# **EXECUTIVE SUMMARY**

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# Lower Brazos Regional Flood Plan: Executive Summary

### ES.1 – Overview of Regional Flood Planning Region

In 2019, the 86<sup>th</sup> Texas Legislature passed Senate Bill 8, authorizing and establishing the regional and state flood planning process. It assigned the oversight and production of this process and its resulting documentation to the Texas Water Development Board (TWDB). Fifteen Regional Flood Planning Groups (RFPGs) were created to represent the major river basins in Texas. This report outlines the <u>draft</u> findings of the <u>Amended</u> Region 8 Lower Brazos Regional Flood Plan for the first cycle of regional and state flood planning.

The Lower Brazos Regional Flood Planning Group (RFPG) is comprised of 12 voting members and 10 nonvoting members who helped guide the production and development of this plan; these members were selected by a nomination process, including liaisons with adjacent planning regions and a coastal liaison. To ensure a diversity of perspectives were included, members represent a wide variety of entities and interest groups potentially affected by flooding, including:

- Agriculture
- Counties
- Electric Generation Utilities
- Environmental Interests
- Flood Districts
- Industry

- Municipalities
- Public
- River Authorities
- Small Businesses
- Water Districts
- Water Utilities

The Lower Brazos Planning Region encompasses all or part of 43 counties and 193 municipalities and covers over 23,000 square miles and approximately 20,000 stream miles. The area spans from the southern tip of Archer County to Freeport in Brazoria County, bordering the Gulf of Mexico and is home to over 3 million residents, and constitutes 10 percent of the population of Texas. Of the 193 local communities, there are at least 40 communities with a population greater than 30,000; and 18 communities with a population greater than 50,000. The coverage of the Lower Brazos Planning Region can be seen in *Figure ES.1*.

Much of the population and associated infrastructure in the Lower Brazos Planning Region is located in the central and southern portions of the basin. Cities in proximity to metropolitan areas, such as Austin and Houston, have greater populations. Additionally, the Bryan/College Station and Waco areas have significant portions of their population located in the Lower Brazos Planning Region. As expected, much of the existing flood infrastructure is located near these areas with high population density, as well as in communities located closer to the coastline. Rural parts of the basin have significant portions of the region's agricultural land and associated economic activity.

### Figure ES.1: Lower Brazos Planning Region



### **ES.2 – Public Participation**

Public outreach and participation played a crucial role in developing the first planning cycle of the State Flood Plan. Feedback obtained from entities and members of the public provided critical insight that aided in identifying and confirming flood risk and project needs in the region. The Lower Brazos Planning Region utilized various methods to reach the public and inform them about the development of the first flood plan for the region.

Early on, a regional website (<u>lowerbrazosflood.org</u>) and email address were developed by the planning group's Sponsor, the Brazos River Authority (BRA), to inform and communicate with the public on the

progress of the Lower Brazos Regional Flood Plan. Updates were also provided by the planning group's Sponsor through social media and monthly email blasts to individuals throughout the region, including those signed up to receive project information about the flood plan. The RFPG posted meeting notices and materials in accordance with the Texas Open Meetings Act, and meeting notices were posted on the Lower Brazos RFPG website. A public outreach survey and interactive webmap were developed and posted to the RFPG website to solicit input and provide an opportunity for interest groups to submit relevant data for incorporation into the plan.

Additionally, the Lower Brazos RFPG held monthly public meetings both in-person and virtually at the BRA's Central Office in Waco to discuss project tasks. The public was provided the opportunity to speak at the beginning of each meeting. Five public roadshow meetings were also held in person at various cities across the region (Waco, Granbury, Georgetown, College Station, and Rosenberg) to inform interested groups about the planning process and also collect information essential to the planning process.

### ES.3 – Existing and Future Flood Exposure

A flood exposure analysis was performed to guide the Lower Brazos Regional Flood Plan by establishing a consistent measure of flood hazard within the basin. The analysis considered vulnerability, land use, estimated precipitation data, and constructed drainage-related infrastructure.

Datasets of hydrologic and hydraulic modeling and flood risk mapping from various sources were collected and compiled together to create a comprehensive, continuous set of the best available existing flood risk data for the Lower Brazos Planning Region. The compiled mapping included both the 1 percent and 0.2 percent annual chance event (ACE) storms. The sources of the flood risk datasets included the United States Army Corps of Engineers (USACE), United States Geological Survey (USGS), Federal Emergency Management Agency (FEMA), and the TWDB. These different datasets were prioritized based on the quality and coverage extents to determine which information to use when the datasets were overlapping. The main flood risk data sources for the Lower Brazos Planning Region, in priority order, are listed below:

- Local Community Submitted Data
- National Flood Hazard Layer (NFHL) Pending (Detailed and Approximate Studies)
- NFHL Effective (Detailed Study Only)
- Base Level Engineering
- Cursory Fathom Data provided by the TWDB
- NFHL Effective (Approximate Study Only)
- Flood-Prone Areas Related to Reservoirs and Levees

A flood hazard "quilt" dataset was developed from the different flood risk datasets to inform the Lower Brazos Regional Flood Planning efforts in identifying vulnerable areas and infrastructure. The flood hazard quilt is not intended to be used for regulatory purposes, such as local floodplain management and development regulation, or by FEMA or the National Flood Insurance Program (NFIP) since the data sources have varying levels of quality and detail. Also, most data sets did not account for Atlas 14 rainfall

rates, the latest rainfall data published by the National Oceanic and Atmospheric Administration (NOAA). Additional studies are needed to develop comprehensive, consistent, and up-to-date existing flood risk data across the region.

Flood risk and vulnerability analyses were performed using the flood hazard quilt with consideration to infrastructure, area, and population of the basin collected previously. Each dataset was overlayed with the extents of the 1 percent and 0.2 percent ACE flood hazard quilts to determine risk. **Approximately 22 percent of the region (5,000 square miles) is located in the extents of the 1 percent and 0.2 percent ACE flood hazard quilts.** *Table ES.1Table ES.1* summarizes the existing flood risk in the Lower Brazos Planning Region. As shown, Waller, Somervell, Robertson, Limestone, Grimes, Falls, Eastland, and Brazoria counties all have high vulnerability to flooding.

Using the existing condition flood hazard data as a baseline, the Lower Brazos RFPG conducted a future condition flood risk analysis, representing a "no action" scenario in 30 years. "No action" assumes continued population growth, regulations, land use, and development trends. Additionally, natural processes such as sea level rise, subsidence, and geomorphic changes were considered as these factors may contribute to changing flood hazards in the future. The future condition flood risk analysis consisted of creating both flood hazard and flood exposure data.

To estimate the 30-year, "no action" future flood hazard data throughout the Lower Brazos Flood Planning Region, the existing 0.2 percent ACE flood hazard extents were used as a proxy for the future 1 percent ACE flood hazard extents in a manner consistent with the guidance provided by the TWDB. To illustrate the future 0.2 percent ACE flood hazard extents, the RFPG utilized the future 1 percent ACE flood hazard extents with an additional buffer consistent with the difference between the existing 1 percent and 0.2 percent ACE water surface elevation or inundation area, depending on available data. The only exception to this methodology was the main stem of the Brazos River; associated flood hazard areas areas were left unchanged after careful consideration by the RFPG. **The extent of the flood hazard areas is estimated to increase by 10 percent in the Lower Brazos Planning Region in the next 30 years if no action is taken. As with existing conditions, additional studies are needed to develop comprehensive, consistent, and up-to-date future flood risk data across the region.** 

The future condition flood exposure and vulnerability analyses were conducted using the flood hazard data described above and the same approach that was implemented to determine the flood exposure and vulnerability for existing conditions. These analyses show potential structures, critical facilities, roadways, agricultural areas, and people are at risk of being impacted by flooding in the future. *Table ES.1Table ES.1* summarizes the increase in flood risk in the Lower Brazos Planning Region with consideration of future conditions. The increase in flood risk will greatly impact growing populations in the region. Infrastructure exposure was also shown to increase in the future conditions flood risk analyses.

Feature	Existing Conditions	Future Conditions	Percent Increase with No Action
Population	261,925	421,657	61%
Total Structures	107,719	168,534	56%
Residential Structures	79,169	134,024	69%
Non-Residential Structures	28,550	34,510	21%
Critical Facilities	303	506	67%
Roadway Crossing	7,799	7,819	0.3%
Roadway Segments (miles)	4,432	5,639	27%
Agricultural Area (sq. mi)	945	1,031	9%

### Table ES.1: Summary of Increased Exposure in 0.2 percent ACE Flood Hazard Area

### **ES.4 – Overarching Goals for the Region**

The results of the flood risk analysis indicated the need to develop regional standards and goals to help manage existing flood risk and prevent the creation of new flood risk in the future.

Existing floodplain management practices within the Lower Brazos Planning Region were evaluated to determine where there is potential for enhancement. Based on this evaluation, two distinct categories of recommended standards were developed, including standards for region-wide application and standards recommended by zone. The four zones were established for the region: Coastal, Upper Coastal, Brazos Valley, and Middle Brazos. The two distinct categories of recommended standards allow for a broad application, as well as a tailored formulation for capturing variability in flood risk, natural hydrography, topography, climatological effects, and demographics throughout the river basin.

It is important to note that the RFPG does not have the authority to enact or enforce floodplain management, land use, or other infrastructure design standards. Any standards considered, recommended, and accepted by the Lower Brazos RFPG are intended to encourage implementation by local entities in the region with flood-related authority. The RFPG determined that standards produced as part of the flood planning effort should be classified as recommendations for general consideration by entities and communities within the region. For context, adopted standards are minimum standards that must be implemented by entities to qualify for the inclusion of any flood management mitigation actions in the regional flood plan on their behalf. Although standards for adoption are not proposed for this initial flood plan, it is conceivable that future updates to the regional flood plans may incorporate standards for adoption. *Table ES.2<del>Table ES.2</del>* summarizes the recommended standards for the Lower Brazos Flood Planning Region.

### Table ES.2: Summary of Recommended Standards

Recommended Standard	Region- wide	Zone 1 "Coastal"	Zone 2 "Upper Coastal"	Zone 3 "Brazos Valley"	Zone 4 "Middle Brazos"
National Flood Insurance Program (NFIP) Participation	Х			·	
Compensatory Storage Requirement in 1% (100- year) Annual Chance Event	Х				
No Adverse Impacts for the 1% (100-year) Annual Chance Event	Х				
Improved Flood Response	Х				
Improved Flood Risk Awareness/ Education	Х				
Use of Best Available Rainfall Data		Х	Х	Х	
No Adverse Impacts for the 1% ACE and 10% ACE		Х	Х	Х	
Form a Voluntary Buyout Program		Х			
Long-term Operation and Maintenance Planning of Drainage Infrastructure		Х			
Drainage Corridor Preservation			Х	Х	
Compensatory Storage Requirement in 0.2% ACE				Х	х
Requirements for Culvert and Bridge Crossings				Х	х
Roadway Requirements within the Floodplain				X	Х
Culvert and Bridge Hydrologic and Hydraulic Analysis Requirement				Х	Х

In addition to the proposal of standards, the Lower Brazos RFPG developed goals to track the region's progress in achieving better flood risk awareness and prevention. As summarized in *Table ES.3Table ES.3*, ten goals were developed with both short- and long-term targets. The achievement of these goals would benefit five categories determined to be critical for the Lower Brazos Planning Region: floodplain management, mitigation projects, flood studies and analysis, flood readiness and warning, and education and outreach. By establishing these goals, the RFPG can track the region's progress and help

guide the development of critical components in future flood planning cycles. The individual Lower Brazos Flood Planning Region goals support the overarching goal of protecting against the loss of life and property by reducing the increase in future flood risk.

### Table ES.3: Lower Brazos Regional Flood Planning Goals

### Goals

1. Increase the number of counties and communities enrolled in the NFIP.

2. Increase the number of counties and communities that have adopted higher than NFIP standards, including directing development away from the floodplain.

3. Increase the number of entities that have adopted the best available data and science for their designs and plans.

4. Improve safety at low water crossings by adding warning systems/signage or improving low water crossings in high-risk areas.

5. Reduce the number of structures at risk of flooding during the 1 percent annual chance flood event by both structural (flood infrastructure) and non-structural (elevation, acquisition, relocation, etc.) means.

6. Reduce the number of critical facilities at risk of flooding during a 1 percent annual chance of flooding to above the 0.2 percent annual chance flood event by both structural (flood infrastructure) and non-structural (elevation, buyouts, relocation, etc.) means.

7. Increase the accuracy of flood hazard data in the region by performing detailed studies using the best available terrain, land use, and precipitation data to reduce gaps in floodplain mapping.

8. Increase the number of communities with warning and emergency response programs that can detect flooding threats and provide timely warning of impending flood danger.

9. Increase the number of flood gauges (rainfall, stream, reservoir, etc.) in the region.

10. Increase public outreach and education activities to improve awareness of flood hazards and the benefits of flood planning in the region.

### ES.5 – Identification, Evaluation, and Recommendation of Flood Management and Mitigation Actions

To address the identified flood risks, the Lower Brazos Planning Region developed a list of potential flood mitigation actions that could lead to a better understanding of flood risk or mitigate the current flood risk in the basin. Those actions included flood management evaluations (FMEs), flood mitigation projects (FMPs), and flood management strategies (FMSs). FMPs are proposed structural or non-structural projects that, when implemented, will reduce flood risk. FMSs are intended to be "big picture" mitigation efforts, capturing flood risk reduction actions that do not align with FMEs or FMPs. An FME is

a proposed study of a specific, flood-prone area that is needed to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs that could mitigate the flood risk.

Previously compiled data, such as assessments of historic flooding, existing infrastructure, flood hazard, flood exposure and vulnerability, and existing policies, were utilized to identify flood mitigation actions. Areas of greatest known flood risk and areas with the greatest gaps in flood risk information were determined to help guide the recommendation and inclusion of the most pertinent flood mitigation actions. To locate these areas, the RFPG considered the specific criteria listed below:

- Buildings in flood-prone areas
- Low water crossings
- Agricultural land in flood-prone areas
- Critical facilities in flood-prone areas
- Community NFIP participation
- Flood risk knowledge gaps
- Emergency need
- Updated Hazard Mitigation Action Plans (HMAPs)
- Historic flooding events
- Social Vulnerability Index (SVI)

These factors were quantified across the region using HUC-12s, which are the smallest available watershed units provided by the TWDB. The RFPG chose to utilize hydrologic areas for this task to support the overarching plan goal of proposing regional solutions that are not confined to jurisdictional boundaries. Scoring related to overall flood risk and flood risk knowledge gaps directed the delineation of FMEs in the form of drainage master plans and regional watershed studies.

Over 550-680 potential FMEs, FMPs, and FMSs were identified through the public outreach survey, roadshow workshops, and-research of publicly available documents, and flood exposure analysis. However, the list of potential flood mitigation actions was not exhaustive for the Lower Brazos Planning region. The RFPG developed several metrics to screen potential FMEs, FMPs, and FMSs and create a finalized list for recommendation. The primary screening criteria that kept many potential FMEs, FMPs, and FMSs from recommendation was the need for explicit sponsorship approval from local entities. The RFPG decided that without the verbal or written affirmation of an entity's desire to implement a specific action, there was confirmation that the FMEs, FMPs, or FMSs needed to be completed or that the identified entity would be willing to drive it forward. Therefore, recommendations were not made for FMEs, FMPs, or FMSs that did not have confirmation from the proposed sponsor.

Each identified flood mitigation action was evaluated, regardless of recommendation. General information was gathered from the source documentation of each FME, FMS, and FMP, including:

- General description and location, including impacted HUCs and counties;
- Sponsor(s) who will manage the implementation of the action; along with other entities that may have oversight;
- Estimated costs determined through source documentation or historical data;
- Potential funding sources;

- Associated RFPG approved flood management and mitigation goals;
- Determination of whether the action meets an emergency need; and,
- Identify associated hydraulic and hydrologic models or maps that would support the action.

Benefit areas were delineated for the FMEs, FMSs, and FMPs, and these bounds were used to generate flood risk and flood risk reduction metrics. For FMEs, the delineations were compared to the flood risk exposure analysis previously described to determine the at-risk infrastructure and population within the evaluation area. A more detailed analysis was performed for FMPs. Hydrologic and hydraulic models were collected for each FMP and used to perform a flood risk analysis using the existing conditions modeling results and a flood risk reduction analysis using modeling results representing the implementation of the proposed project. FMSs are high-level mitigation actions, so flood risk and flood risk reduction were not calculated.

After an extensive screening and evaluation process, the RFPG recommended 24-49 FMPs, 10 FMSs, and 95-97 FMEs for inclusion in the Lower Brazos Regional Flood Plan. The summaries are shown in *Table ES.4*, *Table ES.5*, and *Table ES.6*.

Proposed channel widenings and construction of detention ponds characterize the recommended FMPs, located in Fort Bend CountyRecommended FMPs are largely the results of Master Drainage Plans and FIF studies completed by entities within the region. The projects are largely composed of channel and crossing improvements that would reduce risk to structures and provide better mobility during storm events. The recommended FMSs primarily target flood preparedness through many avenues, including increasing regulations, creating flood warning systems, erosion control, floodproofing of key infrastructure, and property acquisition. Recommended FMEs can be separated into two key categories; the majority are evaluations that will explore the feasibility of potential FMPs and FMSs, while others are proposed studies and evaluations to close gaps in flood risk knowledge. **The estimated budget (2020 dollars) for the recommended FMEs, FMSs, and FMPs, is \$4.6-7 billion.** The estimated cost for nonrecommended FMEs, FMSs, and FMPs is \$256 million. Although FMEs, FMSs, and FMPs without sponsors were ultimately not recommended by the RFPG, these flood mitigation actions have potential merit in flood risk reduction and may be considered in future flood planning cycles.

FMP Types	Number of Identified FMPs	Number of Recommended FMPs	Cost of Recommended FMPs
Low Water Crossings or Bridge Improvements	<del>2</del> 14	<del>0</del> 7	<del>N/A</del> \$26,205,000
Regional Channel Improvements	<del>23</del> 27	<del>23</del> 26	\$4, <del>144,357,000</del> 158,794,000
Regional Detention	1	1	<mark>\$</mark> 8,699,000
Levee	1	1	\$1,594,000
Storm Drainage Improvements	4	4	\$9,419,000
Comprehensive Drainage Improvements	9	9	\$87,866,000
Property Acquisition	1	0	<del>N/A</del> \$600,000

### Table ES.4: Summary of Recommended FMPs

	Total	<del>27</del> 57	<del>24</del> 49	\$4, <del>153</del> 293, <del>056</del> 177,000
LOWER B REGIONAL PLANNING REGIO	RAZOS FLOOD GROUP ON 8			DRAFT EXECUTIVE SUMMARY

### Table ES.5: Summary of Recommended FMSs

FMS Type	Number of	Number of	Cost of
	Identified FMSs	Recommended FMSs	Recommended FMSs
Education and Outreach	1	0	N/A <sup>1</sup>
Erosion Control	1	1	\$360,000,000
Flood Measurement and	16	2	N/A <sup>1</sup>
Warning	10	2	,,,
Flood Preparedness and	57	3	$N/\Delta^1$
Resilience	57	3	
Low Water Crossings or	7	0	N/A
Bridge Improvements	1	8	N/A
Nature Based Strategies	11	0	N/A
Property Acquisition and	10	2	¢14,000,000
Structural Elevation	10	5	\$14,000,000
Regulatory and Guidance	28	1	N/A <sup>1</sup>
Total	139	10	\$374,000,000

### Table ES.6: Summary of Recommended FMEs

<b>FME Туре</b>	Number of Identified FMEs	Number of Recommended FMEs	Cost of Recommended FMEs
Regional Watershed Studies	<del>59</del> 60	14	\$2, <mark>452</mark> 952,000
Studies on Flood Preparedness	<del>24</del> 29	2	\$3, <del>212</del> 712,000
Drainage Master Plans	<del>123</del> 125	<del>3</del> 6	\$ <del>2</del> 3, <del>404</del> 104,000
Feasibility Assessments	32	13	\$4,850,000
Preliminary Engineering	<del>13</del> 4133	4443	\$12, <del>536</del> 428,000
H&H Analysis	44	19	\$2,850,000
Total	<del>416</del> 423	<del>95</del> 97	\$ <del>28</del> 29, <del>504</del> 896,000

# ES.6 – Impacts of the Recommended Flood Management and Mitigation Actions

To determine the impacts of the recommendations made in the Lower Brazos Regional Flood Plan, an analysis was performed to summarize the benefits that would be provided if all recommended FMEs, FMSs, and FMPs were implemented. The analysis included metrics similar to those used in the flood risk

analysis, in addition to potential socioeconomic, recreational, environmental, agricultural, geomorphic, navigation, and water quality benefits. During this cycle, the avoidance of future flood risk resulting from later implementation of actions not recommended by the RFPG and policy changes were also analyzed.

In the near term, implementation of all recommended FMEs in the Lower Brazos Regional Flood Plan would result in a decrease in the percentage of the region with inadequate mapping from 33 percent to 28 percent. Implementation of all recommended FMPs in the Lower Brazos Regional Flood Plan, which are confined to Fort Bend County in this cycle, would result in a 23.8 percent reduction in the Fort Bend County population exposed to the 1 percent ACE storm. Other benefits of plan implementation listed below are more qualitative. These include, but are not limited to:

- Protection of natural riverine features and creating open spaces and pedestrian trails for recreational use.
- Reduction of water pollution associated with flooded structures.
- Protection of agricultural resources.
- Mitigation of water and wastewater services disruption.
- Protection of valuable infrastructure through stabilization of geomorphic processes.

Additional flood risk that might arise in a "no action" future scenario can be avoided through a consistent effort to fulfill the floodplain management goals and standards set forth by the RFPG. This effort would involve the recommendation of "Regulatory and Guidance" FMSs identified in this planning cycle, which are particularly relevant to mitigating future flood risk in a region where construction of over 480,000 new residential structures is anticipated to accommodate population growth over the next 30 years. Furthermore, if all regional watershed study FMEs identified in this planning cycle (recommended and non-recommended) were to be implemented, no areas of the Lower Brazos Flood Planning Region would lack sufficient modeling or mapping data. The implementation of actions mentioned above would facilitate regulation of development, the establishment of higher standards, and the use of the best available data, which are all interdependent strategies for avoiding potential increases in flood exposure over time. Implementing Drainage Master Plan FMEs identified in this plan would help identify potential projects that could be included as FMPs in future planning cycles. The implementation of these identified projects would ultimately mitigate future flood risk.

Impacts to water supply were also evaluated. In 1997, the TWDB established 16 regional water planning areas (RWPA) and appointed members representing key public interests to the regional water planning groups (RWPG). Region 8 primarily covers water planning regions G and H. **None of the recommended FMEs, FMSs, and FMPs would negatively impact or substantially contribute to the water supply.** 

### **ES.7 – Flood Infrastructure Financing Analysis**

The Lower Brazos RFPG recommended 129 flood mitigation actions to address flood risk across the planning region. Combined, these flood mitigation actions are anticipated to cost \$4.6 billion to implement. The RFPG developed a comprehensive assessment of funding opportunities to help the legislature with future funding and grant needs to address flood risk in the region and, ultimately, the state.

As opposed to other types of infrastructure, flood projects do not typically generate revenue, and many communities do not have steady revenue streams to fund flood projects. Consequently, communities often must seek state or federal funding assistance for regional flood mitigation. From the initial public outreach survey, the most referenced difficulty with obtaining funding from state or federal programs was that many entities in the Lower Brazos Flood Planning Region do not meet the requirements of programs they wish to apply for due to having lower social vulnerability than other applicants.

A more targeted survey was provided to the sponsors of recommended actions to determine how much funding they could provide locally. **Overall, an estimated \$4.13-7 billion of funding is needed to implement the recommended FMEs, FMSs, and FMPs in the Lower Brazos Regional Flood Plan beyond what is anticipated to be funded by local sponsors.** This figure represents 90 percent of the total cost of the flood mitigation actions identified in this plan. The state and federal agencies listed below administer grant and loan programs that could be used as potential funding sources for recommended actions:

- Federal Emergency Management Agency (FEMA)
- Department of Housing and Urban Development (HUD)
- Texas Water Development Board (TWDB)
- Texas State Soil and Water Conservation Board (TSSWCB)

The findings presented in this inaugural cycle of flood planning result from extensive data collection and analysis efforts. However, future cycles of Regional Flood Planning will continue to develop more detailed and accurate datasets representing the infrastructure, population, land use, and flood risk of the region. Furthermore, as recognition and understanding of the planning efforts increases, public engagement will help identify additional needed FMEs, FMSs, FMPs, and associated funding, throughout the Lower Brazos basin.

### **ES.8 – Plan Adoption and Recommendations**

The Lower Brazos Regional Flood Plan provided a comprehensive overview of the flood mitigation needs across the region. The needs range from flood reduction projects to flood management strategies to additional flood risk studies. Future flood planning cycles will foster more participation by entities in the region and identify additional flood mitigation actions.

In addition to localized actions, administrative, legislative, and regulatory recommendations were made for state-wide and region-wide policies and programs that could address flood risk on a higher level. These recommendations provide guidance on funding allocation, safety and maintenance programs, distribution of regulatory authority, and improvements to the regional and state flood planning process, among others. **By implementing some, or all, of these recommendations, the RFPG believes the State of Texas could begin to comprehensively address flood risk and allocate resources efficiently.** The Lower Brazos Regional Flood Plan adequately provides for the preservation of life and property, and when implemented would not cause negative impacts to neighboring areas.

The RFPG approved will consider the approval and the submittal of the Amended Region 8 Lower Brazos Regional Flood Plan to the TWDB during a meeting held on December June 13 22, 20232. In accordance



with Title 31 Texas Administrative Code (TAC) §361.20, the Lower Brazos Regional Flood Plan conforms with the guiding principles established in Title 31 TAC §362.3.

# CHAPTER 1

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# **Chapter 1: Lower Brazos Planning Area Description**

### **1.1 – Introduction: The Regional Flood Plan in Context**

### 1.1.1 Origins of the 2023 State Flood Planning Process

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

This plan was prepared because:

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

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

### 1.1.2 Overview of the Planning Process

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

### 1.1.2.a Who's Preparing the Plan?

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

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sponsor. The sponsor's role is to support meetings and communications and manage the technical consultant contract. The Technical Consultant Team, led by Halff Associates, was selected to prepare this plan.

The RFPG's responsibilities include directing the work of the 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 interest groups potentially affected by flooding, including:

- agriculture
- counties
- electric generation utilities
- environmental interests
- flood districts
- industry

- municipalities
- public
- river authorities
- small businesses
- water districts
- water utilities

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

### 1.1.2.b Data Sources

To ensure that flood plans are based upon consistent and reliable information in every basin, the TWDB compiled geographic information system (GIS) data resources in the <u>TWDB Flood Planning Data Hub</u>. GIS layers are provided for:

- critical infrastructure
- flood infrastructure
- flood risk
- hydrology
- jurisdiction boundaries
- parks
- population
- property
- terrain
- transportation

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

To supplement the data provided by the TWDB, the Technical Consultant Team also developed a Lower Brazos RFPG – Interest Groups Survey to gather data from public officials with flood-related responsibilities. At least two recipients from each community received this detailed survey to increase response rates. The total number of recipients in any given community varied with the size of the community – larger communities had four to five recipients, while smaller communities had two to three. Respondents provided contact information and flood-related responsibilities, verified flood information that had already been collected, responded to questions to support the development of the Regional Flood Plan, and verified and provided geospatial data through data uploads and web maps. An interactive web map allowed survey respondents to draw in both problem areas and proposed projects that were not included in other information about the Lower Brazos Planning Region.

### **1.1.2.c Previous Studies**

Relevant studies previously performed in the Lower Brazos Planning Region were collected to be used for reference material. Two studies were performed that looked at the impacts of the Brazos River in the southern portion of the basin. The *Lower Brazos Flood Protection Planning Study*, completed in 2019, and the *Hydrologic and Hydraulic Analysis of the Brazos River*, completed in 2021, provide overviews of the current conditions along the Brazos River in Fort Bend and Brazoria counties. Additionally, the Draft *Fort Bend Drainage Master Plans*, set to be complete later this year (2022), provide detailed analysis of flooding conditions throughout the county. The *Lower Brazos Flood Protection Planning Study* was conducted by the BRA using Flood Protection Planning Grant funds from the TWDB. The *Hydrologic and Hydraulic Analysis of the Brazos River* and the Draft *Fort Bend Drainage Master Plans* were both conducted by the Fort Bend County Drainage District using local funds.

Several studies were also provided by sponsors to support projects submitted to the RFPG for inclusion in the Regional Flood Plan, including master drainage plans and FIF studies.

Additional studies were performed by the RFPG during the Amendment process, as discussed in Chapter 4: Assessment and Identification of Flood Mitigation Needs. These studies assisted in the development of projects for areas within the region that were identified as having high flood risk and outdated flood risk data.

### 1.1.2.d Public Outreach

Over 550 interest group contacts representing entities with flood-related responsibilities received the survey in July via email, which included flood planning basics and the survey link.

*Figure 1.1 Figure 1.1* illustrates all categories of interest groups included in the data collection effort. *Table 1.1 Table 1.1* describes the various methods used to contact interest groups and the number of interest groups reached by each effort.





To ensure everyone had the opportunity to participate, the Technical Consultant Team in coordination with the BRA, followed up over email a week later. Calls went out to recipients who had not yet responded, and the identified interest groups provided some secondary contacts. The second round of calls was made to over 100 recipients who had not responded to the survey and worked for entities with a population greater than 20,000. This outreach effort resulted in a response rate of approximately 14 percent. Survey results are included throughout Chapter 1 and the chapters to follow. More information regarding public outreach is included in Task 10 of this plan.

Method of Outreach	Number of Interest Group Contacts Reached
Email 1	553
Email 2	553
Call 1	569
Call 2	106

Table 1.1: Outreach Efforts to the Lower Brazos Planning Region Interest Group
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(Halff Associates, Outreach Effort Data)

### **1.1.2.e Funding Sources**

To fund projects identified by these plans, the legislature created a new flood financial assistance fund and charged the TWDB with administering the fund. The Texas Infrastructure Resiliency Fund, as approved by Texas voters in November 2019, is being used to finance the preparation of these plans and will also be used to finance the recommended flood-related studies and projects. Communities that identify future projects aimed at flood mitigation will be eligible for financial assistance through grants

and loans from the TWDB. Additional discussion of funding sources available for flood mitigation activities, including federal and state funding, is discussed in Task 4B of this plan.

### **1.2 – Characterizing the Lower Brazos Planning Region**

### 1.2.1 Social and Economic Character

The Lower Brazos Planning Region covers an area of over 23,000 square miles, 43 counties, and 193 municipalities. The Lower Brazos Planning Region boundary is determined by the hydrologic characteristics of the Lower Brazos River basin and intersects with several political jurisdictions, including counties, cities, and special districts (refer to *Figure 1.2Figure 1.2*). To better understand the current and future character and conditions of the Lower Brazos Planning Region, this section will provide a brief, general description of communities, population, the various types of development, economic activities, and industrial sectors at the greatest risk of flood impacts.

### Figure 1.2: Lower Brazos Planning Region



### 1.2.1.a. Municipal Population and Future Growth

### Current Population

According to population estimates by the TWDB, the current population of the Lower Brazos Planning Region is 3,035,000 and constitutes 10 percent of the population of Texas. Of the 193 local communities, there are at least 40 communities with a population greater than 30,000; and 18 communities with a population greater than 50,000, according to the Water User Group Data from the TWDB. The cities with a population between 115,000 and 150,000 include Killeen (Bell County) in the Central Lower Brazos River Basin, Waco (McLennan County) also in the central area of the basin, Sugar Land (Fort Bend County) in the southern area of the basin, and Georgetown and Round Rock (Williamson County) on the western boundary of the basin. College Station in Brazos County in the southern area of the Lower Brazos River basin has a population of just over 100,000. *Table 1.2Table 1.2* details the cities in the Lower Brazos Planning Region with a population of over 80,000.

### Table 1.2: Communities in the Lower Brazos Planning Region with Population Greater than 80,000

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

\*Community is not fully contained in the Lower Brazos Region. The population for the portion of the community within the region may be smaller than listed. (Texas Water Development Board)

*Figure 1.3Figure 1.3* illustrates the total population by census tracts in the Lower Brazos Planning Region utilizing 2021 ESRI population estimates, which are the most current population estimates for 2021. *Figure 1.4Figure 1.4* describes the 2020 population estimate by Water User Groups for communities in the Lower Brazos Planning Region.





### Figure 1.3: Lower Brazos Planning Region Population by Census Tract

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### Projected Growth within the Lower Brazos Planning Region

Based on population projections for Water User Groups (WUGs) by the TWDB, the areas within the Lower Brazos Planning Region are expected to experience high population growth primarily in the metropolitan areas of Killeen-Temple-Fort Hood in the west-central area of the Lower Brazos basin; Waco in the east-central area of the basin; Sugar Land-Houston in the south of the basin; and the Round Rock-Austin Metropolitan Area at the western edge of the basin. By 2050, the total population in Killeen, Round Rock, and Georgetown will exceed 220,000 people each, while the cities of Waco, Sugar Land, and College Station will have a population of greater than 150,000 people each. *Table 1.3Table 1.3* details the population of the cities with the largest population in the Lower Brazos Planning Region in 2050.

# Table 1.3: Communities in the Lower Brazos Planning Region with Projected Population in 2050Greater than 100,000

Community	County	Population 2020	Population 2050	Percent Increase
Georgetown	Williamson	122,109	249,196	104%
Round Rock	Williamson	123,650	238,864	93%
Killeen	Bell	144,243	221,696	54%
College Station	Brazos	100,854	195,852	94%
Waco	McLennan	132,511	160,966	21%
Sugar Land	Fort Bend	124,493	147,048	18%
Bryan	Brazos	84,196	140,827	67%
Temple	Bell	81,736	125,626	54%
Leander	Williamson	53,860	143,840	153%

(Texas Water Development Board)

As described in *Table 1.3<del>Table 1.3</del>*, by 2050, Bryan in the Bryan-College Station Metropolitan Area and Sugar Land in the Sugar Land-Houston-The Woodlands Metropolitan Area will have populations exceeding 140,000. The population for Temple and Leander will also increase to over 110,000 as these cities capture the growth in the Austin Metropolitan Area. *Figure 1.5Figure 1.5* illustrates the expected increase in population for communities in the Lower Brazos Planning Region based on Water User Group Data from the TWDB.

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The cities with the highest population growth rate between 2020 and 2050 will be communities adjacent to or near the metropolitan areas with the largest and most dense pockets of population. These include unincorporated areas of Coryell County (near Killeen), Fort Bend County (near Sugar Land), Brazoria

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County (near Lake Jackson), and the cities of Hutto, Leander, and Georgetown in the Austin-Round Rock-San Marcos Metropolitan Area.

*Table 1.4Table 1.4* details the 10 fastest-growing cities and unincorporated areas within counties in the Lower Brazos Planning Region.

Table 1.4: Top Te	n Fastest Growing	Communities	2020-2050
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Community	Population 2020	Population 2050	Rate of Population Growth
Unincorporated Area in Coryell County, Coryell County	2,474	9,942	302%
Hutto, Williamson County	17,326	56,194	224%
Leander, Travis, and Williamson Counties	59,821	151,328	153%
Unincorporated Area in Fort Bend County	107,087	264,898	147%
Unincorporated Area in Williamson County	39,226	93,158	137%
Sienna, Fort Bend County	21,743	47,894	120%
Prairie View, Waller County	3,400	7,406	118%
Unincorporated Area in Brazoria County	100,247	207,557	107%
Georgetown, Williamson County	118,763	244,043	105%
Copperas Cove, Lampasas, and Coryell Counties	36,253	52,061	104%

(Texas Water Development Board)

As illustrated in *Figure 1.6Figure 1.6*, the communities in the Lower Brazos Planning Region with the highest population density are Sugar Land and Lake Jackson in Austin-Oyster and Lower Brazos Hydraulic Unit Code (HUC)-8; College Station and Bryan in the Navasota HUC-8; Round Rock in San Gabriel HUC-8; Killeen and Temple in Leon and Cowhouse HUC-8; and Waco in Middle Brazos-Lake Whitney HUC-8.

A HUC is a United States Geological Survey watershed delineation or boundary based on surface hydrologic features. Each hydrologic unit is assigned a 2 to 12-digit number that uniquely identifies the unit within a classification system consisting of 21 regions (2-digit), 222 subregions (4-digit), 370 basins (6-digit), 2,270 subbasins (8-digit), approximately 20,000 watersheds (10-digit), and approximately 100,000 subwatersheds (12-digit). A HUC-8 represents the subbasin level analogous to medium-sized river basins. There are 14 HUC-8s in the Lower Brazos Planning Region.

### Figure 1.6: Population Density by Census Tract



### 1.2.1.b. Economic Activity

The Lower Brazos Planning Region is home to key industries, such as wholesale and retail trade, manufacturing, and health care and social assistance, which contribute to the gross domestic product of the Lower Brazos Planning Region and support the local and state economies. Based on the 2017 Economic Survey, the total value of sales or revenue generated by firms and businesses in the Lower Brazos Planning Region amounts to over \$215.9 billion, constituting approximately 4.5 percent of the total revenue generated by all firms and businesses in Texas. As shown in *Figure 1.7Figure 1.7*, the industry sector generating the most revenue for the Lower Brazos Planning Region is manufacturing at

\$53.4 billion, followed closely by retail trade at \$50.4 billion, and health care and social assistance at \$34.2 billion.





### (United States Census Bureau)

The health care and social assistance sector employs the largest number of people in the Lower Brazos Planning Region, at approximately 304,170 employees, followed by the retail trade sector, at approximately 153,120 employees. The industry sector with the third-largest number of employees is accommodation and food services, with approximately 113,130 employees. *Figure 1.8Figure 1.8* illustrates the dominant industry in each county in the Lower Brazos Planning Region.



### Figure 1.8: Major Industry by County



### **Commercial Activity**

Within the Lower Brazos Planning Region, Fort Bend County generates the most commercial activity and largest revenue at \$45.9 billion and has the highest number of firms or businesses (15,663). Its dominant industry sector is wholesale trade. Williamson County has the second largest number of total firms and third-largest revenue, generating over \$29 billion, of which almost \$10 billion is in the retail trade

industry. Brazoria County, south of the Lower Brazos Planning Region and bordering Fort Bend County, generates the second-largest revenue, at \$37 billion, of which \$24 billion is generated in the manufacturing industry sector.

*Table 1.5<del>Table 1.5</del>* lists the five counties generating the most sales and revenue in the Lower Brazos Planning Region. These counties also have the largest number of firms and businesses, and their dominant industry sectors employ between 90,000 and 215,100 employees.

County	Total Revenue (in Billion)	Total Number of Firms and Businesses	Total Number of Employees	Dominant Industry Sector
Fort Bend*	\$45.9	15,663	213,164	Wholesale Trade
Brazoria*	\$37.1	5,304	91,045	Manufacturing
Williamson	\$29.7	9,751	172,007	Retail Trade
Bell	\$22.2	4,670	122,842	Health Care and Social Assistance
Madison*	\$19.3	4,157	84,856	Manufacturing
Total	\$154.2	39,545	683,914	

Table 1.5: Top Five Counties by Total Revenue, Firms, and Employees

\*Counties are not fully contained within the Lower Brazos Planning Region (United States Census Bureau)

### Agricultural Activity

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According to the United States Department of Agriculture (USDA) Landcover data, over 20 million acres in the Lower Brazos Planning Region are rural, contributing to the economy of the state and the region through farming, ranching, and forestry. Approximately 8.8 million acres of the Lower Brazos Planning Region are utilized for ranching, providing critical support to Texas's cattle production, which remains the state's top agricultural commodity in market value (Texas Department of Agriculture, 2021).

Similarly, 9.7 million acres of rural lands in the Lower Brazos Planning Region are comprised of forestry, the sixth top agricultural commodity in the state. Of the 2.3 million acres of farmland in the Lower Brazos Planning Region, significant areas of the rural land are producing wheat, sorghum, corn, and oats, which are in the top 10 most important agricultural commodities in terms of market value in Texas. *Figure 1.9Figure 1.9* illustrates the variety of agricultural uses in the basin (Texas Department of Agriculture, 2021).



### Figure 1.9: Land Cover





### Economic Status of Population

According to the 2019 five-year American Community Survey, the median household income for Texas is \$61,874. Over half of all census tracts in the Lower Brazos Planning Region, approximately 53 percent, have a median household income below the median household income for Texas. As illustrated in *Figure 1.10Figure 1.10*, the census tracts with the lowest median household income (less than \$30,000) are primarily in the urban centers of Killeen, Waco, and College Station. The census tracts with median household income greater than \$30,000 but less than the state's median household income are primarily in the central area of the basin, namely Limestone, Falls, Robertson, Milam, Coryell, and Lampasas counties. In the northern area of the basin, census tracts in Bosque, Eastland, and Palo Pinto counties also have a median household income below the median value for Texas. Census tracts with a median household income higher than \$92,000 are in the suburban areas of Austin and Round Rock in Williamson County, Waco in McLennan County, College Station in Brazos County, Sugar Land in Fort Bend County, and Bellville in Austin County.







### Social Vulnerability in the Lower Brazos Planning Region

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

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The SVI indicates the relative social vulnerability of every census tract in the United States and ranks each tract based on percentile values between zero and one, with higher values indicating greater vulnerability. The index considers 14 factors: poverty, unemployment, income, education, age, disability, single-parent households, race/minority status, limited English-speaking ability, housing type, crowding, and vehicle ownership. The TWDB has provided SVI values for census tracts in the Lower Brazos Planning Region. The census tracts with the highest SVI value (census tracts that are in the top quartile of social vulnerability) are primarily in and around the mid-sized communities of Waco and Temple in the central area of the basin and the small-sized communities of Cameron and Calvert in Milam and Robertson counties (refer to *Figure 1.11Figure 1.11*). Other census tracts with high social vulnerability include the less-populated communities of Hempstead in Waller County and Groesbeck in Limestone County. These communities are at a greater risk of incurring loss of life, property, and livelihood due to high social vulnerability attributed to a higher poverty rate, diminished mobility or access to transportation, and unsafe housing conditions.





### **1.2.2** Flood-Prone Areas and Flood Risks to Life and Property

### 1.2.2.a. Identification of Flood-Prone Areas

By juxtaposing the floodplain quilt, or 1 percent annual chance exceedance (ACE) storm, with the current and expected population in 2050, this flood plan has identified the communities with a high growth rate most at risk of flooding in the future. Specifically, seven communities in the Lower Brazos
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Planning Region have over one-fourth of their land area in the floodplain quilt and will have a population growth rate of 10 percent or more by 2050. These communities include Richwood, Lake Jackson, Clute, and Danbury in Brazoria County. The floodplain quilt was also intersected with critical facilities, agricultural lands, roadways, and low water crossings. The location and quantity of this infrastructure were provided through the TWDB and refined by the Halff Associates Team. *Table 1.6Table 1.6* shows the number of these metrics at flood risk for the 1 and 0.2 percent ACE storms. Approximately 20 percent of the Lower Brazos Planning Region is in the 1 percent ACE storm, as shown in *Figure 1.12Figure 1.12* 





## Table 1.6: Flood-Prone Infrastructure

Potential Flood Risk Event	Number of At-Risk Structures	Number of At-Risk Critical Facilities	Number of At-Risk Roadway Crossings*	Impacted Agricultural Areas (sq mi)
Existing 1 percent ACE	63,060	200	5,170	840
Existing 0.2 percent ACE	107,720	380	5,390	940

\*Includes low water crossings only.

(Texas Water Development Board and Federal Emergency Management Agency)

# **1.2.2.b.** Rates of National Flood Insurance Program (NFIP) Participation and Related Flood Planning Activity

Eighteen communities and two counties within the Lower Brazos Planning Region do not participate in the NFIP administered by FEMA. As shown in *Figure 1.13Figure 1.13*, these cities and towns are primarily located in the central area of the Lower Brazos River Basin in McLennan, Hill, Falls, Limestone, Coryell, Parker, Waller, and Williamson counties. Hamilton and Falls counties in the west-central and central areas of the Lower Brazos River basin do not participate in the NFIP (refer to *Figure 1.13Figure 1.13*). These counties and communities have portions of their land area intersecting the 1 percent ACE floodplain, where residents are at risk of incurring life and property loss during a flood event. Flood planning efforts in the Lower Brazos Planning Region should consider the increased vulnerability of communities within the 1 percent ACE floodplain that do not participate in the NFIP, which helps residents recover from the impact of flood damage to their real estate and personal property.

*Figure 1.14Figure 1.14* illustrates the distribution of flood claims filed with FEMA in the Lower Brazos Planning Area boundary indicating areas where both natural and built flood infrastructure is deficient in protecting homes from flooding. The highest density of FEMA flood claims is in Brazoria and Fort Bend counties in the southern area of the basin, which has high existing and future population growth. The metropolitan areas of Killeen, Waco, Round Rock, and College Station also have a high density of flood claims. In the northern area of the basin, Cleburne and the suburbs of Weatherford have a high density of flood claims.



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## Figure 1.13: NFIP Participation



(Federal Emergency Management Agency)



# Figure 1.14: FEMA Flood Claim Density



(Federal Emergency Management Agency)

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# 1.2.2.c. Agricultural and Natural Resources Most Impacted by Flooding

The Lower Brazos basin is comprised of five main land uses, which include farming, forestry, ranching, urban areas, and open water. *Table 1.7<del>Table 1.7</del>* provides the acreage for each land use in the basin. The following section discusses the detrimental impact of flood events on the agricultural and natural resources of the Lower Brazos Planning Region.

Land Use	Total Area in Lower Brazos Basin (acres)	Total Area in Lower Brazos Basin within the 1 percent ACE Floodplain (acres)	% of Area at 1 percent ACE Flood Risk
Farming	2,325,760	535,424	23%
Forestry	9,732,480	933,057	10%
Ranching	8,783,360	683,035	8%
Urban Development	1,699,840	135,680	8%
Total	22,541,440	2,184,981	10%

## Table 1.7: Lower Brazos Planning Region Land Use Summary

(Texas Water Development Board and United States Department of Agriculture)

## Farming

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

# Forestry

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

# Ranching

Information from Texas A&M AgriLife Extension illustrates how ranching activities in the Lower Brazos Planning Region are also impacted by flooding. Livestock can be swept away, drowned, or injured by flash floods. Livestock exposed to contaminated flood waters can experience health issues such as pneumonia or foot rot. Livestock could also be exposed to disease-carrying mosquitoes during flood events. Flood events can cause delays in building back livestock herds. Damages to feed crops can also reduce ranching capabilities.

# Natural Resources

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

The agricultural land use in the Lower Brazos basin that has the largest acreage within the 1 percent ACE floodplain is forestry, with over 930,000 acres in the 1 percent ACE floodplain. In other words, 10 percent of the entire land area used for forestry is in the 1 percent ACE floodplain. The total acreage of land used for ranching in the Lower Brazos basin in the 1 percent ACE floodplain is over 683,000 acres, which is 8 percent of the entire land area used for ranching in the basin. While the total acreage of land used for farming in the 1 percent ACE floodplain, approximately 433,200 acres, is less than the forestry or ranching land acreage in the 1 percent ACE floodplain, the percentage of the total farming land in the 1 percent ACE floodplain is the highest, at 19 percent, compared to other agricultural uses.

The HUC-8s with the most significant amount of agricultural land area in the 1 percent ACE floodplain are Lower Brazos – Little Brazos and Middle Brazos – Lake Whitney in the northeastern area of the Lower Brazos Planning Region, as detailed in *Table 1.8Table 1.8*.

HUC-8	Farming	Forestry	Ranching	Total	HUC Total Acreage
Austin Oyster	33,552	108,738	36,500	178,790	446,059
Bosque	4,308	9,680	9,545	23,533	269,796
Cowhouse	2,045	15,478	6,950	24,473	465,569
Lampasas	6,293	41,903	13,772	61,968	967,883
Leon	16,825	52,134	22,995	91,954	1,933,332
Little	55,422	34,092	37,372	126,887	642,122

# Table 1.8: Land Use Acreage Within the 1 percent ACE Floodplain by HUC-8

HUC-8	Farming	Forestry	Ranching	Total	HUC Total Acreage
Lower Brazos	38,561	136,259	130,776	305,597	1,051,241
Lower Brazos - Little Brazos	182,840	101,918	131,001	415,759	1,726,263
Middle Brazos - Lake Whitney	39,848	74,575	69,915	184,339	1,598,530
Middle Brazos Palo Pinto	7,954	95,477	59,037	162,468	2,017,175
Navasota	11,466	122,840	76,874	211,181	1,437,563
North Bosque	8,454	31,576	24,562	64,592	795,789
San Gabriel	18,383	34,170	20,870	73,423	874,721
Yegua	7,257	74,217	42,866	124,339	845,755
Total	433,209	933,057	683,035	2,049,302	15,071,798

(Texas Water Development Board and United States Department of Agriculture)

# 1.2.3 Key Historical Flood Events

# 1.2.3.a. Historic Events Before Current Level of Regulation

In December 1913, a notable record flood occurred across the Lower Brazos River Watershed (Ellsworth, 1923). After a very wet autumn which led to high stages, the watershed received about 3 inches of rainfall on average over 10 days, and many levees were damaged. As a result, the confluence of the Brazos River and major tributary Little River at Valley Junction reached a record stage of 55.0 feet on Dec 4, 1913. Four days later, a record stage of 61.2 feet was recorded at the Richmond gage in Fort Bend County, according to the United States Geological Society and firsthand accounts, which notes that the floodplains of the Colorado and Brazos rivers merged with each other. At least 174 people were killed due to flooding along the Brazos River (Sawyer, 2021).

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

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

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

# 1.2.3.b. Historic Tropical Flooding Events

# **Tropical Storm Frances**

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

### Hurricane Ike

Hurricane Ike made landfall on September 13, 2008, near Galveston as a Category 2 hurricane, bringing strong wind and rain to Texas and Louisiana. The National Hurricane Center (NHC) reported wind gusts of 80 mph in Rosharon and 83 mph in Danbury, making Hurricane Ike one of the most destructive weather events on record for the Lower Brazos Planning Region. While Hurricane Ike did not bring record-setting rainfall to the basin, the storm's wind field stretched 400 miles wide and produced severe storm surges ranging from 5 to 10 feet along the coast of Brazoria County, as reported by NHC's Tropical Cyclone Report for Hurricane Ike. As a result, Ike is the second most severe flooding event in the region's history by a number of flood claims.

# Tropical Storm Hermine

Tropical Storm Hermine made landfall on September 5, 2010, in northeast Mexico before turning towards central Texas. The storm developed into a band of intense rainfall along I-35. The NHC reported 16 inches of total rainfall for Lake Georgetown between September 7<sup>th</sup> to 9<sup>th</sup>, 2010, of which 15 inches fell in 24 hours. As a result, Little River, near the City of Little River, reached a gage height of 40.58 feet, the second-highest on record. As reported by NOAA's Storm Event Database, flash flooding in Bell, Johnson, and Williamson counties resulted in three direct fatalities.

### Hurricane Harvey

Hurricane Harvey made landfall near Rockport, Texas, on August 25, 2017, as a Category 4 hurricane. Brazos River recorded the highest gage height since regulation of flows began, with 55.19 feet and 52.65

feet at Richmond and Rosharon, respectively. Rainfall within the Brazos River watershed between August 25 and September 1 ranged from 13 to 39 inches, the highest of which is comparable to the average annual precipitation for the watershed, according to NOAA. This extreme rainfall resulted in Harvey being the most damaging storm in the Lower Brazos Planning Region since the NFIP launched in 1968. As reported by NOAA's Storm Event Database, flash floods in Fort Bend County resulted in three direct fatalities.

# 1.2.3.c. Historic Flooding of Non-Tropical Origin

# Winter 1991-1992

Winter 1991-1992 brought heavy rainfall and flash flooding to most of the Lower Brazos Planning Region (Halff Associates, 2019). According to the United States Geological Survey, the heaviest rain fell in Coryell County, which received an average depth of 7 inches in 12 hours. Little River reached a stage of 38.95 feet at Cameron, which remains the highest stage after the 1957 flood at this location. The Brazos River floodplain reached five miles width near Bryan and merged with Oyster Creek downstream of Rosenberg.

# Spring 2007

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

# Memorial Day 2015

At the end of an above-normal month of rainfall in central Texas, an intense storm produced flash flooding in the Lower Brazos Planning Region on May 23, 2015 (Halff Associates, 2019). The Brazos River near Hempstead reached a stage of 49.97 feet on July 18, its third-highest stage since flood control reservoirs were implemented in the upper watershed. On May 25, 2015, as the system approached Harris County, it merged with a smaller cell in Fort Bend County, resulting in widespread flooding along the lower reach of the Brazos River. Maximum rainfall was recorded at 12 inches over two days near Richmond. Brazos River near Rosharon reached a stage of 51.46 feet on June 5, the sixth-highest recorded stage. Flash floods in the Leon River watershed and Fort Bend County resulted in at least five direct flood fatalities, as reported by the NOAA Storm Event Database.

# Spring 2016

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

# FEMA Flood Claims

The FEMA flood claim data began with the establishment of the NFIP in 1968. Total NFIP flood claims connected to each major historical flood event are summarized in *Table 1.9Table 1.9* for significant historical flood events within the Lower Brazos watershed.

Table 1.9: FEMA Flood Claims for Significant Historical Flood Events within the Lower Braze	S
watershed	

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

(Federal Emergency Management Agency)

# 1.2.3.d. Location of Critical Facilities

Critical facilities are community assets, such as hospitals, fire stations, police stations, storage of critical records, energy-producing facilities, water and wastewater treatment plants, and similar facilities that require special consideration in floodplain management and disaster planning. Critical facilities must always continue to function and provide services during a flood. In the Lower Brazos Planning Region, critical facilities are located in the communities along the Interstate 35 corridor, such as Waco, Killeen, and Round Rock in the central portion of the Lower Brazos Planning Region, as well as the heavily populated areas in Fort Bend and Brazoria Counties in the south of the Lower Brazos Planning Region. *Figure 1.15Figure 1.15* illustrates the density of critical facilities in the Lower Brazos Planning Region.





# **1.2.4** Political Entities with Flood-Related Authority

The Technical Consultant Team, led by Halff Associates, has identified all political subdivisions with flood-related authority as interest groups for the survey distribution in the Lower Brazos Planning Region. These entities include cities, counties, river authorities, soil and water conservation districts, water control and improvement districts, flood control and improvement districts, municipal utility districts, and levee improvement districts, among others.

*Table 1.10Table 1.10* details the number of entities with various levels of flood-related regulatory authority in the Lower Brazos basin. Flood-related authority includes a range of actionable powers, from enforcing ordinances to the ability to raise money to execute flood mitigation projects. The publication and enforcement of flood ordinances and regulations are primarily left to the cities, counties, and drainage districts.

Entity	Number
Cities	193
Counties	43
Municipal Utility District	259
Municipal Water District	4
Water Control and Improvement District	19
Management District	11
Development District	2
Drainage District	8
Levee Improvement District	15
Special Utility District	5
Improvement District	7
Fresh Water Supply District	7
Council of Government	7
Water Authority	11
Total	591

# Table 1.10: Political Entities with Flood-Related Authority

(Texas Water Development Board)

Fort Bend and Brazoria counties at the southern tip of the Lower Brazos basin are among the largest number of water and flood-related entities functioning within the Lower Brazos Planning Region, including drainage districts, fresh water supply districts, and municipal utility districts. In addition to these entities, Fort Bend County has 13 levee improvement districts. Entities in Fort Bend County, such as Fulshear and Sienna, also operate several additional utility districts. The area comprising Williamson County at the western boundary of the basin and nearby communities such as Leander and Round Rock has the next highest number of political entities with several municipal utility districts, water control and improvement districts, and water, sewer, irrigation, and drainage districts. Counties north of the Lower

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#### LOWER BRAZOS REGIONAL FLOOD PLANNING GROUP REGION 8

Brazos basin have relatively fewer flood-related political entities responsible for flood planning, management, and mitigation.

# 1.2.4.a. Summary of Existing Flood Planning Documents

The summary of the existing flood planning documents section provides insight into the regulatory and policy environment governing floodplain management in the various jurisdictions of the Lower Brazos Planning Region. It summarizes the most common types of regulation, structural controls, and planning activities.

# Floodplain Ordinances

The regulatory framework guiding floodplain management in the Lower Brazos Planning Region is comprised primarily of local floodplain ordinances. Overall, there are 255 floodplain management and flood prevention ordinances in the Lower Brazos basin. Cumulatively, these ordinances:

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

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

# Current Local Regulations and Development Codes

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

# Local and Regional Flood Plans

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

# **1.3 – Assessment of Existing Flood Infrastructure**

The assessment of existing flood infrastructure provides an overview of existing flood infrastructure and natural areas that contribute to lowering the flood risk of communities in the Lower Brazos Planning Region. This assessment of existing flood infrastructure, both natural and man-made, is based on data provided by the TWDB. This data includes both structural and natural flood protection features and is summarized in this section. Additional information on major public flood infrastructure self-reported by entities who took the Lower Brazos Basin Community Survey is also included. Existing flood infrastructure is provided in *Table 1* in *Appendix 1.1. Map 1* in *Appendix 0* shows an overview of the location of the flood infrastructure.

# 1.3.1 Natural Features

An inventory of the natural features that perform essential flood-related functions in the Lower Brazos Planning Region is integral to the flood planning process. This inventory includes wetlands, lakes, reservoirs, parks, and preserves. As detailed in *Table 1.11<u>Table 1.11</u>*, there are over 249,000 acres of wetland in the Lower Brazos basin. Over 60 percent of the wetlands in the basin are freshwater forested/shrub wetlands, of which the largest wetland acreage is in the Navasota HUC-8 watershed on the central-eastern boundary of the Lower Brazos Planning Region. The Lower Brazos HUC-8 watershed, which includes mid-sized cities like Sugar Land, Fulshear, and Rosenberg, has 38,214 acres, or 25 percent of the total freshwater forested/shrub wetlands in the basin.

# Table 1.11: Types of Wetland by HUC-8

HUC-8 Watershed	Estuarine and Marine Wetland (acres)	Freshwater Emergent Wetland (acres)	Freshwater Forested / Shrub Wetland (acres)	Total Wetland (acres)	Total Wetland (percent)
Austin-Oyster	25,463	23,854	16,285	65,602	26%
Bosque	-	405	928	1,333	1%
Cowhouse	-	260	1,750	2,010	1%
Lampasas	-	623	1,559	2,182	1%
Leon	-	2,813	5,582	8,395	3%
Little	-	936	3,311	4,247	2%
Lower Brazos	1,973	17,064	38,214	57,251	23%
Lower Brazos- Little Brazos	-	5,578	15,345	20,923	8%
Middle Brazos- Lake Whitney	-	1,888	9,096	10,984	4%
Middle Brazos- Palo Pinto	-	2,477	4,673	7,150	3%
Navasota	-	8,344	40,606	48,950	20%
North Bosque	-	574	1,987	2,561	1%
San Gabriel	-	1,361	5,683	7,044	3%
Yegua	-	2,260	8,426	10,686	4%
Total	27,436	68,437	153,445	249,318	100%

(United States Fish and Wildlife Service)

Overall, the Austin-Oyster HUC-8 watershed at the southern tip of the basin comprises over one-fourth of the total wetland in the Lower Brazos Planning Region, performing critical flood-related functions. Approximately 15 percent of the entire Austin-Oyster HUC-8 watershed land area is covered with wetlands. While Lower Brazos and Navasota HUC-8 watersheds contain over 20 percent each of the total wetland acreage of the Lower Brazos basin, only 5 and 3 percent of their land area, respectively, is comprised of wetland. HUC-8 watersheds in central and northern areas of the basin stretching from Graham and Stephenville in the north to Killeen and Bryan in the south comprise of less than 5 percent of the total wetland acreage of the basin, and less than 1 percent of their land area has wetland coverage. These HUC-8 watersheds, therefore, lack the relative protection and flood mitigation functions performed by natural features, such as wetlands.

Lakes, reservoirs, parks, and preserves are critical natural infrastructure performing mitigating functions during flood events. *Table 1.12Table 1.12* details the acreage of each of these natural features and the total land area in the HUC-8 watersheds covered by these natural features. Austin-Oyster HUC-8 watersheds in the southern tip of the basin and San Gabriel at the southwestern boundary of the Lower

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Brazos Planning Region have approximately 17 percent of the land area covered with lakes, reservoirs, parks, and preserves. Other HUC-8 watersheds in the Lower Brazos Planning Region that have 12 to 13 percent of the land area covered with lakes, reservoirs, parks, and preserves, are Middle Brazos – Palo Pinto and Middle Brazos – Lake Whitney HUC-8 watersheds in the north and northeastern portion of the Lower Brazos Planning Region as well as the Lower Brazos HUC-8 watersheds in the south of the Lower Brazos Planning Region. HUC-8 watersheds in the central and central northern basin area have 2 percent or less of their land area comprising of food mitigating natural features. *Figure 1.16Figure 1.16* illustrates the location of parks, lakes, preserves, and wetlands in the Lower Brazos Planning Region.

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

### Table 1.12: Lakes, Reservoirs, Parks, and Preserves by HUC-8

(United States Fish and Wildlife Service, United States Army Corp of Engineers, Texas Parks and Wildlife Department)





# **1.3.2** Constructed Flood Infrastructure/Structural Protections

The existing major infrastructure features in the Lower Brazos Planning Region include publicly-owned dams, levees, and weirs. In total, there are 485 public dams in the basin, of which 19 percent are in the Middle Brazos – Lake Whitney HUC-8 in the northeastern basin area. Leon HUC-8 watershed has 71 dams, or 15 percent of all dams in the basin. Other HUC-8 watersheds that have close to 10 percent of the dams in the basin are the Cowhouse HUC-8 watershed in the central area and San Gabriel in the southwestern Lower Brazos basin. The San Gabriel HUC-8 also has 36 of the 41 weirs in the basin.

The HUC-8 watersheds with the fewest dams are Bosque, Yegua, Lower Brazos, and Austin-Oyster. However, the Lower Brazos and Austin-Oyster watersheds have a relatively large number of levees, accounting for 66 percent of the total levees in the Lower Brazos Planning Region.

*Table 1.13<u>Table 1.13</u>* details the dams, levees, and weirs in the Lower Brazos Planning Region. *Figure 1.17Figure 1.17* illustrates the location of dams and levees in the Lower Brazos Planning Region.

HUC-8 Watershed	Publicly-owned Dam	Levee	Weir	Total
Austin-Oyster	7	23	-	30
Bosque	3	-	-	3
Cowhouse	46	-	-	46
Lampasas	15	1	-	16
Leon	71	4	-	75
Little	43	1	-	44
Lower Brazos	9	27	1	37
Lower Brazos-Little Brazos	46	7	-	53
Middle Brazos-Lake Whitney	90	4	-	94
Middle Brazos-Palo Pinto	24	1	4	29
Navasota	31	1	-	32
North Bosque	45	1	-	46
San Gabriel	50	-	36	86
Yegua	5	-	-	5
Total	485	59*	41	585

## Table 1.13: Dams, Reservoirs, Levees, and Weirs by HUC-8

\*11 Levees extend through both the Austin-Oyster and Lower Brazos HUC-8 watersheds. (United States Army Corps of Engineers)

The two HUC-8 watersheds that abut the Gulf Coast have coastal barriers and revetments that provide structural protection against coastal flooding, as summarized in *Table 1.14<u>Table 1.14</u>*.

HUC-8 Watershed	Coastal Barrier	Sea Wall	Coastal Revetment
Austin-Oyster	29	8	9
Lower Brazos	4	-	-
Total	32*	8	9

## Table 1.14: Coastal Infrastructure in Austin-Oyster and Lower Brazos HUC-8

\*One coastal barrier extends through both the Austin-Oyster and Lower Brazos HUC-8 watersheds. (United States Fish and Wildlife Service and General Land Office)

Other information that assists flood protection planning in the Lower Brazos Planning Region includes high and low water marks. There are 1,513 high water marks and 1,168 low water marks in the Lower Brazos Planning Region. As detailed in *Table 1.15Table 1.15*, the San Gabriel HUC-8 watershed in the southwestern area and the Austin-Oyster HUC-8 watershed in the southern area have the highest percentage of high and low water marks in the Lower Brazos Planning Region, at 21 percent and 14 percent, respectively. Leon HUC-8 watershed in the central area of the Lower Brazos Planning Region has 313 high and low water marks comprising 12 percent of all flood water marks in the Lower Brazos Planning Region. The HUC-8 watersheds in the northern and central areas of the basin, such as Bosque, Cowhouse, and Lampasas, as well as Yegua in the southwest, have the fewest number of high and low water marks.

HUC-8 Watershed	High Water Mark	Low Water Mark	Total	Percent
Austin-Oyster	368	1	369	14%
Bosque	6	19	25	1%
Cowhouse	6	8	14	1%
Lampasas	68	103	171	6%
Leon	75	238	313	12%
Little	166	60	226	8%
Lower Brazos	90	39	129	5%
Lower Brazos-Little Brazos	125	99	224	8%
Middle Brazos-Lake Whitney	112	107	219	8%
Middle Brazos-Palo Pinto	52	69	121	5%
Navasota	39	106	145	5%
North Bosque	28	51	79	3%
San Gabriel	353	205	558	21%
Yegua	25	63	88	3%
Total	1,513	1,168	2,681	100%



(Texas Water Development Board)



#### Figure 1.17: Constructed Flood Infrastructure in the Lower Brazos Planning Region



# 1.3.3 Non-Functional or Deficient Flood Mitigation Features

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

The following tables provide information on the level of service (LOS) and functional classification of the dams and levees in the Lower Brazos Planning Region. The LOS is dependent on the assumption that regular maintenance has been performed.

*Table 1.16<del>Table 1.16</del> describes the functional classification of levees by HUC-8. Eleven levees extend into both the Austin-Oyster and Lower Brazos HUC-8s and are shown in both categories. <i>Table 1.17<del>Table</del>* <del>1.17</del> provides the total number of levees in each classification.

HUC-8 Watershed	Levees 100-Year LOS	Levees Not Assessed	Levees In Progress	Levees Functional
Austin-Oyster	11	20	1	3
Bosque	-	-	-	-
Cowhouse	-	-	-	-
Lampasas	-	1	-	-
Leon	-	4	-	-
Little	-	1	-	-
Lower Brazos	21	22	1	5
Lower Brazos-Little Brazos	-	7	-	-
Middle Brazos-Lake Whitney	-	4	-	-
Middle Brazos-Palo Pinto	-	1	-	-
Navasota	-	1	-	-
North Bosque	-	1	-	-
San Gabriel	-	-	-	-
Yegua	-	-	-	-

## Table 1.16: Functional Classification of Levees by HUC-8

(United States Army Corps of Engineers)

Functional Classification	Number of Levees
Total Count	59
With 100-Year LOS	25
Levees with 100-Year LOS with an overlap in Austin-Oyster and Lower Brazos HUC-8s	11
Functional	6
In Progress	1
Not Assessed	53
Deficient	1
Non-Deficient	6

## Table 1.17: Functional Classification of Levees in the Lower Brazos Planning Region

(United States Army Corps of Engineers)

Of the 485 dams in the Lower Brazos Planning Region, the deficiency classification is available for 257 dams and is detailed in Table 1.18. Less than 10% of dams that have deficiency data available are classified as deficient or in need of replacement.

Table 1.18: Functional Classification of Dams by HUC-8

HUC-8	Deficient	Non-Deficient	Not Assessed (Unknown)	Total
Austin-Oyster	1	5	1	7
Bosque	-	1	2	3
Cowhouse	-	-	46	46
Lampasas	-	9	6	15
Leon	4	34	33	71
Little	-	18	25	43
Lower Brazos	-	1	8	9
Lower Brazos- Little Brazos	5	10	31	46
Middle Brazos- Lake Whitney	4	37	49	90
Middle Brazos- Palo Pinto	1	19	4	24
Navasota	2	28	1	31
North Bosque	3	25	17	45
San Gabriel	1	46	3	50
Yegua	1	2	2	5

HUC-8	Deficient	Non-Deficient	Not Assessed (Unknown)	Total
Total	22	235	228	485

(United States Army Corps of Engineers)

# **1.4 – Proposed or Ongoing Flood Mitigation Projects**

For a thorough flood planning process that considers the flood protection policy and regulatory framework at the local level, it was essential to document the proposed and ongoing flood mitigation projects in the Lower Brazos Planning Region. The data for this section is derived from two primary sources. The first source is the Lower Brazos RFPG – Interest Group Survey, supplemented by direct outreach to interest group contacts. More detailed results are available in the Summary of *Proposed or Ongoing Flood Mitigation Projects* in *Appendix 1.2* and *Map 2* in *Appendix 0*. The second source is existing Hazard Mitigation Plans in the Lower Brazos Planning Region.

# **1.4.1 Ongoing or Proposed Projects Identified in the Lower Brazos Planning** *Region's Data Collection Tool*

Over 60 communities indicated in the Data Collection Tool that they planned to undertake flood mitigation projects in the coming years. However, there are several gaps in this data set as little data was provided on individual projects. Some communities indicated that they anticipated pursuing a variety of FMPs in the coming years. Almost all the communities responding to the survey question on ongoing or proposed flood management strategies or projects indicated they did intend to pursue more than one type of flood mitigation project. These include projects related to local storm drainage systems, roadway improvements, regional dam improvements, reservoirs and detention areas improvements, sea barriers and revetments, erosion control, and levee improvements. *Figure 1.18* details the distribution of the types of intended flood mitigation projects.





(Lower Brazos Basin Community Survey)

*Table 1.19Table 1.19* details the frequency with which communities plan on implementing a particular type of flood mitigation. While several project types, like local storm drainage systems and roadway improvements, may be local in nature, many other solutions are more regional in nature, such as regional dams and retention, as well as highway improvements that may involve state agencies.

TUDIE 1.13. NUTTIDET OF FIOOD WITTIGUTION FIOPECTS	Table 1	l <b>.19</b> :	Number	of	Flood	Mitig	ation	Project	ts
--	---------	----------------	--------	----	-------	-------	-------	---------	----

Type of Flood Mitigation Project	Number
Channel, canal conveyance improvements	6
Levees, flood walls	2
Local storm drainage systems. tunnels	9
Property acquisition	1
Early flood warning system	2
Erosion mitigation	2
Regional dams, reservoirs, detention, retention basins	6
Roadway and crossing improvements, bridges, culverts	2
Pump station improvements	6
Total	36

(Lower Brazos Basin Community Survey)

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

- local storm drainage systems and tunnels
- regional dams, reservoirs, detention, retention basins
- pump station improvements
- channel, canal conveyance improvements

The projects with no interest were nature-based projects, property floodproofing, and sea barriers, walls, and revetments. It is important to note that there may be more ongoing projects than described in the survey since respondents provided information on projects they were pursuing at the time of the survey, but not every ongoing project in the entity. Potential funding sources identified for these projects as part of the RFPG effort include FEMA, Texas General Land Office, Community Development Block Grant-Mitigation, TWDB, and Texas Department of Emergency Management (TDEM), as well as local funding sources from the general fund, taxes, stormwater utility fees, and other fees.

# 1.4.1.a. Structural Projects under Construction

Information provided in response to outreach efforts is insufficient to provide a complete understanding of structural projects under construction within the entities that responded to the Lower Brazos RFPG –

Interest Group Survey. Entities within Fort Bend County are the only survey respondents that provided information on projects that are under construction. Of the 132 identified proposed or ongoing flood mitigation projects in Fort Bend County, 73 projects reported in the survey have completed the design phase and are in the construction phase.

# 1.4.1.b. Non-Structural Flood Mitigation Projects Being Implemented

Information provided in response to outreach efforts is insufficient to describe the non-structural flood mitigation projects being implemented within the various entities.

# **1.4.1.c.** Structural and Non-Structural Flood Mitigation Projects with Dedicated Funding and Year

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

# 1.4.1.d. Projects Identified in Hazard Mitigation Plans

In addition to the projects identified in the Lower Brazos Basin Community Survey, the community hazard mitigation plans developed or adopted by communities in the Lower Brazos Planning Region are an essential source of information on future flood mitigation activities. Many non-structural initiatives such as education and citizen awareness, outreach and community engagements, and urban planning

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and maintenance can be accomplished with lower investment, while an ongoing program of buyouts and acquisitions may be a longer-term and more expensive initiative. Likely, many flood mitigation projects identified by communities have already been completed since the initial hazard mitigation plan was adopted. See Chapter 4 for more details on how projects from Hazard Mitigation Plans were included in the Lower Brazos Planning Region.

# 1.4.1.e. 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. 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 regarding the scale, complexity, and location of these projects, it is difficult to quantify the benefit received, but it is anticipated that the inventory of this information will continue to expand in future planning cycles.

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# Chapter 4: Assessment and Identification of Flood Mitigation Needs

At the outset, Regional Flood Plan developed a broad understanding of the planning area with a focus on flood risk (*Chapter 1 – Planning Area Description*) and performed an analysis to identify infrastructure, land, and populations at flood risk and prepare an estimation of the associated impacts (*Chapter 2 – Flood Risk Analysis*). The results of these previous efforts were further analyzed to identify regions with the greatest gaps in flood risk information and regions with the greatest flood risk. The results of this effort are utilized in conjunction with information obtained from public outreach to identify areas or communities with specific flood management or mitigation needs, including flood risk mitigation projects, mitigation evaluations, and management.

The descriptions of the flood mitigation and management categories provided by the Texas Water Development Board (TWDB) are as follows:

- Flood Management Evaluation (FME): A proposed flood study of a specific, flood-prone area is needed to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.
- Flood Management Strategy (FMS): A proposed plan to reduce flood risk or mitigate flood hazards to life or property. Any proposed action that the group would like to identify, evaluate, and recommend that does not qualify as either an FME or FMP.
- Flood Mitigation Project (FMP): A proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring costs and when implemented will reduce flood risk and mitigate flood hazards to life or property.

As a result of these two tasks, maps were developed that show the areas of highest flood risk and the most significant information gaps within the region. Additionally, a list and associated maps were created to characterize the potential flood risk mitigation and management needs, or FMEs, FMSs, and FMPs identified for the Lower Brazos Planning Region. These results will be utilized in subsequent Regional Flood Planning tasks.

# Task 4A: Flood Mitigation Needs Analysis

This section describes the process adopted by the Lower Brazos Regional Flood Planning Group (RFPG) to conduct the Flood Mitigation Needs Analysis, resulting in identifying areas with the greatest gaps in flood risk information and the areas of greatest known flood risk and mitigation need. The process consisted of a high-level assessment that guided the efforts to identify FMEs, FMPs, and FMSs. *Table 4.1Table 4.1* summarizes the TWDB guidance and factors considered in the Flood Mitigation Needs Analysis.

## Table 4.1: TWDB Guidance and Factors to Consider

Guidance	Factors to Consider
Most prone to flooding that threatens life and property	<ul> <li>Buildings within a 1 percent annual chance event (ACE) flood hazard area         <ul> <li>Low water crossings</li> </ul> </li> <li>Agricultural and ranching areas in 1 ACE flood hazard area         <ul> <li>Critical facilities in 1 percent ACE flood hazard area</li> </ul> </li> </ul>
Locations, extent, and performance of current floodplain management and land use policies and infrastructure	<ul> <li>Communities not participating in National Flood Insurance Program (NFIP)</li> <li>Community Rating System (CRS) score</li> <li>City/County design manuals         <ul> <li>Land use policies</li> <li>Floodplain ordinance(s)</li> </ul> </li> </ul>
Inadequate inundation mapping	<ul> <li>No Base Level Engineering (BLE) or Zone AE Federal Emergency Management Agency (FEMA) floodplain mapping</li> <li>Presence of Cursory Fathom Data/FEMA Zone A flood risk data</li> </ul>
Lack of hydrologic and hydraulic (H&H) models	<ul> <li>Communities without recent detailed FEMA modeling or models of higher level of detail</li> </ul>
Emergency need	Damaged or failing infrastructure
Existing modeling analyses and flood risk mitigation plans	<ul> <li>Lack of Hazard Mitigation Action plans</li> <li>Hazard Mitigation plans older than five years</li> </ul>
Previously identified and evaluated flood mitigation projects	<ul> <li>Exclude flood mitigation projects already in implementation</li> </ul>
Historic flooding events	<ul><li>Disaster declarations</li><li>Flood insurance claim information</li></ul>
Previously implemented flood mitigation projects	<ul> <li>Exclude areas where flood mitigation projects have already been implemented unless significant residual risk remains</li> </ul>
Additional other factors deemed relevant by RFPG	<ul> <li>Social Vulnerability Index (SVI)</li> </ul>

# 4A.1: Process and Scoring Criteria

The main objectives of the Flood Mitigation Needs Analysis are to identify the areas of greatest known flood risk and areas where the greatest flood risk knowledge gaps exist. To address the needs identified, FMEs were subsequently identified and recommended by the RFPG.

The Flood Mitigation Needs Analysis compiled data collected in Chapters 1 through 3 to achieve the objectives mentioned above. The data was used to conduct a geospatial assessment by assigning scoring metrics associated with factors listed in *Table 4.1<u>Table 4.1</u>* to different areas of the region. Note that

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some factors were excluded from the analysis due to data scarcity, such as locations of identified flooding and pending flood mitigation projects. For the geospatial assessment, Hydraulic Unit Code (HUC)-12 watersheds were selected as the area unit to be scored. A HUC is a unique identifier assigned to watersheds in the United States. As the watersheds get smaller, the number of units used to identify them gets longer. Therefore, the smallest unit of division used to identify a watershed is 12 digits or a HUC-12. The Lower Brazos Planning Region has 560 HUC-12 watersheds, with an average size of 42 square miles. Consideration was made to conduct this analysis at a county level to be consistent with exposure analyses in Chapter 2; however, it was determined that this would not provide a sufficient level of detail for the following reasons:

- much of the compiled data can be summarized within smaller units than counties, such as HUC-12 watersheds
- FMEs identified and recommended based on results of the Flood Mitigation Needs Analysis target needs more appropriately at a finer scale than the county level
- utilizing hydrologic boundaries to address flood risk and knowledge gaps is aligned with the overarching plan goal of proposing regional solutions

A total of 13 data categories were used in the geospatial assessment, each with a scoring range determined based on percentiles. Generally, a scoring scale of zero to five was utilized for each category, with higher scores indicating higher need. Due to data being limited in several categories, only non-zero values were considered in the scoring ranges. The Flood Map Gap and H&H modeling categories were utilized to locate areas with the greatest flood risk knowledge gaps. The scores across the other 11 data categories were totaled to reveal the areas of greatest known flood risk. Further documentation of the scoring methodology is provided in *Section 4A.2*.

The following sections provide descriptions of all scoring factors and how each HUC-12 watershed was scored. Unless otherwise specified, the 1 and 0.2 percent annual chance storm events polygons from the existing flood hazard spatial layer created in Chapter 2 were utilized in this analysis as inundation mapping. Note that the objective of the Flood Mitigation Needs Analysis is to determine the magnitude of all factors present within a given HUC-12, not necessarily to determine the relative importance of each factor in determining flood risk. Therefore, no weight has been applied to any specific category to emphasize one factor over another, although some exceptions were made by setting the maximum possible scores for several categories to be less than five. These exceptions are explained in detail below.

# **4A.1.a.** Areas Most Prone to Flooding that Threatens Life and Property *Buildings*

The building footprints dataset was provided by the TWDB Flood Planning Data Hub. This dataset was utilized in Chapter 2 to determine the total number of buildings in the 1 and 0.2 percent ACE hazard polygons. For the Flood Mitigation Needs Analysis, this category was scored based on the count of these buildings within each HUC-12 watershed. Scoring criteria for this category are shown in *Table 4.2<del>Table</del> 4.2*.

### Low Water Crossings

Low water crossings were identified in Chapter 1 and were downloaded from the TWDB Flood Planning Data Hub. For the Flood Mitigation Needs Analysis, this category was scored based on the count of low water crossings in each HUC-12. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

## Agricultural Areas

Agricultural areas have been defined for this task as land used for farming. Impacted agricultural areas are identified in Chapter 2 as intersecting the 1 and 0.2 percent ACE flood hazard areas. The total impacted agricultural area in each HUC-12 was the criteria for assigning points. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# Critical Facilities

Critical facilities for this assessment include but are not limited to hospitals, schools, and industrial buildings. Existing critical facilities were identified in Chapter 1 and were downloaded from the TWDB Flood Planning Data Hub. This dataset was then utilized in Chapter 2 to determine the total number of critical facilities within the 1 and 0.2 percent ACE flood hazard polygons and areas of unknown flood frequency. This category is scored based on the total number of critical facilities in each HUC-12 identified in Task 2A. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# **4A.1.b. Current Floodplain Management and Land Use Policies and Infrastructure** *Communities Not Participating in the NFIP*

Communities not participating in the NFIP were identified in Chapter 1. If a community is not participating in the NFIP, all HUC-12s intersected by that community were assigned three points. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

### Communities with a Community Rating System (CRS) score below 10

Communities with a CRS score below 10 were identified using publicly available data from FEMA. A score below 10 indicates that a community has adopted higher standards for floodplain management than the basic requirements for participation in the NFIP, with one being the best possible score. College Station has the lowest CRS score (six) in the Lower Brazos Planning Region, and Missouri City and Sugar Land have the second-lowest CRS score (seven). All HUC-12s intersecting communities with a CRS rating less than 10 were assigned a score of zero, and the rest were assigned a score of two. Scoring criteria are shown in *Table 4.2Table 4.2*. Note that the scoring for both categories within *Section 4A.1.b* is arranged for the maximum combined score equals five; the scoring was arranged since each category's data are closely related. Furthermore, a community must participate in the NFIP to receive a CRS score.

# 4A.1.c. Areas Identified as Flood Map Gaps

This analysis was completed using the existing flood hazard layer and areas previously identified as a map gap in Chapter 2. It was assumed that the sources below represented adequate inundation mapping data:

- National Flood Hazard Layer (NFHL) Preliminary Data (zones AE, AH, OH, and VE)
- NFHL Effective Data (zones AE, AH, OH, and VE)

• Base Level Engineering (BLE)

The following inundation mapping data sources were considered lacking in necessary detail in this assessment:

- NFHL Zone A
- First American Flood Data Services (FAFDS)
- Cursory Fathom Data

HUC-12s identified as gaps were assigned a score of five. Note also that some HUC-12s were identified as mapping gaps due to a lack of flood hazard data behind levees and were also assigned a score of five. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# 4A.1.d. Areas Without Hydrologic & Hydraulic Models

Using the existing flood hazard layer created in Chapter 2, HUC-12s were selected that intersect with the 1 percent annual chance storm events flood hazard polygons from the following sources:

- NFHL Preliminary
- NFHL Effective Detailed
- Community Submittal

These mapping sources were assumed to be associated with detailed H&H models. HUC-12s flagged as having no detailed models were assigned a score of five. The main difference between this category and the previous category is that BLE data is considered adequate for mapping purposes but not for modeling purposes. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# 4A.1.e. Areas with Emergency Needs

In the Lower Brazos Planning Region, holistic criteria that define "emergency need" are still being determined. For the purposes of the Flood Mitigation Needs Analysis, identification of damaged or failing infrastructure was utilized as the only scoring metric. Infrastructure points from Chapter 1 that were previously categorized as being in poor or fair condition, deficient, or non-functional were counted in each HUC-12. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# 4A.1.f. Existing Modeling Analyses and Flood Risk Mitigation Plans

Hazard Mitigation Action Plans (HMAPs) were available for most Lower Brazos Planning Region counties. Therefore, only HMAPs equal to or less than five years old were considered to provide meaningful scoring in this category. Scoring criteria for this category are shown in *Table 4.2<del>Table 4.2</del>*.

# 4A.1.g. Already Identified and Evaluated Flood Mitigation Projects

Use of projects classified as "proposed" in the ExFldProjs layer from Chapter 1 was considered for this category. The ExFldProjs layer contains projects currently being implemented at stages ranging from funded to under construction. Since a limited number of projects were identified as such, this category was not included in this assessment.

# 4A.1.h. Historic Flooding Events

# Disaster Declarations

Disaster declaration data was obtained in tabular form from FEMA. Using this data, declarations were totaled for each county. Totals from each county were then assigned to HUC-12s based on the locations of watershed centroids. This was done to avoid bias in favor of HUC-12s that overlap multiple counties. This category was scored based on the number of disaster declarations assigned to each HUC-12 watershed. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# FEMA Claims

To summarize flooding history in the Lower Brazos Planning Region in Chapter 1, publicly available NFIP redacted flood claims were obtained in tabular form from FEMA. All available spatial information within the table was utilized to sum claims within the smallest possible area the claim could have occurred within. This spatial information is:

- census tracts
- zip codes
- counties
- latitude and longitude grids

Claims were geolocated to areas representing unique combinations of the attributes listed above. Where these polygons crossed HUC-12 boundaries, the total number of claims was split between watersheds based on area. For the Flood Mitigation Needs Analysis, this category was scored based on the count of claims within each HUC-12 watershed. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.

# 4A.1.i. Already Implemented Flood Mitigation Projects

Use of projects identified as "ongoing" in the ExFldProjs layer from Chapter 1 was considered for this category. However, since only a limited number of projects were identified, this category was not included in this assessment.

# 4A.1.j. Other Factors - Social Vulnerability Index

Social Vulnerability Index (SVI) refers to the potential negative effects on communities caused by external stresses on human health. Such stresses include natural or human-caused disasters or disease outbreaks. In the context of this analysis, SVI is being used as a metric for assessing the vulnerability of communities. The TWDB provided a building footprints spatial layer with SVI values at each feature for use in Chapter 2. For Task 4A, HUC-12 IDs were spatially assigned to each building to calculate average SVI values for each HUC-12. This category was scored to reflect that higher SVI values correlate with a higher flood risk mitigation need since high SVI areas tend to have greater difficulty recovering from natural disasters. Scoring criteria for this category are shown in *Table 4.2Table 4.2*.
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# Table 4.2: Scoring Criteria

			Score	(points)		
Categories	0	1	2	3	4	5
Number of Buildings in Flood-Prone Areas	0	1-8	9-18	19-42	43-122	123+
Number of Low Water Crossings	0	1	2		3	4+
Agricultural Areas in Flood- Prone Areas (Square Miles)	0	0- 0.119	0.12- 0.299	0.30- 0.729	0.73- 2.059	2.06+
Number of Critical Facilities in Flood-Prone Areas	0	1		2	3-4	4+
Number of Communities not Participating in NFIP	0			1+		
Number of Communities Participating in CRS with Rating Lower than 10	1+		0			
Identified as a Flood Map Gap	No Мар Gap					Gap
Areas without H&H Models	1					0
Damaged or Failing Infrastructure	0	1		2	3	4+
Hazard Mitigation Action Plans	COMPLETE			PARTIAL		NONE
Number of Disaster Declarations	0	6-8	9	10	11-12	13+
Number of FEMA Claims	0	0.01- 0.439	0.44- 1.209	1.21- 4.269	4.27- 15.529	15.53+
Social Vulnerability Index	0	0- 0.249	0.25- 0.339	0.34- 0.439	0.44- 0.549	0.55+

# 4A.2: Scoring Methodology

As previously mentioned, percentiles were used to develop the scoring scale for numerical categories, with the 80<sup>th</sup> percentile receiving a score of five and the 20<sup>th</sup> percentile receiving a score of one. A sample list of 15 non-zero values in increasing order is shown in *Table 4.3Table 4.3* to illustrate how scores are assigned using this methodology. For these categories, zero values received a zero score and were removed from the array of values used to compute percentiles. This was performed to provide meaningful scoring metrics for categories containing a high percentage of zero values. For example, 464 out of 560 HUC-12 watersheds in the Lower Brazos Planning Region have no identified critical facilities in flood hazard areas. Not excluding zero values would assign zero as the 80<sup>th</sup> percentile, resulting in a score of five being assigned to every HUC-12 with a non-zero value. Therefore, zero values were excluded across the board for consistency since this issue was present in several categories. Adjusted percentile values used to score HUC-12s are shown in *Table 4.3Table 4.3*.

## Table 4.3: Scoring Example with Percentiles

	1 (be	low 2	20 <sup>th</sup>	2 (20	<sup>th</sup> to	40 <sup>th</sup>	3 (40 <sup>°</sup>	<sup>th</sup> to	60 <sup>th</sup>	4 (60	) <sup>th</sup> to	80 <sup>th</sup>	5 (al	oove 8	80 <sup>th</sup>
	perc	centi	e)	per	centi	le)	pero	centi	le)	per	centi	Ie)	per	centi	le)
Values	1	1	2	3	4	4	6	8	9	10	17	19	22	24	31

As an alternative to using percentiles, a scoring system that assigns scores from zero to five that are proportional to the full range of values within each category was considered. However, it was determined that this would not provide a clear picture of needs in the region since watersheds near the coast have significantly higher numerical totals than inland areas. For example, the Lower Oyster Creek watershed has the highest total for flood claims (5,674), which is over four times higher than the second watershed by claims. Similar trends are evident in the buildings and critical facilities categories. As a result, assigning proportional scores to values in each category would produce HUC-12 scores near the coast that would eclipse the rest of the region. For this reason, percentiles were chosen as the best option to avoid downplaying flood risk mitigation needs for large portions of the Lower Brazos Planning Region.

# 4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs

As previously discussed, the first goal of the Flood Mitigation Needs Analysis was to identify areas where the greatest flood risk knowledge gaps exist. The Inundation Mapping and H&H modeling categories were utilized to locate these areas. The results of this preliminary assessment show that roughly one-third of the Lower Brazos River watershed has inadequate mapping and no detailed H&H models, as indicated in *Map 14* in *Appendix 0*. The scoring ranges representing each level of severity of flood risk knowledge gaps are included in *Table 4.4Table 4.4*. Most of these areas are in the upper portion of the basin. Specifically, the following major subwatersheds, listed from south to north, contain the <u>most significant gaps in flood risk knowledge</u>:

- Mill Creek
- San Gabriel River
- Leon River

- Bosque River
- Middle Brazos Palo Pinto

# Table 4.4: Scoring Ranges for Severity of Flood Risk Knowledge Gaps

Severity of Flood Risk Knowledge Gap	Score Range
High	4
Medium	1-3
Low	0

The second goal was to determine the areas of greatest known flood risk and flood mitigation needs. The scores across 11 of the 13 categories, which exclude those used to determine flood risk knowledge gaps, were totaled to locate these areas. The scoring ranges used to determine the severity of flood risk of a HUC-12 are included in *Table 4.5Table 4.5*. As shown in *Map 15*, located in *Appendix 0*, HUC-12s determined by this analysis to have high flood risk are distributed throughout the Lower Brazos River watershed, with clusters of particularly high risk located in the following areas, listed from south to north:

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Waller County

Austin County

Fort Bend County

Brazoria County

- Eastland County
- McLennan County
- Williamson County
- Grimes County

# Table 4.5: Scoring Ranges for Severity of Flood Risk

# Severity of Flood RiskScore RangeHigh25 - 41Medium-High21 - 24Medium18 - 20Medium-Low15 - 17Low4 - 14

Each of these areas tends to score high in different combinations of risk factors. For instance, areas downstream of Washington and Grimes counties score exceptionally high with regard to buildings and critical facilities in flood-prone areas, disaster declarations, and flood claims. Conversely, watersheds in Williamson County tend to score higher due to damaged or failing infrastructure and low water crossings.

Ultimately, the results of the Flood Mitigation Needs Analysis guided the RFPG's subsequent efforts to address flood risk identification and mitigation needs in the Flood Mitigation Needs Analysis by informing the creation of drainage master plan and regional watershed study FMEs, which is discussed further in *Section 4B.3*. Additionally, studies to assess flood hazards within areas protected by levees were created and assigned the type "Study on Flood Preparedness." The high risk areas identified in *Map 14*, located in *Appendix 0*, informed the creation of regional watershed and internal levee study FMEs. The high risk areas identified in *Map 15*, located in *Appendix 0*, identifies areas where drainage master plan FMEs were created. Since sponsorship support was identified as a prerequisite for recommending needs in Chapter 5, *Map 15* also directed the RFPG's interest group outreach efforts to obtain approval of FMPs, FMSs, and FMEs identified in Task 4B.

# Task 4B: Identification and Evaluation of Potential FMEs and Potentially Feasible FMSs and FMPs

# 4B.1 Purpose and Intent

Task 4B was the first step in gathering and assessing potential FMEs, FMSs, and FMPs. The identification of FMEs, FMSs, and FMPs was guided by identifying flood-prone areas in previous tasks, along with reviewing publicly sourced information and interest groups outreach.

The RFPG utilized multiple avenues to collect studies, reports, models, and other documentation supporting the region's proposed flood management or mitigation efforts. The most promising items were sourced from the Interest Groups Survey, where interest groups provided the Lower Brazos RFPG

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with the information deemed most important to their current efforts. However, publicly available documentation such as hazard mitigation plans, master drainage plans, and flood protection plans were also analyzed for potential mitigation and management efforts that could be included in the Lower Brazos Regional Flood Plan.

After gathering a substantial amount of information, the RFPG approved an identification process that was used to develop a list of potential FMEs, FMSs, and FMPs.

Finally, each FME, FMS, and FMP was analyzed to determine associated characteristics, existing flood risk, flood risk reduction, and costs depending on the mitigation type. The results of this evaluation were used to help determine which FMEs, FMSs, and FMPs would be recommended for inclusion in the Regional Flood Plan.

# 4B.2 Information Collection

# 4B.2.a. Interest Group Survey

As described in Chapter 10, a survey was sent out to public officials (primarily Public Works Directors and City Engineers, City managers, County Commissioners, etc.) throughout the Lower Brazos Planning Region. The primary intent of the survey was to directly source-specific flood management and mitigation needs from various interest groups within the Lower Brazos Planning Region. This allowed the entities to provide flood mitigation ideas to the group, from high-level concepts to detailed design drawings of projects, for evaluation and incorporation into the plan.

Although the responses were reasonably distributed geographically, a minority of them included submittals of flood management or mitigation needs. The entities that did provide specific mitigation needs, along with supporting documentation and data, are concentrated in the southern portion of the Lower Brazos Planning Region. This uneven distribution is assumed to be due to the higher risk of flooding in this portion of the region, causing increased awareness of flood risk and, in turn, increased engagement with flood planning efforts.

When the survey was initially sent out, the cities of Sugar Land, Fulshear, and Sienna submitted data and documentation supporting their identified flood mitigation and management needs. Through this avenue, only around 30 potential FMEs, FMSs, and FMPs were initially identified for further evaluation.

# 4B.2.b. Other Data Sources

Due to the low participation in the survey (14 percent response rate), few needs were provided directly by regional entities. As a result, several other sources were reviewed to indirectly determine additional needs for the communities throughout the Lower Brazos Planning Region. These other sources included Hazard Mitigation Plans, publicly available Master Drainage Plans, unfunded Community Development Block Grant (CDBG) lists, unfunded Flood Infrastructure Fund (FIF) lists, and Capital Improvement Project (CIP) lists.

Throughout the identification and evaluation process, additional direct outreach with interest groups — targeted to the larger communities that did not respond to the survey — was performed to obtain flood management and mitigation needs in high-population areas where needs were expected. These efforts

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are described in Chapter 10. As a result, several additional needs were provided directly to the Technical Consultant Team, led by Halff Associates, by additional entities. In total, the City of Bryan, City of College Station, McLennan County, Williamson County, and Fort Bend County Drainage District provided almost 90 flood mitigation and management needs.

# 4B.2.c. Final List of Sourced Potentially Feasible Needs

In all, over 540 flood mitigation and management needs were collected both directly and indirectly from interest groups. These flood mitigation needs ranged from high-level flood mitigation planning to preliminary design of flood mitigation infrastructure. *Table 4.6Table 4.6* shows the sources reviewed and the number of flood mitigation or management needs from each source.

Table 4.6: Flood Management and Mitigation Needs Sources	

Source	Number of Needs*
Survey	30
Direct Outreach	66
Hazard Mitigation Plans	237
Master Drainage Plans	133
Capital Improvement Projects	14
Unfunded Community Development Block Grant	25
Unfunded Flood Infrastructure Fund	2
Flood Protection Plan	38
Total	545

\* Some needs were found in multiple sources and are counted by the primary source

The needs sourced directly from interest groups (including the survey) or identified from publicly available master drainage plans typically had the most supporting information, such as H&H modeling, needed to complete the identification and evaluation of flood management and mitigation needs for this plan. As a result, the level of engagement from interest groups directly impacted the flood management and mitigation needs evaluation.

# **4B.3 Identification Process**

# 4B.3.a. Initial Screening Process

After extensive data collection, a screening process was used to identify needs that did not align with the regional flood planning purposes/goals and categorize the remaining flood mitigation and management needs. The screening process was developed to ensure that needs are classified appropriately per the definitions of FME, FMS, and FMP provided by the TWDB. The process was also developed to ensure that needs were classified in a manner that was equitable and consistent across the Lower Brazos Planning Region.

The raw list of collected flood management and mitigation needs was initially screened for relevancy to mitigating existing flood risk. For example, projects related to the water supply without flood mitigation benefits or projects focused on mitigating flood risk associated with future development were discarded.

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After this pre-screening effort, the needs were filtered into two categories (FMPs or FMSs) based on whether the need was classified as a single project or multiple projects. Single projects included separate projects that are hydraulically connected and provided a flood risk-benefit to a single service area. Regional needs such as community-wide flood early warning systems or drainage criteria updates were classified as FMSs. The remaining needs, such as structural mitigation projects were initially classified as FMPs. These projects ranged in level of detail from conceptual project ideas to detailed construction drawings.

The FMP and FMS lists were then screened further based on the level of information provided by the source. The TWDB required an exposure and flood risk reduction analysis be performed for all FMPs and some types of FMSs to ensure the implementation would provide sufficient benefits to justify the associated costs.

Additionally, the TWDB required some other metrics to be evaluated to help characterize this balance, including:

- service area
- percentage of the project that is a nature-based solution (by cost)
- water supply benefit
- project level of service
- no negative impact on neighboring areas

Hydrologic and hydraulic modeling is assumed to be a necessary component to generate a sufficient amount of information to complete this evaluation and, as a result, was a primary metric by which FMPs and FMSs were screened. If modeling was not provided with a provided need, the need was classified as an FME with the assumption that the required data could be obtained by further evaluation of the need.

Note that the FMS category is considered a "catch-all" flood management category intended to capture strategies or ideas that may indirectly reduce flood risk. As a result, some FMSs do not require a quantifiable level of flood risk reduction to still be classified as an FMS. Non-structural actions were considered feasible if they were flood-related and provided a benefit to the community. Some examples of these types of FMSs include drainage criteria updates or education and awareness programs. While neither of these examples have a measurable flood risk reduction benefit, they still provide an indirect benefit to flood risk through policy, education, awareness, and information. If a need was initially classified as an FMS but did not have supporting information, additional screening was completed to determine whether the FMS type required flood risk reduction to be quantified. If not, the need remained an FMS.

A flow chart, shown in *Figure 4.1Figure 4.1*, was created to visually summarize the key elements of this process to increase public awareness of how needs were screened for further evaluation. The RFPG approved this process on November 16, 2021.

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# 4B.3.b. Secondary Screening and Reclassification

Flood management and mitigation needs often passed through the screening process several times as more information became available through ongoing research and interest group feedback. Some needs were initially classified as FMPs, assuming that H&H modeling would become available later in the evaluation process. In some cases, these models were not provided by the responsible entities, and the FMP was subsequently reclassified as an FME. Conversely, some needs were initially classified as an FME due to the scarcity of the provided information but were later reclassified as an FMP based on newly available data.

Several FMPs were also reclassified as FMEs based on the hydrologic data that was initially used to develop the projects. If the project was developed using outdated rainfall rates, it was classified as an FME and specifically tagged as needing further hydrologic modeling. This has the greatest impact on regions in the southern portion due to the recent change in rainfall statistics in this area.

# 4B.3.c. Geopolitical Boundaries and Flood Planning Regions

Some FMEs and FMSs share a common boundary with geopolitical entities such as city limits or county lines, thus causing the boundary of the FMEs, FMSs, and FMPs to expand outside the Lower Brazos Planning Region. If the majority of an FME or FMS was found to be located outside of the Lower Brazos watershed due to its geopolitical tie, it was removed from the FMEs, FMSs, and FMPs lists and no longer considered an identified need for the plan. These FMEs, FMSs, and FMPs were provided to the relevant neighboring regional flood planning groups for their consideration. The communities that were affected are listed in Table 4.7 below. Brazoria County and Young County have been excluded from this process since their boundaries overlap more than two regional flood planning regions. The largest share of the areas for these two entities is located within the Lower Brazos Planning Region.

Community	Neighboring Regional Plan	Reassigned FME	Reassigned FMS
Archer County	Upper Brazos	-	1
Callahan County	Upper Brazos	-	2
Fort Bend LID #2	San Jacinto	1	-
City of Burleson	Trinity	1	-
City of Fairfield	Trinity	1	-
Freestone County	Trinity	2	2
Jack County	Trinity	1	4
Leon County	Trinity	2	2
Madison County	Trinity	1	2
Parker County	Trinity	2	1
Bastrop County	Lower Colorado	3	1
Brown County	Lower Colorado	-	2
Burnet County	Lower Colorado	1	2
City of Brazoria	Lower Colorado	1	-
Mills County	Lower Colorado	-	1
Total		16	20

## Table 4.7: FMEs and FMSs Reassigned to Other Regional Flood Plans

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## Figure 4.1: Identification Process



# 4B.3.c. FMEs Identified by the RFPG

In addition to identifying FMEs through the data collection efforts described above, the RFPG was also responsible for creating FMEs to address information gaps and identify flood risk needs. To support this activity, the flood mitigation needs analysis conducted during Task 4A identified HUC-12 watersheds with the highest flood risk knowledge gaps and the greatest overall flood risk. To address these needs, drainage master plans were recommended for areas with high flood risk to help begin the process of mitigating this flood risk, and regional watershed studies were recommended for those areas with the greatest knowledge gaps.

*Figure 4.2Figure 4.2* below shows areas of the Lower Brazos Planning Region that need further study to close gaps in flood risk knowledge. This information was used to identify the regional watershed studies and studies on flood preparedness within leveed areas mentioned in *Section 4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Studies and obtain the best return on investment for each study, FMEs were delineated using the smallest appropriate hydrologic area rather than political boundaries. In most cases, study extents were defined by major reservoirs or tributary confluences with larger rivers. As a result of utilizing hydrologic boundaries for study extents, regional watershed study FMEs recommended by the RFPG include some areas that are not specifically noted as having flood risk knowledge gaps.* 

*Figure 4.3Figure 4.3* shows areas of the Lower Brazos Planning Region with the most significant overall flood risk based on the factors discussed in *Section 4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs4A.3: Areas with Significant Flood Risk Gaps and Flood Mitigation Needs.* (Also see *Map 14* found in *Appendix 0*). HUC-12s with an overall risk score exceeding the 80<sup>th</sup> percentile were assigned drainage master plan FMEs, which generally follow HUC-12 boundaries. In some cases, two or more HUC-12 areas were combined into a single FME to identify the potential for future FMPs and FMSs to address needs across a broader region.

The potential regional watershed studies and drainage master plans were added to the list as FMEs. The list was then checked for overlaps of existing FMEs and created FMEs to ensure that no duplicates were covering the same area and need type. FMEs created in the Flood Mitigation Needs Analysis generally had priority over FMEs determined from other sources since they are more regional in scope and have the potential to benefit a larger area. Table 4.8Table 4.8 lists the different types of FMEs identified as a result of the Flood Mitigation Needs Analysis.

FME Sub-Type	Number
Drainage Master Plans	81
Regional Watershed Studies	39
Study on Flood Preparedness (leveed areas)	4
Total	124

# Table 4.8: Potential FMEs Identified Under Task 4A Needs Analysis



#### Figure 4.2: Regional Watershed Studies Identified by the Lower Brazos RFPG





# 4B.3.d. Regional Flood Plan Amendment

The Lower Brazos RFPG was granted additional funding from the TWDB and schedule to complete an amendment of the Final Lower Brazos Regional Flood Plan. This amendment consisted of two tasks intended to identify, evaluate, and recommend additional FMPs and incorporate them into the existing Final Lower Brazos Regional Flood Plan report and associated data.

To complete this amendment process, the Lower Brazos RFPG used two avenues to gather additional flood mitigation and management needs. The first was an additional round of outreach. This effort allowed for communities who were completing studies during the development of the Regional Flood Plan to submit their resulting projects for consideration. Additionally, the RFPG approved the Technical Consultant Team to perform evaluations to develop several projects. These evaluations consisted of performing regional watershed studies identified in Task 4A to develop <del>projects</del>FMPs that would help address flood risk in the studied areas, performing additional modeling and benefit cost analysis on FMEs to elevate them to FMPs, and assessing the need for gauging and flood warning throughout the Lower Brazos Region. Memorandums describing the <del>scope and</del>-results of these studies can be found in Appendix 4.5 and 4.6.

After completing the amendment tasks, and additional 22 flood mitigation and management needs were provided by local entities and 15 flood mitigation and management needs were developed by the RFPG for inclusion in the Lower Brazos Regional Flood Plan.

# 4B.3.<sup>fe</sup>. Infeasible FMPs

Based on guidance from the TWDB and direction from the Lower Brazos RFPG, projects with a service drainage area of less than a square mile that did not have sponsorship support were classified as infeasible since they did not conform to the spirit of a "regional" flood plan. Therefore, 68 FMPs were classified as infeasible, as seen in *Appendix 4.4*.

# 4B.3.gf. Final List of FMEs, FMPs, and FMSs

The final list of potential FMEs, FMPs, and FMS included in the plan for further evaluation in Chapter 5 is listed in *Table 4.9Table 4.9*.

# Table 4.9: Final Number of Identified FMEs, FMPs, and FMSs

Need Type	Number
Flood Mitigation Evaluations	423 <del>16</del>
Flood Mitigation Projects	57 <del>27</del>
Flood Management Strategies	139
Infeasible Flood Mitigation Projects	68
Total	687 <del>50</del>

The distribution of FMEs, FMPs, and FMSs throughout the Lower Brazos Planning Region can be seen in *Maps 16, 17, and 18, respectively,* in *Appendix 0*.

Each category had a different set of metrics by which the needs were evaluated. For instance, FMEs are evaluated based primarily on study cost and existing flood risk within the study area. In contrast, FMPs

are evaluated not only by project cost and existing flood risk but also by a reduction in flood risk. Even less so, FMSs predominately do not require information on flood risk or flood risk reduction. The final classification is important to the flood plan because it determines how the need is evaluated and how it will be presented.

# 4B.4 Potential FME Evaluation

# 4B.4.a. FME Types Overview

Needs classified as FMEs were further classified into "types" and "sub-types" to help determine the costs necessary to complete each respective study and facilitate future prioritization and selection. The two broader categories, Watershed Planning and Engineering Project Planning, are based on the scope of the study.

Much of the Lower Brazos Region has Base Level Engineering (BLE) modeling or other existing data – as discussed in Chapter 2 – that could be leveraged to reduce the amount of work needed to close flood risk knowledge gaps and determine flood risk mitigation efforts. Where BLE is available, certain FMEs could improve upon existing BLE models by enhancing hydrology and adding hydraulic features to provide more detail as needed. Additionally, there are ongoing Category 1 FIF studies throughout the Lower Brazos Region. In these areas, the potential FMEs could utilize the results of those ongoing FIF studies, so that efforts are not duplicated.

# Watershed Planning

Watershed planning FMEs characterize those evaluations that are more regional in scope and focused on reducing flood risk information gaps or developing flood mitigation projects for an entire watershed or community.

The **Drainage Master Plans (DMPs)** subtype is an evaluation that estimates flood risk for the entirety or portion of a watershed—sometimes confined to a specific community and its political boundaries—and develops food risk management and mitigation recommendations that will mitigate flood risk. These studies typically identify needs within a community, including FMEs, FMPs, and FMSs.

The **Regional Watershed Studies** subtype is an evaluation that estimates flood risk throughout an entire watershed and can encompass several communities within the watershed. These studies often cover larger areas than a DMP and may not result in the identification of flood mitigation projects like a DMP. Typically, flood risk mapping products are developed as part of this study to be used for regulatory guidance and enforcement.

# Engineering Project Planning

Engineering Project Planning FMEs characterize those evaluations that are more specific to individual or multiple connected projects that serve a single benefit area within a community. These studies either include updates to the supporting modeling data or further evaluation of a project. As mentioned above, many of these FMEs were initially classified as FMPs but later reclassified as FMEs due to a lack of modeling or other supporting information needed to complete flood risk reduction evaluations. Engineering Project Planning FMEs are broken down into three sub-types depending on the level of evaluation needed to upgrade an FME to an FMP.

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The **Feasibility Assessment** sub-type is an evaluation of a specific, unstudied high flood risk area with the goal of developing alternatives to mitigate the identified high flood risk. Feasibility assessments include estimated design and construction costs and the flood risk reduction associated with the alternatives. Evaluations of this kind typically require the development of H&H models to establish existing conditions and determine proposed conditions and flood risk benefits associated with the project. Once completed, the study will give planners a better understanding of the options to mitigate flood risk at a specific location, along with estimated costs and benefits associated with a given alternative. It will also help prioritize a given alternative with other community needs and facilitate implementation.

The **Preliminary Engineering** sub-type is an evaluation of an identified FMP to better determine the flood risk reduction benefits associated with the FMP. This evaluation typically requires the development of, or significant revisions to, H&H modeling to determine flood risk reduction associated with the project and also includes the completion of a detailed cost estimate. Once completed, the study will give planners a better understanding of the cost and benefit associated with a given project, help them prioritize that project with other community needs, and facilitate implementation.

The **Update H&H Modeling** sub-type evaluates an already developed FMP where the underlying modeling data is outdated. To be upgraded to an FMP, this FME H&H modeling needs to be updated. These updates typically include updating rainfall information or other underlying data such as other changes in hydrology, terrain, land cover, land use, etc.

# Studies on Flood Preparedness

Studies on Flood Preparedness are FMEs that analyze specific flood risks of a community and determine how well the community is prepared to respond or how well the existing infrastructure can handle the flood risks. Dam failure analyses and emergency evacuation plans make up the majority of this category.

*Table 4.10Table 4.10* outlines the different types, and sub-types of FMEs, the general category description for each sub-type, and the number of FMEs identified for each category. A full list of the identified FMEs can be found in *Appendix 4.1, Table 12*.

# 4B.4.b. Critical Assessment Information

FMEs are intended to be identified and recommended for areas with higher-than-average flood risk and where areas do not have planned flood mitigation projects or do not have sufficient flood risk information. Since FMEs focus on developing better information or evaluating projects, they do not typically provide any immediate flood reduction benefit. As a result, the evaluation of FMEs focuses on general information about the FME as well as existing flood risk information within the study area. The following metrics were identified for each potential FME, depending on the amount of available information for a given area:

- general description and location of FME, including impacted HUCs, counties, and watersheds
- sponsor(s) who will manage the project; along with other entities that may have oversight
- estimated study cost and potential funding sources (local, state, and federal)

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- associated RFPG approved flood management and mitigation goals (described in Chapter 3B) to ensure the FME meets the goals of the plan
- determination on whether the FME meets an emergency need
- associated flood risks within the study area include:
  - o estimated number of structures (residential and critical facilities) at flood risk
  - estimated population at flood risk
  - $\circ$   $\;$  estimated road and low water crossings at flood risk  $\;$
  - o estimated farm and ranch land at flood risk
- existing or anticipated models

A few of the generic metrics—description, type, location, area, sponsors, and entities with oversight for each FME—were provided by reports, studies, or other sources that indicated the need of the FME. However, some of the metrics required more analysis than available in the source documentation, such as cost to perform the evaluation, existing flood risk within the study area or likely benefit from the study, and determination of whether the evaluation meets an emergency need.

# Evaluation Cost Estimate

An estimate of costs to complete an evaluation was determined for each FME. The TWDB guidance defines the cost estimate for FMEs as a "planning level" cost that describes whether the study would utilize existing hydraulic and hydrologic models or depend on existing information. Some of the FMEs submitted by entities for inclusion in the Regional Flood Plan included planning level cost estimates. However, most of the FMEs that were either collected or created as part of Task 4B do not have estimated costs. Costs had to be developed for these FMEs.

Per the TWDB guidance, the following costs are required to be considered if applicable:

- associated non-engineering studies (floodplain regulation development; flood authority or revenue-raising studies; public awareness program)
- engineering/technical/feasibility studies (H&H modeling/mapping; identification of potential flood risk reduction solutions; BCA and alternative analyses; project design; construction engineering)
- surveying; geotechnical; testing

To estimate study costs while ensuring an accurate comparison between FMEs, a consistent process was developed for all FMEs based on key FME characteristics such as FME sub-type, study area, and estimated project construction cost. For the **Watershed Planning FME** types (Drainage Master Plans and Regional Watershed Studies) and studies on Flood Preparedness types, costs to complete the FMEs were estimated based on records of costs to complete past evaluations of similar types. From this record, a cost-to-study area relationship (i.e., "curve") was developed. These relationships were used to estimate study costs for watershed mapping FME types based on the area of the FME. The FME areas were delineated manually based on the source description of each FME and estimated using the watershed that contributes runoff to the flood risk point — or region of interest.

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# Table 4.10: FME Types

FME Type	FME Sub-Type	Description	Number of FMEs Identified
Watershed Planning	Drainage Master Plan	An assessment of a watershed or community to estimate flood risk and recommend flood management and flood mitigation needs with a focus on potential flood mitigation projects.	123
Watershed Planning	Regional Watershed Studies	An assessment of a watershed with the intent to develop better flood risk information that can include both regulatory and non-regulatory flood risk mapping.	59
Engineering Project Planning	Feasibility Assessment	Develop flood mitigation project alternatives for a discrete high flood risk area, estimate construction costs for the alternatives, and determine flood reduction benefits for the alternatives. Evaluation will require the creation of H&H modeling.	32
Engineering Project Planning	Preliminary Engineering	Further evaluation of an identified potential flood mitigation project, validate construction costs and determine flood reduction benefits for the project. Evaluation will require the creation of H&H modeling.	1334
Engineering Project Planning	Update H&H Modeling	Updates or refinement of previously created models that support a potential flood mitigation project to include the best available data.	44
Studies on Flood Preparedness		Analysis to determine community risk and preparedness in infrastructure failure or severe storm events.	32 <del>24</del>
		Total	423 <del>16</del>

Costs for **Preliminary Engineering FME** sub-types were estimated using a methodology focused on the scope and type of project being evaluated rather than the study area. This methodology was chosen to account for the complexity of design associated with the specific project. Therefore, instead of using the study area for the project to estimate study costs, project construction costs were used to estimate study costs. Construction costs were provided in the supporting documentation for all FMEs classified as Preliminary Engineering. The FME study cost was then estimated as a percentage of the construction rated on a curve, with higher-cost projects having a lower percentage of study cost to construction and lower-cost projects having a higher percentage.

Projects with no associated cost within the source material were classified as **Feasibility Assessment FME** sub-types. Because of this, FME study costs for this sub-type were estimated based on the study area using the cost-to-area curve developed for drainage master plans.

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The **Update H&H Modeling FME** sub-type costs were estimated using a flat rate methodology. The costs to update H&H modeling and re-evaluate the projects were estimated using rates-based records of costs to complete modeling updates of similar types and scope. However, similar to the cost estimates for Engineering Project Planning, costs were estimated based on the construction cost of the project. The studies were separated into three categories based on the cost of the project—small, medium, and large—and flat study costs were assigned to each. *Table 4.11Table 4.11* lists the costs associated with each size study and the range of area that is included for each size category.

# Table 4.11: Update H&H Modeling Costs

Project Cost Range (Millions \$)	Estimated Cost
< 0.5 (Small)	\$50,000
0.5 - 10 (Medium)	\$100,000
> 10 (Large)	\$300,000

The above processes were used consistently for all FMEs regardless of the cost information provided within the source documentation. This ensured that the cost estimate calculated for each FME was based on a consistent and equitable methodology.

The estimated costs associated with each FME depend on broad, high-level assumptions. The FME costs estimated as part of this plan are for high-level planning purposes only. Further evaluation will be required to develop more detailed and accurate cost estimates.

Many needs were originally classified as FMPs based on the descriptions provided in the source material. However, due to a lack of modeling or other supporting information, the FMPs had to be reclassified as FMEs for further evaluation to develop the missing information. However, as a result of this reclassification the associated cost for the need was recalculated to represent the cost of performing additional analysis, as explained above. Due to the advanced state of many of these FMEs, estimated construction costs had already been determined, but were no longer being represented in the associated costs. To preserve this information, a separate column was used to track construction costs associated with advanced FMEs.

# Existing Flood Risk

A flood risk analysis was completed for each FME to provide additional context to the scope and extents of the FME, along with an estimate of the flood risk level within the study area that could potentially be mitigated with the implementation of flood mitigation projects or management strategies.

The flood risk datasets created in Chapter 2 were leveraged as a baseline for at-risk infrastructure. The flood risk data was heavily based on the floodplain quilt developed under this task. The FME study area was used to define the limits of flood risk and the at-risk infrastructure located within the FME boundary was used to calculate the following metrics:

- estimated number of structures at flood risk
- residential structures at flood risk
- estimated population at flood risk

- critical facilities at flood risk
- number of low water crossings at flood risk
- estimated number of road segment closures
- estimated length of roads at flood risk (miles)
- estimated farm and ranch land at flood risk (acres)

This methodology was used consistently for all FMEs regardless of the information provided within the source documentation. This ensured that the associated flood risk calculated for each FME was based on a consistent and equitable dataset.

# Emergency Need Classification

The term "emergency need" is not currently defined by the TWDB and was to be determined by each individual region. For the Lower Brazos Planning Region, the following criteria were decided upon by the RFPG to determine projects, strategies, and evaluations that met emergency needs:

- Remove severe repetitive loss properties that were deemed to meet an emergency need. Severe repetitive loss properties repeatedly flood, causing significant difficulties for property owners. The National Flood Insurance Reform Act of 2004 defined severe repetitive loss as: "a single-family property (consisting of one to four residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding \$5,000 and with the cumulative amount of such claims payments exceeding \$20,000; or for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property".
- Remove critical facilities from the one percent ACE area through various types of mitigation, including but not limited to acquisition, demolition, or elevation, floodproofing or retrofitting, and through infrastructure projects that would improve roads or bridges that cause critical facilities to be inaccessible.

Since FMEs do not execute any sort of flood mitigation, none were classified as meeting an emergency need.

# 4B.5 Potentially Feasible FMP and FMS Evaluation

# 4B.5.a. FMP Types and Overview

The FMP category encompasses many types of flood risk mitigation projects. Both structural and nonstructural efforts can be considered projects as long as they have non-zero capital costs or other nonrecurring costs. Although the TWDB allows for this extensive scope to encompass projects, not all of the project types were identified within the Lower Brazos Planning Region.

Most of the FMPs identified for the region were sourced from the Fort Bend County Master Drainage Plan which consists of mitigation alternatives for each major watershed throughout the county. The projects identified from this plan were similar in type and scope, primarily focusing on channel improvements and detention mitigation as needed. Additional projects were identified in both

McLennan County and the City of Bryan. The FMPs identified for these locations are much more localized, targeting specific flood hot spots and proposing a solution such as property acquisition or crossing improvements.

Nineteen additional projects were <del>either</del> provided by local communities and eleven additional projects were<del>or</del> identified in the Amendment process <del>for several entities</del> through the regional watershed studies across the Lower Brazos Region.

*Table 4.12Table 4.12* outlines the number of FMPs identified by project type in the Lower Brazos Planning Region. A full list of the identified FMPs can be found in *Appendix 4.2, Table 14*. Although there are a limited number of identified FMPs, many of the identified FMEs represent projects that have not yet been fully evaluated.

FMP Type	Description	Number of FMPs Identified
Structural: Low Water Crossing or Bridge Improvements	Structural improvements that mitigate flood risk to roads at culvert and bridge crossings. to bridges, culverts, and other road infrastructure to lessen flood risk to transportation routes.	14 <del>2</del>
Structural: Regional Channel Improvements	Channel improvements are intended to mitigate flooding for multiple sites or large regions. Improvements such as expansion, addition of lining, and implementation of banks to existing channels used for conveyance. Creation of new channels to divert water from flood-prone areas and ensure the confluence of channels does not cause overflow.	27 <del>3</del>
Structural: Regional Detention	Creation of detention ponds to mitigate channelization and current flood risk by delaying the conveyance of stormwater.	1
Structural: Levee	Creation of a levee to form a barrier between flood waters and location with severe flood risk.	1
Structural: Storm Drainage Improvements	Creation of or improvement to existing storm drain systems to provide flood relief along transportation routes and nearby buildings.	4
Structural: Comprehensive Drainage Improvements	Implementation or improvement of several, varied improvement types such as storm drain systems, berms, ditches, detention, and crossing structures intended to work in unison to mitigate flooding.	9
Non-Structural: Property Easement or Acquisition	Property buyouts to remove structures identified as being at flood risk <del>and would be difficult or expensive to</del> mitigate by other means.that would be difficult, expensive, or impractical to mitigate for flood risk by other means.	1

## Table 4.12: FMP Classifications

<b>FMP Туре</b>	Description	Number of FMPs Identified
	Total	57 <del>27</del>

# 4B.5.b. FMS Types and Overview

The FMS category is the broadest, including most flood mitigation or management efforts that do not fit into the types described previously. FMS listings cannot have associated capital costs but may have reoccurring or non-capital costs. These guidelines make the FMS category ideal for regulatory and bigpicture flood mitigation efforts.

FMSs were identified uniformly throughout the Lower Brazos Planning Region. Hazard Mitigation Plans, and other publicly available documentation, provided significant insight on large-scale, flood management ideas that are prevalent throughout the region.

The types of potentially feasible FMSs identified for the Lower Brazos Planning Region can be seen in *Error! Not a valid bookmark self-reference.Table 4.13*. A full list of identified FMSs can be found in *Appendix 4.3, Table 13*.

FMS Type	Description	Number of FMSs Identified
Education & Outreach	Programs or initiatives aim to educate the public on the hazards and risks of flooding.	1
Flood Preparedness & Resilience	Programs and initiatives to ensure entities are aware of the current flood risk and conditions, such as installation of flood risk signage, programs to ensure regulation compliance, and creation of databases to consolidate flood risk data, etc.	40
Floodproofing	Structural improvements to ensure critical infrastructure performs during flood events.	19
Infrastructure Improvements	Big picture ideas for extensive flood infrastructure improvements throughout a community.	6
Early Flood Warning System	Installation of rain or stream gauges to monitor water levels and have real-time feedback during flood events.	15
Nature-Based Improvements	Preservation and restoration programs aim to utilize natural flood mitigation to reduce risk.	11
Erosion Repair	Program to implement improvements to rivers, creeks, or channels to mitigate bank erosion	1
Property Acquisition & Structural Elevation	Buyouts or elevation of all structures with designated hazard levels such as one percent annual chance storm events floodplain, repetitive loss structures, structures downstream of dams, etc.	17

# Table 4.13: FMS Types

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FMS Type	Description	Number of FMSs Identified
Regulatory & Guidance	Updates or creation of new ordinances, development codes, design standards, maintenance codes, etc., to prevent the creation of new flood risk or mitigate current flood risk.	28
	Total	139

# 4B.5.c. Critical Assessment Information

FMPs and certain FMSs are intended to be identified and recommended for areas with higher-thanaverage flood risk. Since FMPs focus on reducing flood risk, they typically need to provide a high level of immediate flood reduction benefit to be feasible. This is also true for certain types of FMSs. As a result, the evaluation of FMPs and FMSs—as part of this plan—focuses on general information about the FMP or FMS as well as existing flood risk information within the study area and flood reduction benefit associated with the FMP or FMS.

The following metrics were considered for each identified potential FMP and structural FMSs, depending on the amount of available information for a given area:

- general description and location of FMP or FMS, including impacted HUCs, counties, and watersheds
- sponsors who will manage the project or strategy along with other entities that may have oversight
- estimated costs and potential funding sources (local, state, and federal)
- associated RFPG approved flood management and mitigation goals (described in Chapter 3B) to ensure the FMP or FMS meets the goals of the plan
- determination on whether the FMP or FMS meets an emergency need
- associated flood risk within the study area
- existing or anticipated models

A few generic metrics—description, type, location, area, costs, sponsors, and interested parties for each FMP or FMS—were provided by reports, studies, or other sources that indicated the need for the FMP or FMS. However, some of the metrics required more analysis than available in the source documentation, such as existing flood risk within the FMP or FMS service area, expected flood risk reduction when the project or strategy is implemented, a determination on whether the project or strategy meets an emergency need, how the FMP or FMS contributes or impacts water supply if the FMP or FMS has negative impacts to neighboring areas or resources, a benefit-cost-ratio, and potential funding sources.

# Estimated Capital Costs of FMPs and FMSs

The source documentation for FMPs included estimated capital costs. These estimates were utilized and adjusted, when necessary, to account for inflation to 2020 dollars.

Most FMSs are only developed to a conceptual planning level and cannot be accurately assigned a cost estimate. Further evaluation of these FMSs is needed to define the scope such that a more specific cost estimate can be developed. An exception is the Regulatory and Guidance FMS, which is estimated to be

\$400,000 to update regulations for each county identified as needing regulatory updates. Other categories were not provided a cost.

The estimated costs associated with each FMP and FMS depend on broad assumptions or source documentation that could not be thoroughly vetted. The FMP and FMS cost estimated as part of this plan are for high-level planning purposes only. Further evaluation will be required to develop more detailed and accurate cost estimates.

# Comparison of Estimated Benefits of Potentially Feasible FMSs and FMPs

All of the identified FMSs are high-level and general in scope. They consist of updates to regulations, public outreach and education efforts, and broad identification of potential infrastructure improvements which have largely undefined extents and effects. This uncertainty makes it difficult to quantify what is being addressed by the strategy without severely overestimating both flood risk and benefits. Therefore, the flood risk and flood risk reduction evaluation was limited to FMPs. Some of the infrastructure improvement FMSs may be refined further in future cycles to become future FMPs or FMEs.

To ensure consistency throughout the analysis process, each assessment component was approached the same way for each identified FMPs. This consistency allows for the estimated benefits associated with the individual FMPs to be comparable.

Estimated benefits were determined using provided hydraulic and hydrologic models, results maps, or values provided as part of the source documentation. A comparison of existing and proposed conditions was used to determine the flood risk reduction benefits associated with each FMP. A list of the flood risk metrics that were evaluated for each FMP is provided in *Table 4.14Table 4.14*.

Category	Existing Risk	Reduction in Risk
Structures	Estimated number of structures at 1 percent ACE flood risk	Number of structures with reduced 1 percent ACE flood risk
Structures	Estimated number of structures at 1 percent ACE flood risk	Number of structures removed from 1 percent ACE flood risk
Structures	Estimated number of structures at 1 percent ACE flood risk	Number of structures removed from 0.2 percent ACE flood risk
Structures	Residential structures at 1 percent ACE flood risk	Residential structures removed from 1 percent ACE flood risk
Structures	Critical facilities at 1 percent ACE flood risk	Critical facilities removed from 1 percent ACE flood risk
Population	Estimated population at 1 percent ACE flood risk	Estimated population removed from 1 percent ACE flood risk
Roads	Number of low water crossings at flood risk	Number of low water crossings removed from 1 percent ACE flood risk
Roads	Estimated number of road closures	Estimated reduction in road closure occurrences

# Table 4.14: FMS and FMP Benefit Analysis

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Category	Existing Risk	Reduction in Risk
Roads	Estimated length of roads at 1	Estimated length of roads removed from 1
	percent ACE flood risk (mi)	percent ACE flood risk (miles)
Agricultural	Estimated farm and ranch land	Estimated farm & ranch land removed from 1
Land	at 1 percent ACE risk (acre)	percent ACE risk (acre)

Other benefits analyzed for the FMPs would include the overall change in service capacity from preproject to post-project and estimated reduction in fatalities or injuries if the project or strategy was implemented. However, these metrics were difficult to determine with the modeling results. Unless stated directly in the source documentation, these items were left unidentified for many of the FMPs.

## Emergency Need Classification

The term emergency need is not currently defined by the TWDB and was to be determined by each individual region. For the Lower Brazos Planning Region, the following criteria were decided upon by the RFPG to determine projects, strategies, and evaluations that met emergency needs:

- Removing severe repetitive loss properties that were deemed to meet an emergency need. Severe
  repetitive loss properties repeatedly flood, causing significant difficulties for property owners. The
  National Flood Insurance Reform Act of 2004 defined severe repetitive loss as: "a single-family
  property (consisting of one to four residences) that is covered under flood insurance by the NFIP and
  has incurred flood-related damage for which four or more separate claims payments have been paid
  under flood insurance coverage, with the amount of each claim payment exceeding \$5,000 and with
  the cumulative amount of such claims payments exceeding \$20,000; or for which at least two
  separate claims payments have been made with the cumulative amount of such claims exceeding
  the reported value of the property".
- **Remove critical facilities from the one percent annual chance storm events** area through various types of mitigation, including but not limited to acquisition, demolition, or elevation, floodproofing or retrofitting, and through infrastructure projects that would improve roads or bridges that cause critical facilities to be inaccessible.

FMSs and FMPs were classified as meeting an emergency need if meeting any of the criteria listed above.

# Contributions to Water Supply

All potentially feasible FMPs and FMSs were screened for potential impacts on water supply. This review identified no projects or strategies having the potential to contribute to water supply in the Lower Brazos Planning Region. Potential negative impacts to water supply are analyzed in Chapters 5 and 6.

## Nature-Based Solutions

The TWDB encourages the RFPGs to consider nature-based methods of flood risk reduction. The Lower Brazos Region considered solutions to be nature-based if the intent of the strategy or project was to create or protect green infrastructure. This definition is quite broad and includes many different types of flood risk reduction efforts including the preservation of open spaces, incorporation of wetlands into structural mitigation, and utilizing vegetation to prevent erosion and other geomorphic changes. These

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solutions provide additional benefits to the communities and wildlife surrounding the area. Improvements to air quality, water quality, creation of habitats, and quality of life benefits can all be byproducts of the implementation of nature based solutions.

In the Lower Brazos Planning Region, none of the 27-57 potentially feasible FMPs include nature-based flood mitigation solutions. Of the 139 FMSs, 10 were identified as including a nature-based solution to flooding. Within this set of strategies, eight involve preservation and creation of open space, and two involve stabilizing erosion through planting and supporting natural vegetation. In addition to flood mitigation, these nature-based strategies have the potential to provide environmental and social benefits such as improvements to air quality, water quality, and the creation of recreational space for communities.

# No Negative Impact

The TWDB *Technical Guidelines* for Regional Flood Planning require demonstrating that each identified FMS or FMP will not negatively affect a neighboring area, based on the best available data. Demonstrations of no negative impact must reference the one percent annual chance events water surface elevations (WSELs) and peak discharges in pre-project and post-project conditions.

It is important to note the criteria listed below have no regulatory implications at a local, state, or federal level due to the approximate nature of flood planning. For flood planning efforts, a determination of no negative impact can be established if a project or strategy does not increase the inundation of residential and commercial buildings and structures. Additionally, all of the following requirements, per the TWDB *Technical Guidelines*, should be met to establish no negative impact, as applicable:

- **1.** Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
- 2. Stormwater does not increase the inundation of storm drainage networks, channels, and roadways beyond design capacity.
- **3.** The maximum increase of one-dimensional (1D) Water Surface Elevation must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.
- **4.** The maximum increase of two-dimensional (2D) Water Surface Elevations must round to 0.3 feet (< 0.35ft) measured at each computational cell.
- 5. The maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.</p>

Non-structural FMPs can be determined to have no negative impact on neighboring areas by default. These projects do not propose physical changes to the floodplain and resulting flood hazard areas, which eliminates the potential for increases in one percent annual change storm events discharges or WSELs. Instead, these project types reduce flood exposure by removing individuals and property from flood hazard areas. Similarly, one Property Acquisition FMP reduces flood risk by removing structures from areas prone to flooding.

Similarly, a significant portion of FMSs can also be determined to have no negative impact on neighboring areas without a detailed supporting analysis due to being non-structural in nature. These types of FMSs are listed below:

- education and outreach (1)
- early flood warning systems (15)
- property acquisition and structural elevation (17)
- regulatory and guidance (28)
- others include maintenance, restoration, land use policies, sign installation, etc. (2)

To demonstrate no negative impact at a planning level, restoration, preservation, and maintenance activities encompassed by the "other" strategy type will be assumed to retain the present function of natural or built flood infrastructure. Therefore, these strategies demonstrate no adverse impact on the basis of not significantly altering the physical environment.

For structural FMPs and FMSs, reports were checked for certified statements by an engineer registered in the State of Texas that the associated project or strategy would not cause negative impacts upstream, downstream, or within the project area in events up to and including the one percent annual chance events. For FMPs and FMSs without these certifications, H&H models were reviewed for negative impacts as defined in the TWDB *Technical Guidelines*. As previously mentioned, many structural FMPs and FMSs without accompanying models were reclassified as Preliminary Engineering FMEs.

# Benefit-Cost Analysis Determination

One of the most concise ways to compare and prioritize proposed projects is using a benefit-cost ratio (BCR), which measures the benefits a project achieves compared to the required implementation cost. BCRs greater than one indicates that there are more associated benefits than costs over the life of the proposed project.

Many different processes can be used to determine the BCR for a project, each looking at different types of benefits and costs and weighing their importance on a different scale. For this analysis, the TWDB provided benefit-cost analysis (BCA) tool was selected to develop BCRs for projects or strategies when BCRs were not provided in the source material. The BCA tool was selected due to its alignment with the information already required by the TWDB to evaluate the FMPs. The benefits provided to commercial and residential structures, critical facilities, streets, utilities, agriculture, water supply, and recreation are balanced by the construction cost, right-of-way acquisition costs, utility relocation costs, operation and maintenance costs, and the lifespan of the proposed project to determine if the benefits outweigh the costs.

In some cases, the benefits provided by flood risk reduction to structures and agricultural areas were the driving factors behind the BCA calculation. For these FMPs, the resulting BCR had little sensitivity to the inclusion of street flooding reductions. Since the calculation of road reduction benefits requires many detailed assumptions, including EMS travel times and routes, it was not evaluated for projects that had structural risk reduction as the primary benefit. However, some of the FMPs for the Lower Brazos Planning Region were specifically targeted at improving roadway crossings so neighborhoods could be

accessed during storm events. For these, the reduction in street flooding was the driving factor for the BCA tool, so it was calculated.

Structural flood risk reduction was determined using the hydraulic modeling results associated with each FMP. The pre-project flood depth rasters provided by the modeling results were intersected with the structure database provided by the TWDB to determine the level of flooding a structure experiences during a flood event. To account for the elevation of the top of slab of a typical slab-on-grade structure above the adjacent grade, 6 inches of flood depth was removed from each structure. The same process was performed using the post-project flood depth information provided by the modeling results. The difference in flood depths from pre-project to post-project was used to estimate the reduction of damages to the structure using the damage costs provided by the TWDB BCA tool.

Ultimately, the dollar per inch reduction in flood depth for each structure was estimated based on the square footage and the type of structure. Given that the BCA process is a planning-level effort, some generalizations were accepted to simplify the BCR calculating process. Residential structures were grouped into small, medium, and large-sized structures to match the BCA tool classifications. Each structure was categorized based on the measured square footage of each structure shape as provided in the structure database. Non-residential structures were generalized into broad categories of the type of industry the building serves (commercial, industrial, public, etc.). This was done to align the existing industry-type attributes assigned to the structures, as provided by the TWDB, to the BCA tool classifications. The TWDB tool then calculated the value provided by the mitigation using the structure square footage, industry classification, and the provided flood reduction. For instance, fast food restaurant damage costs provided in the BCA tool. Therefore, all commercial buildings were classified as fast-food restaurants to achieve an average damage cost.

A similar process was performed for agricultural land, except the depth of flooding was not considered. The TWDB also provided the agricultural land classification as a raster dataset. This dataset included two agricultural regions: farmland and ranchland. Approximate dollar per acre estimates were associated with each type of land. Farmland was considered a low-value crop based on the average crop type for the Lower Brazos Planning Region (corn, rice, sorghum, etc.), and ranchland was considered a hay-type value crop. Values for each are based on the average crop yield values for each category taken from the Texas Almanac. Ranchland was assumed to be a hay-type value crop based on the primary assumption that, during a flooding event, livestock can be transported away from flood risk.

To determine the benefits provided by reducing flood risk to streets, the modeling results were intersected with the roadways. Pre- and post-project depths and miles of roadway exposed to flooding were calculated. In the event that access to a neighborhood was completely restricted by the flooding, emergency medical service delays, the number of houses inaccessible, and the duration of inaccessibility were calculated. These metrics helped capture the larger impacts caused by the flooded streets, and the TWDB BCA tool calculated the associated monetary benefits and costs.

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SomeMost FMPs only included flood risk-benefit simulations for the one percent annual chance event. Therefore, the BCA considered only this event. Even though if only one storm event was analyzed, all known sources of flooding were incorporated into the analysis. For many of the FMPs in Fort Bend County, modeling results of flood events along the Brazos River were used in conjunction with modeling of local rivers and tributaries to determine the extents of flooding. The FMPs sourced from the Fort Bend County Master Drainage Plan for this area are not intended to mitigate Brazos River flooding, although they provide significant benefits in localized flooding events. Due to this, many of the benefits provided by the FMPs are superseded by the Brazos River floodplain, and the resulting BCRs are very low.

The calculated benefits depend on broad assumptions—as stated above—regarding the value of structures, agricultural land, and other factors. The costs and BCRs developed as part of this plan are for high-level planning purposes only, and further evaluation and modeling will be required to develop a more extensive and detailed BCR for each FMP.

# Potential Funding

The RFPG researched funding mechanisms for FMEs, FMSs, and FMPs. While potential funding is assessed in more detail in Chapter 9, the Lower Brazos RFPG considers the funding mechanisms below to encompass the widest variety of needs:

- Stormwater Utility Local
- TWDB Flood Infrastructure Fund (FIF) State
- TWDB Clean Water State Revolving Fund (CWSRF) State
- FEMA Building Resilient Infrastructure and Communities (BRIC) Federal
- FEMA Flood Mitigation Assistance Grant Program (FMA) Federal
- HUD Community Development Block Grant Mitigation (CDBG-MIT) Federal

The State of Texas provides municipalities the opportunity to establish a stormwater utility fee, which is a legal mechanism used to generate revenue to finance an individual municipality's cost to provide and manage stormwater services. Typically, stormwater utility revenues fund local drainage and maintenance projects, making this funding source particularly suitable for FMSs that involve recurring costs. Establishing a stormwater utility fee can be difficult as it is often considered by residents as a tax. Counties do not have the authority to establish a stormwater utility to fund drainage improvement projects.

At the state level, the TWDB FIF provides financial assistance for a wide variety of flood-related projects, including planning evaluations and studies. Since priority is given to projects that include multiple jurisdictions, FIF is an ideal funding mechanism for regional solutions. The CWSRF is another TWDB funding source that supports similar flood mitigation activities. The CWSRF is less oriented toward hydrologic and hydraulic studies and more oriented toward mitigation activities. Since both programs appropriate funding from planning level activities to design, they are suitable mechanisms for FMEs, FMSs, and FMPs.

At the federal level, the FEMA FMA appropriates funds to applicants with FEMA-approved HMAPs to support activities that mitigate severe repetitive loss. Additionally, CDBG-MIT was created in 2018 to

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fund activities to reduce future losses in areas affected by qualifying disasters in 2015, 2016, and 2017. Lastly, the FEMA BRIC program provides funding to applicants with FEMA-approved HMAPs for a broad range of mitigation activities. Since these programs prioritize flood hazard reduction, they are suitable for FMPs.

The specified federal funding options have varying local cost shares, making them suited for FMPs at varying scales. While BRIC grants have the highest local cost share of these programs at 25 percent, priority is given to applications with local shares that exceed this baseline. This may make BRIC a suitable option for smaller projects that benefit multiple entities. FMA has a local share that varies from 0 percent to 25 percent depending on the degree to which the application benefits repetitive loss structures, which may make FMA a suitable option for projects that benefit areas with a high number of flood claims as identified by previous tasks. CDBG-MIT has no required local share, which would simplify funding of projects with widespread, regional benefits. The funding mechanisms mentioned in this section will be discussed in more detail in Chapter 9, where specific funding strategies are proposed for each need.

# Chapter 5

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# Chapter 5: Recommendation of Flood Management Evaluations, Flood Management Strategies, and Associated Flood Mitigation Projects

The recommendation of Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs) is a direct advancement of the information collected and evaluated in Chapter 4 Task 4B. This list of potential FMEs, FMSs, and FMPs developed in Chapter 4 was further analyzed and screened to determine which mitigation and management needs should be recommended in the Regional Flood Plan.

Although several hundred mitigations and management efforts were collected and evaluated in Task 4B, not all align with the goals and purpose of the Regional Flood Plan. The Regional Flood Planning Group (RFPG) considered the region's needs, the overarching purpose of the Regional Flood Plan, and the guidance provided by the Texas Water Development Board (TWDB) to develop an equitable approach to recommend FMEs, FMSs, and FMPs. This chapter discusses the metrics used by the RFPG to determine recommendation status and summarizes recommended mitigation and management efforts.

# 5.1 – Recommendations

The RFPG had several discussions about metrics needed for flood mitigation or management to fulfill the Regional Flood Plan's intent. These discussions considered two main components of the needs: the type of evaluation, strategy, or project being proposed and how the need was identified. These two components guided the RFPG in determining the regionality of the impact of the need and the proposed sponsor's level of interest and urgency in actually performing or implementing the mitigation or management effort. After analyzing the distribution of the needs with regard to these components, as well as others, the RFPG was able to determine metrics that should be met for a need to be recommended.

Additionally, the TWDB provided the following guidance on what should be recommended:

- FMSs and FMPs to mitigate the 1 percent annual chance event (ACE) flood where feasible
- FMEs that are most likely to result in the identification of potentially feasible FMSs and FMPs
- FMSs and FMPs may not negatively impact a neighboring area.

These standards for recommendation were considered where applicable.

# 5.1.1 Regional Benefit and Location

# 5.1.1.a. Benefit Area

A key point of discussion throughout the recommendation process was ensuring that the recommended FMEs, FMSs, and FMPs provide regional benefits. One of the simplest ways to pre-screen for this was to

identify the benefit drainage areas. This was largely done as part of *Task 4B* but was further refined during Task 5 as more information became available. The TWDB guidance encourages FMSs and FMPs only to be considered for inclusion in the Regional Flood Plan if they have benefit contributing -drainage areas of greater than 1 square mile except in "instances of flooding of critical facilities or transportation routes or for other reasons, including levels of risk or project size, determined by the RFPG<del>or provide mitigation to a severe need, such as removing a critical facility from 1 percent annual chance storm event risk.</del>." On May 25<sup>th</sup>, 2023, For the Lower Brazos Planning Region, it was decided that the benefit area threshold should be a hard limit for recommendation and that this screening metric should be extended to FMEs.Tthe Lower Brazos RFPG approved specific guidance principles to further define the qualifications that aforn FMPs with a contributing drainage area of less than 1 square mile needs to meet to be recommended to be potentially included within the in the Lower Brazos Regional Flood Plan. If any of the following guidance principles are met, an FMP can may be recommended within the Lower Brazos Regional Flood Plan regardless of drainage area.

- 1. The FMP provides flood mitigation benefits to a critical facility as defined by the TWDB, FEMA, or State of Texas.
- 2. The FMP removes an established TxDOT evacuation route from flood risk.
- 3. The FMP removes a low water crossing within the TWDB dataset that is a singular ingress or egress point from flood risk.
- 4. The FMP falls within a high flood risk HUC as defined by the analysis completed under Task 4A.
- 5. The FMP provides benefits to a repetitive loss structure.

# 5.1.1.b. Combination of FMEs, FMSs, and FMPs

Some sponsors brought forth several small flood mitigation and management needs. Individually, these needs were localized and did not meet the previously discussed benefit-drainage area requirement. However, when combined, they often exceeded 1 square mile of benefit-drainage area. Several discussions were held to determine when it would be appropriate to combine these needs and boost the benefit area. It was decided that the following metrics must be met for mitigation and management needs to be combined:

- hydraulically connected and have interlocking benefit drainage areas
- sponsor of the needs must provide approval for the combinations proposed

If both conditions were met, the mitigation and management needs were considered for combination. This type of consolidation was largely done for Preliminary Engineering and Feasibility Assessment FMEs, which considered the development of several consecutive projects along the same stream or channel segment. FMEs considering localized storm sewer projects were mainly left uncombined due to the lack of hydraulic connection between the different proposed networks.

# 5.1.1.c. Flood Mitigation or Management Type

Another way to identify flood mitigation and management needs that may not provide regional benefit was determined by looking at the proposed mitigation type. Several identified needs were localized.

Although these needs are important and have the potential to reduce flood risk if implemented, they do not satisfy the purpose and intent of a regional flood plan. Specifically, maintenance and inspection programs were considered to be the local entity's responsibility and not a strategy that could provide benefit outside of the political boundaries in which they were proposed. The proposed flood mitigation and management needs (shown in *Table 5.1<del>Table 0.1</del>*) were not recommended as individual needs in the Regional Flood Plan. These needs were generally identified as potentially feasible FMSs.

# Table 59.1: Localized Flood Mitigation and Management Types

Flood Mitigation or Management Type	Description
Maintenance Programs	Recurring maintenance efforts to remove debris or sediment from local storm infrastructure
Public Awareness Programs	Programs targeted at increasing public participation in the National Flood Insurance Program (NFIP) or other flood-related programs and exercises
Inspection Programs	Formation of system, team, and schedule to regularly inspect flood infrastructure to determine potential degradation that could lead to failure

# 5.1.1.d. Flood Mitigation or Management Location

Flood mitigation and management needs located along the border of the Lower Brazos Planning Region were given special consideration. Some of the flood mitigation and management needs identified had benefit areas that extended into multiple regions. As mentioned in Task 4B, if the majority of any individual need fell into a neighboring region, then it was removed from the Lower Brazos Planning Region list and sent to the associated RFPG's for consideration. If the need had the majority of its benefit area within the Lower Brazos Planning Region, it was determined that it would be considered for a recommendation if all the other requirements were met.

# 5.1.2 Latest Data

The RFPG determined in Chapter 3 that a key standard that should be carried forth in the Lower Brazos Planning Region is the use of the best available data when developing criteria, projects, or mapping. Both the recommended standards and goals established in Chapter 3 reflect the necessity of using the latest data, including rainfall statistics, to generate equitable and accurate estimations of flood risk during modeling efforts. To ensure consistency throughout the plan, this concept was applied to the recommendation process for FMEs, FMPs, and FMSs. Any flood mitigation or management needs developed before 2019 were examined to establish whether they require updates to include current data.

This evaluation was primarily important for FMPs. Using outdated data could cause modeling results to indicate that proposed projects would provide more benefit than they truly would. Additionally, the equitable comparison of FMPs, especially when looking at flood risk reduction and benefit-cost ratios (BCRs), would be impossible if they were not held to the same standard. However, the RFPG did not want to completely disregard flood management and mitigation needs if the proposed solution was outdated. FMPs flagged as needing updates to include the best available data were demoted to

hydrologic and hydraulic (H&H) modeling FMEs. These FMEs were recommended for inclusion within the plan as long as they met all of the other established requirements.

# 5.1.3 Sponsorship

The metric that kept the largest amount of flood mitigation and management needs from being recommended was the need for explicit sponsorship approval.

# 5.1.3.a. TWDB Guidance

A sponsor is defined in the TWDB *Technical Guidelines* as an entity or multiple entities responsible for "financing and implementing" a flood mitigation or management need. The identified sponsor would be responsible for executing and administrating the need. The funding necessary to carry out a proposed need could be from various sources, including grants, and does not have to be directly funded by the identified entity. Additionally, the recommendation of a need does not indicate an entity's obligation to complete the identified strategy, project, or evaluation.

In a Technical Consultants Call hosted by the TWDB on May 24<sup>th</sup>, 2022, it was confirmed that explicit sponsorship approval is not required for an FME, FMS, or FMP to be included in the Regional Flood Plan. However, if a sponsor explicitly requests that the flood mitigation or management need is outdated or should not be included in the plan, this must be respected. The RFPG is only responsible for attempting to contact the identified sponsor to indicate the intent to include the flood mitigation or management need in the Regional Flood Plan.

Additionally, the TWDB indicated the RFPGs could list themselves as sponsors for any flood mitigation or management needs for which they could not identify sponsors but wanted to recommend for inclusion within the plan.

# 5.1.3.b. Lower Brazos Planning Region's Sponsorship Requirements

The Lower Brazos RFPG discussed the guidance on sponsorship provided by the TWDB. Several concerns with the allowable usage of sponsorship were identified.

For needs with an identified sponsor that was not responsive to the outreach performed, several potential causes were identified. The lack of response could indicate that the sponsor did not understand the purpose and importance of incorporating their needs into the Regional Flood Plan, did not have the resources to provide the requested information or approval, or may not have as severe of a need for flood mitigation. Without coordination with the identified sponsor, there is no way to be confident that the need or solution identified still exists. Recommending flood mitigation or management efforts associated with a sponsor may create the perception that there is a risk where there is not or that there are potential projects underway that are not actually being developed.

The FMEs developed in Task 4A included identified sponsors. However, the scope and extent of the identified flood mitigation and assessment needs made aligning interest groups with these evaluations difficult and imprecise. Since the FME boundaries cover multiple communities and counties, it would be beneficial if multiple entities were to coordinate to oversee and procure funding for the evaluation. The RFPG considered the possibility of naming itself as a sponsor for these needs; however, the implications

of naming the RFPG as a sponsor for these needs were concerning to the group. Although the TWDB intended this label as a placeholder to indicate support for flood mitigation or management needs, it could create confusion about the role of the RFPG within the regional and state flood planning process by implying that the group has the authority to carry out projects within the Lower Brazos Planning Region.

Due to these concerns, the Lower Brazos RFPG decided on April 28<sup>th</sup>, 2022, not to recommend any flood mitigation or management needs that did not have explicit sponsorship approval. An FME, FMS, or FMP was considered to have sponsorship approval if the need was brought forth directly by an entity or if verbal or written approval was obtained for a need's inclusion during outreach efforts. *Figure 5-1Figure 01* shows the distribution of sponsorship approval for the identified FMEs, FMSs, and FMPs.



# Figure 5-15-1: Sponsorship Summary

# 5.1.3.c. Outreach Efforts

Many FMEs, FMSs, and FMPs were collected through research performed by the Technical Consultant Team. This research included public documentation such as hazard mitigation plans, master drainage plans, and flood protection plans that indicated the need for specific flood mitigation projects or evaluations. These ideas were collected and included within the initial list created in Task 4B, characterizing flood needs throughout the Lower Brazos Planning Region. Once these needs were collected and evaluated, the identified associated sponsors were contacted to request any additional information they may possess pertaining to the needs. However, not all of these outreach attempts were successful. Many identified sponsors could not confirm the identified need was still present or that the proposed solution was still feasible.

Additional FMEs were identified in Task 4A. Due to the short turnaround between the completion of the analysis resulting in the identification of the FMEs, and the RFPG recommendation process, sSpecific outreach to sponsors regarding these FMEs was not performed. Potential sponsors were identified;

however, since many of the identified Task 4A FMEs adhere to watershed boundaries, instead of political boundaries, sponsorship would likely need to be shared by multiple entities for each FME.

# 5.1.4 Recommendation

The Lower Brazos RFPG met on May 26<sup>th</sup>, 2022, and approved the proposed lists of recommended FMEs, FMSs, and FMPs; 118 of the 582 collected FMEs, FMSs, and FMPs were recommended.

During the public comment period on the Draft Regional Flood Plan, several sponsors submitted comments providing their support for FMEs, FMSs, and FMPs that were on the not-recommended list. The RFPG considered the submitted comments on October 27<sup>th</sup>, <del>2022</del>2022, and approved 129 of the 582 collected listings for recommendation.

With the additional work completed under tDuring the amendment process, several additional flood mitigation and management needs were identified and recommended. The RFPG considered the additional FMEs, FMSs, and FMPs on May 25<sup>th</sup>, <del>2023</del>2023, <del>and recommended</del> bringing the total number of recommended needs to 145 of 619 collected needs.

# 5.2 – Recommended FMEs

# 5.2.1 FME Recommendation Approach

The RFPG identified and evaluated 42316 potential FMEs as described in Chapter 4. The FMEs that meet the requirements set by the TWDB and the additional metrics decided upon by the Lower Brazos RFPG were recommended. To ensure that the need was truly present and had public backing, explicit sponsorship approval was required for recommendation. Additionally, a study area of at least 1 square mile was a prerequisite to screen out FMEs that would not provide regional benefits. FMEs in close proximity to one another were only combined if they provided hydraulically interconnected benefits. All recommended FMEs were aligned with regional floodplain management and flood mitigation goal as developed in Chapter 3. Recommended FMEs will work towards developing potentially feasible flood mitigation projects and strategies for inclusion in a future planning cycle. Much of the Lower Brazos Region has Base Level Engineering (BLE) modeling or other existing data – as discussed in Chapter 2 – that could be leveraged to reduce the amount of work needed to close flood risk knowledge gaps and determine flood risk mitigation efforts. Where BLE is available, certain FMEs could improve upon existing BLE models by enhancing hydrology and adding hydraulic features to provide more detail as needed. Additionally, there are ongoing Category 1 FIF studies throughout the Lower Brazos Region. In these areas, the potential FMEs could utilize the results of those ongoing FIF studies, so that efforts are not duplicated.

The recommended FMEs consist of six types:

1. Regional Watershed Studies: Studies focused on generating new mapping, or otherwise increasing knowledge of flood risk throughout an entire watershed, typically a Hydraulic Unit Code (HUC)-8.



- 2. Studies on Flood Preparedness: Studies focused on generating emergency action plans or determining the risk associated with catastrophic events or failure of flood infrastructure (such as dams or levees).
- **3. Drainage Master Plans:** Evaluation of flood risk with the intent to identify flood-prone areas and begin developing potentially FMPs or FMSs.
- **4. Feasibility Assessments**: Evaluation of a previously identified flood-prone area to identify a feasible flood mitigation solution.
- **5. Preliminary Engineering:** Continued evaluation of a proposed flood mitigation solution to develop it to the point of becoming an FMP.
- **6.** Hydraulic and Hydrologic Analysis: Modeling updates to a previously developed FMP to implement current data, including new rainfall statistics, terrain, or land use.

A detailed description of the types and how FMEs were classified can also be found in Task 4B.

# 5.2.2 Summary of Recommended FMEs

In total, 42316 potential FMEs were presented to the RFPG for recommendation. Of these, 975 were recommended by the Lower Brazos RFPG. Over \$28Almost \$30 million in flood mitigation and management needs and 18-19 locations are represented by these recommended evaluations. *Figure 5-2Figure 02* shows the associated sponsors of the recommended FMEs, and *Figure 5-3Figure 03* and *Map 19* in *Appendix 0* show the distribution of FMEs throughout the region. A summary of the recommendations is presented in

*Table 5.2 Table 5.2Table 0.2*. One-page fact sheets for each recommended FME can be found in *Appendix 5.5*, and a table of the recommendations and their evaluations can be found in *Appendix 5.1*. Many of the recommended FMEs only lack a few necessary details to qualify as FMPs. The Preliminary Engineering and Hydraulic and Hydrologic Analysis type FMEs<del>, in particular, are</del> were developed enough to have estimated construction costs associated. By definition, an FME cost only represents the cost required to complete analysis and design; for this reason, a separate tracking category was created for potential construction costs of FMEs. There is \$558 million in associated construction costs for the recommended Lower Brazos Planning Region's FMEs.

FME Type	Number of Identified FMEs	Number of Recommended FMEs	Cost of Recommended FMEs
Regional Watershed Studies	60 <del>59</del>	144	\$2, <mark>452</mark> 952,000
Studies on Flood Preparedness	294	2	\$3, <del>212</del> 712,000
Drainage Master Plans	12 <mark>53</mark>	6 <del>3</del>	\$ <mark>32,14</mark> 04,000
Feasibility Assessments	32	13	\$4,850,000
Preliminary Engineering	1334	434	\$12, <mark>428<del>536</del>,000</mark>
H&H Analysis	44	19	\$2,850,000

# Table 5.2: Summary of Recommended FMEs
## DRAFT CHAPTER 5: RECOMMENDATION OF FMES, FMSS, AND FMPS



Number of Recommended FMEs

LOWER BRAZOS REGIONAL FLOOD

PLANNING GROUP REGION 8

## Figure 5-35-3: Distribution of Recommended FMEs



## 5.3 – Recommended FMSs

## **5.3.1 FMS Recommendation Approach**

The Lower Brazos Planning Region identified several types of FMSs. These strategies consist of "big picture" ideas that do not need the same level of study as FMEs or have the same level of detail as required for FMPs. Many of the collected FMSs were identified through publicly available Hazard Mitigation Plans. These plans have some similar entries across the counties and region; many align closely with the goals and standards set forth by the Lower Brazos Planning Region. However, most identified sponsors were not responsive to outreach, and the FMSs were subsequently not recommended. The TWDB guidance encourages the recommendation of FMSs that mitigate for the 1 percent annual chance event. Since the nature of FMSs is strategic, the level of mitigation could not be explicitly confirmed. However, the FMSs could potentially provide benefits for the 1 percent annual chance event and beyond, depending upon their development. The following five types of FMSs were recommended:

- **1. Erosion Control:** Stabilization efforts at 11 identified locations in Fort Bend County from Simonton to Sienna to maintain the integrity of the Brazos River.
- 2. Flood Measurement and Warning: Implementation of early flood warning systems, including stream gauges and monitoring equipment to alert officials when flooding may be imminent.
- **3.** Flood Preparedness and Resilience: Several types of structural and non-structural strategies to protect flood infrastructure, critical facilities, and the general population during storm events
- 4. Property Acquisition and Structural Elevation: Elevation or acquisition of all structures within a flood hazard area.
- 5. Regulatory and Guidance: Formation of new drainage entities to manage flood control or/and updates to drainage manual criteria and ordinances to ensure best practices are implemented.

Other types of FMSs were identified throughout Task 4B, but due to lack of sponsorship, they were not recommended as part of the Lower Brazos Regional Flood Plan. Descriptions of these types of FMSs can be found in Chapter 4.

## 5.3.2 Summary of Recommended FMSs

In total, 139 FMSs were collected through outreach to interested parties and the examination of publicly available documentation. Of these, ten were recommended by the Lower Brazos RFPG. Around \$360 million is estimated to be needed for the erosion projects in Fort Bend County, and additional \$14 million is estimated for the City of Waco property acquisitions. The remaining FMSs do not have estimated costs at this time. As the ideas behind the FMSs develop further, additional associated costs will likely be identified. The cost estimations provided as part of this effort are approximations of the level of effort required to execute the strategies as proposed. *Figure 5-4Figure 04* shows the associated sponsors of the recommended FMSs, and *Figure 5-5Figure 05* and *Map 21* in *Appendix 0* show the distribution of the FMSs throughout the Lower Brazos Planning Region. A summary of the recommendations is presented in *Table 5.3Table 0.3*. One-page fact sheets for each recommended FMS

can be found in *Appendix 5.6,* and a table of the recommendations and their evaluations can be found in *Appendix 5.3*.

Table 5.3: Summary of Recommended FMSs

FMS Type	Number of Identified FMSs	Number of Recommended FMSs	Cost of Recommended FMSs
Education and Outreach	1	0	N/A <sup>1</sup>
Erosion Control	1	1	\$360,000,000
Flood Measurement and Warning	16	2	N/A <sup>1</sup>
Flood Preparedness and Resilience	57	3	N/A <sup>1</sup>
Low Water Crossings or Bridge Improvements	7	0	N/A <sup>1</sup>
Nature Based Strategies	11	0	N/A <sup>1</sup>
Property Acquisition and Structural Elevation	18	3	\$14,000,000
Regulatory and Guidance	28	1	N/A <sup>1</sup>
Total	139	10	\$374,000,000

<sup>1</sup> Enough information was not available to determine the extent of these FMSs and to develop an estimated cost to implement.





### Figure 5-55-5: Recommended FMS Distribution



## 5.4 – Recommended FMPs

## **5.4.1 FMP Recommendation Approach**

The recommendation of FMPs was a simpler process than for the other categories. Without a sponsor providing the RFPG with supporting models and project details, the FMPs could not be evaluated to the extent required by the TWDB. If a flood mitigation or management effort was initially identified as an FMP, but supporting modeling and data were never obtained, it was demoted to an FME under the assumption that more evaluation would be necessary to provide the required evaluation metrics. The only FMPs with supporting data that lacked sponsorship support<sub>7</sub> were those developed under the amendment tasks by the Technical Consultant Team. Outreach was performed to give potential sponsors an opportunity to engage and provide their support for the FMPs developed for their communities. However, not all sponsors were reactive interested or supportive of the proposed projects. FMPs developed under this effort that did not receive explicit sponsorship support were not recommended.

All identified FMPs provided flood mitigation benefits for the 1 percent annual chance storm event and were determined to have no negative impacts on neighboring areas as required by the TWDB. No negative impacts for all recommended FMPs were determined based on signed and sealed statements submitted by the engineers originally responsible for modeling the projects or evaluation of supporting models. These documents are provided in Appendices 5.9 and 5.10.

Additionally, FMPs were evaluated based on the drainage area requirements. The only screening metric that impacted the recommendation of FMPs is the requirement for the benefit areas to be equal to or greater than 1 square mile. The application of this screening process removed three FMPs one FMP from the recommended list. The types of FMPs that were recommended in the Lower Brazos Regional Flood Plan are described below:

- Low Water Crossings or Bridge Improvements: Structural improvements to bridges, culverts, and other infrastructure surrounding roads to lessen flooding across roadways.road infrastructure to lessen flood risk to transportation routes.
- 1.
- 2. Regional Channel Improvements: Improvements such as expansion, the addition of lining, and implementation of banks to existing channels used for conveyance. Creation of new channels to divert water from flood-prone areas and ensure the confluence of channels does not cause overflow.
- **3. Regional Detention Improvements:** Creation of detention ponds to mitigate channelization and current flood risk by delaying the conveyance of stormwater.
- **4.** Levees: Creation of a levee to form a barrier between flood waters and locations with severe flood risk.
- **5. Storm Drainage Improvements:** Creation of, or improvement to existing, storm drain systems to provide flood relief along transportation routes and nearby buildings.

- 6. Comprehensive Drainage Improvements: Implementation or improvement of several, varied improvement types such as storm drain systems, berms, ditches, detention, and crossing structures intended to work in unison to mitigate flooding.
- **1.7. Property Easement or Acquisition:** Property buyouts to remove structures identified as being at flood risk that would be difficult, expensive, or impractical to mitigate for flood risk by other means.
- **2.8.** Low Water Crossings or Bridge Improvements: Structural improvements to bridges, culverts, and other infrastructure surround roads to lessen flooding across the road.

## **Regional Detention: Creation of detention ponds to mitigate channelization and current flood risk by delaying the conveyance of stormwater.**

## Infrastructure Improvements: Implementation or improvement of several, varied improvement types, such as storm sewer, berms, and ditches, intended to work in unison to mitigate flooding.

**Descriptions of the other types of identified FMPs can be found in Chapter 4.** 5.4.2 Summary of Recommended FMPs

## 5.4.2.a. Overview

In total, 527 FMPs were collected through outreach to interested parties, and the examination of publicly available documentation, and the development of FMPs by the Technical Consultant Team during the amendment process. Of these, 4924 were recommended by the Lower Brazos RFPG. One proposed FMP was not recommended due to having a drainage area of less than 1 square mile and not meeting any of the additional guidance principles outline by the RFPG. A total of 7 FMPs were not recommended due to lack of local sponsor<del>ship approval</del>support.<del>All 3 of the proposed FMPs that were not recommended were excluded due to having benefit areas of less than one square mile.</del>

Most of the recommended FMPs are sponsored by Fort Bend County Drainage District. These projects are composed primarily of regional channel improvements to major streams and tributaries throughout the County, as well as a regional detention opportunity to mitigate flooding through the implementation of basins. The recommended FMPs are scattered throughout the Lower Brazos Region, representing 9 locations

These recommended projects representand over \$4 billion in flood mitigation and management needsfunding needs. *Figure 5-7Figure 07* and *Map 20* in *Appendix 0* show the distribution of the FMPs throughout the region. A summary of the recommendations is presented in *Table 5.4Table 0.4*. *Figure 5-6* Sponsors of Recommended FMPs*0* shows the associated sponsors of the recommended FMPs. One-page fact sheets for each recommended FMP can be found in *Appendix 5.7*, and a table of the recommendations and their evaluations can be found in *Appendix 5.2*.

## Table 5.4: Summary of Recommended FMPs

FMP Types	Number of Identified FMPs	Number of Recommended FMPs	Cost of Recommended FMPs
Low Water Crossing <del>s</del> or Bridge Improvements	<del>2</del> 14	7 <del>0</del>	\$26,205,000 <del>N/A</del>
Regional Channel Improvements	27 <del>3</del>	<del>23</del> 26	\$4, <del>144</del> 158,794 <del>357</del> ,000
Regional Detention	1	1	\$8,699,000
Levee	1	1	\$1,022,000
Storm Drainage Improvements	4	4	\$9,419,000
Comprehensive Drainage Improvements	9	9	\$88,438,000
Property Acquisition	1	10	\$600,000 <del>N/A</del>
Total	5 <del>2</del> 7	49 <del>24</del>	\$4, <del>153</del> 293, <del>056</del> 177,000

## Figure 5-6 Sponsors of Recommended FMPs



Figure 5-7<del>5.6</del>: Recommended FMP Distribution

## DRAFT CHAPTER 5: RECOMMENDATION OF FMES, FMSS, AND FMPS



## 5.5 – Not Recommended FMEs, FMSs, and FMPs

As mentioned previously, the Lower Brazos Planning Region determined that several criteria must be met for flood mitigation or management need to be recommended within the Regional Flood Plan. These metrics were applied to ensure that the recommended needs provided regional benefits and were supported on a local level, and, therefore, more likely to be carried forward and implemented.

However, many FMEs, FMSs, and FMPs that were not recommended as part of the Lower Brazos Regional Flood Plan may still provide flood reduction or mitigation if implemented. For example, the FMEs generated in *Task 4A – Flood Mitigation Needs Analysis* were not recommended due to lack of sponsorship but are highly indicative of flood-prone areas and areas of unknown flood risk. The not recommended lists of FMEs, FMSs, and FMPs have merit and should be explored by local entities when possible. Ongoing outreach is recommended, especially during the infancy of the Regional Flood Plan, to ensure that entities are aware of the plan's importance in addressing their flood mitigation needs and getting funding for their identified flood mitigation projects and studies. Additionally, if entities express support for not recommended FMEs, FMSs, and FMPs that do not currently have sponsor approval, they may be considered for recommendation during the amendment period of Regional Flood Planning or during future flood planning cycles. *Table 5.5Table 0.5* summarizes the FMEs, FMSs, and FMPs that were not recommended for the Lower Brazos Regional Flood Plan. A detailed list of these items can be located is in *Appendix 5.4*.

Classification	Number Not Recommended	Reason for Recommendation Status*	Associated Costs
FME	294 <del>89</del>	No official sponsor approval was obtained.	\$211, <del>086</del> 603,000
FME	32	The study area is less than 1 square mile.	\$3,850,000
FMS	129	No official sponsor approval was obtained.	Not enough information was available to determine the extent of these FMSs and to develop an estimated cost to implement
FMP	<del>3</del> 1	The project drainage area is less than one square mile and does not meet guidance principles. <del>.</del>	\$ <del>1,880,000</del> 669,000
FMP	7	No official sponsor approval was obtained.	\$22,510,000
Total	463 <del>53</del>		\$ <del>216</del> 238,632 <del>816</del> ,000

## Table 5.5: Summary of Not Recommended FMEs, FMSs, and FMPs

\*Some flood mitigation and management needs may have multiple reasons for not being recommended.

In total, 4653 flood mitigation and management needs were identified but not recommended as part of the Lower Brazos Regional Flood Plan. Of these, 43018 were not recommended due to the lack of explicit sponsorship approval. Although there are many reasons that identified interest groups may not have responded to outreach, in some cases, it may indicate the lack of flood risk and mitigation needs in those areas.

## 5.6 – Evaluation of Recommended FMPs and FMSs

Although all collected FMEs, FMSs, and FMPs were evaluated as previously explained in Chapter 4, the recommended FMPs and FMSs had some additional metrics examined. Ensuring that the recommendations did not cause any negative impacts to neighboring areas was critical to adhere to the plan's goals and the state flood planning process as a whole. Additionally, the recommendations were looked at closely for any potential interactions with water supply, guaranteeing that their implementation would not cause any adverse effects on this metric.

FMPs were then evaluated for all benefits and costs on a detailed level. This assessment will provide the basis for the ranking process implemented by the TWDB to present the recommended projects to the State Legislature. Since the TWDB will only be requesting funding for the recommended FMPs, only these need to be evaluated to the level of detail explained below.

## 5.6.1 Water Supply Interactions

No recommended FMPs or FMSs were identified as having the potential to contribute to or negatively impact water supply since the projects and strategies do not propose modifications to aquifers or water supply reservoirs.

## 5.6.2 Negative Impact Identification

As previously mentioned, no negative impact can be determined if a project or strategy does not increase the inundation of infrastructures such as residential and commercial buildings and structures. A detailed definition of negative impacts is provided in Section 4B.5.c. Of all the identified strategies and projects, only six strategies were flagged as having the potential to negatively impact a neighboring area. These strategies involve improving or elevating low water crossings, which requires further analysis to ensure that proper mitigation is implemented to offset the reduction or expansion of channel conveyance. Ultimately, no recommended FMP or FMS was identified as having the potential to negatively impact a neighboring area.

The FMPs recommended in the Lower Brazos Region have signed and sealed supporting documentationdocumentation, but the no negative impact statements included in the documentation are not always explicitly stated in a way that ensures that the requirements set forth by the TWDB are being met. To ensure that the projects are in fact meeting the TWDB no-impact requirements, the models for several of the FMPs were evaluated in further detail. Following the guidance provided by the

## DRAFT CHAPTER 5: RECOMMENDATION OF FMES, FMSS, AND FMPS

TWDB in Exhibit C, the models were checked for any increases in the max water surface elevations equal to or greater than 0.05-ft from existing to proposed conditions. Additionally, the inundation extents were checked to ensure that there are no increases in inundation extents outside of public right-of-way, project property, or easement or any inundation of storm drainage infrastructure beyond its capacity. These conditions were met for all the recommended FMPs. Peak flows at computational nodes were also checked for any increases. Several of the proposed projects increased conveyance capacity of the respective conveyance systems which results in higher peak flow rates. However, water surface elevations associated with these conveyance systems did not increase over the TWDB minimum requirements due to changes in hydrograph time-to-peak from existing to proposed conditions or due to increase in hydraulic capacity in the conveyance system allowing it to convey the increased flow rate. As a result, these flow increases were considered to be acceptable and should not be considered a negative impact. Finally, FMPs on creeks that feed into the Brazos River directly were considered to not create a negative impact, even if the flow increased. Due to the Brazos River's substantially large watershed size, inceases increases in flow from the tributaries are likely to occur well before the Brazos River crests and, in-turn, unlikely to affect the max water surface elevations or inundation limits associated with Brazos River flows. The method and supporting data, such as models and signed and sealed reports, used to verify that the recommended FMPs will not cause negative impacts are described in Appendix 5.10. models and supporting documentation used to verify that the FMPs will not cause negative impacts is described in Table 5.6.

Each FME, FMP, and FMS should be continually evaluated and maintained during the final design and construction to ensure that, when implemented, the flood mitigation strategy or project will not have an adverse impact. It is also important that regular maintenance of these projects and strategies be implemented to ensure that the infrastructure operates as intended. Poor operations and maintenance can result in drainage infrastructure losing its functionality which, in turn, increases the potential negative impacts.

Recommended FMP ID and Name	Supporting Model I <del>D(s)</del>	Supporting Documentation
083000784: Bessie's and Brookshire	<del>08000000002,</del>	Bessie's Creek Master Drainage Plan
Creek Channel Improvements	<del>08000000007</del>	for Fort Bend County
083000786: Bee Creek Channel	<del>08000000001,</del>	Cow, Turkey, Bee Creeks Master
Improvements	<del>08000000006</del>	Drainage Plan for Fort Bend County
083000797: Big Creek Channel	<del>08000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>08000000010</del>	Fort Bend County
083000800: Coon Creek Channel	<del>08000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>08000000010</del>	Fort Bend County
083000801: Cow Creek Channel	<del>080000000001,</del>	Cow, Turkey, Bee Creeks Master
Improvements	<del>080000000006</del>	Drainage Plan for Fort Bend County

#### Table 5.6: Supporting Data for No Negative Impact Determinations

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Recommended FMP ID and Name	Supporting Model ID(s)	Supporting Documentation
083000805: Cottonwood Creek	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Channel Improvements	<del>080000000010</del>	Fort Bend County
083000809: Diversion Channel Ditch	<del>080000000005,</del>	Big Creek Master Drainage Plan for
and Drop Structure	<del>080000000010</del>	Fort Bend County
0830000811: Dry Creek Channel	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>080000000010</del>	Fort Bend County
083000814: Dutch John Channel	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>080000000010</del>	Fort Bend County
083000817: Fairchild Creek Channel	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>080000000010</del>	Fort Bend County
083000818: Flewellen Creek	<del>08000000003,</del>	Jones Creek Master Drainage Plan for
Channel Improvements	<del>08000000008</del>	Fort Bend County
083000820: Gapps Slough Channel	<del>08000000005,</del>	Big Creek Master Drainage Plan for
Improvements	<del>08000000010</del>	Fort Bend County
083000821: Jones Creek Channel	<del>08000000003,</del>	Jones Creek Master Drainage Plan for
Improvements	<del>08000000008</del>	Fort Bend County
083000823: Lateral IIB-7 &	<del>080000000005,</del>	Big Creek Master Drainage Plan for
IIB-9 Channel Improvements	<del>080000000010</del>	Fort Bend County
083000827: Lower Dry Creek	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Channel Improvement	08000000010	Fort Bend County
083000828: Seabourne Creek	<del>080000000005,</del>	Big Creek Master Drainage Plan for
Channel improvements	<del>08000000010</del>	Fort Bend County
083000829: Turkey Creek Channel	<del>080000000001,</del>	Cow, Turkey, Bee Creeks Master
Improvements	<del>080000000006</del>	Drainage Plan for Fort Bend County
083000834: Oyster Creek Channel	<del>080000000004,</del>	Oyster Creek Master Drainage Plan for
Improvements	<del>080000000009</del>	Fort Bend County
083000838: Lower Oyster Creek	<del>080000000004,</del>	Oyster Creek Master Drainage Plan for
Channel Improvements	<del>080000000009</del>	Fort Bend County
083000841: Red Gully Channel	<del>080000000004,</del>	Oyster Creek Master Drainage Plan for
Improvements	<del>080000000009</del>	Fort Bend County
083000843: Bullhead Bayou	<del>08000000004,</del>	Oyster Creek Master Drainage Plan for
Channels and Detention	<del>08000000009</del>	Fort Bend County
083000847: Stafford Run Channel	<del>08000000004,</del>	Oyster Creek Master Drainage Plan for
and Detentions	08000000009	Fort Bend County

Recommended FMP ID and Name	<del>Supporting Model</del> <del>ID(s)</del>	Supporting Documentation
083000853: Long Point Creek	<del>080000000004,</del>	Oyster Creek Master Drainage Plan for
Channel Improvements	<del>080000000009</del>	Fort Bend County
083000855: Rabb's Bayou	<del>08000000033,</del>	Rabbs Bayou Master Drainage Plan for
Detention	<del>08000000034</del>	Fort Bend County

## 5.6.3 Additional Project Details Evaluation

## 5.6.3.a. Overview

The FMPs recommended for inclusion in the Lower Brazos Regional Flood Plan required additional evaluation efforts beyond the information produced to determine benefit-cost ratios (BCRs) and the metrics required for the Task 4B TWDB-required tables. These details will provide the baseline data for the TWDB to compare the projects equitably within the State Flood Plan and determine prioritization for funding and presentation to the State Legislature. The evaluation process looks at many metrics that could potentially be used to determine the benefits and impacts caused by implementing the FMPs. Some categories rely on qualitative assessments of the FMPs, in contrast to the purely quantitative analyses during previous Tasks. The full table of project details can be found in *Appendix 5.8*.

Much of the general project data required for the evaluation had been gathered previously. However, two classifications were determined for each project: FIUP (Flood Intended Use Plan) Project Category and Rural Applicant Classification. The definitions and classification process for both of these can be found in the TWDB <u>2020 Flood Intended Use Plan</u> and are briefly described below (www.twdb.texas.gov/financial/programs/fif/doc/2020 Flood Intended Use Plan.pdf).

FIUP Project Category describes the development stage of a project or study.

- **Category 1:** Planning of entire watersheds to inform the development of structural and nonstructural mitigation strategies
- **Category 2:** Planning, acquisition, and design efforts in relation to an identified flood mitigation project
- **Category 3:** Projects that have already received federal funding contingent on matching with local funds
- **Category 4:** Projects that can be implemented quickly and will immediately protect life and property

All the FMPs recommended for the Lower Brazos Planning Region are aligned with Category 2.

A project classifies as a Rural Applicant if any of the following conditions are met:

- all entities within the project benefit area are outside metropolitan statistical areas and have populations < 10,000</li>
- district or municipality with a service area of 10,000 or less in population

• county in which no urban area exceeds 50,000 in population

Six-Roughly half of the recommended FMPs were identified as rural applicants.

## 5.6.3.b. Severity Evaluation

To understand the severity of risk in the existing conditions of the project area, the average depth of flooding for structures was calculated. The flood depths (raster format) obtained from the models were used to find the depth of flooding adjacent to each structure. These flood depths were then adjusted by 6 inches to reflect the difference between Light Detection and Ranging (lidar) elevations and the finished floor elevations of structures, which are typically elevated above the existing topography. The average flood depth at the structures was calculated and used to compare the severity of flooding under existing conditions.

The affected population was another metric determined to characterize the existing needs. This helped account for the potential overestimation of severity due to the presence of uninhabited structures at flood risk. To determine community need, the population within the floodplain was compared to the total population of the affected community. The sponsor of the FMP was determined to represent the affected community, and the entire population of that jurisdiction was used as the baseline.

## 5.6.3.c. Flood Risk Reduction Evaluation

To determine the flood reduction benefits provided by the implementation of the proposed FMPs, the number of structures removed from 1 percent ACE flood risk was considered. This metric was previously calculated in Task 4B and contributed to the BCR calculations. The flood depths associated with the proposed conditions (including the implementation of the projects) were utilized to see how many structures previously identified as being flooded were no longer within the floodplain. The percentage of at-risk structures shown as having been removed from flood risk in proposed conditions was calculated for each FMP.

Additionally, any structures that were provided with some level of flood risk reduction for the 1 percent ACE were considered. Damages associated with the flood depths pre-and post-project were determined. These calculations were pulled from the BCR spreadsheet provided by the TWDB, and used previously in Task 4B. The percent decrease in these damages represented the amount of reduction benefit provided.

The number of critical facilities removed from flood risk was also determined. A similar process was used to determine the existing and proposed flood risk conditions for critical facilities as was applied to the structure data set. However, no adjustment factor was applied to the depths due to the variation in what is included within the critical facilities data set. Data points representing facilities such as water and wastewater treatment plants and power plants may be damaged by any flooding depth.

Benefits associated with increasing access to transportation were also considered. Not only were preand post-flood depths on roadways used to determine the rating for this category, the classification of the road with flood benefits was also considered. The Texas Department of Transportation road classifications emphasized major collectors, principal arterials, and interstates, as all are major thoroughfares for emergency vehicles.

## 5.6.3.d. Life and Safety Evaluation

Many different components were considered to characterize the risk of fatalities or injuries caused by flooding. An area hazard rating was calculated by considering the depth, velocity, and land use at key points of flood concern. This metric helped inform the potential for debris to be carried with flood waters, increasing the risk of loss of life due to flooding. An area vulnerability rating was also determined. This factor was based on the speed of flood onset, the presence of flood warning mechanisms, and the nature of the area. Together, these metrics indicated the ability of residents to evacuate a flood-prone area. Finally, when available, narratives divulging historic loss of life in a project area were used to scale the ratings. All these factors determined the risk of loss of life within a project area.

Another indication of the risk to the community is the Social Vulnerability Index (SVI). This rating is determined by the Centers for Disease Control and Prevention (CDC) by census tract. It is defined as characterizing the ability of a community to respond to a disaster. Factors considered include education levels, economic status, and access to transport. When a project benefit area intersected multiple census tracts, the SVI was calculated by weighting the areas of the different census tracts within the project area.

## 5.6.3.e. Other Benefits Evaluation

Although providing flood mitigation benefits is the primary goal of the recommended projects, other types of benefits were considered where applicable. Projects that achieve multiple benefits can save money and time and encourage using creative and innovative solutions.

Environmental benefits provided by the implementation of the recommended FMPs were another interaction that was considered. The following categories were considered:

- Water Quality: Implementation of vegetation or flood infrastructure that could provide improvements to water quality or reduction of risk to water and wastewater treatment plants that could prevent overflow during storm events
- Cultural Heritage: Reduction of flood risk to an identified Texas Historical Commission site
- Habitat, Biodiversity, and Ecology: Preservation or creation of habitats, wetland areas, or wildlife corridors.
- Air Quality: Creation of open space or recreation areas or addition of vegetation that improves air quality
- Natural Resources: Protection of natural resources
- Agricultural Resources/Properties: Reduction of flood risk to agricultural property
- Soil Quality, Erosion, and Sedimentation: Stream armoring or reduction in water velocities to improve stream stabilization

For the Lower Brazos Planning Region's recommendations, water quality and agricultural resource benefits were the only environmental benefits identified for any of the recommended projects. several of these environmental benefits were identified including reduction of flood risk to wastewater plants

and THC sites, creation of open space and recreation areas, reduction of flood risk to agricultural areas, and reduction in water velocities.

Similar to environmental benefits, the FMPs were also examined for the contribution of nature-based solutions to the FMP. Several types of mitigation solutions would have qualified as being nature-based, such as creating wetlands or urban parks, restorations, or reforestation efforts. However, none of the projects recommended in this plan proposed these design components.

As mentioned previously, potential benefits provided to water supply through the flood mitigation projects identified were explored. However, for the FMPs recommended for the Lower Brazos Planning Region, there was determined to be no interaction with water supply.

Finally, other benefits were reviewed in the broadest sense possible. Any improvements to public establishments, from recreation centers to hospitals; improvements to transportation features such as parking lots and bike paths; potential economic impacts from the relief provided to businesses; economic and environmental benefits associated with project resilience and sustainability; and many other types of indirect benefits were considered. For the recommended FMPs, the primary associated benefits wasere identified to be recreational recreational and transportation benefits. Pedestrian and bike trails would be constructed alongside many of the proposed channel improvements, which would supply communities with additional recreational and transportation outlets. Additionally, projects aimed at improving low water crossings would be accompanied by repaving and re-grading the effected roads providing additional transportation benefits

## 5.6.3.f. Other Impacts Evaluation

An extensive effort was made to identify drawbacks associated with implementing the FMPs beyond the estimated cost. This analysis helped identify potential indirect costs or negative impacts that help characterize whether the benefits outweigh the impacts.

Recurring costs associated with the recommended FMPs were not incorporated into the initial cost estimates. To ensure an accurate cost representation was considered, operation and maintenance (O&M) costs were estimated and evaluated as part of the collection of the project details. The qualifications of those performing the O&M efforts and how the O&M costs compare to the overall estimated cost were considered. For most of the recommended FMPs, O&M costs accounted for less than 1% of the overall estimated project costs. However, the experience and capacity of the sponsors to perform O&M varies from experienced drainage authorities, to smaller entities that may not have drainage dedicated staff. The entity responsible for the upkeep of the projects recommended for the Lower Brazos Regional Flood Plan is a dedicated drainage authority. This indicates that these efforts are well within the entity's capabilities and expertise. Additionally, the anticipated O&M costs were only a small percentage of the overall estimated project costs.

Obstacles that could hinder or create additional costs to the implementation of the recommended FMPs were also considered. Three primary categories were examined: the number of permits required to begin construction (local, federal, and state), the number of reviews needed to approve the projects (Texas Commission on Environmental Quality (TCEQ) standards reviews and others), and the number of

property acquisitions needed to implement the project. The Many of the FMPs recommended for the Lower Brazos Planning Region are all-large efforts that require significant permitting and property acquisition.

Additionally, environmental impacts were reviewed for each recommended FMP. This analysis was a mirror of the environmental benefits analysis described previously. The same categories were considered, looking instead at how the proposed projects may cause negative effects. Several of the recommended FMPs were identified as including work within a watershed identified by TCEQ's Watershed Action Planning as being an impaired or special interest area. This flagged the FMPs as having potential impacts on water quality. Additionally, work proposed in wetlands and the need for acquisition of agricultural property flagged many of the recommended FMPs as having potential impacts.

## 5.6.3.g. Summary of Project Details

This extensive evaluation of the recommended FMPs for the Lower Brazos Planning Region provides much of the necessary information for the ranking process used by the TWDB to compare the recommended FMPs in the State Flood Plan. However, the analysis results in *Appendix 5.8* of this plan do not indicate any final ranking or prioritization by the RFPG. The numbers and details provided are only intended to characterize and evaluate the associated costs and benefits of the FMPs recommended for inclusion in the Lower Brazos Regional Flood Plan.

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# Chapter 6: Impact and Contribution of the Regional Flood Plan

The Lower Brazos Regional Flood Planning Group (RFPG) was tasked with summarizing the impacts and contributions the Regional Flood Plan is expected to have if the plan is implemented as recommended. The following sections describe the impacts and contributions of this plan to various aspects of water resources. Implementation of the plan as recommended assumes that all recommended flood mitigation projects (FMP), flood management strategies (FMS), and flood management evaluations (FME) are fully funded and completed. Additionally, avoidance of future flood risk due to policy recommendations and potential future recommendations of all identified projects, strategies, and evaluations are described in this chapter since many potential FMPs, FMSs, and FMEs only require sponsor approval to be recommended by the Lower Brazos RFPG.

# Task 6A – Impacts of the Regional Flood Plan

The overall impacts of the Regional Flood Plan include potential benefits to areas:

- at risk of flooding
- structures and populations in the floodplain
- low water crossings
- water supply
- impacts on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation

This chapter describes the processes undertaken by the RFPG to summarize the benefit of the Regional Flood Plan if fully implemented.

The impact of the plan also includes how future flood risk will be avoided through the implementation of recommended improvements to the region's floodplain management policies. Direct and indirect benefits of other FMPs, FMSs, and FMEs not currently recommended are also discussed. These details highlight the importance of public involvement, especially at the entity level, and support in maximizing the plan's effectiveness during amendment periods and future cycles.

## 6A.1 Relative Reduction in Flood Risk

The impacts of the plan on existing flood risk were determined based on a before-and-after (regional flood plan implementation) comparison of the same type of information provided in Chapter 2. All of the recommended projects were developed and analyzed outside of the regional flood planning process and were only analyzed for the 1 percent annual chance event. Since none of the recommended projects were analyzed for the 0.2 percent annual chance event, metrics were only provided to summarize benefits in the 1 percent annual chance event. The quantitative comparison of 1 percent annual chance exceedance data with and without the plan illustrates how much the region's existing flood risk will be reduced through the implementation of the plan as recommended by the RFPG.



## DRAFT CHAPTER 6: IMPACT AND CONTRIBUTION OF REGIONAL FLOOD PLAN

## 6A.1.a. Reduction in Flood Risk Identification Needs

In Chapter 2, 33 percent of the Lower Brazos Planning Region was identified as needing flood risk identification or updates to existing flood risk information. After the completion of recommended FMEs, 28 percent of the region area will need flood risk identification, a reduction of 1,172 square miles (5 percent). *Figure 6.1Figure 6.1* represents the existing and remaining gaps in flood risk information compared to the overall area in the region. *Figure 6.2Figure 6.2* shows the location of existing gaps in flood risk information, identified FMEs, and recommended FMEs. Although the RFPG identified additional FMEs in Chapter 4, most were not recommended due to a lack of sponsor response. More information on the process used to recommend FMEs is included in Chapter 5.



## Figure 6.1: Gaps in Flood Risk Information After Implementation of Regional Flood Plan

- Square Miles of Adequate Flood Risk Information
- Square Miles of Remaining Gaps in Flood Risk Information After Implementation
- Square Miles of Reduced Gaps in Flood Risk Information After Implemenation







## 6A.1.b. Reduction in Flood Risk Exposure

When implemented, FMPs positively impact or benefit flood risk exposure by removing or reducing population and property from flood risk. The Lower Brazos RFPG recommended <del>25</del>-49 FMPs for implementation, and these projects <del>are mostly channel conveyance improvement projects or regional detention ponds</del>consist of crossing improvements, regional channel improvements, and comprehensive drainage improvements, among others. *Table 6.1<del>Table 6.1</del>* summarizes the benefit to people and property expected if the FMPs in the regional flood plan are implemented as recommended.

Flood Exposure	Existing Conditions	After Implementation	Reduction in Exposure
Region-wide	1% ACE*	1% ACE	1% ACE
Total Structures	63,056	59, <del>196</del> 074	3, <del>860</del> 982
Residential Structures	42,646	39, <del>6</del> 44263	3, <del>002</del> 383
Critical Facilities	<del>203</del> 187	<del>184</del> 168	19
Population	129,888	<del>123</del> 118, <del>467</del> 803	<del>6,421</del> 11,085
Low Water Crossings	<del>5,170</del> 7,500	<del>5</del> 7, <del>170</del> 495	<del>0</del> 5

Table 6.1: Summary of Impact on People and Property After Implementation of Recommended FMPs

\* 2020 conditions

All FMPs recommended by the RFPG are located in Fort Bend County; therefore, all benefits shown are limited to a single county. Benefits are specifically summarized for Fort Bend County in *Table 6.2*. All flood risk exposure outside Fort Bend County is considered a residual risk after implementing the Regional Flood Plan. Since recommended projects were only evaluated using the 1 percent annual chance event, no summary of benefits is provided for the 0.2 percent annual chance event. Table 6.2: Summary of Impact on People and Property After Implementation of Recommended FMPs

Flood Exposure	Existing Conditions	<mark>After</mark>	Reduction in
within Fort Bend	1% ACE*	Implementation	Exposure 1% ACE
County		1% ACE	
Total Structures	<del>14,227</del>	<del>10,367</del>	<del>27.1 %</del>
<b>Residential</b>	<del>11,612</del>	<del>8,610</del>	<del>25.9 %</del>
<b>Structures</b>			
Critical Facilities	<mark>30</mark>	<del>11</del>	<del>63.3 %</del>
Population	<del>26,966</del>	<del>20,545</del>	<del>23.8 %</del>
Low Water	<del>200</del>	<del>200</del>	<mark>0 %</mark>
<b>Crossings</b>			

## 6A.1.c. No Negative Impact

As proposed, implementing the recommended FMPs will not negatively impact neighboring areas within or outside the Lower Brazos Planning Region according to their respective reports and/or models. All recommended FMPs were previously modeled to ensure "no negative flood impact" on upstream,

downstream, or neighboring areas. These impact analyses were conducted outside the flood planning process and performed using regional planning level data. The local sponsor will ultimately be responsible for ensuring the final project design has no negative flood impact before initiating construction.

## 6A.2 Other Impacts

The sections below describe the anticipated impacts of the plan on each of the following categories: socioeconomic, recreation, environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

## 6A.2.a. Socioeconomic Impacts

Disadvantaged socioeconomic status can limit access to resources which could hinder response and recovery from flood events. Flooding not only results in damaged infrastructure and destroyed property but also has an adverse social impact on affected citizens. Short- and long-term impacts on physical and mental health result in changes to the livelihoods of affected citizens, creating greater socioeconomic disparity.

The recommended projects in Fort Bend County provide watershed-wide benefits to the areaareas with Social Vulnerability Index (SVI) values ranging from 0.14-05 to 0.5887. The SVI indicates the relative social vulnerability of a census tract between zero and one, with higher values indicating greater vulnerability. Watershed planning can contribute to the Lower Brazos Planning Region's ability to prepare for, respond to, and recover from flood events. Reducing socioeconomic disparities through implementing measures to create equity can be initiated through planning. This is done by ensuring that vulnerable populations have the same access to resources and social infrastructure as those unaffected by flooding.

## 6A.2.b. Recreational Impacts

Using natural or man-made bodies of water for recreation is highly valued in the Lower Brazos Planning Region and throughout Texas. Many waterfront parks are spaces that are designed to be flooded with minimal damage during storm events. These floodplains and wetlands can support tourism, recreation, and freshwater fisheries.

Recreational benefits can also accompany flood mitigation projects. Along the Brazos River, many floodcontrol reservoirs are utilized for recreation, including boating and fishing. The FMPs recommended by the RFPG will not impact recreational use in these areas. In Fort Bend County, pedestrian and bike trails will accompany channel improvement FMPs, providing mobility and recreational benefits in tributary watersheds. Erosion prevention efforts included in the regional flood plan also provide recreational benefits since all land within the streambed is state-owned property and can be used for camping, fishing, or picnicking. The recommended FMS, Project Brazos, provides recreational benefits in Fort Bend County by protecting streambeds and adjacent communities from erosion.

Additionally, the list of recommended FMSs includes developing a property acquisition program in the cities of College Station and Hutto. These strategies would provide recreational benefits by opening opportunities for creating common gathering spaces for the respective communities.

While parks and camping areas are a valuable asset to the region, there are potential disadvantages to using the floodplain and waterfront parks for recreation. Recreational bodies of water can become dangerous to use when damaged due to flooding. Therefore, consideration must include adequate warning systems for individuals using these facilities.

## **6A.2.c. Environmental Impacts**

The property acquisition FMSs previously mentioned will remove structures from flood risk through demolition and, by doing so, would benefit the environment by eliminating the release of pollutants associated with flooded homes. Although it is unknown what the cities' intended use for the land is after demolition, one possible use would be as local park space, which would benefit the environment by promoting the development of habitats for native plant and animal species.

While land acquisition and development regulations can have positive impacts on the environment, structural projects recommended in the plan have the potential to harm wetland ecosystems in undeveloped land that frequently receives nutrients from flooding. During detailed design phases of recommended projects, consideration of maintaining natural conditions of these ecosystems should be made through implementing hydraulic connections between the floodplain and improved infrastructure. In some cases, additional permitting could be required.

## 6A.2.d. Agricultural Impacts

Flooding or excess precipitation can wash nutrients downstream or result in the loss of crops due to excessive moisture. Livestock can be swept away, drowned or injured by flood waters, or exposed to contaminated flood waters, resulting in health issues. After the implementation of the Regional Flood Plan, 54 square miles of farming or ranching agricultural land is anticipated to be removed from the 1 percent annual chance flood hazard area as a result of recommended FMPs in Fort Bend County, which will reduce the risk of damage to cropland and excessive transport of fertilizers. The existing and future conditions can be seen in *Table 6.2Table 6.3*. While mitigation projects will primarily provide benefits to agricultural land and water quality, they also have the potential to negatively impact the natural process of nutrient transport in the wide floodplains of Fort Bend County. Ultimately, since farming does not reflect the land's natural condition, and soils rely on human activity for nutrients instead of natural processes, the drawbacks of protecting agricultural land from flooding are likely to be outweighed by the benefits.

Table 6.23: Summary of Impact on Agriculture Region-wide After Implementation of Regional Floo	d
Plan	

Flood Exposure	Existing Conditions 1% ACE*	After Implementation 1% ACE	Reduction in Exposure 1% ACE
Agricultural Land (Sq. Mi)	837	783	54
*			

\* 2020 conditions

## 6A.2.e. Water Quality Impacts

Water quality concerns within the Lower Brazos Planning Region are high nutrient loads, high bacterial and salinity levels, and low dissolved oxygen. Mitigation of flooded agricultural land mentioned in the previous section will address nutrient load issues by reducing quantities of fertilizer conveyed in runoff.

The list of recommended FMSs includes floodproofing lift stations and manholes within the City of Georgetown. Additionally, the recommended FMPs in Fort Bend County provide widespread reductions in water surface elevations and inundation, which greatly reduces the risk of stormwater overwhelming water and wastewater treatment plants that serve many municipal utility districts (MUDs) in the area. Both floodproofing and structural projects mitigate the overflow of sanitary lift stations in a flood event, preventing the release of untreated sewage that can harm water quality in the region. These strategies and projects can also reduce the disruption of raw water treatment.

## 6A.2.f. Erosion and Sedimentation Impacts

The list of recommended FMSs includes Project Brazos, which will primarily benefit erosion issues along the main stem of the Brazos River. This strategy includes stabilization efforts for 11 identified locations throughout Fort Bend County where critical infrastructure, such as accredited levees, highways, or historic sites, are at risk of damage due to migration of the Brazos River, which has been accelerated by recent flooding. Implementation of this strategy will reduce erosion and sedimentation along the Brazos River and potentially avoid significant future losses to public infrastructure, buildings, and vulnerability to levees.

## 6A.2.g. Navigation Impacts

Historically, the Brazos River was navigable from the Gulf Coast to Washington County for approximately 250 miles. Today, the Brazos River is no longer used for navigation purposes. The implementation of recommended FMPs and FMSs in the Regional Flood Plan will not impact navigation on the Brazos River.

## 6A.3 Avoidance of Future Flood Risk

The following sections illustrate how additional future flood risks (that might otherwise arise if no changes were made to floodplain policies, etc.) will be avoided by implementing the Regional Flood Plan. Impacts of the plan on existing flood risk that also impact future flood risk are not included in the discussion.

## 6A.3.a. Floodplain Management Policy Future Impacts

Floodplain management recommendations and goals were established by the RFPG as a part of Chapter 3. While most of the Regional Flood Plan focuses on the current cycle, Chapter 3 established a long-term vision for target metrics that subsequent cycles of the plan should achieve. Of the 10 goals set forth by the RFPG, the floodplain management goals presented in Chapter 3 (*Appendix 3.3 Table 11*), listed below, will be most impactful in helping communities in the region avoid increases in flood hazard exposure.

- increase the number of counties and communities that are enrolled in the National Flood Insurance Program (NFIP)
- increase the number of counties and communities that have adopted higher than minimum NFIP standards, including directing development away from the floodplain
- increase the number of entities that have adopted the best available data and science for their designs and plans

Regulation of development, implementation of higher standards, and use of the best available data are all interdependent strategies for avoiding potential increases in flood exposure over time. "Higher standard" is defined by the *Technical Guidelines for Regional Flood Planning* as freeboard requirements, detention requirements, or fill restrictions. Higher standards provide a factor of safety to account for future uncertainty in identified flood risk. Yet, in order to set higher standards, foundational standards should be set through NFIP participation, and flood risk should be accurately identified through reliable and robust methods. The goals listed above will be realized through the execution of FMSs recommended in each planning cycle.

## 6A.3.b. Flood Management Strategy (FMS) Future Impacts

The RFPG identified FMSs encompassing 27 counties in the region from publicly available Hazard Mitigation Plans (HMPs) that are directly aligned with the goal of implementing higher standards in the Lower Brazos Planning Region. These strategies are assigned the type "Regulatory and Guidance." Through the development regulations mentioned in the previous section, the Regulatory and Guidance FMSs have the potential to reduce flood risk for newly constructed buildings in the Lower Brazos Planning Region.

Based on the future flood hazard analysis from *Task 2B* in Chapter 2, over 480,000 new structures are projected to be constructed across the region to accommodate population growth over the next 30 years. Potential flood risk can be reduced, and resiliency could be increased for many of these structures by communities adopting higher floodplain management criteria and standards. While many FMSs related to updated floodplain management criteria were identified, none were recommended by the RFPG due to a lack of sponsor response. While the RFPG does not recommend these FMSs, documentation of the strategies in HMPs implies the potential for their recommendation in subsequent amendments or cycles of the plan.

In addition to reducing the risk for newly constructed buildings, higher standards also help communities avoid additional future flood risks through the following regulations:

- mitigating impacts on receiving waterways from development due to increased runoff conveyance, which also stabilizes erosion and sedimentation in natural channels
- preserving floodplain capacity by requiring compensatory storage for all fill-in 1 percent or 0.2 percent ACE flood hazard areas
- incentivizing development away from flood hazard areas, which protects the natural environment and water quality

• higher freeboard requirements and improved resilience through requiring the design of extreme event overflows

## 6A.3.c. Flood Management Evaluation (FME) Future Impacts

As shown in *Figure 6.2Figure 6.2*, FMEs in the form of regional watershed studies were identified across the Lower Brazos Planning Region to address gaps in flood risk information as a part of *Task 4A*. While these evaluations are not recommended by the RFPG due to a lack of sponsor approval, their future recommendation during subsequent amendments or cycles of the plan could result in an increase in quantified flood exposure, as defined in Chapter 2. While an increase in quantified exposure may not indicate progress in fulfilling the plan's stated goals at first glance, identifying new flood exposure through state-of-the-art studies is a critical step in proposing solutions in the form of FMPs. Implementation of regional studies in a consistent manner throughout the Lower Brazos Planning Region facilitates the following future benefits:

- better understanding of flooding sources and the frequency of flooding
- equitable assessment of flood exposure throughout the Lower Brazos Planning Region during future planning cycles
- widespread availability of existing conditions modeling for evaluation of future FMPs
- regional hydrologic study extents will facilitate future FMPs that focus on regional mitigation rather than a prioritization of benefits within specific political jurisdictions

In summary, avoidance of future flood risk begins with identifying this risk through new studies. Beyond addressing the immediate need to close knowledge gaps, the execution of regional watershed studies created by the Lower Brazos RFPG will provide a foundation for effective FMP identification and recommendation in future planning cycles.

## Task 6B – Contributions to and Impacts on Water Supply

Regional Flood Plans must include a region-wide summary and description of the contribution that the Regional Flood Plan would have to water supply development, including positive and negative impacts of the flood plan on the State Water Plan. The Lower Brazos Planning Region covers portions of the Brazos G, Lower Colorado (Region K), Region H, Region F, and Region C Water Planning Regions. *Figure 6.3Figure 6.3* shows all Regional Water Planning Areas and the Lower Brazos Flood Planning area.

The Lower Brazos RFPG coordinated with each of these planning groups as a part of the flood planning process. No FMPs or FMSs recommended in the Lower Brazos Regional Flood Plan, if implemented, would contribute to or negatively impact and/or reduce the water supply in any of the water planning regions.





### Figure 6.3: Water Planning Areas and Lower Brazos Planning Region

# CHAPTER 10

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# **Chapter 10: Adoption of Plan and Public Participation**

Public outreach and participation played a crucial role in developing the first planning cycle of the State Flood Plan. Not only has this feedback been important for identifying and confirming flood risk and project needs in the state, but collecting data for these communities and entities has been critical to developing a successful plan. The Texas Water Development Board (TWDB) allocated funding provided by the legislature in early 2020 for each of the 15 new flood planning regions within the state to specifically focus on tasks covering public participation and flood planning development for their respective basins. In September 2021, the TWDB allocated additional funding to prioritize outreach and data collection efforts for each flood planning region.

The Lower Brazos Regional Flood Planning Group (RFPG) has utilized various methods to reach the public about the development of the first flood plan for the region. A regional website and email address were developed early on by the planning group's Sponsor, the Brazos River Authority (BRA), to provide a robust tool to inform and communicate with the public on the progress of the Lower Brazos Regional Flood Plan. The planning group's Sponsor provided project updates via social media and sent out monthly email blasts to their customers within the Lower Brazos Planning Region, as well as those signed up to receive project information about the flood plan.

The Lower Brazos RFPG held monthly public meetings to discuss project task updates. The public was provided the opportunity to speak at the beginning of each meeting. In addition to the online public outreach survey, the Lower Brazos RFPG conducted a public roadshow in five different cities across the basin to reach the communities in person. The Lower Brazos RFPG has complied with the Texas Open Meeting Act and Public Information Act requirements while developing the 2023 Lower Brazos Regional Flood Plan.

## **10.1 – Lower Brazos RFPG Communications**

## 10.1.1 New Regional Website and Email Address

To effectively communicate with the entities and communities throughout the Lower Brazos Basin, the Brazos River Authority developed a website for the Lower Brazos RFPG (<u>lowerbrazosflood.org</u>). This website has been an important tool used to publicize the following:

- Upcoming monthly RFPG meetings, including a virtual meeting option with a link to Microsoft Teams;
- 'Current Events' section on the home page, which highlights monthly updates on the planning process and draft documents for the public to review and provide comments;
- Frequently asked questions (FAQ) about the flood planning process for Texas and the Lower Brazos Planning Region;
- Meeting archive containing past meeting details, including agendas, supporting documentation, information flyers, audio recordings, and meeting minutes;

- Flood risk map available for electronic data collection;
- Portal to upload entity data for the regional plan in a secure manner;
- Links to other flood-related state and federal agencies; and,
- Method to submit public comments for a particular agenda item and/or submit a question(s) to the BRA and Lower Brazos RFPG.

In addition, the planning group's Sponsor created a regional email address (<u>LBFlood@brazos.org</u>) to simplify the process for the public contacting them and/or submitting questions to the Lower Brazos RFPG.

## 10.1.2 Social Media

In addition to using the Lower Brazos RFPG website to publicize meetings and events, the BRA leveraged social media (i.e., Facebook, Twitter, Instagram) to notify and update the public. For each of the monthly RFPG meetings, a colorful and informative flyer was developed by the Halff Associates Team for the BRA to post on their social media accounts for the Lower Brazos RFPG (see examples of meeting flyers in *Appendix 10.3*). For the public roadshow, a 'Save the Date' flyer was initially created and posted on social media in advance that summarized all five open house meeting dates and locations; individual roadshow flyers were then developed to publicize each of the meeting locations closer to the date of the event (reference *Confirm location* for copies of the roadshow flyers). Email blasts that publicized important meetings and event details were typically sent out one to two weeks in advance by the BRA to their database of customers, as well as those signed up to receive notifications about the Lower Brazos RFPG.

## **10.2 – Targeted Outreach**

## 10.2.1 Interest Group Survey

## 10.2.1.a. Interest Groups Identified

To ensure public input was received and incorporated into the Regional Flood Plan, the TWDB identified specific scope items requiring the RFPGs to engage with public officials with flood related responsibilities. For the Lower Brazos Planning Region, a survey was one of the methodologies used to fulfill this requirement and gather data upfront to characterize flooding needs and efforts.

A list of entities and individuals identified to have some flood-related authority or interest was compiled, and contact information was gathered. Public officials such as floodplain managers, city engineers, mayors, and representatives of special interest districts (such as municipal utility districts and levee improvement districts) made up the majority of the list created. Over 550 interest groups were identified to represent the 43 counties and almost 200 municipalities within the Lower Brazos Basin. Additionally, any member of the public that registered for flood planning updates through the website was added to the contact list. This list formed the target audience for the public outreach survey.



## 10.2.1.b. Survey Overview

The Technical Consultant Team developed the public outreach survey to be a comprehensive questionnaire working to identify background information, current flood risk, flood-related resources, and existing flood infrastructure within a community. *Figure 10.1Figure 10.1* shows the categories encompassed by the 65 questions included in the survey. A copy of the entire questionnaire can be found in *Appendix 10.1*.

## Figure 10.1: Stakeholder Survey Topics

Welcome
Your Info
Backgrounder
<ul> <li>Community Questionnaire</li> </ul>
Floodplain Management/Ordinances
Flood History
Floodplain Studies/Maps
Risk Reduction Alternatives
Flood Finance
Natural Resources & Condition Changes
Hazard Mitigation & Emergency Planning
<ul> <li>Existing Infrastructure</li> </ul>
Levees/Dams
Storm Drainage Systems
Roadways
Coastal
Critical Infrastructure

Some questions included opportunities for individuals to upload relevant data, including information about current floodplain management practices and ordinances, studies backing ongoing flood mitigation efforts, or documentation regarding flooding and flood infrastructure conditions in their community.

In addition to the survey provided to the interest groups, an interactive web map was available to all members of the public for input. Users could drop pins at locations where they had knowledge of flood

concerns. Comments and priority levels regarding this flooding could then be indicated, as seen in *Figure 10.2Figure 10.2*.





The survey was initially sent out by the BRA to the identified interest groups through email on June 30, 2021, with a due date extension from August 13 to August 31, 2021. However, the survey was still accessible throughout the regional flood planning process. Information was continually collected, but only submittals provided by the due date were ensured to be incorporated into the Lower Brazos Regional Flood Plan. Records were kept of submittals received past August 31, 2022 to be considered during the amendment period or future planning cycles as applicable.

## 10.2.1.c. Follow-Up Communications

Several forms of follow-up communication were utilized to boost response rates and ensure all interest groups had the opportunity to provide their feedback. The initial notification was provided through an email blast, and several email reminders were sent in the following weeks. Posts to the website and social media accounts were also used to promote the survey.

However, the greatest follow-up effort was achieved through phone calls. From July 20<sup>th</sup> to July 30<sup>th</sup>, the first round of over 350 calls was made to the identified interest groups. Every identified contact that had not yet opened the survey or responded to the survey request in some manner was identified. Individuals that had previously established relationships with members of the Halff Associates Team were contacted on a case-by-case basis. All other identified contacts were given a phone call to ensure the interest group received the email containing the survey, understood the importance and purpose of the survey, and was provided with any help needed to navigate or respond to the questionnaire. The distribution of the dates of when the calls were performed can be seen in *Figure 10.3Figure 10.3*.
Figure 10.3: First Round of Outreach Phone Calls



After this initial outreach to all interest groups that received the survey, a more targeted approach was taken. Contacts representing counties or entities with populations greater than 20,000 were targeted for another round of phone calls. These targeted entities were determined to be more likely to have the information requested by the survey easily accessible and likely have a larger impact on the characterization of the region as a whole. One hundred twenty-eight interest groups were contacted during this round. Ongoing outreach was performed throughout August and September to follow up with contacts who had previously shown interest in the regional flood planning efforts or were otherwise deemed as "promising" candidates to fill out the questionnaire or provide the team with pertinent information. A list of the representatives contacted can be found in *Appendix 10.2*.

# 10.2.1.d. Responses

The extensive outreach efforts performed gleaned 64 responses to the survey. *Figure 10.4Figure 10.4* shows the outreach extents, *Figure 10.5Figure 10.5* and shows the distribution of responses throughout the Lower Brazos Region. Although this only amounted to a 14 percent response rate, the region could be characterized by the coverage. Additionally, the density of responses in the southern portion of the basin indicated to the RFPG the higher interest and needs associated with the geographical location. *Figure 10.6Figure 10.6* and *Figure 10.7Figure 10.7* provide context on the number of counties and municipalities represented in the responses. Other respondents to the survey include representatives of management districts, river authorities, and councils of governments.



## Figure 10.4: Outreach Calls



### Figure 10.5: Survey Response Distribution







Figure 10.7: City Response Rate to Outreach



# 10.2.2 Additional Data Collection Efforts

Although the interest group survey generated some feedback, additional data needs were identified throughout the flood planning process, and targeted outreach was performed to fill these gaps. Specifically, when developing the list of flood mitigation and management projects, strategies, and evaluations, extensive data was needed to perform the required evaluations. In particular, FMPs needed associated models to adequately examine them. Due to many of the FMPs being collected through publicly available documentation found during research, the associated models were not previously provided by most of the entities. A targeted outreach effort was performed to try and obtain hydrologic and hydraulic models for potentially feasible FMPs.

Emails were sent to the associated interest groups for the identified sponsors of the collected FMPs. Nine entities were contacted in November 2021 and again in February 2022 to request modeling associated with the potentially feasible FMPs collected for their community. Out of these, three entities provided the additional information requested to develop their flood mitigation and management needs and ensure they were included within the Lower Brazos Regional Flood Plan.

# 10.3 – Lower Brazos RFPG Meetings

# 10.3.1 Pre-Planning RFPG Meetings

Pre-planning meetings were held on June 2, 2021, and June 24, 2021, to provide background on forming the RFPG and planning process. During the meetings, the RFPG also gathered suggestions and recommendations regarding issues, provisions, projects, and strategies that should be considered in developing the Regional Flood Plan. The roles and responsibilities of the RFPG and the Technical Consultant Team were conveyed to the public and are listed in *Table 10.1Table 10.1*.

# Table 10.1: Responsibilities

RFPG Responsibilities	Technical Consultant Responsibilities
Support public and stakeholder	Ensure compliance with the TWDB requirements
engagement	and schedule
Identify key communities	Guide and facilitate the
and entities	planning process
Prepare for and participate in meetings and	Facilitate public and
workshops	entity engagement
Review and provide feedback on consultant	Gather
deliverables	data/information
Approve submittal of Chapters, Technical Memo,	Conduct planning and
and Draft Regional Plan	technical analysis
Adopt and submit the	Prepare Chapters, Technical Memo, Draft Report,
Regional Flood Plan	and Final Report based on RFPG input

During the pre-planning meetings, the Halff Associates Team provided an overview of the regional flood planning expectations. The plan is not expected to solve flooding but lead to future flooding reduction.

The planning effort depends on the data and information provided by communities and entities, and no new floodplain modeling is expected. For the effort to be successful, regional participation was critical. The need for further studies or flood management evaluations to determine true flood risk throughout the Lower Brazos Planning Region was discussed by the Technical Consultant Team. Additionally, preliminary plans for stakeholder engagement through a survey were proposed and discussed.

# 10.3.2 Monthly RFPG Meetings

The Lower Brazos RFPG held monthly meetings to obtain updates from the Technical Consultant Team, led by Halff Associates, discuss potential processes and methodologies, and provide approval of components of the Draft Lower Brazos Regional Flood Plan. These meetings were open to the public and complied with TWDB Rules and the Texas Open Meetings Act. The meetings were held at the Brazos River Authority's Central Office in Waco, Texas, and simultaneously hosted through Microsoft Teams for a videoconferencing option. The Lower Brazos RFPG decided to hold meetings on the fourth Thursday of every month at 10:00 am unless they conflicted with members' schedules or holidays. *Table 10.2Table 10.2Table 10.2* summarizes the RFPG meeting date and key discussions or approvals at each monthly meeting. Meeting minutes, documents, and recordings can be accessed under the 'Meeting Archive' tab on the Lower Brazos RFPG website. The RFPG posted meeting notices and meeting materials in accordance with the Texas Open Meetings Act. The RFPG meet all the requirements of under the Texas Open Meetings Act and the Public Information Act.

Meeting Date	Key Discussion Items	Voting Items
June 24, 2021	Timeline and tasks planned for public outreach and data collection. Discussion of flooding concerns with each interest category.	N/A
July 22, 2021	Introduction and overview of Tasks 1, 2, and 3. Update on public outreach and data collection efforts.	N/A
August 26, 2021	Updates on the development of Tasks 1 and 2A. Discussion on Task 2B approach as it relates to developing future conditions. Discussion of potential public meeting locations and dates. Discussion of draft goals and standards as related to Task 3.	N/A
September 23, 2021	Discussion of adoption vs. recommendation in the development of Task 3A standards. Discussion of draft Task 3B goals. Update on Task 2B as related to the previous discussion. Introduction to Task 4B.	N/A
October 28, 2021	Discussion of the evaluation process, sources, and benefit areas related to Task 4B. Updates on Tasks 1, 2, and 10.	Approval of Task 3A Standards and 3B Goals.

## Table 10.2: Summary of Lower Brazos RFPG Meetings

LOWER BRAZOS REGIONAL FLOOD PLANNING GROUP REGION 8

Meeting Date	Key Discussion Items	Voting Items
November 16, 2021	Updates on Tasks 1, 2, 3, 4A, and 4C.	Approval of Task 4B Identification and Evaluation Process.
December 14, 2021	Discussion on public outreach meeting locations and dates. Discussion on existing conditions analyses as related to Task 2A. Agreement with Task 2B approach provided.	Approval of Technical Memorandum for submittal.
January 27, 2022	Introduction and overview of Task 5. Discussion of meeting materials, dates, attendees, and locations for public meetings. Updates on Task 2A and emergency need definition as related to Task 4B. Discussion of Water Supply and Flood Control interactions as related to Task 6.	N/A
February 24, 2022	Discussion of Technical Memorandum Addendum and related Task 2. Discussion of emergency needs definition as related to Task 4B. Updates and introductions of Tasks 1, 6, 7, 8, and 10.	Approval of Technical Memorandum Addendum for submittal.
March 24, 2022	Discussion of Task 3 report. Discussion of Task 5 evaluation and recommendation process. Updates on Tasks 6, 7, 8, and 10.	N/A
April 28, 2022	Public Roadshow Meetings recap and review of Task 2 report. Discussion of Task 5 evaluation and recommendation process. Presentation and discussion of preliminary Task 4A results.	N/A
May 26, 2022	Update on Tasks 4A, 8, and 9. Discussion of Flood Control and Water Supply interaction as related to Task 6.	Approval of Task 5 Flood Management Evaluation (FME), Flood Management Strategy (FMS), and Flood Mitigation Project (FMP) Recommendations.
June 23, 2022	Comments on chapters 1 through 10 of the Regional Flood Plan. Discussion on Task 8 recommendations.	N/A
July 21, 2022	Draft Regional Flood Plan.	Approval of the Draft Regional Flood Plan.
September 22, 2022	Opportunity for public to provide comments on the Draft Plan. Discussion of potential uses of Amendment Tasks (12 and 13).	N/A

LOWER BRAZOS REGIONAL FLOOD PLANNING GROUP REGION 8

Meeting Date	Key Discussion Items	Voting Items
October 28, 2022	Discussion of comments received on Draft Regional Flood Plan. Discussion of potential uses of Amendment Tasks (12 and 13).	Approval of Task 4 and 5 FME, FMS, and FMP lists to include changes due to public comment. Approval of FMEs to be carried out under Task 12.
December 13, 2022	Discussion of comments received on Draft Regional Flood Plan and major resulting changes. Update on Tasks 12 and 13 progress.	Approval of Task 4 and 5 FME, FMS, and FMP lists to include changes due to public and TWDB comments. Approval of budget adjustments. Adoption of Lower Brazos Regional Flood Plan.
January 26, 2023	Discussion of submittal of Final Lower Brazos Regional Flood Plan to TWDB. Update on Tasks 12 and 13 progress.	Approval of Carl Burch as voting member of RFPG representing Electric Generating Utilities. Nominations and approvals of RFPG member positions.
March 23, 2023	Updates on Tasks 12 and 13 progress. Discussion of 1 square mile FMP restriction.	N/A
April 27, 2023	Discussion of comments received from TWDB on Final Lower Brazos Regional Flood Plan. Discussion of formation of a Technical Committee.	N/A
May 4, 2023	Discussion on additional criteria to evaluate and recommend FMPs with drainage areas less than 1 square mile.	N/A
May 25, 2023	Discussion and acceptance of Technical Committee recommendations. Discussion of Task 12 and 13 preliminary results.	Approval of FMS, FME, and FMP lists to include additional entries based on Task 12 efforts and submittals received from public.
June 22, 2023	Discussion of Amended Lower Brazos Regional Flood Plan.	Adoption of Amended Lower Brazos Regional Flood Plan.

# **10.4 – Coordination with Other Planning Regions**

# **10.4.1** Summary of Coordination Efforts

# 10.4.1.a. TWDB Regional Team Calls

Throughout the regional flood planning process, TWDB held regional calls on a quarterly basis with the RFPG Chairs, Technical Consultants and RFPG Sponsors. These virtual meetings were facilitated by TWDB's Director of Flood Planning and Manager of Regional Flood Planning, on a quarterly basis to provide additional guidance and allow time for questions and discussion between the regions and TWDB. In addition, TWDB held regional calls prior to the submittal deadlines for the RFPG Technical

Memorandum, RFPG Technical Memorandum Addendum and Draft Regional Flood Plans to address questions and facilitate discussion between the regions. There was also significant coordination between the regions on utilized approaches and datasets that helped identify solutions to problems encountered throughout the state.

# 10.4.1.b. Meeting Agenda

The Lower Brazos RFPG selected by nomination voting members to serve as liaisons with adjacent regions and a coastal liaison. During the monthly Lower Brazos RFPG meetings, liaisons provided updates on the progress of those regions. These updates helped facilitate discussions concerning timelines and different approaches across the regions. In addition, it allowed the Lower Brazos RFPG members to express concerns over inequities experienced between different areas within the region, allowing for Technical Consultant Team to consider different methodologies.

## 10.4.2.c. Other Coordination

In addition to the previously mentioned official avenues of coordination, many regions had ongoing communication to facilitate the flood planning process. With the regional flood planning effort in its inaugural cycle, there was the prevailing discussion over how to best execute the scope of work provided by the TWDB. Coordination was key to ensuring the Regional Flood Plans could be combined into a cohesive State Flood Plan.

One particular cause for communication was the overlap between neighboring regions. Some entities, strategies, and evaluations spanned more than one region. Coordination was required to ensure they were treated equitably between the regions, and the information provided was considered appropriate. Several flood mitigation and management need initially identified for potential inclusion in the Lower Brazos Regional Flood Plan were determined to have a greater impact on neighboring regions. As discussed in Chapter 4, these were provided to the applicable neighboring regions.

# 10.5 – Public Roadshow

The Lower Brazos RFPG held five public roadshow meetings throughout the basin during late March 2022 and early April 2022. The purpose of these meetings was to inform the public on the current progress of regional flood planning for the Lower Brazos Planning Region and to gather feedback on the information included in the Draft Lower Brazos Regional Flood Plan.

# 10.5.1 Meeting Locations and Format

The Lower Brazos Basin was divided into four subregions for the public roadshow: (1) Upper Basin, (2) Upper to Mid Basin, (3) Mid to Lower Basin, and (4) Lower Basin. One public meeting was held within each subregion except for the Upper to Mid Basin area. Two public meetings were scheduled in this subregion, with the initial one being held following the March RFPG meeting at the Brazos River Authority's Central Office in Waco (reference *Figure 10.8Figure 10.8*). Also, the criteria for selecting the meeting sites included not overlapping with the outreach efforts of the Texas General Land Office combined River Base Flood Study for the Western Region, being available for use without a fee, and

having a space large enough to accommodate approximately 50 attendees along with having the necessary presentation equipment.

#### Figure 10.8: Public Roadshow Meetings



The public roadshow meetings were designed to have an open house format, allowing the public to 'come and go' depending on their schedule. Each of the five meetings had the same information presented at the beginning of the meeting, including a welcome provided by the RFPG Chair, Vice-Chair, or RFPG Voting Member. The presentation included an overview of the Lower Brazos RFPG, the TWDB planning process, and the timeline for completing the First State Flood Plan. An interactive workshop was held following the initial presentation to allow the meeting attendees an opportunity to visit with the Halff Associates Team and the TWDB staff and provide feedback at each of the following meeting stations:

- Station 1: The TWDB State and Regional Flood Planning Process
- Station 2: Lower Brazos Regional Flood Plan Goals and Practices
- **Station 3:** Draft Flood Risk Maps for the Lower Brazos Region (laptop computer provided at this station)
- Station 4: Draft FMEs, FMPs, and FMSs identified for the Lower Brazos Region

Questions and answers from the initial presentation were addressed at the four meeting stations. Also, a half-page handout that listed the Lower Brazos RFPG website and email address was provided to the attendees at the sign-in table at each meeting location (reference copy of meeting handout in *Appendix 10.4*). Copies of the presentation slides were posted on the Lower Brazos RFPG website in advance of each public meeting. In addition, phone calls were made before each meeting to key interest groups to encourage their attendance. *Appendix 10.5* provides a copy of the roadshow presentation. *Appendix 10.6* provides the attendance lists for each meeting location.

# 10.5.2 Meeting Recap

# 10.5.2.a. Waco Meeting

The roadshow was kicked off with the first open house meeting following the Lower Brazos RFPG meeting from 1:00 to 3:00 pm on March 24, 2022, at the Brazos River Authority's Central Office in Waco. Eleven members of the public attended the open house, representing Bell, Coryell, Falls, and McLennan Counties, as well as the Cities of Harker Heights, Hillsboro, and Robinson. The TWDB Project Manager, Lower Brazos RFPG Chair, other RFPG Voting Members, Brazos River Authority, and the Halff Associates Team attended the meeting. The primary feedback from the attendees focused on the availability of future flood infrastructure funding and specific FMPs listed in the draft plan.

# 10.5.2.b. Granbury Meeting

The second open house meeting was held in the Upper Basin in the City of Granbury at the Hood County Annex Building on March 29, 2022, from 4:00 to 6:00 pm. This meeting had 11 members of the public in attendance, representing Hood County and the City of Granbury. The TWDB Project Manager, Lower Brazos RFPG Chair, Brazos River Authority, and the Technical Consultant Team led by Halff Associates also attended the meeting. The primary feedback included adding a freeboard recommendation to the Lower Brazos RFPG goals and standards as guidance for engineering designers.

# **10.5.2.c.** Georgetown Meeting

The third open house meeting was held in the Upper to Mid Basin area in the City of Georgetown at the Williamson County Engineer's Office on March 30, 2022, from 4:00 to 6:00 pm. Only two members of the public attended the meeting, both from Williamson County. The TWDB Project Manager, Regional Flood Planning Manager, Lower Brazos RFPG Chair, other RFPG Voting Members, Brazos River Authority, and the Technical Consultant Team led by Halff Associates also attended the meeting. The primary feedback from Williamson County was the interest in consistent regional floodplain regulations.

# 10.5.2.d. College Station Meeting

The fourth open house meeting was held in the Mid to Lower Basin in the City of College Station at the Carter Creek Wastewater Facility Training Room on April 5, 2022, from 4:00 to 6:00 pm. A picture of the meeting attendees can be seen in *Figure 10.9Figure 10.9*. This meeting had our largest turnout of 40 members of the public in attendance, representing the Lake Limestone Property Association, Navasota River residents, SLC Water Supply Corporation, Fort Bend County Drainage District, Texas A&M University, and the Cities of Bryan and College Station. The TWDB Project Manager and Director of Flood Planning, Lower Brazos RFPG Vice-Chair, Brazos River Authority, and the Technical Consultant Team led by Halff Associates also attended the meeting. The primary feedback from the attendees focused on the concern of future projects impacting releases from Lake Limestone. The attendees also recommended including an FMS to fund drainage maintenance throughout the basin to address localized flooding issues.



### Figure 10.9: College Station Roadshow Meeting



## 10.5.2.e. Rosenberg Meeting

The final open house meeting was held in the Lower Basin in the City of Rosenberg at the Rosenberg Civic Center on April 7, 2022, from 4:00 to 6:00 pm. This meeting had a large turnout of 30 members of the public in attendance, representing Fort Bend County, Fort Bend County Drainage District, Angleton Drainage District, Velasco Drainage District, Fort Bend EDC, Fort Bend County MUD No. 25, Fort Bend County Levee Improvement Districts (#2, 6, 10, 11, 14, 19), Bayou Park, and the City of Sugar Land. The TWDB Project Manager, Lower Brazos Voting Members, Brazos River Authority, and the Technical Consultant Team led by Halff Associates also attended the meeting. The common theme of the feedback received from the attendees focused on extensive erosion issues along the banks of the Brazos River.

# 10.6 – Public Hearing and Responses to Public Comments on the Draft Regional Flood Plan and Amended Plan

The Lower Brazos RFPG held a public hearing on September 22, 2022, to receive comments from the public on the Draft 2023 Lower Brazos Regional Flood Plan. The public comment process included 60 days centered around the public hearing date to allow the public to review and comment on the Draft Lower Brazos Regional Flood Plan. During the 60-day comment period, the draft Regional Flood Plan was available for the public to view on the Lower Brazos RFPG website. Hard copies of the draft plan were

also available for the public to review in person at three publicly accessible locations, Hood County Library, Sugar Land Branch Library, and Taylor Public Library. The hard copies were available within the region for 30 days before and also 30 days after the public hearing date.

A copy of the sign-in sheets, verbal/written comments received during the public hearing and public comment process, and the corresponding responses from the Lower Brazos RFPG are provided in *Appendix 10.7* for reference. Comments from the public on the Draft Regional Flood Plan were closed out during the Lower Brazos RFPG meeting on October 27, 2022. Afterward, the public comments were addressed, incorporated into the Final Regional Flood Plan, and adopted by the Lower Brazos RFPG.

After the submittal of the Final Regional Flood Plan, several communities provided the Lower Brazos RFPG with additional FMXs for consideration. These comments were addressed, incorporated into the Amended Regional Flood Plan, and adopted by the Lower Brazos RFPG. The comments received from the public are included in *Appendix 10.8* for reference.

# **10.7 – Responses to the TWDB Comments on Regional Flood** Plan

The Lower Brazos RFPG submitted the Draft Regional Flood Plan to the TWDB by August 1, 2022, to initiate the TWDB staff review. Following the public hearing on September 22, 2022, the TWDB provided review comments to be addressed by the Lower Brazos RFPG and Technical Consultant Team on October 21, 2022. A copy of the review comments received from the TWDB staff is provided in *Appendix 10.7* for reference. Comments received from the TWDB staff on the Draft Regional Flood Plan were addressed, incorporated into the Final Regional Flood Plan, and adopted by the Lower Brazos RFPG.

The Lower Brazos RFPG submitted the Final Regional Flood Plan to the TWDB by January 10, 2023<del>, to initiate the TWDB staff review.</del> The TWDB provided review comments to be addressed by the Lower Brazos RFPG and Technical Consultant Team on March 29, 2023. A copy of the comments received form the TWDB staff is provided in *Appendix 10.8* for reference. Comments received from the TWDB staff on the Final Regional Flood plan were addressed and, incorporated into the Amended Regional Flood Plan, and adopted by the Lower Brazos RFPG..

# 10.8 – Plan Adoption

The Lower Brazos RFPG formally adopted the Final 2023 Lower Brazos Regional Flood Plan on December 13, 2022 and directed the Brazos River Authority and Technical Consultant Team to submit the Final Regional Plan to the TWDB on or before January 10, 2023.

The Lower Brazos RFPG formally will consider the adopted adoption of the Amended Lower Brazos Regional Flood Plan on June 22, 2023 and potentially directed the Brazos River Authority and Technical Consultant Team to submit the Amended Regional Plan to the TWDB on or before July 14, 2023. An index of the changes made during the amendment process are provided in *Appendix 10.9* for reference.

# **10.9 – Conformance with Title 31 TAC §362.3 Guidance** Principles

In accordance with Title 31 TAC §361.20, the Lower Brazos Regional Flood Plan conformed with the guidance principles established in Title 31 TAC §362.3. The Lower Brazos RFPG performed a No Negative Impact assessment for each potentially feasible FMP and FMS. Those that had, or appeared to have, a potential negative impact was removed from further consideration and was not included as recommended FMPs or FMSs in the draft or final regional flood plan. Implementation of the regional flood plan would not negatively impact a neighboring area and would adequately provide for the preservation of life and property. *Table 10.3Table 10.3* includes a list of the 39 regional flood planning principles and where they are addressed in this plan.

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
1	shall be a guide to state, regional, and local flood risk management policy	Incorporated throughout the regional flood planning process
2	shall be based on the best available science, data, models, and flood risk mapping	Included in <i>Chapters 2, 4, 5, 6</i> , and <i>9</i>
3	shall focus on identifying both current and future flood risks, including hazard, exposure, vulnerability and residual risks; selecting achievable flood mitigation goals, as determined by each RFPG for their region; and incorporating strategies and projects to reduce the identified risks accordingly	Included in <i>Chapters 2, 3, 4,</i> and 5
4	shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2 percent annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historic flood events	Included in <i>Chapter 2</i>
5	shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0 percent annual chance flood event (the 100-year flood) and address, through recommended strategies and projects, the flood mitigation goals of the RFPG (per item 2 above) to address flood events associated with a 1.0 percent annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historic flood events	Included in <i>Chapters 2, 3,</i> and 5; <i>TWDB-Required Tables 15, 16,</i> and <i>17</i>

## Table 10.3: Conformance with Title 31 TAC §362.3

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
6	shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk	Included in <i>Chapter 3</i>
7	shall consider future development within the planning region and its potential to impact the benefits of flood management strategies (and associated projects) recommended in the plan	Included in <i>Chapters 2, 3, 4,</i> and 5
8	shall consider various types of flooding risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, flash flooding, and coastal flooding, including relative sea level change and storm surge	Included in <i>Chapters 2, 4, 5,</i> and 7
9	shall focus primarily on flood management strategies and projects with a contributing drainage area greater than or equal to 1.0 (one) square miles except in instances of flooding of critical facilities or transportation routes or for other reasons, including levels of risk or project size, determined by the RFPG	Included in <i>Chapter 5</i> and <i>TWDB</i> - <i>Required Tables 15, 16,</i> and 17
10	shall consider the potential upstream and downstream effects, including environmental, of potential flood management strategies (and associated projects) on neighboring areas. In recommending strategies, RFPGs shall ensure that no neighboring area is negatively affected by the regional flood plan	Included in <i>Chapters 4, 5,</i> and <i>6</i>

#### LOWER BRAZOS REGIONAL FLOOD PLANNING GROUP REGION 8

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
11	shall include an assessment of existing, major flood mitigation infrastructure and will recommend both new strategies and projects that will further reduce risk, beyond what existing flood strategies and projects were designed to provide, and make recommendations regarding required expenditures to address deferred maintenance on or repairs to existing flood infrastructure	Included in <i>Chapters 2</i> and 5 and TWDB-Required Tables 1, 16, and 17
12	shall include the estimate of costs and benefits at a level of detail sufficient for RFPGs and sponsors of flood mitigation projects to understand project benefits and, when applicable, compare the relative benefits and costs, including environmental and social benefits and costs, between feasible options	Included in <i>Chapters 4</i> and 5 and <i>TWDB-Required Tables 12, 13, 14,</i> <i>15, 16,</i> and <i>17</i>
13	shall provide for the orderly preparation for and response to flood conditions to protect against the loss of life and property and reduce injuries and other flood-related human suffering	Included in <i>Chapter 7</i>
14	shall provide for an achievable reduction in flood risk at a reasonable cost to protect against the loss of life and property from flooding	Included in <i>Chapters 5</i> and <i>9</i> and <i>TWDB-Required Tables 15, 16, 17,</i> and <i>19</i>
15	shall be supported by state agencies, including the TWDB, General Land Office, Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, Texas Parks, and Wildlife Department, and the Texas Department of Agriculture, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources	Held conference calls as appropriate and shared data and files with these agencies and others upon request.
16	shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits	Included in <i>Chapters 5</i> and <i>6</i>

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17	shall include strategies and projects that provide for a balance of structural and nonstructural flood mitigation measures, including projects that use nature-based features, that lead to long-term mitigation of flood risk	Included in <i>Chapters 4</i> and 5 and <i>TWDB-Required Tables 13, 14, 16,</i> and <i>17</i>
18	shall contribute to water supply development where possible	Discussed in <i>Chapter 6</i>
19	shall also follow all regional and state water planning guidance principles (31 TAC 358.3) in instances where recommended flood projects also include a water supply component	Discussed in <i>Chapter 6</i>
20	shall be based on decision-making that is open to, understandable for, and accountable to the public with full dissemination of planning results except for those matters made confidential by law	Included in <i>Chapter 10</i>
21	shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation	Included in <i>Chapter 10</i> ; bylaws are available on the RFPG website
22	shall include flood management strategies and projects recommended by the RFPGs that are based upon identification, analysis, and comparison of all flood management strategies the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals	Included in <i>Chapter 5</i> and <i>TWDB-</i> <i>Required Tables 16</i> and <i>17</i>
23	shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals	Included in <i>Chapter 3</i> and <i>TWDB-</i> <i>Required Tables 6</i> and <i>10</i>
24	shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services	Included in <i>Chapters 1, 3, 4,</i> and 5
25	shall be consistent with the National Flood Insurance Program (NFIP) and shall not undermine participation in nor the incentives or benefits associated with the NFIP	Included in <i>Chapter 3</i> and <i>TWDB-</i> <i>Required Table 6</i>
26	shall emphasize the fundamental importance of floodplain management policies that reduce flood risk	Included in <i>Chapter 3</i> and <i>TWDB-</i> <i>Required Table 6</i>

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27	shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains	Included in <i>Chapter 5</i> and <i>TWDB-</i> <i>Required Table 16</i>
28	shall not cause long-term impairment to the designated water quality as shown in the state water quality management plan as a result of a recommended flood management strategy or project	Included in <i>Chapter 6</i>
29	shall be based on identifying common needs, issues, and challenges; achieving efficiencies; fostering cooperative planning with local, state, and federal partners; and resolving conflicts in a fair, equitable, and efficient manner	Included in <i>Chapters 3, 8,</i> and 10
30	shall include recommended strategies and projects that are described in sufficient detail to allow a state agency making a financial or regulatory decision to determine if a proposed action before the state agency is consistent with an approved regional flood plan	Included in <i>Chapters 5</i> and <i>9</i> and <i>TWDB-Required Tables 15, 16, 17,</i> and <i>19</i>
31	shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction	Included in <i>Chapter 1</i> and <i>TWDB-</i> <i>Required Table 2</i>
32	shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property	Included in <i>Chapter 8</i>
33	shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals	Included in <i>Chapters 1, 3, 5, 9,</i> and 10 and TWDB-Required Tables 16 and 17
34	shall be in accordance with all existing water rights laws, including but not limited to Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties	Included in <i>Chapter 6</i>
35	shall consider protection of vulnerable populations	Included in <i>Chapters 1</i> and 5 and TWDB-Required Tables 3, 13, and 16

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
36	shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation as appropriate	Included in <i>Chapter 6</i>
37	shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards	Discussed in <i>Chapter 6</i>
38	shall consider how long-term maintenance and operation of flood strategies will be conducted and funded	Discussed in <b>Chapters 4</b> and <b>6</b>
39	shall consider multi-use opportunities such as green space, parks, water quality, or recreation, portions of which could be funded, constructed, and or maintained by additional third-party project participants	Included in <i>Chapters 5, 6, 8,</i> and <i>9</i>