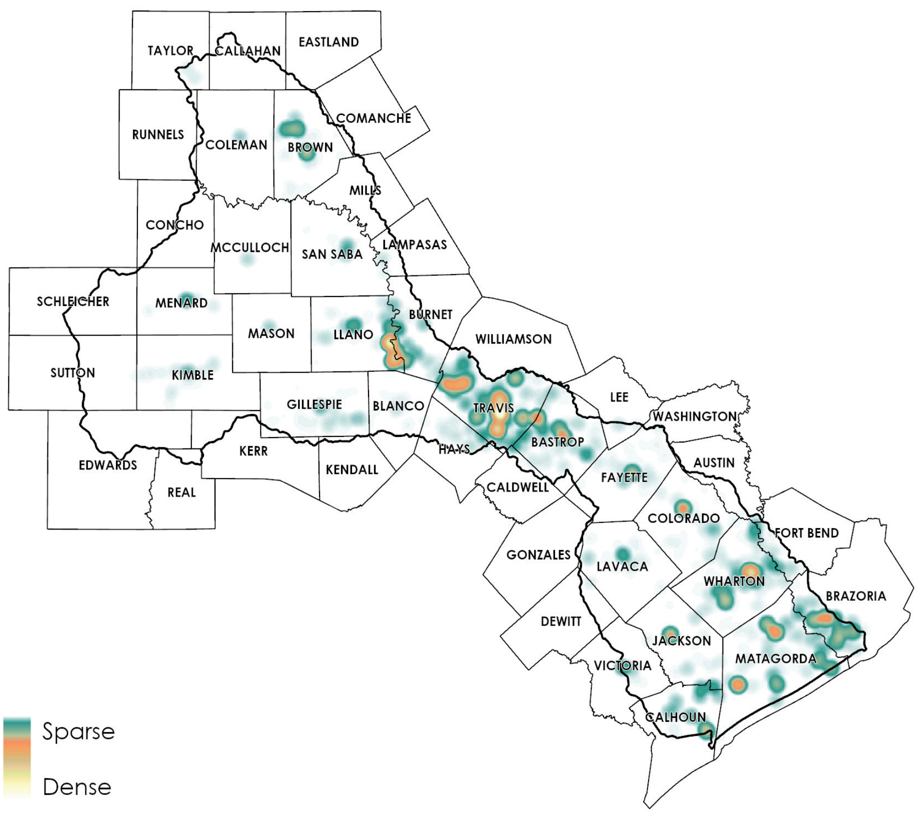
- **Structural Failure Floods**: Structural failure flooding rarely occurs in Texas. Failure of flood infrastructure (e.g., dams, levees, etc.) may occur when excessive rainfall over an extended period causes an uncontrolled release of floodwaters. The severity of structural failure flooding is determined by the extent of failure, downstream topography, and downstream hazards (e.g., people, properties, roadways, etc.).

Flood Exposure

(TBD with new floodplain quilt.) An initial assessment of exposure to flood risk can be observed utilizing building footprints in relation to the region-wide existing condition 1% ACE floodplain.

The least amount of structures are found in the northwest portion of the region while the southeast portion from Llano County to the Gulf of Mexico contains a much larger number of structures in multiple communities. *Figure 16: Structures Heat Map* shows the number of structures by density in the region. The City of Austin in Travis County contains the most dense and largest number of structures in the entire region. The cities of Kingsland and Horseshoe Bay in Llano County contain the second largest number of structures in the region at *TBD structures.*

Figure 16: Structures Heat Map *(Temporary Map)*



Source: Building Heat map derived from existing condition floodplain in relation to TWDB building footprints.

Impact to structures after flooding in the Central Texas region. Source: Shutterstock.

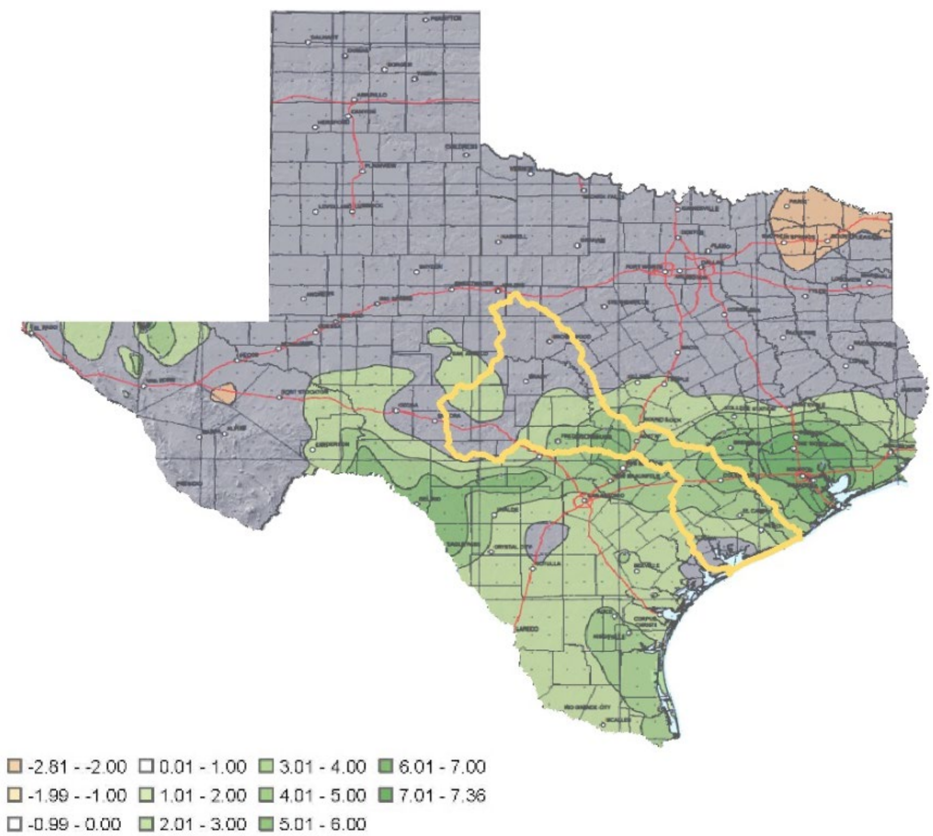
Changes in Rainfall Data

On September 27, 2018, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation-frequency values for Texas.

This new publication, *NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas*, is a reassessment of historical rainfall data up to 2017, adding an additional 20 years of record to the USGS publications (Perica et al. 2018).

Major events during this time period include Tropical Storm Hermine in 2010, Blanco River Memorial Day Flood in 2015, and Hurricane Harvey in 2017.

Figure 17: Atlas 14 Rainfall increase from USGS Rainfall



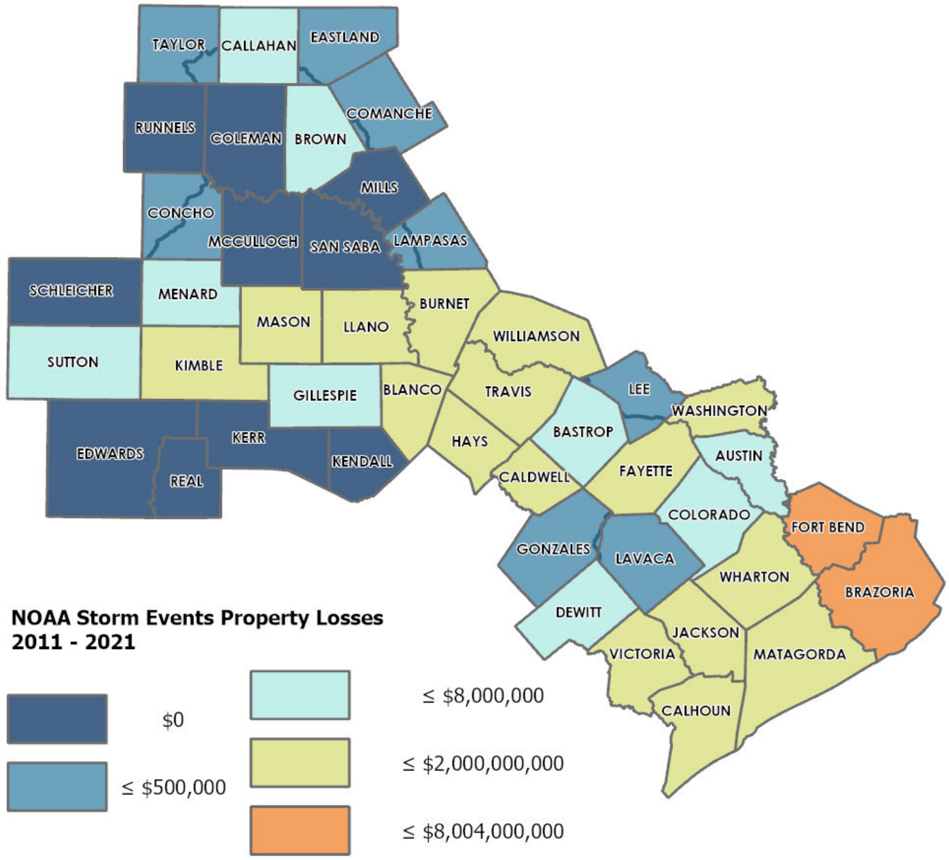
Source: National Oceanic and Atmospheric Administration (NOAA) Atlas 14.

Rainfall data is commonly used to predict flood risk and as an input to analyze and design flood protection/mitigation infrastructure such as bridges, culverts, channels, storm drainage systems, detention facilities, and others.

The Atlas 14 publication indicates that the 1% annual chance, 24-hour rain event may be greater than what was previously considered in many areas. The greatest rainfall changes occurred in Central Texas and along the Texas coast. Outlined in yellow on *Figure 17: Atlas 14 Rainfall increase from USGS Rainfall* is the Lower Colorado-Lavaca region. The green areas in the map indicate areas where rainfall depth increased compared to the USGS publications. There are minimal changes in the upper portion of the basin with the greatest increases (approximately 3 inches) in the Austin Metropolitan Area. While three inches may not seem significant, in Austin, it expanded the extent of the 100-year floodplain dramatically.

Key Historical Flood Events

Figure 18: Historical Property Losses



Source: NOAA Storm Event Database

The frequency and impact of historical events in the Lower Colorado-Lavaca region can be evaluated using a variety of datasets such as previous occurrence disaster declarations, major rainfall events, stream gage data, insurance claims, NOAA reported losses, and others.

Disaster Declarations and Major Events

According to FEMA Disaster Declarations Summary data, there have been 50 federally declared major disasters (DR's) and six emergency declarations in the Region between 1953 and March 2020. It should be noted that over 25% of the disaster declarations and 50% of the emergency declarations have occurred within the region since 2008 indicating a flooding related disaster occurs approximately every year in the region. *Figure 18: Historical Property Losses* displays the total property losses from flooding events between 2011 and 2021 (NOAA Storm Event Database). Within the region, the counties with the most property losses in the last 10 years were Fort Bend County and Brazoria County encompassing over 80 percent of the total losses. In the heart of flash flood alley, both Travis County and Hays County have experienced the most flood related fatalities.

The cycle of catastrophic disasters in the Colorado-Lavaca region varies each year. Many years, there is no recorded disaster that reaches either the level of a national Disaster Declaration (DR) or an Emergency Declaration (EM). Frequently, however, when one disaster occurs, it is followed by one or more catastrophic events in the same year. Since 1953, there have been six Emergency Declarations and 50 Disaster Declarations within the Colorado-Lavaca Basin regions. Some of the most significant events in the Lower Colorado-Lavaca region include:

- **October 2018 Flood Events:** In October 2018, the Highland Lakes watershed had historic flooding with two flood events along the Llano River and Lakes LBJ and Marble Falls. The Lower Colorado River Authority (LCRA) opened eight floodgates at Buchanan Dam, 10 floodgates at Wirtz Dam, and four floodgates at Mansfield Dam. Lake Travis rose to 704.39 feet mean sea level, 23 feet above its full elevation.

- **2017 Hurricane Harvey Flooding Response:** Employees across LCRA worked together to address the challenges from Hurricane Harvey. LCRA activated the Emergency Operations Center and representatives from numerous departments shared updates and coordinated ways to solve challenges from the hurricane. In some areas, the Lower Colorado River rose to levels not seen in over a century.
- **2015 Wimberley Flood:** On May 26, 2015, a widespread eight to 10 inches of rain fell across Bandera, Kerr, Kendall, Blanco, and far west Comal and Hays counties with totals up to 10 to 13 inches in southern Blanco County. Most of the rain occurred in only a few hours. The Blanco River at Wimberley rose 36 feet in four hours, with a maximum rise of 20 feet in one hour. Twelve people were killed and over 1,000 homes were destroyed or damaged with public damages estimated at $33 million.
- **2015 Memorial Day Austin Flood:** The Wimberley rains moved on into downtown Austin dropping three inches on already saturated ground within three hours. Shoal Creek, which drains west of Austin, rose to almost the 1981 elevation. The House Park High School football stadium and nearby areas flooded necessitating swift water rescues of local residents.
- **2015 Halloween Austin Flood:** Two years before on Halloween, Onion Creek in southeast Travis County received heavy rains and flooded numerous homes. For the second time in 2015, a similar storm hit almost the exact location with the same results. Hundreds of homes were flooded and four people were killed. Onion Creek rose to 41 feet, surpassing the record of 38 feet set in 1869 and 1921.
- **2010 Tropical Storm Hermine:** Hermine made landfall in northeast Mexico and headed north through Texas. From September 6th to 9th, 2010, rains from the Tropical Storm were four to six inches in Victoria and over 10 inches in Austin, with 15.62 inches recorded in Georgetown. A large band of 10 to 15 inches of rain fell from Austin to Waco.
- **2007 A "Rain Bomb":** In June 2007, around 19 inches of rain fell over the Marble Falls' area in a 12-hour period. Most of the rain and runoff went into the Pedernales River and into Lake Travis, which rose over 20 feet above its full elevation. The neighborhood of Graveyard Point, located far into the Lake Travis flood pool, was affected as the lake rose to 701.51 feet above mean sea level—its fifth highest all-time elevation.
- **1991 The "Christmas Flood":** The "Christmas Flood" of 1991 rose Lake Travis to its record high elevation, creating flooding in the Lower Colorado River basin. This was the first flood of 10 years of substantial, reoccurring flooding that changed how LCRA responds to floods.
- **1981 Lavaca:** On August 31st, 1981, Hallettsville was struck by a flood. Every business on the square received flood damage. At one time the Square was submerged with 5.5 to 6.5 feet of water.


"-DESTROY OUR FARMS AND GRASS WILL GROW ON THE STREETS OF OUR CITIES" — (William Jennings Bryan)
THE LAVACA COUNTY NEW ERA
TRIBUNE - HERALD
"The Community and Whole Country Stand or Fall With the Farmers"
FIGHT POVERTY The American Way — GO TO WOR
THINK
City Hit By Great Flood
FLOOD DAMAGE RUNS INTO MILLIONS
Only 1 Paper Next Week
ICE

1981 Lavaca Flood newspaper article. Source: Unknown.

1981 Shoal Creek flood near Lamar Boulevard. Source: Unknown.

- **1981 Memorial Day Austin Flood:** May 24, 1981 several hours of rain turned Shoal Creek into a raging torrent, 13 people drowned. This flood is credited with "waking Austin up to floods." Since then the city has spent $200 million to buy 450 homes, built flood walls and retention ponds, expand creek capacity, and improve storm drains.
- **1940 Hallettsville**: In the 1940 Hallettsville Flood, the Lavaca River rose to 41 feet which was 10 feet above any previous record. Several people were killed and several hundred thousand dollars in property were lost. A four-inch rain occurred on a Saturday morning followed by a downpour at night. A 10.5 -inch rain fell supplemented by a 16-inch rain in the Moulton section.
- **1936 LCRA'S First Major Test:** The Colorado River basin previously endured substantial floods in the 1930s, including a 1935 flood through downtown Austin. LCRA was still securing federal funding to continue building the Buchanan Dam when the June 1935 flood occurred. Floodwaters from over 50 inches of rain passed through the Buchanan Dam construction site. The substantial flooding on the Colorado River split Austin in half, leaving the bridge the only passable connection from north to south Austin. Flooding that occurred in July 1938 almost put LCRA out of business, but exposed the need for LCRA to construct the Mansfield Dam to a higher elevation. An additional disastrous flood occurred in the basin in September 1936. Immense floodwaters from a record 25 inches of rain in July 1938 forced LCRA to open 22 of Buchanan Dam's 37 floodgates. LCRA added 78 feet to the height of Mansfield Dam and created a system of rainfall and river gauges—the forerunner of LCRA's modern electronic Hydromet system.

Past Causalities and Property Damage

The National Oceanic and Atmospheric (NOAA) storm events database include a record of historic financial property and crop losses, injuries and fatalities for each hazard since 1996. It should be noted that this database relies upon communities to provide estimates of loss and therefore may somewhat underestimate losses due to lack of data. Since the data provides a date, state, and county of impact, the data could be assessed to evaluate flood related losses for the Lower Colorado-Lavaca region. *Table 6*, on the next page, displays historical losses per county for the last 10 years (2011-2021). The graphic below provides a spatial view of losses across the region.

Table 6: NOAA Storm Event Losses between 2011 and 2021 for Flood Related Hazards

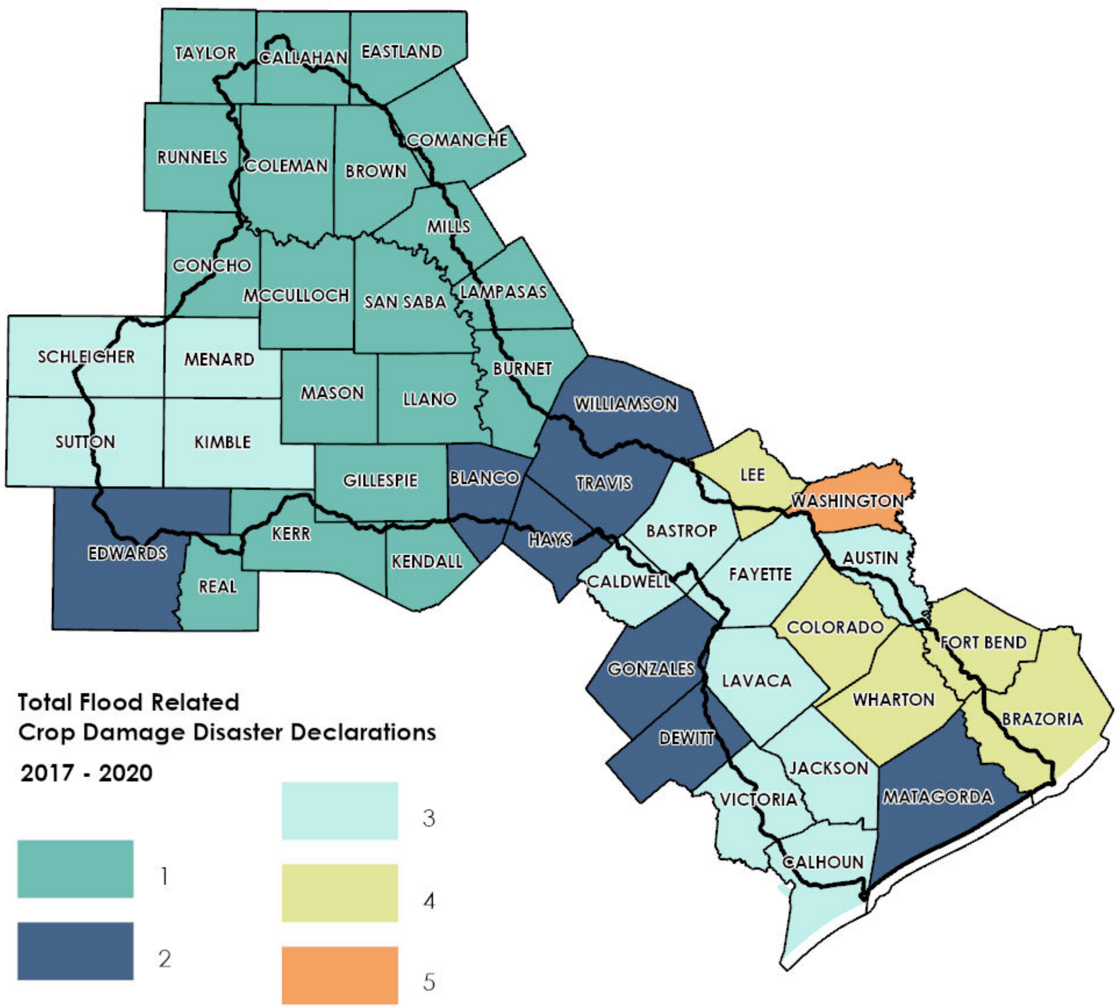
Region	Property Losses	Crop Losses	Injuries	Fatalities
Austin County	$2,420,000	$50,000	-	1
Bastrop County	$5,610,000	-	-	-
Blanco County	$20,000,000	-	-	3
Brazoria County	$2,000,556,000	$100,000	-	-
Brown County	$2,405,000	-	-	2
Burnet County	$30,000,000	-	-	-
Caldwell County	$13,900,000	-	-	5
Calhoun County	$282,410,000	$20,100,000	-	-
Callahan County	$1,060,000	-	-	-
Coleman County	-	-	-	-
Colorado County	$2,550,000	-	-	-
Comanche County	$7,000	$10,000	-	-
Concho County	$150,000	-	-	-
De Witt County	$3,100,000	-	-	-
Eastland County	$106,000	$6,000	-	-
Edwards County	-	-	-	-
Fayette County	$50,010,000	-	-	-
Fort Bend County	$8,003,243,000	$52,000	-	4
Gillespie County	$510,000	-	-	1
Gonzales County	$110,000	-	-	-
Hays County	$212,705,000	-	-	11
Jackson County	$500,210,000	-	-	-
Kendall County	-	-	-	1
Kerr County	-	-	-	-
Kimble County	$19,000,000	-	3	4
Lampasas County	$330,000	-	-	-
Lavaca County	$100,000	-	-	-
Lee County	$350,000	-	-	2
Llano County	$71,000,000	-	-	1
Mason County	$8,500,000	-	-	-
Matagorda County	$500,000,000	-	-	-
McCulloch County	-	-	-	-
Menard County	$7,100,000	-	-	-
Mills County	-	-	-	-
Real County	-	-	-	-
Runnels County	-	-	-	-
San Saba County	-	-	-	-
Schleicher County	-	-	-	-
Sutton County	$8,000,000	-	-	-
Taylor County	$394,000	-	-	-
Travis County	$132,100,000	-	-	14
Victoria County	$160,330,000	$20,000,000	1	1
Wharton County	$200,001,000	-	-	-
Region 10 Totals	$12,238,267,000	$40,318,000	4	50
Average Annual Loss (over the 10-year period)	$1.2 billion	$4 million	0.4	5

Crop Damage

The National Oceanic and Atmospheric (NOAA) storm events database was also used to summarize reported historical flood related losses from the last 10-years. This database includes all storm events as provided by public submission to a NWS representative. In the last 10-years, reported crop losses in the region total $40 million.

Figure 19: Disaster Declarations with Crop Damages displays the total number of disaster declarations with crop damage between 2017 and 2020 per county. Within the region, the counties with the most declared disasters with crop damage were Colorado, Lee and Wharton Countifies, with a total of four disaster declarations with crop damages in each county. During this time, the counties located in the southeast and west have experienced more total crop disasters than the rest of the region.

Figure 19: Disaster Declarations with Crop Damages



Source: USDA Farm Service Agency *Disaster Designation Information*

Political Subdivisions with Flood-Related Authority

There are various political subdivisions with flood control authority in the region, some with overlapping and/ or joint regulatory responsibilities. In some instances, there may be competing interests and priorities even within the same area. State guidelines for "Flood Protection Planning for Watersheds" define political subdivisions with flood-related authority as cities, counties, districts, or authorities created under Article III, Section 52, or Article XVI, Section 59, of the Texas Constitution, any other political subdivision of the state, any interstate compact commission to which the state is a party, and any nonprofit water supply corporation created and operating under Chapter 67. Of the political subdivisions referred to above, the majority are municipal or county governments, both of which enjoy broad authority to set policy to mitigate flood risk.

The TWDB provided a list of 348 political subdivisions, or entities, that were thought to have some degree of flood-related authority in the region (Table 7, below). It is important to note that in the literal sense, “authority” could be any entity/agency that constructs, maintains, or otherwise touches a drainage system. In its purest sense, “authority” would only indicate entities with the authority to enact and enforce NFIP floodplain regulations (e.g., municipalities and counties). Throughout this report, distinctions are made to indicate whether the data is referencing all political entities or those with regulatory authority.

Representatives from each political subdivision were solicited to ensure receipt of the highest quality of information for each entity. Approximately 25 percent of the entities who received an invitation to participate in the flood planning process via the Region 10 *Data Collection Survey Tool and Interactive Webmap* provided at least some measure of response at varying levels of detail. Some of this information will be discussed below. Additional information and analysis will be further detailed in Chapter 3.

Table 7: Political Subdivisions with Potential Flood-Related Authority

Entity Types	Number of Entities	NFIP Participants
Municipality	92	89
County	43	43
River Authority	3	N/A
Flood Control, WCIDs, Drainage Districts, Ports, Navigation Districts	70	N/A
Water Supply, Improvement, Utility Districts, MUDs, FWSDs, MWDs, SUDs, COGs	140	N/A

Source: TWDB Data Hub

In the Lower Colorado-Lavaca region, 98 percent of eligible entities (municipalities and counties) participate in the National Flood Insurance Program (NFIP). The Texas Water Code § 16.315 requires NFIP participants to adopt a floodplain management ordinance and to designate a floodplain administrator who will be responsible for understanding and interpreting local floodplain management regulations and reviewing them for compliance with NFIP standards. Some of the rights and responsibilities granted under this authority include:

- applying for grants and financing to support mitigation activities
- guiding the development of future construction away from locations threatened by flood hazards
- setting land use standards to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses
- collecting reasonable fees to cover the cost of administering floodplain management activities
- using regional or watershed approaches to improve floodplain management
- cooperating with the state to assess the adequacy of local structural and non-structural mitigation activities.

Summary of Existing Flood Plans and Regulations

The tables that follow summarize the entities' responses to questions about their existing regulatory environment, as well as any measures they may have in place to increase resilience. The information in these tables is strictly based on responses to the data collection survey.

Table 8 summarizes the number of survey participants that have a particular regulatory or planning measure in place. These plans and regulations were divided into four categories: Drainage Criteria Manual/Design Manual, Land Use Regulations, Ordinances (Floodplain, Drainage, Stormwater, etc.), Unified Development Code (UDC) and/or Zoning Ordinance with map. From the four types of regulations and plans; the largest number of respondents indicated that they had an active floodplain, drainage, and/or stormwater ordinance.

Table 8: Summary of Flood Plan and Regulations Provided via Survey

Type of Regulation	Count
Drainage Criteria Manual/Design Manual	12
Land use regulations	16
Ordinances (Floodplain, Drainage, Stormwater, etc.)	25
Unified Development Code (UDC) and/or Zoning Ordinance with map	11

Source: Region 10 Data Collection Tool and Interactive Webmap

In general, these regulations and ordinances cumulatively:

- 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

Beyond regulations, *Table 9*, below, identifies additional measures entities undertake to comprehensively promote resilience in flood-prone areas to mitigate the effects of flooding. As defined by FEMA, resilience aims to build a culture of preparedness through insurance, mitigation, continuity, preparedness programs and grants. These measures include such things as education and training, pre-planning, early warning systems, among others.

Table 9: Types of Measures to Promote Resilience in Flood-Prone Areas

Measures to Promote Flood Resilience	**Count**
Acquisition of flood prone properties	6
Flood readiness education and training	6
Flood response planning	11
Flood warning system	9
Higher Standards for floodplain management	14
Land use regulations that limit future flood risk	13
Participation in the Community Rating System (CRS)	5
Participation in the National Flood Insurance Program (NFIP)	24

Source: Region 10 Data Collection Tool and Interactive Webmap

Using plans and policies to reduce the exposure of people and properties to flood risk is a form of non-structural flood control. By encouraging or requiring communities to avoid developing in flood prone areas altogether, or to take precautions such as increasing building elevation, preserving overflow areas through buffering and avoiding sensitive natural areas such as wetlands, communities can prevent new development from being in harm's way.

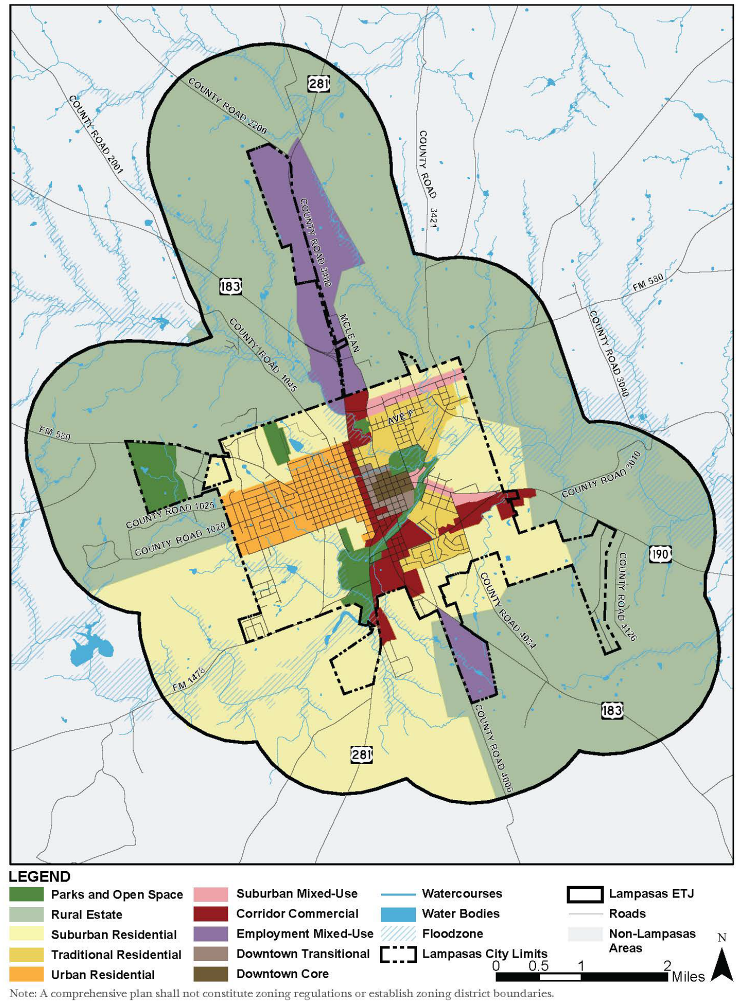
Floodplain Ordinances and Local and Regional Flood Plans

Floodplain ordinances dictate how development is to interact with or avoid a city's floodplain. FEMA provides communities with flood hazard information upon which floodplain management regulations are based. Floodplain ordinances are subject to the National Flood Insurance Program and ensure that communities and entities are taking flood hazards into account when making land use and land management decisions. Ordinances may include maps with base flood elevations (BFE), any freeboard requirements, as well as criteria for land management and use. This information will be discussed in greater detail in Chapter 3.

Comprehensive Plans and Future Land Use Plans

The comprehensive plan establishes policies and a program of action for long-term growth and development of a community. The future land use plan, sometimes called a FLU, provides a guide for future areas of growth and development, as well as areas that are to be conserved in their natural state. The comprehensive plan and its embodied FLU set the groundwork that is necessary to undertake quality decision-making for future growth and development. While many cities have future land use plans, the content of these plans varies widely in specificity. Irrespective, the existence of a future land use plan may mean that the City is likely taking a more detailed approach to the type and location of future development.

Figure 20: City of Lampasas Future Land Use Plan



Delineating regulatory floodplains on the city's future land use map in the comprehensive plans ensures that reducing future flood risk is part of the conversations of early development discussions, decisions, and approvals. Source: City of Lampasas

Comprehensive plans and their associated future land use plans also provide legal authority for zoning regulations in the State of Texas and consider capital improvements necessary to support current and future populations and often consider social and environmental concerns the community wishes to address. To produce a comprehensive plan, communities undertake an extensive planning process that encourages discussion about topics such as risk from natural hazards, and may include recommendations regarding the location of development with respect to floodplains, the need for future drainage improvements, etc. (Figure 20). As many development decisions are made during the first step in the development process, particularly during negotiated development proposals like planned unit developments (PUDs), it is critical for floodplains to be accounted for in these conversations.

Land Use Regulations and Policies: Zoning, Subdivision

Zoning ordinances regulate on how property owners can use their property and what types of uses are allowed within a certain area. It is one of the most important tools that communities use to regulate the form and function of current and future development. Within the zoning ordinance, communities may incorporate a variety of tools, which may include, among others:

- Stream buffers
- Setbacks from wetlands and other natural areas
- Conservation easements

Subdivision regulations get into a more focused regulation of the design and form of the building blocks of a city. They regulate platting processes, standards for design and layouts of streets and other types of infrastructure, the design and configuration of parcel boundaries, as well as standards for protecting natural resources and open space. While both cities and counties have subdivision ordinances, in Texas, counties do not have zoning authority. As identified by the survey results, 16 jurisdictions indicated that they have land use regulations which are used to manage existing or future flood risk as part of development. Eleven jurisdictions have indicated that they currently have unified development codes and/or zoning.

Drainage Criteria

Drainage criteria is created to set the minimum standards for design engineers to follow when preparing plans for construction within the jurisdictions in which they serve. These could be for municipalities or counties within the basin. The document covers standards pertaining to submissions, right of way/easements, hydrology, and hydraulics.

A storm drain system is defined as a network of open channels and underground pipes designed to capture and convey concentrated storm water flows to a point beyond the limits of the property being developed. Developers may sometimes oversee creating drainage infrastructure that will be continuous and synergistic with the existing storm drain system and will not prevent surrounding property owners of extracting economic benefit from their properties. As identified by the survey results, 12 jurisdictions have indicated that they currently have drainage criteria manuals/design manuals.

Drainage structures include such things as culverts to collect surface runoff and deliver it to underground stormwater conveyance systems.

Assessment - Existing Flood Infrastructure

Understanding the current context of the existing natural and structural flood infrastructure in the region is an important step in helping to identify the appropriate strategies and recommendations to reduce flood risk throughout the region. Since the Lower Colorado watershed connects communities from Rocksprings in Edwards County to Matagorda County on the Matagorda Bay, flood infrastructure in this region benefits the community where it is located but could also have significant benefits for people and places downstream.

When evaluating flood risk management infrastructure, this plan considers both the natural and manmade features that contribute to risk reduction. Examples are provided in *Table 10*.

Table 10: Examples of Natural and Structural Flood Infrastructure

Natural Features	Region Counts	Structural Features	Region Counts
rivers, tributaries, functioning floodplains	*TBD*	levees	24
lakes, reservoirs, *playa lakes*	267	dams that provide flood protection	696
parks, preserves, natural areas	471	*regional detention, retention ponds*	*TBD*
wetlands and marshes	49,081	local stormwater systems, including tunnels, canals	*TBD*
karst features, sinkholes	7	roadways, low water crossings	1,352
alluvial fans	0	sea walls, revetments	431
coastal barriers, nourishment, dunes	81	*tidal barriers, gates*	0

Note: Features shown above in italics have not been identified as major components of flood control systems in the Lower Colorado-Lavaca region.

Flood infrastructure in the region consists of an intricate network of natural areas and built features which are owned and managed by stakeholders ranging from the public sector entities to individual property-owners. Flood infrastructure may include non-structural measures, such as natural area preservation, buyout of repetitive flood loss properties, and flood warning systems, but also includes all major public infrastructure, such as regional detention. The Texas Water Development Board provided numerous data sources to assist with the identification of flood management infrastructure in the Flood Data Hub. The region's database was populated with available information from TWDB and many other state and federal datasets as outlined in the following sections. Where overlap occurred, the data sources were reviewed and amended to only include a single inventory per location.

There were also several questions posed in the data collection survey that were used to complement the information provided by existing data sources to generate a more comprehensive picture of how communities in the region protect themselves from flood risk.

Natural Features

As pasture and fields are replaced by urban development, the permeability of soil decreases. This makes land less efficient at slowing down rainwater and letting it percolate into the soil and recharge the aquifer. Instead, urban drainage infrastructure oftentimes collects rainwater and speeds it directly into a drainage channel and networks. This increases the speed and intensity of runoff making flood water peak quicker and potentially higher.

Since 2017, the Texas Land Trends project, by Texas A&M's Natural Resources Institute (NRI), found that the region lost over 213,000 acres of working land (crops, grazing lands, timber, and wildlife management) to urban and suburban development. While the population increased by more than 50% in the region during that time, only one percent of the total acreage of the natural areas were replaced with structures, roads and parking lots. These types of hard, oftentimes impervious, surfaces, increase the potential for runoff to burden waterbodies downstream. The acreage that did remain as open space grew increasingly fragmented (Texas A&M Natural Resources Institute, 2021).

As the trend toward urbanization and fragmentation continues, the entities within the region will need to take a more thoughtful approach to managing its natural infrastructure to continue to receive the benefits of open spaces, something which the U.S. Army Corps of Engineers addresses in its Engineering with Nature initiatives. This initiative aligns natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative projects. Currently, state and federal-level government are managing local, state and National Parks and Wildlife Management Areas, like the Aransas National Wildlife Refuge, that form part of the region's natural infrastructure.

When left in their natural state, landscapes are very efficient at handling rainfall. As raindrops fall from the sky, they are captured by trees, shrubs or grasses which slow their passage to the area's waterways and allows the rain time to soak into the soil. Wetlands and woodlands are most efficient at recycling rainfall, as the branches and undergrowth intercept water before it even reaches the ground, thus minimizing overland flow to tributaries and the river. Pastureland performs this function effectively as well, whereas cropland may shed a greater degree of water so as not to inundate the fields. Similarly, parkland in urban areas that is designed for dual functions can achieve nearly the same rate of capture of stormwater as lands in undeveloped areas (Marsh, 2010). For natural features to achieve maximum effectiveness at flood mitigation, they should form part of an interconnected network of open space consisting of natural areas and other green features that also protect ecosystem functions and contribute to clean air. This is sometimes known as green infrastructure, the practice of replicating natural processes to capture stormwater runoff (Low Impact Development Center). Even small changes in developed area can have significant impact on downstream flooding.

Natural areas can be managed to be even more efficient at these functions in a variety of settings, including:

- **Watershed or Landscape Scale**: Where natural areas are interconnected to provide opportunities for water to slow down and soak in, and to overtop the banks of creeks and channels when needed. These solutions often include multiple jurisdictions and restoration of natural habitat to achieve maximum effectiveness. These areas may be embodied within the river corridors and tributaries which exist in many of cities and towns across Texas. When combined with regional greenway trail and recreation systems, these areas provide multiple benefits beyond just the conveyance of rainwater.
- **Neighborhood Scale**: Solutions built into corridors or neighborhoods that better manage rain where it falls. Communities establish regulatory standards for development that guide the use of neighborhood scale strategies. These also provide great opportunities for neighborhood recreational connections to the regional greenway system.
- **Coastal Solutions:** To protect against erosion, and mitigate storm surge and tidally influenced flooding, nature-based solutions can be used to stabilize shorelines and restore wetlands. (FEMA, 2021)

Rivers, Tributaries and Functioning Floodplains

The natural flood storage capacity of all streams and rivers and the adjacent floodplains contribute greatly to overall flood control and management. Surface water, floodplains, and other features of the landscape function as a single integrated natural system. Disrupting one of these elements can lead to effects throughout the watershed, which increase the risk of flooding to adjacent communities and working lands. Maintaining the floodplain in an undeveloped state provides rivers and streams with room to spread out and store floodwaters to reduce flood peaks and velocities. Even in urban areas, preservation of this integrated system of waterways and floodplains serves a valuable function, as even small floods resulting from a 20% ACE (5-year) and 10% ACE (10-year) event can cause severe flood damage.

At over 800 miles long, the Colorado River is one of the longest rivers to start and end in the same state and is the major river in this region. It originates in the rural areas of the High Plains and meanders southeast through farm, ranchland, and forest on their way south to the Gulf of Mexico. It is a critical resource to the Texas economy, the environment, industry, and agriculture. It also affects many Texans in that it passes through many of urban areas, including the region's most heavily populated urban area, Austin, before reaching the coast at Matagorda Bay.

Similar to the floodplain quilt, the region's streams were populated with available information from FEMA, USGS, TWDB, and stakeholders. It should be noted that the streams are compiled of best available datasets however they generally do not align to current topography. Along with statewide mapping, the TWDB is developing updated stream layers that can be integrated into the next planning cycle. As displayed in *Table 11: Streams by HUC 8 Watershed*, there are over TBD stream miles in the Lower Colorado-Lavaca region.

Table 11: Streams by HUC 8 Watershed *(TBD with new floodplain quilt)*

HUC 8 Name	Detailed Studies (miles)	Approximate Studies (miles)	Base Level Engineering (miles)	Fathom (miles)	HUC 8 Totals (acres)	Percentage of HUC 8 (% of total miles)
Austin-Travis Lakes						
Brady						
Buchanan-Lyndon B						
East Matagorda Bay						
East Matagorda Bay						
Jim Ned						
Lavaca						
Llano						
Lower Colorado						
Lower Colorado-Cummins						
Middle Colorado						
Navidad						
North Llano						
Pecan Bayou						
Pedernales						
San Bernard						
San Saba						
South Llano						
West Matagorda Bay						
Region Totals						

Source: FEMA Coordinated Management Needs System (CNMS), USGS National Hydrography Dataset, and TWDB provided Major Streams and TNRIS rivers

Lakes, Reservoirs, Parks and Preserves

Lakes, reservoirs, parks and preserves serve as essential components of the ecosystem as they house a wide variety of local flora and fauna, and physical features that is necessary for the continued ecological health of the region. Additionally, these areas can also be essential components of water retention during flooding and severe rainfall events. These types of natural flood infrastructure are generally located in or close to floodplain areas throughout the basin with higher concentrations of them being located along or close to the major rivers and tributaries. Indeed, in many of the region's original core areas of the city (e.g., Austin, Lampasas, Llano, Marble Falls, and Wharton), these areas were oftentimes set aside for public parks and green spaces.

Table 12: Lakes, Reservoirs, Parks, and Preserves by HUC 8 details the acreage of each of these natural features and the total land area in the HUC 8 covered by these natural features. East Matagorda Bay 1 in the southern tip of the basin, Austin-Travis Lakes in the central portion of the region, and San Bernard in the southern end contain the greatest percentages of land area covered with lakes, reservoirs, parks, and preserves. Other HUC 8s in the Planning Region have one to two percent of the land area covered with lakes, reservoirs, parks, and preserves.

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

HUC 8 Name	Lakes, Reservoirs (acres)	Parks (acres)	Preserves (acres)	HUC 8 Totals (acres)	Percentage of HUC 8 Area (% of land)
Middle Colorado	12,833			12,833	1%
Pecan Bayou	3,909	2,377		6,286	1%
Jim Ned	6,131			6,131	1%
San Saba	191	1,220		1,411	0%
Brady	2,135			2,135	0%
Buchanan-Lyndon B	28,751	8,723		37,474	5%
North Llano	37			37	0%
South Llano	42	2,754		2,796	0%
Llano	622	4,088		4,710	0%
Austin-Travis Lakes	21,011	16,922	779	38,711	5%
Pedernales	1,237	9,198	232	10,666	1%
Lower Colorado-Cummins	5,576	11,228	348	17,152	1%
Lower Colorado	3,103	168		3,271	1%
San Bernard	3,852	25,475		29,327	4%
East Matagorda Bay 1	6,739	41,493		48,232	9%
Lavaca	2,249			2,249	0%
Navidad	9,808	1		9,809	1%
East Matagorda Bay 2	10,881	8,364		19,245	2%
West Matagorda Bay	2,580			2,580	0%
Region Totals	121,686	132,010	1,359	255,055	2%

Source: USGS National Hydrography Dataset, TWDB provided Waterbodies and Major Reservoirs, TPWD Wildlife Management Areas, USFWS Critical Habitat Areas, and TWDB provided Municipal, County, State, and National Parks

Wetlands and Marshes

Wetlands and marshes are some of the most effective features at recycling water, by minimizing the overland flow and reducing the need for other types of flooding infrastructure. There is a robust concentration of wetlands directly surrounding the Colorado River with less-concentrated wetlands throughout the region. As the Colorado River heads southward towards the coast, the concentration of wetlands increases. This not only mitigates flooding coming from upstream areas, but also flooding coming from the coast in the form of hurricanes and other tropical storms. According to the USGS National Wetlands Inventory, wetlands comprise of approximately 275,000 acres within the basin as displayed in *Table 13*. This means that wetlands are one of the largest types of natural infrastructure in the basin.

Table 13: Wetlands by HUC 8 Watershed

HUC 8 Name	Wetlands (acres)	Percentage of HUC 8 (% of land)
Middle Colorado	1,615	0%
Pecan Bayou	1,542	0%
Jim Ned	1,772	0%
San Saba	1,167	0%
Brady	832	0%
Buchanan-Lyndon B	2,019	0%
North Llano	275	0%
South Llano	545	0%
Llano	3,180	0%
Austin-Travis Lakes	1,951	0%
Pedernales	1,291	0%
Lower Colorado-Cummins	7,147	1%
Lower Colorado	13,000	3%
San Bernard	47,519	7%
East Matagorda Bay 1	100,041	19%
Lavaca	9,806	2%
Navidad	13,181	1%
East Matagorda Bay 2	37,564	4%
West Matagorda Bay	29,558	6%
Region Totals	274,004	2%

Source: USFWS Delineated Wetlands

The wetlands at White Lake at Cullinan Park in Fort Bend County are a good example of natural infrastructure. Source: Shutterstock.

Natural Coastal Features

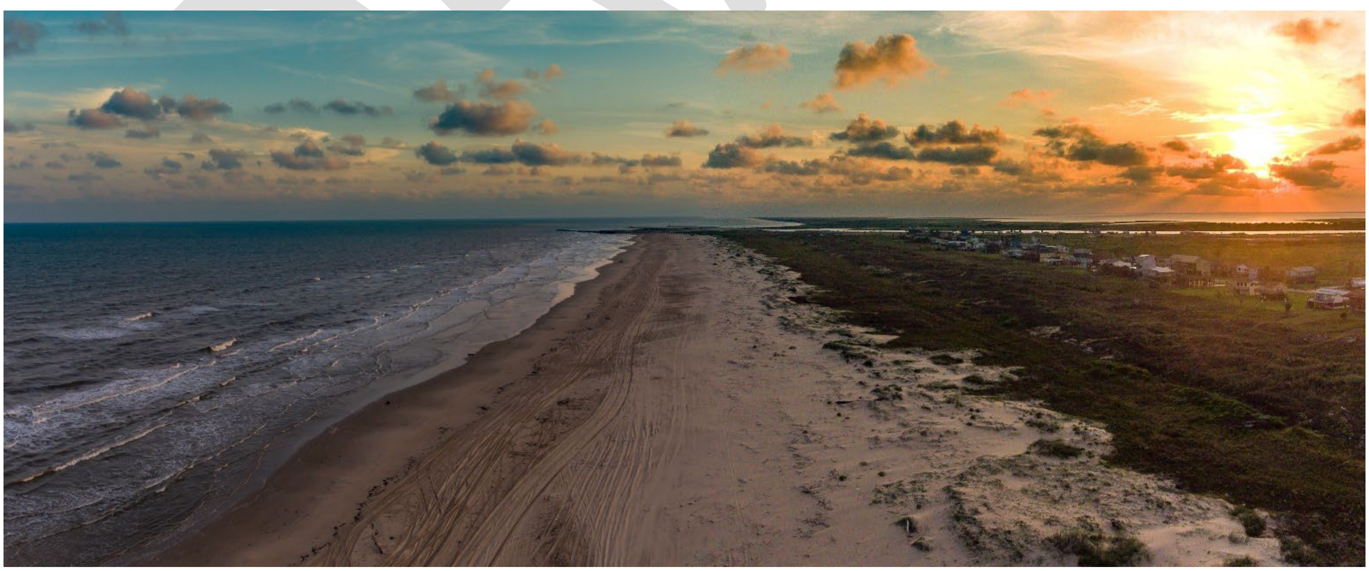
The National Coastal Zone Management Program is a voluntary partnership between NOAA and coastal states that was formed between states and the federal government following the passage of the Coastal Zone Management Act of 1972. In Texas, this program is managed by the Texas General Land Office (GLO) and implemented through the 2019 Coastal Resiliency Master Plan (CRMP). The dynamics of flooding in coastal areas differ from riverine flooding, in that they are influenced by issues such as sea level rise, land subsidence, tidal flooding and storm surge as well as rainfall events. Mitigating coastal flooding is one of the primary objectives of CRMP, and proposed natural solutions include: incorporating green infrastructure into development, creating flood resilient parks and recreational spaces, retaining and restoring open space, and maintaining/creating freshwater wetlands and coastal prairies. The state is in the process of updating the 2019 CRMP and anticipates the release of a new plan in 2023 that will include a list of projects in each region which can be incorporated in future planning cycles (Texas General Land Office, 2019).

Coastal features in the region are located in the southeast portion within Calhoun County, Jackson County, Matagorda County, and Brazoria County. Natural features along the coasts that could reduce flood impacts include tidal marshes, sandy beaches, mangrove-covered areas, and many bays, estuaries, and lagoons.

Table 14: Natural Coastal Features by HUC 8 Watershed

HUC 8 Name	Dunes (miles)	Natural Barriers (miles)	Beach Nourishment Areas (count)
Lower Colorado	1	3	
San Bernard	2	9	
East Matagorda Bay 1	44	63	2
Lavaca			
Navidad			
East Matagorda Bay 2	34	34	
West Matagorda Bay			2
Region Totals	80	109	4

Source: UT Bureau of Economic Geology Dune Locations, USFWS Coastal Barrier Resources System database, and GLO coastal resiliency and master plan datasets



Sand dunes provide natural coastal protection against storm surge and high waves, preventing or at least reducing coastal flooding and structural damage to the houses that are set back behind the dunes near Matagorda Bay. Source. Shutterstock.

Structural Flood Infrastructure

Although there are a wide variety of measures Texas communities use to protect themselves from future flooding (e.g., flood control reservoirs, dams, levees and local storm drainage infrastructure, etc.), dams may provide the most significant structural mitigation to regionally reduce future flood risk. Dams in Texas serve many purposes including flood risk mitigation, irrigation, water supply and fire protection, and creating waterbodies for recreation. About one in three of the state's dams are for flood risk mitigation and one in seven dams are for irrigation or water supply.

Dams

The U.S. Army Corps of Engineers (USACE) maintains a database of dams nationwide totaling 7,324 in Texas. The Texas Commission on Environmental Quality (TCEQ) maintains a database of the similar state regulated Texas dams (i.e dams above the size thresholds of Texas Administrative Code Title 30, Part 1, Chapter 299). Dams of unregulated size are deemed not to provide a safety risk to lives in the event of a breach. And finally, the Texas State Soil and Water Conservation Board (TSSCWCB) maintains a list of 2,041 earthen dams that were designed and constructed by the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS). These data sources were reviewed and amended to only include a single dam per location ultimately identifying a total of 696 dams in the region.

Dams can be owned and operated by a wide range of organizations and people, including state and local governments, public and private agencies, and private citizens. Because of the diverse nature of ownership, the capacity of dams and the frequency of inspection may vary widely as well. Although reasons for building dams may include water storage for human consumption, agricultural use, power generation, industrial use, and recreation, for the purposes of this report the analyses will focus on how dams are used as part of flood control.

Levees

Levees are man-made structures that provide flood protection. More than one million Texans and $127 billion dollars' worth of property are protected by levees. The Texas 2018 Levee Inventory Report lists 51 USACE levee systems in the State (2021 Texas Infrastructure Report Card, 2021). These USACE levees are frequently maintained and inspected to federal standards and provide a high standard of flood protection. Although not all are used for flood control purposes, failure of a single levee could have multiple consequences for property and human safety downstream.

According to the USACE National Levee Database, there are 24 levees in the Lower Colorado-Lavaca region with one managed by the USACE – Fort Worth District. The Texas Water Code §16.236 requires that the design be based on the 1% annual chance (100-year) event and provide three to four feet of freeboard in urbanized areas. The Water Code also outlines a review and approval process for the construction and improvement of levees following the filing of an application and a set of preliminary plans for the levee that includes sufficient engineering detail for evaluation. Applications must include the location and extent of the structure, location of surrounding levees, reservoirs, dams or other flood control structures which may be affected and the location and ownership of all properties lying within any proposed protected area or others which may be affected by the project's alteration of the flood flows. The preliminary plans must demonstrate the effects the proposed project will impose on existing flood conditions. (Texas Commission on Environmental Quality, 2005). Map 9: Maps and Levees, and *Table 15,* provides the number of levees by HUC 8 watershed throughout the region.

***Figure 21**: Dams and Levees*

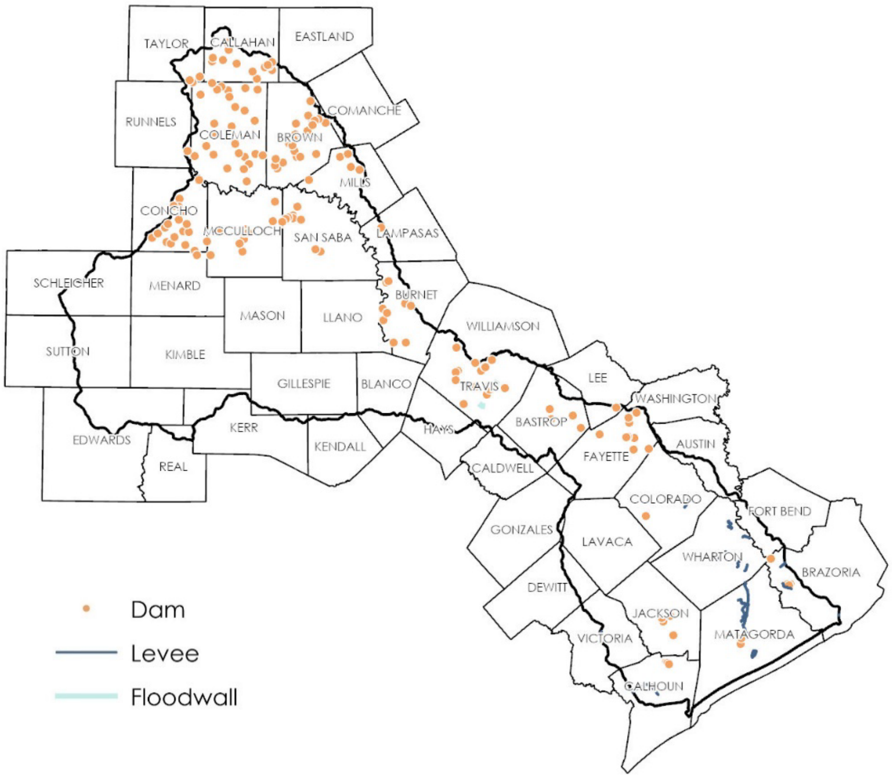


Table 15: Dams and Levees by HUC 8 Watershed

HUC 8 Name	Dams (count)	Percentage of Region (% of total dams)	Levees (miles)	Percentage of Region (% of total levees)
Middle Colorado	132	19%		
Pecan Bayou	132	19%		
Jim Ned	53	8%		
San Saba	19	3%		
Brady	51	7%		
Buchanan-Lyndon B	17	2%		
North Llano	1	0%		
South Llano	3	0%		
Llano	7	1%		
Austin-Travis Lakes	82	12%	3	3%
Pedernales	15	2%		
Lower Colorado-Cummins	116	17%		
Lower Colorado	6	1%	65	59%
San Bernard	18	3%	19	18%
East Matagorda Bay 1	5	1%	6	6%
Lavaca	6	1%		
Navidad	17	2%		
East Matagorda Bay 2	10	1%		
West Matagorda Bay	6	1%	16	15%
Region Totals	696	100%	109	100%

Source: USACE National Inventory of Dams, TSSWCB Local Dams Listing, USACE National Levee Database

Stormwater Management Systems

Stormwater management systems serve to manage both the quantity and quality of the water that drains into the region's rivers and tributaries. Although survey respondents provided limited information as to their own stormwater management systems, participants in the Texas Pollutant Discharge Elimination System (TPDES) which is managed by the TCEQ, are likely to have storm drainage infrastructure. Six cities in the region have drainage systems and are classified as Phase I Municipal Separate Storm Sewer Systems (MS4s): Austin, Pflugerville, Rollingwood, San Leanna, Sunset Valley and West Lake Hills. An additional four cities in the region are classified as Phase II MS4s: Bee Cave, Buda, Hays, and Victoria.

Roadways

Low water crossings and at-risk roadway segments are utilized to assess existing condition risk, future condition risk, and potential mitigation benefits. The TWDB defines a low water crossing as a roadway crossing that is overtopped by the 1% ACE (100-year) or more frequent events. At-risk roadway segments are portions of roadway that are inundated or impassable during flooding events that may impact emergency response or evacuation. The region's database was initially populated with TWDB provided low water crossings and then refined using input from stakeholders.

Structural Coastal Features

As stated previously, the GLO is in the process of updating the 2019 CRMP for Texas and anticipates the release of a new plan in 2023 (Texas General Land Office, 2019). The identified structural coastal projects will be incorporated in the next planning cycle. Structural coastal features along the region's coast in Calhoun, Jackson, Matagorda, and Brazoria Counties that help to reduce flood impacts include sea walls, tidal dikes/barriers, revetments, and tidal gates.

Table 16: Storm Drainage, Roadways, and Coastal Infrastructure

HUC 8 Name	Storm Drain Systems (count)	Low Water Crossings (count)	Percentage of Region (% of total LWX)	Sea Walls (miles)	Percentage of Region (% of total walls)
Middle Colorado	*TBD*	33	2%		
Pecan Bayou		49	4%		
Jim Ned		38	3%		
San Saba		48	4%		
Brady		52	4%		
Buchanan-Lyndon B		109	8%		
North Llano		13	1%		
South Llano		11	1%		
Llano		277	20%		
Austin-Travis Lakes		377	28%		
Pedernales		167	12%		
Lower Colorado-Cummins		96	7%		
Lower Colorado		3	0%	6	19%
San Bernard		16	1%		
East Matagorda Bay 1		5	0%	19	59%
Lavaca		13	1%		
Navidad		23	2%		
East Matagorda Bay 2		10	1%	4	13%
West Matagorda Bay		12	1%	3	9%
Region Totals		1,352	100%	32	100%

Source: Stakeholders, TWDB low water crossings, USFWS Coastal Barrier Resources System database, and GLO coastal resiliency and master plan

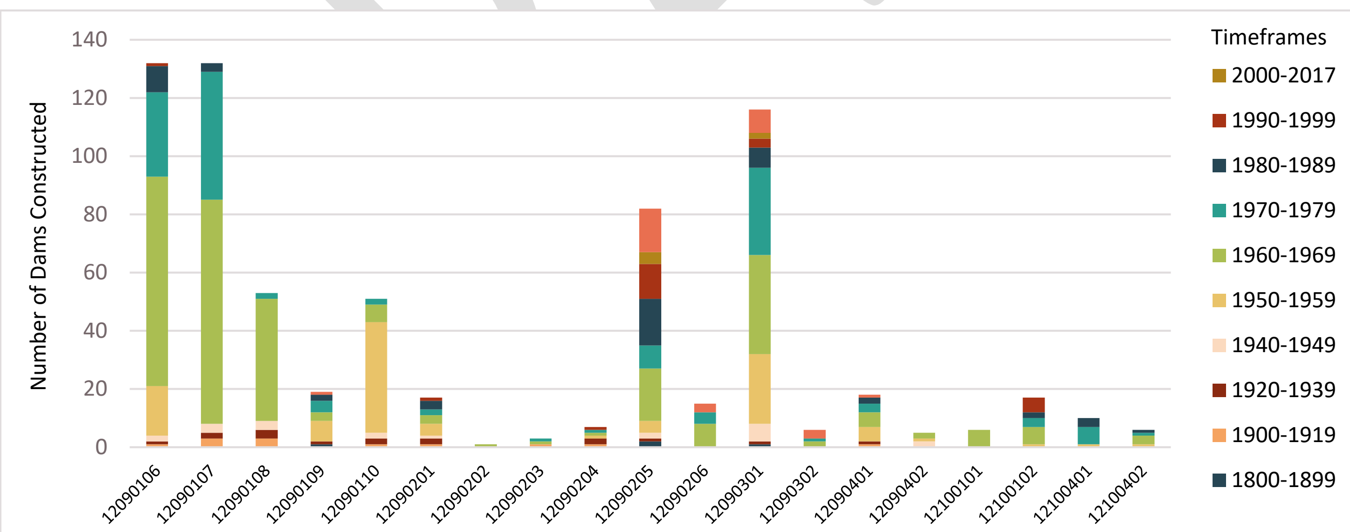
Condition and Functionality of Existing Flood Infrastructure

The TWDB provided information and research of existing flood infrastructure provided little relevant information about the state of the region's existing flood infrastructure, and no direct input was provided by survey respondents regarding infrastructure condition and functionality. The TWDB defines functional infrastructure as infrastructure that is serving current design level of service where a non-functional classification would indicate the infrastructure needs upgrades to meet a higher level of service. Similarly, the TWDB defines deficient infrastructure as being in poor physical condition indicating the infrastructure needs replacement, restoration, or rehabilitation. To provide some level of assessment, the age of dams and levees was utilized where avaliable to provide insight about the state of the region's existing flood infrastructure.

Throughout Texas, flood infrastructure is rapidly aging and in need of repair. In 2019, the Association of State Dam Safety Officials (ASDSO) estimated the cost to rehabilitate all non-federal dams in Texas at about $5 billion. The TSSWCB estimates around $2.1 billion is required to repair or rehabilitate dams included in the Small Watershed Programs. Even though the minority of the dams in the region were constructed for flood control, the consequences of failure can still be severe, with potential loss of life, agricultural resources and property. Of the about 7,200 non-federal dams in Texas, about 25 percent could result in loss of life should they fail and more than 3,200 Texas dams are exempt from dam safety requirements by State legislation.

The year of construction is available for the majority of the 696 dams in the Lower Colorado Lavaca region, 77 percent of dams were constructed between 1950 – 1979. The 1960s were the most prolific period of dam construction in the region, when over 41 percent were constructed. The percentage of dams constructed between 1950-1959 and 1970-1979 were roughly equal, at about 35 percent. With a typical life span of 50-years, over 50 percent of the dams in the region are reaching their life span.

Figure 22: Year of Dam Construction by HUC-8



Source: USACE National Inventory of Dams, TSSWCB Local Dams Listing

The most common reasons for dam failure include: overtopping by floods, foundation defects, piping and seepage (Texas Commission on Environmental Quality, 2006). Although stakeholders provided little information about the nature of their dam infrastructure, the age of these structures alone indicates that many may be due for modernization, upgrades, maintenance, rehabilitation or even retirement.

Failure of the Bastrop State Park Dam that was originally constructed in 1913 during the 2015 Memorial Day flood event. Source. Texas Parks and Wildlife.

Condition-related data for the region's levees is mostly unknown, since most of the levees in the state are built, inspected and/or maintained by local governing agencies who may not have the resources for routine assessment and performance tracking. Over one million Texans and $127 billion dollars-worth of property are protected by levees. The Texas 2018 Levee Inventory Report lists 51 USACE levee systems with 291 miles protecting a population of 291,200 and 276 known non-USACE levee systems with 1,562 miles protecting a population of 707,700 statewide. Recent increases in frequency and intensity of storms and hurricanes continue to test the capacity of the state's levees. Without a clearer picture of the state's levee infrastructure and concentrated funding to assist private owners, the vast majority of the state's levees will remain in the presumed deficient status. (2021 Texas Infrastructure Report Card, 2021) Additionally, the American Society of Civil Engineers (ASCE) continues to give the state's levees a grade of D and emphasizes that the lack of a state Levee Safety program means that few levees may be conducting regular safety inspections and preparing public evacuation plans for affected communities.

Of the 109 miles of levee in the Lower Colorado-Lavaca region, approximately 45 miles (41 percent) of them are identified as being accredited by the USACE. This indicates that several of the levees in the region may be due for modernization, upgrades, maintenance, or rehabilitation.

Action - Proposed / Ongoing Flood Mitigation

The data for this section is derived from two primary sources. The first source of this data is the region's data collection survey, which was supplemented by direct outreach and interviews with stakeholders. The second source is existing Hazard Mitigation Plans in the region.

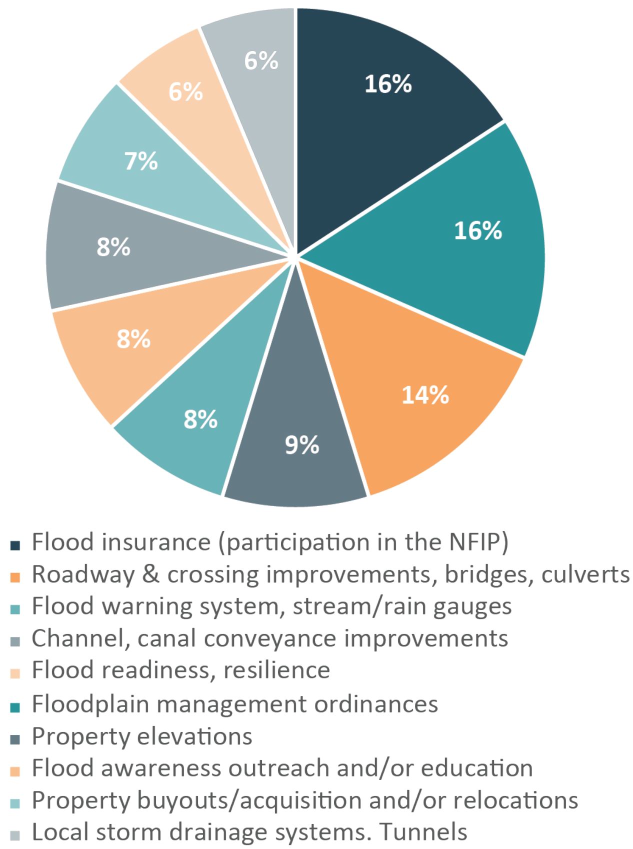
Current Flood Mitigation Activities

These proposed or ongoing flood mitigation projects are derived from the survey responses coming from the communities throughout the basin. They are being completed by cities, counties, and additional entities throughout the basin.

Overall, 15 communities indicated in the survey that they planned to undertake a variety of Flood Mitigation Projects (FMPs) in the coming years (respondents could select more than one alternative). The predominant types of projects being pursued are:

- Flood insurance (participation in the NFIP);
- Floodplain management ordinances; and
- Roadway and crossing improvements, bridges, culverts.

Figure 23: Top 10 Types of Proposed or Ongoing Flood Mitigation Projects



Source: Region 10 Data Collection Tool and Interactive Webmap

Figure 23: Top 10 Types of Proposed or Ongoing Flood Mitigation Projects, represents the top 10 types of potential projects identified by survey respondents. *Table 17: Proposed Projects by Type*, on the next page, details the number of responses for all project types.

The largest number of respondents indicated continued participation in the NFIP flood insurance program and floodplain management ordinances (15 responses) followed by projects related to roadway and crossing improvements, bridges, culverts; and channel, canal conveyance improvements (8 responses).

Additionally, several respondents indicated projects related to flood mitigation, including property elevation (9 responses), flood awareness outreach and/or education (8 responses), and flood warning system, stream/rain gauges (8 responses). While many of these project types are local in nature (e.g., property buyouts/acquisition and/or relocations), some may be better implemented regionally (e.g., flood warning).

Table *17: Proposed Projects by Type*

Type of Projects	Count
Channel, canal conveyance improvements	8
Coastal groins, jetties, breakwaters	1
Flood awareness outreach and/or education	8
Flood insurance (participation in the NFIP)	15
Flood readiness, resilience	6
Flood warning system, stream/rain gauges	8
Floodplain management ordinances	15
Levees, flood walls	2
Local storm drainage systems. Tunnels	6
Nature based projects	1
Property buyouts/acquisition and/or relocations	7
Property demolition/reconstruction	4
Property elevations	9
Property floodproofing and/or flood retrofits	1
Regional dams, reservoirs, detention, retention basins	4
Roadway and crossing improvements, bridges, culverts	13
Sea barriers, walls, revetments	1

Source: Region 10 Data Collection Tool and Interactive Webmap

It is important to note that there are gaps and limitations provided by this data set. Overall, it only represents a small number of the communities within the basin and little data was provided on individual projects. It is also important to note that there may be a larger number of projects than displayed, since entities submitted the categories of projects they were pursuing, but not the number of projects within each category. Future funding sources for these projects include FEMA, GLO, CDBG-MIT, TWDB, TDEM, as well as cities' typical funding sources coming from their general fund, taxes, and other fees.

Structural Projects under Construction

In the survey, 20 respondents listed that some of their proposed infrastructure or flood mitigation projects were at or above a 30% level of design. However, responses regarding projects under construction were insufficient to provide additional details regarding these projects. Chapter 2 a more detailed assessment of projects under construction.

Nonstructural Flood Mitigation Projects being Implemented

Information provided in response stakeholder outreach was insufficient to provide a complete answer to this question. Chapter 2 includes more information regarding nonstructural flood mitigation projects being implemented.

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

Information provided in response stakeholder outreach is insufficient to provide a complete answer to this question. However, several respondents to the survey who indicated that they did have projects at 30% level of design also indicated that Stormwater Utility Fees, Bond Programs, Ad Valorem Tax and the General Fund were anticipated to be their primary source of revenue to complete these improvements. In particular, the General Fund was the funding source most identified. Additionally, nine communities identified that they do not have a local funding source for their flood management activities. Non-local funding sources that the entities intend to pursue to complete these projects include:

- Hazard Mitigation Grant Program (HMGP) [FEMA/TDEM]
- Community Development Block Grant-Disaster Recovery (CDBG-DR) [HUD/GLO]
- Flood Mitigation Assistance [FEMA]
- Community Development Block Grant-Mitigation (CDBG-MIT) [HUD/GLO]
- Flood Protection Planning Grants [TWDB]

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 grow in future planning cycles.