

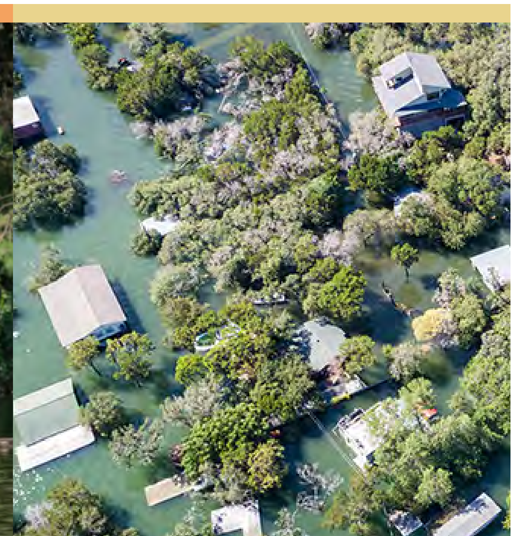

2023

LOWER COLORADO-LAVACA REGIONAL FLOOD PLAN

Lower Colorado-Lavaca
REGIONAL FLOOD PLANNING GROUP
REGION 10

Submitted by the Lower Colorado-Lavaca Regional Flood Planning Group to the Texas Water Development Board | July 2023

Members of Lower Colorado-Lavaca Regional Planning Group (Region 10)

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Vice Chair:	Ann Yakimovicz
Secretary:	Kelly Payne, P.E.
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Lower Colorado-Lavaca
REGIONAL FLOOD
PLANNING GROUP
REGION 10

Lower Colorado-Lavaca Regional Flood Plan

November 2023

Prepared for:

Texas Water Development Board

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Lower Colorado-Lavaca Regional Flood Planning Group (Region 10)

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Executive Summary

Source: Lower Colorado River Authority

In 2019, the Texas Legislature enacted Senate Bill 8 directing the creation of the first-ever State Flood Plan to be prepared by the Texas Water Development Board (TWDB) and to follow a similar regional "bottom-up" approach that has been used for water supply planning in Texas for more than 20 years. As outlined by the Texas Water Code, the purpose of the regional and state flood plans is to:

- provide for orderly preparation for and response to flood conditions to protect against the loss of life and property
- guide state and local flood control policy
- contribute to water development, where possible

As depicted in *Figure ES.1*, adopted Regional Flood Plans (RFP) are to be submitted to the TWDB by January 10, 2023. Subsequently, regional flood plans will be amended to incorporate any new or additional information by July 14, 2023. Regional Flood Plans will then be used to prepare the first State Flood Plan for adoption by TWDB by September 1, 2024. Regional and state flood plans are to be updated every five years.

Figure ES.1 TWDB Timeline

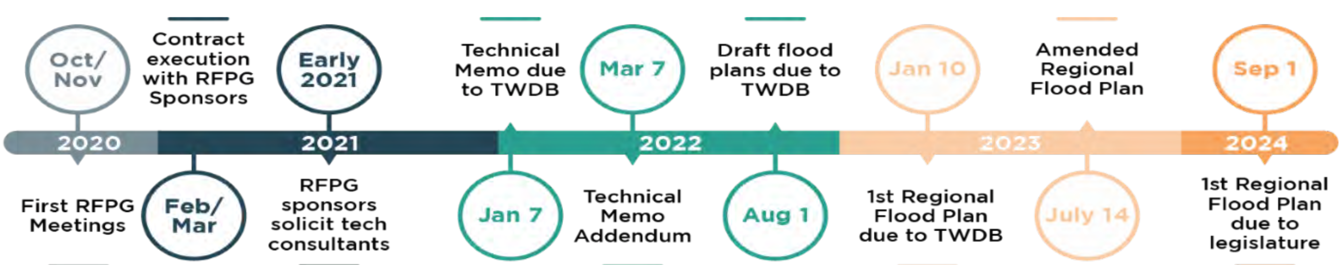
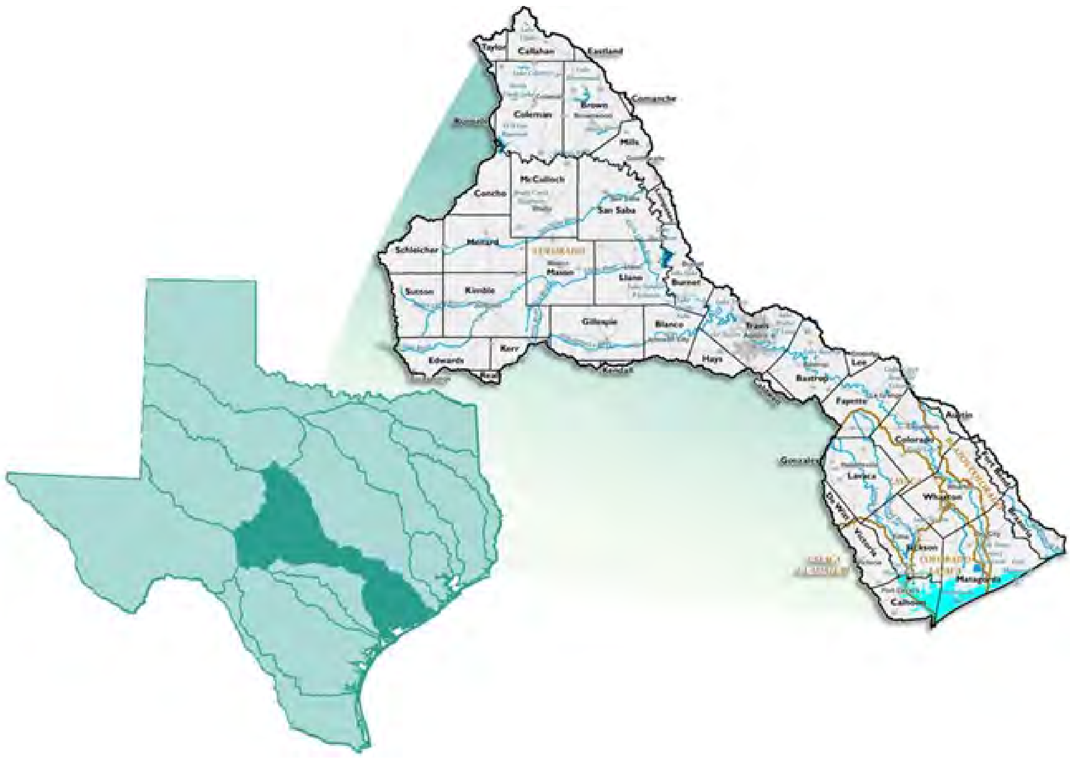


Figure ES.2 shows the river basin delineations of the 15 flood planning regions established by the TWDB, as well as the boundaries (dark green) of the Lower Colorado-Lavaca Flood Planning Region enlarged to show its 43 counties. The TWBD has also designated the region as Region 10. The region encompasses the Lower Colorado, Lavaca, and San Bernard River Basins, an area of more than 24,000 square miles, and nearly 55,000 miles of streams. A few "quick facts" about the region are presented in *Figure ES.3*.

Figure ES.2 Lower Colorado-Lavaca Flood Planning Region



Who is Preparing the Regional Flood Plans?

Early in implementing the regional flood planning process, the TWDB established and convened Regional Flood Planning Groups (RFPG) for each of the 15 regions. The Regional Flood Planning Group's responsibilities include directing technical consultants' work, soliciting and considering public and stakeholder input, identifying specific flood risks, and identifying, evaluating, and recommending flood management studies, strategies, and projects to reduce flood risk. To ensure a diversity of perspectives throughout the planning process, the TWDB appointed RFPG members representing 11 interest groups:

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

The TWDB has administered the regional flood planning process through a contractual relationship with a sponsor selected by the RFPG, the Lower Colorado River Authority (LCRA). LCRA's role as the sponsor is to provide administrative and logistical support for RFPG meetings and required public meetings, to develop and manage the RFPG's website, to administer a contract with the project technical consultant team, and administer grant funds provided by the TWDB for the regional flood planning process.

Figure ES.3 Quick Facts – Lower Colorado-Lavaca Flood Planning Region

43 Counties **92 Municipalities** a portion of each are included in this basin	**24,380** **square miles** total area of the region	**54,550** **stream miles** total stream mileage in the region	**1.9 to 2.9** **million people** projected 2020 to 2050 population in the region
50 **federal disasters** 1953-2020 flood related federal disasters	**6 emergency** **declarations** 1953-2020 flood related declarations	**$4 billion/year** **crop damages** 2011-2021 crop average annual losses	**$1.2 billion/year** **property damages** 2011-2021 average annual losses

Regional Flood Planning Tasks

The TWDB rules, scope-of-work, and technical guidelines for regional flood planning prescribe a process consisting of 13 tasks, as outlined in *Table ES.1*.

Table ES.1 Regional Flood Planning Tasks

Task	Description
1	Planning Area Description
2	Existing and Future Condition Flood Risk Analysis
3	Floodplain Management Practices and Flood Mitigation and Floodplain Management Goals
4	Flood Mitigation Needs Analysis and Identification and Evaluation of Potential Flood Management Evaluations (FMEs), Potentially Feasible Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs)
5	Recommendation of FMEs and FMSs and Associated FMPs
6	Impacts of Regional Flood Plan and Contributions to and Impacts on Water Supply Development and the State Water Plan
7	Flood Response Information and Activities
8	Administrative, Regulatory, and Legislative Recommendations
9	Flood Infrastructure Financing Analyses
10	Public Participation and Plan Adoption
11	Outreach and Data Collection to Support Tasks 1 – 9
12	Identified Flood Management Evaluations, Identified, Evaluated, and Recommend Additional Flood Mitigation Projects
13	Preparation and Adoption of an Amended Regional Flood Plan

The results of the regional flood planning process for the Lower Colorado-Lavaca Region – key findings and recommendations - are reported in this Regional Flood Plan in 10 chapters, each corresponding to the first 10 tasks listed above. Because of its importance to the entire regional flood planning process, from start to finish, public outreach and engagement activities performed under Task 10 are discussed first.

Public Outreach and Engagement

From the beginning to the conclusion of the regional flood planning process, public and entity outreach, and engagement have been a high priority of the Lower Colorado-Lavaca RFPG. This has included how the Lower Colorado-Lavaca RFPG meetings have been conducted; the development and maintenance of a robust and user-friendly website (LowerColoradoLavacaFlood.org); an online survey to gather information from the public and local entities; the use of e-mail blasts, social media, and press releases to notify the public and local entities of upcoming RFPG meetings and the availability of draft documents for review; and direct outreach to local entities, particularly to local sponsors of Flood Management Evaluations (FME) and Strategies (FMS) and Flood Mitigation Projects (FMP).

The Lower Colorado-Lavaca RFPG convened its first meeting in November 2020, at which time it elected a chairperson, a vice-chairperson, a secretary, and two additional RFPG members to serve on an Executive Committee. At its December 2021 meeting, the RFPG established a Technical Committee to review, on behalf of the full RFPG, potential FMEs, FMPs, and FMSs for possible inclusion as recommendations in the Regional Flood Plan. Five members of the RFPG were selected to serve on the committee.

All meetings of the Lower Colorado-Lavaca RFPG have been conducted following the requirements of the Texas Open Meetings Act (Chapters 551 and 552, Government Code), the Public Information Act, COVID-related disaster proclamations issued by Governor Abbott, and the RFPG's bylaws. Throughout the planning process, all RFPG meetings have been convened either virtually via the Zoom webinar platform or in a hybrid (virtual and in-person) format. At each meeting since February 2021, the RFPG has provided two opportunities for public comment, one at the beginning of the meeting and the other at the conclusion.

The LCRA has been responsible for posting all meetings of the RFPG and its committees following the Texas Open Meetings Act requirements. The LCRA also distributes agendas and meeting materials via e-mail to all voting and non-voting RFPG members, as well as to any person or entity who has requested notice of RFPG meetings and activities.

Key Findings and Recommendations

An overview of key findings and recommendations included in this Regional Flood Plan follows:

Existing and Future Flood Risk, Exposure, and Vulnerability

Assessment of flood risk is a critical early step in the regional flood planning process. The objective is to identify flood hazard areas within the Lower Colorado-Lavaca Region and assess the exposure and vulnerability of people, property, critical facilities, and public infrastructure under both existing and future conditions. This three-part analytical process is represented below in *Figure ES-4*.

Figure ES.4 Flood Risk Analysis Framework

Perform existing and future condition **flood hazard analyses** to determine the location and magnitude of both the 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events

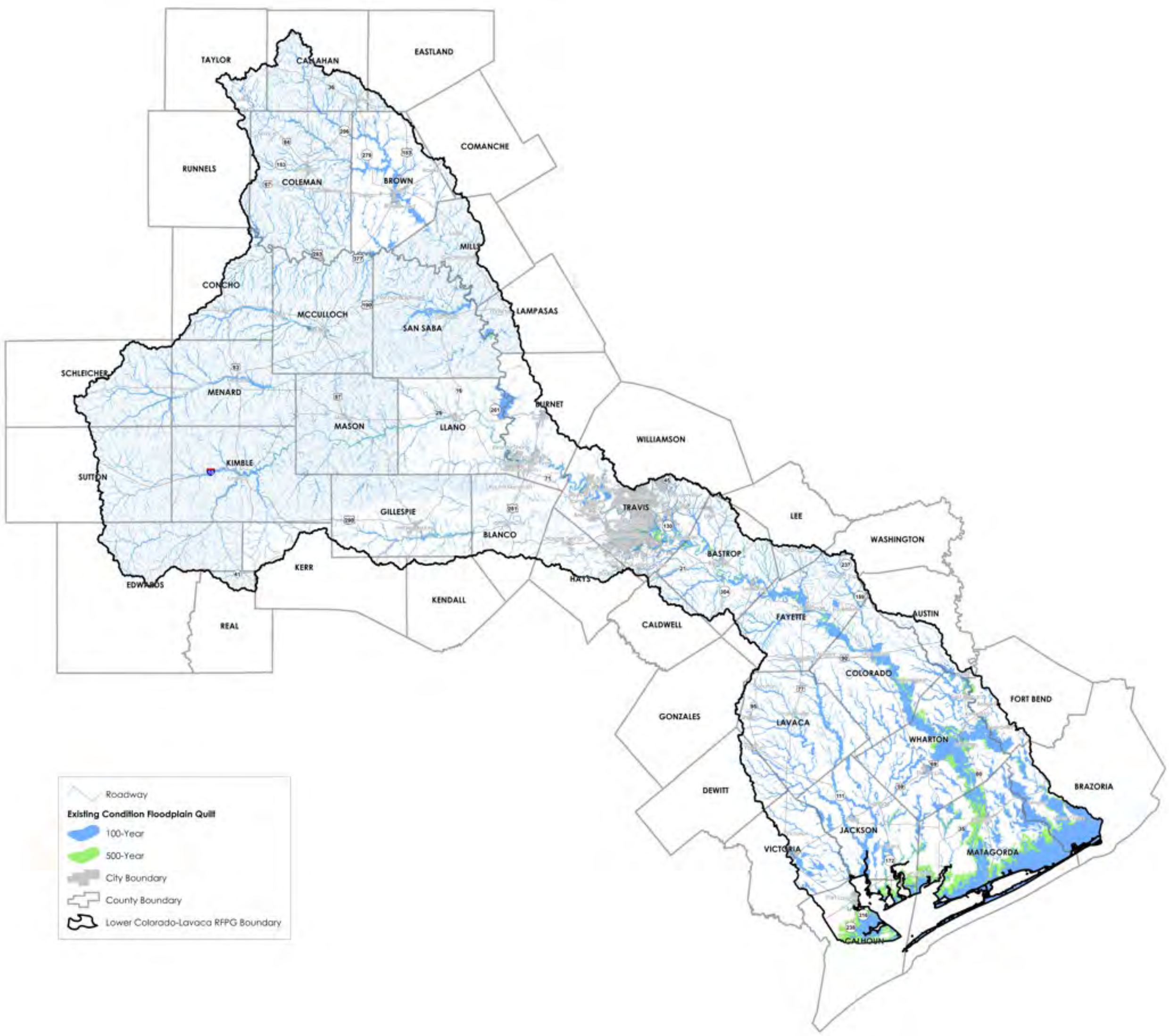
Develop existing and future condition **flood exposure analyses** to identify who and what might be harmed by both 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events

Perform existing and future condition vulnerability analyses to identify vulnerability of communities and critical facilities

A key step in analyzing current and future flood risk was to assemble a "floodplain quilt" for the region. This analysis was performed for both the 1 percent annual chance flood (100-year) and the 0.2 percent annual chance flood (500-year). The floodplain quilt combines data layers from the Federal Emergency Management Agency (FEMA), including effective floodplain maps, preliminary maps, base level elevation (BLE) maps, and other federal agencies. Data and information from local and sub-regional flood studies were also used to develop quilt "patches." Any remaining gaps in the floodplain quilt were filled using the cursory floodplain dataset provided by the TWDB. The RFPG ultimately assembled the existing condition floodplain quilt using the data source hierarchy outlined below. The resultant floodplain quilt is displayed in *Figure ES.5*.

1. Local Studies
2. FEMA National Flood Hazard Layer
    - Pending and Preliminary Data
    - Effective Data for Detailed Study Areas (Zone AE, AO, AH, and VE)
3. Base Level Engineering
4. National Flood Hazard Layer
    - Effective Data for Approximate Study Areas (Zone A and V)
5. Cursory Floodplain Data

Figure ES.5 Existing Condition Flood Hazard Map



The exposure analysis for the Lower Colorado-Lavaca Region considered floodplain areas, buildings including residential and non-residential properties, populations, critical facilities, and public infrastructure, including industrial and power generating facilities, roadways, and agricultural areas within the region. *Table ES.2* displays the results of the exposure analysis for the region for the existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance flood events.

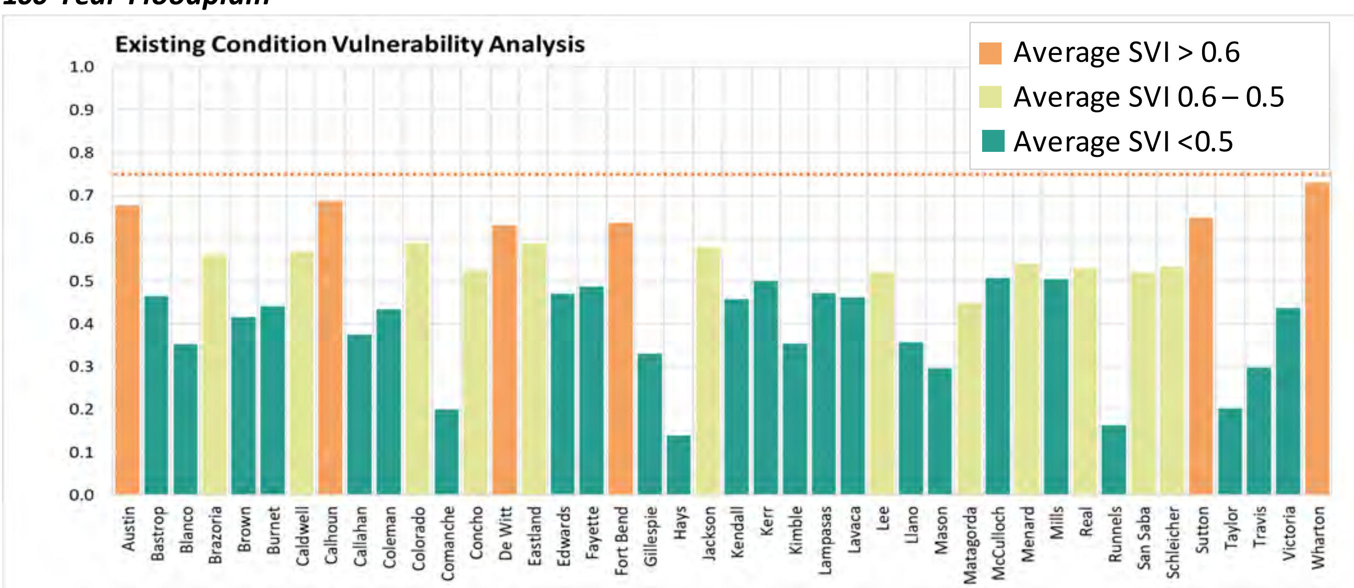
The number of buildings and associated population exposure to flood hazards are likely less than estimated. The estimated exposure identified building footprints and associated populations located within floodplain boundaries regardless of building elevations.

Table ES.2 Summary of Existing Condition Exposure in the Lower Colorado-Lavaca Region

Exposure Category	1% (100-year) Floodplain	0.2% (500-year) Floodplain	Difference
Floodplain Area (square miles)	4,515	5,238	+723
Buildings	67,824	102,301	+34,477
Residential Structures	*45,799*	*71,243*	*+25,444*
Non-Residential Structures	*22,025*	*31,058*	*+9,033*
Population (All Buildings)	149,830	244,664	+94,834
Critical Facilities	99	158	+59
Industrial and Power Generating Facilities	*12*	*18*	*+6*
Roadway Low Water Crossings	1,109	1,132	+23
Roadway Segments (miles)	2,374	3,285	+911
Area of Agriculture (square miles)	3,544	4,154	+610

The third component of the existing conditions analysis is the consideration of the social vulnerability of communities in the region in terms of the potential negative impacts of flooding. The 2018 Social Vulnerability Index (SVI) data developed by the United States Centers for Disease Control and Prevention (CDC) assessed social vulnerabilities within the Lower Colorado-Lavaca Region. Social vulnerability is the measure of the capacity of a community to weather, resist, or recover from the impacts of a hazard in the long and short term. SVI values between 0.75 and 1 denote populations with high vulnerability. *Figure ES.6* shows the SVI results associated with structures within the existing condition 1 percent annual chance (100-year) floodplain. Austin, Calhoun, De Witt, Fort Bend, Sutton, and Wharton counties all have a mean SVI of over 0.6. All but Sutton County are located in the lower third of the Lower Colorado-Lavaca Region.

Figure ES.6 Existing Condition Vulnerability Analysis for Exposed Buildings and Critical Facilities in the 100-Year Floodplain



The existing condition flood risk analysis also served as the basis for assessing potential future flood risk conditions in the Lower Colorado-Lavaca Region. This is a characterization of future conditions for the planning area based on a "no-action" scenario of approximately 30 years of continued development and population growth under current development trends and patterns, existing flood regulations and policies, as well as anticipated climate and land use changes. To project potential future conditions for a no-action scenario, a floodplain quilt was developed for the region using the following methods:

- Utilize the existing condition 0.2 percent annual chance (500-year) floodplain as a proxy for the potential future condition 1 percent annual chance (100-year) floodplain
- Estimate the potential future condition 0.2 percent annual chance (500-year) floodplain using a horizontal buffer based on the measured difference (delta) between the existing condition 1 percent annual chance (100-year) and the existing 0.2 percent annual chance (500-year) floodplain

The resultant future conditions floodplain quilt provided the basis for estimating future conditions flood risk, exposure, and vulnerability. The results of this analysis and the complete results of the existing conditions analysis are presented in *Chapter 2*.

Recommended Floodplain Management Practices and Flood Mitigation Goals

Chapter 3 of this Regional Flood Plan presents the results of Task 3 in two parts. The first part assesses current floodplain management practices within the region (Task 3A), while the second part presents the flood mitigation and floodplain management goals adopted by the Lower Colorado-Lavaca RFPG to guide the planning process (Task 3B).

Overall, the current state of floodplain management practices, as measured by the number of counties and cities in the region that have adopted and enforced floodplain management standards and regulations, can be considered "excellent." Nearly all counties and cities in the region have adopted and enforced at least minimum floodplain management standards and regulations, and many have adopted "higher" standards. Notably, all but two of 43 counties and 11 of 92 cities in the region currently participate in the National Flood Insurance Program (NFIP). In the aggregate, approximately 90 percent of the region's land area and virtually 100 percent of the region's population is within areas that have and enforce floodplain management standards and regulations. TWDB-required Table 6 in *Appendix B* provides an overview of the current state of floodplain management in the Lower Colorado-Lavaca Region.

In addition to assessing the state of floodplain management practices in the region, the Lower Colorado-Lavaca RFPG was required to consider whether to adopt and require region-specific floodplain management standards as a prerequisite for the inclusion of recommended FME, FMS, or FMP in the regional flood plan. The Lower Colorado-Lavaca RFPG believes that existing state and federal requirements combined with the very high level of NFIP participation in the region is sufficient. The RFPG, therefore, does not recommend adopting region-specific floodplain management standards and regulations for this initial regional flood planning cycle. However, the RFPG has adopted recommendations that, if implemented by local entities, will strengthen or enhance floodplain management in many areas of the region that have not adopted higher standards. The RFPG's recommendations are:

- If appropriate, communities in the region not currently participating in the NFIP are encouraged to do so.
- Communities in the region are also encouraged to adopt "higher" or enhanced standards for floodplain management and land development and are encouraged to consider participation in the FEMA Community Rating System (CRS).
- Updating outdated floodplain maps and associated models is a priority and should occur as soon as possible, particularly in areas affected by updated Atlas 14 rainfall statistics (i.e., increased rainfall rates).
- Cities and counties, within the limits of their authority, should consider flood hazards, floodplain management, and stream corridor protection in their comprehensive land use plans and associated land use regulations (e.g., zoning, subdivision platting).

As noted, *Chapter 3* also includes flood mitigation and floodplain management goals adopted by the Lower Colorado-Lavaca RFPG. Importantly, in addition to guiding the overall flood planning process for the region, each recommended FME, FMS, and FMP must be tied to at least one goal. In total, the RFPG adopted 14 goals in six focus areas: education and outreach (1), flood warning and readiness (1), flood studies and analysis (3), flood prevention (5), non-structural flood infrastructure projects (2), and structural flood infrastructure projects (2).

Areas with the Greatest Flood Mitigation and Flood Risk Study Needs

Utilizing the results of the flood risk analysis reported in *Chapter 2*, a high-level assessment was performed to identify areas within the Lower Colorado-Lavaca Region with the greatest flood risk and the greatest need for flood management and mitigation activities and projects. A related objective was to identify areas with the greatest gaps in terms of knowledge and understanding of flood risk. The analysis results are presented in *Chapter 4* of the Regional Flood Plan.

The region-wide assessment of flood risk, flood mitigation needs, and knowledge gaps was performed using a geospatial analysis process using data collected for Tasks 1 through 3. The spatial scale of the analysis was performed at the level of a Hydrologic Unit Code (HUC)-12, of which there are 560 HUC-12 watersheds in the Lower Colorado-Lavaca Region, with an average area of 43 square miles. Ten data categories were used in the geospatial analysis (see *Figure ES.7*). A uniform scoring scale of one to five was applied, and each HUC-12 was assigned an appropriate score for each of the 10 categories. The scores for each HUC-12 for each of the 10 categories were then summed to obtain a total score, which reveals the areas of greatest known flood risk and the greatest need for mitigation activities. These areas are depicted in *Figure ES.8*.

Figure ES.7 Flood Mitigation Needs Analysis Categories

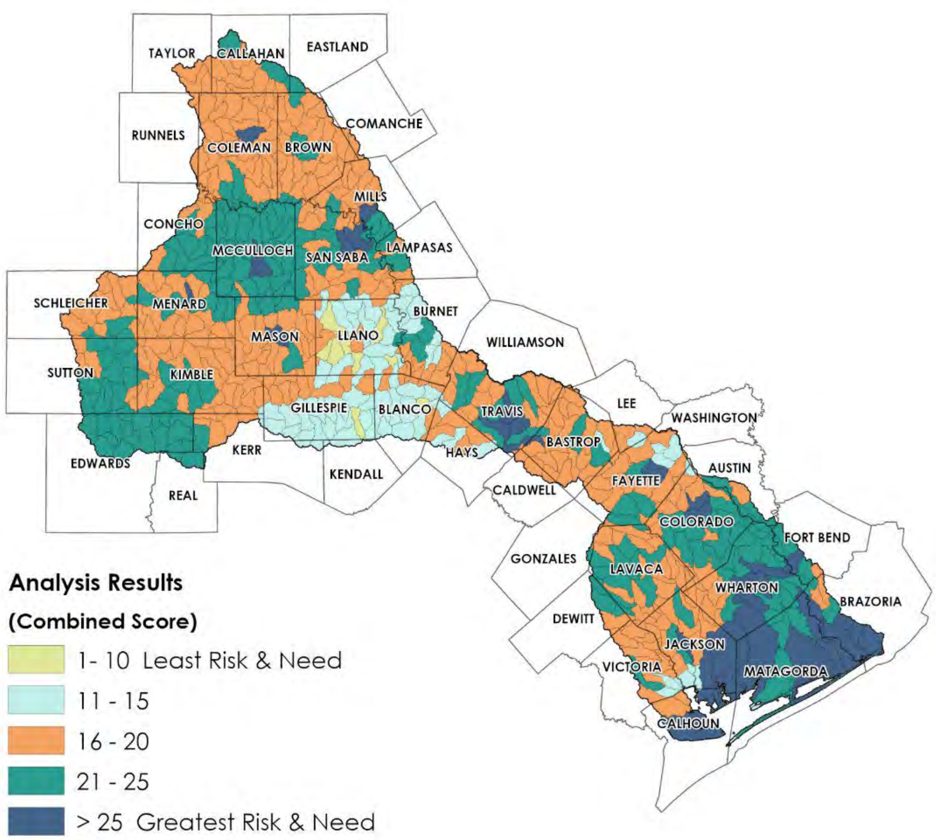
Threat to Life and Property
- Exposed Buildings
- Exposed Critical Facilities
- Exposed Low Water Crossings
- Inundated Roadways
- Inundated Agricultural Areas

Floodplain Management
- National Flood Insurance Program Participation

Data Gaps
- Inundation Boundary Mapping Gaps
- Hydrology and Hydraulic Model Gaps

Needs
- Emergency Needs
- Social Vulnerability Index

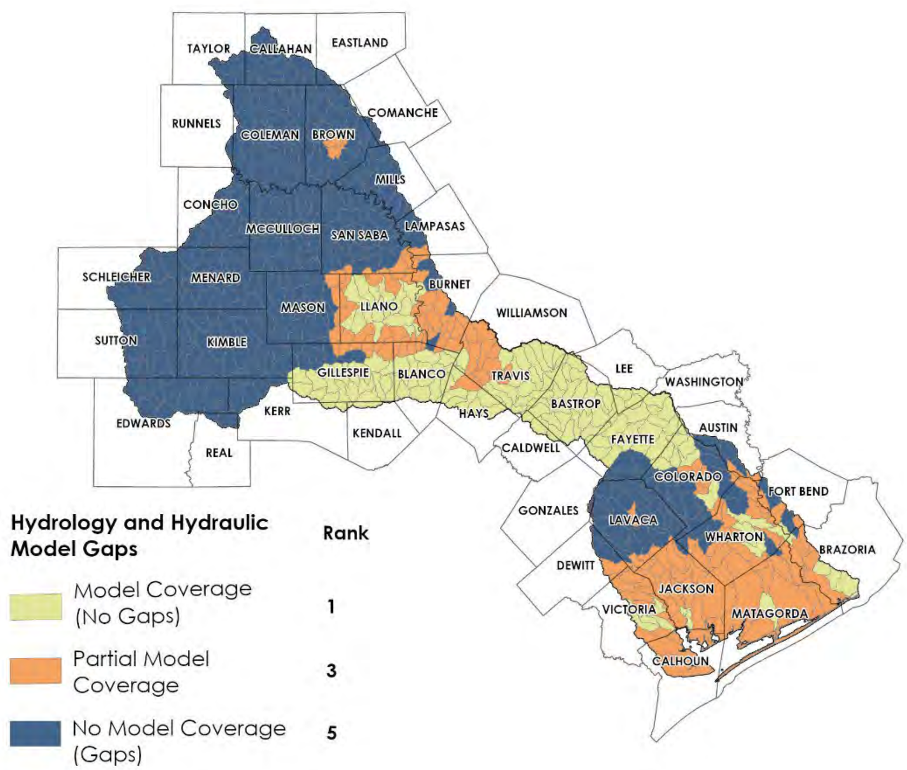
Figure ES.8 Scoring of Flood Mitigation Needs Analysis



The analysis to identify areas of the Lower Colorado-Lavaca Region with the greatest flood risk information gaps was based on the availability of or lack thereof, hydrologic and hydraulic (H&H)

models. The H&H model gap areas exclude areas where local studies, base level engineering (BLE), and FEMA detailed or limited detailed studies are available. Scoring was determined based on whether a HUC-12 watershed had total, partial, or no coverage of model-based floodplains. The results of the analysis are displayed in *Figure ES.9*. As indicated, large areas of the region lack H&H models and therefore lack accurate floodplain maps and knowledge of flood risk. These areas are, by and large, rural with low and dispersed populations; hence flood risk exposure in these areas is likely limited. Importantly, the urbanized and more densely populated areas, particularly in and around the Austin Metropolitan Area, do not have significant H&H model gaps or have only partial gaps. That said, as discussed in various chapters of the plan, even these areas have an immediate need to update existing H&H models and floodplain maps, particularly in the areas affected by updated Atlas 14 rainfall data. As discussed elsewhere, such updates are underway in some of the most populated areas of the region.

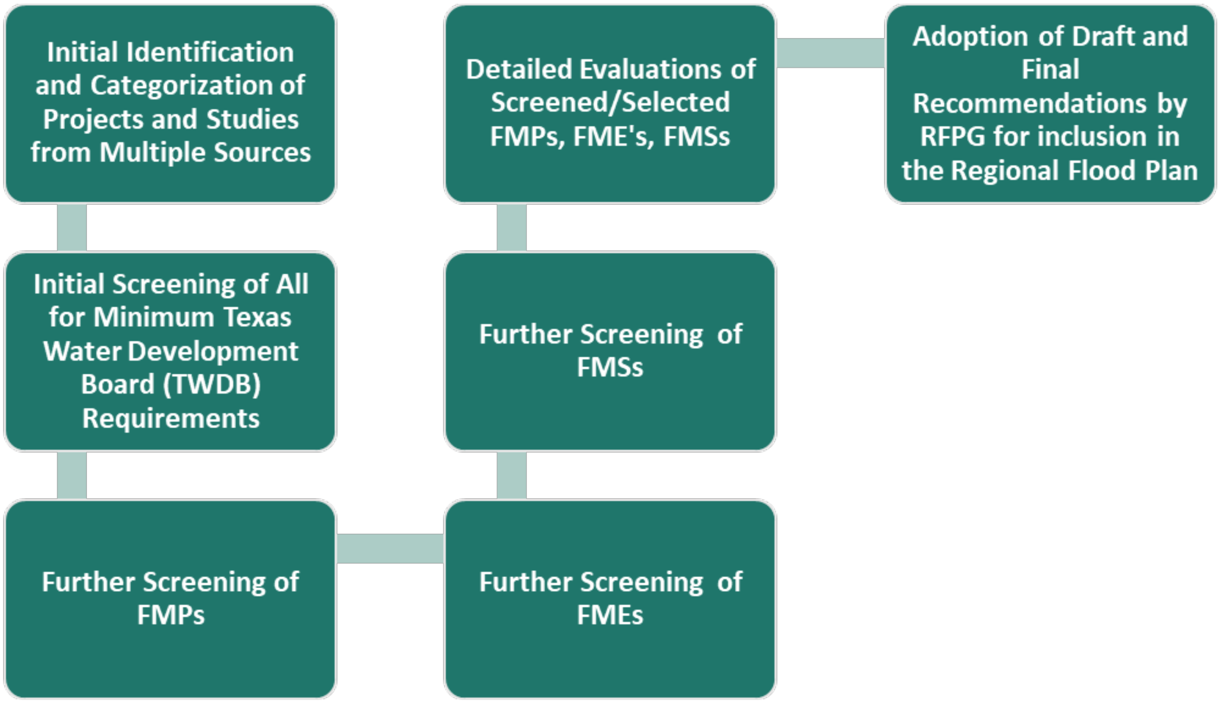
Figure ES.9 Scoring of Hydrologic and Hydraulic Model Gaps



Overview of Recommended FMEs, FMSs, and FMPs

Chapter 5 of this Regional Flood Plan presents the results of Tasks 4B and 5. In Task 4B, potentially feasible FMEs, FMSs, and FMPs were identified and screened for compliance with the TWDB requirements. Those deemed potentially feasible were further evaluated in Task 5 and ultimately were considered by the Lower Colorado-Lavaca RFPG for inclusion in the Regional Flood Plan. As noted previously, a Technical Committee of the RFPG was established to assist with the evaluation process, which was adopted by the RFPG and is depicted in *Figure ES.10*.

Figure ES.10 Process Overview Flow Diagram of Tasks 4B and 5



The Lower Colorado-Lavaca RFPG opted to take an inclusive approach to evaluate and recommend FMEs, FMSs, and FMPs. If an evaluation, strategy, or project generally met the TWDB requirements, was aligned with the RFPG's flood mitigation and floodplain management goals, seemed reasonable, and had the support of a local sponsor, the RFPG chose to give deference to the local sponsor and included those actions in the Regional Flood Plan. The conclusion of this process resulted in the RFPG's recommendations to include a total of 184 flood management evaluations (studies), 49 flood mitigation projects, and 5 flood management strategies in the Amended Regional Flood Plan. Each category of flood management/mitigation actions is summarized below. Note that individual single-page summaries were developed for each recommended action and are included in *Appendix C*.

Amended Regional Flood Plan

As noted at the outset of this Executive Summary, the TWDB extended the first flood planning cycle to include an amendment phase, culminating with the submittal of this Amended Regional Flood Plan in July 2023. TWDB also provided additional funding to support the amendment process, specifically allocated to Tasks 12 and 13.

Task 12 focused on performing conducting Flood Management Evaluations (FMEs) with the objective of reclassifying FMEs to meet the criteria for FMPs. Candidate FMEs for the Task 12 studies were required to be approved by the RFPG and adhere to all relevant TWDB requirements and guidelines, particularly those pertaining to Task 5 - Recommendation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects. After a screening process to identify FME candidates for further study, the RFPG approved seven Task 12 studies. The outcome of these studies was to reclassify five FMEs to FMPs, revise one FME with an expanded scope of work, and remove one FME. These changes have been incorporated into the Amended Regional Flood Plan as adopted by the RFPG on June 22, 2023. The findings, conclusions, and recommendations for each of the seven Task 12 studies are documented in Technical Memoranda, which can be found in *Appendix E*.

Under Task 13, additional TWDB funding was provided for the amendment of the Regional Flood Plan, including additional RFPG and Technical Committee meetings and revisions to portions of the plan and, with prior TWDB approval, other enhancements to the January 2023 Regional Flood Plan. With approval from the TWDB and the RFPG, a significant portion of the Task 13 effort focused on identifying, evaluating, and recommending additional FMEs and FMPs to incorporate into the Amended Regional Flood Plan. Task 13 resulted in the addition of 29 new FMEs and 9 FMPs based on additional outreach and sponsor-provided information. All amendments to plan chapters, maps, tables, geospatial data, and supporting data are incorporated into the Amended Regional Flood Plan.

Recommended Flood Management Evaluations

A flood management evaluation (FME), by the TWDB definition, is "a proposed flood 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." There are four general categories of FMEs, as described below in *Table ES.3*.

Table ES.3 Summary of Recommended FMEs

FME Type	FME Type	Description	Number
Watershed Planning	Drainage Master Plans, Other Community-Scale Plans	Supports the development and analysis of hydrologic and hydraulic models to evaluate flood risk within a given jurisdiction, evaluate potential alternatives to mitigate flood risk, and develop a capital improvement plan; Planning is often at a community scale.	20
Watershed Planning	Floodplain Modeling, Mapping, and Risk Assessment Studies	Studies to quantify flood risk in areas where significant flood risk is thought to exist but lacks flood risk data or has insufficient or outdated flood risk data. An example of this type of FME is a floodplain modeling and mapping study of a chronic flood-prone area with a certain population at risk that has not been previously. Often floodplain map products are approved and adopted as NFIP Flood Insurance Rate Maps (FIRMs).	12

FME Type	FME Type	Description	Number
Project Planning	Feasibility Studies and Preliminary Engineering	Studies typically employ flood hazard and flood risk/exposure data for a known flood problem area to evaluate structural and non-structural flood mitigation alternatives or FMP-types to provide the greatest flood risk reduction benefit for the least capital cost, considering adverse impacts and other factors. These FMEs typically include benefit-cost analysis and evaluations of other factors such as ongoing operations and maintenance costs, environmental constraints, permitting requirements, land acquisition and utility relocation requirements, constructability, and public input and social factors. Preliminary engineering typically includes a more detailed evaluation of a preferred flood risk reduction solution(s) to verify feasibility (e.g., technical, economic, environmental) and often includes a full engineering assessment, engineering design up to 30 percent, and refined estimates of probable cost.	136
Preparedness	Flood Emergency Preparedness Studies and Planning	Studies need to develop flood emergency action plans such as hurricane evacuation plans, flood emergency response and recovery plans, and dam breach emergency action plans.	16

Recommended Flood Mitigation Projects

By the TWDB definition, a flood mitigation project is "a proposed project that has a non-zero capital cost or other non-recurring costs and that, when implemented, will reduce flood risk and mitigate flood hazards to life or property."[1] FMPs are further categorized as either structural or non-structural. Structural FMPs are defined as building or modifying infrastructure to alter flood characteristics to reduce flood risk and are infrastructure projects with advanced analysis and 30 percent to 100 percent design development, including construction plans, specifications, and cost estimates. Non-structural FMPs are flood mitigation projects or actions that change how people interact with flood risk and move people out of harm's way. These types of projects do not involve modifications to the watershed or flood infrastructure and therefore do not negatively impact adjacent areas or environmental impacts. Of note is that in some situations, the preferred solution to a flooding problem is a combination of structural improvements and non-structural actions. As shown in *Table ES.4,* there are six types of FMPs, 49 in total, that are recommended in this Amended Regional Flood Plan.

[1] Title 31 Texas Administrative Code §361.10(n)

Table ES.4 Summary of Recommended FMPs

FMP Type	General Description	Number
Stormwater Infrastructure Improvements	Stormwater infrastructure improvements include channels, ditches, ponds, stormwater pipes, etc.	12
Roadway Drainage Improvements	Roadway drainage infrastructure improvements include side ditches, culvert crossings, bridge crossings, etc.	15
Regional Detention Facilities	Runoff control and management via detention facilities	2
Property Acquisition	Voluntary acquisition of flood-prone structures	1
Flood Warning Systems	Install gauges, sensors, or barricades to monitor streams and low water crossings for potential flooding and support emergency response	9
Emergency Generators	Purchase and install emergency generators at critical facilities	10

Recommended Flood Management Strategies

By TWDB definition, a Flood Management Strategy is "a proposed plan to reduce flood risk or mitigate flood hazards to life or property. A flood management strategy may or may not require associated Flood Mitigation Projects to be implemented". The Lower Colorado-Lavaca RFPG has recommended five regional FMSs, as displayed in *Table ES.5*.

Table ES.5 Summary of Recommended FMSs

FMS Name	FMS Description
Floodplain Management and Regulation	This strategy will consist of education, outreach, and direct technical assistance to cities and counties throughout the Lower Colorado-Lavaca Region, with a particular focus on providing targeted assistance to cities that are eligible but not currently participating in the NFIP; and other communities with the identification, evaluation, adoption, and implementation of enhanced floodplain management practices and regulations and land development, land use, and comprehensive drainage regulations.
Flood Awareness and Preparation Education and Outreach	This strategy includes the Lower Colorado-Lavaca RFPG continuing its public outreach and engagement efforts through ongoing TWDB funding. This would include periodic e-mail news blasts, additional public meetings to present the initial Regional Flood Plan, and continuing outreach to key stakeholders (e.g., state and local elected officials, floodplain administrators, and emergency coordinators).

FMS Name	FMS Description
Low Water Crossing Assessment, Prioritization, and Mitigation	There are an estimated 1,354 low-water roadway crossings within the Lower Colorado-Lavaca Region. Many of these crossings experience frequent flooding but may have relatively minor flood risk in terms of public safety and/or the integrity of the roadway. This strategy is for the Lower Colorado-Lavaca RFPG to provide technical assistance to communities assessing flood risk at low water crossings.
Stream Corridor Protection and Restoration	This strategy is focused on encouraging public/private partnerships to enhance the protection and restoration of stream corridors. The essence of this strategy is open space acquisition, either through fee-simple purchases of property within stream corridors or through voluntary agreements (i.e., conservation easements) between governmental and/or non-governmental organizations and private landowners.
Watershed Modeling and Floodplain Mapping	This strategy is intended to address the need for immediate region-wide effort and funding to update watershed models, floodplain mapping, and associated geospatial products needed to understand flood risk and exposure; provide effective floodplain management; identify and evaluate flood risk reduction solutions and enhance flood emergency preparedness and response.

Estimated Cost to Implement the Regional Flood Plan

Overall, the estimated cost to implement recommended FMEs and FMPs is $441 million. It is estimated that about $395 million may be needed from state and federal sources. The breakdown of estimated cost by category of flood risk reduction actions is shown in *Table ES.6*.

Table ES.6 Estimated Costs to Implement Recommended FMEs, FMPs, and FMSs

Recommended Flood Risk Reduction Actions	Estimated Implementation Costs
Flood Management Evaluations	$62,217,500
Flood Mitigation Projects	$379,160,000
Flood Management Strategies	*Unknown*
Total	**$441,377,500**

Impacts of the Regional Flood Plan

Implementing this Regional Flood Plan, specifically the recommended Flood Mitigation Projects will directly benefit (i.e., reduce flood risk) the areas targeted by those FMPs and will not negatively impact flooding in neighboring areas within or outside the region. Benefits will vary from one location to another due to the highly variable and location-specific nature of flood hazard areas. At a regional level, implementing the recommended FMPs is expected to reduce the number and/or spatial extent of areas with high flood hazard and exposure. For example, previously impacted flood risk areas will see a reduction in the spatial extent of current flood risk by approximately 0.03 percent or a reduction of approximately 1.8 square miles (see *Table ES.7*). Implementation of the plan is also expected to remove an estimated 665 at-risk structures and three critical facilities from flood-prone areas. Most importantly, although not readily quantifiable, implementation of the plan will unquestionably reduce the future risk of loss of life and injury to residents of the region by reducing the frequency and severity of flooding, improving flood early warning capabilities and coverage, removing or reducing risk at low water crossings, and by improving the protection and management of floodplains and stream corridors.

Table ES.7 Reduction in Existing Flood-Impacted Areas

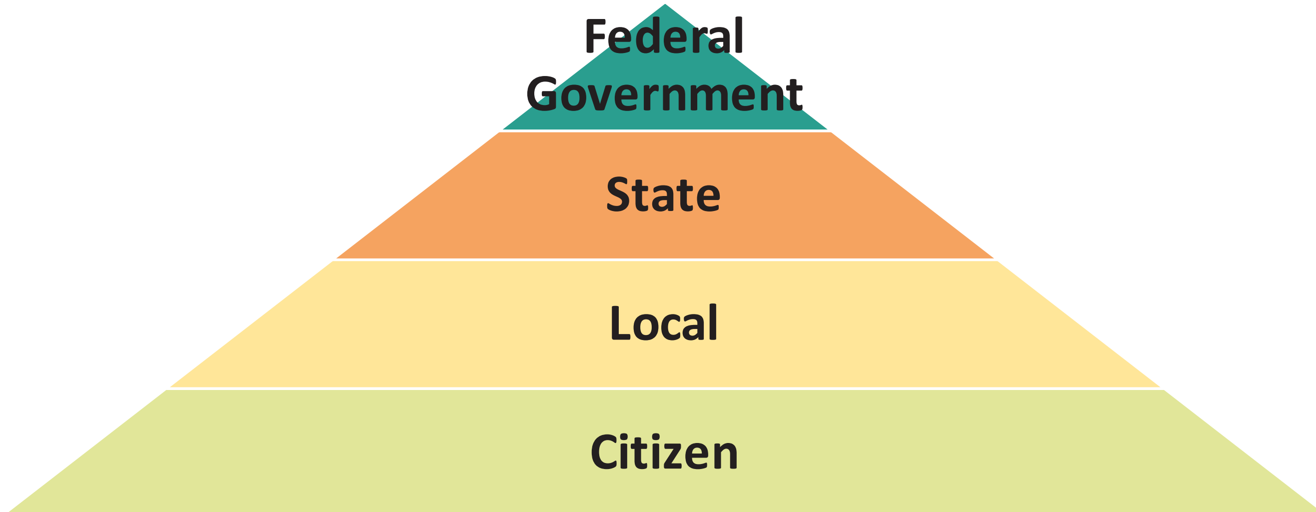
Annual Chance Event Flood Risk	Area in Floodplain (square miles)	Reduction of Floodplain after Implementation (square miles)
1%	4,515	1.44
0.2%	723	0.36
Total	**5,238**	**1.80**

As noted above, implementing the FMPs recommended in this plan will not negatively or adversely affect other areas. Similarly, it has been determined that there will be no measurable impacts, beneficial or adverse, from implementing the recommended FMPs on water supply, water availability, or projects in the State Water Plan.

Flood Preparedness

Responsibility for flood emergency preparedness, response, and recovery is a shared responsibility between multiple federal agencies, the states (as well as tribes and territories), and communities (i.e., individuals, businesses, and local government) operating within a national emergency management framework. In many respects, it's a "bottom-up" framework with much of the responsibility and authority for emergency management resting with local government and the communities they serve. This allows emergency management processes and activities to be tailored to only those areas affected by a natural disaster, such as a flood emergency. That said, federal and state agencies play a critical and often central role in coordinating emergency management activities and providing support and assistance to local entities with emergency preparedness planning and training, emergency response, and post-disaster recovery.

Figure ES.11 Emergency Management Support



Source: Emergency Management Institute, Are You Ready?

Looking at the state of "flood response information and activities" as a whole for the Lower Colorado-Lavaca Region, the RFPG has concluded that the region is relatively well-prepared, in some areas more so than others, and always with the potential for improvement. Importantly, in the most populated areas of the region, there is a well-developed understanding of flood risk, ready access to real-time weather and hydrologic data and forecasts, and notification systems in place to alert the media and public to impending or ongoing flood conditions. There is also support for ongoing flood education and awareness. Importantly, local emergency management officials throughout the region operate within a well-established national framework for emergency preparedness, response, and recovery.

Figure ES.12 Example Advertising and Outreach Campaigns from the City of Austin Watershed Protection Department

Overview of Policy Recommendations

The regional flood planning process also allowed the RFPGs to consider and adopt policy recommendations. *Chapter 8* of this regional flood plan presents legislative, regulatory, and administrative recommendations (Task 8) adopted by the Lower Colorado-Lavaca RFPG. Recommendations are also provided regarding improvements to the regional flood planning process. The RFPG adopted 26 policy recommendations - eight legislative recommendations, nine regulatory and administrative recommendations, and eleven flood planning recommendations. The legislative recommendations are:

- Extend Local Government Code, Title 13, Subtitle A, Chapter 552 to allow counties to establish drainage utilities and collect drainage utility fees in unincorporated areas
- TWDB should investigate legal impediments and potential legislative or other remedies to the use of local government funds for the elevation and/or floodproofing of privately-owned structures at-risk of severe flooding
- Establish and provide state budget appropriations and/or assess fees to fund the implementation of a levee safety program similar to the TCEQ dam safety program
- Enact legislation updating the state building code to a more recent edition (e.g., the 2018 edition of the International Building Code and International Residential Code)
- Provide ongoing state appropriations to the TWDB for additional grant funding for RFPGs to continue functioning during the interim between planning cycles
- Increase state funding and technical assistance to develop accurate watershed models and FEMA Flood Insurance Rate Maps (FIRMs)
- TWDB should consider mapping updates as a high priority for future flood planning grants through the Flood Infrastructure Fund
- Establish and fund a state program to assist counties and cities with assessing and prioritizing low water crossings
- Funding should be provided on a cost-sharing basis to implement structural and/or non-structural flood risk reduction measures at high-risk, low water crossings
- Consider establishing property tax incentives to protect stream corridors by private landowner.

Role of the State in Flood Infrastructure Finance

The TWDB requires that each RFPG conduct a survey to assess and report on how Sponsors propose to finance recommended Flood Management Evaluations (FME), Flood Management Strategies (FMS), and Flood Mitigation Projects (FMP). The objective of the survey was to understand Sponsors' funding needs and the methods they use to fund projects; and to inform RFPG recommendations regarding the state's role in financing recommended FMEs, FMSs, and FMPs. *Chapter 9* presents the results of the Sponsor survey and provides an overview of the various means and sources of funding and financial assistance available to local entities for flood-related activities and projects (see *Table ES.8*). *Chapter 9* also presents the Lower Colorado-Lavaca RFPG's recommendation regarding the role of the state in flood infrastructure finance, in which the RFPG expresses support for an expanded state role in financing flood-related activities, programs, and flood mitigation infrastructure and that ongoing and increased funding for both technical and financial assistance should be made available through existing financial assistance programs administered by the TWDB and the Texas State Soil & Water Conservation Board (TSSWCB).

Table ES.8 Common Sources of Flood Infrastructure Funding in Texas

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
Federal	FEMA	TDEM	Hazard Mitigation Grant Program (HMGP)	G	-	D
Federal	FEMA	TWDB	Flood Mitigation Assistance (FMA)	G	-	-
Federal	FEMA	TDEM	Building Resilient Infrastructure and Communities (BRIC)	G	-	-
Federal	FEMA	TCEQ	Rehabilitation of High Hazard Potential Dam Grant Program (HHPD)	G	-	-
Federal	FEMA	*TBD*	Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM)	-	L	-
Federal	FEMA	TDEM	Public Assistance (PA)	G	-	D
Federal	HUD	GLO	Community Development Block Grant – Mitigation (CDBG-MIT)	G	-	D
Federal	HUD	GLO	Community Development Block Grant Disaster Recovery Funds (CDBG-DR)	G	-	D
Federal	HUD	TDA	Community Development Block Grant (TxCDBG) Program for Rural Texas	G	-	-
Federal	USACE	-	Partnerships with USACE, funded through Continuing Authorities Program (CAP), Water Resources Development Acts (WRDA), or other legislative vehicles*	-	-	-
Federal	EPA	TWDB	Clean Water State Revolving Fund (CWSRF)	G**	L	-
State	-	TWDB	Flood Infrastructure Fund (FIF)	G	L	-

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
State	-	TWDB	Texas Water Development Fund (Dfund)	-	L	-
State	-	TSSWCB	Structural Dam Repair Grant Program	G	-	-
State	-	TSSWCB	Operation and Maintenance (O&M) Grant Program	G	-	-
State	-	TSSWCB	Flood Control Dam Infrastructure Projects - Supplemental Funding	G	-	-
Local	-	-	General fund	-	-	-
Local	-	-	Bonds	-	-	-
Local	-	-	Stormwater or drainage utility fee	-	-	-
Local	-	-	Special-purpose district taxes and fees	-	-	-

**Opportunities to partner with the United States Army Corps of Engineers (USACE) are not considered grant or loan opportunities but shared participation projects where USACE performs planning work and shares in the construction cost.*

***The CWSRF program offers principal forgiveness, similar to grant funding.*

Chapter 1: Planning Area Description

Source: Lower Colorado River Authority Mansfield Dam Flood Gates

Introduction - The Regional Flood Plan in Context

Overview of Establishing Legislation

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

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

The TWDB presented its findings to the Texas Legislature during the 86th legislative session in 2019. Later that year, the Legislature adopted changes to Texas Water Code §16.061, establishing a regional and state flood planning process led by the TWDB. The legislation provided funding to improve the state's floodplain mapping efforts and develop regional plans to mitigate the impact of future flooding. A mandate required the TWDB to facilitate the creation of a regional flood plan for each of the state's 15 major river basins by January 10, 2023. Updates are required every five years thereafter (*TWDB Flood Planning Frequently Asked Questions, 2021*).

The overarching intent of the plans is to protect against the loss of life and property to:

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

Overview of the Planning Process

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

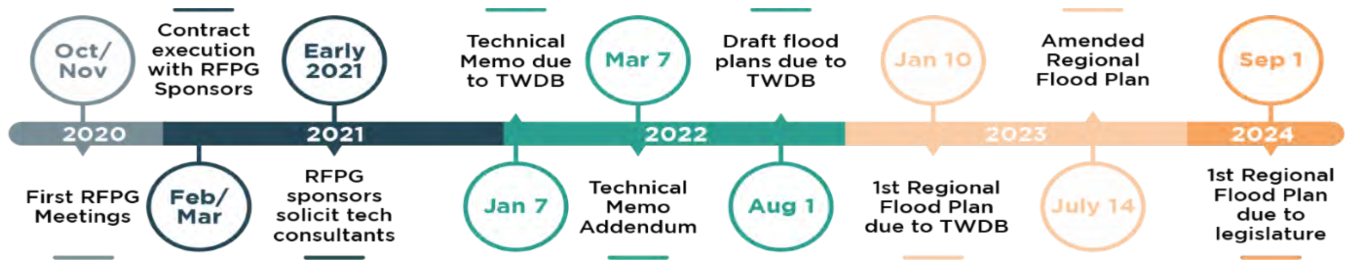
Who Prepared the Plan?

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

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

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

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



Funding Sources

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

Characterization - The Lower Colorado-Lavaca Region

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

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

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

Figure 1.1 Lower Colorado-Lavaca Region

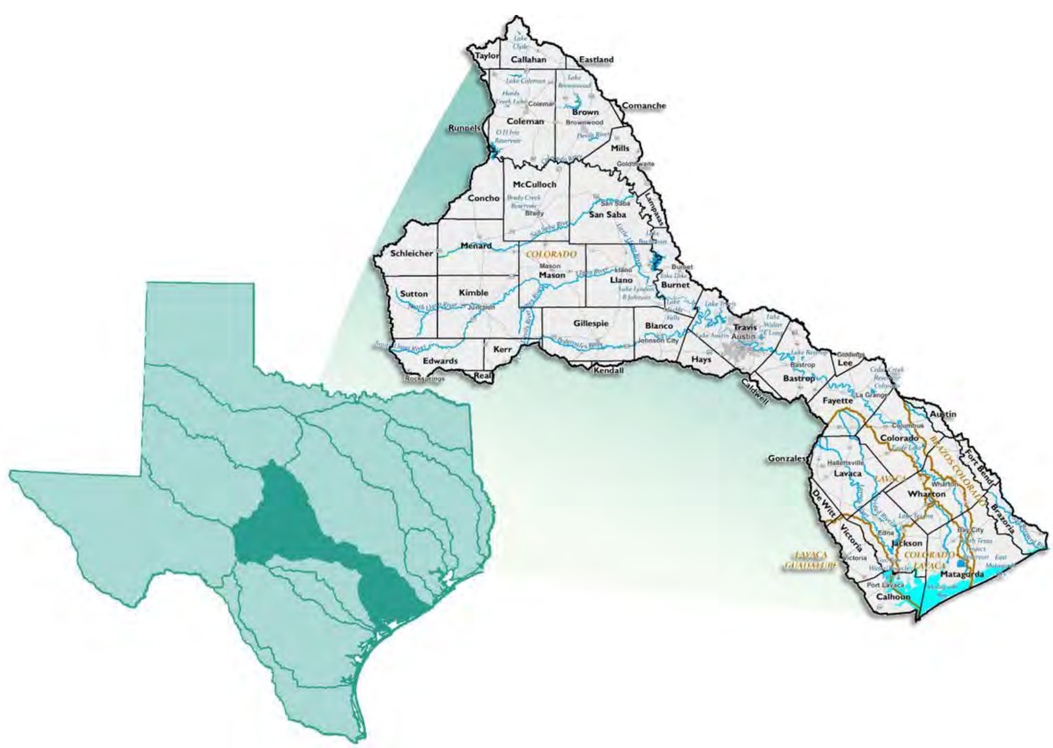


Figure 1.2 Lower Colorado-Lavaca Region Quick Facts

43 Counties

43 counties, or a portion of each, are included in this basin

~19% within 1% ACE

10 percent of the Region is within the 1% annual chance flood event (100-year) floodplain quilt

24,380 sq. miles

Total area of the Region

1,877,786 people

2019 Population today in the basin

2,866,025 people

Population 2050, projected to be in the basin by 2050; approximately a *50% increase*

3 river basins

Three major river basins: the lower portion of the Colorado River, San Bernard, and the Lavaca River basin

Major tributaries

Major tributaries: Llano, Pedernales, San Saba, San Bernard Lavaca, and Navidad rivers, Sandy, Onion, Cummins and Champion creeks

110 flood events

110 major flood events have occurred in the last 20 years with significant losses to life and property

50 flood disasters

Between 1953-2020: 50 major disaster declarations and six emergency declarations

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

Social and Economic Character

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

The Lower Colorado-Lavaca Region stretches over 24,380 square miles, 43 counties, and 305 local communities and special districts. It is important to note that the river basins do not neatly follow or conform to county boundaries. The Lower Colorado-Lavaca area includes only portions of many of the 43 counties (*Table 1.1*).

Table 1.1 Lower Colorado-Lavaca Regional Flood Plan Counties

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

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

Population and Future Growth

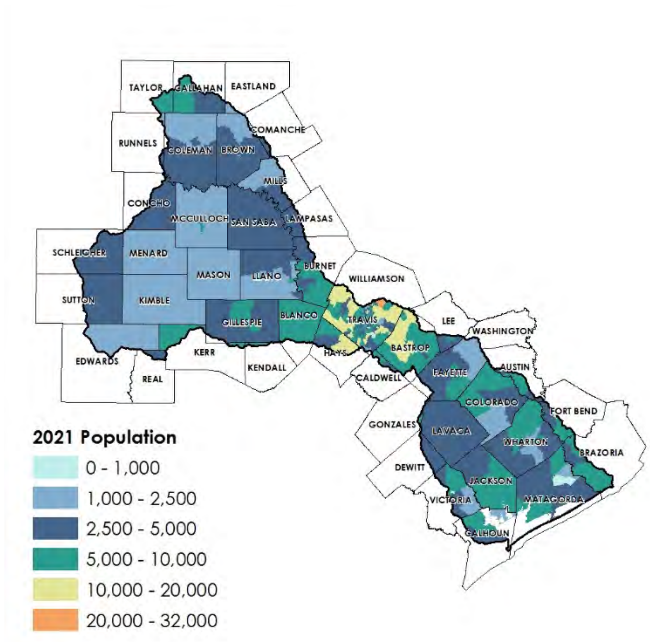
Current Population

The 2020 five-year American Community Survey (*U.S. Census Bureau*) estimates show that the existing population of the region is 1,916,344, which is over 6 percent of the population of Texas. As indicated in *Figure 1.3 2021 Population by Census Tract*, the northern portion of the region is largely embodied within the Texas Hill Country. The Texas Hill Country is characterized by sparsely populated small towns with pockets of populations concentrated in and near downtowns. In 2020 approximately two-thirds of the population (1.3 million) of the flood planning region resides in Travis County in the central part of the region. The southern portion of the region is also characterized by smaller population centers embodied within rural counties.

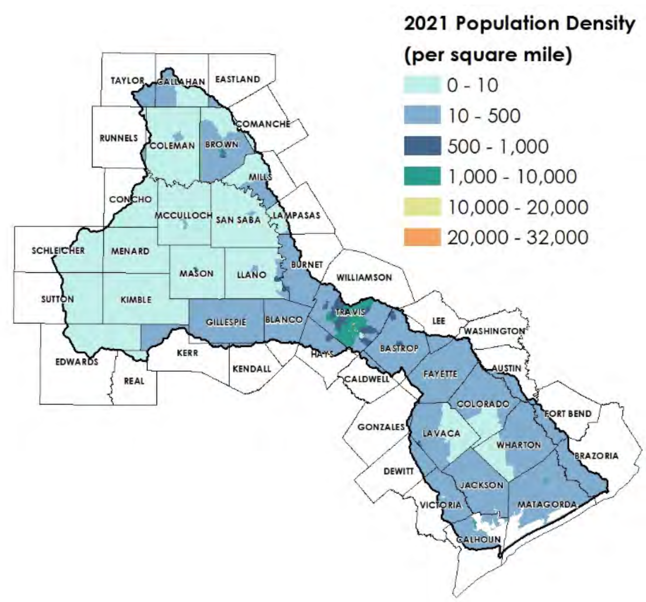
Map 1.3A (Figure 1.3) also shows that the greatest numbers of people, by census tract, are largely located along the major river corridors. This indicates many large cities historically were developed close to water.

Figure 1.3 2021 Population by Census Tract

Map 1.3A



Map 1.3B



Source: U.S. Census Bureau, 2021

Population Density and Character of Development

Beyond just total population numbers, the concentration of population density as well as form and character of development, also varies widely across the region. *Map 1.3B* (*Figure 1.3*) shows that the northern part of the region has the lowest density of development (i.e., lowest population density per square mile), and the southern portion is slightly denser but not by much. Various counties show small pockets of denser development, mostly located around the downtown of cities that serve as the county seats. The central portion of the region, particularly around Austin, has the densest concentration of population.

The form and character of development also change across the region, including changing characteristics between areas of rural, suburban, and urban character and special considerations for those areas along the coast (*Figure 1.4*). Each of these areas exhibits different characteristics and needs related to flood prevention and mitigation.

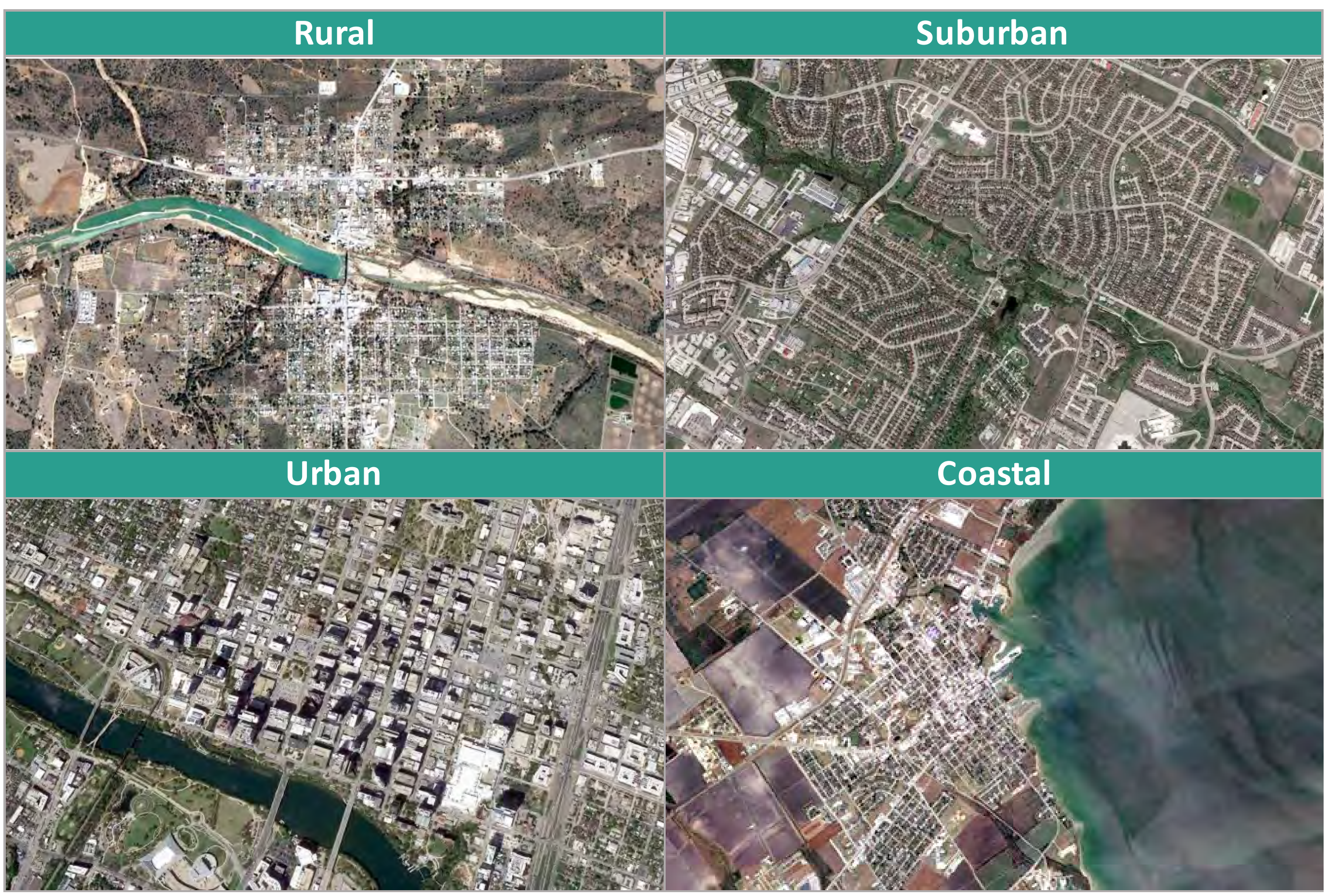
In sparsely populated rural areas, flooding often impacts rural roadways, low water crossings, and small downtowns close to major watercourses (e.g., the City of Llano). Many small towns often struggle to proactively reduce future flood risk due to limited resources such as staffing and funding.

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

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

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

Figure 1.4 Character of Development and Flood Risk



Urbanized Areas

Of the 92 local municipalities in the Lower Colorado-Lavaca Region (as detailed in the TWDB Water User Group Data), there are eight communities with a population greater than 10,000 and three communities with a population greater than 30,000 *(Table 1.2).* The cities with the largest population in the northern, central, and southern portions of the basin include Brownwood (Brown County; 39,761) in the northern portion of the region, Austin (Travis County; 1,298,624) in the central portion of the region, and Victoria (Victoria County; 93,857) in the southern portion of the region.

Table 1.2 Cities in the Lower Colorado-Lavaca River Basin with Populations Greater than 10,000

Austin*	Bay City	El Campo	Pflugerville
Bastrop	Brownwood*	Fredericksburg	Victoria*

**Indicates cities with a population greater than 30,000*

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

Existing and Projected Growth by Hydraulic Unit Code (HUC)-8

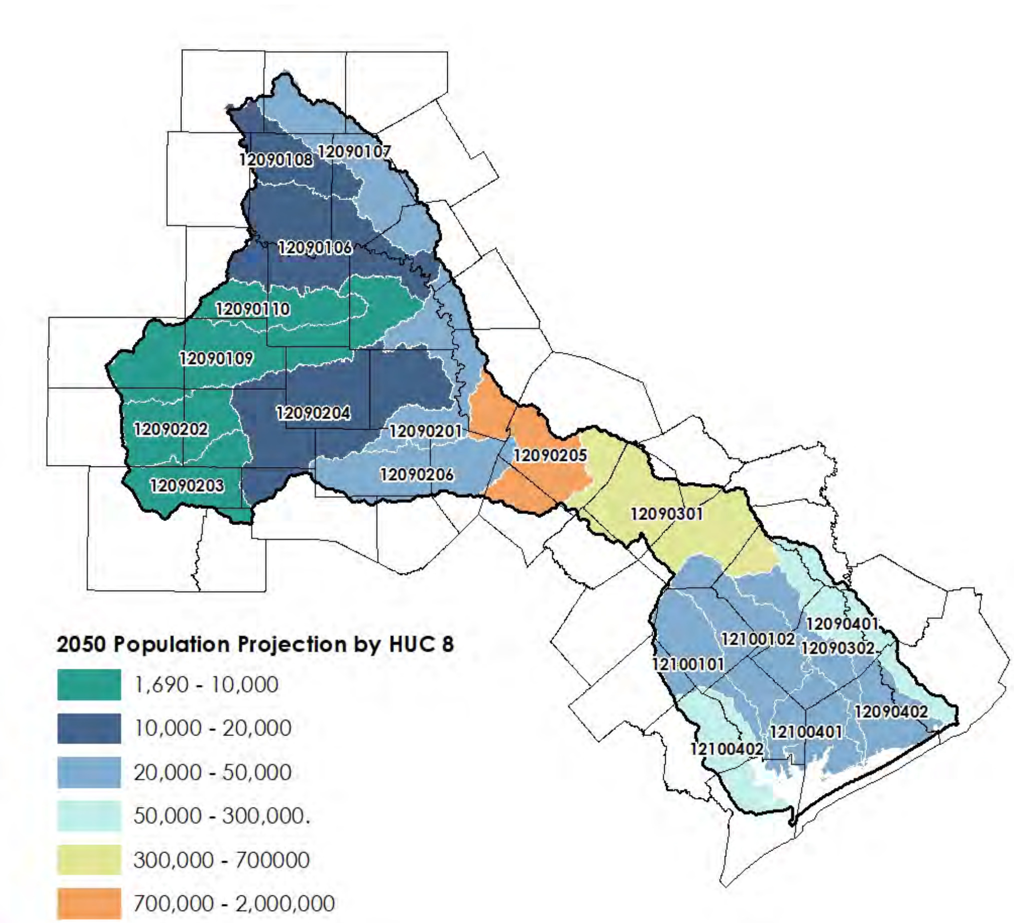
The current growth patterns are generally projected to continue over the next 30 years, with greater concentrations of the population being aggregated in urbanized areas and the possible continuation of a declining population in more rural areas. The analysis for this section was undertaken using the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

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

By 2050, the Austin-Travis Lakes HUC-8 is projected to contain almost 1.8 million people. This is an increase of 34 percent from 2020 to 2050. The second largest population within the region is projected to be in the Lower Colorado-Cummins HUC-8, which will contain 567,772 people by 2050, an increase of 43 percent over the next 30 years (*Figure 1.3*).

In this timeframe, the Lower Colorado-Lavaca Region is projected to have a population increase of almost 33 percent *(Table 1.3*). See *Figure 1.5,* illustrating the projected growth in population in each HUC-8 watershed.

Figure 1.5 2050 HUC-8 Watershed Population Projections



Source: TWDB Population Estimates

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

Table 1.3 Existing and Projected Population by HUC-8 Watershed

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

Source: TWDB Flood Data Hub

2019 Daytime and Nighttime Population Grids

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

As seen in *Figure 1.6 2019 Daytime/Nighttime Population Grids,* the LandScan™ geodatabase shows that Travis County contains the greatest daytime population in 2019 out of all counties in the region (*Map 1.6A*). This indicates a large number of individuals either working or spending daytime hours in or around the City of Austin. In 2019, Bastrop County and Hays County contained the second and third largest number of individuals during daytime hours.

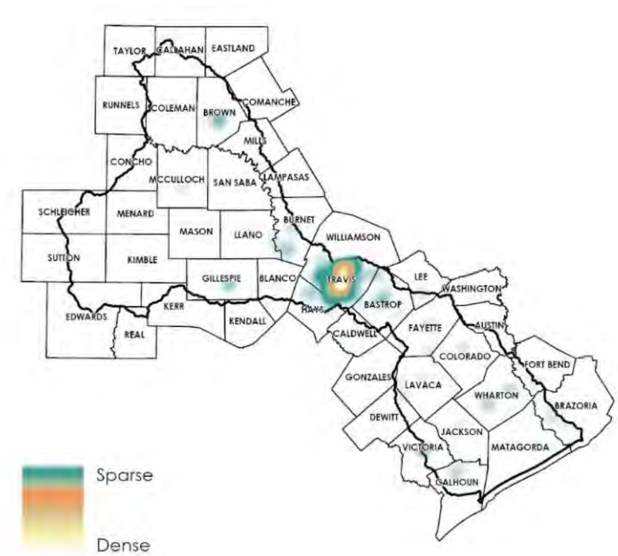
Map 1.6B shows that a larger concentration of individuals spent nighttime hours in Travis County in 2019 compared to other counties in the region. During the day, individuals who spend time in Austin disperse to the surrounding suburbs of Pflugerville, Manor, and Del Valle at night.

LandScan™ Population Projection Geodatabase

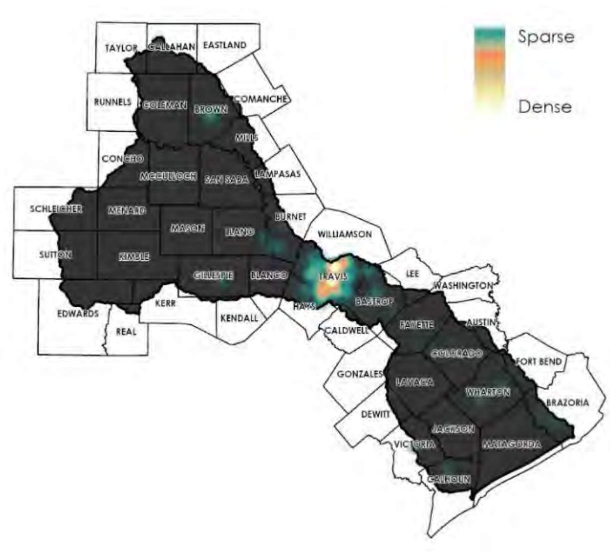
Oak Ridge National Laboratory's (ORNL's) LandScan™ is a community standard for understanding population distribution. It uses geographic information system (GIS) mapping and remote sensing to disaggregate census counts within a specific area to develop day and night population estimates. Since individual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

Figure 1.6 2019 Daytime/Nighttime Population Grids

Map 1.6A: Daytime



Map 1.6B: Nighttime



Source: 2019 LandScanTM USA for Day/Night Populations

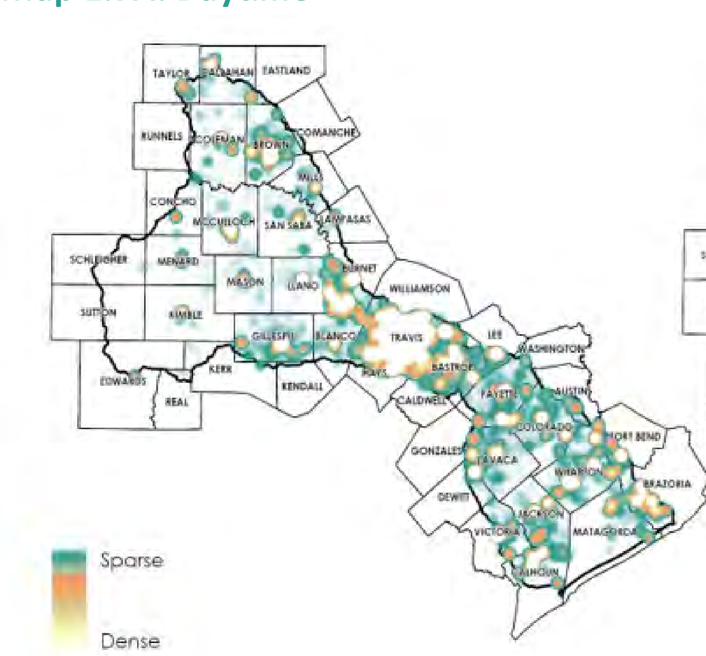
2019 Daytime and Nighttime Building Populations

The TWDB also provided building footprints (e.g., homes, structures, etc.) with LandScanTM geodatabase populations to indicate how many people occupy the buildings during the daytime and nighttime hours. As indicated in *Figure 1.7 2019 Daytime/Nighttime Building Populations,* the yellow areas illustrate the highest concentrations of the population. The brownish-to-orange areas show the next level of population concentration.

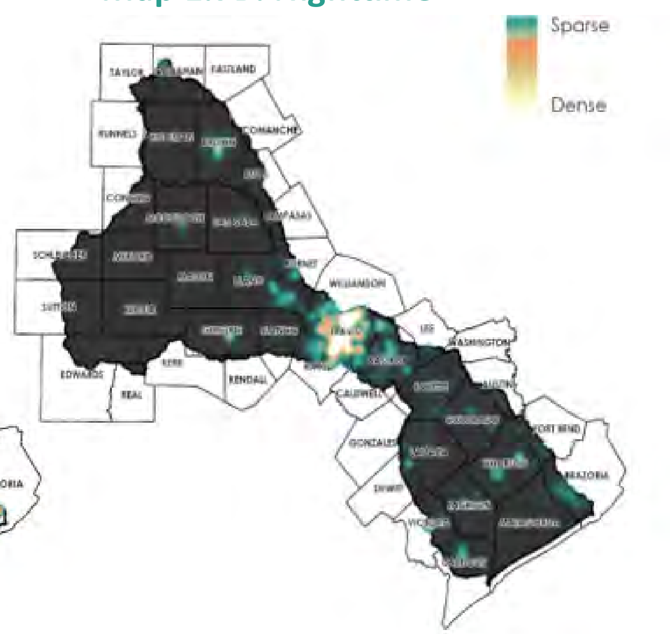
As is evident on *Maps 1.7A and 1.7B (Figure 1.7),* the general population aggregates into higher-intensity employment centers during the daytime working hours, with the largest concentration occurring in the Austin Metropolitan Area. During nighttime hours, the general population disperses to lower-intensity residential areas. Although the Austin Metropolitan Area still has the greatest concentration of nighttime population, it is more dispersed than during daytime hours.

Figure 1.7 2019 Daytime/Nighttime Building Populations

Map 1.7A: Daytime



Map 1.7B: Nighttime



Source: TWDB Buildings with SVI and Estimated LandScanTM 2019 Populations

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

Economic Activity

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

1. Number of establishments
2. Annual payroll
3. Total annual revenue

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

Number of Establishments

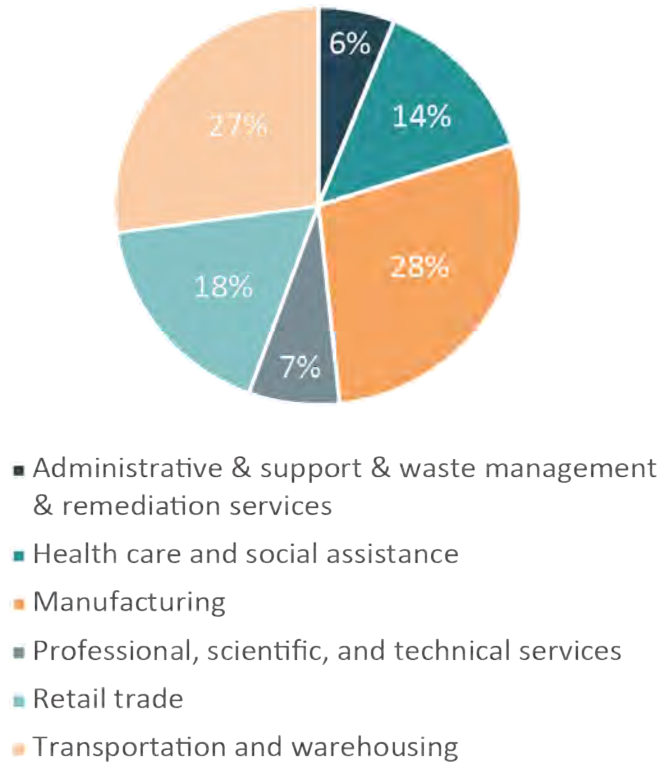
The Lower Colorado-Lavaca Planning Region contains important industries such as accommodation and food services; professional, scientific, and technical services; and retail trade, which contribute to the region's gross domestic product and support the local and state economies. Based on the 2017 Economic Survey, the total value of sales or revenue generated by firms and businesses in the region amounts to over $325 billion, constituting approximately 13 percent of the total sales/revenue generated by all firms and businesses in Texas. The main industry in the basin, by the number of establishments (i.e., the number of firms or businesses), is professional, scientific, and technical services at 67 percent. The retail trade industry makes up an additional 32 percent, and the accommodation and food service industry is only one percent. The professional, scientific, and technical services sector employs approximately 137,884 employees, followed by the retail trade sector, with approximately 487,909 employees. The industry sector employing the third-largest number of employees is accommodation and food services, with approximately 178,263 employees.

Annual Payroll

The total annual payroll in the Lower Colorado-Lavaca basin is $58,301,823,000. *Figure 1.8 Major Industries by Payroll* shows that manufacturing is the largest industry by payroll in the region (28 percent), followed by transportation and warehousing (27 percent). Professional, scientific, and technical services and health care and social assistance represent the next largest share of all industries by payroll.

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

Figure 1.8 Major Industries by Payroll



Source: U.S. Census Bureau, 2017 Economic Census - Summary Statistics Table EC1700BASIC, Dataset ECNBASIC2017

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

Total Annual Revenue

Of the three economic activity measures, the total revenue by industry may provide the most useful insight into a potential economic disruption of a major flood event by indicating the sectors most likely to be exposed to this risk, as it serves as a good indicator of which industries have the greatest economic impact. In the region, Travis County produces the largest commercial activity and most revenue, at $163.7 billion, with the greatest number of firms or businesses (26,318)(*Table 1.4*). Its main industry sector is wholesale trade. Fort Bend County has the second-greatest number of total firms and revenue, producing over $45.9 billion, of which almost $10 billion is in the retail trade industry. Brazoria County, in the southeast portion of the region and bordering Fort Bend County, produces the third-highest revenue, at $37.1 billion, of which $24 billion is produced in the manufacturing industry sector. The western side of rural Fort Bend County and Brazoria County are in the Lower Colorado basin and the greater economic activity is in the Lower Brazos Basin. The eastern sides of each of these counties are within the Houston Metropolitan Area. *Table 1.4 Top Four Counties by Total Revenue, Firms, and Employees* lists the four counties producing the most sales and revenue in the region. Travis and Fort Bend counties also have the greatest number of firms and businesses, and their main industry sectors employ between 28,190 and 87,164 employees.

Table 1.4 Top Four Counties by Total Revenue, Firms, and Employees

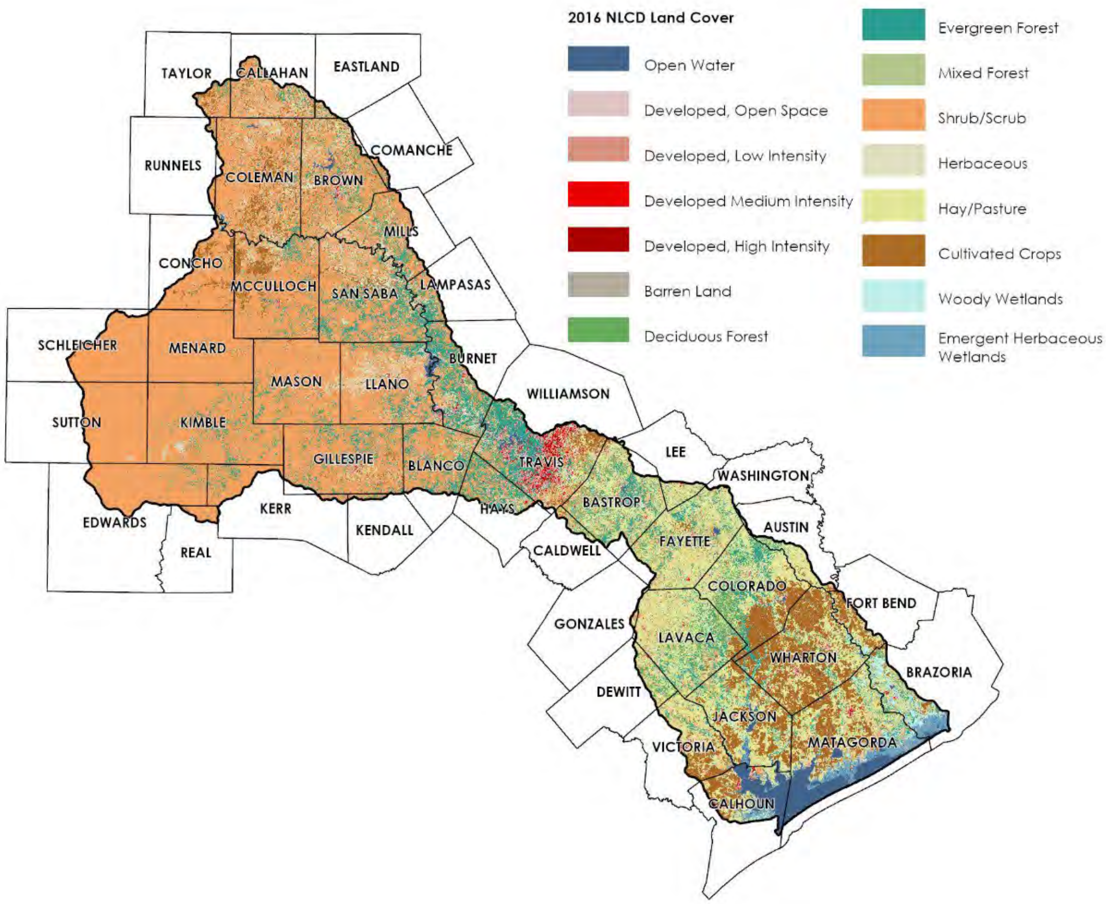
County	Total Revenue (in Billions)	Total Number of Firms and Businesses	Total Number of Employees	Dominant Industry Sector
Travis	163.7	26,318	540,055	Wholesale Trade
Fort Bend*	45.9	15,663	213,164	Wholesale Trade
Brazoria*	37.1	5,304	91,045	Manufacturing
Hays*	10.2	3,066	51,798	Retail Trade

** Indicating counties partially in the region*
Source: U.S. Census (Economic Census Summary Table, 2017, By County)

Land Cover and Use

As shown in *Figure 1.9 Land Cover*, the most prevalent land cover in the region is shrub/scrub at around 46 percent. It is the predominant land cover for much of the northern portion of the Lower Colorado-Lavaca basin. In the central portion of the region, the most developed area, only about 1.5 percent is developed at a low, medium, or high intensity. In these areas, however, increased impervious surfaces made up of materials that water cannot penetrate (e.g., roadways, rooftops, and parking) generally increase the potential for flood risk. However, the underlying geology of the Texas Hill Country is already fairly impervious bedrock such that increased development has less of an impact, although replacing natural vegetative cover with impervious surfaces (e.g., roadways) does increase runoff. Over time, the rapid development that is currently occurring in the Austin Metropolitan Area will continue to increase the area of impervious surfaces in this portion of the Lower Colorado-Lavaca Region. Hay/pasture and deciduous, evergreen, or mixed forest make up around 14 percent of the region and are predominantly located within the southern portion of the basin.

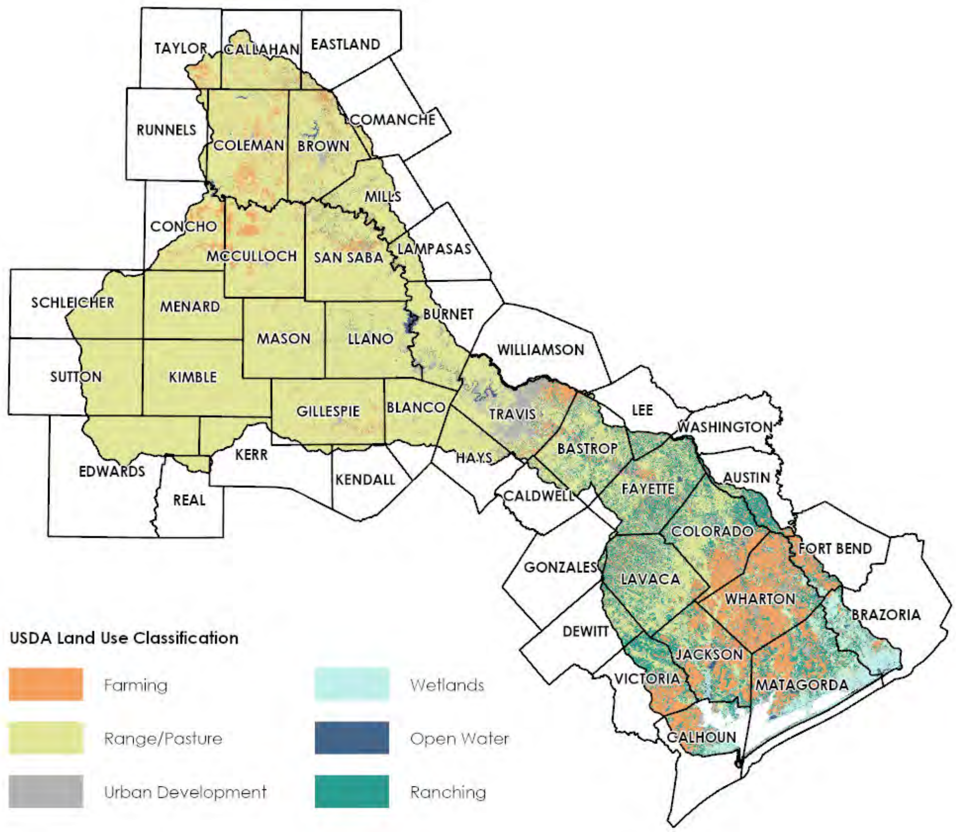
Figure 1.9 Land Cover



Source: United States Geological Survey (USGS) National Land Cover Database 2016 (USGS, 2016)

According to the United States Department of Agriculture (USDA) Land Cover data, the rural areas in the Lower Colorado-Lavaca basin contribute to the region's economy through farming, ranching, and range/pasture. *Figure 1.10 Land Use* displays the USDA land use classifications in the region. The largest land use classification is range/pasture at 64 percent of the region, followed by farming at 12 percent. Only a small portion of the region falls under the urban development land use classification and is comprised of only 4 percent. However, highly urbanized areas often have the greatest exposure to flood hazards as these areas have the greatest concentration of people, buildings, roadways, and utilities.

Figure 1.10 Land Use



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

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

Agricultural and Ranching Activity

The Colorado River is the largest river in the Lower Colorado-Lavaca Region. It passes through highly productive agricultural areas with a rich farming and ranching heritage. Although fewer individuals are exposed to flood hazards in these areas than compared to more urbanized areas, the impact of flooding on agriculture, ranching, and range/pasture can be severe and have serious local and regional economic consequences.

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

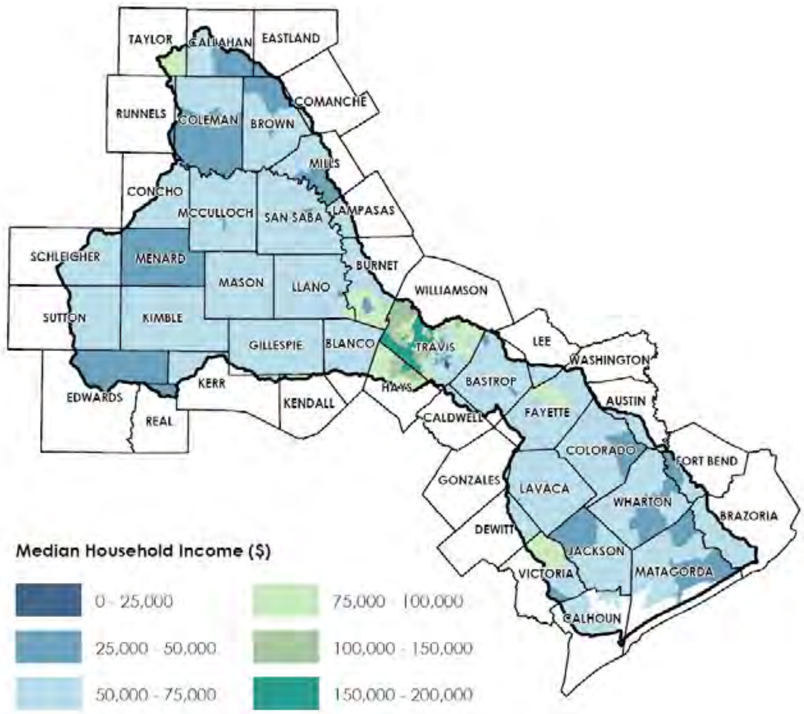
Floods can delay the planting season as flooding immerses the fields, making them impassable for heavy equipment. This can lead to decreased crop size, lower yields, and reduced profits. When floods occur as crops grow in the fields, they can destroy an entire season's work and investment. Floods at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

Economic Status of Population

Median household incomes can be affected by many factors, including education levels, employment opportunities, and location. The median household income measure divides the data into two halves and compares income levels across the basin.

Figure 1.11 Median Household Income displays the median household income in the region and *Table 1.5 Median Household Income Per County* displays the average median household income of all counties in the region. The highest median household income in this area is between $85,580 and $100,795 in Travis and Hays counties. The lowest median household income is in the northwest and southeast areas of the region. The counties in the southeast portion of the region are disproportionally affected by the projected increased rainfall from NOAA Atlas 14.

Figure 1.11 Median Household Income



Source: U.S. Census

Table 1.5 Median Household Income Per County

County	Average of Median Household Income (in dollars)	County	Average of Median Household Income (in dollars)
Hays County	100,795	Sutton County	57,014
Travis County	85,580	Gonzales County	56,346
Taylor County	84,459	Colorado County	54,198
Kendall County	84,239	Schleicher County	53,753
Blanco County	66,195	Matagorda County	52,941
Burnet County	65,858	Victoria County	52,190
Jackson County	65,194	Mills County	52,000
Comanche County	64,425	Concho County	51,325
Austin County	64,045	Coleman County	51,118
Brazoria County	63,331	Runnels County	50,969
Lampasas County	62,920	McCulloch County	50,417
Fayette County	61,845	Callahan County	49,922
De Witt County	61,810	Brown County	48,673
Fort Bend County	61,414	San Saba County	48,448
Llano County	61,098	Edwards County	48,163
Washington County	60,859	Wharton County	48,153

County	Average of Median Household Income (in dollars)	County	Average of Median Household Income (in dollars)
Calhoun County	60,122	Mason County	47,570
Lavaca County	59,932	Kimble County	44,825
Gillespie County	59,304	Eastland County	40,128
Kerr County	58,952	Menard County	38,828
Lee County	58,261	Real County	36,673
Bastrop County	57,905		

Source: U.S. Census

Social Vulnerability Analysis

When anticipating the likely extent of damages to a community from catastrophic floods, it is important to consider “exposure” based on the geographic location of people and property. It is also important to consider the “vulnerability” of populations to flooding impacts. Vulnerability is the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long term as well as the short term.

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

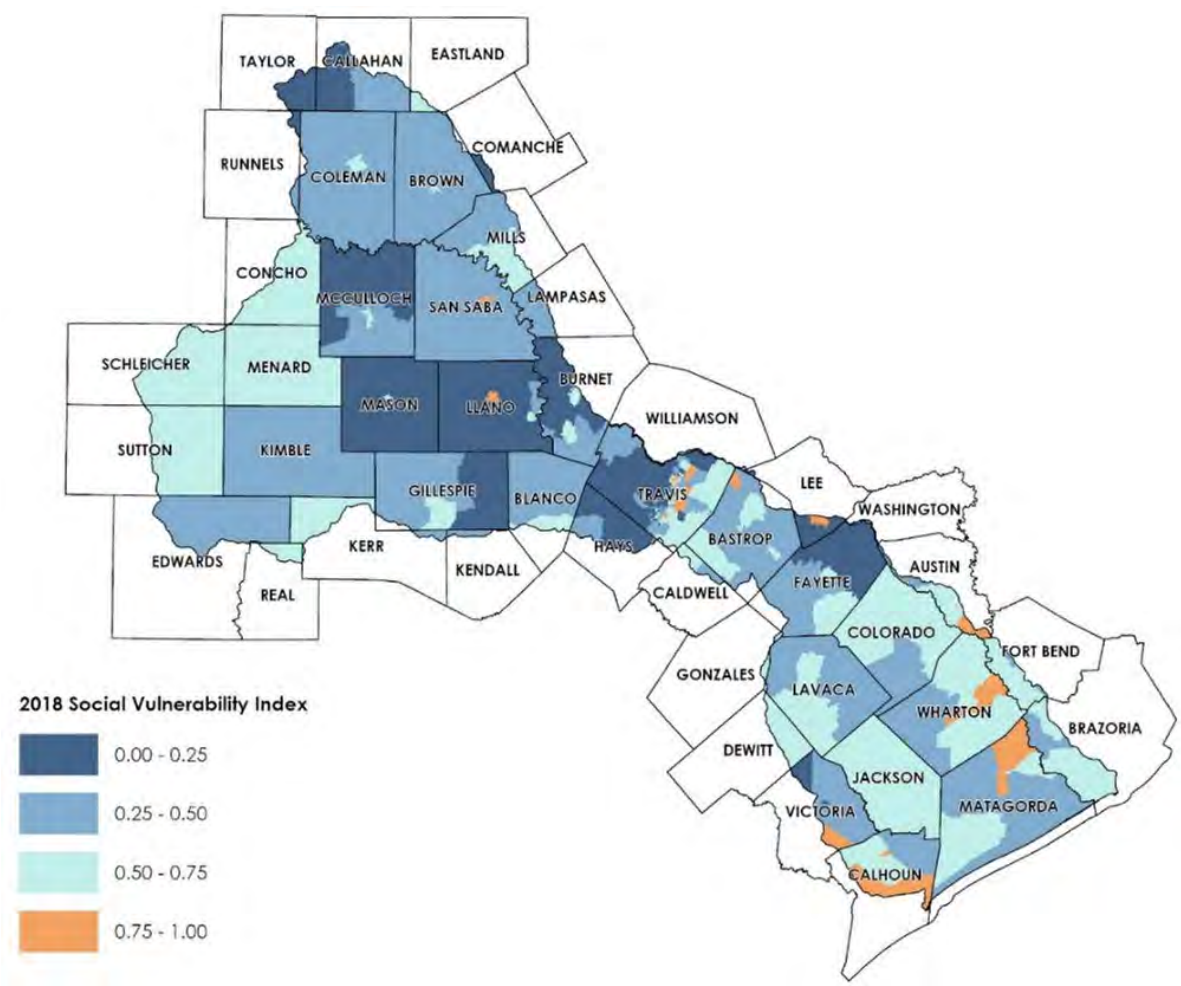
Measures of vulnerability are on a scale of zero to one, with one being the highest level of vulnerability, and are used to map social vulnerability in the region at various scales. The index focuses on 15 demographic indicators (*Jaimie Hicks Masterson, 2014*). These include:

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

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

Figure 1.12 Social Vulnerability Index (SVI) shows the counties with the highest SVI in the region. They include Matagorda County (Bay City), Calhoun County (Seadrift and Port O'Connor), and Wharton County (El Campo, Wharton, and Hungerford). Identifying the locations of social vulnerability clusters helps inform where changes to flood mitigation programs, policies, and interventions can help lessen their social vulnerability. Interventions to reduce flood impacts in socially vulnerable areas can occur at all phases of a disaster, including pre-disaster mitigation and preparedness, response, and recovery. Focusing just on reducing the physical exposure to flooding may fail to adequately protect those most vulnerable and have the least ability to prepare, respond, and recover from flood impacts.

Figure 1.12 Social Vulnerability Index (SVI)



Source: Centers for Disease Control and Prevention (CDC) via the TWDB

Flood-Prone Areas and Flood Risks to Life and Property

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

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

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

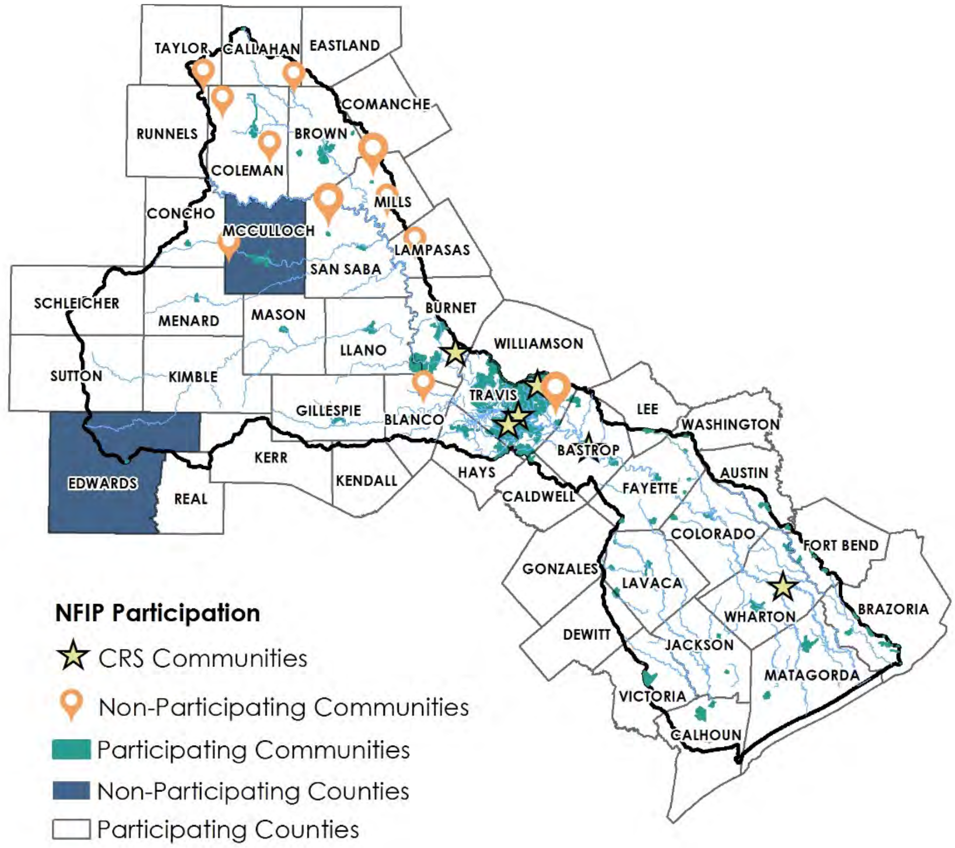
Figure 1.13 National Flood Insurance Program Participation displays the region's communities participating in the NFIP. The map also shows the communities participating in the Community Rating System (CRS), which is a voluntary incentive program that identifies and encourages community floodplain management practices that exceed the minimum requirements of the NFIP. The CRS uses a class rating system similar to a Fire Insurance Services Office rating that helps identify how prepared a community is for fires. The CRS helps identify how prepared a community is for floods.

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

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

Only four municipalities are CRS participants in the Lower Colorado-Lavaca Region – Austin, Pflugerville, Sunset Valley, and Wharton. Bastrop and Burnet Counties are also CRS participants. All counties in the region except Edwards and McCulloch Counties participate in the NFIP, and all municipalities are participants, with the exception of Cross Plains, Goldthwaite, Lawn, Lometa, Melvin, Mullin, Novice, Richland Springs, Round Mountain, Santa Anna, and Webberville are NFIP participants.

Figure 1.13 National Flood Insurance Program Participation



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

Identification of Flood-Prone Areas

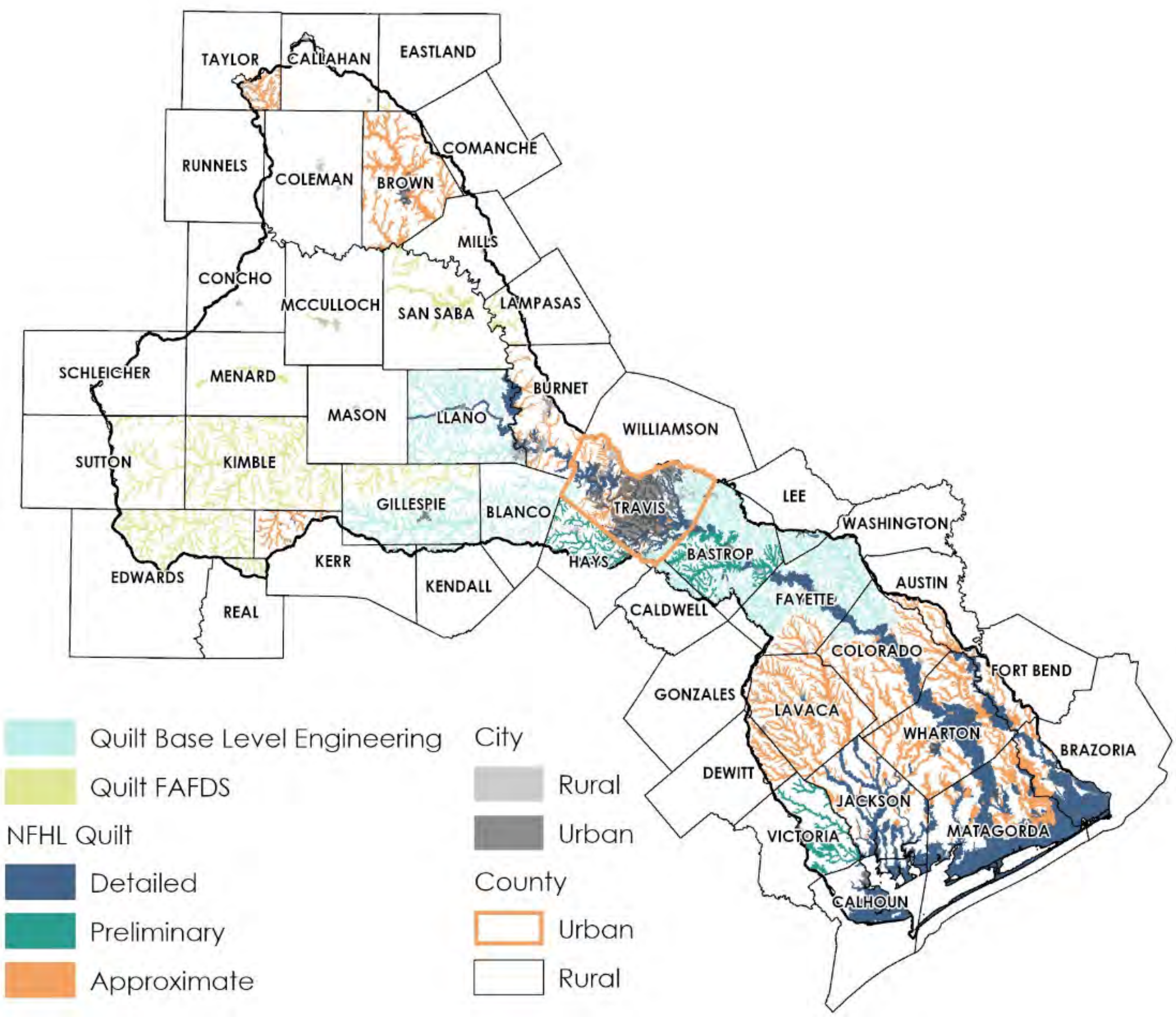
According to current NFIP mapping, 10 percent of the total area in the region is within the 1 percent to 0.2 percent annual chance event (ACE) which can otherwise be described as facing between a 1 percent or/and 0.2 percent annual risk of loss. This does not provide a comprehensive accounting for all flood risks, as not all floodplains within the Lower Colorado-Lavaca Region have been modeled and mapped. Even in areas with delineated floodplains, not all risk areas are included, such as the headwaters areas of small streams and minor drainage systems. While developing a comprehensive flood risk model of the region is beyond the scope of this planning effort, the TWDB floodplain quilt used in this plan is “sewn” together from various sources of data (e.g., National Flood Hazard Layer, Base Level Engineering, Local Studies, etc.) to provide comprehensive coverage of all known existing statewide flood hazard information.

In the absence of a unified flood map that applies throughout the region, the subsequent chapters of this assessment will piece together an intricate floodplain quilt, combining numerous data layers from FEMA, including effective maps, preliminary maps, base level elevation maps, data from other federal agencies, local and regional studies, and commercial data from Fathom. *Chapter 2: Flood Risk Analysis* provides additional details regarding these datasets and lists previous studies and models relevant to developing this regional flood plan.

Types of Flood Risk

Figure 1.14 Initial Floodplain Quilt versus Urban Areas shows the initial floodplain quilt information provided by the TWDB that serves as the Lower Colorado-Lavaca Region's starting point, providing an approximation of region-wide flood risk currently available data.

Figure 1.14 Initial Floodplain Quilt versus Urban Areas



Source: TWDB Floodplain Quilt with TxDOT Urban Areas

The TWDB provided this data to provide the RFPGs with a common starting point for their compilation of flood risk data in their regions. In subsequent chapters, this "quilt" will be confirmed, updated, and otherwise enhanced as appropriate to prepare a larger flood risk assessment (TWDB, 2021). When complete, this regional floodplain quilt will identify information gaps and more accurately approximate the distribution of flood risk across the region.

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

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

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

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

  The severity of a riverine flood is determined by the amount of precipitation in an area, how long it takes for precipitation to accumulate, the previous saturation of local soils, and the terrain in the watershed or catchment area. In flatter areas, floodwater rises slower, is generally shallow, and may remain longer. In hilly areas, floods can occur within minutes after a heavy rain/flash flood event. To determine the probability of river flooding, hydrologic and hydraulic models consider past precipitation, forecasted precipitation, current river levels, the effectiveness of flood control structures, and other related factors. Riverine flooding depicted on the community's FIRM is intended to show the extent of riverine floodplains in a community. Thus, updating outdated FIRMs, modeling areas that have never been mapped, and performing detailed studies where there are currently no detailed studies would improve the definition of riverine flood risk.

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

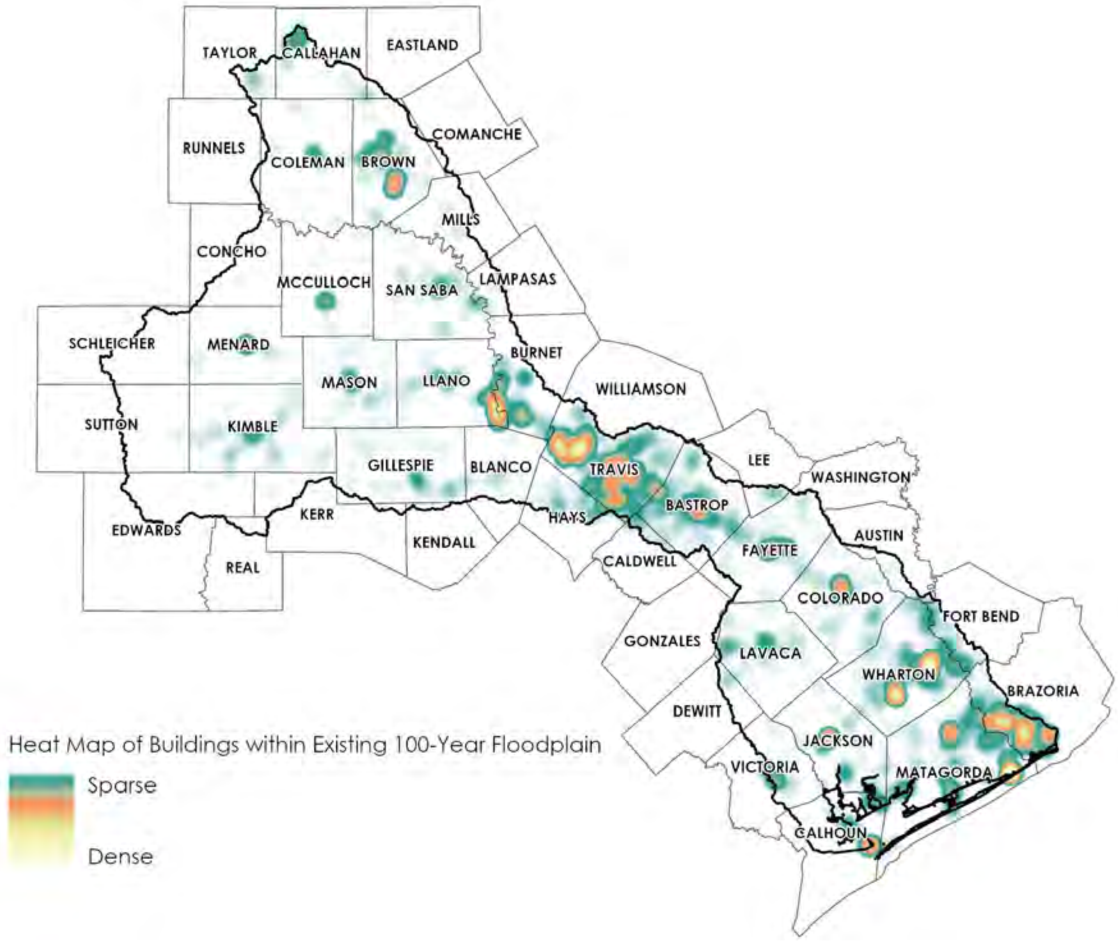
  The severity of a coastal flood is determined by several factors, including the strength, size, speed, and direction of the storm. The onshore and offshore topography also plays an important role. To determine the probability and magnitude of a storm surge, coastal flood models consider this information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

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

Flood Exposure

An initial assessment of exposure to flood risk can be observed utilizing building footprints in relation to the region-wide existing condition 1 percent annual chance (100-year) floodplain.

Figure 1.15 At-Risk Structures Heat Map



Source: Building heat map derived from existing condition floodplain in relation to the TWDB building footprints

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

The least number of structures are found in the northwest portion of the region, while the southeast portion from Llano County to the Gulf of Mexico contains a much larger number of structures in multiple communities. *Figure 1.16 At-Risk Structures Heat Map* shows the number of structures by density. The City of Austin in Travis County contains the densest and largest number of structures in the entire region. Brazoria, Matagorda, and Wharton counties also contain a significant number of structures at risk of flooding.

Changes in Rainfall Data

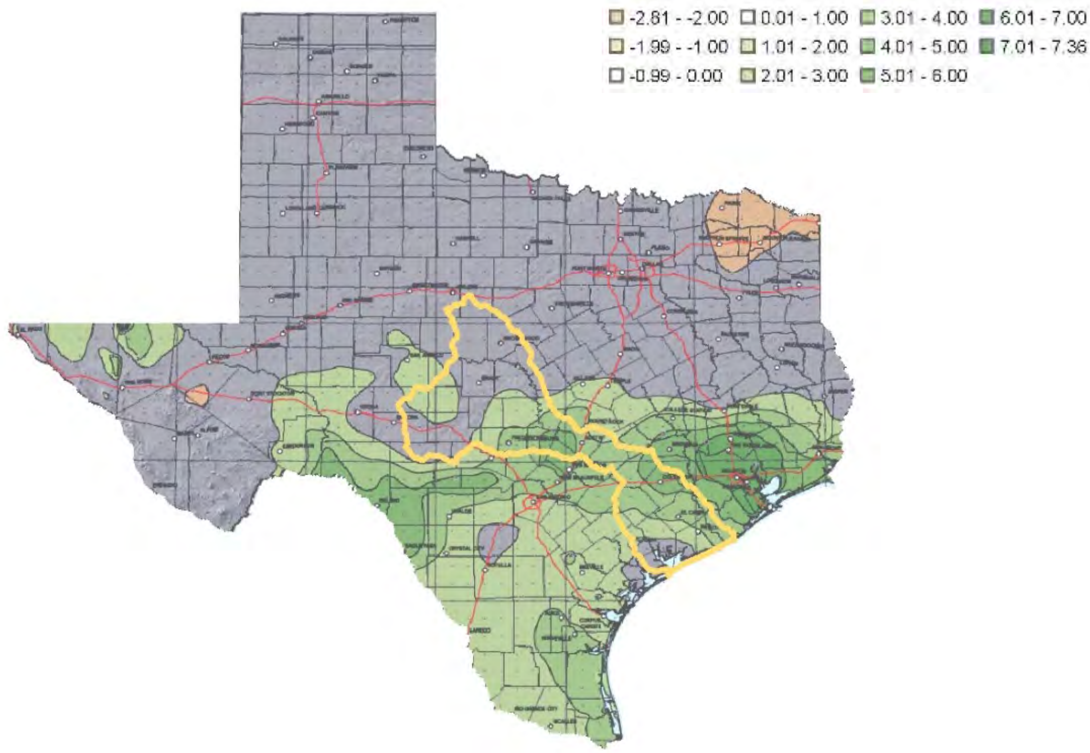
On September 27, 2018, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation-frequency values for Texas.

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

Major events during this time period include Tropical Storm Hermine in 2010, the Halloween floods of 2013 and 2015, the Memorial Day Flood in 2015, and Hurricane Harvey in 2017.

Rainfall data is commonly used to predict flood risk and as an input to analyze and design flood protection/mitigation infrastructure such as bridges, culverts, channels, storm drainage systems, detention facilities, and others. The Atlas 14 publication indicates that the 1 percent annual chance, 24-hour rain event may be greater than previously considered in many areas. The greatest rainfall changes occurred in Central Texas and along the Texas coast. Outlined in yellow in *Figure 1.16 Atlas 14 Rainfall increase from USGS Rainfall* is the Lower Colorado-Lavaca Region. The green areas in the map indicate areas where rainfall depth increased compared to the USGS publications. There are minimal changes in the upper portion of the basin, with the greatest increases (approximately 3 inches) in the Austin Metropolitan Area. While three inches may not seem significant, it dramatically expanded the extent of the 1 percent annual chance (100-year) floodplain in Austin, affecting areas with flatter topography the most.

Figure 1.16 Atlas 14 Rainfall increase from USGS Rainfall



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

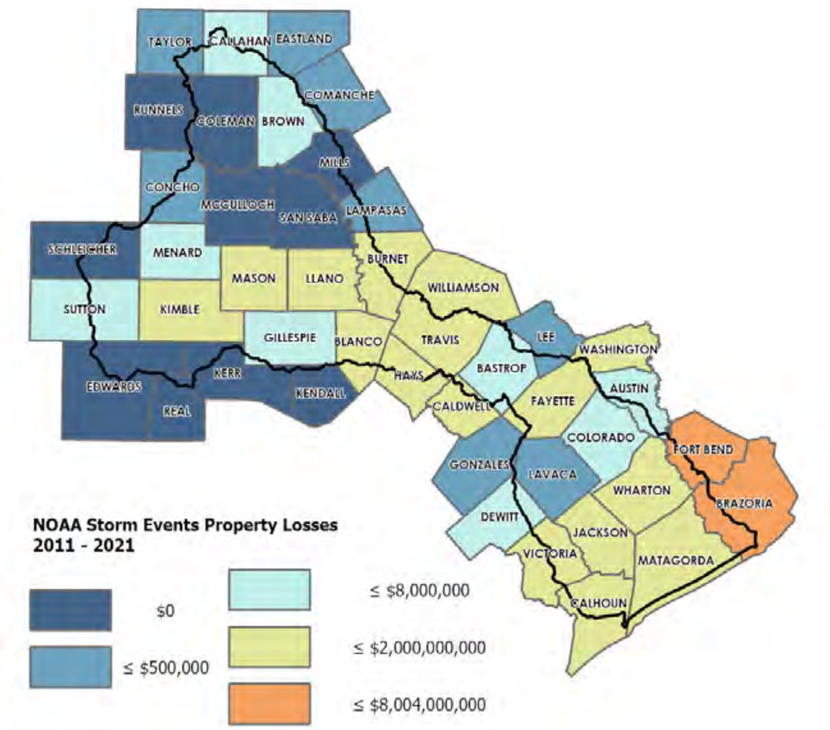
Key Historical Flood Events

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

Disaster Declarations and Major Events

According to FEMA Disaster Declarations Summary data, there have been 50 federally declared major disasters and six emergency declarations in the region between 1953 and March 2020. Over 25 percent of the disaster declarations and 50 percent of the emergency declarations have occurred within the region since 2008, indicating that a flooding-related disaster occurs in the region approximately every year. *Figure 1.17 Historical Property Losses* displays the total property losses from flooding events between 2011 and *2021 (NOAA Storm Event Database).* Within the Lower Colorado-Lavaca Region, the counties with the most property losses in the last 10 years were Fort Bend County and Brazoria County, encompassing over 80 percent of the total losses. In the heart of Flash Flood Alley, Travis County and Hays County have experienced the most flood-related fatalities.

Figure 1.17 Historical Property Losses



Source: NOAA Storm Event Database

The cycle of catastrophic disasters in the Colorado-Lavaca Region varies each year. For many years, no recorded disaster has reached either the level of a national Disaster Declaration or an Emergency Declaration. Frequently, however, when one disaster occurs, it is followed by one or more catastrophic events in the same year. Since 1953, there have been six Emergency Declarations and 50 Disaster Declarations within the Colorado-Lavaca Basin regions. Some of the most significant events in the Lower Colorado-Lavaca Region since the 1930s include:

- **October 2018 Flood Events:** In October 2018, the Highland Lakes watershed had historic flooding with two flood events along the Llano River and Lakes LBJ and Marble Falls. The Lower Colorado River Authority (LCRA) opened eight floodgates at Buchanan Dam, 10 floodgates at Wirtz Dam, and four floodgates at Mansfield Dam. Lake Travis rose to 704.39 feet mean sea level, 23 feet above its full elevation. The enormous sediment load generated by flooding caused severe water quality problems (i.e., turbidity and high suspended solids) with the operations of the City of Austin water treatment plants resulting in a multi-day boil water notice.

- **2017 Hurricane Harvey Flooding Response:** Employees across LCRA worked together to address the challenges from Hurricane Harvey. LCRA activated the Emergency Operations Center, and representatives from numerous departments shared updates and coordinated ways to solve challenges from the hurricane. In some areas, the Lower Colorado River rose to levels not seen in over a century.

- **2015 Memorial Day Austin Flood:** The Wimberley rains moved into downtown Austin dropping three inches on the already saturated ground within three hours. Shoal Creek, which drains west of Austin, rose to almost the 1981 elevation. The House Park High School football stadium and nearby areas flooded, necessitating swift-water rescues of residents.
- **2013 and 2015 Halloween Austin Flood:** Back on Halloween Day in 2013, heavy rains flooded over 800 homes along Onion Creek in southeast Travis County, killing four people. During this event, Onion Creek rose to 41 feet, surpassing the record of 38 feet set in 1869 and 1921. In 2015, a second storm hit almost the exact location with similar effects.
- **2010 Tropical Storm Hermine:** Hermine made landfall in northeast Mexico and headed north through Texas. From September 6-9, 2010, rains from the Tropical Storm were four to six inches in Victoria and over 10 inches in Austin, with 15.62 inches recorded in Georgetown. A large band of 10-15 inches of rain fell from Austin to Waco.
- **2007 Marble Falls "Rain Bomb":** In June 2007, around 19 inches of rain fell over the Marble Falls area in 12 hours. Most of the rain and runoff went into the Pedernales River and Lake Travis, which rose over 20 feet above its full elevation. The neighborhood of Graveyard Point, located far into the Lake Travis flood pool, was affected as the lake rose to 701.51 feet above mean sea level—its fifth-highest all-time elevation.
- **1991 "Christmas Flood":** The "Christmas Flood" of 1991 rose Lake Travis to its record high elevation, creating flooding in the Lower Colorado River basin. This experience of substantial, reoccurring flooding changed how the Lower Colorado River Authority responds to floods.
- **1981 Lavaca:** On August 31, 1981, Hallettsville was struck by a flood. Every business on the square received flood damage. At one time, the Square was submerged with 5.5 to 6.5 feet of water.
- **1981 Memorial Day Austin Flood:** On May 24, 1981, several hours of rain turned Shoal Creek into a raging torrent; 13 people drowned. This flood is credited with "waking Austin up to floods." Since then, the city has spent hundreds of millions of dollars to buy, acquire and remove over 1,000 at-risk homes, build flood walls and retention ponds, expand creek capacity, and improve storm drains.


THE LAVACA COUNTY
NEW ERA
TRIBUNE - HERALD
City Hit By Great Flood
FLOOD DAMAGE RUNS INTO MILLIONS
Only 1 Paper Next Week

1981 Lavaca Flood newspaper article. Source: Unknown

1981 Shoal Creek flood near Lamar Boulevard. Source: Unknown

- **1940 Hallettsville**: In the 1940 Hallettsville Flood, the Lavaca River rose to 41 feet which was 10 feet above any previous record. Several people were killed and several hundred thousand dollars in property were lost. A 4-inch rain occurred on a Saturday morning, followed by a downpour at night. A 10.5-inch rain fell, supplemented by a 16-inch rain in the Moulton section.
- **1935, 1936, and 1938 Colorado River Floods:** The Colorado River basin previously endured substantial floods in the 1930s, including a 1935 flood through downtown Austin. LCRA was still securing federal funding to build the Buchanan Dam when the June 1935 flood occurred. Flood waters from over 50 inches of rain passed through the Buchanan Dam construction site. The substantial flooding on the Colorado River split Austin in half, leaving a bridge as the only passable connection between north and south Austin. Flooding in July 1938 almost put LCRA out of business but revealed a need to construct the Mansfield Dam to a higher elevation. An additional disastrous flood occurred in the basin in September 1936. Immense floodwaters from a record 25 inches of rain in July 1938 forced LCRA to open 22 of Buchanan Dam's 37 floodgates. LCRA added 78 feet to the height of Mansfield Dam and created a system of rainfall and river gauges—the forerunner of LCRA's modern electronic Hydromet system.

Past Causalities and Property Damage

The National Oceanic and Atmospheric (NOAA) storm events database includes a record of historic financial property and crop losses, injuries, and fatalities for each hazard since 1996. It should be noted that this database relies upon communities to provide estimates of loss and, therefore, may somewhat underestimate losses due to uneven data reporting. Since the data provides a date, state, and county of impact, the data could be assessed to evaluate flood-related losses for the Lower Colorado-Lavaca Region. *Table 1.6* displays historical losses per county for the last 10 years (2011-2021). The graphic below provides a spatial view of losses across the Lower Colorado-Lavaca Region.

Table 1.6 NOAA Storm Event Losses between 2011 and 2021 for Flood-Related Hazards

Region	Property Losses	Crop Losses	Injuries	Fatalities
Austin County	$2,420,000	$50,000	-	1
Bastrop County	$5,610,000	-	-	-
Blanco County	$20,000,000	-	-	3
Brazoria County	$2,000,556,000	$100,000	-	-
Brown County	$2,405,000	-	-	2
Burnet County	$30,000,000	-	-	-
Caldwell County	$13,900,000	-	-	5
Calhoun County	$282,410,000	$20,100,000	-	-
Callahan County	$1,060,000	-	-	-
Coleman County	-	-	-	-
Colorado County	$2,550,000	-	-	-
Comanche County	$7,000	$10,000	-	-
Concho County	$150,000	-	-	-
De Witt County	$3,100,000	-	-	-
Eastland County	$106,000	$6,000	-	-
Edwards County	-	-	-	-
Fayette County	$50,010,000	-	-	-
Fort Bend County	$8,003,243,000	$52,000	-	4
Gillespie County	$510,000	-	-	1
Gonzales County	$110,000	-	-	-
Hays County	$212,705,000	-	-	11
Jackson County	$500,210,000	-	-	-
Kendall County	-	-	-	1
Kerr County	-	-	-	-
Kimble County	$19,000,000	-	3	4
Lampasas County	$330,000	-	-	-
Lavaca County	$100,000	-	-	-
Lee County	$350,000	-	-	2
Llano County	$71,000,000	-	-	1
Mason County	$8,500,000	-	-	-
Matagorda County	$500,000,000	-	-	-
McCulloch County	-	-	-	-
Menard County	$7,100,000	-	-	-
Mills County	-	-	-	-
Real County	-	-	-	-
Runnels County	-	-	-	-
San Saba County	-	-	-	-
Schleicher County	-	-	-	-
Sutton County	$8,000,000	-	-	-

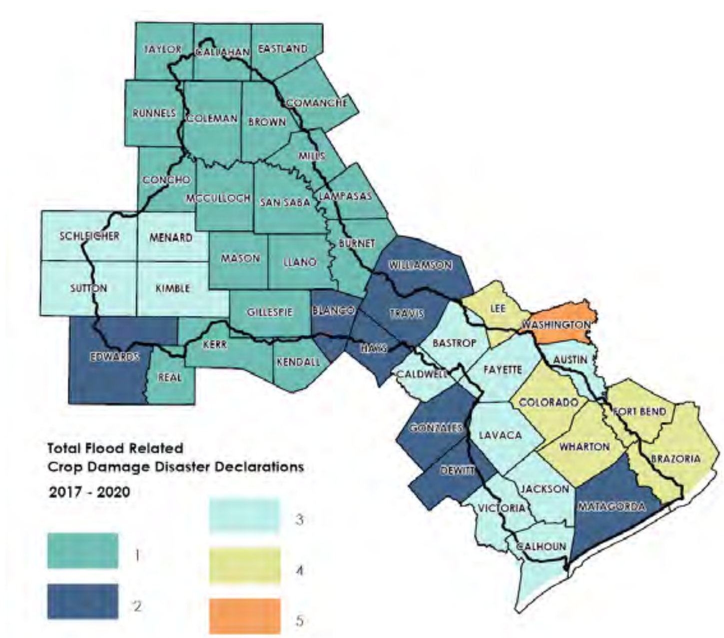
Region	Property Losses	Crop Losses	Injuries	Fatalities
Taylor County	$394,000	-	-	-
Travis County	$132,100,000	-	-	14
Victoria County	$160,330,000	$20,000,000	1	1
Wharton County	$200,001,000	-	-	-
Lower Colorado-Lavaca Region Totals	**$12,238,267,000**	**$40,318,000**	**4**	**50**
Average Annual Loss (over the 10-year period)	**$1.2 billion**	**$4 million**	**0.4**	**5**

Crop Damage

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

Figure 1.18 displays the total number of disaster declarations with crop damage between 2017 and 2020 per county. Within the Lower Colorado-Lavaca Region, the counties with the most declared disasters with crop damage were Colorado, Lee, and Wharton counties, with a total of four disaster declarations with crop damages in each county. During this time, the counties in the southeast and west have experienced more total crop disasters than the rest of the region.

Figure 1.18 Disaster Declarations with Crop Damages



Source: USDA Farm Service Agency Disaster Designation Information

Political Subdivisions with Flood-Related Authority

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

The TWDB provided a list of 348 political subdivisions or entities that were thought to have some degree of flood-related authority in the region (*Table 1.7*). It is important to note that in the literal sense, “authority” could be any entity/agency that constructs, maintains, or otherwise touches a drainage system. In its purest sense, “authority” would only indicate entities with the authority to enact and enforce NFIP floodplain regulations (e.g., municipalities and counties). Throughout this report, distinctions are made to indicate whether the data is referencing all political entities or those with regulatory authority.

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

Table 1.7 Political Subdivisions with Potential Flood-Related Authority

Entity Types	Number of Entities	NFIP Participants
Municipality	92	81
County	43	41
River Authority	3	N/A
Flood Control, WCIDs, Drainage Districts, Ports, Navigation Districts	70	N/A
Water Supply, Improvement, Utility Districts, MUDs, FWSDs, MWDs, SUDs, COGs	140	N/A

Source: TWDB Data Hub

In the Lower Colorado-Lavaca Region, 90 percent of eligible entities (municipalities and counties) participate in the NFIP. The Texas Water Code §16.315 requires NFIP participants to adopt a floodplain management ordinance and designate a floodplain administrator who will be responsible for understanding and interpreting local floodplain management regulations and reviewing them for compliance with NFIP standards. Some of the rights and responsibilities granted under this authority include:

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

Summary of Existing Flood Plans and Regulations

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

Table 1.8 summarizes the number of survey participants that have a particular regulatory or planning measure in place. These plans and regulations were divided into four categories: Drainage Criteria Manual/Design Manual, Land Use Regulations, Ordinances (Floodplain, Drainage, Stormwater, etc.), Unified Development Code (UDC), and/or Zoning Ordinance with map. Of the four types of regulations and plans, the largest number of respondents indicated that they had an active floodplain, drainage, and/or stormwater ordinance.

In general, these regulations and ordinances cumulatively:

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

Beyond regulations, *Table 1.8* identifies additional measures entities undertake to comprehensively promote resilience in flood-prone areas to mitigate the effects of flooding. As defined by FEMA, resilience aims to build a culture of preparedness through insurance, mitigation, continuity, preparedness programs, and grants. These measures include education and training, pre-planning, and early warning systems, among others.

Table 1.8 Types of Measures to Promote Resilience in Flood-Prone Areas

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

Source: Lower Colorado-Lavaca Region Data Collection Tool and Interactive Webmap

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

Floodplain Ordinances and Local and Regional Flood Plans

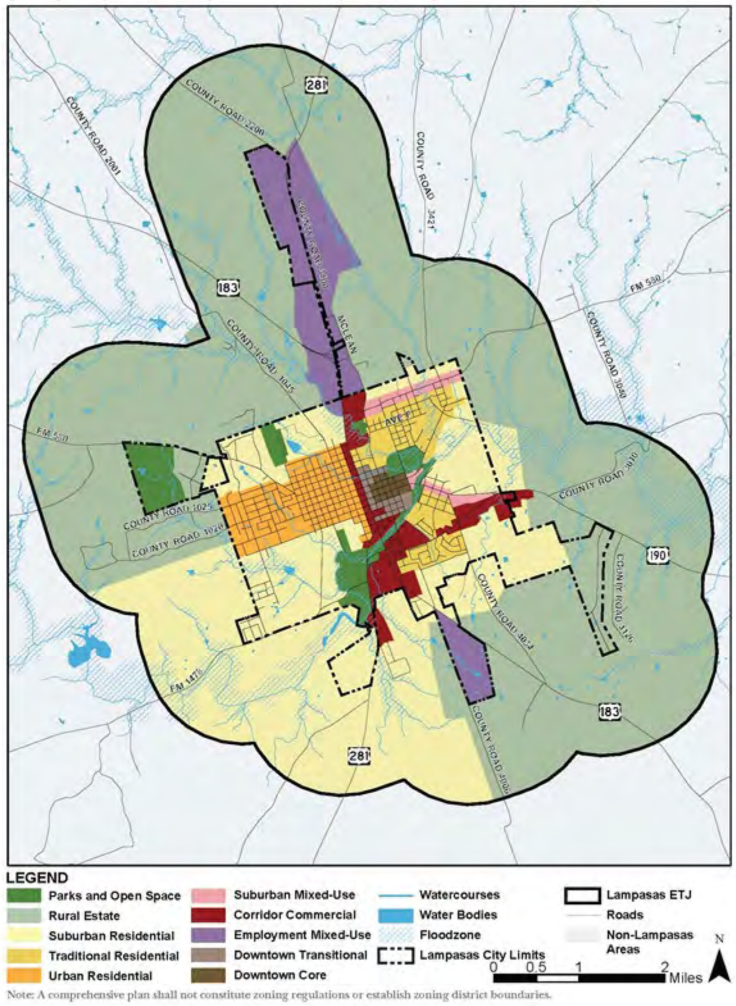
Floodplain ordinances dictate how development is to interact with or avoid a city's floodplain. FEMA provides communities with flood hazard information based on floodplain management regulations. Floodplain ordinances are subject to the National Flood Insurance Program and ensure that communities and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

Comprehensive Plans and Future Land Use Plans

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

Comprehensive plans and their associated future land use plans also provide legal authority for zoning regulations in the State of Texas. They consider capital improvements necessary to support current and future populations and often consider social and environmental concerns the community wishes to address. To produce a comprehensive plan, communities undertake an extensive planning process that encourages discussion about topics such as risk from natural hazards and may include recommendations regarding the development location with respect to floodplains, the need for future drainage improvements, etc. (*Figure 1.19*). As many development decisions are made during the first step in the development process, particularly during negotiated development proposals like planned unit developments (PUDs), it is critical for floodplains to be accounted for in these conversations.

Figure 1.19 City of Lampasas Future Land Use Plan



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

Land Use Regulations and Policies: Zoning and Subdivision

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

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

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

Drainage Criteria

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

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

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

Assessment - Existing Flood Infrastructure

Understanding the current context of the existing natural and structural flood infrastructure in the Lower Colorado-Lavaca Region is an important step in helping to identify the appropriate strategies and recommendations to reduce flood risk. Since the Lower Colorado watershed connects communities from Rocksprings in Edwards County to Matagorda County on the Matagorda Bay, flood infrastructure in this region benefits the community where it is located but could also have significant benefits for people and places downstream. When evaluating flood risk management infrastructure, this plan considers natural and manmade features that contribute to risk reduction. Examples are provided in *Table 1.9*. *Table 1.9* also includes the number of features collected and included in the supporting geodatabase for the region. It is anticipated for these counts to adjust as infrastructure inventories are refined through future planning cycles.

Table 1.9 Examples of Natural and Structural Flood Infrastructure

Natural Features	Region Counts	Structural Features	Region Counts
Rivers, tributaries, functioning floodplains	1,897,093	Levees	23
Lakes, reservoirs, *playa* lakes	2,030	Dams that provide flood protection	700
Parks, preserves, natural areas	451	Regional detention, *retention ponds*	0
Wetlands and marshes	36,628	Local stormwater systems, including tunnels, canals	0
Karst features, sinkholes	7	Roadway - low water crossings	1,354
Alluvial fans	0	Sea walls, revetments	414
Coastal barriers, nourishment, dunes	81	*Tidal barriers, gates*	0

Note: Features shown above in italics have not been identified as major flood infrastructure features in the Lower Colorado-Lavaca Region

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

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

Natural Features

As pasture, forests, and fields are replaced by urban development, soil permeability decreases. This makes land less effective at slowing down stormwater runoff and allowing it to percolate into the soil and recharge groundwater and aquifers. Instead, urban drainage infrastructure often collects stormwater and speeds it directly into a drainage channel, networks, and receiving streams. This can increase the speed and intensity of runoff, potentially resulting in higher downstream peak flows and higher water surface elevations.

From 1997 to 2017, the Texas Land Trends project by Texas A&M's Natural Resources Institute (NRI) found that the state of Texas lost over 2.2 million acres of working land (crops, grazing lands, timber, and wildlife management) to urban and suburban development. The state's population increased by more than 48 percent during that time. Natural areas were replaced with structures, roads, and parking lots. These hard, typically impervious surfaces increase the potential for runoff to burden waterbodies downstream. The acreage that did remain as open space grew increasingly fragmented (*Texas A&M Natural Resources Institute, 2021*).

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

When left in their natural state, landscapes are very effective in handling rainfall. As raindrops fall from the sky, they are captured by trees, shrubs, or grasses, slowing their passage to the area's waterways and allowing runoff to soak into the soil. Wetlands and woodlands are most efficient at recycling rainfall, as the branches and undergrowth intercept water before it even reaches the ground, thus minimizing overland flow to tributaries and the river. Pastureland performs this function effectively as well, whereas cropland may shed a greater degree of water so as not to inundate the fields. Similarly, parkland in urban areas designed for dual functions can achieve nearly the same rate of stormwater capture as lands in undeveloped areas (*Marsh, 2010*). For natural features to achieve maximum effectiveness at flood mitigation, they should form part of an interconnected network of open space consisting of natural areas and other green features that also protect ecosystem functions and contribute to clean air. This is sometimes known as green infrastructure, the practice of replicating natural processes to capture stormwater runoff (Low Impact Development Center, 2021). Even small changes in developed areas can significantly impact downstream flooding.

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

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

Rivers, Tributaries, and Functioning Floodplains

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

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

Similar to the floodplain quilt, the region’s streams were populated with available information from FEMA, USGS, TWDB, and local entities. It should be noted that the streams are compiled from the best available datasets; however, they generally do not align with the current topography. Along with statewide mapping, the TWDB is developing updated stream layers that can be integrated into the next planning cycle. As displayed in *Table 1.10,* there are over 54,000 stream miles in the Lower Colorado-Lavaca Region.

Table 1.10 Floodplains by HUC-8 Watershed

HUC-8 Name	Detailed Studies (square miles)	Approximate Studies (square miles)	Base Level Engineering (square miles)	Fathom (square miles)	HUC-8 Totals (square miles)	Percentage of HUC-8 Area (% of land)
Austin-Travis Lakes	133	19		4	156	13%
Brady				156	156	20%
Buchanan-Lyndon B	53	7	20	142	222	18%
East Matagorda Bay	302	122			424	33%
East Matagorda Bay	292	49			341	43%
Jim Ned		36		113	149	19%
Lavaca	45	116			161	18%
Llano	18	16	52	344	430	17%
Lower Colorado	345	34			379	54%
Lower Colorado-Cummins	73		420		493	23%
Middle Colorado		26		375	400	20%
Navidad	56	176			232	17%
North Llano				151	151	17%
Pecan Bayou	7	82		161	250	18%
Pedernales			117		118	9%
San Bernard	254	118			372	35%
San Saba				437	437	19%
South Llano				150	150	16%
West Matagorda Bay	200	17			217	24%
Region Totals	**1,779**	**817**	**610**	**2,032**	**5,238**	**21%**

Source: Floodplain Quilt

Lakes, Reservoirs, Parks, and Preserves

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

Table 1.11 Lakes, Reservoirs, Parks, and Preserves by HUC-8 Watershed details the acreage of each of these natural features and the total land area in the HUC-8 covered by these natural features. East Matagorda Bay 1 in the southern tip of the basin, Austin-Travis Lakes and Buchanan-Lyndon B Johnson in the central portion of the region, and San Bernard in the southern end contain the greatest percentages of land area covered with lakes, reservoirs, parks, and preserves. Other HUC-8s in the planning region have one to two percent of the land area covered with lakes, reservoirs, parks, and preserves.

Table 1.11 Lakes, Reservoirs, Parks, and Preserves by HUC-8 Watershed

HUC-8 Name	Lakes, Reservoirs (acres)	Parks (acres)	Preserves (acres)	HUC-8 Totals (acres)	Percentage of HUC-8 Area (% of land)
Austin-Travis Lakes	20,929	16,473	776	38,178	5%
Brady	2,126			2,126	< 1%
Buchanan-Lyndon B	28,637	8,688		37,325	5%
East Matagorda Bay 1	6,714	41,711		48,425	8%
East Matagorda Bay 2	10,842	7,244		18,086	2%
Jim Ned	6,106			6,106	1%
Lavaca	3,530			3,530	1%
Llano	620	4,072		4,691	< 1%
Lower Colorado	3,076	168		3,243	1%
Lower Colorado-Cummins	7,147	11,164	347	18,657	1%
Middle Colorado	12,977			12,977	1%
Navidad	9,996	1		9,997	1%
North Llano	37			37	< 1%
Pecan Bayou	3,892	2,459		6,351	1%
Pedernales	1,232	9,168	231	10,631	1%
San Bernard	3,838	25,523		29,361	4%
San Saba	191	1,215		1,405	< 1%

HUC-8 Name	Lakes, Reservoirs (acres)	Parks (acres)	Preserves (acres)	HUC-8 Totals (acres)	Percentage of HUC-8 Area (% of land)
South Llano	42	2,743		2,785	< 1%
West Matagorda Bay	2,571			2,571	< 1%
Region Totals	**124,501**	**130,628**	**1,354**	**256,483**	**2%**

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

Wetlands and Marshes

Wetlands and marshes are some of the most effective features of recycling water, minimizing the overland flow and reducing the need for other flooding infrastructure. A robust concentration of wetlands directly surrounds the Colorado River, with less-concentrated wetlands throughout the region. As the Colorado River heads southward towards the coast, the concentration of wetlands increases. This not only mitigates flooding coming from upstream areas but also flooding coming from the coast in the form of hurricanes and other tropical storms. According to the USGS National Wetlands Inventory, wetlands comprise approximately 275,000 acres within the basin, as displayed in *Table 1.12 Wetlands by HUC-8 Watershed.* This means that wetlands are one of the basin's largest types of natural infrastructure.

Table 1.12 Wetlands by HUC-8 Watershed

HUC-8 Name	Wetlands (acres)	Percentage of HUC-8 (% of land)
Austin-Travis Lakes	1,957	< 1%
Brady	829	< 1%
Buchanan-Lyndon B	2,017	< 1%
East Matagorda Bay 1	100,019	16%
East Matagorda Bay 2	38,199	4%
Jim Ned	1,766	< 1%
Lavaca	9,362	2%
Llano	3,168	< 1%
Lower Colorado	12,956	3%
Lower Colorado-Cummins	7,126	1%
Middle Colorado	1,609	< 1%
Navidad	13,132	1%
North Llano	274	< 1%
Pecan Bayou	1,546	< 1 %
Pedernales	1,286	< 1%

HUC-8 Name	Wetlands (acres)	Percentage of HUC-8 (% of land)
San Bernard	48,853	7%
San Saba	1,162	< 1%
South Llano	543	< 1%
West Matagorda Bay	29,767	5%
Region Totals	**275,589**	**2%**

Source: USFWS Delineated Wetlands

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

Natural Coastal Features

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

The state is updating the 2019 CRMP and anticipates the release of a new plan in 2023 that will include a list of projects in each region that can be incorporated into future planning cycles (Texas General Land Office, 2019).

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

Table 1.13 Natural Coastal Features by HUC-8 Watershed

HUC-8 Name	Dunes (miles)	Natural Barriers (miles)	Beach Nourishment Areas (count)
East Matagorda Bay 1	45	63	2
East Matagorda Bay 2	34	34	
Lavaca			
Lower Colorado		3	
Navidad			
San Bernard	1	10	
West Matagorda Bay			2
Region Totals	**80**	**110**	**4**

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

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

Structural Flood Infrastructure

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

Dams

USACE maintains a database of dams nationwide, totaling 7,324 in Texas. The Texas Commission on Environmental Quality (TCEQ) maintains a database of similar state-regulated Texas dams (i.e., dams above the size thresholds of Texas Administrative Code Title 30, Part 1, Chapter 299). Dams of unregulated size are deemed not to provide a safety risk to lives in the event of a breach. Finally, the Texas State Soil and Water Conservation Board maintain a list of 2,041 earthen dams designed and constructed by the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). These data sources were reviewed and amended to only include a single dam per location, ultimately identifying 700 dams in the region.

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

Levees

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

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

Figure 1.20 Dams and Levees and *Table 1.14 Dams and Levees by HUC-8 Watershed* provides the number of levees by HUC-8 watershed throughout the region.

Figure 1.20 Dams and Levees

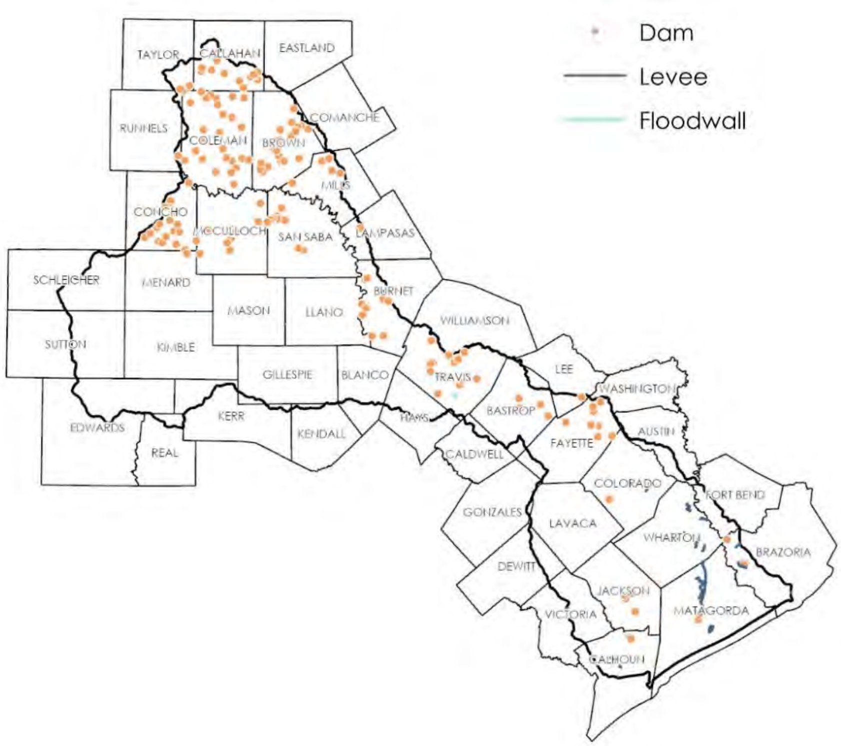


Table 1.14 Dams and Levees by HUC-8 Watershed

HUC-8 Name	Dams (count)	Percentage of Region (% of total dams)	Levees (miles)	Percentage of Region (% of total levees)
Austin-Travis Lakes	82	12%	3	3%
Brady	51	7%		0%
Buchanan-Lyndon B	17	2%		0%
East Matagorda Bay 1	6	1%	6	5%
East Matagorda Bay 2	10	1%		0%
Jim Ned	53	8%		0%
Lavaca	6	1%		0%
Llano	7	1%		0%
Lower Colorado	7	1%	64	59%
Lower Colorado-Cummins	117	17%		0%

HUC-8 Name	Dams (count)	Percentage of Region (% of total dams)	Levees (miles)	Percentage of Region (% of total levees)
Middle Colorado	132	19%		0%
Navidad	17	2%		0%
North Llano	1	0%		0%
Pecan Bayou	133	19%		0%
Pedernales	15	2%		0%
San Bernard	18	3%	20	18%
San Saba	19	3%		0%
South Llano	3	0%		0%
West Matagorda Bay	6	1%	16	15%
Region Totals	**700**	**100%**	**110**	**100%**

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

Stormwater Management Systems

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

Roadways

Low water crossings and at-risk roadway segments are utilized to assess existing condition risk, future condition risk, and potential mitigation benefits. The TWDB defines a low water crossing as a roadway crossing overtopped by the 1 percent annual chance (100-year) event or more frequent events. The low water crossings were obtained from the TWDB and amended with survey input. At-risk roadway segments are portions of the roadway that are inundated or impassable during flooding events that may impact emergency response or evacuation. The Lower Colorado-Lavaca Region's database was initially populated with the TWDB-provided low water crossings and then refined using input from entities.

Structural Coastal Features

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

Table 1.15 Roadways and Coastal Infrastructure

HUC-8 Name	Low Water Crossings (LWC)	Percentage of Region (% of total LWC)	Sea Walls (miles)	Percentage of Region (% of total walls)
Austin-Travis Lakes	377	28%		
Brady	52	4%		
Buchanan-Lyndon B	109	8%		
East Matagorda Bay 1	5	0%	19	59%
East Matagorda Bay 2	10	1%	4	12%
Jim Ned	38	3%		
Lavaca	13	1%		
Llano	279	21%		
Lower Colorado	3	0%	6	19%
Lower Colorado-Cummins	96	7%		
Middle Colorado	33	2%		
Navidad	23	2%		
North Llano	13	1%		
Pecan Bayou	49	4%		
Pedernales	167	12%		
San Bernard	16	1%		
San Saba	48	4%		
South Llano	11	1%		
West Matagorda Bay	12	1%	3	9%
Region Totals	**1,354**	**100%**	**32**	**100%**

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

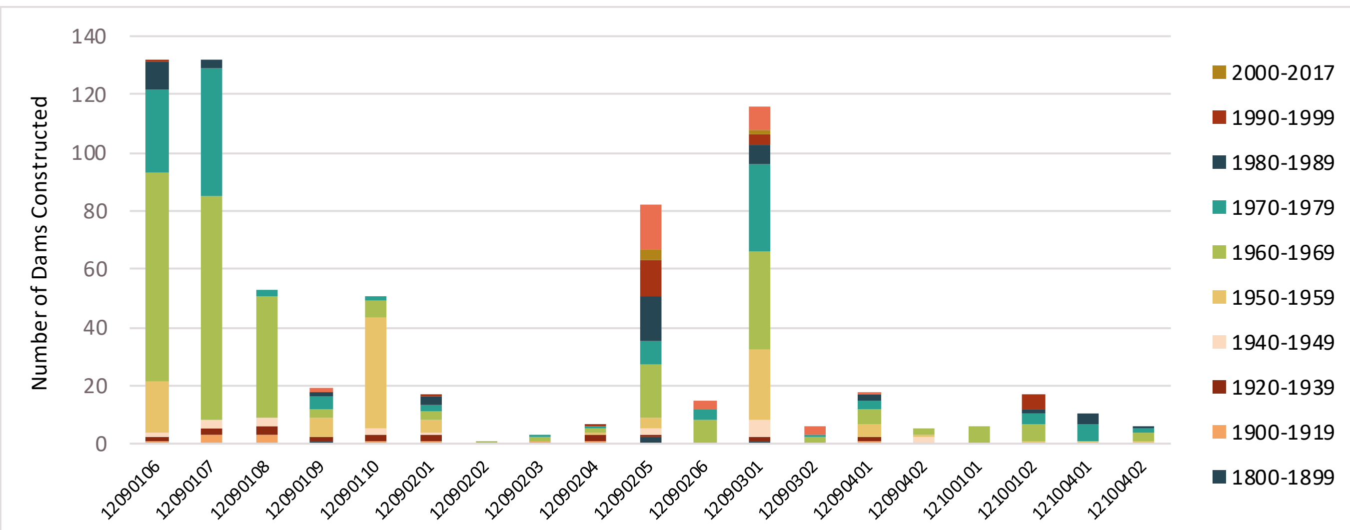
Condition and Functionality of Existing Flood Infrastructure

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

Throughout Texas, flood infrastructure is rapidly aging and in need of repair. In 2019, the Association of State Dam Safety Officials estimated the cost to rehabilitate all non-federal dams in Texas at about $5 billion. The TSSWCB estimates around $2.1 billion is required to repair or rehabilitate dams included in the Small Watershed Programs. Even though the minority of the dams in the region were constructed for flood control, the consequences of failure can still be severe, with the potential loss of life, agricultural resources, and property. Of the approximately 7,200 non-federal dams in Texas, about 25 percent could result in loss of life should they fail, and more than 3,200 Texas dams are exempt from dam safety requirements by state legislation. Of particular importance is Mansfield Dam, which impounds Lake Travis and is the only major flood control facility on the main stem of the Lower Colorado River. This facility provides a high degree of protection for large portions of the City of Austin and downstream communities. Lake Travis, along with Lake Buchannan, is also the primary source of water supply for over one million residents of the Lower Colorado-Lavaca Region.

The year of construction is available for the majority of the 700 dams in the Lower Colorado Lavaca Region, 77 percent of dams were constructed between 1950-1979. The 1960s were the most prolific period of dam construction in the region when over 40 percent were constructed. The percentage of dams constructed between 1950-1959 and 1970-1979 were roughly equal, at about 35 percent. With a typical life span of 50 years, over 50 percent of the dams in the region are reaching their life span.

Figure 1.21 Year of Dam Construction by HUC-8



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

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

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

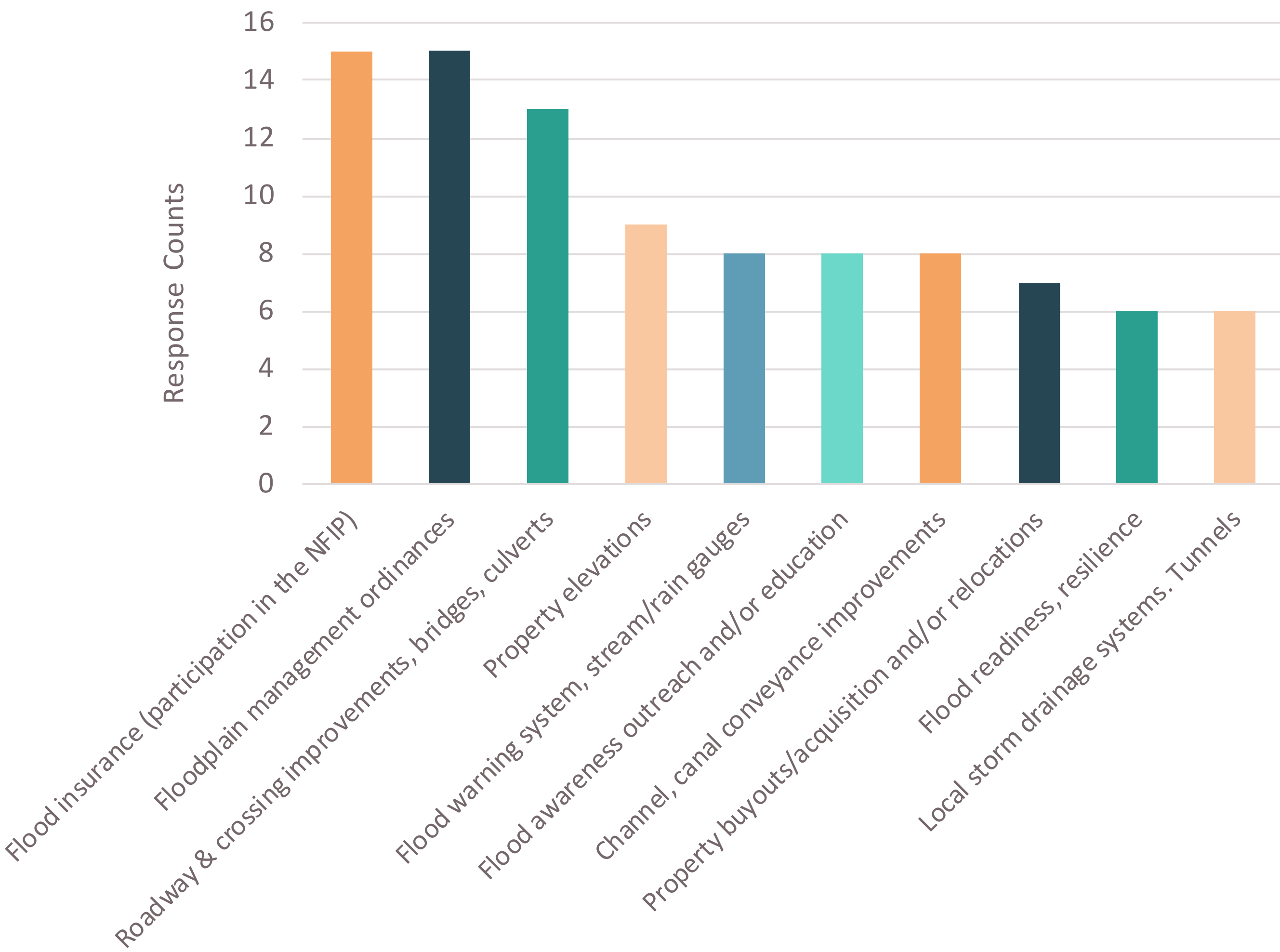
Condition-related data for the region’s levees is mostly unknown, since most of the levees in the state are built, inspected, and/or maintained by local governing agencies that may not have the resources for routine assessment and performance tracking. Levees protect over one million Texans and $127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

Of the 110 miles of levees in the Lower Colorado-Lavaca Region, approximately 45 miles (41 percent) of them are identified as being accredited by the USACE. This also indicates that several of the region's levees may be due for modernization, upgrades, maintenance, or rehabilitation.

Action - Proposed/Ongoing Flood Mitigation

The data for this section is derived from three primary sources. The first source is the region's data collection survey, which was supplemented by direct outreach and entity interviews. The other sources are existing hazard mitigation plans and current grant funding in the Lower Colorado-Lavaca Region.

Figure 1.22 Top 10 Types of Proposed or Ongoing Flood Mitigation Projects



Source: Lower Colorado-Lavaca Region Data Collection Tool and Interactive Webmap

Current Flood Mitigation Activities

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

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

The predominant types of projects being pursued are:

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

Figure 1.22 represents the top 10 types of potential projects identified by survey respondents. *Table 1.16* details the number of responses for all project types.

The largest number of respondents indicated continued participation in the NFIP flood insurance program and floodplain management ordinances (15 responses), followed by projects related to roadway and crossing improvements, bridges, culverts (13 responses), and channels and canal conveyance improvements (eight responses).

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

Table 1.16 Proposed Projects by Type

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

Source: Lower Colorado-Lavaca Region Data Collection Tool and Interactive Webmap

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

Structural Projects under Construction

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

Nonstructural Flood Mitigation Projects being Implemented

Information provided in response to entity outreach was insufficient to answer this question completely. *Appendix B Table 2* includes more information regarding nonstructural flood mitigation projects being implemented.

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

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

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

Potential Benefits of Planned Mitigation Projects

Although most communities did not provide detailed information about their intended projects, there does appear to be substantial awareness of the value of preparing for future flood events. 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. Still, it is anticipated that the inventory of this information will continue to grow in future planning cycles.

In all the region was able to document 63 proposed or ongoing projects within the Region. Data associated with these projects is found in the geospatial submittal, *Appendix A Map 2*, and *Appendix B Table 2*.

Chapter 2: Flood Risk Analysis

Source: City of Austin Lower Shoal Creek Risk Reduction Study – Flood Hazard Analysis of the Shoal Creek Saloon

An important aspect of developing a regional flood plan involves accurately assessing the flood risk. This includes a description of the flood, identifying what is at risk, and estimating the associated impacts. In terms of understanding the environment, the Lower Colorado-Lavaca Regional Flood Plan assessed flood risk for existing and future conditions. In this plan, the existing and future conditions flood risk assessment focused on the following three main components:

1. Flood hazard analyses to determine the location, magnitude, and frequency of flooding
2. Flood exposure analyses to identify who and what might be harmed within the region; and
3. Vulnerability analyses to identify the degree to which communities and critical facilities may be affected by flooding.

Figure 2.1 TWDB Flood Risk Analyses Triangle Framework

Flood risk is generally identified through hydrologic and hydraulic (H&H) analysis. In flood risk analysis, hydrology is the study of how rainfall, topography, land cover, and land use affect the amount of water on the region's surface. Hydraulics investigates the movement or flow of that water as it travels across the region by rivers and streams or man-made conveyance structures such as storm drainage systems.

The 1 percent annual chance (100-year) event is the regulatory basis for the National Flood Insurance Program and has a one in a hundred chance of being equaled or exceeded in any given year. It is often referred to as the "100-year flood", the "Special Flood Hazard Area (SFHA)," or the "base flood." This boundary is a convenient tool for assessing vulnerability and risk in communities. The 1 percent annual chance (100-year) event is a mapped high-risk flood area subject to a 1 percent or greater annual chance of flooding in any given year. These areas may also be susceptible to erosion, deposition, and sedimentation.

The base flood or 1 percent annual chance (100-year) event floodplain is the national standard used by the National Flood Insurance Program and other federal agencies to regulate development and require the purchase of flood insurance. On Flood Insurance Rate Maps (or FIRMs), the Federal Emergency Management Agency (FEMA) plots both the 1 percent (100-year) and 0.2 percent (500-year) annual chance events.

Task 2A: Existing Condition Flood Risk Analyses

Existing Condition Flood Hazard Analysis

Sufficiency of Existing Conditions for Planning Purposes

In terms of flood risk analysis, the assessment of the existing conditions represents a current snapshot of certain elements that contribute to or protect from flooding. These conditions include the current land cover and use, estimated rainfall data, and constructed drainage-related infrastructure. These variable factors have the potential to change in the future, which will be discussed in Task 2B. The following paragraphs summarize the RFPG's assessment of current condition factors. Refer to *Chapter 1: Planning Area Description* for a more detailed outline of these existing condition components.

Land Cover and Use

Land cover and land use are the spatial and visual representation of features generally seen on the surface in a given area. Land use is an important factor in determining the propensity for flooding under existing conditions. It affects the hydrological processes such as evaporation, interception of natural flow paths, and infiltration into the soil as water flows across the land. As urban development (characterized by impervious areas) increases in a watershed, the hydrologic response of the runoff across the land changes, and surface runoff often increases. *Figures 1.10* and *1.11* in *Chapter 1: Planning Area and Description* show the land cover and use across the Lower Colorado-Lavaca Region.

Cultivated agricultural and ranch land can change the watershed's response to rainfall. Additionally, population changes can impact the development rate and land use changes. The previous results can be invalidated if the incidence of change since the last flooding analysis is very high. However, if the changes in land use have remained unchanged, the results of previous studies may still be used as valid and up-to-date data.

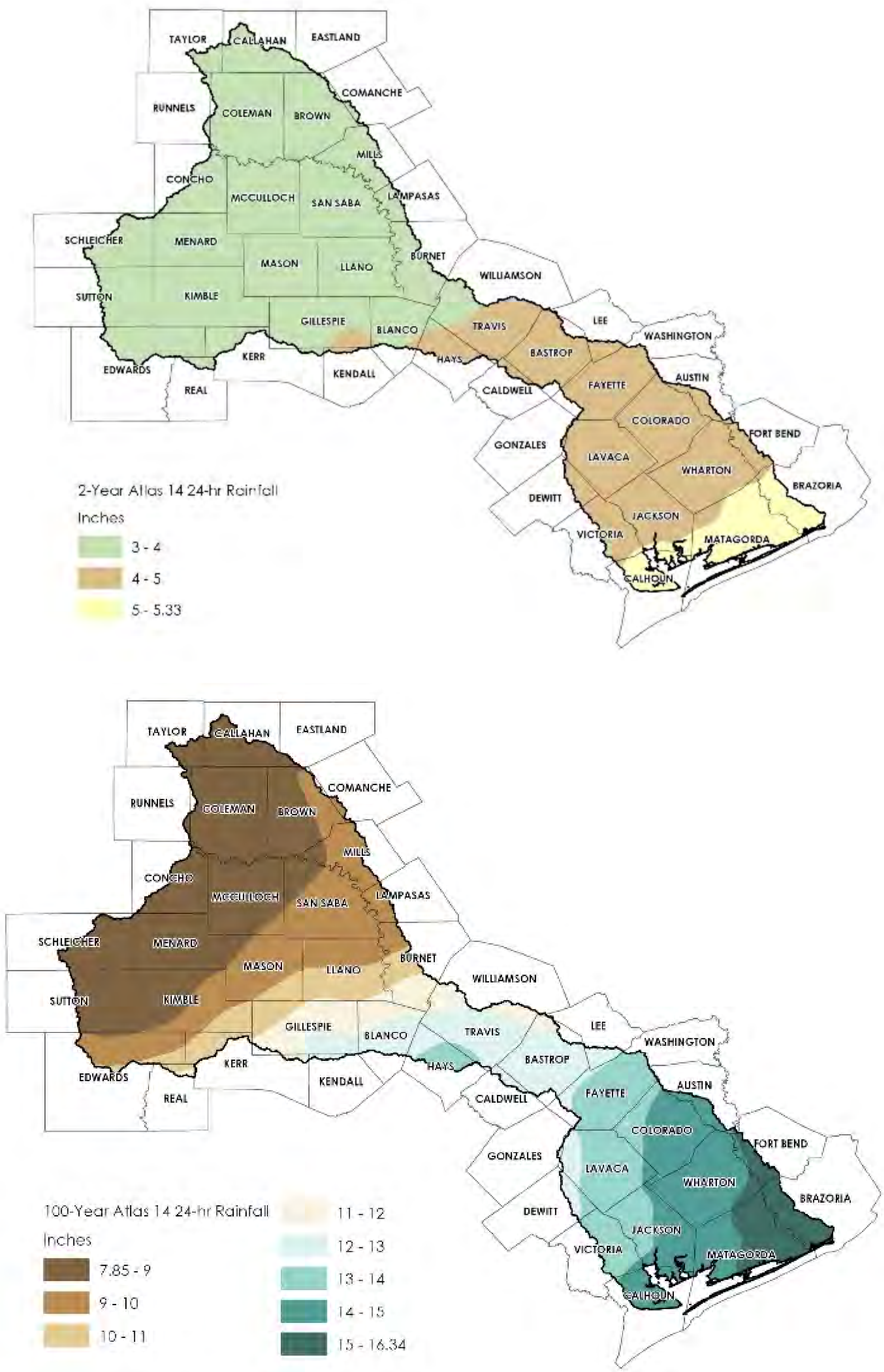
The Lower Colorado-Lavaca Region includes a distinct divide in the topographic features that occurs due to the presence of the Balcones Escarpment land formation, which separates the Texas Hill Country from the Coastal Plains. The Hill Country portion of the region is characterized by lower infiltration rates and hydraulic conveyance through confined natural channels. The portion of the Region along the Balcones Escarpment is distinguished by higher infiltration rates and hydraulic conveyance through steep natural channels. The region downstream of the Balcones Escarpment may also be referred to as the Coastal Plains of Texas and constitutes the downstream portion of the region. The Coastal Plains are distinguished by flat terrain with higher infiltration rates and hydraulic conveyance through overland areas and natural channels.

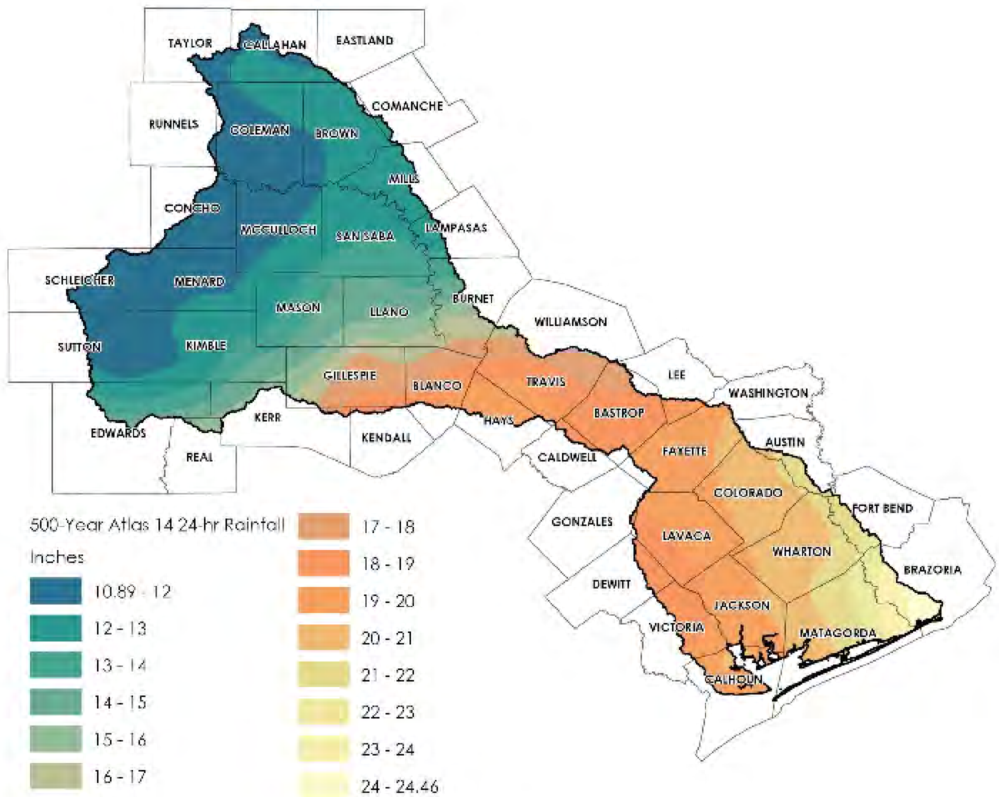
Rainfall Data

When planning for existing conditions flood risk, assessing rainfall depths and frequency of occurrence is crucial. Rainfall data in terms of inches for a 24-hour duration is commonly utilized for flood hazard analysis. In 1973, the National Flood Insurance Program set the standard for flood hazard areas based on the 1 percent annual chance (100-year) event. For the State Flood Plan, all risk assessments are based on this recurrence interval.

In 2018, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation-frequency values for Texas based on historical rainfall data up to 2017. This Atlas 14 publication indicates that the 1 percent annual chance (100-year) event may be greater than previously considered in many areas of the Lower Colorado-Lavaca Region, as shown in *Figure 1.17* in *Chapter 1: Planning Area and Description*. *Figure 2.2* displays Atlas 14 rainfall depths for the 50 percent (2-year), 1 percent (100-year), and 0.2 percent (500-year) annual chance events.

Figure 2.2 Atlas 14 Rainfall Depths for Various Frequency Events





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

The City of Austin and other entities in the region are in the process of updating hydrologic and hydraulic models to incorporate NOAA Atlas 14 rainfall data. These updated models, and the resultant map products, are expected to be available for use in the next regional flood planning cycle.

Flood Infrastructure

Drainage-related infrastructure is a key element in determining the existing conditions of flood risk. As described in *Chapter 1: Planning Area and Description*, drainage-related infrastructure includes natural and structural infrastructure such as dams, levees, detention and retention ponds, bridges, culverts, low water crossings, drainage stormwater tunnels, urban storm drain networks, breakwaters, bulkheads, and revetments.

Structural infrastructure is intended to mitigate or reduce flood risk. However, outdated, undersized, or unmaintained drainage infrastructure may increase flood risk. Bridges, culverts, and storm drain systems designed and constructed before major land use changes, rainfall changes, and/or higher floodplain management standards may no longer serve their intended purpose during significant storm events. The result is increased flood risk to both property and life. Structural flood infrastructure must be inspected and maintained regularly to perform as designed in the event of a flood.

Best Available Flood Risk Data

Due to the varying ecoregions and topography, the Lower Colorado-Lavaca Region experiences multiple types of flood risk, as described in *Chapter 1: Planning Area and Description*. The best available flood risk data within the Lower Colorado-Lavaca Region is primarily riverine with some coastal influence in Calhoun, Jackson, Matagorda, and Fort Bend counties in the south, where they are directly (and frequently) affected by hurricanes from the Gulf of Mexico. Hurricanes typically fade and downgrade to tropical storms or depressions as they move inland away from the coast. Riverine flooding is mostly from general rainfall and thunderstorm floods. Flash floods are common from these rainfall events, which can occur within a few minutes or hours of excessive rainfall, exposing millions of dollars in valuable public and private property to flood risk.

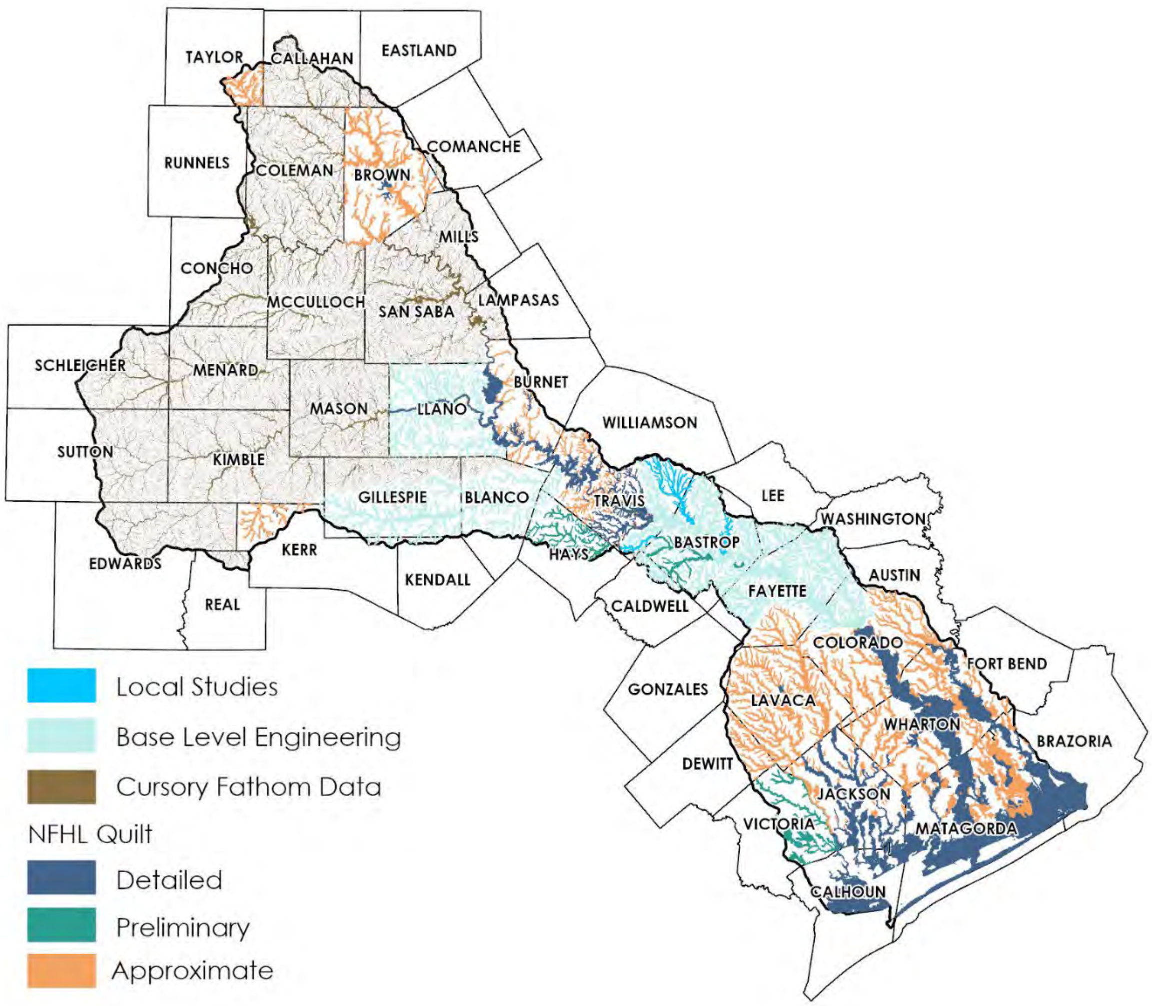
Local floodplains are flood-prone areas outside of mapped effective FEMA flood zones, designated Special Flood Hazard Areas (SFHA), shown on FIRMs. Some communities have begun taking steps to better define and understand local flooding risks in their community using strategies such as local knowledge, historical events, and approximate or detailed local flood modeling studies, drainage master planning, local neighborhood analysis, and large-scale two-dimensional (2D) hydraulic modeling. All flood risk types were considered in identifying the best available, existing condition flood hazard data for the Lower Colorado-Lavaca Region.

Floodplain Quilt

While developing a comprehensive flood risk model of the region is beyond the scope of this planning effort, the TWDB “floodplain quilt” that is being used in the planning process is “stitched” together from various sources of data to provide comprehensive coverage of all known existing statewide flood hazard information. The floodplain quilt combines numerous data layers from FEMA, including effective floodplain maps, preliminary maps, and base level elevation (BLE) maps, as well as data from other federal agencies. Information from local and regional flood studies was used to refine the Lower Colorado-Lavaca Region’s floodplain quilt “patches” derived from such sources. Finally, the remaining floodplain quilt gaps were filled using the cursory floodplain dataset provided by the TWDB. Upon review of the various floodplain datasets, it was ultimately recommended that the existing condition floodplain quilt be compiled using the hierarchy outlined below. The resultant floodplain quilt is displayed in *Figure 2.3.*

1. Local Studies
2. National Flood Hazard Layer
    - Pending and Preliminary Data
    - Effective Data for Detailed Study Areas (Zone AE, AO, AH, and VE)
3. Base Level Engineering
4. National Flood Hazard Layer
    - Effective Data for Approximate Study Areas (Zone A and V)
5. Cursory Floodplain Data

Figure 2.3 Floodplain Quilt



Source: TWDB Floodplain Quilt with regional enhancements

Local Studies

A list of previous studies has been compiled using collected and researched information and is presented in *Table 2.1.* The previous flood studies and associated models included on the list are those that are being used to refine the Lower Colorado-Lavaca Region's floodplain quilt and/or studies that are being used to identify/validate potential evaluations, strategies, and/or projects. In addition to provided studies via the *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap*, the previous studies were collected through online searches and consultant team experience in the Lower Colorado-Lavaca Region. Study reports and communication with sponsors reveal whether hydrologic and hydraulic models are available or presumed available. It was also verified that these local studies reflect current conditions, such as the latest topography and Atlas 14 rainfall data. There are other local studies and the TWDB flood protection planning studies conducted in the Lower Colorado-Lavaca Region. These other local studies were incorporated into the FEMA's National Flood Hazard Layer (NFHL); therefore, they are not listed as local studies in this plan.

Table 2.1 Local Studies Incorporated into Floodplain Quilt

Study Name	County	HUC-8 IDs	Watersheds	Study Completion Year
Bastrop County Flood Protection Planning Study - Alum Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Alum	2021
Travis County Maha Creek Atlas 14 Floodplain Study	Travis	12090301	Maha	2021
Bastrop County Flood Protection Planning Study - Wilbarger Creek Watershed (TWDB Contract No. 1800012308)	Travis, Bastrop	12090301	Wilbarger	2021

National Flood Hazard Layer

The FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies represent existing conditions to depict risk for insurance purposes. As such, they represent a snapshot in time and do not consider future conditions or climate change. FEMA's NFHL is a geospatial database that includes digital FEMA floodplain datasets that are currently effective and have become available for the National Flood Insurance Program regulatory use. Related to the NFHL are FEMA's floodplain datasets that are preliminary or pending adoption before becoming effective. These datasets are described below.

Effective Detailed Studies

Detailed studies are developed using detailed hydrologic and hydraulic models and methodologies. Products of a detailed study (Zone AE, AO, AH, and VE) generally include hydrologic models, hydraulic models, survey data, floodplains, floodways, depth grids, profiles, and base flood elevations. Zone AE analysis is a more costly analysis that is generally conducted in urban areas. These studies include both the 1 percent (100-year) and 0.2 percent (500-year) annual chance event floodplains.

Effective Approximate Studies

Approximate studies are developed using approximate methods. Approximate hydrology may utilize regional regression equations to compute flow. Hydraulic simulations do not include survey data, depth grids, profiles, or base flood elevations. Depending on the model, some hydraulic simulations may not include data representing stream crossings. Approximate (Zone A and V) analysis is more appropriate for rural areas or locations with no structures in or near the floodplain. These studies generally only include the 1 percent (100-year) annual chance event floodplain.

Pending and Preliminary Data

Pending flood hazard data is in FEMA's Letter of Final Determination stage, which means the data is considered final and assigned an effective date. The pending timeframe is generally five to six months in advance of the assigned effective date. Preliminary flood hazard data is issued for public review of the proposed floodplain changes, and this data is subject to refinement before finalization. Both the pending and preliminary datasets include both detailed and approximate study data. Because these pending and preliminary studies are more current than effective studies, they were utilized as the best available data in the floodplain quilt.

Base Level Engineering

The TWDB and FEMA have invested in base level engineering (BLE) across the state with the goal of full coverage by the fiscal year 2024. The BLE studies incorporate automated techniques with traditional model development to produce approximate flood hazard boundaries for the 1 percent (100-year) and 0.2 percent (500-year) annual chance events as well as other events. In the Lower Colorado-Lavaca Region, there are three areas where one-dimensional BLE is available. These areas are within Llano County, the Pedernales watershed, and the Lower Colorado-Cummins watershed. The BLE data is the best available data, above the effective approximate studies and the cursory floodplain data. Existing condition base level engineering studies were determined to be current, reflecting current topography and alignment to current stream gage statistics. Additionally, there are seven HUC-8 watersheds in the lower half of Region 10 where two-dimensional BLE was just completed. The two-dimensional BLE was not incorporated into the floodplain quilt as the data was not available at the time of the risk analysis.

Cursory Floodplain Data

As displayed in *Chapter 1: Planning Area and Description Figure 1.15*, a significant portion of the state lacks floodplain maps. For those where data is missing or outdated, the TWDB provided a "cursory floodplain" derived from the Fathom dataset to append the State's initial floodplain quilt. Fathom is developed by a research group at the University of Bristol, England. The intention of the Fathom rapid assessment flood data is to fill the gaps where flood risk data is unavailable. The cursory floodplain dataset includes pluvial (riverine), fluvial (local or urban), and coastal flood risk produced using models developed at 30-meter (approximately 100-feet) resolution for the entire state of Texas. The 30-meter produced Fathom models incorporate TWDB-provided Light Detection and Ranging (Lidar) data in all areas of the state, with model results hydrologically mapped at a 3-meter (approximately 10-feet) resolution. The cursory floodplain dataset has been peer-reviewed and compares reasonably well to the FEMA flood data and BLE. The cursory floodplain data includes mapping for the 1 percent (100-year) and 0.2 percent (500-year) annual chance events, as well as other storm frequencies.

Fathom's fluvial, pluvial, and coastal flood depth data for the Lower Colorado-Lavaca Region were mosaicked together utilizing the greatest depths where the datasets overlap. The RFPG processed the flood depth data to develop flood polygon boundaries using guidance provided by the TWDB. The cursory floodplain data served as a supplemental dataset for inclusion in the existing flood boundaries where no other data or digitally converted FIRMs from the First American Flood Data Services (FAFDS) were available. Observation of the cursory floodplain dataset in relation to the FAFDS revealed the two datasets were similar, and since the cursory floodplain dataset was better aligned with the current topography, it was decided to replace the FAFDS flood risk data with the cursory floodplain dataset.

An interesting aspect of the Fathom dataset is the pluvial flood risk information. The pluvial flood risk is also referred to as the local or urban flood risk. This flood risk is generally identified by dropping water onto the terrain and letting the topography dictate where water flows. The pluvial flood risk is not intended for regulatory purposes but provides a great resource for flood planning as this dataset displays flood risk beyond the traditional riverine flood risk. This local (urban) flood risk better defines where water will gather and flow once the rain hits the ground.

Possible Flood-Prone Areas and Other Floodplain Data

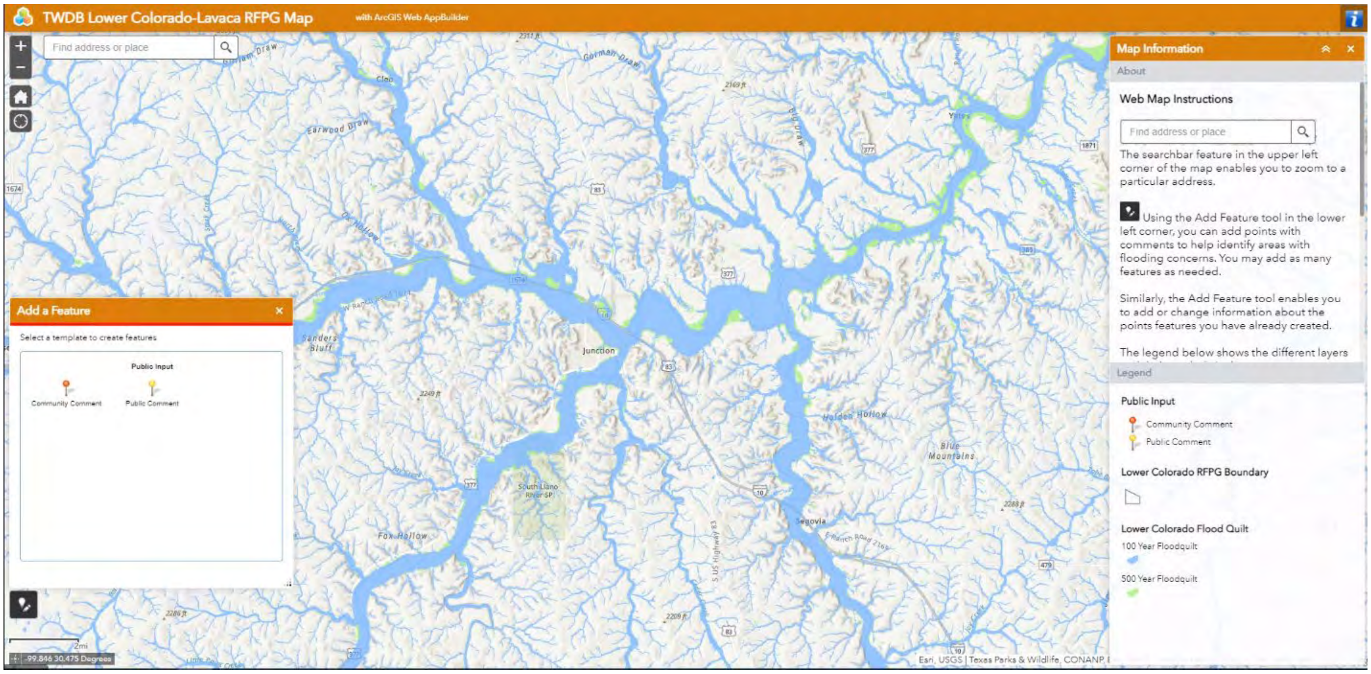
Due to the varying ecoregions and topography, the Lower Colorado-Lavaca Region experiences various types of flood risk. The flood risk identified throughout the region's planning process is primarily associated with riverine systems. Coastal flood risk identified by the National Flood Hazard Layer is present across Calhoun, Matagorda, and Brazoria counties. Local (sometimes also referred to as urban or pluvial) flood risk data was considered for inclusion in the existing floodplain quilt. This local (urban) flood risk better defines where water will gather and flow once the rain hits the ground. Local (urban) flood risk is incorporated in the areas where the cursory floodplain data was used to fill prior flood risk gaps within the region; however, no other local (urban) flood risk information was provided for incorporation into the region's floodplain quilt. Structural failure flood risk is also present in the region as being associated with the potential failure of flood control structures such as dams and levees, which may cause an uncontrolled release of floodwaters. No structural failure flood risk information was provided for incorporation into the Lower Colorado-Lavaca Region's floodplain quilt.

Other possible flood-prone areas include areas of historical flooding events and areas of reported flood concerns provided by regional entities. Through the summer and fall of 2021, the *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap* provided entities an opportunity to identify flood-prone areas and provide the best available flood risk information for consideration in the amendment of the Lower Colorado-Lavaca Region's floodplain quilt. All information and areas of flood concern were considered in the flood hazard analysis. It was determined that the historical flooding events were well represented by the Lower Colorado-Lavaca Region's floodplain quilt. It was also determined that the survey responses of reported flood concerns were also represented in the Lower Colorado-Lavaca Region's floodplain quilt.

Summary

The draft existing condition flood hazard map was discussed during the RFPG meeting on January 31, 2022. A *Flood Risk Webmap* was employed to obtain interest groups and public comments on the draft flood hazard maps. The *Flood Risk Webmap* provided a tool for users to review and comment on the data presented in the maps and to identify and locate additional potential flood hazard areas. The webmap was launched on February 10, 2022, and was accessible through the end of May. *Figure 2.4* displays a screen capture of the interactive *Lower Colorado-Lavaca Region Flood Risk Webmap*.

Figure 2.4 Draft Flood Hazard Interactive Webmap



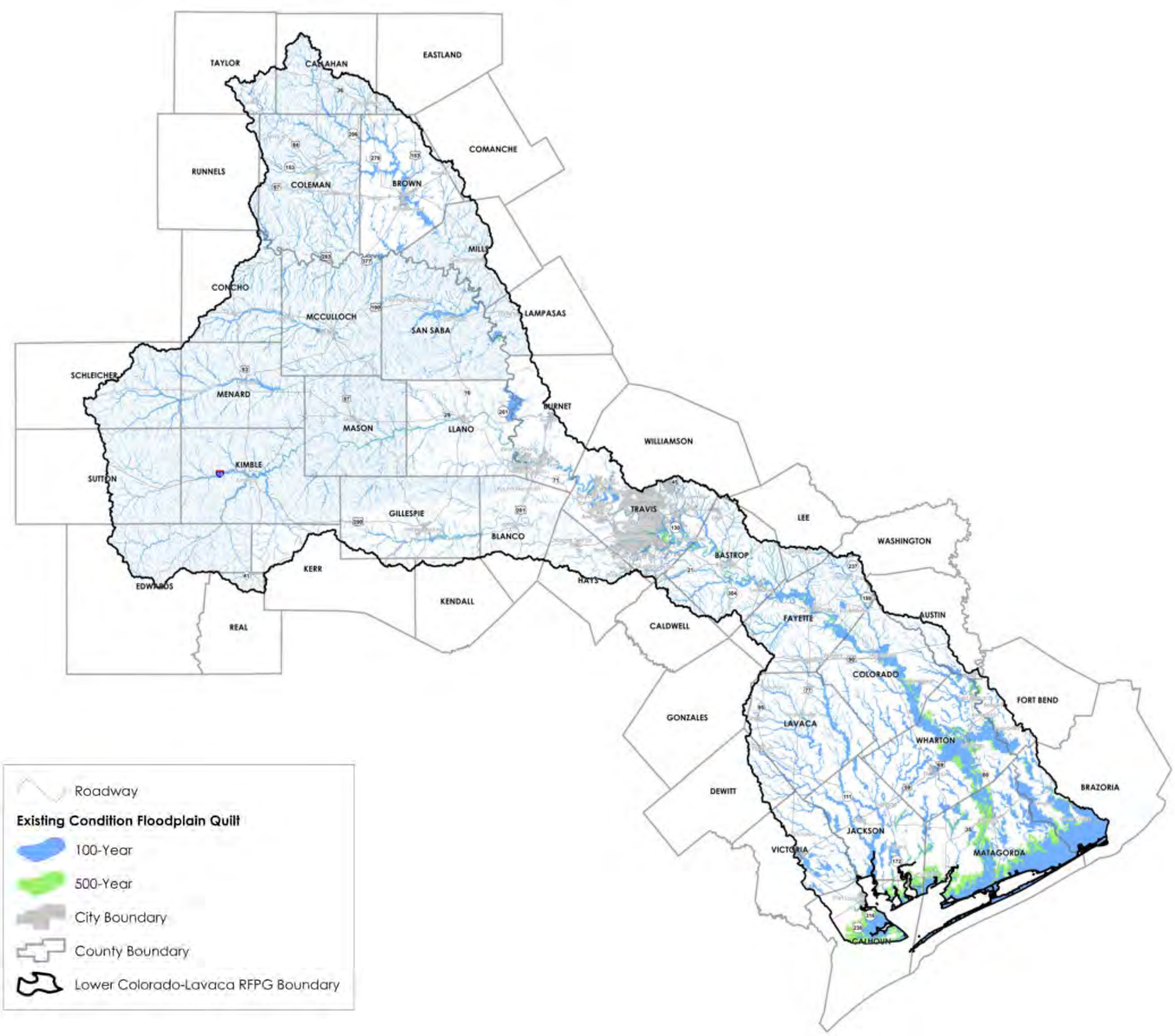
The compiled existing condition floodplain quilt data for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.5* shows a map of the comprehensive existing flood hazard data compiled for the Lower Colorado-Lavaca Region. A larger, more detailed version of this figure is included as *TWDB-required Map 4 in Appendix A.* A summary of existing condition flood risk by flood type and frequency is provided in *Table 2.2*.

Table 2.2 Summary of Existing Condition Floodplain Area (square miles) by Flood Type

County	1% Riverine	1% Coastal	1% Local	0.2% Riverine	0.2% Coastal	0.2% Local
Austin	18			18		
Bastrop	138			168		
Blanco	28		14	35		16
Brazoria	174	59		195	59	
Brown	131			131		
Burnet	52			57		
Caldwell	8			9		
Calhoun	30	49		37	120	
Callahan			79			88
Coleman			236			265
Colorado	194			214		
Comanche			4			4
Concho			96			108
De Witt	20			20		

County	1% Riverine	1% Coastal	1% Local	0.2% Riverine	0.2% Coastal	0.2% Local
Eastland			5			6
Edwards			94			102
Fayette	177			202		
Fort Bend	39			46		
Gillespie	59		59	74		65
Hays	20			22		
Jackson	148	29		162	41	
Kendall	1			1		
Kerr	17			18		
Kimble			213			232
Lampasas			29			32
Lavaca	159			159		
Lee	14			17		
Llano	100			120		
Mason			172			193
Matagorda	236	220		389	241	
McCulloch			188			213
Menard			148			161
Mills			79			90
Real			8			9
Runnels			5			6
San Saba			222			247
Schleicher			89			98
Sutton			88			97
Taylor	19			19		
Travis	143			172		
Victoria	65	4		66	4	
Wharton	335			389		
Totals	**2,326**	**361**	**1,828**	**2,740**	**466**	**2,032**

Figure 2.5 Existing Condition Flood Hazard Map



Hydrology & Hydraulic (H&H) Model Availability

H&H modeling is necessary to determine how water moves across the Lower Colorado-Lavaca Region. It is vital to develop effective flood planning strategies. Various entities within the Lower Colorado-Lavaca Region have previously developed hydrology and hydraulic models to further understand how water impacts their communities.

Since the 1970s, H&H analyses have used computer software applications to identify areas at risk of flooding and mitigation measures to reduce flood risk. Within the Lower Colorado-Lavaca Region, there are hundreds of H&H models, each calibrated for a specific study extent and purpose. The best available data from the various modeling efforts were ultimately incorporated into the Lower Colorado-Lavaca Region's floodplain quilt. *Table 2.3* lists previous studies in the region that were compiled using collected and researched information. The previous flood studies and associated models included on the list are those that are being used to refine the Lower Colorado-Lavaca Region's floodplain quilt and/or studies that are being used to identify/validate potential evaluations, strategies, and/or projects. In addition to provided studies via the *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap*, the previous studies were collected through online searches and the technical consultant team's experience in the Lower Colorado-Lavaca Region.

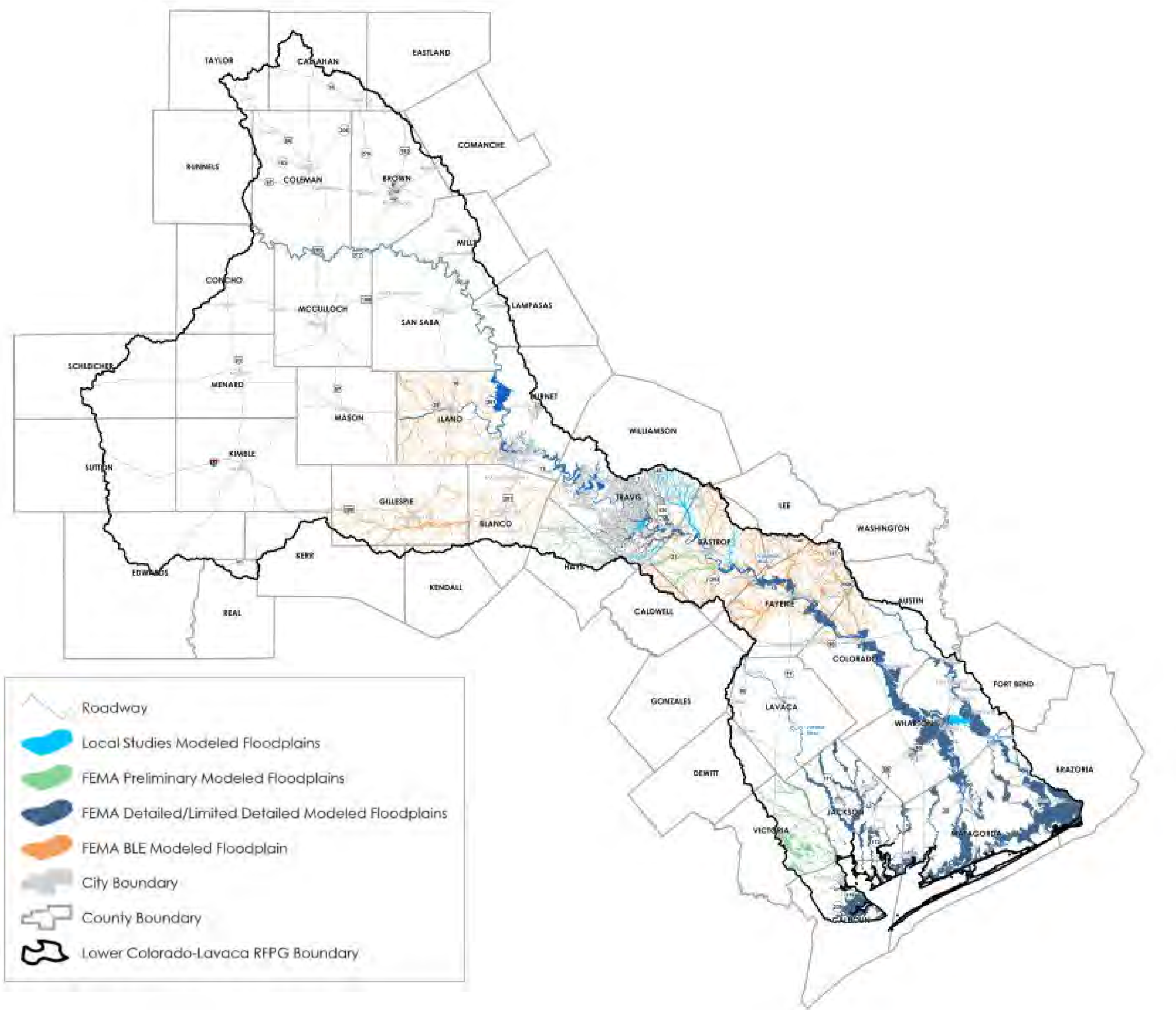
Table 2.3 Available H&H Models in the Lower Colorado-Lavaca Region

Study Name	County	HUC-8 IDs	Watersheds	Study Completion Year	How Study used in Plan
Bastrop County Flood Protection Planning Study - Alum Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Alum	2021	Floodplain Quilt, FMEs
Bastrop County Physical Map Revision	Bastrop	12090301	Cedar, Walnut, Piney, Gills, Willow-Gazley	2021	Floodplain Quilt
Bastrop County Flood Protection Planning Study - Willow-Gazley Creeks (TWDB Contract No. 0848322056)	Bastrop	12090301	Willow and Gazley	2018	FMEs
Bastrop County Flood Protection Planning Study - Piney Creek Watershed (TWDB Contract No. 0848322056)	Bastrop	12090301	Piney	2018	FMEs
City of Bastrop Gills Branch Flood Mitigation Improvements	Bastrop	12090301	Gills	2021	FMP
Bastrop County Flood Protection Planning Study - Walnut Creek Watershed (TWDB Contract No. 0804830834)	Bastrop	12090301	Walnut	2018	FMEs
City of Fredericksburg Drainage Master Plan	Gillespie	12090206	Pedernales	2016	FMEs
City of Brady Drainage Master Plan	McCulloch	12090110	Brady Creek	2015	FMEs

Study Name	County	HUC-8 IDs	Watersheds	Study Completion Year	How Study used in Plan
City of Bee Cave Capital Improvements Project Great Divide	Travis	12090205	Little Barton Creek	2021	FMP
Travis County Maha Creek Atlas 14 Floodplain Study	Travis	12090301	Maha	2021	Floodplain Quilt
Travis County Flood Mitigation Study	Travis	12090301, 12090205	Onion and Dry Creek East	2017	FMEs
Bastrop County Flood Protection Planning Study - Wilbarger Creek Watershed (TWDB Contract No. 1800012308)	Travis, Bastrop	12090301	Wilbarger	2021	Floodplain Quilt, FMEs
1D Base Level Engineering: Pedernales Watershed	Gillespie, Blanco, Hays, Travis	12090206	Pedernales	2021	Floodplain Quilt
1D Base Level Engineering: Lower Colorado-Cummins Watershed	Travis, Bastrop, Caldwell, Lee, Fayette, Colorado	12090301	Lower Colorado-Cummins	2018	Floodplain Quilt
1D Base Level Engineering: Llano County	Llano	12090204, 12090201	Watersheds in Llano County	2017	Floodplain Quilt
FEMA Detailed and Limited Detailed Modeled Floodplains (Effective and Preliminary)	Multiple	Multiple	Multiple	Varies	Floodplain Quilt

These local studies, BLE studies, and FEMA detailed and limited detailed studies are locations where H&H models are available. It should be noted that for use in developing evaluations, strategies, or projects, these models will likely require some level of enhancement. A graphical representation of these locations is provided in *Figure 2.6.* A larger, more detailed version of this figure is included as *TWDB-required Map 22* in *Appendix A*. The geodatabase feature classes titled 'ModelCoverage' provides a spatial representation of available models in the Lower Colorado-Lavaca Region.

Figure 2.6 Locations where Hydrologic and Hydraulic Models are Available



Data Gaps

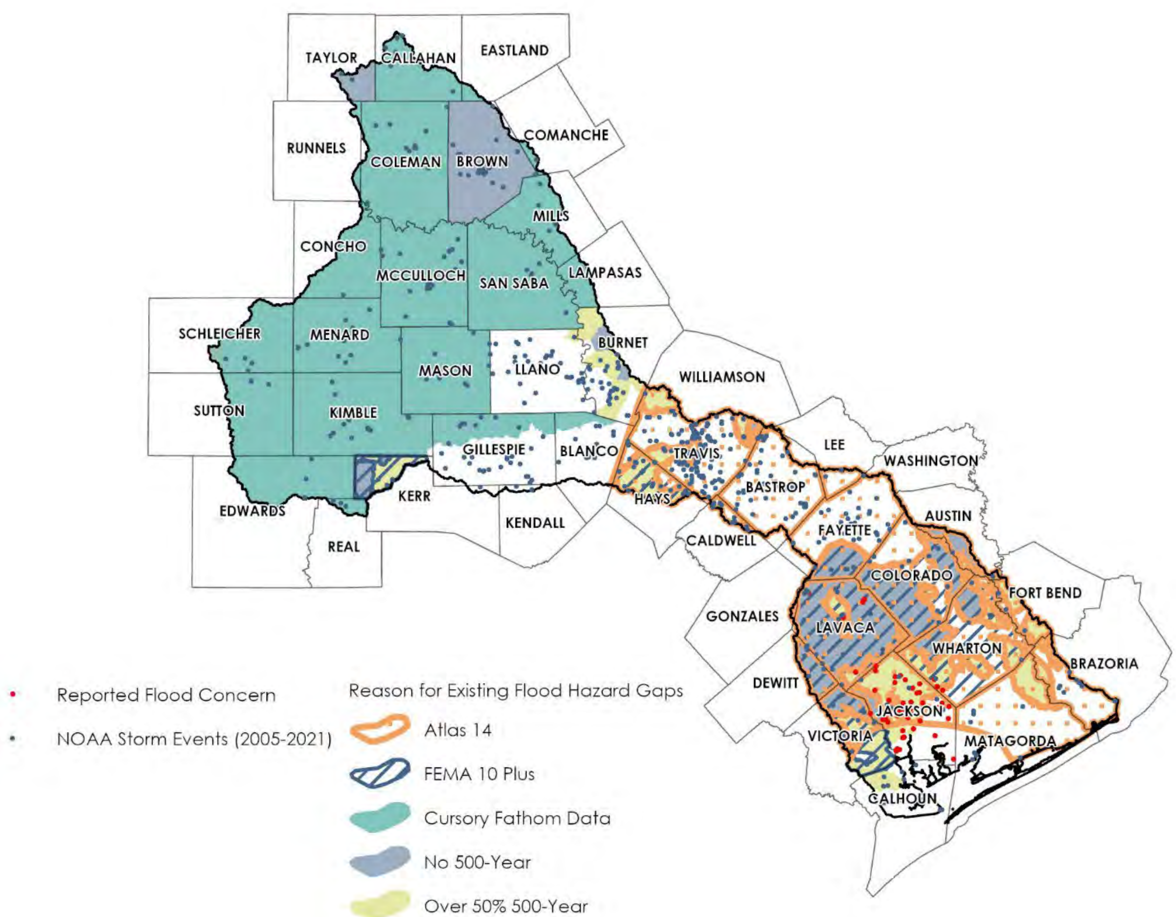
Once the best available comprehensive existing flood data was complied, the data gaps were assessed to identify any remaining areas where flood inundation boundary mapping was missing, lacked modeling and/or mapping, or used outdated modeling and/or mapping. Other contributing engineering factors used to identify data gaps included modeling technology, significant topographic change, significant land use and/or impervious area change, change in flood control structures, channel configuration (including erosion and sedimentation) changes, and rainfall pattern changes altering peaks discharges.

Following the compilation of the floodplain quilt, a flood hazard gap analysis was performed to identify known or "apparent" flood-prone areas that lack models and maps or have existing models and maps that are outdated or otherwise not considered reliable.

The existing condition gap analysis identifies the following:

- absence of hydrologic and hydraulic models where the cursory floodplain mapping is utilized
- outdated National Flood Hazard Layer data greater than 10 years old
- absence of 0.2 percent annual chance (500-year) flood risk data
- more than 50 percent absence of 0.2 percent annual chance (500-year) flood risk data
- absence of modeling and mapping utilizing NOAA Atlas 14 rainfall data

Figure 2.7 Existing Condition Flood Hazard Gaps



The compiled existing condition gap analysis for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.7* shows a map of the locations of identified existing condition flood data gaps. A larger, more detailed version of this figure is included as *TWDB-required Map 5* in *Appendix A*.

While areas were identified within the floodplain quilt as data gaps with outdated information, the complied existing floodplain quilt still comprised the best available floodplain datasets for the Lower Colorado-Lavaca Region and was used for the flood risk analysis in the Lower Colorado-Lavaca Regional Flood Plan. It is an objective of this plan to further evaluate these data gaps and potentially address the gaps in recommended Flood Management Evaluations (FMEs). These data gaps are further discussed in *Chapter 4: Flood Mitigation Needs*.

Existing Condition Flood Exposure Analysis

In Texas, flooding frequency and intensity have been increasing in recent years, sometimes necessitating state and federal relief, which has risen to record levels. Flooding can become a significant hazard when it inundates the built environment and causes direct damage to buildings, critical facilities, crops, and occasionally injuries or loss of life.

The existing condition flood risk exposure analysis leveraged the compiled existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt in the Lower Colorado-Lavaca Region to determine existing flooding exposure to identify who and what might be at risk of flooding. This floodplain quilt is comprised of the best available flood hazard data. The *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap* discussed in *Chapter 1: Planning Area and Description* included multiple opportunities for entities to submit conceptual, planning, or ongoing projects or studies related to flooding. No entities in the Lower Colorado-Lavaca Region submitted revised floodplains that would result from flood mitigation projects with dedicated construction funding and a completion date before the completion of this plan.

Potential Flood Exposure

Exposure is the estimated quantification of what is at risk of flooding. Multiple assets can be exposed to flooding, including buildings, businesses, infrastructure systems, and even people. Exposure also refers to the economic value of assets subjected to flood hazards. For the Lower Colorado-Lavaca Region, the flood exposure analysis considered floodplain areas, buildings including residential and non-residential properties, populations, critical facilities, and public infrastructure, including industrial and power generating facilities, roadways, and agricultural areas within the Lower Colorado-Lavaca Region.

The table below displays the region-wide exposure results for the existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The following sections further describe the exposure analysis results for each exposure category.

Table 2.4 Summary of Existing Condition Exposure in the Lower Colorado-Lavaca Region

Exposure Category	1% (100-year) Floodplain	0.2% (500-year) Floodplain	Difference
Floodplain Area (square miles)	4,515	5,238	723
Buildings*	67,824	102,301	34,477
Residential Structures	*45,799*	*71,243*	*25,444*
Non-Residential Structures	*22,025*	*31,058*	*9,033*
Population (All Buildings)*	149,830	244,664	94,834
Critical Facilities	99	158	59
Industrial and Power Generating Facilities	*12*	*18*	*6*
Roadway Low Water Crossings	1,109	1,132	23
Roadway Segments (miles)	2,374	3,285	911
Area of Agriculture (square miles)	3,544	4,154	610

**The number of buildings and associated population exposure to flood hazards are likely less than estimated. The estimated exposure identified building footprints and associated populations located within floodplain boundaries regardless of building elevations.*

Existing Development

Buildings (Structures)

In December 2021, the TWDB provided a building dataset that was built on available Light Detection and Ranging (Lidar) information (2010 to 2021), Microsoft Artificial Intelligence Version 2 data, and 2021 Open Street Map (OSM) buildings. As displayed in *Figure 2.9,* the intersection of the floodplain quilt with the building footprints revealed that the greatest numbers of buildings are exposed in Travis, Brazoria, Matagorda, and Wharton counties.

At risk buildings are quantified by overlaying the existing condition floodplains over the building footprints in the region. Elevation certificates for every structure within the Lower Colorado-Lavaca Region are not available and are impractical for the Lower Colorado-Lavaca Region's size. The TWDB provided the building footprints as of 2018. This approach assumes that the building footprint is essentially constructed at grade and does not consider elevated foundations. Therefore, the approach likely over-estimates the number of structures that are actually at risk of flooding than would be at risk if the elevation was considered. *Figure 2.8* shows a heat map of structures within the 1 percent annual chance (100-year) event, and *Figure 2.9* shows the results of building existing condition exposure analysis per county within the Lower Colorado-Lavaca Region.

Figure 2.8 Heat map of Buildings within the Existing 100-Year Floodplain

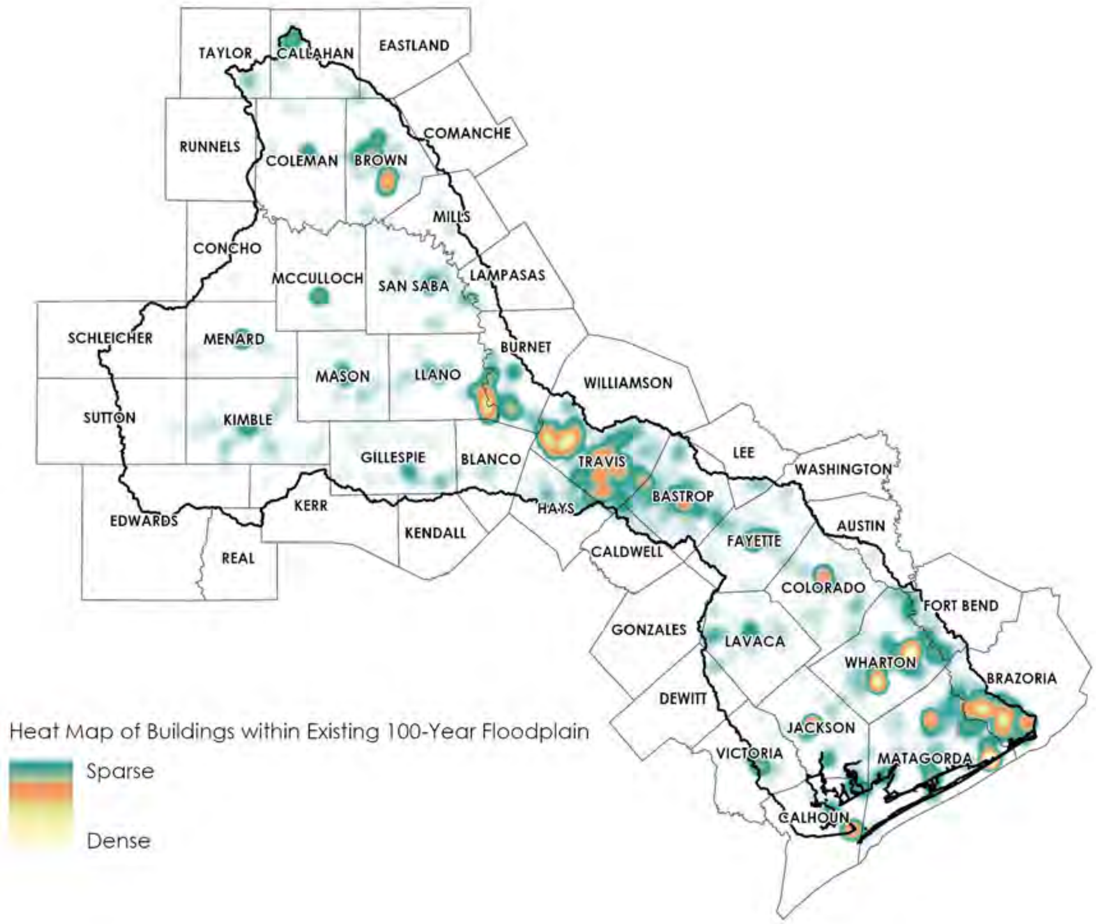
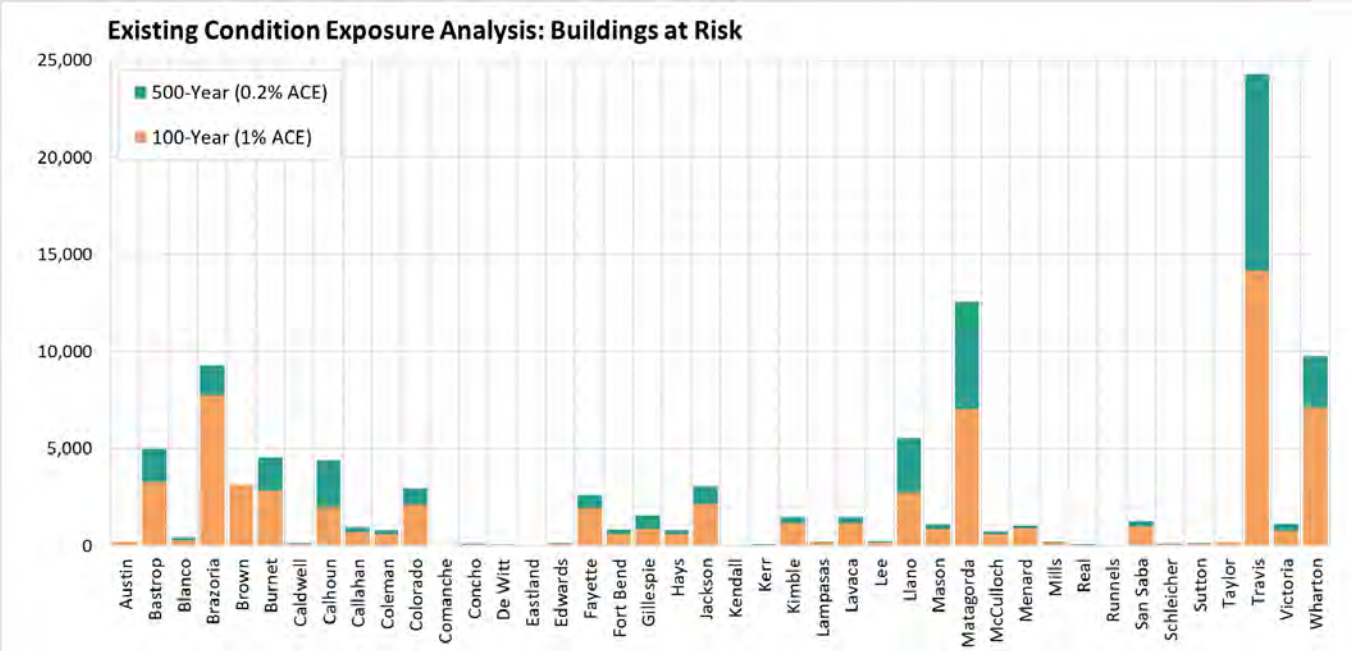


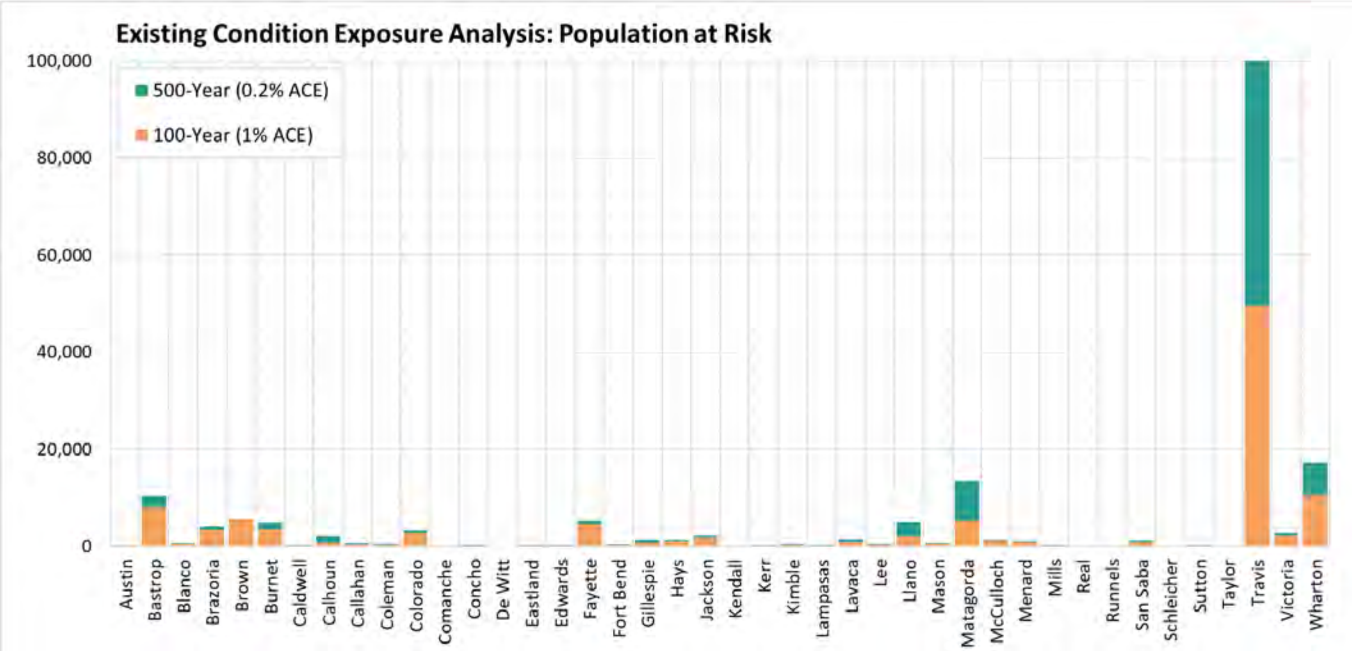
Figure 2.9 Existing Condition Exposure Analysis Results for Buildings in the Floodplain



Population

The TWDB building dataset includes population estimates per building for both day and night using the 2019 LandScan USA dataset from Oak Ridge National Laboratory (ORNL). Buildings with zero populations identified were evaluated were updated where additional information was available. It was assumed that residential structures in the Lower Colorado-Lavaca Region include an average population of 2.6 persons, as outlined in the TWDB Technical Guidance. The source of this estimation is the 2015-2019 American Community Survey five-year estimates. The chart below displays population estimations of existing condition exposure per county within the Lower Colorado-Lavaca Region. While the buildings at risk in *Figure 2.8* display high building exposure in Travis, Brazoria, Matagorda, and Wharton counties, the population counts at risk of flooding in *Figure 2.10,* indicating that the at-risk buildings in Brazoria and Matagorda counties have low population counts. Travis County contains 47 percent of the estimated population at risk.

Figure 2.10 Existing Condition Exposure Analysis Results for Populations in the Floodplain



Residential Properties

As provided by the TWDB, the building dataset indicated residential structures. Residential property data utilized in the Regional Flood Plan included single-family homes, townhomes, mobile homes, and multi-family residences like apartments and condominiums. Nearly 46,000 residential building footprints are located within the existing 1 percent (100-year) annual chance floodplain, and over 71,000 residential building footprints are within the 0.2 percent (500-year) annual chance floodplain. An associated residential population of over 95,000 is estimated to be at risk of flooding.

Non-Residential Properties

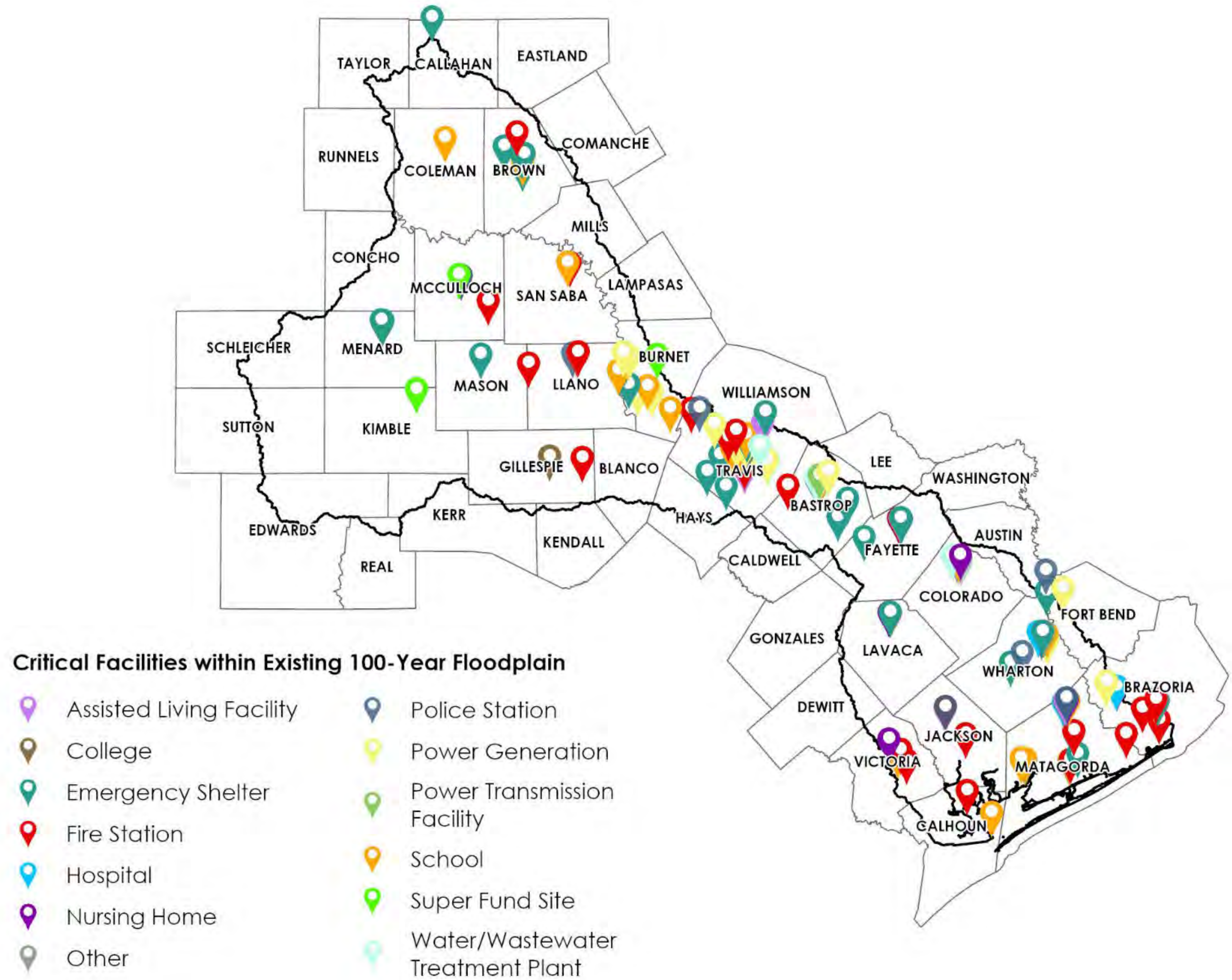
The building dataset also included agricultural, commercial, industrial, and other public buildings. Approximately 22,000 non-residential building footprints are within the floodplain for the existing 1 percent (100-year) annual chance event, and approximately 31,000 residential building footprints are within the 0.2 percent (500-year) annual chance floodplain. Of the total number of at-risk building footprints, roughly 30 percent are non-residential structures.

Critical Facilities and Public Infrastructure

A critical facility provides services and functions essential to a community, especially during and after a disaster. As defined by the TWDB Technical Guidelines, critical infrastructure includes all public or private assets, systems, and functions vital to the security, governance, public health and safety, economy, or morale of the state or the nation. Critical facilities include hospitals, nursing homes, assisted living facilities, schools (K-12 and private), colleges, fire stations, police stations, emergency shelters, super fund sites, water and wastewater treatment plants, and power generating and transmitting facilities. Critical facilities data was compiled using data from the TWDB, Texas Commission on Environmental Quality, Homeland Infrastructure Foundation Level Data, as well as data from Lower

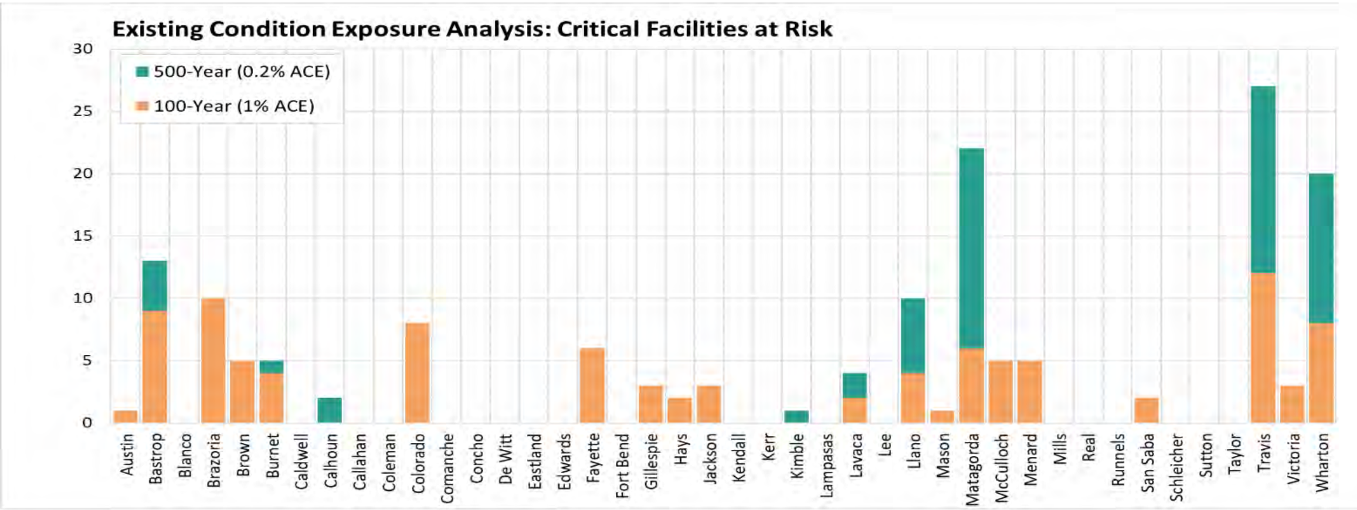
Colorado-Lavaca Region entities. The critical facilities were received as point locations. These point locations were generally tied to the nearest building footprints with other attempts to avoid potential overestimation of exposure.

Figure 2.11 Critical Facilities within the Existing 100-Year Floodplain



Over 1,700 critical facilities were documented in the Lower Colorado-Lavaca Region. An estimated 6 percent of these critical facilities appear to be exposed to flooding within the existing 1 percent annual chance (100-year) event. Critical facilities within the 1 percent annual chance event floodplain in the Lower Colorado-Lavaca Region are shown in *Figure 2.11* and on the *TWDB-Required Map 7* in *Appendix A*. *Figure 2.12* shows the results of critical facility existing condition exposure analysis per county within the Lower Colorado-Lavaca Region. The majority of at-risk critical facilities are within Bastrop, Matagorda, Travis, and Wharton Counties, accounting for 52 percent of the total at risk within the Lower Colorado-Lavaca Region.

Figure 2.12 Existing Condition Critical Facilities in the Floodplain



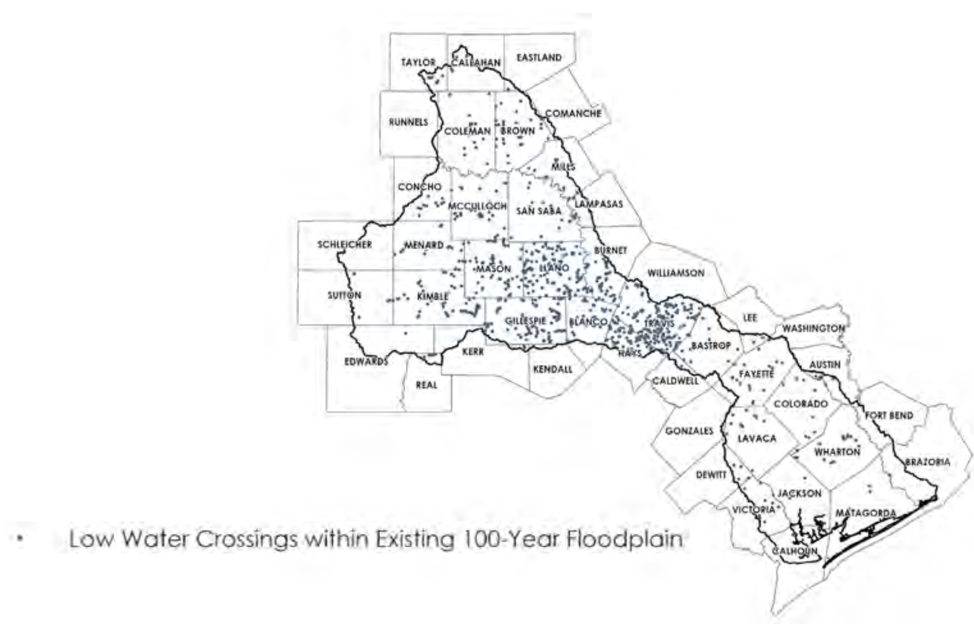
Major Industrial and Power Generation Facilities

Lifeline utility systems data such as power generation and transmission facilities were included as critical facilities for this exposure analysis. There are 18 power generation facilities at risk of flooding in the Lower Colorado-Lavaca Region, and the majority of these facilities are energy plants.

Transportation

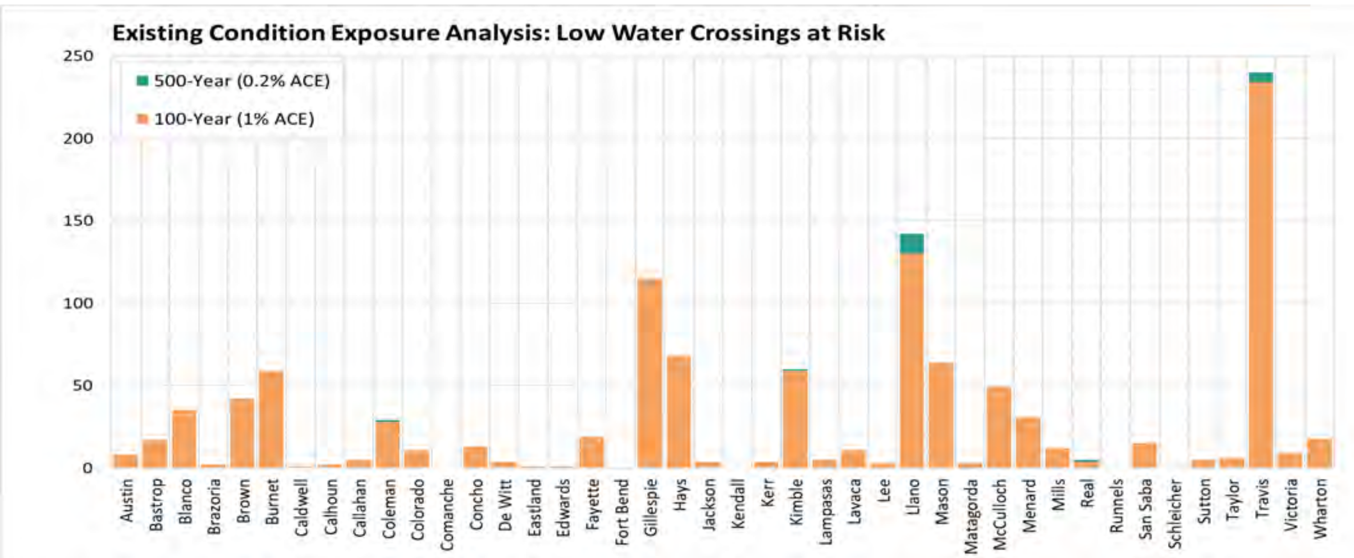
Transportation line data (roadways and railroads) from the Texas Department of Transportation (TxDOT) was used to estimate road and railway segments at risk of flooding. There are over 29,000 transportation miles in the Lower Colorado-Lavaca Region, with an estimated 12 percent of these segments at risk of flooding. The highest mileage exposures are observed in Matagorda, Travis, and Wharton counties, all with over 400 miles of at-risk road and railway segments.

Figure 2.13 Low Water Crossings within the Existing 100-Year Floodplain



Low water crossing data provided by the TWDB and confirmed by the Lower Colorado-Lavaca Region entities were also used to identify exposed roadway crossings. There are over 1,300 low water crossings in the region, with an estimated 84 percent of these crossings at risk of flooding. *Figure 2.14* displays the low water crossing exposure totals per county within the Lower Colorado-Lavaca Region. Travis County contains the highest number of at-risk crossings accounting for 23 percent of the total.

Figure 2.14 Existing Condition Exposure Analysis Results for Low Water Crossings in the Floodplain

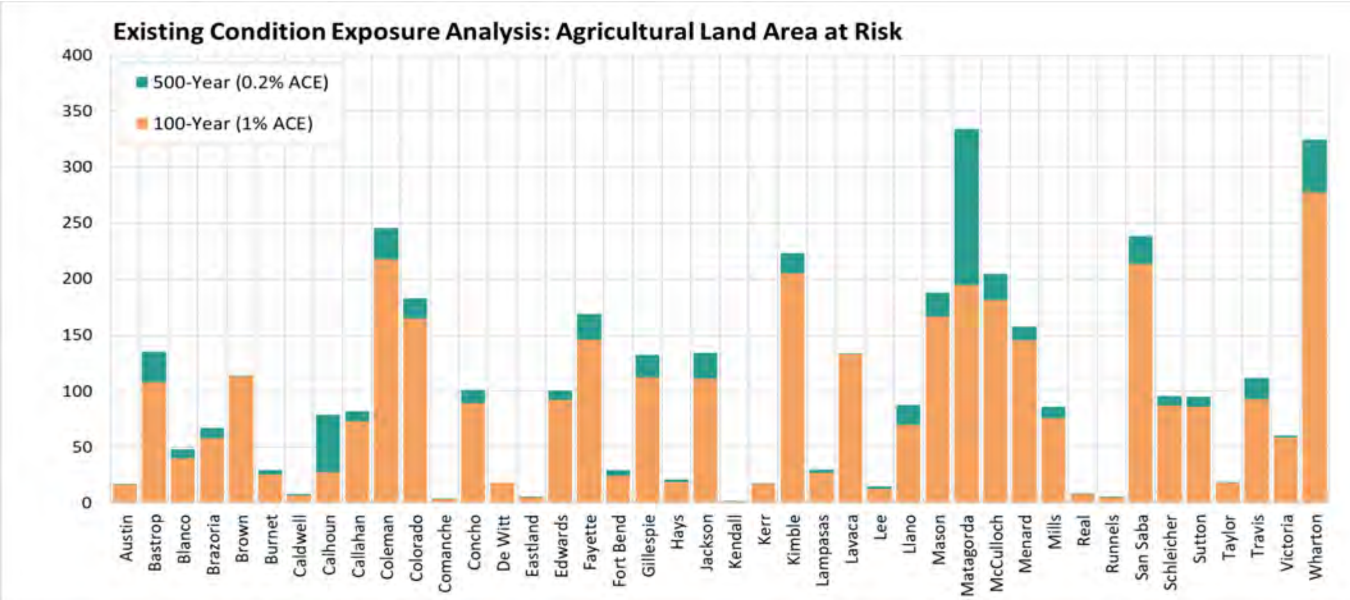


Agriculture

While water is a vital commodity for agriculture and ranching, flooding can destroy crops, dwindle herd numbers, or cause contamination of livestock and farming exports. Agricultural land use data in the Lower Colorado-Lavaca Region was obtained from the 2020 Texas Cropland Data layer developed by the United States Department of Agriculture National Agricultural Statistics Service. In the Lower Colorado-Lavaca Region, the vast majority of land use is grazing land transitioning to farming and ranching moving south. Approximately 3,500 square miles of agricultural land are at risk during the 1 percent annual chance (100-year) event, and approximately 4,200 square miles are at risk during the 0.2 percent annual chance (500-year) event. These values are calculated from all land use types except urban development, wetlands, and open water.

Figure 2.15 shows the results of agricultural land existing condition exposure analysis per county within the Lower Colorado-Lavaca Region. Each county has agricultural land at risk of flooding within the Lower Colorado-Lavaca Region, with the risk being more evenly distributed than other exposure categories. As described in *Chapter 1: Planning Area and Description*, NOAA's Storm Event Database shows crop losses in the Lower Colorado-Lavaca Region to total $40 million in the past 10 years. The database shows counties in the southeast and west have experienced more total crop disasters than the rest of the Lower Colorado-Lavaca Region.

Figure 2.15 Existing Condition Exposure Analysis Results for Agricultural Land Area (square miles) in the Floodplain



Existing Dams and Levees

Existing dams, floodwalls, and levees within the Lower Colorado-Lavaca Region are described in *Chapter 1: Planning Area and Description. Figure 1.21* in *Chapter 1: Planning Area and Description* shows the locations of dams, floodwalls, and levees in the Lower Colorado-Lavaca Region. The National Inventory of Dams is a database maintained by the United States Army Corps of Engineers that includes the location and age of dams, among other attributes. In addition to the National Inventory of Dams, dam information within the Lower Colorado-Lavaca Region was gathered from additional sources, including the Texas Commission on Environmental Quality and Texas State Soil & Water Conservation Board. The combined sources show 700 dams within the Lower Colorado-Lavaca Region. As outlined in *Chapter 1: Planning Area and Description,* over 50 percent of the dams in the Lower Colorado-Lavaca Region are reaching their life span, typically considered 50 years old. The average age of dams within most Lower Colorado-Lavaca Region counties exceeds 50 years. *Table 2.5* shows the quantification of dams in the Lower Colorado-Lavaca Region counties. Although entities provided little information about the flood risk associated with dam infrastructure, the age of these structures alone indicates that many may be due for modernization, upgrades, maintenance, rehabilitation, or even retirement. Potential flood hazard exposure associated with dams could not be evaluated without entities providing dam breach information.

Table 2.5 Quantification of Dams by County

County	Dams within County Limits	Avg Age of Dams (years)	County	Dams within County Limits	Avg Age of Dams (years)
Austin	4	67	Jackson	6	44
Bastrop	33	57	Kimble	4	79
Blanco	3	48	Lampasas	1	113
Brazoria	8	65	Lavaca	2	59
Brown	70	57	Lee	16	62
Burnet	20	55	Llano	10	62
Calhoun	4	61	Mason	1	83
Callahan	34	56	Matagorda	10	56
Coleman	113	59	McCulloch	40	65
Colorado	18	52	Menard	4	60
Comanche	4	55	Mills	35	55
Concho	40	59	Runnels	1	57
De Witt	5	61	San Saba	39	58
Eastland	1	-	Sutton	1	59
Fayette	49	53	Taylor	11	67
Fort Bend	2	52	Travis	77	43
Gillespie	11	54	Victoria	2	57
Hays	9	46	Wharton	12	52

According to the United States Army Corps of Engineers (USACE) National Levee Database, 23 floodwalls and levees are in the Lower Colorado-Lavaca Region, with one managed by the USACE – Fort Worth District. There are 110 miles of levees in the Lower Colorado-Lavaca Region; approximately 45 miles (41 percent) are identified as being accredited by the USACE. *Table 2.6* shows floodwall and levee mileage within each county. Flood risk associated with non-accredited levees is generally displayed on FEMA floodplain maps. Potential flood hazard exposure associated with floodwalls and levees beyond FEMA's floodplains could not be evaluated without entities providing additional flood risk information.

Table 2.6 Levee Length by County

County	Levee Miles
Brazoria	8
Calhoun	14
Colorado	9
Matagorda	49
Travis	3
Victoria	2
Wharton	25
Region Total	**110**

Expected Loss of Function

Severe flooding results in a loss of function of community infrastructure and economy, impacting the socioeconomic systems supported by them. These impacts include disruptions to life, business, and public services. Some public services are essential to a community during and after a flood event. Flood inundation depth and duration are typically considered the best flood characteristics in predicting expected functionality losses.

Inundated Structures

Inundated buildings (structures) are often not functional during the flood event and through the recovery process. Structural inundation may result in physical damage, displacement costs, occupants' inability to work, as well as mental health and welfare impacts to occupants. These impacts are dependent on the severity of damage to the structure, interrupted access, and lingering health hazards. While all building types may experience these impacts, the loss of function of business in commercial and industrial services may also be extensive.

Critical Facilities

Critical facilities provide essential services for communities and are integral to maintaining stability after a flood event. During and after hazard events, the availability and functionality of first responders, health and human services, water supply and treatment, and operable utilities are vital. These facilities can become inoperable or impaired in the incidence of flooding, severely impacting their communities.

Health and Human Services

Floods can have an extensive impact on the health of the public, directly and indirectly. Most flood-related deaths are from drowning, but physical trauma, heart attacks, electrocution, and carbon monoxide poisoning also account for flood-related mortalities. Furthermore, flooding can damage and restrict access and utilities to schools, hospitals, nursing homes, and assisted living facilities infrastructure, leading to loss of education and health care services.

Water Supply and Water Treatment

Water supply and wastewater treatment facilities generally operate 24 hours a day, seven days a week, 365 days of a year. Floods can contaminate water supply sources such as wells, springs, and lakes/ponds through polluted runoff laden with sediment, bacteria, animal waste, pesticides, and industrial waste and chemicals. Floods can also physically damage or render inoperable water treatment plants to further incapacitate a community's water supply.

Due to their usual proximity to active water bodies such as rivers and streams, multiple wastewater treatment plants are located in low-lying areas within the region. These low-lying areas are generally within or near floodplains. Flooded wastewater treatment plants can cause physical damage, chemical spills, and raw sewage spills, among other issues. These facilities generally receive chemical deliveries, material deliveries, and other critical equipment deliveries regularly. Without those deliveries, operations may cease within a couple of days. Additionally, shift changes enable safe operation. Without access to the facility, personnel are unable to relieve the shift on duty, causing unsafe conditions for on-duty staff.

Utilities and Energy Generation

Energy generating and distributing facilities generally operate 24 hours a day, seven days a week, 365 days a year. Flooded energy generation and distribution facilities can cause physical damage and loss of operation. These facilities regularly receive chemical, hydrogen, and other critical equipment deliveries. Without those deliveries, operations may cease for a couple of days. Additionally, shift changes enable safe operation. Without access to the facility, personnel are unable to relieve the shift on duty, causing unsafe conditions for on-duty staff.

Transportation

Transportation systems are vital to the Lower Colorado-Lavaca Region's economy. This plan evaluates transportation as exposed roadway crossings or roadway segments impacted by flood events, such as poorly drained stretches of road or low water crossings. Roadway segments impacted by flooding result in the loss of transportation routes needed by the first responders and the public alike.

Agriculture

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

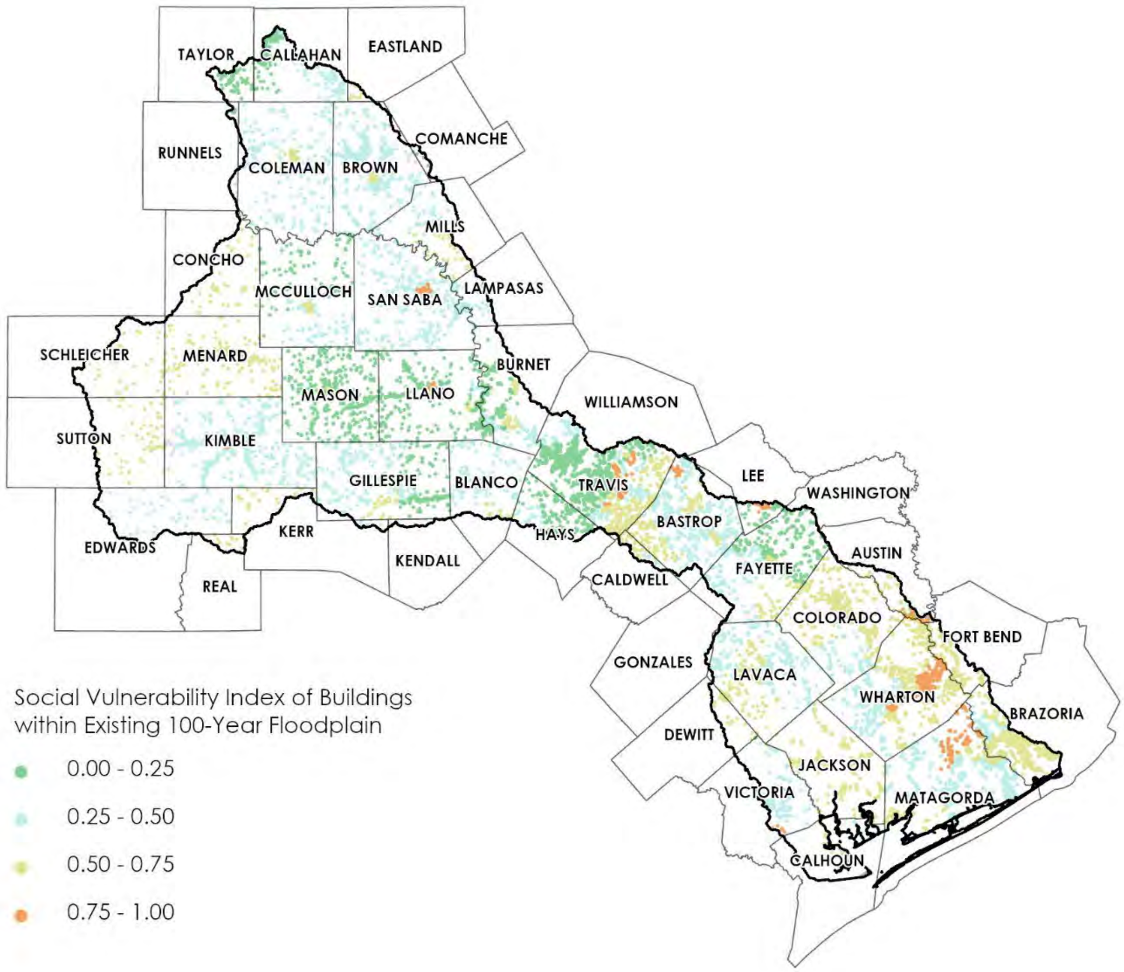
Existing Conditions Vulnerability Analysis

The vulnerability analysis uses the data from the existing condition flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. Vulnerability is an assessment of the potential negative impact of flood hazards on communities as well as a description of the impacts. The 2018 Social Vulnerability Index (SVI) data developed by the United States Centers for Disease Control and Prevention (CDC) assesses social vulnerabilities within the Lower Colorado-Lavaca Region.

Figure 2.16 CDC Themes considered in the Social Vulnerability Index

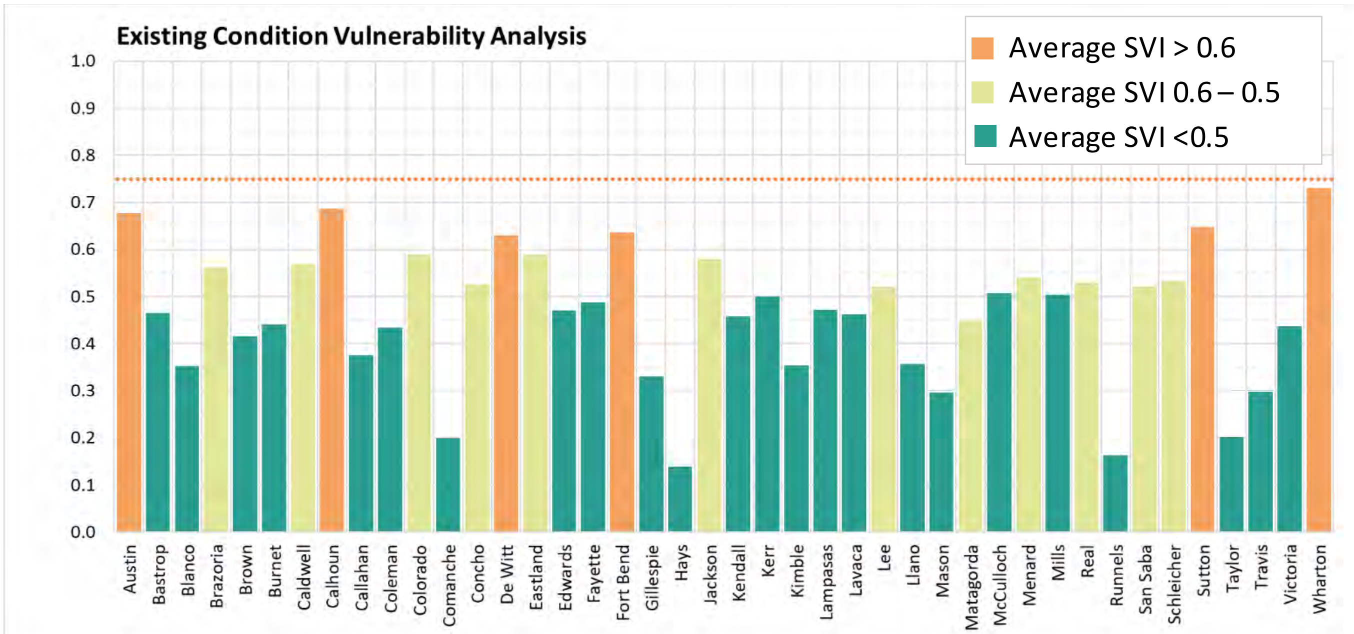
The CDC calculates the SVI at the census tract level within a specified county using 15 sociable factors, including poverty, housing, ethnicity, and vehicle access. It groups them into four related themes: Socioeconomic Status, Household Composition, Race/Ethnicity/Language, and Housing/Transportation. Each tract receives a separate ranking for each of the four themes, as well as an overall ranking. *Figure 2.16* shows the CDC themes used in the SVI calculation.

Figure 2.17 Social Vulnerability Index of Buildings within the Existing 100-Year Floodplain



Social vulnerability is the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long and short term. An SVI rating represents the relative level of a community's vulnerability compared to similar communities. SVI values between 0.75 and 1 denote populations with high vulnerability. *Figure 2.17* and *Figure 2.18* show the SVI results of structures within the existing condition 1 percent annual chance (100-year) floodplain. *Figure 2.17* shows the largest clusters of buildings with the highest vulnerabilities are within Wharton and Matagorda counties. Austin, Calhoun, De Witt, Fort Bend, Sutton, and Wharton counties all have a mean SVI of over 0.6. All but Sutton are in the lower third of the Lower Colorado-Lavaca Region.

Figure 2.18 Existing Condition Vulnerability Analysis Results for Exposed Buildings and Critical Facilities in the Floodplain



Vulnerability of Critical Facilities

The 2018 CDC SVI data was overlaid with the at-risk critical facility dataset for the Lower Colorado-Lavaca Region to attribute their associated SVI values. The SVI values for the critical facilities are summarized by county averages, as shown in *Table 2.7*.

Table 2.7 SVI Averages of At Risk Critical Facilities by County

County*	Critical Facilities at Risk	Critical Facility SVI Average	County*	Critical Facilities at Risk	Critical Facility SVI Average
Austin	1	0.77	Kimble	1	0.31
Bastrop	13	0.42	Lavaca	4	0.70
Brazoria	10	0.56	Llano	10	0.62
Brown	5	0.51	Mason	1	0.74
Burnet	5	0.59	Matagorda	22	0.65
Calhoun	2	0.75	McCulloch	5	0.59
Colorado	8	0.62	Menard	5	0.54
Fayette	6	0.68	San Saba	2	0.81
Gillespie	3	0.29	Travis	27	0.34
Hays	2	0.06	Victoria	3	0.46
Jackson	3	0.57	Wharton	20	0.81

**Not all counties are listed in the table, as not all counties in the region have at risk critical facilities within their limits.*

Not all counties are listed in the table as not all counties in the Lower Colorado-Lavaca Region have critical facilities within the existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain.

Austin, San Saba, and Wharton counties all have an average SVI for at risk critical facilities of over 0.75, indicating high vulnerability. Although Matagorda's average is slightly lower at 0.65, it has a large critical facility count of 22 within the County.

Resiliency of Communities

Community resilience is a measure of the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. FEMA has created a Resilience Analysis and Planning Tool (RAPT) that calculates the resiliency of a community (in this case, by county) compared to similar communities. RAPT takes into consideration a multitude of factors by county, including, but not limited to:

- population over age 65
- population with a disability
- population without a high school diploma
- unemployed population
- population lacking health insurance
- households with limited English proficiency
- single-parent households
- households without a vehicle
- public schools per 5,000 residents
- hospitals per 10,000 residents

The community resilience score is inversely proportional to a community's risk. A higher community resilience score results in a lower risk index score. A score of zero is the average resilience for similar communities. A positive number between zero and one indicates better resilience than similar communities, and a negative number between negative one and zero indicates less resilience than similar communities. *Table 2.8* shows the resiliency score for the counties in the Lower Colorado-Lavaca Region as calculated by RAPT. The RAPT resiliency scores are computed for the entire county, while *Figure 2.18* displays the SVI of buildings within the floodplain.

Table 2.8 Resiliency Score by County

County	Score	County	Score	County	Score	County	Score
Austin	-0.05	Comanche	-0.08	Kendall	0.07	Mills	-0.27
Bastrop	-0.29	Concho	-0.72	Kerr	-0.34	Real	-0.37
Blanco	-0.25	De Witt	-0.14`	Kimble	-0.14	Runnels	0.07
Brazoria	0.3	Eastland	-0.2	Lampasas	-0.25	San Saba	-0.17
Brown	-0.02	Edwards	-0.4	Lavaca	0.27	Schleicher	-0.07
Burnet	-0.29	Fayette	-0.21	Lee	-0.1	Sutton	0.14
Caldwell	-0.44	Fort Bend	0.37	Llano	-0.72	Taylor	0.07
Calhoun	-0.32	Gillespie	-0.11	Mason	-0.56	Travis	0.07
Callahan	-0.1	Gonzales	-0.34	Matagorda	-0.17	Victoria	0
Coleman	-0.1	Hays	-0.02	McCulloch	-0.22	Wharton	-0.25
Colorado	-0.06	Jackson	-0.05	Menard	-0.82		

Certain documentation can help promote a community's flood resiliency, such as Hazard Mitigation Plans (HMPs) or Floodplain Ordinances. Creating these and similar publications indicates an awareness of guidelines and best practices where flood resiliency is concerned.

Hazard Mitigation Plans are not an indicator of the likelihood of a given hazard but are a great planning tool to better understand hazards and potential mitigation measures. HMPs are not a requirement, but entities without HMPs can be considered less resilient than those with HMPs, sheerly from a preparedness standpoint. Currently, 33 (77 percent) of the counties in the Lower Colorado-Lavaca Region either have an HMP on file with the Texas Department of Emergency Management (TDEM) or are actively in the development or adoption phases of the process. Ten counties (23 percent) do not have an HMP on file with TDEM, or the HMP on file has expired.

Table 2.9 Status of Hazard Mitigation Plans within the Lower Colorado-Lavaca Region

County	HMP Approved by FEMA	HMP Approved - Expires within Next Year	HMP in Review, Revision, or Adoption	HMP in Development or Update	HMP Expired - Seeking or Pending Funding	HMP Expired - Not Developing
Austin	X					
Bastrop				X		
Blanco				X		
Brazoria	X					
Brown	X					
Burnet				X		
Caldwell	X					
Calhoun		X				

County	HMP Approved by FEMA	HMP Approved - Expires within Next Year	HMP in Review, Revision, or Adoption	HMP in Development or Update	HMP Expired - Seeking or Pending Funding	HMP Expired - Not Developing
Callahan	X					
Coleman	X					
Colorado					X	
Comanche	X					
Concho						X
De Witt	X					
Eastland	X					
Edwards					X	
Fayette					X	
Fort Bend		X				
Gillespie	X					
Gonzales		X				
Hays		X				
Jackson			X			
Kendall	X					
Kerr	X					
Kimble					X	
Lampasas				X		
Lavaca	X					
Lee		X				
Llano				X		
Mason		X				
Matagorda		X				
McCulloch						X
Menard						X
Mills		X				
Real					X	
Runnels	X					
San Saba		X				
Schleicher						X
Sutton						X
Taylor	X					
Travis		X				
Victoria		X				
Wharton	X					

Like Hazard Mitigation Plans, floodplain ordinances are not an indicator of flood events; however, they are an indicator of the degree of resiliency planning in a community. Much of the state is experiencing unprecedented population growth and development along with a likely increase in rainfall caused by climate variability. Floodplain ordinances help guide the community to develop safely and with minimal impacts on the day-to-day life of their constituents in the case (however unlikely) of a flood event. Only 21 counties (58 percent) in the Lower Colorado-Lavaca Region have Floodplain Ordinances on file with the National Flood Insurance Program or the Texas Water Development Board. Fifteen counties (42 percent) do not have floodplain ordinances on file. This does not consider any individual cities, towns, or other smaller jurisdictions within a county that may have adopted more stringent floodplain ordinances than the counties where they reside. The concern in locations that do not manage or regulate floodplains is that development may occur in flood hazard areas and create avoidable exposure to public safety and property.

Summary of Existing Conditions Flood Exposure Analysis and Vulnerability

The existing flood risk, exposure, and vulnerability for the Lower Colorado-Lavaca Region are summarized in *TWDB-Required Table 3* in *Appendix B*. *Table 3* in *Appendix B* provides the results of the existing flood exposure and vulnerability analysis by county as outlined in the Technical Guidelines for Regional Flood Planning.

Table 2.10 outlines the files in the TWDB-required geodatabase included with this chapter. These deliverables comply with Exhibit D: Data Submittal Guidelines for Regional Flood Planning.

Table 2.10 Geodatabase Layers Indicative of Existing Condition Flood Risk in the Region

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Existing Flood Hazard	Perform existing condition flood hazard analyses to determine the locations and magnitude of both 1% and 0.2% annual chance flood events.	ExFldHazard	Polygon
Flood Mapping Gaps	Gaps in the existing condition inundation boundary mapping	Fld_Map_Gaps	Polygon

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Existing Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polygons) that may be at risk for the existing condition of 1% and 0.2% annual chance flood events.	ExFldExpPol	Polygon
Existing Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polylines) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpLn	Line
Existing Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as points) that may be at risk for the existing condition of 1% and 0.2% annual chance flood events.	ExFldExpPt	Point

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Existing Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating all features (represented as points) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpAll	Point

Task 2B: Future Condition Flood Risk Analyses

Future Condition Flood Hazard Analysis

Estimation of Future Conditions for Planning Purposes

In terms of flood risk analysis, the future conditions assessment is a characterization of conditions for the planning area based on a "no-action" scenario of approximately 30 years of continued development and population growth under current development trends and patterns, existing flood regulations and policies, as well as anticipated climate and land changes. The following paragraphs summarize the RFPG’s assessment of future condition factors.

Development and Population Growth

As described in *Chapter 1: Planning Area and Description*, the current growth patterns are generally projected to continue over the next 30 years, with greater population concentrations being aggregated in urbanized areas and possibly continuing declining populations in more rural areas. The analysis for this section was undertaken using the Water User Groups and HUC-8 watershed population projections provided to each region by the TWDB from the State Water Plan. From 2020 to 2050, the population is projected to increase from 1.9 million people to almost 2.9 million people. This is an increase of 33 percent from 2020 to 2050. *Figures 1.3, 1.5, 1.6,* and *1.7* in *Chapter 1: Planning Area and Description* show the population distributions across the Lower Colorado-Lavaca Region.

Population increases typically lead to more development. New growth generally develops over open lands and natural areas by increasing impervious surfaces while simultaneously reducing the land’s natural ability to absorb flood water. In these areas, increased flood management and mitigation efforts are needed to prevent future populations from being placed in areas of increased flood risk.

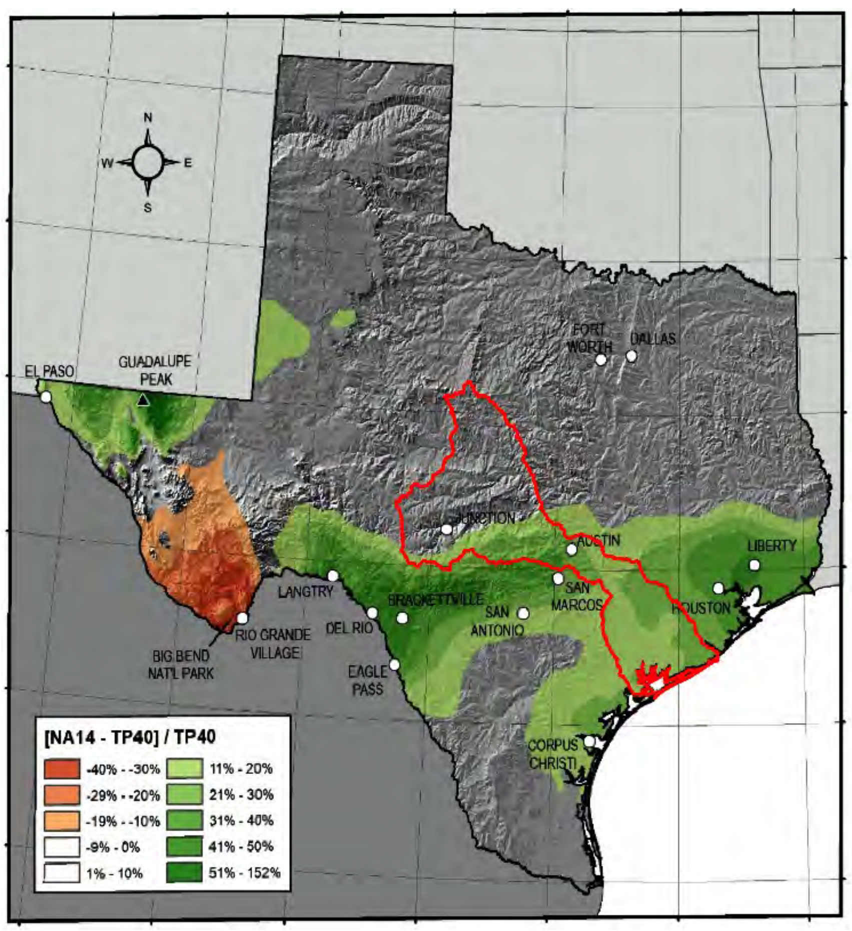
Climate Changes

Climate change refers to long-term shifts in temperatures and weather patterns. These changes may be due to changes in natural patterns or activities directly or indirectly linked to human activities. In addition to the observed changes, the period of record for gathering and analyzing weather data allows for a better understanding of future risks due to severe weather. An example is the long-term observation and analysis of rainfall data updated in 2018, 50 years after its initial release.

Potential Future Rainfall

Changing rainfall patterns in the basin significantly contribute to increased flood risk. Two major rainfall atlases have been completed in the Lower Colorado-Lavaca Region, ultimately covering the entire country. Technical Paper Number 40 (TP-40) was released in 1962, and NOAA Atlas 14, an update to TP-40, was released in 2018. As a result of the new analysis, the rainfall associated with a 1 percent annual chance flood event and used to create floodplain models and maps increased 10-30 percent in the lower third of the basin and 10-40 percent in the central portion of the region. *Figure 2.9* shows the statewide historical change in rainfall. The Texas State Climatologist report, "Climate Change Recommendations for Regional Flood Planning," states that *climate change may lead to substantial increases in flood vulnerability over and above increases due to greater population*. Increased rainfall in a community without increased mitigation will result in more expansive flood hazard areas. Anticipated further increases in rainfall throughout the region were reflected in the increased future conditions flood hazard area.

Figure 2.19 Rainfall Increase between Atlas 14 and TP-40



Potential Future Sea Level

Relative sea level change refers to the change in sea level compared to land elevation at a particular location. Sea level change is understood to be affected by global and local phenomena, including changes in:

- ocean mass associated with long-term forcing of the ice ages ultimately caused by small variations in the orbit of the earth around the sun
- density from total salinity
- heat content of the world's ocean
- estuarine and shelf hydrodynamics
- regional oceanographic circulation patterns (often caused by changes in regional atmospheric patterns)
- hydrologic cycles (river flow)
- local and/or regional vertical land motion (subsidence or uplift)

Relative sea level change can increase flood hazards in low-lying coastal communities. The Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE) developed a methodology for tracking relative sea level change by quantifying the average number of coastal flood events annually and estimating anticipated future relative sea level change. *Figure 2.20* shows the average number of coastal flood events per year for various Gulf Coast communities. The EPA found that each station experienced a significant increase in the quantity of annual coastal flooding compared to previous decades. From 1960 to the present, the National Oceanic and Atmospheric Administration (NOAA) tide gauges along the Texas and Louisiana coasts recorded a relative sea level increase of 10 to 20 inches, as shown in *Figure 2.21*. During this timeframe, the Rockport Gage has experienced approximately 18 total inches of measured sea level rise.

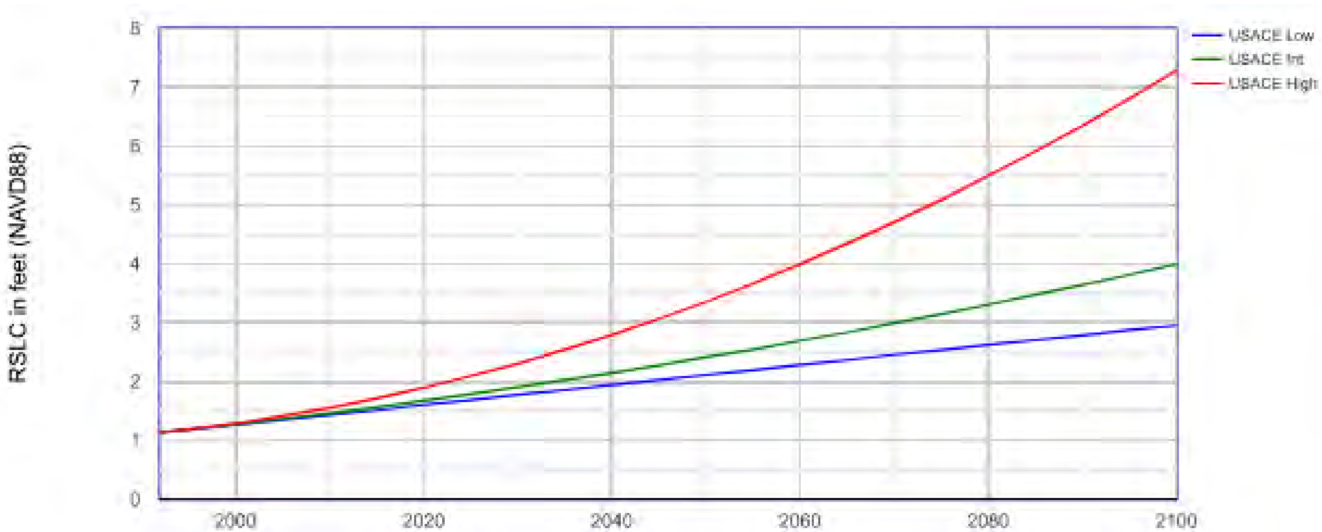
The USACE has developed a methodology to estimate future relative sea level change by calculating "low," "intermediate," and "high" scenarios. The "low" scenario projects a continuation of the currently observed linear sea level trend. The "intermediate" scenario uses the National Research Council (NRC) I model with low assumed values for global and local phenomena. The "high" scenario uses the NRC III model with assumed values for global and local phenomena, as well as low assumptions for glacier melt.

Figure 2.20 shows the relative sea level change experience along the Gulf Coast from 1960-2020. *Figure 2.21* shows the USACE projected relative sea level change at Rockport, Texas. The projected "low" relative sea level change over the next 30 years is approximately 1.1 feet. The "intermediate" sea level rise projected over the next 30 years is approximately 1.5 feet, and the "high" scenario is approximately 2.5 feet by 2050.

Figure 2.20 Relative Sea Level Change Along Gulf Coast

Adapted from EPA's Climate Change Indicators in the United States: www.epa.gov/climate-indicators

Figure 2.21 Relative Sea Level Change Projection for Rockport (Gauge: 8774770)



Land Changes

Sedimentation, erosion, and geomorphic changes throughout the basin can influence flood risk, particularly along the affected river reaches but are not anticipated to significantly impact future floodplains. Geomorphic changes, for instance, are not likely to have significant regional impacts. However, erosion or shifts in the river plan form or profile can affect the existing infrastructure by threatening the structural stability of bridges or pump stations and reducing the conveyance in stream segments and culverts.

Potential Geomorphic Changes

Sediment transport on a river system is a complex phenomenon with substantial geographic and temporal variability, and predicting geomorphic changes requires detailed data collection and modeling. Predicting stream plan form, profile, and shape changes are even more difficult at a regional scale due to variations in rainfall, geology, and topography. Therefore, predicting how geomorphic changes could impact future flood risk is not feasible at the regional scale. However, the general or potential effects can be considered. Two common impacts are channel degradation, which can result in the downcutting and widening of creeks and rivers that threaten surrounding infrastructure and damage riparian corridors, or channel aggregation, which is often the result of man-made structures (i.e., culverts) that reduce local conveyance capacity and increase local flood risk. These challenges can be addressed through routine maintenance programs and project designs considering pre-and post-project channel dynamics.

Another method many cities use to account for uncertainty is implementing erosion hazard setbacks. These include a stream buffer to prohibit development and disturbance, and the methods used to establish the zones vary from community to community.

Potential Sedimentation

Sediment transport on a river system is a complex phenomenon with substantial geographic and temporal variability. The Lower Colorado-Lavaca Basin has a number of reservoirs and dams that protect people and property from floods; many have other uses, such as recreational and water supply. Historically, reservoirs have been designed with storage capacities to offset sediment deposition and achieve the desired reservoir life, commonly known as “dead storage,” which is a portion of its storage capacity that is essentially set aside for sediment deposition during the design life of the structure. Thus, sedimentation within the reservoirs will primarily impact the conservation pool, which is more likely to impact future water supply rather than flood control. The TWDB Surface Water Resources Division conducts surveys on major reservoirs (>5,000 ac-ft storage) about every 10 to 12 years to, among other things, estimate sedimentation levels and rates to support the State Water Planning efforts.

Completed Flood Mitigation Projects

Approximately 20 sponsors indicated they had ongoing or proposed flood mitigation projects far enough in design or implementation to be considered complete for the 2023 Regional Flood Plan. The information about these projects is limited; however, the projects appear to be focused on local flood mitigation and are not anticipated to have a statistically significant impact on future regional flood risk exposure or vulnerability. If additional information or review changes the initial assessment, the flood risk assessment will be updated accordingly.

Best Available Future Condition Flood Risk Data

Consistent with the existing condition analysis, all flood risk types were considered in identifying the best available future condition flood hazard data for the Lower Colorado-Lavaca Region. It should be noted that the potential future condition flood hazard maps, as with existing conditions maps, are for planning purposes only and are not to be used for floodplain regulation. Rather, these flood hazards represent the potential future flood risk in 30 years if no mitigation actions are implemented.

Future Condition Hydrology & Hydraulic (H&H) Model Availability

As noted under the existing condition model availability, H&H models are not available across the Lower Colorado-Lavaca Region. The City of Austin and other regional entities are updating hydrologic and hydraulic models to incorporate NOAA Atlas 14 rainfall data. Many of these studies will also include future condition hazard analysis. These updated models, and the resultant map products, are expected to be available for use in the next regional flood planning cycle. There are currently no future condition hydrology and hydraulic models available within the Lower Colorado-Lavaca Region that account for a "no-action" scenario of approximately 30 years of continued development, population growth, and anticipated climate and land changes.

Future Condition Floodplain Quilt

As outlined in the guidance documents, the TWDB suggested four options for estimating potential future condition flood risk. These four options include increasing water surface elevation or floodplain extent, utilizing a proxy floodplain, combining methods, or requesting TWDB desktop analysis. Given the lack of sufficient future condition models, a combination of a proxy floodplain and an increase in floodplain extent would be utilized to estimate the potential future condition flood hazard boundaries.

For the Lower Colorado-Lavaca Region, the potential future condition flood risk was estimated using the following methods:

- Utilize the existing condition 0.2 percent annual chance (500-year) floodplain as a proxy for the potential future condition 1 percent annual chance (100-year) floodplain.
- Estimate the potential future condition 0.2 percent annual chance (500-year) floodplain using a horizontal buffer based on the measured difference (delta) between the existing condition 1 percent annual chance (100-year) and the existing 0.2 percent annual chance (500-year) floodplain.

Table 2.11 outlines the specific sources and methods for generating the future condition floodplain quilt. The process used to compute the horizontal buffers (deltas) is explained below.

Table 2.11 Summary of Flood Hazard Analysis by Source

	Source	1%	0.2%
Best Available Data	Local Studies	Existing: Local Study 1% Future: Local Study Existing 0.2%	Existing: Local Study 0.2% Future: Delta Mapping applied to Local Study Existing 0.2%
↓	NFHL Detailed Studies (Zone AE, AO, AH, and VE)	Existing: NFHL 1% Future: NFHL Existing 0.2%	Existing: NFHL 0.2 Future: Delta Mapping applied to NFHL Existing 0.2%
↓	Base Level Engineering	Existing: BLE 1% Future: BLE Existing 0.2%	Existing: BLE 0.2% Future: Delta Mapping applied to BLE Existing 0.2%
↓	NFHL Approximate Studies (Zone A)	Existing: NFHL 1% Future: Delta Mapping applied to NFHL Existing 1%	Existing: Areas without 0.2% are gaps Future: Areas without 0.2% are gaps
Most Approximate	Cursory Floodplain Data	Existing: Fathom 1% Future: Fathom Existing 0.2%	Existing: Fathom 0.2% Future: Delta Mapping applied to Fathom Existing 0.2%

Based on a sampling of 155 delta locations across the Lower Colorado-Lavaca Region, it was decided a uniform horizontal buffer would not be appropriate. Rather horizontal buffers were generated in six regions, as shown in *Figure 2.22* and outlined in *Table 2.12*. Following the application of the delta buffers, small islands less than or equal to 2 acres were filled to avoid small gaps in the future condition floodplain boundary.

Figure 2.22 Draft Future Condition Buffer Regions

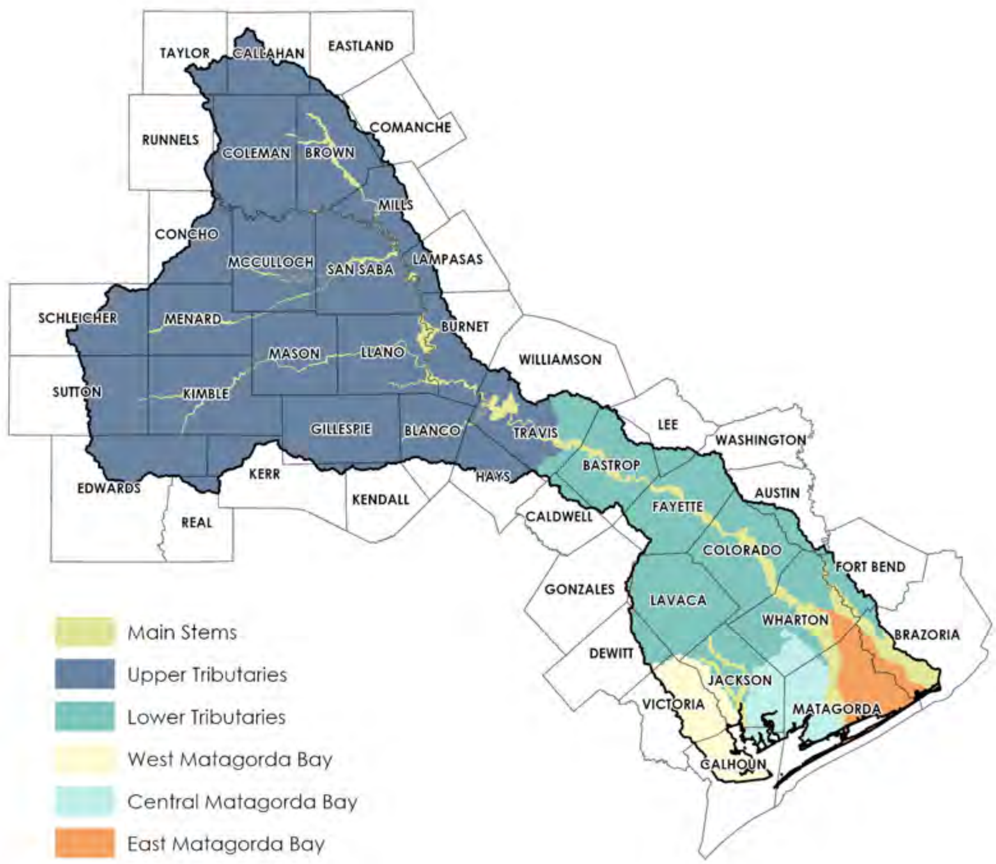


Table 2.12 Draft Future Condition Horizontal Buffers

Buffer Regions	Description	Buffer (feet)
River Main Stems	Main stem of rivers within each HUC	260
Tributaries Upper	Tributaries to the main stems north of Austin	15
Tributaries Lower	Tributaries to the main stems south of Austin	70
West Matagorda Bay	Tributaries west of the Lavaca River	75
Central Matagorda Bay	Tributaries between the Lavaca and Colorado Rivers	315
East Matagorda Bay	Tributaries between the Colorado and San Bernard Rivers	405

It should be noted that the potential future condition flood hazard maps, as is the case with existing conditions maps, are for planning purposes only and are not to be used for floodplain regulation. Rather, these flood hazards represent the potential future flood risk in 30 years if no mitigation actions are implemented.

The compiled future floodplain quilt data for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.23* shows a map of the comprehensive future flood hazard data compiled for the Lower Colorado-Lavaca Region. A larger, more detailed version of this figure is included as

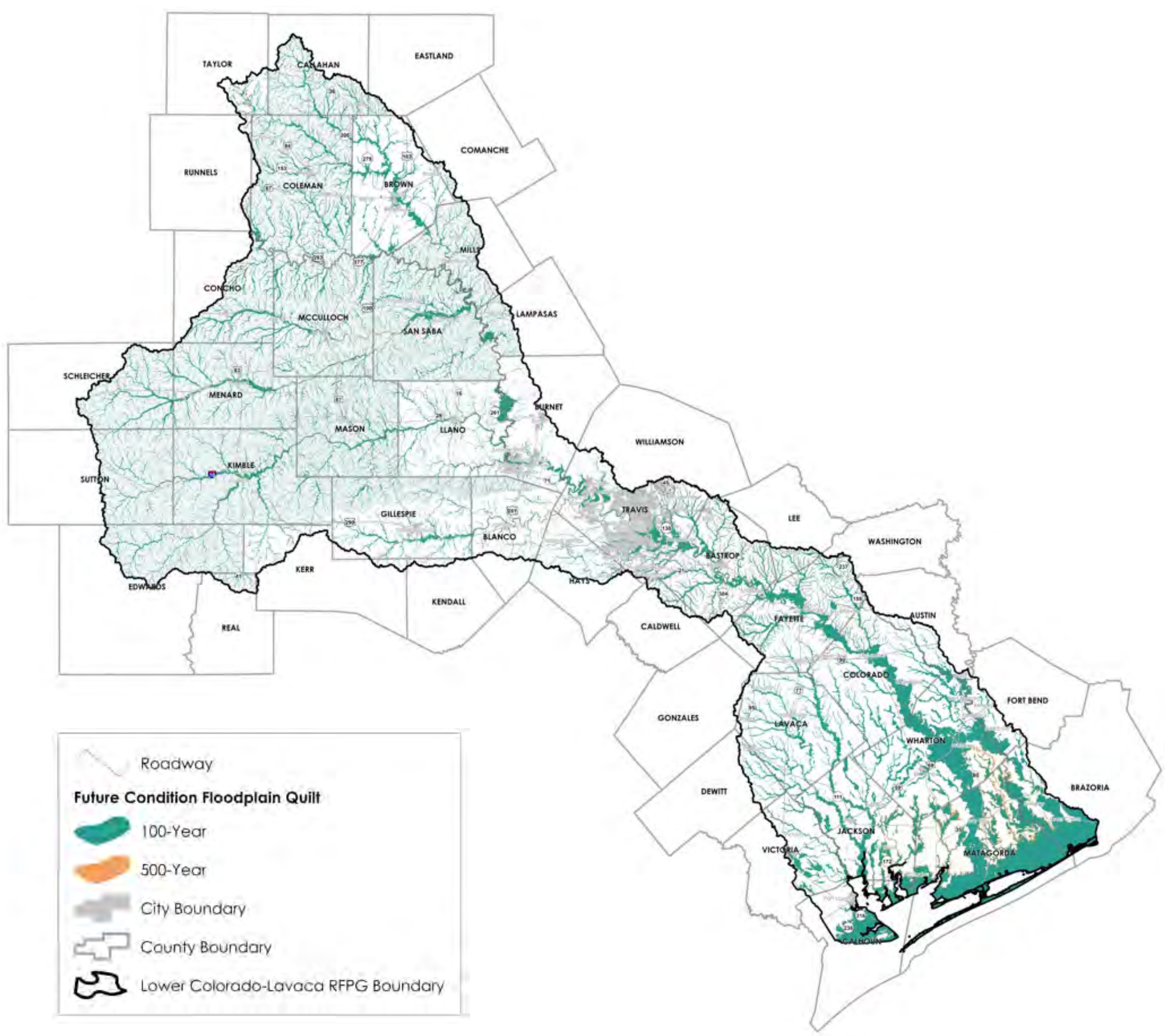
TWDB-required Map 8 in *Appendix A*. A summary of future condition flood risk by flood type and frequency is provided in *Table 2.13*.

Table 2.13 Summary of Future Condition Floodplain Area (square miles) by Flood Type

County	1% Riverine	1% Coastal	1% Local	0.2% Riverine	0.2% Coastal	0.2% Local
Austin	22			22		
Bastrop	167			210		
Blanco	35		16	43		17
Brazoria	201	59		213	60	
Brown	140			141		
Burnet	60			67		
Caldwell	9			12		
Calhoun	37	120		37	130	
Callahan			88			99
Coleman			265			293
Colorado	226			241		
Comanche			4			5
Concho			108			117
De Witt	24			24		
Eastland			6			7
Edwards			102			115
Fayette	205			237		
Fort Bend	47			51		
Gillespie	74		65	80		73
Hays	22			24		
Jackson	170	41		186	58	
Kendall	1			1		
Kerr	19			19		
Kimble			232			266
Lampasas			32			36
Lavaca	186			186		
Lee	17			21		
Llano	120			138		
Mason			193	2		220
Matagorda	428	241		471	249	
McCulloch			213			242
Menard			161			183
Mills			90			107
Real			9			10
Runnels			6			7
San Saba			247	1		286

County	1% Riverine	1% Coastal	1% Local	0.2% Riverine	0.2% Coastal	0.2% Local
Schleicher			98			107
Sutton			97			109
Taylor	20			20		
Travis	174			206		
Victoria	66	4		75	6	
Wharton	416			433		
Totals	**2,887**	**466**	**2,032**	**3,162**	**503**	**2,299**

Figure 2.23 Future Condition Flood Hazard Map

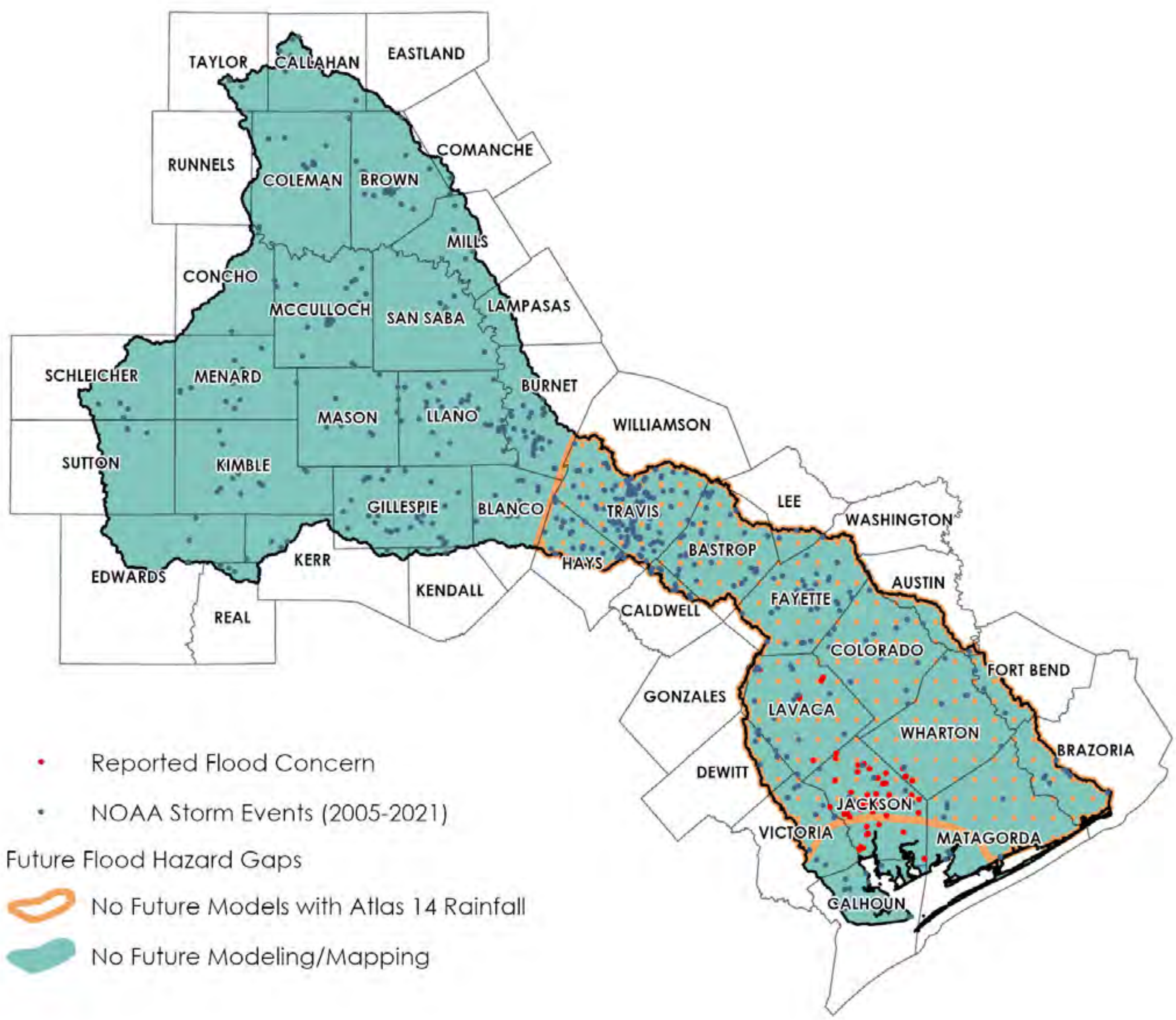


Future Condition Data Gaps

Once the best available comprehensive future condition flood data was compiled, data gaps were assessed to identify any remaining areas where flood inundation boundary mapping was missing, lacked modeling and/or mapping, or used outdated modeling and/or mapping. Other contributing engineering factors considered to identify data gaps included anticipated development and population growth and anticipated climate and land changes.

Due to the absence of future condition analysis, the entire region is considered a gap lacking future condition modeling and mapping. The compiled existing condition gap analysis for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.24* shows a map of the locations of identified existing condition flood data gaps. A larger, more detailed version of this figure is included as *TWDB-required Map 9* in *Appendix A*.

Figure 2.24 Future Condition Flood Hazard Gaps



Future Condition Flood Exposure Analysis

The future condition flood risk exposure analysis leveraged the compiled future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt in the Lower Colorado-Lavaca Region to estimate future flooding exposure to identify who and what might be at risk of flooding.

Potential Flood Exposure

Table 2.14 below displays the region-wide exposure results for the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The following sections further describe the exposure analysis results for each exposure category.

Table 2.14 Summary of Future Condition Exposure in the Lower Colorado-Lavaca Region

Exposure Category	1% (100-year) Floodplain	0.2% (500-year) Floodplain	Difference
Floodplain Area (square miles)	5,385	5,963	578
Buildings*	106,636	139,284	32,648
Residential Structures	*74,045*	*98,181*	*24,136*
Non-Residential Structures	*32,591*	*41,103*	*8,512*
Population (All Buildings)*	251,626	326,169	74,543
Critical Facilities	177	210	33
Industrial and Power Generating Facilities	*19*	*20*	*1*
Roadway Low Water Crossings	1,120	1,141	21
Roadway Segments (miles)	4,353	5,599	1,246
Area of Agriculture (square miles)	4,269	4,785	516

**The number of buildings and associated population exposure to flood hazards are likely less than estimated. The estimated exposure identified building footprints and associated populations located within floodplain boundaries regardless of building elevations.*

Existing Development

Buildings (Structures)

A total of over 139,000 structures are located within the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt within the Lower Colorado-Lavaca Region. This reflects an increase of 36 percent in total buildings at risk and a 57 percent increase within the 1 percent annual chance (100-year) event from existing conditions.

Population

Population estimations of future condition exposure is approximately 250,000 and 326,000 people within the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt within the Lower Colorado-Lavaca Region. This reflects an increase of 33 percent of the total population and a 68 percent increase within the 1 percent annual chance (100-year) event from existing conditions.

Residential Properties

Over 98,000 residential building footprints are within the future 1 percent (100-year) and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region. An associated residential population of over 129,000 is estimated to be at risk of flooding. Residential structures account for 70 percent of the total future condition at risk structures, and 69 percent of those are within the 1 percent annual chance (100-year) event.

Non-Residential Properties

The building dataset also included agricultural, commercial, industrial, and other public buildings. Over 41,000 non-residential building footprints were documented in the floodplain for the future 1 percent (100-year) and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region, indicating an estimated 30 percent of at-risk buildings are non-residential structures.

Critical Facilities and Public Infrastructure

Of the over 1,700 critical facilities documented in the Lower Colorado-Lavaca Region, an estimated 10 percent of these critical facilities appear to be exposed to flooding within the future 1 percent annual chance (100-year) event. There are 210 critical facilities at risk within both the future 1 percent (100-year) and 0.2 percent (500-year) annual chance events accounting for over 12 percent of those documented within the Lower Colorado-Lavaca Region.

Major Industrial and Power Generation Facilities

The future flood exposure analysis results indicate 22 power generation facilities at risk of flooding in the Lower Colorado-Lavaca Region. Similar to existing conditions, the majority of these facilities are energy plants.

Transportation

Of the over 29,000 transportation miles in the Lower Colorado-Lavaca Region, an estimated 21 percent of these segments are at risk of flooding in the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The highest mileage exposures are observed in Matagorda, Travis, and Wharton counties as was the result of existing condition exposure analysis, each with approximately 600 miles or more of at-risk transportation segments. Roadways and railroad data from TxDOT were utilized following tabulating existing condition transportation values.

Of the over 1,300 low water crossings in the Lower Colorado-Lavaca Region, an estimated 84 percent of these crossings are at risk of flooding in the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events.

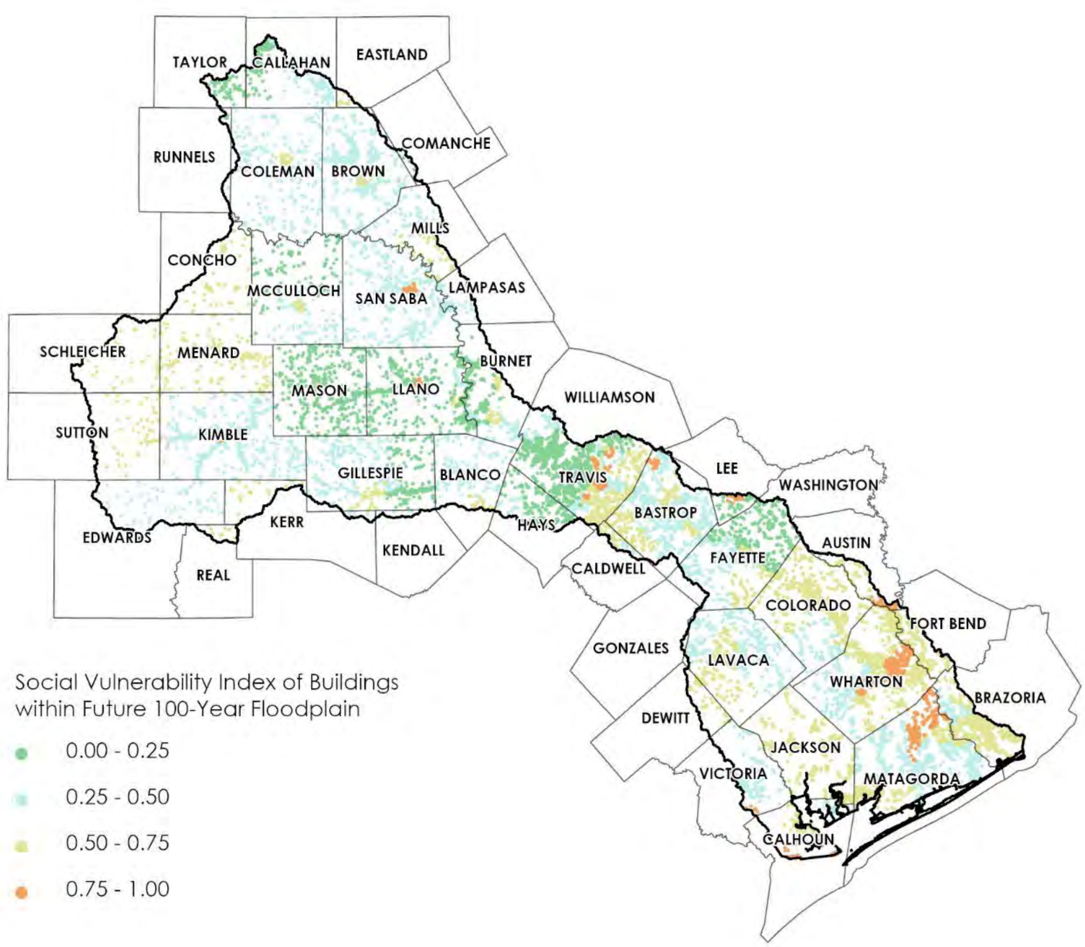
Agriculture

Future condition flood exposure analysis results show over 4,200 square miles of agricultural land at risk during the 1 percent annual chance (100-year) event and over 4,700 square miles at risk during the 0.2 percent annual chance (500-year) event. This is a 20 percent increase for the 100-year event and a 15 percent increase overall for both events from existing condition results.

Future Conditions Vulnerability Analysis

The vulnerability analysis uses the data from the future condition flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. Consistent with the existing condition vulnerability analysis, the future condition vulnerability uses the 2018 SVI data developed by the CDC. An SVI rating represents the relative level of a community's vulnerability compared to similar communities. SVI values between 0.75 and 1 denote populations with high vulnerability. *Figure 2.25* shows the SVI results of structures within the future condition 1 percent annual chance (100-year) floodplain. Although the distribution of SVI values is similar to existing conditions, clusters are generally larger and denser due to the increase of at-risk buildings in future conditions.

Figure 2.25 Social Vulnerability Index of Buildings within Future 100-Year Floodplain



Vulnerability of Critical Facilities

The increased flood risk associated with future conditions denotes greater risk for the critical facilities serving communities in these future flood scenarios. Increased losses following flooding of a greater magnitude result in more need for communities to receive support and access; however, it is coupled with an equally escalated vulnerability for the facilities needed to provide essential services.

Summary of Future Conditions Flood Exposure Analysis and Vulnerability

The future flood risk, exposure, and vulnerability for the Lower Colorado-Lavaca Region are summarized in *TWDB-Required Table 5* in *Appendix B*. *Table 5* in *Appendix B* provides the results of the future flood exposure and vulnerability analysis by county as outlined in the Technical Guidelines for Regional Flood Planning.

Table 2.15 outlines the files in the TWDB-required geodatabase included with this chapter. These deliverables comply with Exhibit D: Data Submittal Guidelines for Regional Flood Planning.

Table 2.15 Geodatabase Layers Indicative of Future Condition Flood Risk in the Region

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Future Flood Hazard	Perform future condition flood hazard analyses to determine the locations and magnitude of both 1% and 0.2% annual chance flood events	FutFldHazard	Polygon
Future Flood Mapping Gaps	Gaps in the future condition inundation boundary mapping	FutFld_Map_ Gaps	Polygon
Future Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polygons) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpPol	Polygon
Future Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polylines) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpLn	Line
Future Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as points) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpPt	Point

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Future Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating all features (represented as points) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpAll	Point

Chapter 3: Floodplain Management Practices and Flood Protection Goals

Source: Llano River Dam, Llano, TX

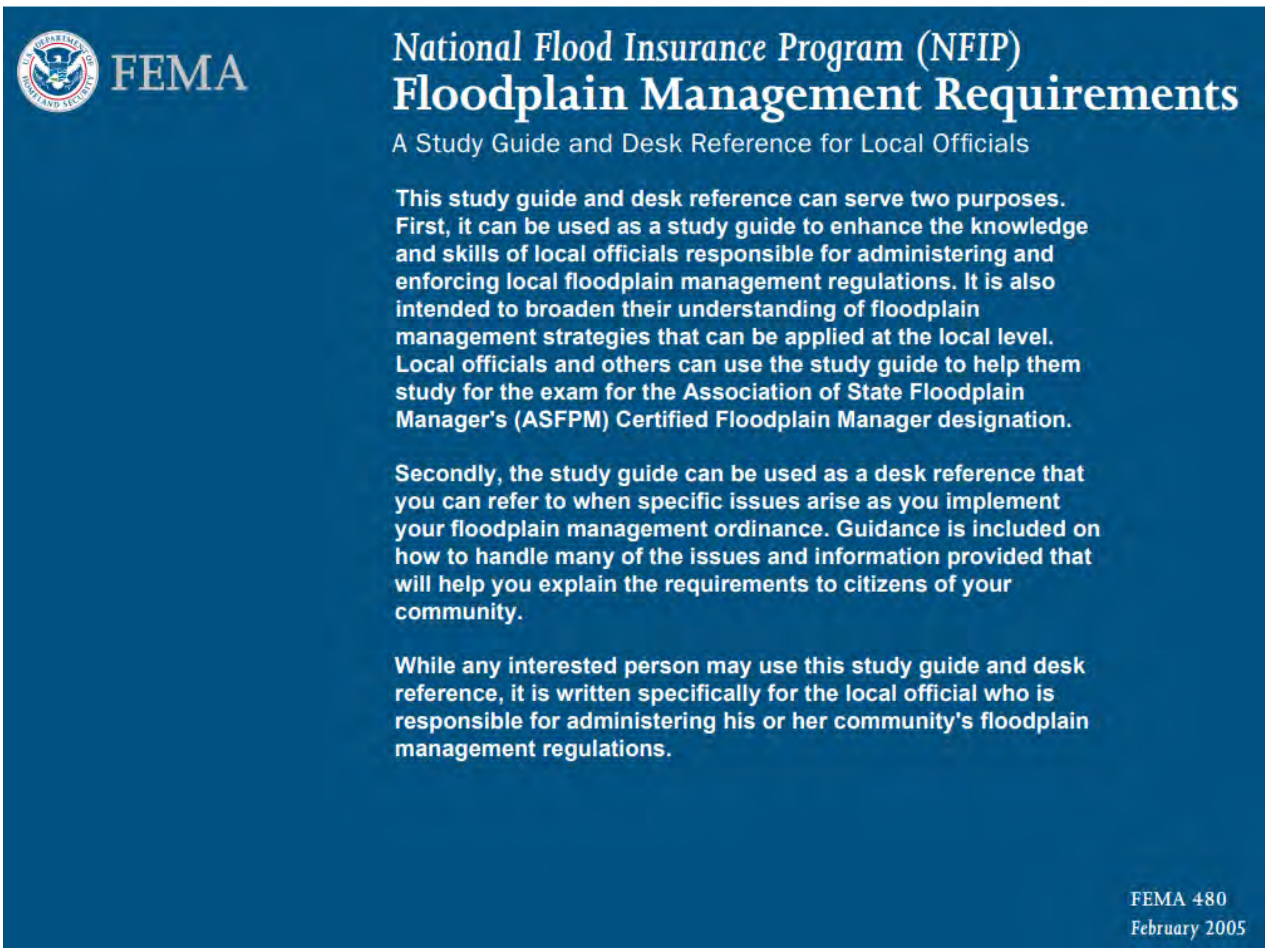
Chapter 3 of the regional flood planning process consists of two interrelated subtasks. For Task 3A - Evaluation and Recommendations on Floodplain Management Practices, the Regional Flood Planning Group (RFPG) is to "Consider the extent to which a lack of, insufficient, or ineffective current floodplain management and land use practices, regulations, policies, and trends related to land use, economic development, and population growth, allow, cause, or otherwise encourage increases to flood risks to both: a. existing population and property, and b. future population and property." Based on this analysis, the RFPG is to make recommendations regarding future floodplain management, land use, and economic development practices that entities in the Lower Colorado-Lavaca Region should implement. At its discretion, the RFPG may also opt to make recommendations regarding minimum floodplain, land use, or other standards that are specific to the Lower Colorado-Lavaca Region or for sub-regions of the flood planning region. Such standards, if recommended by the RFPG, are to be adopted by the sponsors of any recommended Flood Management Evaluations or Strategies and Flood Mitigation Projects as a prerequisite for their inclusion in the Regional Flood Plan. For Task 3B, the RFPG is to adopt "…specific and achievable flood mitigation goals along with target years to meeting those goals…". This includes short-term goals and performance measures (10 years) and long-term goals and measures (30 years).

This chapter presents the findings and recommendations associated with these subtasks in two corresponding sections.

Task 3A: Evaluation and Recommendations on Floodplain Management Practices

Minimum Standards and Regulations

The National Flood Insurance Program (NFIP) is the foundation for floodplain management throughout the U.S. and the logical starting point for evaluating the current state of floodplain management in the Lower Colorado-Lavaca Region. The NFIP, established by Congress in 1968 and administered by the Federal Emergency Management Agency (FEMA), provides subsidies for private flood insurance for property owners in communities that participate in the NFIP. The overall goal of the NFIP is to reduce exposure to flood risk and protect public safety and prevent or minimize damage to property and public infrastructure.



FEMA

National Flood Insurance Program (NFIP)
Floodplain Management Requirements
A Study Guide and Desk Reference for Local Officials

This study guide and desk reference can serve two purposes. First, it can be used as a study guide to enhance the knowledge and skills of local officials responsible for administering and enforcing local floodplain management regulations. It is also intended to broaden their understanding of floodplain management strategies that can be applied at the local level. Local officials and others can use the study guide to help them study for the exam for the Association of State Floodplain Manager's (ASFPM) Certified Floodplain Manager designation.

Secondly, the study guide can be used as a desk reference that you can refer to when specific issues arise as you implement your floodplain management ordinance. Guidance is included on how to handle many of the issues and information provided that will help you explain the requirements to citizens of your community.

While any interested person may use this study guide and desk reference, it is written specifically for the local official who is responsible for administering his or her community's floodplain management regulations.

FEMA 480
February 2005

Minimum NFIP Standards and Requirements

- Adoption and enforcement of a flood damage prevention ordinance (or court order)
- Require permits for all types of development in floodplains
- Ensure that building sites are reasonably safe from flooding
- Estimate flood elevations for areas that lack FEMA determinations
- Require that new or substantially improved buildings be constructed at or above the Base Flood Elevation
- Require Elevation Certificates to document compliance
- Require other buildings to be elevated or floodproofed
- Conduct inspections and cite violations
- Resolve/remedy non-compliance and violations
- Minimize variances
- Inform FEMA when updates to flood maps are needed

Source: Quick Guide – Floodplain Management in Texas, Texas Floodplain Management Association, 2015

Local entities become eligible to participate in the NFIP by adopting and enforcing minimum regulatory standards for land use, development, and other activities within floodplains. The delineation of regulatory floodplains is based on data provided by FEMA, which may include floodplain boundaries, base flood elevations (BFE), Flood Insurance Rate Map (FIRM) zones and floodway boundaries, Flood Boundary Floodway Map, and/or a Flood Insurance Study.

The NFIP minimum standard for floodplain regulation is the Base Flood Elevation (BFE), which is the water surface elevation resulting from a flood with a 1 percent chance of equaling or exceeding that level in any given year, commonly referred to as the 100-year floodplain (*FEMA*). Of note is that communities are encouraged by FEMA to go beyond minimums and adopt higher or more restrictive standards and requirements. Also of note is that NFIP participants are subject to audit by FEMA and/or the Texas Water Development Board (TWDB) to ensure that they are in compliance with minimum requirements.

Regarding the overall state of floodplain regulation in the Lower Colorado-Lavaca Region, it can be considered "excellent" as, at present, 122 of the 135 counties and cities within the Lower Colorado-Lavaca Region are participants in "good standing" in the NFIP. All counties except Edwards and McCulloch Counties participate in the NFIP, and all cities except Cross Plains, Goldthwaite, Lawn, Melvin, Mullin, Novice, Richland Springs, Round Mountain, Santa Anna, and Webberville are NFIP participants.

A table summarizing the current status of floodplain management and regulation in the Lower Colorado-Lavaca Region is included in *Appendix B*. This required table includes NFIP participation status, whether a county or city has adopted "higher" floodplain standards and requirements, a qualitative assessment of the level of enforcement, and whether a city has established a drainage or stormwater utility. Local Government Code, Title 13, Subtitle A, Chapter 552 authorizes cities to establish stormwater utilities and assess stormwater utility fees, also referred to as drainage fees. Only cities have the authority to establish and assess stormwater utility fees. As indicated in the table in Appendix *B*, only three cities within the Lower Colorado-Lavaca Region have drainage utilities and assess drainage fees – Austin, Fredericksburg, and Sunset Valley.

Many participating NFIP communities are using floodplain data and maps that are outdated. Older floodplain maps are often based on outdated and somewhat inaccurate topographic data, outdated rainfall and hydrologic data, and/or outdated hydrologic and hydraulic models. To the extent that communities are using outdated maps for floodplain regulation, the current level of protection from flood damages through floodplain regulation may be less than the minimum level required by the NFIP (i.e., less than the benchmark 1 percent annual chance or 100-year event).

As discussed in *Chapter 1*, the National Weather Service published an updated rainfall statistical analysis for Texas in 2018 using additional historical data through 2017. This study, known as Atlas 14, shows that a large area of Texas, including roughly two-thirds of the Lower Colorado-Lavaca Region, has experienced more intense rainfall, resulting in a greater amount of flood risk than previously thought. As depicted in *Figure 1.17* in *Chapter 1*, the entire lower portion of the Lower Colorado-Lavaca Region downstream of the Highland Lakes has increased rainfall rates per Atlas 14. To illustrate, in the Austin area, existing FEMA floodplain maps for the 1 percent annual chance flood event are based on approximately 10 inches of rainfall in 24 hours (the 1 percent annual chance event). The updated Atlas 14 rainfall data shows that the 24-hour rainfall rate is nearly 13 inches in some areas (e.g., Onion Creek watershed).

Consequently, the City of Austin, Travis County, and other communities in the Austin Metropolitan Area have started updating floodplain maps using the new Atlas 14 rainfall rates. It is expected that updated floodplain maps for these areas and other areas within the Lower Colorado-Lavaca Region will be available for the second cycle of regional flood planning. Of note is that until new floodplain maps based on Atlas 14 data are available, both Austin and Travis County are using the pre-Atlas 14 FEMA 500-year floodplain maps as a proxy for post-Atlas 14 100-year floodplain.

The Lower Colorado-Lavaca Region RFPG has included a recommended Flood Management Strategy (ID No. 102000005) and a related policy recommendation in *Chapter 8* to address the need for floodplain map updates and the need for additional federal and state funding for map updates.

Higher Standards

Both FEMA and the State of Texas encourage participating NFIP communities to adopt higher or enhanced standards and requirements for floodplain management and regulation. At the federal level, FEMA offers incentives through the Community Rating System (CRS), established in 1990, to encourage, recognize, and reward NFIP-participating communities that have adopted floodplain management practices that exceed NFIP minimums and, in doing so, support the three goals of the CRS program:

1) reduce flood damages to insurable properties; 2) strengthen the insurance aspects of the NFIP; and 3) support a comprehensive approach to floodplain management. The incentive for participating in CRS is discounted flood insurance premium rates awarded in 5 percent increments according to ratings from 1 to 10. Class 1 communities receive a 45 percent discount, while Class 10 communities receive no discount.

Participation in the CRS program is voluntary and requires the submittal of a letter of interest, a "Quick Check" application, and verification by FEMA, as well as periodic audits to remain a CRS participant in good standing. Classifications or ratings are based on scores assigned to various floodplain management practices or activities, as shown in *Table 3.1*.

Table 3.1 CRS Example Floodplain Management Practices or Activities

Categories	Example Floodplain Management Practices or Activities
Community Self-Assessment	• Inventory of the floodplain (e.g., structures, natural functions) • Describe and map hazards • Identify specific flood problem areas • Analyze flood problem areas • Assess flood hazards, exposures, and activities
Mapping and Flood Data	• Develop new maps and data • Maintain and provide maps and data • Make data and maps available to the public • Map special flood-related hazards (e.g., coastal erosion)
Managing Future Development to Minimize Future Flood Risk and Damages	• Preserve open space • Protect natural floodplain functions • Regulate development in floodplains • Regulate development in watersheds • Maintain designations of special flood-related hazards
Development and Adoption of a Community Floodplain Management Plan	• Plan development process • Risk assessment • Mitigation strategies • Plan maintenance
Reduced Flood Risk and Losses to Existing Development	• Acquire or relocate flood-prone structures • Protect flood-prone structures in place (e.g., increased elevation, flood-proofing) • Improve drainage system maintenance • Address repetitive loss properties
Improved Emergency Preparedness and Response	• Flood warning and response planning • Warning and response for areas protected by levees • Warning and response for areas downstream of a dam

Categories	Example Floodplain Management Practices or Activities
Public Information and Outreach	• Overall plan for public information program • Flood awareness and preparedness outreach • Providing detailed information on potential flooding and protecting against flood losses (e.g., online access to floodplain maps)

Five entities in the Lower Colorado-Lavaca Region currently participate in the CRS program. These communities have a CRS class rating between Class 9 and Class 6, representing a 5 to 20 percent discount on flood insurance premiums. The CRS participants in the Lower Colorado-Lavaca Region are Bastrop County and the cities of Austin, Pflugerville, Sunset Valley, and Wharton.

The TWDB guidance provides a much narrower definition of the term “higher standard” as compared to the many “creditable” CRS actions listed above that a community might implement. The TWDB’s definition has three elements: additional freeboard, stormwater detention requirements, and floodplain fill restrictions. Freeboard is generally considered the single most important enhancement to floodplain standards and regulations. Freeboard refers to the additional elevation of the lowest occupied floor of a structure above the Base Flood Elevation (100-year floodplain). It is intended to provide an extra margin of safety for structures built in regulatory floodplains.

The online survey conducted on behalf of the Lower Colorado-Lavaca RFPG included a question about whether an entity has adopted any higher standards and specifically whether an entity has adopted freeboard requirements. Survey response options were:

- At or above current Base Flood Elevations
- BFE + 1 foot (current 1% ACE conditions)
- BFE + 1 foot (future 1% ACE conditions)
- BFE + 2 feet (current 1% ACE conditions)
- BFE + 2 feet (future 1% ACE conditions)
- BFE + 3 feet (current 1% ACE conditions)
- Blank/unknown

In addition to the online survey, the number of counties and cities in the Lower Colorado-Lavaca Region that have adopted and enforced higher standards has also been estimated by the Texas Floodplain Management Association (TFMA), which conducts a “Higher Standards Survey.” The results of the TFMA survey for 2019-2020 show that 19 entities in the Lower Colorado-Lavaca Region self-report as having freeboard one or more feet above the Base Flood Elevation for current or fully developed conditions. As shown in *Table 3.2*, 18 of the total number of entities that responded to both the online and TFMA surveys have not adopted freeboard requirements above the current BFE. However, almost as many, as 16 have reported adopting freeboard requirements above the BFE. Only one entity reports that it has adopted a future condition freeboard requirement at two feet above the BFE, based on watershed modeling assuming full development build-out of a given watershed.

Table 3.2 Summary of Freeboard Requirements in the Lower Colorado-Lavaca Region

Freeboard	Current 1% ACE Conditions	Future 1% ACE Conditions
At or above current base flood elevations	18	0
BFE + 1 foot	6	0
BFE + 2 feet (current 100-year conditions)	7	1
BFE + 2 feet (current 500-year conditions)	2	0
BFE + 3 feet	1	0
Total	**34**	**1**

Note: The Lower Colorado-Lavaca Region Data Collection Tool and Interactive Webmap

The TWDB guidance for regional flood planning also classifies existing floodplain management practices as:

- **Strong -** Significant regulation that exceeds the NFIP standards with enforcement or community belongs to the Community Rating System
- **Moderate -** Some higher standards, such as freeboard, detention requirements, or fill restrictions
- **Low -** Regulations meet the minimum NFIP standards
- **None -** No floodplain management practices in place

According to these classifications, entities with standards that exceed the NFIP minimum requirements but have self-reported through the RFPG's online survey as having relatively low levels of enforcement are classified as having "moderate" floodplain management practices. Entities participating in the FEMA CRS have "strong" floodplain management practices.

For those entities in the Lower Colorado-Lavaca Region that self-reported through the online survey as having adopted requirements for structures to be built at or above Base Flood Elevation, floodplain management practices are classified as "low." If an entity has some form of higher standards as determined from other information sources (e.g., TFMA survey, review of local ordinances) but did not respond to the survey or responded with "I do not know" with regard to enforcement, the floodplain management practices were also categorized as "low," unless the known level of enforcement warranted a higher classification, or if the entity has adopted requirements for the elevation of structures above the BFE. In some instances, an entity responded that its level of enforcement was "none," even though other information indicated that it had adopted some form of higher standards. In these situations, the floodplain management practices were classified as "none." *Table 3.3* summarizes the classifications of local floodplain management practices based on survey responses and other information.

The responses to the online survey differ somewhat from the results reported in the TFMA 2019-2020 survey. To better understand and reconcile the differences, the RFPG's Technical Consultant reviewed local floodplain ordinances for those entities that responded to the online survey and compared those local standards to the results of the TFMA survey. Otherwise, the information provided in *Table 3.3* is derived almost entirely from self-reported information.

Table 3.3 Floodplain Management Practices as Self-Reported by Online Survey Respondents

Classification	Number of Responses	Percent
Strong	9	29%
Moderate	13	42%
Low	7	23%
None	2	6%
Total	**31**	**100%**

In all, 40 of the 122 cities and counties in the Lower Colorado-Lavaca Region that are NFIP participants, or 33 percent, have adopted some form of higher floodplain management standards, whether it be freeboard requirements, stormwater detention requirements, and/or floodplain fill restrictions.

Enforcement

Another question posed in the online survey pertains to enforcing floodplain standards and regulations. Specifically, respondents were asked to select a description that best represents the level of enforcement of their community's floodplain regulations. The TWDB guidance provided the options to choose from and are as follows:

- **High -** Actively enforces all adopted requirements, performs multiple inspections throughout the construction process, issues fines for violations as appropriate, and enforces substantial damage and improvement policies
- **Moderate -** Enforces much of the ordinance, performs limited inspections, and is limited in issuing fines and violations
- **Low -** Provides permitting of development in the floodplain but may not perform inspections or issue fines or violation
- **None -** Does not enforce floodplain management regulations

Roughly 55 percent of those responding to this survey question describe the level of enforcement of their floodplain standards and regulations as moderate or high. The remaining 45 percent self-report as having low, none, or an unknown level of enforcement. *Table 3.4* summarizes these findings.

Table 3.4 Survey Participant Level of Enforcement of Floodplain Regulations

Level of Enforcement	Number of Responses	Percent
High Activity	10	29%
Moderate Activity	9	26%
Low Activity	8	23%
None	5	14%
I do not know	3	9%
Total	**35**	**100%**

Based on September 9, 2021, survey responses.

Future Floodplain Management Practices and Flood Risk

As indicated above, all counties and nearly all eligible cities in the Lower Colorado-Lavaca Region are current NFIP participants. Very nearly 100 percent of the region's population is within jurisdictions that have adopted at least the minimum required standards for floodplain management. Consequently, by their nature and intent, existing floodplain regulations should prevent most additional future flood exposure by limiting new development in floodplains. In addition, periodic updates of models and maps for regulated floodplains should also help prevent increased future exposure to flood hazards. Using high-resolution hydrologic and topographic data and advanced watershed modeling technology, map updates will enable local entities to stay current with potential climate and watershed changes due to development that could affect the spatial extent of regulatory floodplains.

However, several factors could lead to greater flood risk and increased exposure to populations and property in the Lower Colorado-Lavaca Region in the future. One factor is inadequate enforcement of existing floodplain standards and regulations. Regulations must be administered and enforced consistently and uniformly to realize the intended benefits. A related factor is that some communities do not explicitly consider and incorporate flood risk and avoidance of flood hazards in their comprehensive land use plans, associated regulations, and economic development plans and policies. Fortunately, flood risk is explicitly addressed in the comprehensive land use plan adopted by the City of Austin, the largest municipality in the Lower Colorado-Lavaca Region, representing more than half of the population of the region.

Another consideration in assessing potential future flood risk and exposure is the potential effects of land development and urbanization in contributing watersheds of regulatory floodplains. Absent robust local regulations and standards for stormwater management in new development and specific restrictions on impervious cover and requirements to maintain some level of pre-development hydrology, the severity of downstream flooding could increase over time. To address this concern, some counties and cities, as reported, have adopted higher or enhanced standards that include limitations on impervious cover in new development, requirements that new development preserves a degree of pre-development hydrology or otherwise mitigates increases in peak flood flows during floods, and other measures to reduce current and future flood risk. The City of Austin, as a CRS participant, and other local entities in the Austin area have adopted these and other higher or enhanced floodplain standards and land use regulations.

Areas without floodplain maps or outdated or otherwise inaccurate watershed models and floodplain maps also raise concerns about the possibility of increasing exposure of populations and property to flood hazards. For example, Flood Rate Insurance Maps are typically based on current watershed conditions rather than conditions that may exist in the future with new development and urbanization. Some cities and counties in the Lower Colorado-Lavaca Region do, however, base their watershed modeling and mapping on both current and future conditions. Within the City of Austin, for example, FEMA Flood Insurance Rate Maps are used for flood insurance purposes, while the city regulates floodplain development based on projections of fully developed watershed conditions.

Another related concern is potential future climate changes, particularly increases in the amplitude – intensity and/or duration – of extreme storm events. As discussed previously above and in *Chapter 1*, the recent update of rainfall statistics for Texas, published in Atlas 14, shows significantly higher rainfall rates for extreme events (e.g., the 100-year storm) across a large east to west swath of Texas, including about two-thirds of the land area of the Lower Colorado-Lavaca Region. In the affected areas, rainfall rates, flood risk, and exposure may be significantly greater than we understood before. It is also possible that future Atlas 14 updates will result in benchmark design storm rainfall rate increases. Hence, updating watershed models and floodplain maps to account for higher rainfall rates is critical in maintaining the current and future level of protection provided by floodplain and land development regulations.

Changing climate conditions are projected to lead to substantial increases in flood variability over and above due to population growth (Swain et al. 2020). This will increase flood risk across the rural, suburban, and urban spectrum, particularly impacting our already developed areas (e.g., Shoal Creek in Austin).

Recommended Floodplain Management Practices

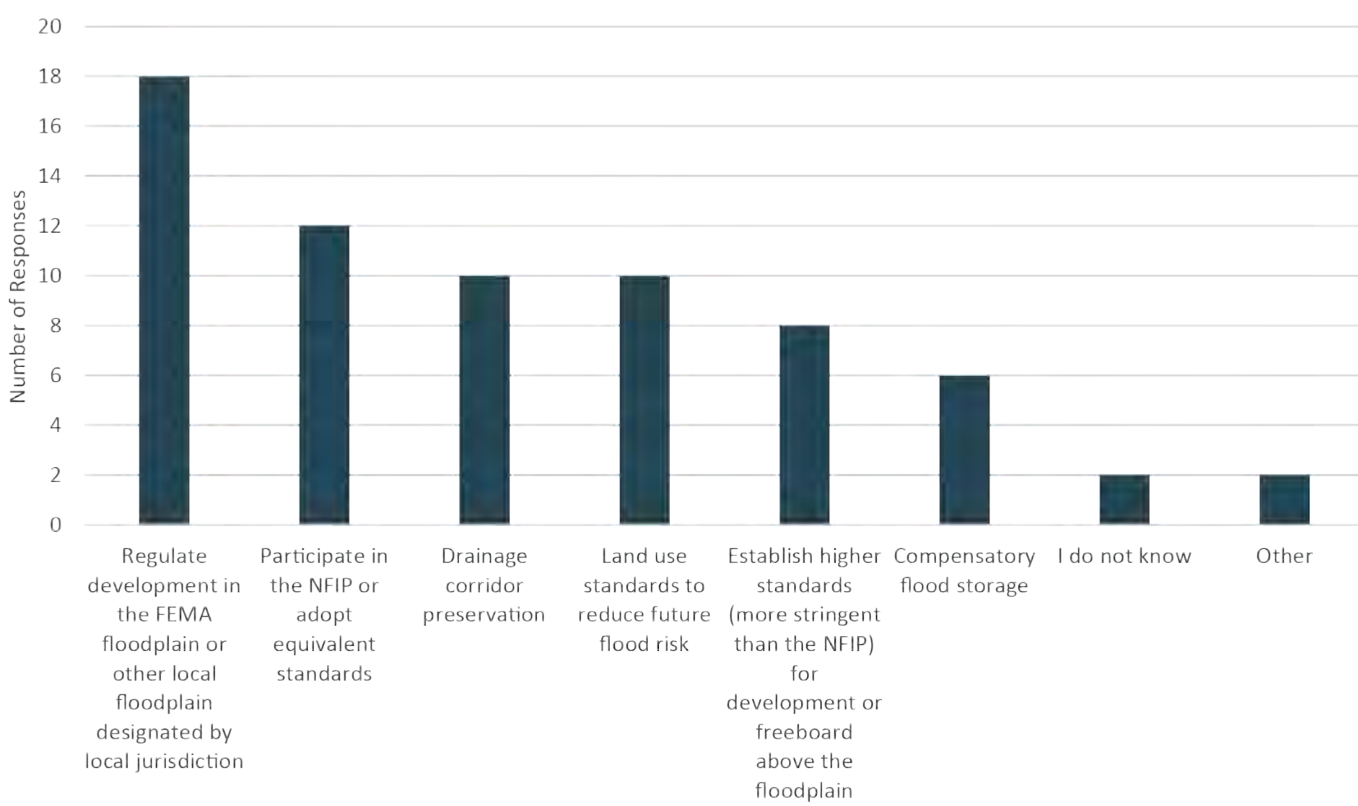
The regional flood planning process requires the RFPGs to consider whether to recommend the adoption of consistent minimum floodplain management standards and land use practices for the entire region. To help inform the Lower Colorado-Lavaca RFPG's decisions and recommendations, several questions were included in the online survey about region-wide minimum floodplain management standards. Survey participants were asked if they thought the RFPG should recommend consistent minimum standards across the region. Thirty-five entities responded and answered a follow-up question about floodplain management practices that the RFPG should consider recommending. *Table 3.5* summarizes responses to the question of region-wide minimum floodplain management practices. *Figure 3.1* shows survey responses supporting various floodplain management practices (note that respondents were able to select multiple practices).

Table 3.5 Survey Responses for Potentially Recommending Consistent Minimum Floodplain Management Standards

Description	Number of Responses	Percent
Yes	28	80%
No	2	6%
I don't know	5	14%
Total	**35**	**100%**

Based on September 9, 2021, survey responses.

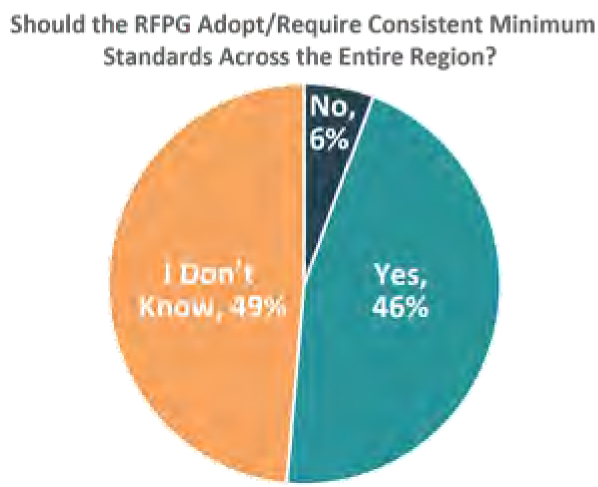
Figure 3.1 Survey Responses in Support of Potential Recommended Minimum Floodplain Management Standards



Based on September 9, 2021, survey responses.

Given the very high level of participation in the NFIP by eligible local entities in the Lower Colorado-Lavaca Region, it should not be surprising that a majority (57 percent were supportive of recommending it and 46 percent were supportive of requiring it) of survey respondents support having consistent minimum floodplain management standards for the Lower Colorado-Lavaca Region. Survey participants strongly support regulating development in the FEMA floodplain or floodplains designated by local jurisdictions. Responses also indicate strong support for participation in the NFIP or adoption and enforcement of equivalent standards. *Figure 3.2* and *Figure 3.3* show the percent support of these two potential recommended minimum standards.

Figure 3.2 Survey Participants in Support of Adopting/Requiring Consistent Minimum Standards Across the Entire Region



Based on September 9, 2021, survey responses.

Figure 3.3 Survey Participants in Support of Recommending Consistent Minimum Standards Across the Entire Region

Based on September 9, 2021, survey responses.

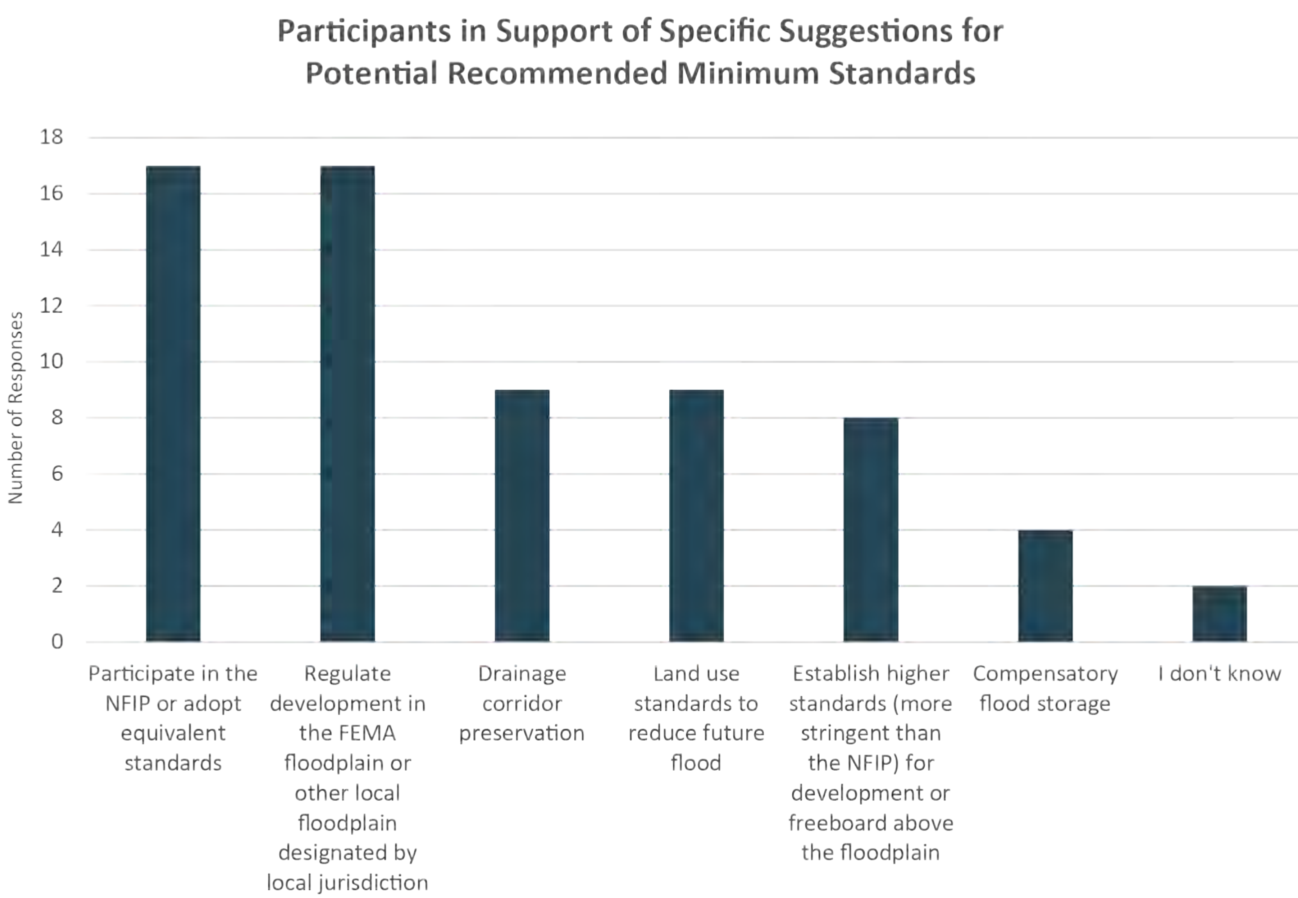
Survey respondents were also asked for their opinion as to whether the Lower Colorado-Lavaca RFPG should adopt consistent minimum standards across the entire region. The survey question clarified that such a requirement would require sponsors of Flood Management Evaluations and Strategies and Flood Mitigation Projects to adopt such standards as a prerequisite for their inclusion by the RFPG in the Regional Flood Plan. Again, 35 entities responded to the question, and the results indicate significantly less support for requiring consistent minimum standards as a prerequisite for including Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs) in the Regional Flood Plan. *Table 3.6* summarizes the participant responses, and *Figure* 3.4 shows the number of survey participants supporting specific standards.

Table 3.6 Survey Responses for Potentially Adopting (Requiring) Consistent Minimum Floodplain Management Standards

Description	Number of Responses	Percent
Yes	16	46%
No	2	6%
I don't know	17	49%
Total	**35**	**100%**

Based on September 9, 2021, survey responses.

Figure 3.4 Survey Responses for Potential Adopted (Required) Minimum Floodplain Management Standards



Based on September 9, 2021, survey responses.

Again, the Regional Flood Planning process requires the RFPGs to consider whether or not to recommend the adoption of consistent minimum floodplain management standards and land use practices for the entire Region. Of note is that the State of Texas already requires by statute *(Texas Water Code Section 16.3145)* that "the *governing body of each city and county shall adopt ordinances or orders, as appropriate, necessary for the city or county to be eligible to participate in the National Flood Insurance Program…"*. Reinforcing this requirement are the TWDB rules for obtaining financial assistance through the Flood Infrastructure Fund (FIF) that require applicants to have and enforce regulations that meet or exceed the NFIP minimum standards. In effect, state law and policy establish minimum standards for floodplain management applicable to the entire state per the requirements of the NFIP. Actual participation in the NFIP is, however, discretionary. As discussed, there is almost universal participation in the NFIP by eligible entities in the Lower Colorado-Lavaca Region.

Given these considerations and the feedback received from survey respondents, the Lower Colorado-Lavaca RFPG recommends the following with respect to current floodplain management practices in the Lower Colorado-Lavaca Region:

1. The RFPG does not recommend adopting region-specific floodplain management standards and regulations as a prerequisite for the inclusion of recommended Flood Management Evaluations and Strategies or Flood Mitigation Projects in this Regional Flood Plan. The RFPG believes that existing state and federal requirements combined with nearly 100 percent NFIP participation in the Lower Colorado-Lavaca Region are sufficient. The RFPG recommends that the handful of local entities in the Lower Colorado-Lavaca Region not participating in the NFIP join the program. However, the RFPG recognizes that some or all of these rural communities may not have a compelling reason to participate in the NFIP, such as not having significant existing flood risk and very little or no anticipated future growth and development.
2. The RFPG encourages and supports the adoption of higher standards for floodplain management and land development but does not recommend requiring the adoption of higher standards at this time. The RFPG strongly encourages all counties and cities in the Region to consider adopting higher or enhanced standards for floodplain management and regulation, particularly those communities with significant existing flood risk and/or are experiencing or are expected to experience significant population growth and land development activity. Higher standards, if adopted, should include additional freeboard over and above the Base Flood Elevation (1 percent annual chance flood), impervious cover limitations, stormwater detention requirements in new development (with exceptions), and restrictions on the placement of fill-in floodplains or physical alteration of floodplains that could reduce channel storage. The RFPG further recommends that counties and cities in the Lower Colorado-Lavaca Region consider participation in the FEMA Community Rating System.
3. The RFPG recommends that all outdated Flood Insurance Rate Maps be updated as soon as possible, particularly in the areas affected by updated Atlas 14 rainfall statistics.
4. The RFPG recommends that municipalities in the Lower Colorado-Lavaca Region explicitly consider flood hazards, floodplain management, and stream corridor protection in their

comprehensive land use plans and associated land use regulations (e.g., zoning, subdivision platting).

5. The RFPG recommends that counties in the region explicitly consider flood hazards, floodplain management, and stream corridor protection in the subdivision platting process.

Task 3B: Flood Mitigation and Floodplain Management Goals

As noted in the introduction to this chapter, for Task 3B, the RFPGs are to identify and adopt "…specific and achievable flood mitigation goals along with target years to meeting those goals…". This includes short-term goals and associated performance measures (10 years) as well as long-term goals and performance measures (30 years). As set out in the TWDB rules for regional flood planning (Guidance Principles in 31 TAC §362.3), the intent of the goals adopted by the RFPGs is "…to protect against the loss of life and property." This is further defined as:

1. Identification and reduction of the risk and impact to life and property that already exists, and
2. Avoid increasing or creating new flood risks by addressing future development within areas with existing or future flood risks.

The RFPG's adopted goals, when implemented, must demonstrate progress toward achieving the overarching goals set by the state.

Early in the regional flood planning process, the Lower Colorado-Lavaca RFPG devoted significant time and effort to exploring values and discussing what they felt were reasonable goals for the Lower Colorado-Lavaca Region. This section presents the flood mitigation and floodplain management goals and associated performance measures adopted by the Lower Colorado-Lavaca RFPG for the Lower Colorado-Lavaca Regional Flood Planning Area.

Goal Focus Areas

The RFPG adopted goals covering six focus areas. These focus areas were defined to create a one-to-one connection with the Flood Management Strategy types as outlined in the TWDB Data Submittal Guidelines.

The adopted goals will guide the development of Flood Management Strategies (FMSs), Flood Management Evaluations (FMEs), and Flood Mitigation Projects (FMPs) for the Lower Colorado-Lavaca Region. They build upon the TWDB regional flood planning guidance and provide a comprehensive framework for future strategy development focused on reducing flood risk to people and property while not negatively affecting neighboring areas.

The six-goal focus areas include:

1. Flood Education and Outreach
2. Flood Warning and Readiness
3. Flood Studies and Analysis
4. Flood Prevention

5. Non-Structural Flood Infrastructure Projects
6. Structural Flood Infrastructure Projects

The six focus areas are further detailed below and include specific goal statements that are achievable, measurable, and time-specific. Per the TWDB requirements and guidelines, the goals adopted by the RFPG must be specific and achievable and include the information listed below:

- Description of the goal
- Term of the goal is set at 10 years (short-term) and 30 years (long-term)
- Extent or geographic area to which the goal applies
- Residual risk that remains after the goal is met
- Measurement method that will be used to measure goal attainment
- Association with overarching goal focus areas

Lower Colorado-Lavaca Region Goals

The RFPG identified and adopted 14 goals within the six focus areas. They include:

Focus Area 1. Education and Outreach

Increase the amount of flood education and outreach opportunities to improve awareness of flood hazards and future participation throughout the Lower Colorado-Lavaca Region.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
1.1 Increase the number of public outreach and educational communications and activities conducted by the RFPG to improve awareness of flood hazards and the benefits of flood planning in the Flood Planning Region.	Baseline: 175 260 public communications (over the next two cycles)	Maintain	Number of public communications (emails, social media, news blasts, public service announcements, educational packets, etc.)

Focus Area 2. Flood Warning and Readiness

Improve the dissemination of information regarding early flood recognition and danger, emergency response procedures, and post-flood recovery actions.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
2.1 Increase the number of cities and counties which utilize real-time data from regional or local flood monitoring systems (e.g., LCRA Hydromet, City of Austin Early Warning System) to enhance flood warning, readiness, and other preparedness activities.	Establish a baseline through a survey of flood monitoring system users	Increase	Number of cities and counties which utilize real-time data from flood monitoring systems to improve flood preparedness

Focus Area 3. Flood Studies and Analysis

Increase the number and extent of regional flood planning studies and analyses to identify flood risk and better prepare entities for implementing flood mitigation projects.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
3.1 Increase the number of cities and counties with updated watershed models and floodplain maps to reflect current data (e.g., Atlas 14 revised rainfall data).	Baseline: 7 of 135 Additional 60	Baseline: 67 of 135 Additional 34 which is 75%	Number of cities and counties that have updated watershed models and floodplain maps
3.2 Increase the number of cities and counties that have evaluated priority flood risk areas and risk reduction measures (e.g., alternatives analysis and preliminary engineering).	Baseline: 49 of 135 Additional 26	Baseline: 75 Additional 40	Number of cities and counties that identify risk reduction measures
3.3 Increase the number of counties with digital flood insurance rate maps (DFIRMs) that reflect current conditions.	Baseline: 19 of 43 Additional 5	Baseline: 24 of 43 Additional 10	Number of counties that have digital flood insurance rate maps (DFIRMS)

Focus Area 4. Flood Prevention

Increase the number and extent of protective regulatory measures and programs to limit future risk and reduce flood damage in the Lower Colorado-Lavaca Region.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
4.1 Increase the number of cities and counties participating in the National Flood Insurance Program (NFIP).	Baseline: 122 of 135 100% NFIP participation	Maintain	Number of cities and counties that are participating in the NFIP
4.2 Increase the number of cities and counties that have adopted higher standards over and above NFIP minimum standards, including regulating to one or more feet above the Base Flood Elevation (BFE) for existing 1% annual chance event (100-year) conditions.	Baseline: 40 of 135 Additional 20	Baseline: 60 of 135 Additional 20	Number of cities and counties that regulate with higher standards (e.g., regulating Base Flood Elevation (BFE) + 1 as part of the regulatory framework)
4.3 Increase the number of cities and counties that have adopted regulations to reduce the risk from localized flooding.	Establish baseline	Increase	Number of cities and counties that have local drainage protection requirements in their development code
4.4 Increase the number of cities and counties which provide alternate compliance options that allow or incentivize nature-based solutions to reduce future flood risk.	Establish baseline	Increase	Number of cities and counties that allow/incentivize nature-based solutions as part of alternate compliance
4.5 Increase the number of cities and counties in the flood planning region considering the 1% annual chance (100-year) floodplain on the entity's future land use plans and development regulations.	Establish baseline	Increase	Number of cities and counties that consider 100-year floodplains on land use maps and development regulations

Area 5. Non-Structural Flood Infrastructure Projects

Reduce the amount of existing and future vulnerable properties within the flood planning region through property/easement acquisition, improved elevation, and other floodproofing programs and initiatives.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
5.1 Reduce the number of structures at risk of flooding through property/easement acquisitions, relocations, flood-proofing, and/or elevation.	Baseline: 68,000 structures in 100-year Reduce by 1,000 structures	Reduce by additional 1,500 structures	Number of at-risk structures mitigated by acquisitions, relocations, flood-proofing, and/or elevation
5.2 Increase the acreage of publicly protected open space in perpetuity to reduce future impacts of flooding through property buyouts, land conservation easements, acquisitions, or other comparable means.	Baseline: 133,000 acres Increase by 15%	Increase by additional 25%	Acreage of preserved land in the region

Focus Area 6. Structural Flood Infrastructure Projects

Reduce flood risk and mitigate flood hazards to life and property by implementing structural flood infrastructure projects.

Specific Goal Statements	Short-Term (2033)	Long-Term (2053)	Metric
6.1 Reduce the number of structures and critical facilities at risk of flooding by implementing structural flood mitigation projects.	Baseline: 68,000 structures and 99 critical facilities in 100-year Reduce by 1,000 structures and three critical facilities	Reduce by additional 1,500 structures and five critical facilities	Number of at-risk structures mitigated by structural flood mitigation projects
6.2 Increase the number of entities that mitigate flood risk at vulnerable roadways or waterways (e.g., low-water crossings, irrigation canals).	Establish baseline	Increase	Number of entities that mitigate low-water crossings or vulnerable roadways or waterways

Benefits and Residual Risk after Goals are Met

The adopted goal statements were developed in a manner to set the stage for specific actions that can be quantified and measured through subsequent state flood planning processes, including future discovery data collection processes, or through the implementation of evaluations, strategies, and/or projects, rather than high-level goal statements associated with outcomes (e.g., reducing fatalities). The established baselines will be used for future measurements to determine progress toward achieving the goals. Implementation efforts will also demonstrate progress towards the overall purpose and intent of the regional flood planning process and will result in various benefits to individuals, communities, and the entire region. The benefits of implementing the Lower Colorado-Lavaca Regional Flood Plan are presented in *Table 3.7*.

Beyond protecting against the loss of life and property, the goals offer several benefits, including protecting infrastructure, water supply, and environmental sustainability. The types of benefits to be realized by implementing the Lower Colorado-Lavaca Regional Flood Plan are presented in *Table 3.7*.

Table 3.7 Lower Colorado-Lavaca Region Flood Planning Goal Focus Areas and Benefits

Benefits/ Goals	1. Flood Education and Outreach	2. Flood Warning and Readiness	3. Flood Studies and Analysis	4. Flood Prevention	5. Non-Structural Flood Infrastructure Projects	6. Structural Flood Infrastructure Projects
Protect life	◑	●	◑	◑	●	●
Protect infrastructure	◑		◑	●	◑	●
Protect property	◑	◑	◑	●	●	●
Protect the environment	◑		◑	●	●	●
Protect/ enhance water supply				◑	◑	◑
Sustain the economy	◑	◑		◑	●	◑
Achieve co-benefits*				◑	◑	◑
Increase public awareness	●	●	◑	◑	◑	
Build community support	●	●	◑	◑		

◑ – *Potential benefit* ● – *Direct benefit*

** Co-benefits that could be achieved through flood protection include improved water supply, increased public recreation opportunities, etc.*

Residual Risk

The residual risk should be minimal if the goals are fully achieved. However, residual risks should be anticipated for each overarching goal focus area. Overall, the focus areas fall into one or more of the following residual risks:

1. Storm events exceeding the design capacity of the infrastructure
2. Time and budget limitations
3. Human behavior
4. Funding limitations for maintenance
5. Policy and regulation changes

Table 3.8 Residual Risk After Achieving Goals

Focus Area	Residual Risk
Flood Education and Outreach	Flood education and outreach primarily provide benefits when implemented. The primary residual risks associated with public education and outreach are lack of reach (i.e., not reaching everyone), lack of attention to detail, and outright misunderstandings. Misunderstandings happen when the public becomes confused about the message, possibly due to its length or complexity.
Flood Warning and Readiness	Flood warning and readiness residual risk depend on public response to flood warnings. Drivers may ignore flood warning signs or barricaded roads for various reasons (e.g., despite an entity's best efforts, the risk remains at low water crossings).
Flood Studies and Analysis	Reducing residual risk associated with improving flood analyses involves technology that is always changing and improving. Due to the change and updates to terrain, land use, precipitation, and other data, the risk associated with floodplains may change over time. While a new development may be constructed outside the 1 percent ACE floodplain, future improvements in technology and other data (e.g., additional increase in rainfall rates) may change the floodplain boundary resulting in some structures being located within the floodplain.
Flood Prevention	Reducing residual risk through flood prevention depends on the local community's floodplain management policies and political leaders. Getting every community within the Lower Colorado-Lavaca Region to adopt and enforce NFIP minimum standards, let alone higher standards, may prove to be challenging. The lack of local enforcement of floodplain regulations also creates residual risk.
Non-Structural Flood Infrastructure Projects	The primary residual risk associated with non-structural flood infrastructure projects relates to the level of application and/or participation in the non-structural solutions (e.g., not achieving 100 percent participation in elevating structures in a high-risk area).
Structural Flood Infrastructure Projects	Flood infrastructure improvements can only be expected to perform based on the design capacity. In other words, if any storm that exceeds the design capacity were to occur, the infrastructure would still be at risk. Due to cost constraints, most community stormwater collection systems are not designed to collect the 1 percent ACE. Even if the system were designed for that storm, a larger storm would still overwhelm the system. Likewise, storm intensities can overwhelm stormwater collection systems resulting in flooded roadways, bridges, culverts, and other damages. Also, routine infrastructure maintenance is required to maintain the design capacity. Maintenance is sometimes overlooked due to budget, staff, and time constraints.

Chapter 4: Flood Mitigation Needs

Source: Bastrop County Flood Photo

Utilizing the flood risk analysis and flood planning goals adopted by the Regional Flood Planning Group (RFPG), this chapter outlines the process used to identify areas within the Lower Colorado-Lavaca Region with the greatest risk of flooding and the need for flood management and mitigation activities. The assessment conducted in this chapter provides a high-level evaluation to help guide the identification of Flood Management Evaluations (FMEs), Flood Mitigation Projects (FMPs), and Flood Management Strategies (FMSs) in future chapters. *Figure 4.1* provides a summary of the categories that were considered in the Flood Mitigation Needs Analysis.

Figure 4.1 Flood Mitigation Needs Analysis Categories

Threat to Life and Property

- Exposed Buildings
- Exposed Critical Facilities
- Exposed Low Water Crossings
- Inundated Roadways
- Inundated Agricultural Areas

Floodplain Management

- National Flood Insurance Program Participation

Data Gaps

- Inundation Boundary Mapping Gaps
- Hydrology and Hydraulic Model Gaps

Needs

- Emergency Needs
- Social Vulnerability Index

Flood Mitigation Needs Analysis

The flood mitigation needs analysis leveraged the Lower Colorado-Lavaca Region's existing condition 1 percent annual chance (100-year) flood exposure analysis to assess the threat to life and property as well as social vulnerability. This leveraged exposure analysis accounts for the use of the best available flood hazard data, including existing modeling analysis and documentation of historical flooding events. The *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap* discussed in *Chapter 1: Planning Area and Description* included multiple opportunities for entities to submit conceptual, planning, or ongoing projects or studies/plans related to flooding. No entities in the Lower Colorado-Lavaca Region submitted revised floodplains that would result from flood mitigation projects with dedicated construction funding and completion date before the completion of this plan.

Analysis Process

The main objectives of Task 4A are to identify the areas of greatest known flood risk and areas where the greatest lack of flood risk knowledge exists. The Task 4A analysis is based on a geospatial process that combines information from multiple datasets representing the criterion listed in *Figure 4.1* and provides a basis for achieving the Task 4A objectives. The geospatial process was developed in a geographic information system (GIS) based on the data collected in *Chapters 1* through *3*. The geospatial assessment was conducted at a HUC-12 watershed level of detail, which is consistent with TWDB guidelines and rules. A Hydrologic Unit Code (HUC) is a unique code 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 Colorado-Lavaca Region has 560 HUC-12 watersheds, with an average area of 43 square miles.

A total of 10 data categories (summarized in *Figure 4.1*) were used in the geospatial analysis. A scoring range was determined for each data category based on the statistical distribution of the data. The scoring ranges vary for each category based on the HUC-12s with the smallest and largest quantity. A uniform scoring scale of one to five was adopted, and each HUC-12 was assigned an appropriate score for each category. The scores for each HUC-12 under each category were then added to obtain a total score that was used to reveal the areas of greatest known flood risk and the need for mitigation activities. The areas with the greatest gaps of flood risk information were identified using the hydrologic and hydraulic modeling gaps.

The following sections briefly describe the data categories included in the assessment and how each HUC-12 watershed was scored. Note that the objective of the Task 4A process is to determine the factors present within a given HUC-12 and to what degree, not necessarily to determine the relative importance of each factor in determining flood risk. Therefore, no weight has been applied to emphasize one factor over another at this time.

Analysis Categories and Matrix

The 10 categories applied in this analysis were selected based on their inherent reflection of either risk or absence of information for each of the Lower Colorado-Lavaca Region's HUC-12 watersheds and are described in the sections below. Each category and its respective categories and score distributions are shown in *Table 4.1*. The geospatial assessment was conducted using the existing condition 1 percent annual chance (100-year) event, which is the most representative of current conditions.

Table 4.1 Flood Mitigation Needs Analysis Matrix

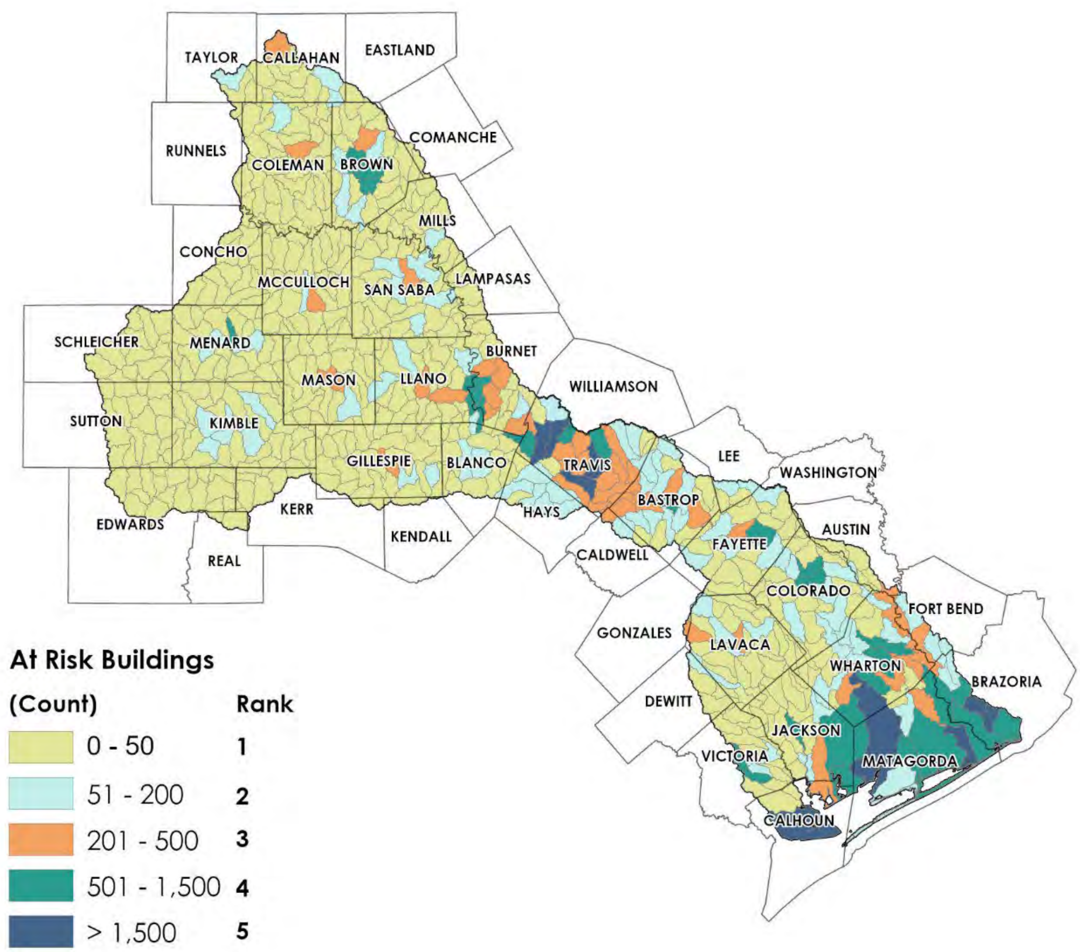
Category	Criteria	1 Point	2 Points	3 Points	4 Points	5 Points
Threat to Life and Property	Number of Exposed Buildings	0-50	51-200	201-500	501-1,500	1,500+
Threat to Life and Property	Number of Exposed Critical Facilities	0-1	2	3	4	5
Threat to Life and Property	Number of Exposed Low Water Crossings	0-5	6-10	11-15	16-20	21+
Threat to Life and Property	Miles of Inundated Roadway Segments	0-5	5.1-10	10.1-15	15.1-30	30+
Threat to Life and Property	Square Miles of Inundated Agricultural Area	0-5	5.1-10	10.1-15	15.1-30	30+
Floodplain Management	NFIP Participation	100% within Participating Counties		< 50% within Participating Counties		> 50% within Participating Counties
Data Gaps	Inundation Boundary Mapping Gaps	None-Partial 0.2% Flood Risk	Missing 0.2% Flood Risk	Outdated NFHL (10+ Years Old)	Not Model-Backed (Cursory Data)	Missing Atlas 14 Analysis
Data Gaps	H&H Model Gaps	No Gaps		Partial Gaps		Gaps
Need	Emergency Need	No				Yes
Need	Average Social Vulnerability Index of Exposed Buildings	0-0.25	0.251-0.45	0.451-0.55	0.551-0.65	0.65+

Threat to Life and Property

Exposed Buildings

The TWDB provided a building dataset utilized in *Chapter 2: Flood Risk Analysis* to conservatively identify buildings with a footprint within the existing condition 1 percent annual chance (100-year) event floodplain. Using this exposed building dataset, each HUC-12 was populated with the number of exposed buildings within each HUC-12 boundary. The exposed building counts ranged widely across the region, with rural HUC-12s only having only a few buildings in the floodplain, while urban HUC-12s may have over 1,000 exposed buildings. The scoring associated with the number of exposed buildings per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.2*. The navy watersheds represent the HUC-12s with the greatest number of exposed buildings. These watersheds are located in more urban areas near Lake Travis, the City of Austin, and along the coast.

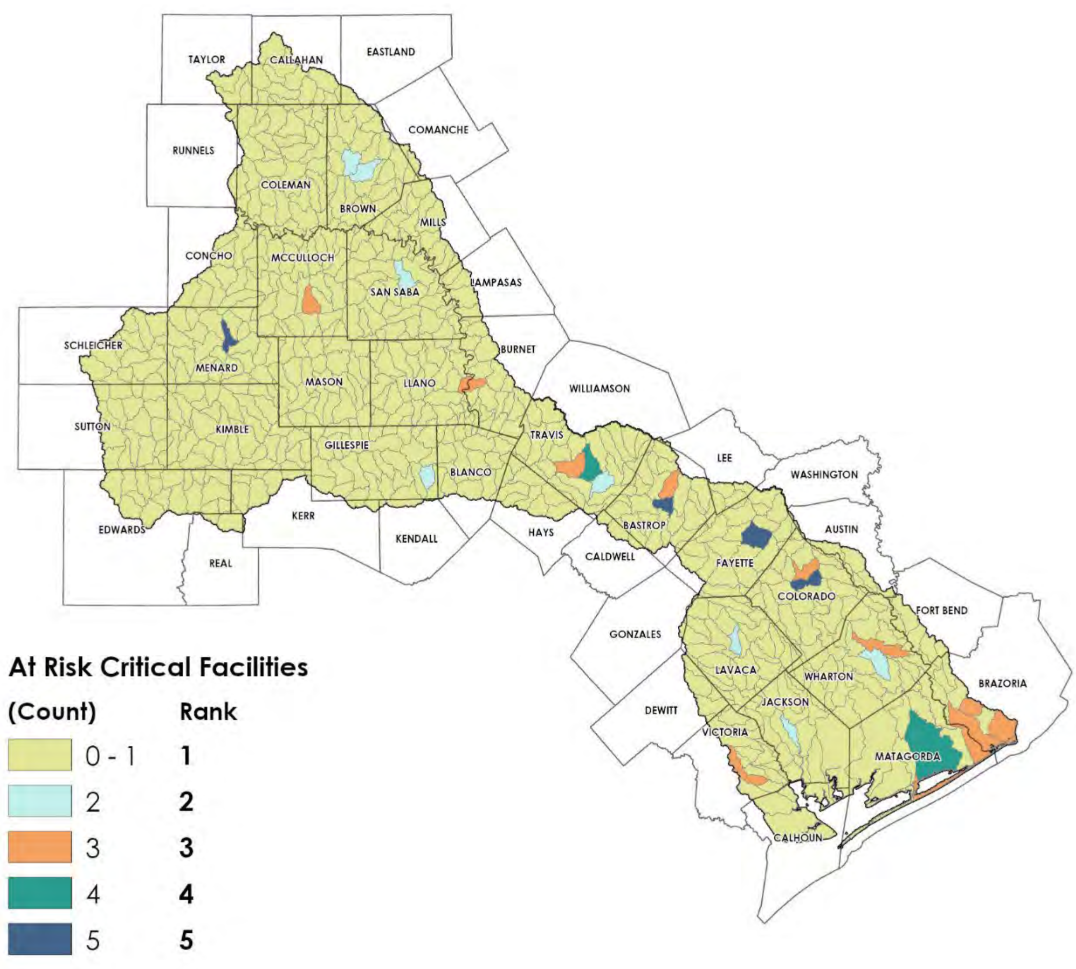
Figure 4.2 Scoring of Exposed Buildings



Exposed Critical Facilities

The exposure analysis in *Chapter 2: Flood Risk Analysis* conservatively identified critical facilities with a footprint within the existing condition 1 percent annual chance (100-year) event floodplain. Using this exposed critical facility dataset, each HUC-12 was populated with the number of exposed critical facilities located within each HUC-12 boundary. The exposed critical facility counts are relatively low across the region; however, there are four watersheds with five critical facilities potentially at risk of flooding. The scoring associated with the number of exposed critical facilities per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.3.* The navy watersheds represent the HUC-12s with the greatest number of exposed critical facilities.

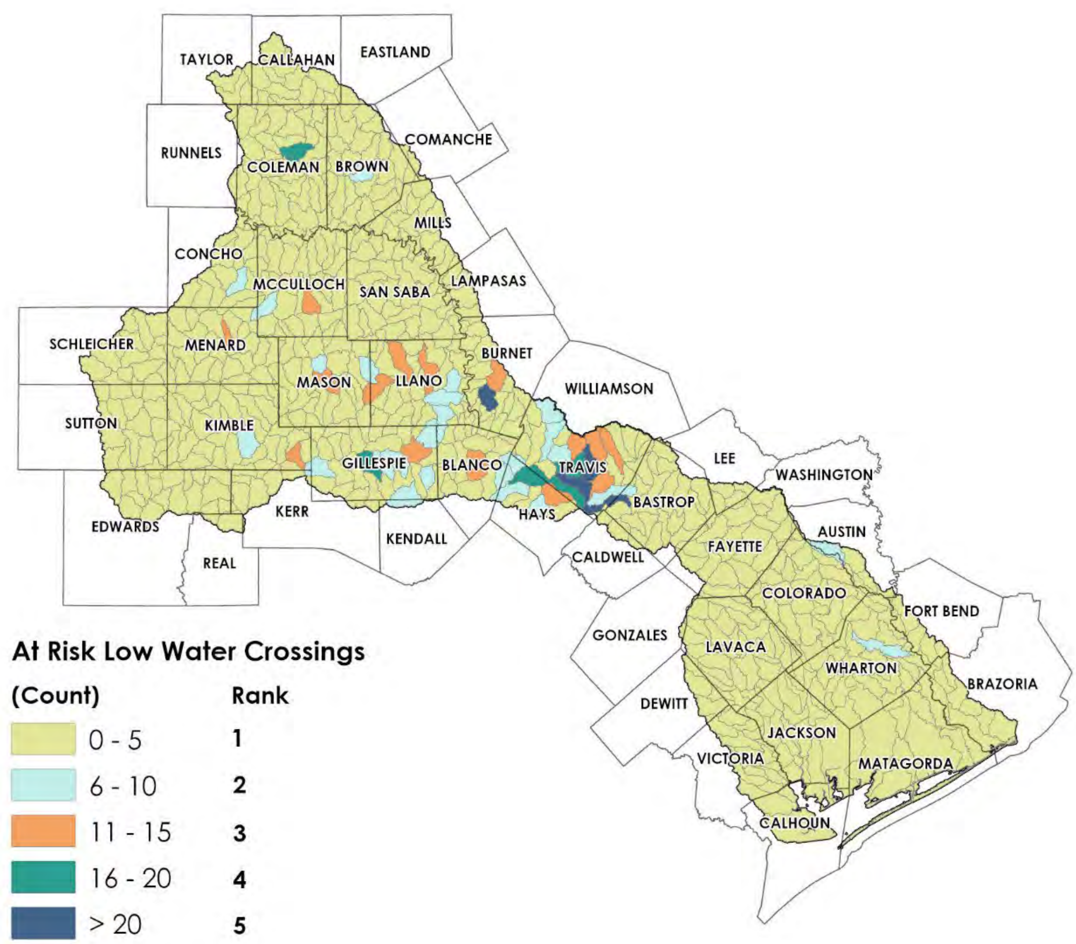
Figure 4.3 Scoring of Exposed Critical Facilities



Exposed Low Water Crossings

The exposure analysis in *Chapter 2: Flood Risk Analysis* identified low water crossings located within the existing condition 1 percent annual chance (100-year) event floodplain. Using this exposed low water crossing dataset, each HUC-12 was populated with the number of exposed low water crossings located within each HUC-12 boundary. The exposed low water crossing counts are relatively low across the region; however, there are 10 watersheds with 16 or more exposed low water crossings. The scoring associated with the number of exposed low water crossings per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.4.* The dark green and navy watersheds represent the HUC-12s with the greatest number of exposed low water crossings.

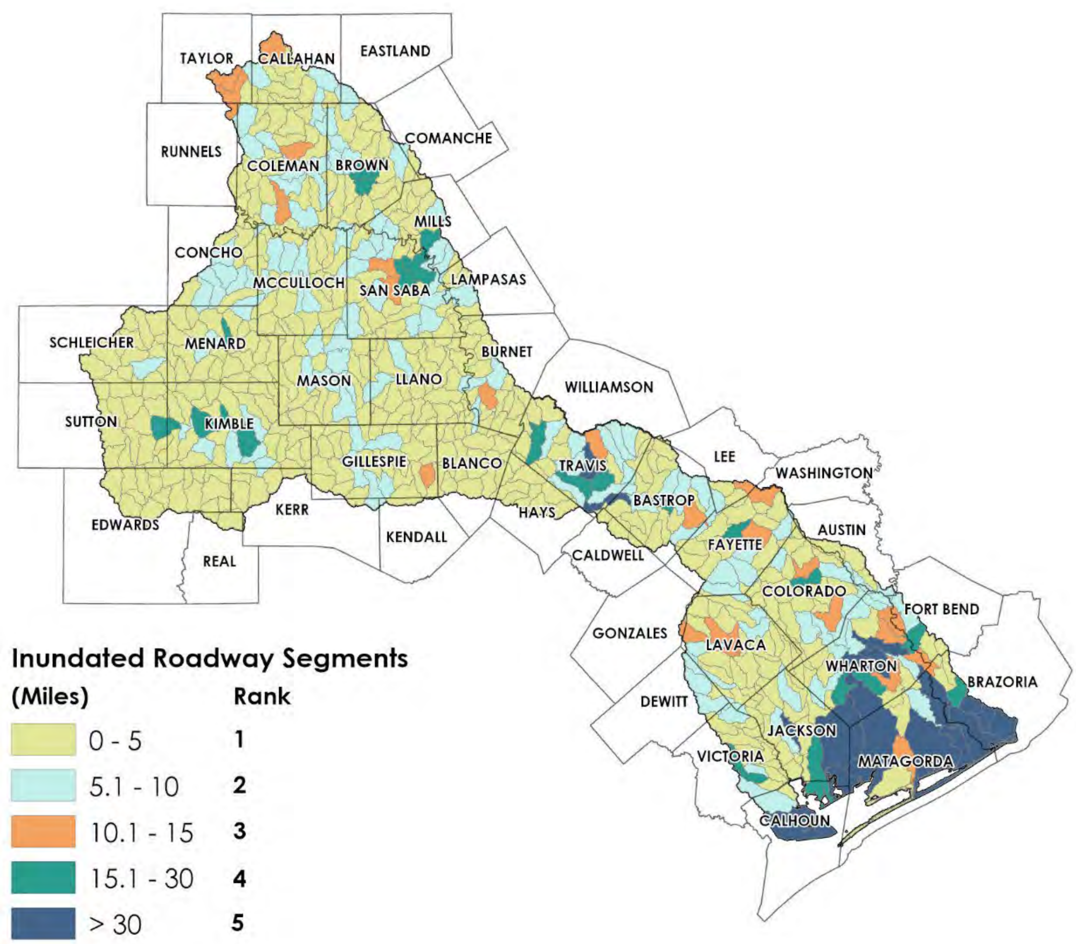
Figure 4.4 Scoring of Exposed Low Water Crossings



Inundated Roadway Segments

As described in *Chapter 2: Flood Risk Analysis,* inundated roadway segments were identified by clipping the Texas Department of Transportation (TxDOT) geospatial linework with the existing condition 1 percent annual chance (100-year) floodplain. Using this dataset, each HUC-12 was populated with the miles of inundated roadway segments located within each HUC-12 boundary. The inundated roadway mileage ranged widely across the region, with the majority of HUC-12s having less than five miles of roadway in the floodplain, while coastal HUC-12s may have over 30 miles of inundated roadway segments. The scoring associated with the miles of inundated roadway segments per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.5.* The navy watersheds represent the HUC-12s with the greatest number of inundated roadway segments.

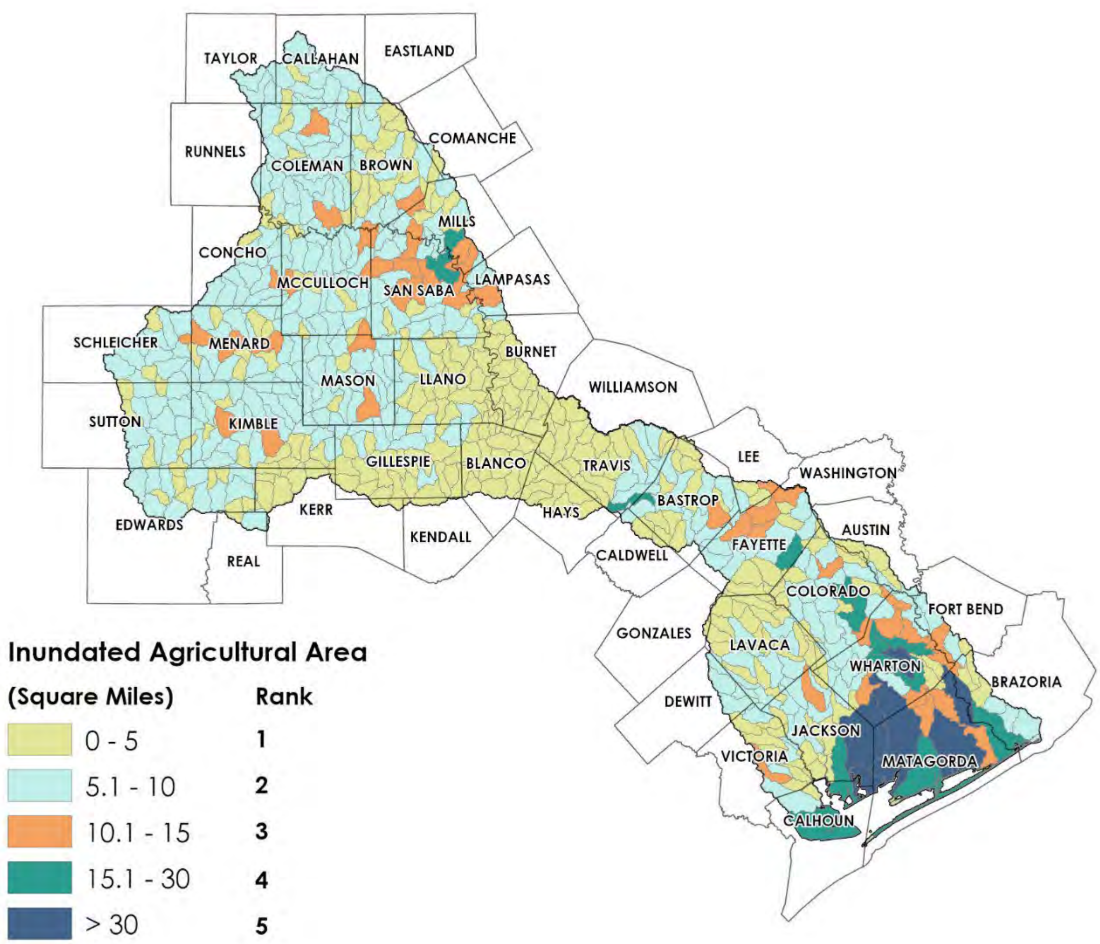
Figure 4.5 Scoring of Exposed Roadway Segments



Inundated Agricultural Areas

Agricultural land use data in the Lower Colorado-Lavaca Region was obtained from the 2020 Texas Cropland Data layer developed by the United States Department of Agriculture National Agricultural Statistics Service. The exposure analysis in *Chapter 2: Flood Risk Analysis* identified agricultural areas with a footprint within the existing condition 1 percent annual chance (100-year) event floodplain. Using this dataset, each HUC-12 was populated with the square miles of inundated agricultural areas within each HUC-12 boundary. As anticipated, the urban watersheds display less inundated agricultural areas than the rural watersheds. The scoring associated with the square miles of inundated agricultural areas per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.6.* The navy watersheds represent the HUC-12s with the greatest number of inundated agricultural areas.

Figure 4.6 Scoring of Inundated Agricultural Areas

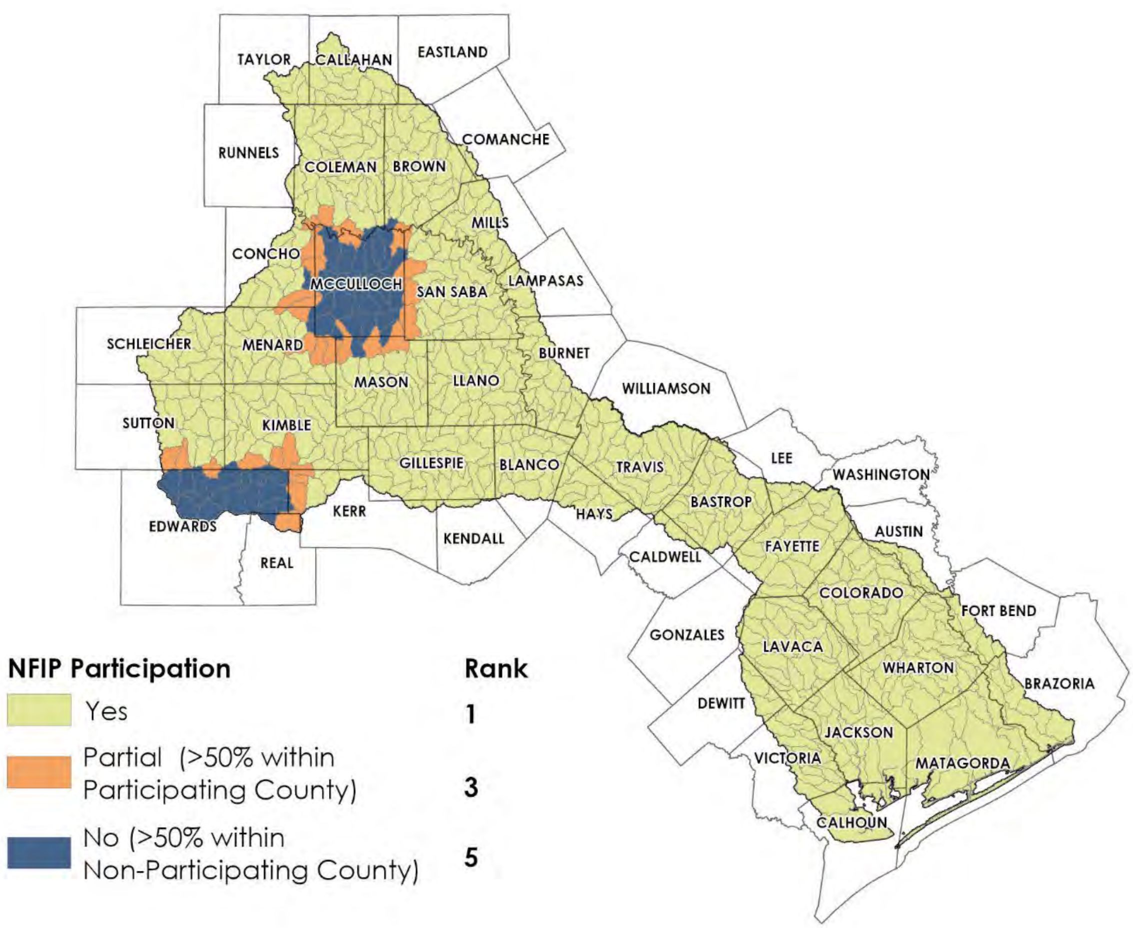


Floodplain Management

National Flood Insurance Program (NFIP) Participation

Participation in the NFIP was considered as a proxy for having adequate floodplain management regulations and land use policies for this assessment. The NFIP participation status for each county and community is presented in *Chapter 3: Floodplain Management Practices and Flood Protection Goals*. Non-participating entities likely have limited floodplain management regulations and are not eligible for flood insurance under the NFIP. Furthermore, if a presidentially declared disaster occurs as a result of flooding, no federal financial assistance can be provided to these entities for repairing or reconstructing damaged infrastructure. All but two counties within the Lower Colorado-Lavaca Region participate in the NFIP, with only 11 municipalities currently not participating. Scoring was defined based on the area of each HUC-12 watershed within a participating or non-participating county. Watersheds completely within participating counties were assigned a score of one, indicating a low risk for this category. Those with less than 50 percent were assigned a score of three, while those with over 50 percent received a score of five. The scoring results are displayed in *Figure 4.7*.

Figure 4.7 Scoring of National Flood Insurance Program Participation

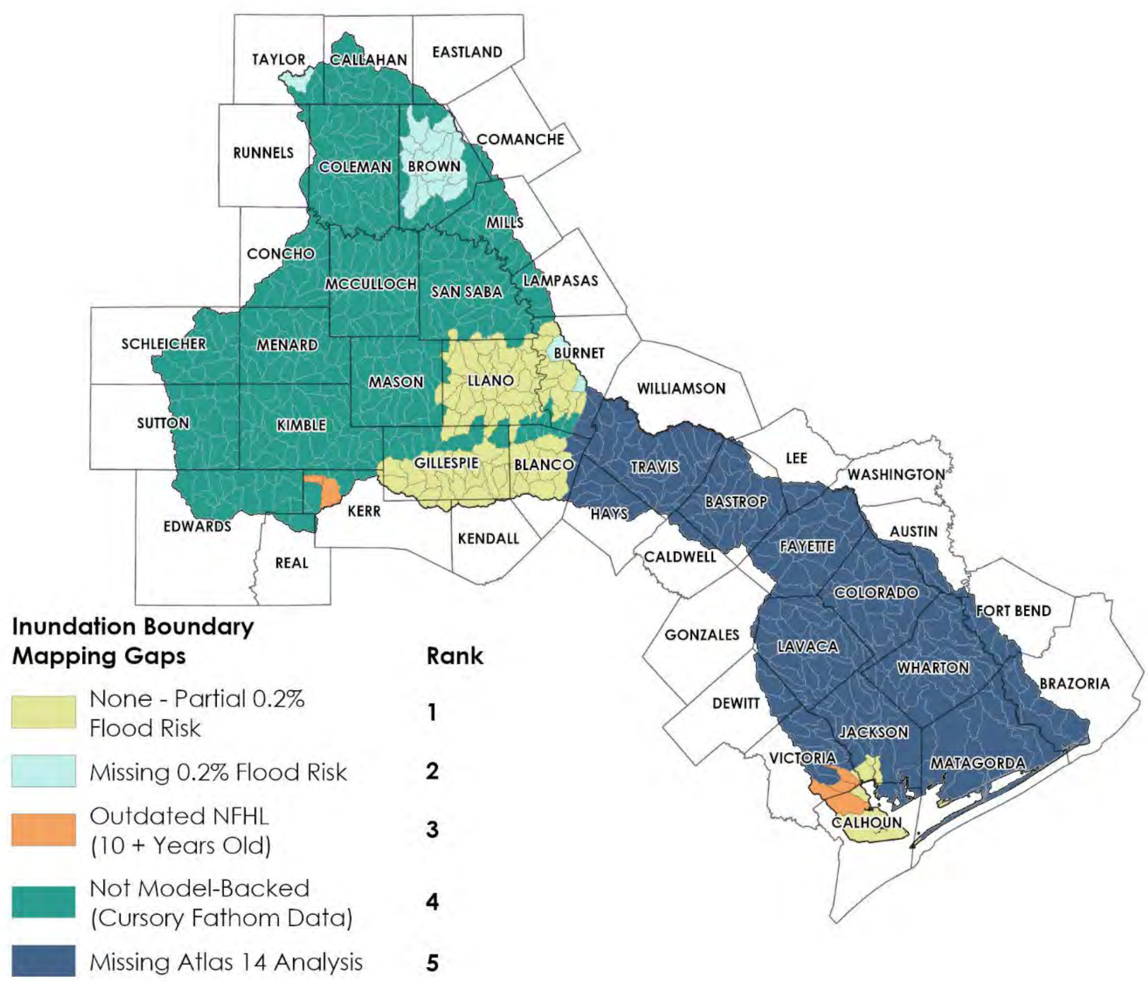


Data Gaps

Inundation Boundary Mapping Gaps

In *Chapter 2: Flood Risk Analysis,* inundation boundary mapping gaps were identified for areas where flood inundation boundary mapping for the 0.2 percent annual (500-year) event was missing, modeling and/or mapping was outdated, modeling and/or mapping was not reflective of the current scientific data, or mapping was not model-backed. The scoring associated with the inundation boundary mapping gaps per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.8.* The navy watersheds represent the HUC-12s with the greatest need for FMEs to assess the impacts of NOAA Atlas 14 rainfall data through the more populated portion of the region.

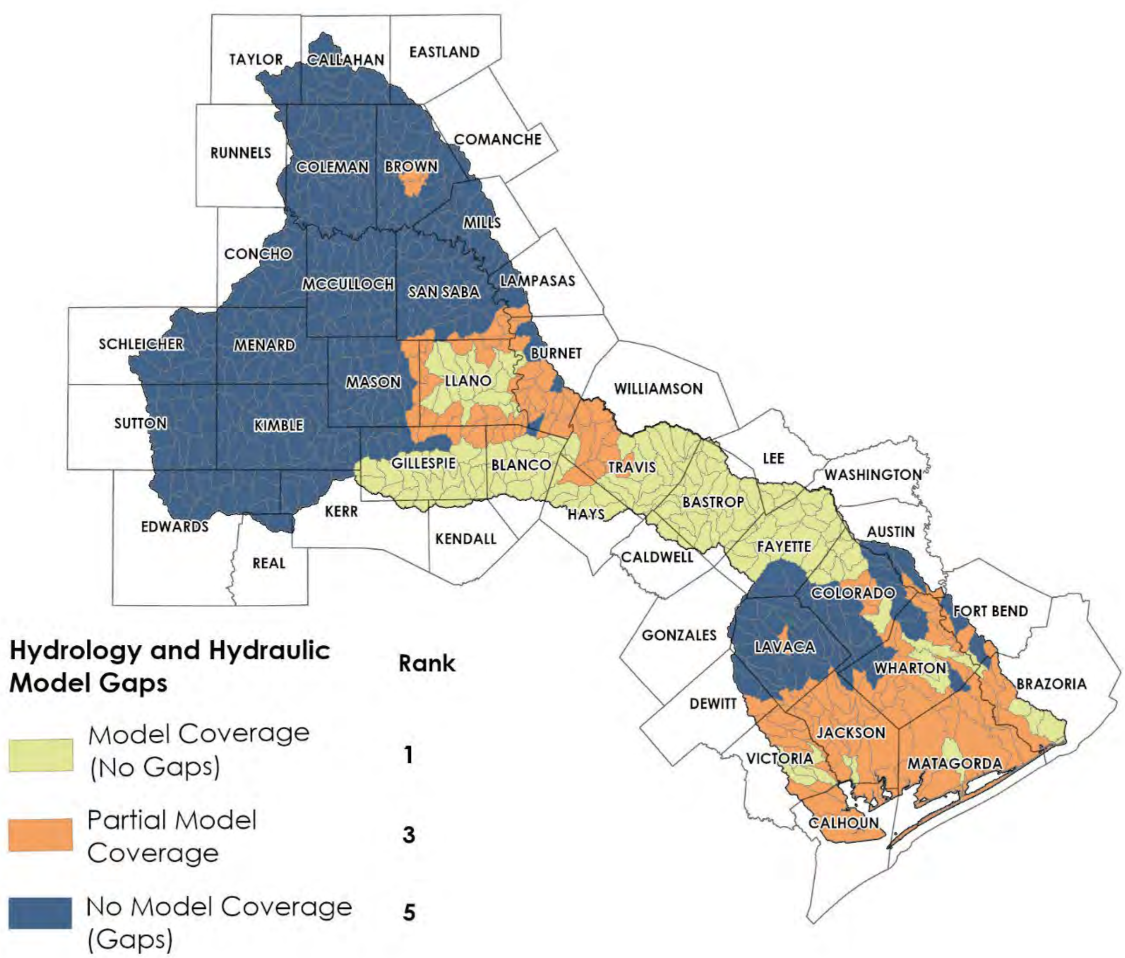
Figure 4.8 Scoring of Inundation Boundary Mapping Gaps



Hydrologic & Hydraulic (H&H) Model Gaps

In *Chapter 2: Flood Risk Analysis,* hydrologic and hydraulic model gaps were identified. The H&H gap areas exclude areas where local studies, base level engineering, and FEMA detailed or limited detailed studies are present because these areas are locations where H&H models are available. Scoring was determined based on whether a HUC-12 watershed had total, partial, or no coverage of model-backed floodplains. The scoring associated with the H&H model gaps per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.9.* The navy watersheds represent the HUC-12s with the greatest need for FMEs to generate hydrologic and hydraulic models where flood risk knowledge is limited.

Figure 4.9 Scoring of Hydrologic and Hydraulic Model Gaps

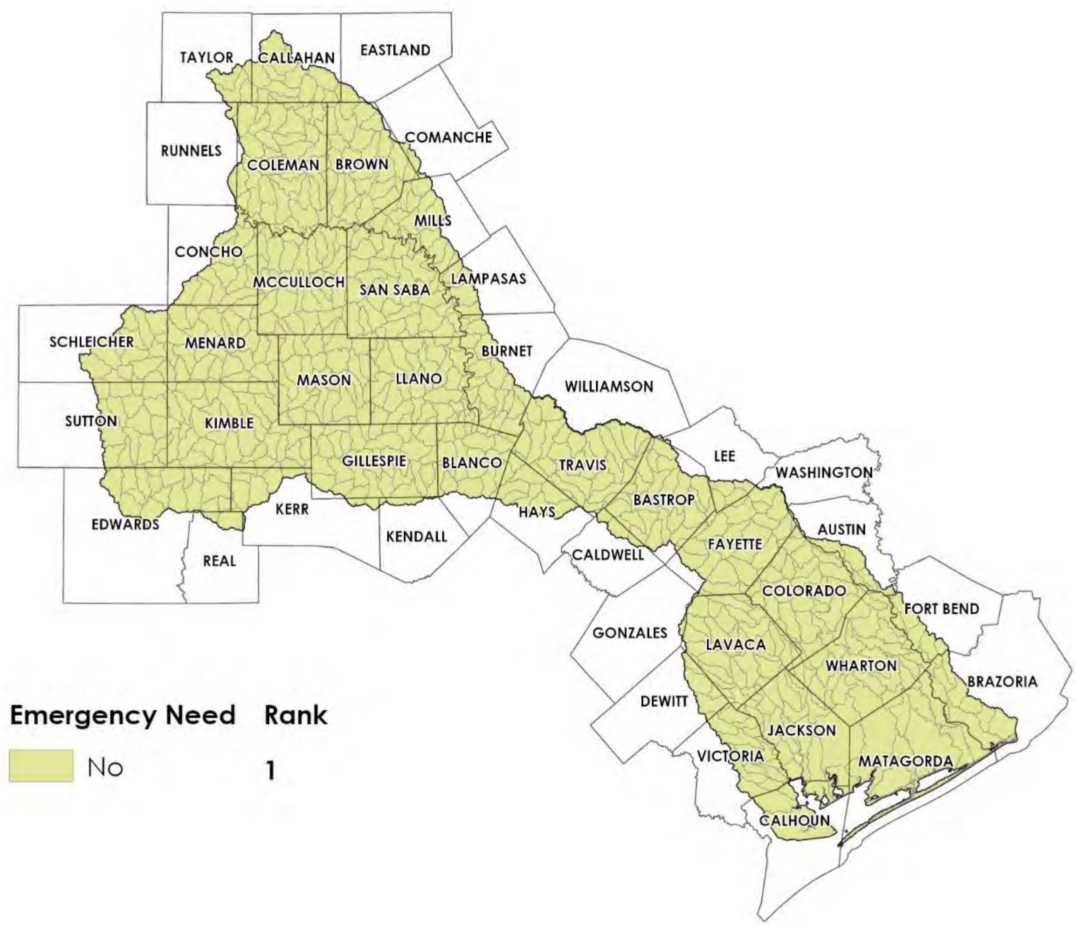


Areas of Need

Emergency Needs

The Lower Colorado-Lavaca RFPG has not developed a definition for Emergency Needs. This category is included as a placeholder for the next planning cycle. Since the category has not yet been defined, all watersheds were assigned a score of one, indicating a low risk for this category. The scoring results are displayed in *Figure 4.10*.

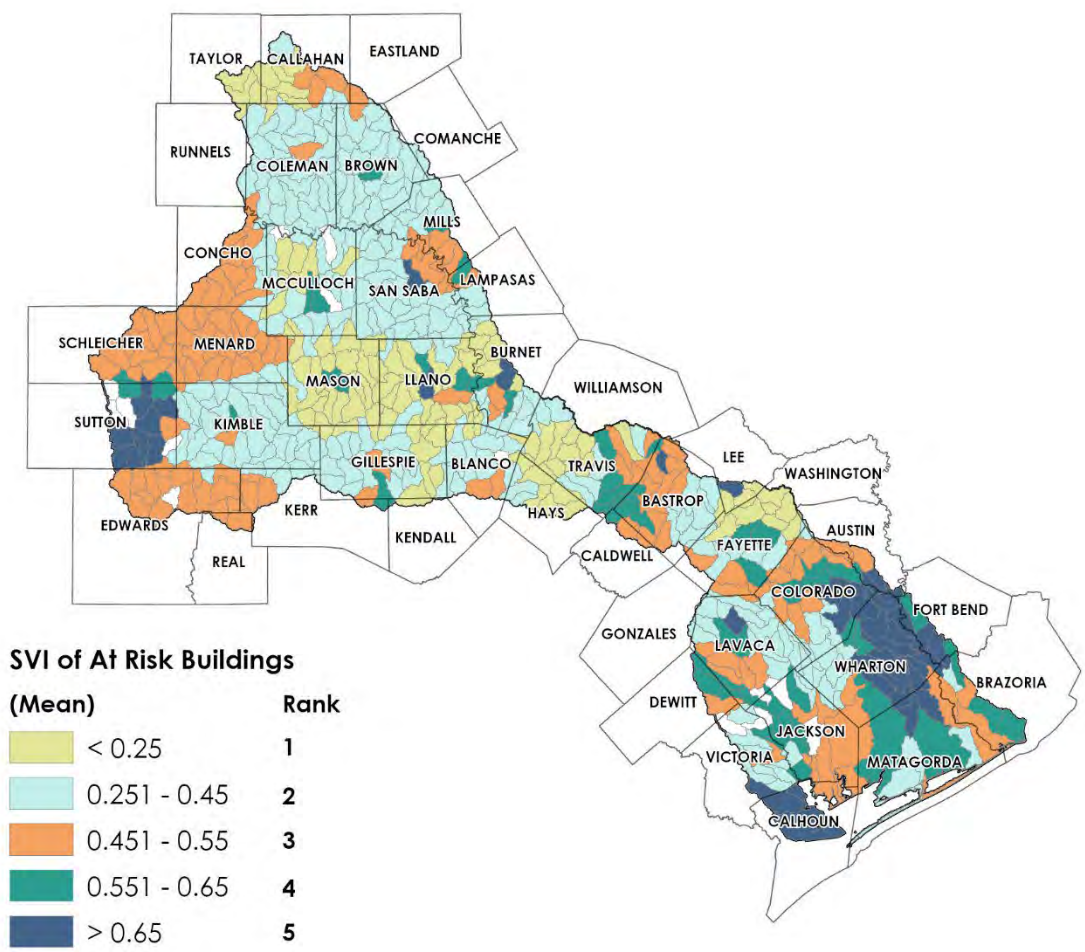
Figure 4.10 Scoring of Emergency Needs



Social Vulnerability Index (SVI)

Social vulnerability is the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long and short term. SVI values are present within the building footprints dataset provided by the TWDB and used in the existing condition vulnerability analysis discussed in *Chapter 2: Flood Risk Analysis*. Using the SVI values for the exposed building dataset, each HUC-12 was populated with the average SVI within each HUC-12 boundary. Higher SVI values represent watersheds with greater vulnerability, while lower SVI values represent watersheds with higher resilience. The scoring associated with the SVI of exposed buildings per watershed is displayed in *Table 4.1,* and the scoring results are displayed in *Figure 4.11.* The navy watersheds represent the HUC-12s with the greatest social vulnerability.

Figure 4.11 Scoring of Social Vulnerability



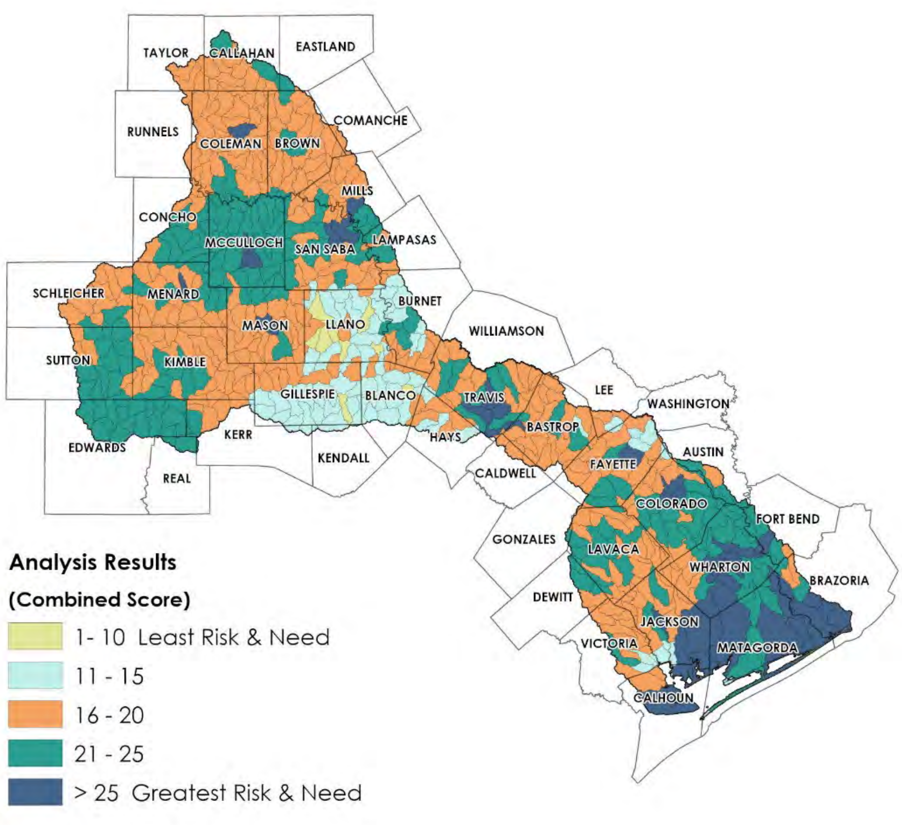
Mitigation Needs Analysis Results

The process and scoring methodology described above were implemented across the entire Lower Colorado-Lavaca Region. As previously discussed, this assessment was performed to address the two objectives of Task 4A. The first objective was to identify the areas where the greatest flood risk knowledge gaps exist. These areas were identified using the hydrologic and hydraulic modeling gaps. As observed in *Figure 4.9*, the majority of the region lacks hydrologic and hydraulic models, as indicated by the orange and navy watersheds.

The second objective was to determine the areas of greatest known flood risk and flood mitigation needs. For each HUC-12 in the Lower Colorado-Lavaca Region, the scores from the 10 categories in the assessment matrix were added to obtain a total score. Based on the distribution of the final scores in this preliminary assessment, the watersheds with the greatest risk of flooding and the need for flood management and mitigation activities are displayed in navy. It is important to note that low-scoring HUC-12 watersheds likely have flood risks, but the risk is relatively low compared to the others.

The maps resulting from the Task 4A assessment served as a guide to the RFPG's subsequent efforts in *Chapter 5*. The orange and navy HUC-12s in *Figure 4.12* highlight the areas in the Lower Colorado-Lavaca Region where potentially feasible FMEs should be considered as part of Task 4B. The dark green and navy HUC-12s in *Figure 4.12* emphasize watersheds where the RFPG should strive to identify and implement FMEs, FMPs, and FMSs to reduce the known flood risks within those areas.

Figure 4.12 Scoring of Flood Mitigation Needs Analysis



Chapter 5: Identification, Evaluation, and Recommendation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects

Reconstruction of the Bastrop State Park Dam

Overview and Objectives

This chapter focuses on Tasks 4B and 5 as prescribed in the State Flood Plan rules and guidelines. The scope of Task 4B involves the identification and assessment of potential flood management evaluations (FMEs) and potentially feasible flood management strategies (FMSs) and flood mitigation projects (FMPs). Task 5 further evaluates identified FMEs, FMSs, and FMPs through a final recommended list of actions to be incorporated into the Lower Colorado-Lavaca Regional Flood Plan.

Objectives of Tasks 4B and 5

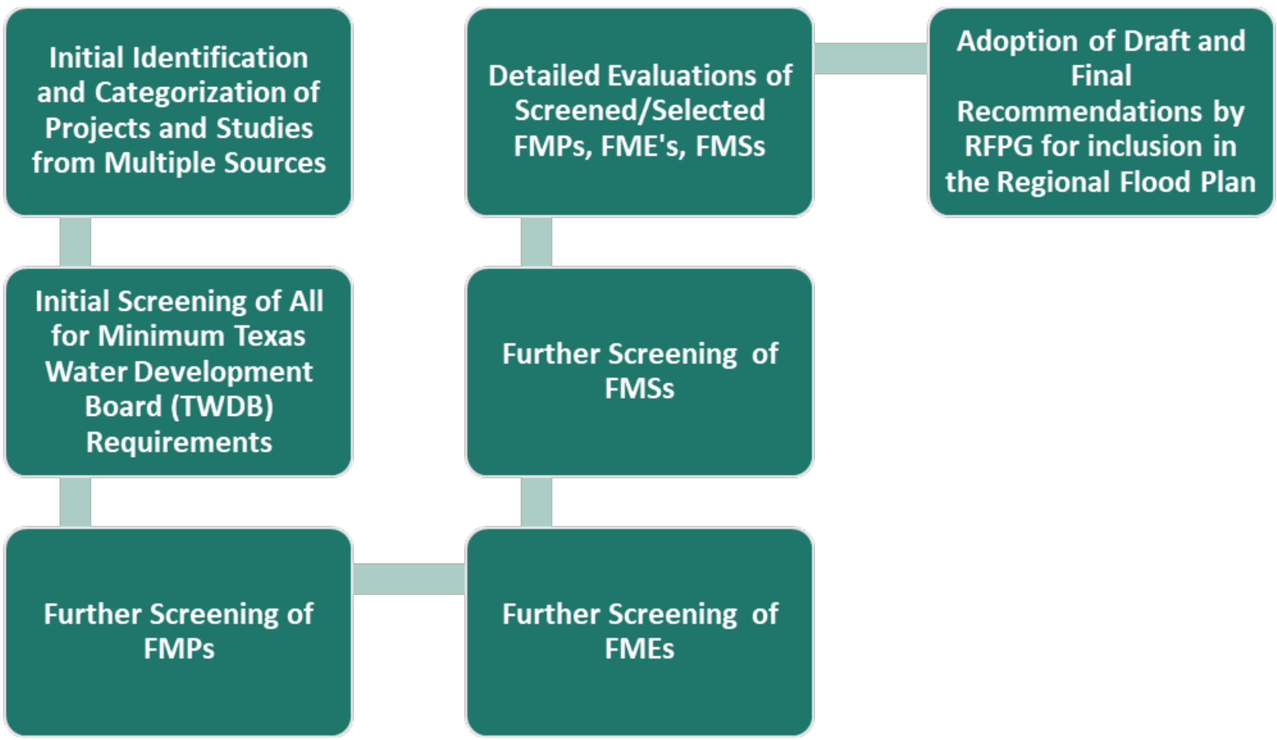
Tasks 4B and 5 build on previous Tasks 1 through 4a with the ultimate objective of recommending FMEs, FMSs, and FMPs that:

- reduce flood risk identified in *Chapter 2 – Existing and Future Conditions Flood Risk Analyses*
- address flood mitigation and floodplain management goals established *in Chapter 3 – Evaluation and Recommendation of Flood Mitigation and Floodplain Management Practices and Goals*
- address flood mitigation needs identified in *Chapter 4 – Flood Mitigation Needs Analysis*

Process Overview of Tasks 4B and 5

The Lower Colorado-Lavaca Regional Flood Planning Group (RFPG) adopted a process for screening and evaluating FMEs, FMSs, and FMPs as summarized in the graphic *Figure 5.1* based on requirements and guidance within the State Flood Plan rules and guidelines, including region-specific interpretations and preferences. The RFPG formed a "Task 5" Technical Committee following state flood plan rules to oversee the process and eventual recommendations from the Technical Consultant team.

Figure 5.1 Process Overview Flow Diagram of Tasks 4B and 5



The state flood plan rules and guidelines allow for region-specific flexibility and interpretation when recommending Regional Flood Plan FMPs, FMEs, and FMSs. The Lower Colorado-Lavaca RFPG's general approach to this flexibility was to be more inclusive as opposed to being more restrictive for this first cycle of the Regional Flood Plan. The following sections summarize the process and draft results of Tasks 4B and 5 for the Lower Colorado-Lavaca Region.

Initial Identification and Categorization of Flood Mitigation and Management Actions

Flood mitigation and management actions were identified from multiple sources and initially categorized as FMPs, FMEs, or FMSs to begin the initial screening process. Actions were categorized based on the available information obtained from each potential sponsor community using industry-standard flood mitigation categories and types and following TWDB state flood plan rules and guidelines.

Below is a general description of the categories and types of FMPs, FMEs, and FMSs used for the Lower Colorado-Lavaca Region.

Flood Mitigation Projects (FMPs)

One of the primary objectives of the state flood plan is to identify and fund flood mitigation projects for implementation; therefore, identifying FMPs that meet state flood plan criteria and requirements for inclusion in the state flood plan is priority one. Per the TWDB rules of the four common phases of emergency management shown in *Figure 5.2*, the regional flood planning process focuses primarily on *mitigation* projects but may also include *preparedness* projects.

Figure 5.2 Four Common Phases of Emergency Management

By the TWDB definition, a flood mitigation project is "a proposed project that has a non-zero capital cost or other non-recurring costs and that, when implemented, will reduce flood risk and mitigate flood hazards to life or property."[1] FMPs are further categorized as either structural or non-structural.

Structural FMPs

Structural FMPs are defined as building or modifying infrastructure to change flood characteristics to reduce flood risk. They are infrastructure projects with advanced analysis and 30 – 100 percent design development, including construction plans, specifications, and cost estimates. Structure FMPs include one or a combination of the following project types:

- culvert/bridge improvements
- channel improvements
- flood detention
- flood walls/levees
- flood diversion
- storm drain improvements
- coastal protections

[1] Title 31 Texas Administrative Code §361.10(n)

Culvert and Bridge Improvements

Typical culvert and bridge improvements address roadway flooding at waterways ranging from large riverine crossings to roadway crossings at smaller creeks and streams. The TWDB rules define low water crossings as roadway creek crossings overtopped by a 50 percent annual chance storm event (2-year storm). Bridges and culverts with insufficient area to convey higher flows tend to overtop frequently, preventing the passage of vehicles during high flow times and producing excess backwater that may result in flooding upstream properties. Bridges and culverts that overtop frequently pose a significant threat to public safety, as most flood-related deaths occur at these types of crossings. Culvert and bridge improvement FMPs are often part of larger flood risk reduction projects (such as channel widening projects) and not just single low water crossing projects.

Example of Flooded Low Water Crossing at Bee Creek Road and Bee Creek in Travis County as well as an Example Low Water Crossing Upgrade with Precast Bridge Units, David Moore Drive, Austin

Channel Improvements

Channel improvements generally lower flood levels by improving the hydraulic conveyance of a stream or roadside channel by enlarging, straightening, and/or reducing the channel friction by smoothing the contours and/or lining of the channel banks and removing obstructions. Channel improvements can reduce flood risk to large populations but require significant modifications to mitigate the 1 percent annual chance (100-year) flood. Channel improvement projects typically require land acquisition, can be costly and difficult to implement in urbanized areas, and face permitting challenges due to adverse environmental impacts, which can be significant. Channel improvements may also require significant ongoing maintenance costs. Importantly, channel improvement projects can incorporate nature-based natural channel design techniques to mitigate adverse environmental impacts and, in some cases, restore or otherwise improve ecological function and repair and stabilize the channel and streambank erosion. In urban settings, channel improvements often include recreational, cultural, and educational features providing socioeconomic benefits.

Example Channel Improvements - Shoal Creek Channel Improvement and Restoration Project, Austin

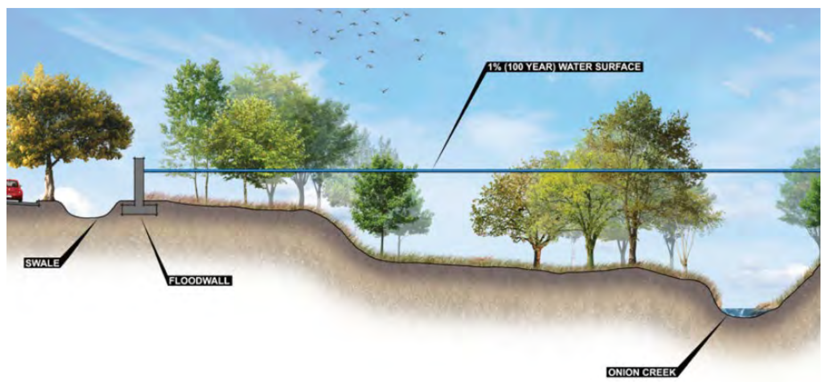
Flood Detention

Typical flood detention projects are regional, ranging from large flood control reservoirs to smaller regional flood detention ponds. They can provide benefits to relatively large populations and or agricultural areas. Regional flood detention facilities require significant storage volume to mitigate the 1 percent annual chance (100-year) floods, requiring large tracts of land in suitable locations and can be costly and difficult to implement in urban areas. They also require long-term operations and maintenance costs. Flood detention can reduce flood risk and provide additional benefits such as recreation and water supply but can create dam safety risks and environmental impacts.

Example of Large Flood-Control Reservoir - Lake Travis, LCRA and Example of Regional Detention - Upper Brushy Creek WCID Flood Detention Structure No. 20

Floodwalls/Levees

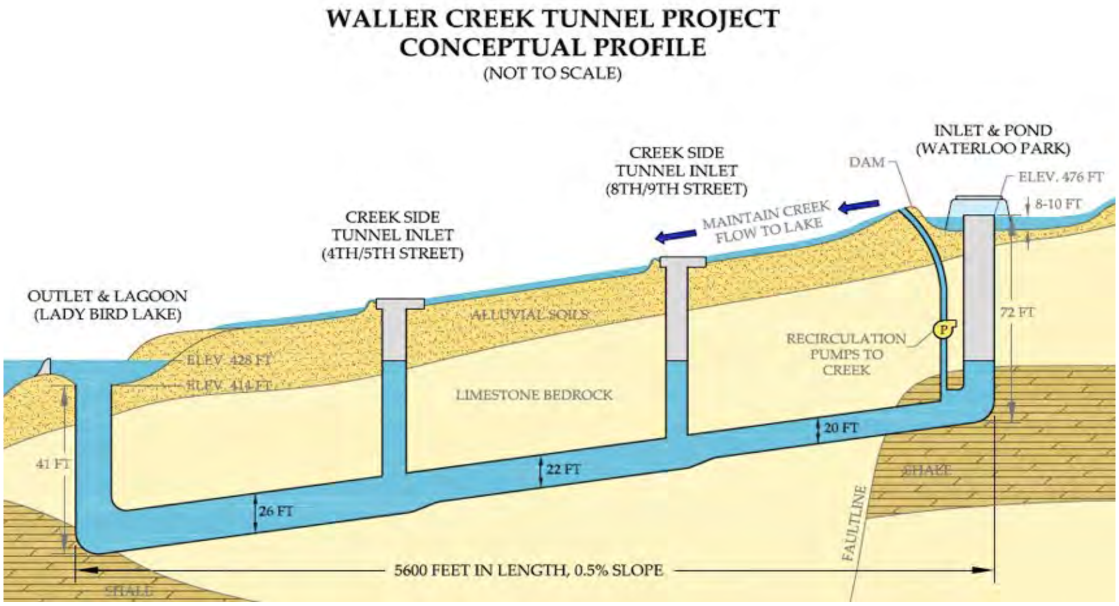
Levees and floodwalls confine out-of-bank flows to areas along rivers and streams to reduce flood risk to properties located in the natural flood plain. The confinement of floodwaters using levees or floodwalls considerably alters the characteristics of flood flows. Reducing natural valley storage capacity in the floodplain can increase peak discharges for a given flood and flood damages downstream of a project. Land must be reserved behind levees or floodwalls for ponding areas, and impounded water must be retained or pumped over the levee. Levees are most applicable where the floodplain is wide and development is located a considerable distance from the channel. Levees can cause catastrophic damage if overtopped, damaged, and fail from a flood greater than their design flood. Therefore, the design flood for levees is typically the 1 percent annual chance (100-year) flood at a minimum, with additional freeboard to reduce the risk of overtopping. Levees and floodwall facilities can require significant land acquisition and be costly and difficult to implement in urban areas. They require closures at the road and railroad crossings and interior drainage measures such as stormwater pump stations. They also require long-term operations and maintenance costs typically associated with Federal Emergency Management Agency (FEMA) certification. Levees and floodwalls can reduce flood risk but can create levee safety risks, environmental impacts, and negative socioeconomic impacts.



Example Floodwall - Floodwall Concepts for Onion Creek Flood Risk Reduction, Austin

Flood Diversions

Typical flood diversion projects include diversion channels or diversion conduits (tunnels). Diversion channels intercept flood waters upstream of populated areas and convey them safely above ground to a discharge point downstream of the populated areas. They require significant land acquisition and can be difficult and costly to build in urbanized areas. Diversion tunnels convey flood waters underground to reduce flood risk to largely populated areas. Due to land costs, surface constraints and impacts, and utility conflicts, they can be a preferred alternative in highly urbanized areas. They require long-term O&M costs. Flood diversions can reduce flood risk but cause downstream hydrologic and environmental impacts.



Example Diversion Tunnel, Source: Austintexas.Gov

Storm Drain Improvements

Excessive street flow in urbanized areas can cause flooding of residential and commercial structures, traffic safety issues, pavement damage, and in some cases, life loss. Installing new storm drain systems to collect runoff and convey it underground to a receiving stream is a typical solution for improving street flow and diverting stormwater around problem areas. Storm drain improvements can reduce flood risk to large populations but can require significant sizes of conduit or box sections to mitigate the 1 percent annual chance (100-year) floods. Storm drain improvement projects typically require other measures to mitigate increases in flood discharges to downstream areas and can be costly and difficult to implement in urbanized areas.

Example Storm Drain Improvements - Storm Drain Project Area Map, Guadalupe Storm Drain Improvement Project, Austin

Coastal Protections

Coastal flood protections reduce flood risk to large populations from coastal storm surges and combined riverine and coastal effects. Typical coastal protections include coastal levees, dikes, and seawalls and often include beach erosion countermeasures such as riprap revetments. Similar to inland levees and floodwall facilities, coastal protections can require significant land acquisition and can be costly and difficult to implement in urban areas. They require closures at the road and railroad crossings and interior drainage measures such as stormwater pump stations. They also require long-term operations and maintenance costs typically associated with FEMA certification. Coastal protections can reduce flood risk but create levee safety risks, environmental impacts, and negative socioeconomic impacts.

Example Coastal Protections – Sea Wall and Rock Riprap Revetment

Nature-Based Features

FMPs can include nature-based features as part of flood mitigation solutions where applicable, including, but not limited to, stream and coastal restorations, wetlands, natural channel design, other green infrastructure elements, and land preservation. Although nature-based solutions generally do not provide significant flood risk reduction relative to a 1 percent annual chance flood, they can provide some degree of flood mitigation, protect and improve stormwater quality, enhance ecological functions, and reduce riverine and coastal erosion risk. Nature-based features are often integrated into and compliment other structural and non-structural flood risk reduction strategies. For example, restoring or improving stream conveyance or repairing streambank erosion can include measures to restore and improve aquatic habitat and riparian ecological functions. Nature-based features can also provide or enhance recreational opportunities. Given the many potential benefits of nature-based features, they should be given consideration when evaluating and prioritizing alternatives to reduce flood risk and exposure.

Example Channel and Bridge Upgrade Project with Natural Channel Design Elements, Fort Branch Creek, Austin

Non-Structural FMPs

Non-structural FMPs are flood mitigation projects or actions that change the way people interact with flood risk and move people out of harm's way. These types of projects do not involve modifications to the watershed or flood infrastructure and therefore do not negatively impact adjacent areas or environmental impacts. Non-structure FMPs include one or a combination of the following project types:

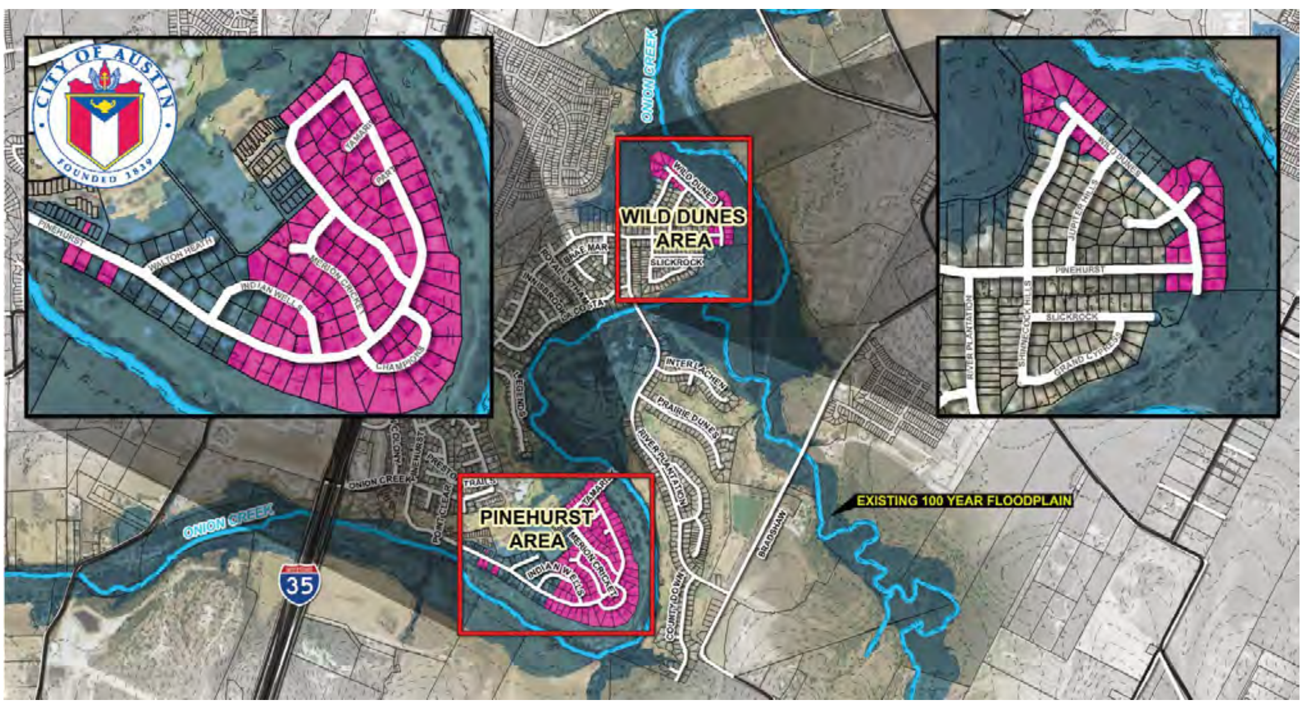
- regulatory improvements
- floodplain evacuation (property acquisition/ " buyouts")
- flood warning
- floodproofing
- flood readiness and resilience

Regulatory Improvements

Adopting regulations by local governments, such as the minimum FEMA NFIP requirements described in *Chapter 3*, provides legal measures to control development in flood-prone areas and prevent future drainage-related problems. Regulatory improvements create or improve local regulatory requirements such as floodplain development ordinances and drainage design criteria related to planning, zoning, land development, and building codes. Regulatory improvements include requirements of those proposing new developments or redevelopment to identify flood hazard areas and keep people out of them. This non-structural FMP has a very low capital cost compared to structural FMPs. Regulation of flood-prone land increases the likelihood that such property will be properly used in the best interest of public health, safety, and welfare. However, such regulations offer no relief for existing development.

Floodplain Evacuation

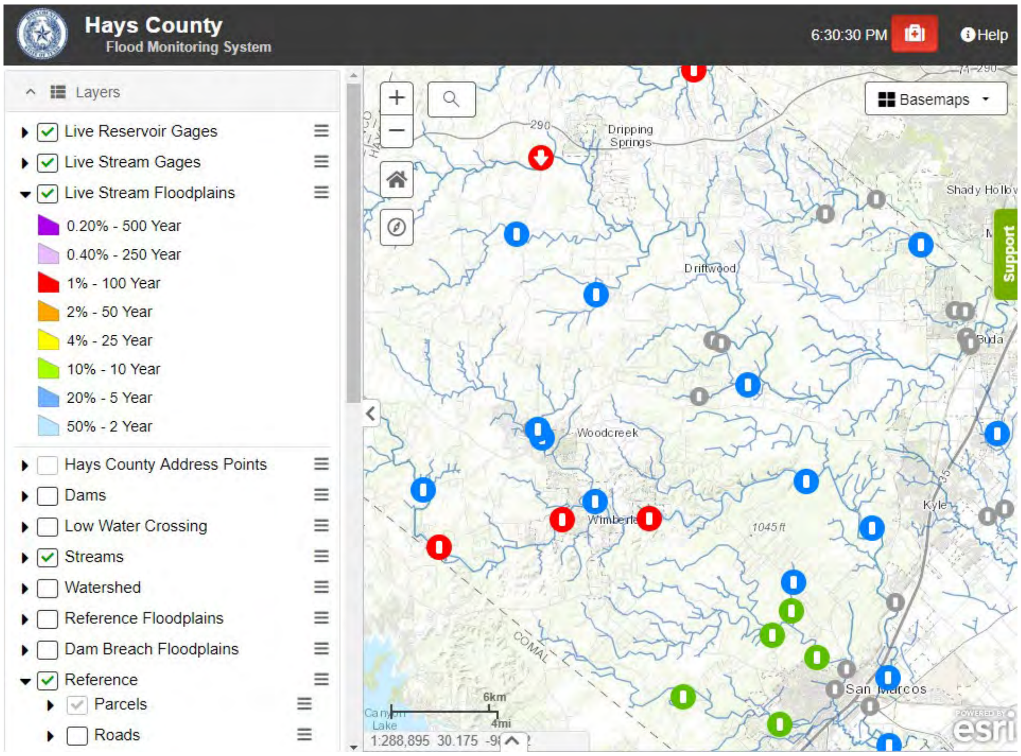
Floodplain evacuation involves acquiring real property at high risk of incurring flood damages and loss of life. Typically referred to as floodplain "buyouts," these can be voluntary or involuntary. One major advantage of this type of FMP is that it *eliminates* flood risk leaving no residual risk. Buyouts are costly upfront but typically have no long-term O&M costs beyond property maintenance (e.g., mowing). Buyouts can provide environmental enhancements by creating open space, riparian restoration, and park land, but can also have negative socioeconomic impacts.



Example: Floodplain Evacuation - Onion Creek Buyout Program, Austin

Flood Warning

Typical flood warning measures or systems provide means for temporary evacuation of flood hazard areas during floods to reduce flood risk. These types of measures range from simple stream gauges and warning signals to more complex early flood warning systems that can forecast floods and warn large populations to evacuate. Flood warning systems save lives but do not save property. This type of non-structural FMP has low capital costs compared to structural FMPs.



Example: Hays County Flood Monitoring System Online Map Viewer

Floodproofing

Floodproofing typically consists of providing watertight coverings for door and window openings of habitable structures, raising structures in place, raising access roads and escape routes, constructing levees and floodwalls around individual or groups of buildings or critical infrastructure, and waterproofing walls and mechanical and electrical equipment. Floodproofing is more easily applied to new construction and is more applicable where flooding is short-duration, low-lag velocity, infrequent, and shallow depths. Floodproofing is appropriate for locations where other structural flood mitigation alternatives are not feasible. Floodproofing can mitigate the risk of the 1 percent annual chance (100-year) floods but does not eliminate all flood risks.

Example: Wastewater Treatment Facility Floodproofing (Source: RT Group, Inc.)

Flood Readiness and Resilience

Typical flood readiness and resilience projects or actions focus on improving flood preparedness and response to save lives. They include developing flood response plans, flood or hurricane evacuation plans, and flood or dam emergency action plans. This type of non-structural FMP has low capital costs compared to structural FMPs.

Flood Management Evaluations (FMEs)

By the TWDB definition, a flood management evaluation (FME) is "a proposed flood 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."[2] There are four general categories of FMEs, as described below. An FME may include any or all of these study elements or phases.

Floodplain Modeling and Mapping/Risk Assessment Studies

These studies quantify flood risk in areas where significant flood risk is thought to exist but do not have flood risk data or insufficient flood risk data. An example of this type of FME is a floodplain modeling and

[2] Technical Guidelines for Regional Flood Planning, page 53.

mapping study of a chronic flood-prone area with a certain population at risk that has not been studied before.

Flood Mitigation Alternatives Analysis/Feasibility Studies

These FMEs use flood hazard and flood risk data for a known flood problem area to evaluate structural and non-structural flood mitigation alternatives, such as the FMP types described above, to provide the greatest flood risk reduction benefit for the least capital cost, considering potential adverse impacts and other factors. These FMEs typically include a benefit-cost analysis and evaluations of other factors such as environmental constraints and permitting requirements; land acquisition and utility relocation requirements; constructability and other constraints; and public input and social factors.

Preliminary Engineering Studies

Once a flood-prone area has been studied and a preferred flood mitigation alternative or set of alternatives has been identified from a feasibility study, a preliminary engineering study of these alternatives would develop at least a 30 percent level design, including initial plans, permitting assessments, and refined capital cost estimates. Potential FMPs that have previously been studied within the region but do not meet the standards set by the TWDB for FMPs fall into this category of FME.

Flood Emergency Preparedness Studies

These FMEs are studies needed to develop flood emergency action plans such as hurricane evacuation plans, flood emergency response plans, or dam breach emergency action plans.

Flood Management Strategies (FMSs)

Proposed actions that did not qualify as an FMP or FME but were similar for communities across the region were initially grouped together as regional or subregional "strategies." The term *flood management strategy* is not typically used in the flood mitigation industry; however, in a few cases, community sponsor-specific strategies were provided to the RFPG that met the TWDB definition. A flood management strategy, by TWDB definition, is "a proposed plan to reduce flood risk or mitigate flood hazards to life or property. A flood management strategy may or may not require associated Flood Mitigation Projects to be implemented".[3] Regional or subregional FMSs generally fall into the following five categories:

- Flood mitigation education and outreach
- Area-wide low water crossing flood mitigation studies and projects
- Identify and fund buyout programs
- Develop regional flood warning measures
- Strengthen flood management regulations

[3] Title 31 Texas Administrative Code §361.10(k)

Initial Identification of FMP, FME, and FMS

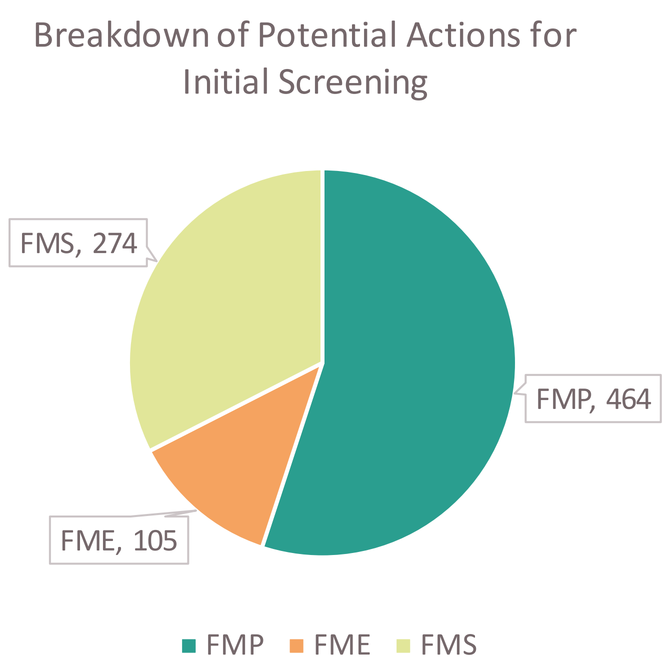
The initial list of potential actions (FMP, FME, FMS) identified for screening and evaluation was collected from four primary sources:

- Data collected from the initial introductory community outreach
- TWDB Flood Protection Planning grant studies
- Community drainage master plans or capital improvement programs (CIPs)
- Hazard Mitigation Plans for each county and community within the region

Documents from these sources were obtained from online archives of the TWDB, various communities within the region, and the Technical Consultant's archives. From a review of these documents, potential actions were identified and then initially categorized.

A total of 843 potential actions were identified and categorized, providing an initial list of potentially feasible FMPs, FMEs, and FMSs to start the screening process. A breakdown of the initial actions collected and categorized is shown in *Figure 5.3*.

Figure 5.3 Breakdown of Potential Actions for Initial Screening



Task 4B: Screening and Evaluation of FMPs, FMEs, and FMSs

The TWDB requirements for Task 4B state that each RFPG is to develop and receive public comment on a "…proposed process to be used by the RFPG to identify and select flood management evaluations, flood mitigation strategies, and flood mitigation projects. This process is to be documented, and such documentation is to be included in the draft and final adopted Regional Flood Plan."

The Lower Colorado-Lavaca RFPG developed and adopted their evaluation process over the course of several RFPG meetings. The process was developed to conform to the TWDB requirements expressed in the rules, the scope of work for the regional flood planning process, and technical guidelines. In August 2021, the RFPG received a presentation from their Technical Consultant outlining a proposed process for screening, evaluating, and recommending potential FMEs, FMSs, and FMPs. Subsequently, in its October 2021 meeting, the RFPG reviewed and discussed the proposed process and accepted public comment. At its November 2021 meeting, the RFPG adopted the process displayed in *Figure 5.4*. The process is further described below.

Figure 5.4 Adopted Screening and Evaluation Process

STEP 1	**INITIAL SCREENING OF *STUDIES, PROJECTS & STRATEGIES* RECEIVED** Screen for minimum TWDB rules and guidance requirements
STEP 2	**SCREENING OF *PROJECTS*** Screen per TWDB flowchart and guidance
STEP 3	**SCREENING OF *STUDIES*** Screen for minimum TWDB guidance requirements
STEP 4	**SCREENING OF *STRATEGIES*** Screen for minimum TWDB guidance requirements

Initial Screening

Each floodplain management and mitigation action was initially screened following steps one through four above. This process is further explained in the following sections.

Step 0: Verify the FMPs, FMEs, and FMSs are not completed, in progress, or no longer needed

In this initial step before screening Step 1, potential FMP, FME, and FMSs were disqualified if they were found to have already been completed or implemented, were in progress, or were no longer needed or wanted by the sponsoring community. The Technical Consultant team made this verification based on direct knowledge of the potential actions or by direct community sponsor engagement.

Step 1: Initial screening of FMPs, FMEs, and FMSs for minimum TWDB requirements

This first step was screening based on minimum TWDB rules and guidance requirements for all actions. The screening criteria applied in this step are:

- Study/strategy/project is related to a flood mitigation or floodplain management goal.
- Study/strategy/project meets an emergency need.
- Study/strategy/project addresses a flood problem with a drainage area of 1 square mile or greater.
- Study/strategy/project reduces flood risk for the 1 percent annual chance (100-year) flood.
- Exceptions for a level of flood risk reduction or problem area size include instances of flooding of critical facilities, transportation routes, or other factors as determined by the RFPG.

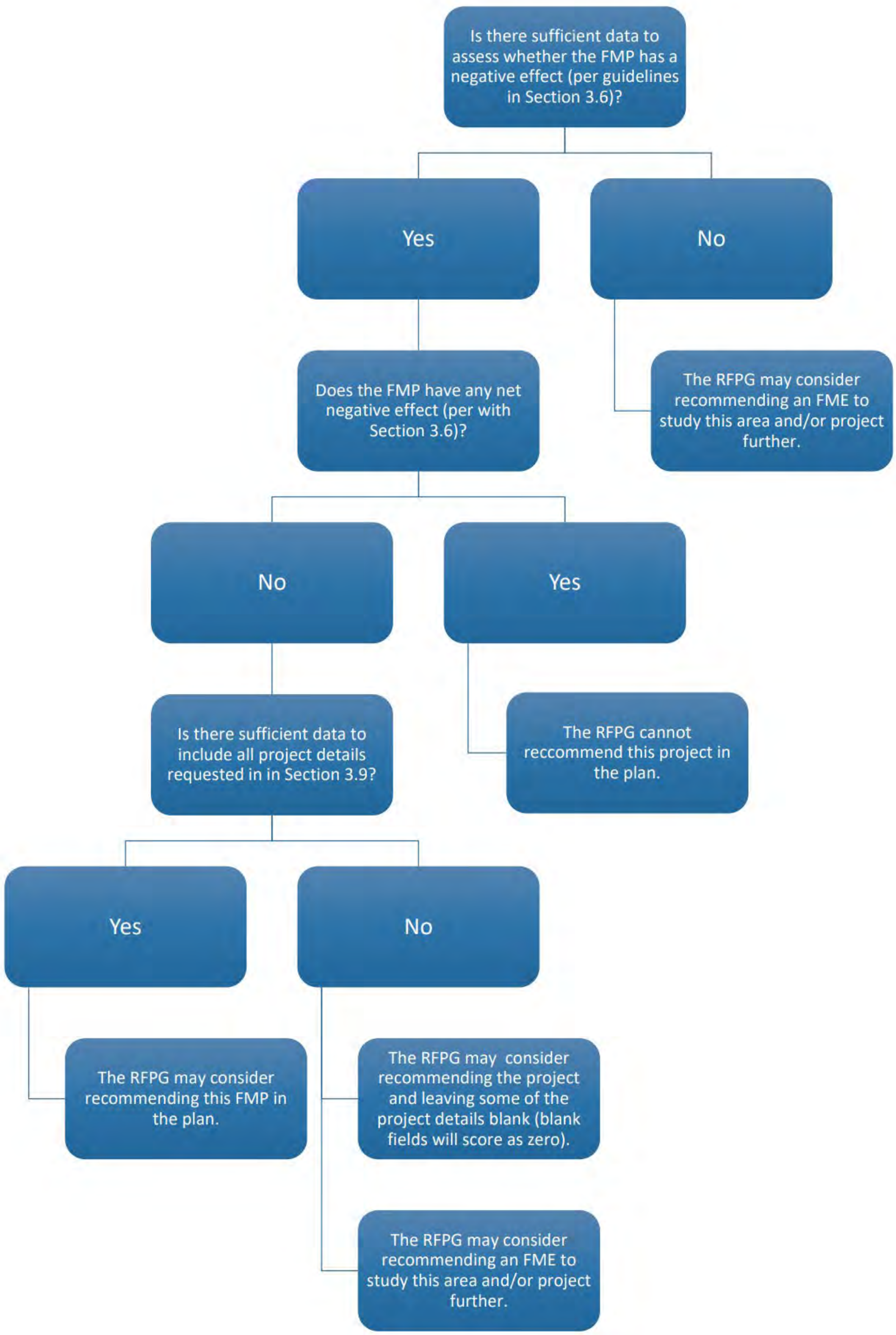
Step 2: Screening of Projects (FMPs)

In the second step, potential Flood Mitigation Projects were subjected to a screening-level evaluation based on the TWDB Technical Guidelines for Regional Flood Planning (April 2021) and specifically in *Figure 5.5*.

If a potential FMP does not satisfy this step's screening criteria, it will become a potential Flood Management Evaluation. Three criteria are applied in this step; "sufficient data," "no negative impact," and "project details."

- **Sufficient data**: The data upon which an assessment of no negative effect has been made must be reliable and have minimal uncertainty. H&H modeling, mapping, and basis for mitigation analysis must generally meet Section 3.5 of the TWDB technical guidelines.
- **No negative impact:** The potential project must not negatively impact the 1 percent annual chance (100-year) flood event. It must not raise the flood elevation or increase the discharge of the 1 percent annual chance flood event. Any of the following will disqualify the potential project in this screening step:
  - increases inundation of homes or commercial buildings
  - increases inundation beyond existing or proposed ROW or easements
  - increases inundation beyond existing drainage infrastructure capacity
- **Project details:** Data used to define the potential project must include sufficient project details as described in Section 3.9 of TWDB technical guidelines, including but not limited to the following:
  - flood severity level metrics
  - flood risk/damage reduction metrics
  - estimated capital and O&M costs
  - benefit/cost ratios
  - environmental benefits/impacts
  - implementation constraints
  - water supply benefits

Figure 5.5 Regional Flood Planning Technical Guidelines



Step 3: Screening of Studies (FMEs)

In this step, potential studies were screened based on criteria from the TWDB technical guidelines. Each potential study must:

- be sensible in that it can be implemented with a reasonable amount of resources
- have a reasonable planning-level cost estimate
- have a willing sponsor(s) identified that are willing to commit resources and some level of potential cost-sharing
- identify structures, populations, and critical facilities at risk within the flood problem area being studied
- identify roadways impacted by flooding within the flood problem area being studied
- quantify the area of farm and ranch land at risk within the study area, if applicable

If there is a sufficiently detailed H&H analysis and flood mitigation alternatives analysis, the study may be considered an FMP or FMS.

Step 4: Screening of Strategies (FMSs)

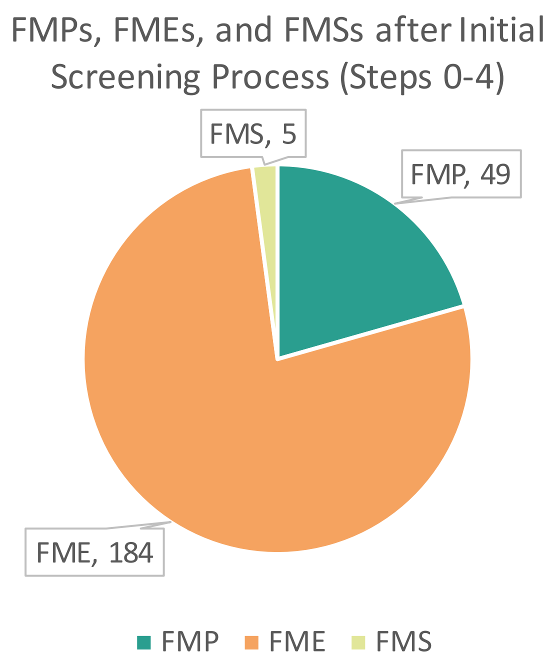
In this step, strategies are screened based on the following criteria from the TWDB technical guidelines:

- potential strategies must include a planning-level cost estimate
- potential strategies must have an identified sponsor(s) willing to commit resources and some level of potential cost-sharing
- potential strategies must quantify the estimated flood risk being addressed and the potential level of flood risk reduction

Initial Screening Sponsor Outreach

The RFPG conducted a targeted outreach effort to contact each potential sponsoring community to discuss the initial list of potential actions for potential additions, deletions, or edits to the actions and their attributes and to verify that they are a willing sponsor. A total of 108 potential sponsors were contacted, and approximately 45 responded and met to discuss via online video conferences. Documentation of this outreach effort was captured using the online database Jotform.

Figure 5.6 Breakdown of Actions Identified after Initial Screening Steps 0-4



Initial Screening Results

Each action was screened based on its category through each minimum criterion described above. Through the screening process, initially identified FMPs that did not meet the requirements in Step 2 were downgraded to FMEs and screened again. Most initial actions temporarily designated as FMSs were actions from existing Hazard Mitigation Plans that were not specific to a quantifiable flood problem or flood risk-benefit and were generally broad ideas or actions that did not meet the minimum requirements for an FMS. Through the review process, the RFPG recognized some general themes within the actions and determined these could be consolidated into five potential regional strategies. A breakdown of the initial screening process results is shown in *Figure 5.6.* All identified FMEs, FMPs, and FMSs are included in Tables 12, 13, and 14, respectively.

None of the actions resulting from the Task 4B screening process were considered infeasible. They were transitioned to Task 5, where additional information was collected, and Sponsor interest and commitment were confirmed.

Task 5: Detailed Evaluation and Recommendation of FMPs, FMEs, and FMSs

The objective of Task 5 is for RFPGs to use the information developed in Task 4B to recommend flood mitigation actions for inclusion in the Regional Flood Plan. In essence, Task 5 was a continuation of 4B. As described above, Task 4B was an initial technical evaluation and screening of potential FMEs and potentially feasible FMSs and FMPs. Task 5 and the remainder of *Chapter 5* focus on how the RFPG used this information to further evaluate and develop its recommendations for the inclusion of flood mitigation actions in the Regional Flood Plan. This chapter summarizes and documents:

1. Process is undertaken to make final recommendations on flood mitigation actions
2. Potential FMEs and potentially feasible FMSs and FMPs identified and evaluated under Task 4B and whether the RFPG recommends these actions
3. Entities that will benefit from the recommended flood mitigation actions

While there is a significant need across the Lower Colorado-Lavaca Region to improve flood risk awareness and develop and implement actions to reduce existing and future flood risk, not every flood mitigation action can be recommended in the Regional Flood Plan or included in the State Flood Plan. The Lower Colorado-Lavaca RFPG opted to take an inclusive approach to the evaluation and recommendation process. If an evaluation, strategy, or project met the TWDB requirements, was aligned with the Regions' flood mitigation and floodplain management goals, and seemed reasonable, the planning group chose to show deference to the local communities/sponsors and leaned towards including those actions in the Regional Flood Plan.

Figure 5.5 Adopted Detailed Evaluation and Selection Process

STEP 5	**DETAILED EVALUATIONS OF SELECTED *STUDIES, PROJECTS & STRATEGIES***
STEP 6	**FINAL RECOMMENDATIONS OF *STUDIES, PROJECTS & STRATEGIES***

Step 5: Detailed Evaluations of FMPs, FMEs, and FMSs

Due to the overlap of Tasks 4B and 5, the recommendation process was, in many ways, an extension of the initial screening process, with a more detailed evaluation of each action, geospatial location, and determination of flood risk indicators and risk reduction potential.

Figure 5.7 and *Figure 5.8* expand upon the initial screening process previously described for FMPs, FMSs, and FMEs, respectively. These processes were developed following the TWDB rules and requirements that left some evaluation criteria at the discretion of the RFPG. The discretionary evaluation criteria are the following:

- **Level of Service (LOS) to be provided:** If a 1 percent annual chance (100-year) LOS is not feasible, the RFGP can recommend an FMP with a lower LOS.
- **Benefit-Cost Ratio (BCR) for the project:** The TWDB recommends that proposed actions have a BCR greater than one, but the RFPG may recommend FMPs with a BCR lower than one with proper justification.
- **Drainage Area (DA):** The TWDB recommends actions with a DA greater than 1 square mile to encourage regional actions and cooperation, but the RFPG may recommend FMPs with a smaller DA and justification.

Due to many projects being physically and financially constrained, the RFPG decided they did not want to exclude viable flood risk reduction projects based on the level of service or benefit-cost ratio. Similarly, because many of the known flood mitigation projects were identified by local jurisdictions, the drainage areas are often under 1 square mile, and the RFPG did not want to exclude those from the plan. The RFPG did express a desire to identify and group small individual projects to create larger FMPs within single jurisdictions where allowed and to encourage communities to work together on regional projects. Those efforts are somewhat limited in this first cycle but will be an important aspect of the amended plan due to be submitted in July 2023.

Figure 5.7 FMP and FMS Screening Process

1. Goals	• Confirm FMPs/FMSs support an RFPG goal.
2. Unfeasible	• Remove FMPs/FMSs deemed not to be feasible. For example, focuses on addressing response and recovery rather than mitigation
3. Contact Sponsors	• Determine if the FMP/FMS is still viable and/or has not been completed or funded • Request additional data • Remove FMPs/FMSs that have been completed or Sponsor is not interested
4. Initial Analysis	• Populate Flood Risk Indicators • Calculate Reduction in Flood Risk for FMPs • Update or Calculate Costs
5. Full Analysis	• Verify no Negative Impacts • Benefit-Cost Analysis (existing or can be determined)
6. Unfeasible	• Remove FMPs/FMSs deemed not to be feasible. • Causes negative impacts, No quantifiable flood reduction benefits, Duplicate Benefits
7. Reassign	• Determine if there are any FMPs that need to be reassigned as an FME
8. Evaluate	• Quantifiable results to ID FMPs/FMSs with the most complete information and/or result in the greatest benefits • Identify FMPs/FMSs located in areas of greatest need (use Task 4A results)
9. Recommend	• Final FMP/FMS Recommendations

Figure 5.8 FME Screening Process

1. Goals	• Confirm FMEs support an RFPG goal
2. Contact Sponsors	• Verify if study has been completed • Verify interest in potential FME • Request additional data to refine FME Areas • Remove FMEs that have been completed or Sponsor is not interested
3. Analysis	• Refine FME areas as needed • Populate Flood Risk Indicators • Calculate cost for FME
4. Evaluate	• Evaluate quantifiable • Identify FMEs that have potential to develop into FMPs for the next planning cycle • Identify FMEs that could be promoted to FMP • Identify FMEs located in areas of greatest need (use Task 4A results)
5. Recommend	• Final FME Recommendations

Costs and Benefit-Cost Ratio

FME Planning Level Cost Estimates

Planning level cost estimates are based on sponsor provided information from community studies with high-level verification and validation of those costs. For actions that did not have a sponsor identified cost, cost estimates were developed using the processes outlined in the following sections. Cost estimates presented are for planning purposes only and are not supported by detailed scopes of work or workhour estimates. Sponsors were provided the opportunity to confirm or alter the costs through the Flood Infrastructure Financing survey discussed in *Chapter 9*. The RFPG will continue to review costs to improve these estimates moving forward, particularly if additional feedback is received from potential Sponsors. Local sponsors will develop detailed scopes of work and associated cost estimates before submitting future funding applications through the TWDB or other sources.

- **Watershed Planning – Floodplain Modeling and Mapping:** Sponsor-provided costs were utilized for all FMEs entailing flood mapping updates or large-scale hydrologic and hydraulic modeling. The costs provided by Sponsors were reviewed for reasonableness based on the information available and validated before inclusion as cost-level estimates in this plan.

- **Watershed Planning – Drainage Master Plans:** Separate planning level cost estimates were developed for drainage master plans depending on whether the Sponsor is a county or city. After a comparative analysis of previously completed Countywide Studies, it was determined that a uniform cost estimate of $500,000 would be appropriate to provide sufficient funds to broadly evaluate their jurisdiction and develop potential FMEs and FMPs to be included in future Regional Flood Plans. Similarly, previously completed citywide studies were reviewed, three categories were identified for population sizes, and a corresponding cost estimate was assigned (*Table 5.1*).

Table 5.1 Citywide Drainage Master Plan Cost Estimate Ranges

Relative City Size	Population (2020 Census)	Cost Estimate
Small	< 25,000	$250,000
Medium	25,000 – 100,000	$500,000
Large	> 100,000	$1,000,000

- **Engineering Project Planning**: These studies consider two components: evaluating a proposed project to determine whether implementation would be feasible (conceptual design) and an initial engineering assessment including alternative analysis and up to 30 percent engineering design. Each evaluation area is project-specific and varies due to the wide range of potential improvements in channels, culverts and low water crossings, roads and bridges, storm drain systems, and stream stabilization. Costs were taken from existing plans and studies when available. If estimated construction costs were provided, those costs were escalated to 2020 values based on the study's date. The evaluation effort was estimated to equal 15 percent of the total construction cost or a minimum of $150,000. All costs provided by Sponsors were reviewed for reasonableness based on the information available. When a source document or report was unavailable for the FME, or no cost estimate was provided, costs were estimated based on costs for similar FMEs identified and professional judgment of the local area and project type.

Estimated Capital Cost of FMPs and FMSs

Cost estimates for each FMP were taken from associated engineering reports and were adjusted as needed. These costs were escalated using construction cost indices to account for inflation and other changes to the construction market. The cost estimates in *Table 5.4* and *Table 5.5* are expressed in September 2020 dollars.

Currently, the cost for the FMSs is undefined as the RFPG decided to take a regional approach to implementation, and no cost data has been developed.

Benefit-cost Ratios for FMPs

Benefit-Cost Analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The result is a Benefit-Cost Ratio (BCR), calculated by dividing the project's total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost-effectiveness" of a project. A project is generally considered cost-effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (Federal Emergency Management Agency, 2009). However, a BCR greater than 1.0 is not required for inclusion in the Regional Flood Plan, and the RFPG can recommend a project with a lower BCR with appropriate justification.

When a BCR had been previously calculated in an engineering report or study used to create an FMP, the previously calculated BCR value was utilized for the FMP analysis. For any FMP that did not already have a calculated BCR value, the TWDB BCA Input Spreadsheet was utilized in conjunction with the FEMA BCA Toolkit 6.0 to generate BCR values.

Willing Sponsors for FMEs, FMPs, and FMSs

Initial efforts to contact potential sponsors occurred at the end of Step 4 of the initial screening process, as described in the previous section.

While these efforts furthered the goal of receiving some level of community feedback on what actions they wanted to pursue and were willing to sponsor, not all communities were responsive. Accordingly, the RFPG decided that an affirmative willingness to sponsor a given action would not be a prerequisite for inclusion in the plan. Therefore, all potential actions were considered for inclusion in the draft plan for this first cycle unless an entity had specifically declined to be listed as a sponsor and no other appropriate potential sponsor was identified. This approach was adopted because:

1. It provides a conservative estimate of the flood mitigation need in the region.
2. Inclusion in the plan does not obligate an entity to sponsor an action; it simply allows an entity to be eligible for funding if they have the interest and capacity to pursue an action.

It is important to note that all sponsors associated with recommended actions were subsequently sent a survey to identify potential funding sources for the actions listed in the plan. This effort is detailed in *Chapter 9*.

Residual, Post-Project, and Future Risks of FMPs

Implementing recommended FMPs is expected to reduce current and future levels of flood risk in the region. While it is not possible to protect against all potential flood risks, the evaluation of FMPs should consider their associated residual, post-project, and future risks, including the risk of potentially catastrophic failure and the potential for future increases to these risks due to lack of maintenance.

During project development, communities must balance existing risk and risk reduction, physical and financial constraints, permitting and constructability, and adverse impacts (environmental, flood, community) to identify possible mitigation measures.

As a result of finding the right balance, it is not uncommon for flood control projects to be designed to a storm smaller than a 1 percent annual chance (100-year) event. This does not mean projects should not evaluate the 1 percent annual chance (100-year) storm, nor does it mean they will not provide risk reduction for the larger storms; rather, it means the community needs to understand what the residual risk will be. Common examples include flooding in developed areas where limited right-of-way and utility conflicts can limit the size or impart a significant financial burden or creek crossings where bridge construction is not practicable due to topography, right-of-way, and costs.

Figure 5.9 FMP Evaluation Considerations

The only FMP type that fully eliminates all flood risk, including residual risk, is buyouts. In general, residual and future risks for other FMP types could be characterized as follows:

1. Flood events may exceed the level of service for which infrastructure is designed
2. Potential failure or overtopping of dams and levees
3. Lack of routine maintenance to maintain, repair or replace its design capacity
4. Policy changes that adversely impact budgets, prior plans, assets, and design or floodplain management standards
5. Human behavior is unpredictable, and people may choose to ignore flood warning systems or cross over flooded roadways for a variety of reasons

Insurmountable Constraints of FMPs

Potential project implementation issues include conflicts pertaining to rights-of-way, permitting, easement and property acquisitions, utility or transportation relocations, among other issues that might be encountered before an FMP can be fully implemented. Such issues are an inherent part of flood mitigation projects, so they do not exclude actions from being considered for the plan.

Because an easement provides for public use on private land, it can create issues when needing secure access to a projects location for construction and maintenance. Acquiring right-of-way or other property and utility relocation located near or on a property impacted by a project requires close coordination between government agencies, private entities, and landowners. Coordination and early engagement with the appropriate entities are key to facilitating projects.

Most FMPs will require a variety of permits from local to state and federal depending on the scale. Permitting can be a lengthy process; the goal is to identify permitting needs during the project development phase and initiate it as early as practicable during the final design. This will minimize significant design changes and delays in project implementation.

The terms “buyout” and “acquisition” are often utilized interchangeably, but in the context of flood protection, both generally refer to the purchase of private property by the government for public benefit. In the case of flood acquisitions, the process most often involves purchasing property in a floodplain to reduce repetitive flood damage. Voluntary buyout programs are a specific subset of property acquisitions in which private land is purchased, existing structures are demolished, and the land is returned to an undeveloped state. Voluntary property acquisition is not a simple process and requires the property owner's and local jurisdiction's agreement. The process could include other governmental agencies and program requirements if state or federal funding is involved. The process can also be financially burdensome and lengthy.

Utility relocations may include water and wastewater lines, existing storm drain systems, telecommunication, power lines, and similar infrastructure. Depending on the project, the local government and franchise utility owners are usually responsible for utility relocations; however, developers may also assume responsibility for utility relocations. Utility relocation includes removing and reinstalling the utility, including installation of necessary temporary utilities, acquiring necessary land through easements or purchase, and taking necessary safety and protective measures. Utility relocations can take a significant lead time and a significant portion of the total project implementation cost.

Table 5.2 Summary of Recommended FMEs

FME Type	FME Type	Description	Number
Watershed Planning	Drainage Master Plans, Other Community-Scale Plans	Supports the development and analysis of hydrologic and hydraulic models to evaluate flood risk within a given jurisdiction, evaluate potential alternatives to mitigate flood risk, and develop capital improvement plans	20
Watershed Planning	H&H Modeling, Regional Watershed Studies	Supports the development and analysis of hydrologic and hydraulic models to define flood risk or identify flood-prone areas or large-scale studies that are likely to benefit multiple jurisdictions	4
Watershed Planning	Flood Mapping Updates	Promotes the development and/or refinement of detailed flood risk maps to address data gaps and inadequate mapping. Create FEMA mapping in previously unmapped areas and update existing FEMA maps as needed	8
Project Planning	Engineering Project Planning	Evaluation of a proposed project to determine whether implementation would be feasible or initial engineering assessment, including conceptual design, alternative analysis, and up to 30 percent engineering design	136
Preparedness	Studies on Flood Preparedness	Encourages preemptive evaluations and strategies to better prepare an area in the event of a flood	16

Figure 5.10 Geographical Distribution of Recommended FMEs

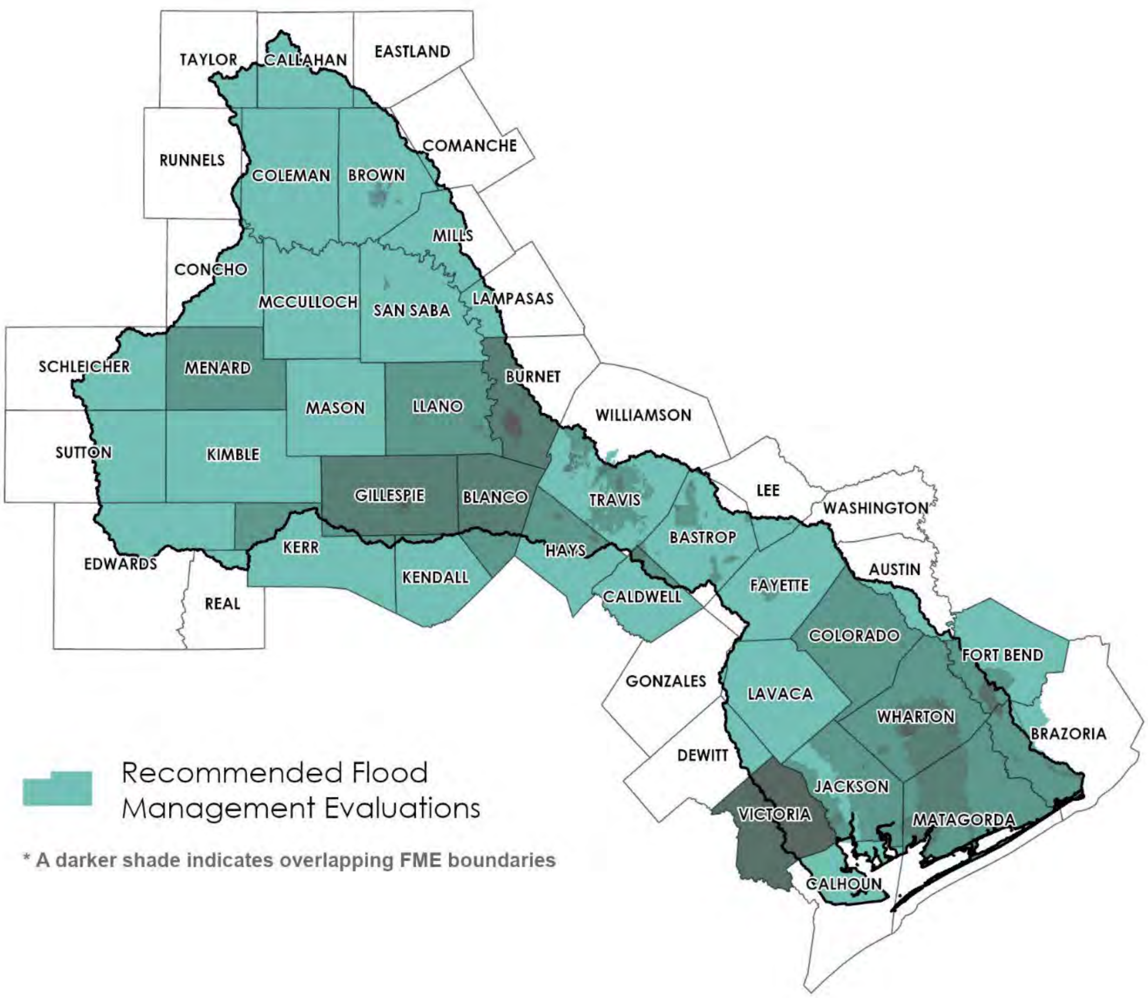
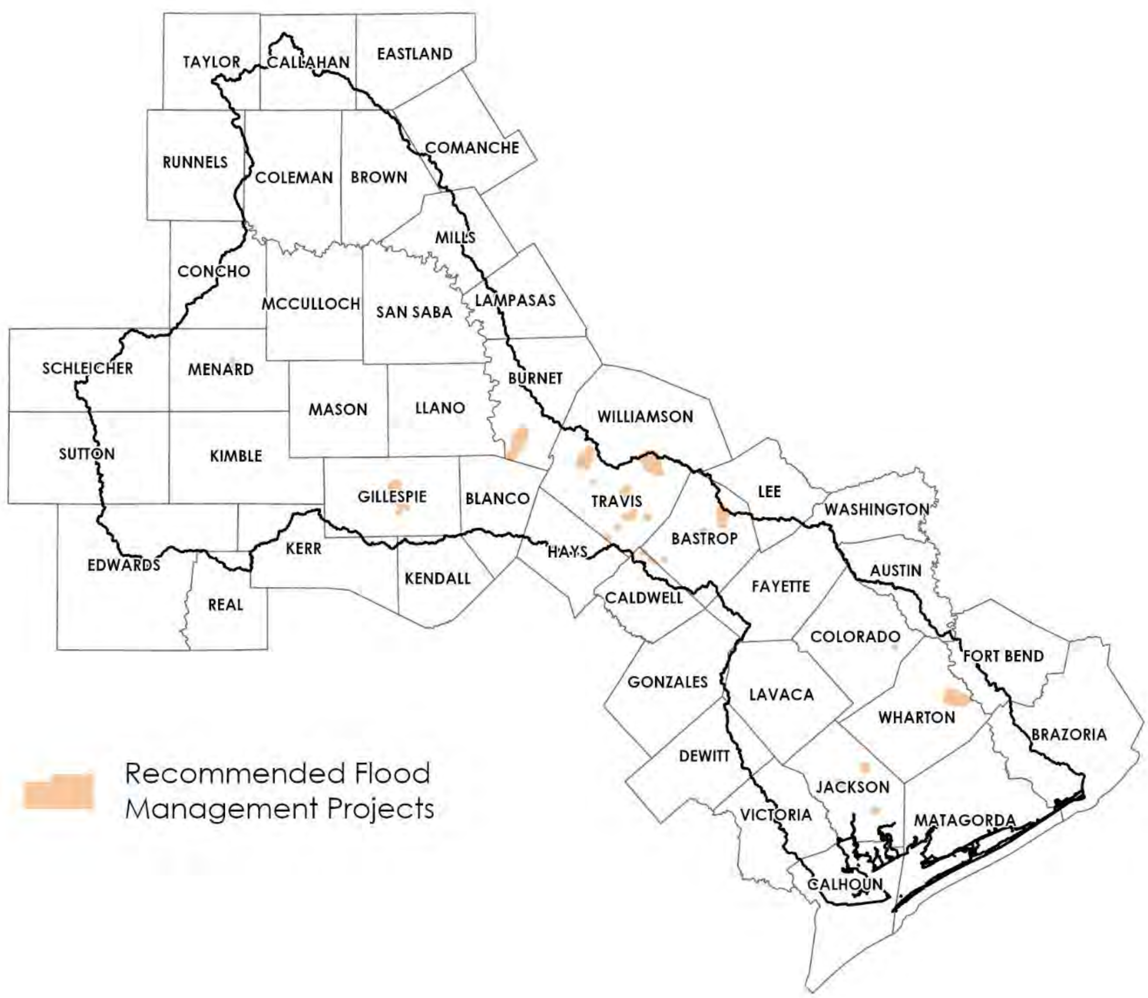


Table 5.3 Summary of Recommended FMPs

FMP Type	General Description	Number of FMPs Identified
Stormwater Infrastructure Improvements	Stormwater infrastructure improvements include channels, ditches, ponds, stormwater pipes, etc.	12
Roadway Drainage Improvements	Roadway drainage infrastructure improvements include side ditches, culvert crossings, bridge crossings, etc.	15
Regional Detention Facilities	Runoff control and management via detention facilities	2
Property Acquisition	Voluntary acquisition of flood-prone structures	1

FMP Type	General Description	Number of FMPs Identified
Flood Warning Systems	Install gauges, sensors, or barricades to monitor streams and low water crossings for potential flooding and support emergency response	9
Emergency Generators	Purchase and install emergency generators at critical facilities	10

Figure 5.11 Geographical Distribution of Recommended FMPs



Step 6: FMPs, FMEs, and FMSs Recommendations

Technical Committee Formation and Recommendations

The RFPG created a Technical Committee tasked with establishing a selection methodology, implementing the evaluation and selection process, and reporting their findings and recommendations to the RFPG for formal approval. The methodology included screening all potential flood mitigation actions based on the general process described in the Initial Screening sections as well as other evaluation and selection considerations established by the Technical Committee. The reasons for not recommending a particular flood mitigation action were clearly documented as part of the evaluation and recommendation process.

At the Technical Committee meeting on January 27, 2022, the members reviewed, discussed, and approved the process and timeline for reviewing FMEs, FMSs, and FMPs and making recommendations to the full RFPG. The Technical Committee met over several meetings in March, April, May, June, July, September, and December 2022, leading up to the January 2023 plan submittal. The Technical Committee met in April and May 2023 to review, discuss and make recommendations for the Amended Regional Flood Plan submitted in July 2023. Refer to the *Tasks 11-13: Plan Amendment Phase* section at the end of this chapter for additional information.

Initial meetings of the Technical Committee focused on completing the initial screening process to identify potentially feasible evaluations, projects, and strategies. This included discussing how the actions were being categorized, the limitations of the available data, and confirmation of how the discretionary evaluation criteria were applied to each action.

The Technical Committee also worked with the Technical Consultant Team to develop one-page decision document templates for each type of action. The purpose of the decision documents is to provide an easy-to-understand summary of each action for the RFPG and the general public. The summaries include pertinent information such as the type, location, sponsor, and flood risk indicators. Additionally, the summary sheets include information related to potential benefits, costs, and links to the RFPG goals.

On April 28, 2022, the Technical Committee reviewed the initial batch of potential actions for a recommendation. That "pilot" batch included three FMSs, one FMP, and 21 FMEs. The FMSs and FMEs were voted on and recommended to the forwarded to the full RFPG for consideration and pending minor changes to the decision documents templates. During this meeting, the technical committee established a process for reviewing, discussing, and making recommendations. In short, the committee agreed that future batches would be reviewed before the meeting at which they were to be considered, and the actions would be brought forward in groups or batches for consideration in a manner similar to a consent agenda. This format allowed each committee member to provide comments on or discuss any of the individual actions and allowed the committee to make recommendations to the RFPG for each batch.

At the May 25, 2022 Technical Committee meeting, the group reviewed and forwarded recommendations to the full RFPG for 122 individual FMEs and 53 FMPs. During the June 16, 2022 meeting, the committee reviewed and recommended one additional FMS, one additional FMP, and seven additional FMEs. One additional FMS and one FME were recommended at the June 30, 2022, and July 11, 2002, Technical Committee meetings, respectively. The full RFPG recommended including all of the recommended FMSs, FMEs, and FMPs forwarded by the Technical committee for inclusion in the Draft Regional Flood Plan. Based on a combination of additional information and Sponsor requests several of the FMEs and FMPs in the Draft Plan were removed or modified in the Final Plan. The Technical Committee recommended the revisions to the recommended FMEs and FMPs on December 1, 2022, and the full RFPG recommended adopting the revised actions at the December 15, 2022 meeting.

After submitting the Regional Flood Plan in January 2023, the Technical Committee met again on April 20 and May 15, 2023, to review and forward recommendations to the full RFPG. The resulting changes to the January 2023 Plan included the following:

- Reclassification/Removal of 10 FMEs due to the reclassification of FMEs to FMPs or removal of FMEs due to sponsor request.
- Addition of 29 new FMEs as a result of additional outreach and sponsor requests.
- Addition of 10 new FMPs due to the reclassification of FMEs to FMPs and sponsor requests.

Flood Management Evaluations (FMEs) Recommendation Approach

In considering potential FMEs for a recommendation, the RFPG sought to determine which FMEs would most likely result in identifying potentially feasible FMSs and FMPs in future planning cycles. Recommended FMEs were also required to demonstrate alignment with at least one regional floodplain management and flood mitigation goal developed under Task 3. Finally, each recommended FME should identify and investigate at least one solution to mitigate the 1 percent annual chance flood. It is the intent that all FMEs with a hydrologic and hydraulic modeling component will evaluate multiple storm events, including the 1 percent annual chance flood. The potential solutions and level of service that will be identified are unknown; however, it is expected that analyses will evaluate potential negative impacts and potential flood risk reduction for the 1 percent annual chance flood to help inform recommended alternatives and to define potentially feasible FMPs under this planning framework. Based on the TWDB requirements, the RFPG identified two main reasons for recommending FMEs.

The first subset of recommended FMEs would increase flood risk modeling and mapping coverage across the region as they are implemented. These types of FMEs have two major implications for identifying potentially feasible FMSs and FMPs. First, a current and comprehensive understanding of flood risk across the basin is necessary to identify high-risk areas for evaluating and developing flood risk reduction alternatives. Secondly, FMPs, and in some cases, FMSs, require a demonstrated potential reduction in flood risk to be recommended in the Regional Flood Plan. For this metric to be assessed, hydrologic and hydraulic modeling must be available to compare existing and post-project flood risk.

The second subset of recommended FMEs was project planning type FMEs. These FMEs are generally studies or preliminary designs to address a specific, known flood need. These actions include low water crossing improvements, storm drain or channel projects, city or countywide studies, and evaluations of possible buyouts or elevations. While, in many cases, a specific location is known, the actions currently lack some or all the detailed technical data necessary for evaluation and recommendation as an FMP. An example would be an existing study that identifies potential drainage construction projects but does not provide a full negative impact analysis. Completing these components as part of an FME will result in a potentially feasible FMP for consideration during future flood planning efforts.

Sponsor input was a major driver for choosing not to recommend FMEs. FMEs indicated by the sponsor as being in progress, completed, or lacking the interest to pursue were not recommended. Additionally, some FMEs located near one another were combined into a single FME for a recommendation, a process the RFPG plans to continue as it develops the amended plan (due July 2023) and in future planning cycles.

Recommended Flood Management Evaluations (FMEs)

A total of 184 potential FMEs were identified and evaluated by the RFPG. All of these were recommended, representing a combined total of $62,267,500 of flood management evaluation needs across the Lower Colorado-Lavaca Region. The final number and cost of the FMEs reflect the changes from the Tasks 12 and 13 amendments. The number and types of studies recommended by the RFPG are summarized in *Table 5.4.* The full list of FMEs and supporting technical data is included in *Table 12*. A map and table of recommended FMEs are presented in *Appendix A* and *Appendix B*, respectively. The recommended FMEs represent over 15,000 square miles of contributing drainage area. While some are in the upper basin, the FMEs are concentrated in the middle and lower reaches of the Flood Planning Region.

Table 5.4 Recommended FMEs

FME ID	Name	Type	Cost
101000001	Willow-Gazley Local Drainage Alternative 3	Project Planning	$250,000
101000002	Shiloh Road Bridge West of State HWY 304	Project Planning	$100,000
101000003	Willie May Way in Precinct 4 at Trib	Project Planning	$100,000
101000004	Gotier Trace Low Water Crossing	Project Planning	$100,000
101000005	Lakeview Drive & Tuck Street	Project Planning	$100,000
101000006	Green Valley Drive in Precinct 1	Project Planning	$100,000
101000007	Old McDade Rd in Precinct 4 near Norwood Rd	Project Planning	$100,000
101000008	Clear Springs Lake Dam	Project Planning	$100,000
101000009	Pecan Shores Subdivision	Project Planning	$150,000
101000010	Hidden Shores Subdivision	Project Planning	$150,000
101000011	Waters Edge Terrace Subdivision	Project Planning	$100,000
101000012	Old Sayers Rd & Little Sandy Creek	Project Planning	$100,000
101000013	Paffen Rd & Grassy Creek Draw	Project Planning	$100,000
101000014	Meduna Rd & Barton Oaks Draw 1	Project Planning	$100,000
101000015	Pine Canyon Dr & Wet Weather Creek	Project Planning	$100,000
101000016	Hall Rd & Young's Branch	Project Planning	$100,000
101000017	Friendship Rd & Turner Creek A and B	Project Planning	$100,000
101000018	Patterson Rd & Barton's Creek	Project Planning	$100,000
101000019	Upper Elgin River Rd & Cotton Creek	Project Planning	$100,000
101000020	Old Sayers Rd & Big Sandy Creek	Project Planning	$100,000

FME ID	Name	Type	Cost
101000021	Caldwell Rd & Wet Weather Creek	Project Planning	$100,000
101000026	Smithville Recreation Center Expansion	Project Planning	$100,000
101000028	FM 812 at Alum Creek South	Project Planning	$100,000
101000029	Magnolia St	Project Planning	$100,000
101000032	Mission Hills Street	Project Planning	$100,000
101000034	Lump Rd, Hilltop Rd, FM 2919 N	Project Planning	$100,000
101000035	Drainage Improvements to Crawford Outlet Right-of-Way	Project Planning	$50,000
101000037	Gene and Church Streets	Project Planning	$50,000
101000038	800 Block W San Antonio	Project Planning	$50,000
101000039	South End of Acorn Street	Project Planning	$50,000
101000042	Bowie & Peach Street	Project Planning	$100,000
101000043	Barons Creek Watershed - Southwest City	Project Planning	$150,000
101000044	112 W Park	Project Planning	$50,000
101000048	Trailmoor near Llano Hwy	Project Planning	$250,000
101000050	Drainage Channel near EMS Building	Project Planning	$50,000
101000051	Bob White Trail	Project Planning	$50,000
101000053	N Edison Low Water Crossing	Project Planning	$15,000
101000054	Schubert Low Water Crossing	Project Planning	$50,000
101000055	200 Block N Orange	Project Planning	$50,000
101000056	Crockett Street South of Travis	Project Planning	$100,000
101000057	Cross Mountain West	Project Planning	$100,000
101000058	N Milam at West Travis	Project Planning	$150,000
101000059	Repair of Little Barton Creek Dam	Project Planning	$100,000
101000061	Prepare Evacuation Plan	Preparedness	$25,000
101000062	MLK Blvd to Mexico Street	Project Planning	$100,000
101000063	Stormwater Diversion Project	Project Planning	$200,000
101000064	Land Purchase for New EMS/Fire/Police Building	Project Planning	$100,000
101000065	Jackson County Hospital District	Project Planning	$150,000
101000066	County Road 480	Project Planning	$100,000
101000067	Various Streets - Install Flood Early Warning System	Preparedness	$50,000
101000068	Lake Junction Dredging	Project Planning	$50,000
101000069	Llano River Erosion	Project Planning	$200,000
101000070	Llano River Channel Maintenance/Improvements	Project Planning	$100,000
101000071	Drainage Ditch Maintenance/Improvements	Project Planning	$100,000
101000072	Prepare Evacuation Plan	Preparedness	$25,000
101000073	Comanche Rancherias Subdivision	Project Planning	$100,000
101000074	Construct Emergency Operation Center	Project Planning	$100,000

FME ID	Name	Type	Cost
101000075	Airport Drainage Improvements	Project Planning	$100,000
101000076	Tres Palacios River	Preparedness	$50,000
101000077	Update Flood Insurance Study & Flood Insurance Rate Maps	Watershed Planning	$3,000,000
101000078	Hooten Holler in Richland Springs	Project Planning	$100,000
101000080	Community Evacuation Plan	Preparedness	$25,000
101000082	Citywide Drainage Study	Watershed Planning	$250,000
101000083	Community Evacuation Plan	Preparedness	$25,000
101000084	Bee Creek Drainage Improvements	Project Planning	$100,000
101000085	Create an Emergency Evacuation Plan	Preparedness	$25,000
101000086	Citywide Drainage Study	Watershed Planning	$250,000
101000088	Review and Update Floodplain Management Plan	Preparedness	$25,000
101000089	Develop an Emergency Operations and Evacuation Plan	Preparedness	$25,000
101000090	Various Streets - Upgrade Existing Roadway Crossings	Project Planning	$100,000
101000091	Harden City Buildings, Critical Infrastructure	Project Planning	$100,000
101000092	Citywide Drainage Study	Watershed Planning	$250,000
101000093	Various Streets - Upgrade Existing Roadway Crossings and Bridges	Project Planning	$100,000
101000095	Identify and Buyout Repetitive Loss Properties	Project Planning	$250,000
101000096	Harden County Buildings, Critical Infrastructure, and Government Buildings	Project Planning	$100,000
101000098	Tres Palacios, Blue Creek, East Mustang Creek	Watershed Planning	$150,000
101000099	Use Digital Maps of All Hazards and Educate Residents	Preparedness	$100,000
101000100	Pecan Street	Project Planning	$100,000
101000101	Town & Country Drive	Project Planning	$100,000
101000103	Drainage System Improvements - JC Madison Addition	Project Planning	$100,000
101000104	Citywide Drainage System Improvements	Watershed Planning	$500,000
101000105	Update and Maintain Emergency Management Plan	Preparedness	$25,000
101000106	Various Locations - Upgrade Low Water Crossings	Project Planning	$100,000
101000107	Citywide Drainage Plan	Watershed Planning	$250,000
101000108	Develop New/Updated Floodplain Maps	Watershed Planning	$250,000
101000109	CR 332 Drainage Improvements	Project Planning	$50,000
101000110	Various Culverts Along Stevenson Slough	Project Planning	$125,000
101000111	Adopt Flood Insurance Rate Maps	Watershed Planning	$250,000

FME ID	Name	Type	Cost
101000112	Willis Creek Detention	Project Planning	$250,000
101000118	Sandy Oaks Subdivision	Project Planning	$100,000
101000119	Frisch Auf Buyout	Project Planning	$100,000
101000120	Flood Proof Wastewater Treatment Plants	Project Planning	$50,000
101000121	Various Streets - Install Flood Early Warning Systems	Preparedness	$150,000
101000122	Carriage Hills	Project Planning	$100,000
101000123	Post Oak Subdivision	Project Planning	$150,000
101000125	Alum Creek - Tributary 8, Bowie Drive	Project Planning	$100,000
101000126	Flood Proofing Repetitive Loss Structures	Project Planning	$50,000
101000127	Wastewater Treatment Plant Flooding	Project Planning	$200,000
101000128	City Hall Hardening and Safe Room	Project Planning	$100,000
101000129	Palmetto Bend Spillway	Project Planning	$250,000
101000130	Relocate Fire Department Building	Project Planning	$250,000
101000131	Police Station Relocation and Safe Room	Project Planning	$250,000
101000136	Highway Drainage	Project Planning	$100,000
101000137	CR257 at Pecan Bayou (Tenmile Crossing)	Project Planning	$100,000
101000138	Dam Emergency Action Plan	Preparedness	$50,000
101000153	City of Buda Garlic Creek Culvert	Project Planning	$100,000
101000155	Taylor Lane Drainage Improvements	Project Planning	$100,000
101000156	Storm Water Detention at Morris Park	Project Planning	$150,000
101000158	Citywide Storm Drain Infrastructure Modeling	Watershed Planning	$12,600,000
101000159	Wastewater Treatment Plant Flood Study	Project Planning	$150,000
101000160	Delaware Creek Flood Study	Watershed Planning	$150,000
101000161	VFW Flood Study	Project Planning	$100,000
101000162	City of Wharton Citywide Floodplain Map Update	Watershed Planning	$250,000
101000163	Jones Brothers Park Flooding	Project Planning	$100,000
101000164	East Reed Park Road Flooding	Project Planning	$100,000
101000166	Ave J Bridge Replacement	Project Planning	$100,000
101000168	1431/281 Detention	Project Planning	$150,000
101000169	Backbone Branch Detention Pond	Project Planning	$150,000
101000170	Marble Falls Creek Walk	Project Planning	$100,000
101000171	Citywide Floodplain Remapping	Watershed Planning	$250,000
101000172	2nd Street at Backbone Creek Low Water Crossing	Project Planning	$100,000
101000173	Ave L at Whitman Creek Low Water Crossing	Project Planning	$100,000
101000174	Broadway at Backbone Creek Low Water Crossing	Project Planning	$100,000
101000175	102 Beach Dr Low Water Crossing	Project Planning	$100,000
101000176	124 Sunrise Drive Low Water Crossing	Project Planning	$100,000

FME ID	Name	Type	Cost
101000177	Countywide Floodplain Map Update	Watershed Planning	$250,000
101000178	Low Water Crossings at 4 locations	Project Planning	$200,000
101000179	Various Streets - Install Flood Early Warning System	Preparedness	$15,000
101000180	Countywide Floodplain Map Update	Watershed Planning	$250,000
101000181	Harris Hollow Neighborhood Flooding	Project Planning	$100,000
101000183	South Polk Street Study	Project Planning	$150,000
101000184	City of Wharton City-wide Flood Warning Systems	Preparedness	$250,000
101000185	City of Wharton City-wide Drainage Master Plan	Watershed Planning	$250,000
101000188	City-wide Drainage Master Plan (integrate with Dry Creek Study)	Watershed Planning	$400,000
101000190	Devers Creek Regional Detention and Channel Improvements	Project Planning	$250,000
101000192	City-wide Drainage Master Plan	Watershed Planning	$400,000
101000193	City-wide Drainage Master Plan	Watershed Planning	$400,000
101000194	Identify and Assess Flood Risk and Potential Mitigation Solutions for Low SVI Communities	Watershed Planning	$150,000
101000195	Spicewood Springs Road Low Water Crossing #1 Project Planning	Project Planning	$682,500
101000196	Navidad River - Stem Branch Erosion Control Structure Project Planning	Project Planning	$40,000
101000197	La Salle Erosion Control Structure Project Planning	Project Planning	$40,000
101000198	Goat Trail Erosion Control Structure Project Planning	Project Planning	$225,000
101000199	County Road 106 Erosion Control Structure Project Planning	Project Planning	$75,000
101000200	Lake Travis/Cross Street Area Buyout Project Planning	Project Planning	$100,000
101000201	Hays County Buyout Project Planning	Project Planning	$500,000
101000203	Highland Hills Crossing Improvements Project Planning	Project Planning	$150,000
101000204	Shoal Creek - Nueces St Flood Risk Reduction Project Planning	Project Planning	$100,000
101000207	Highway St Improvements Project Planning	Project Planning	$600,000
101000208	Glen Flora Drainage Master Plan and Levee Project	Watershed Planning	$300,000
101000209	Jackson County Phase 2 DMP	Watershed Planning	$4,000,000
101000210	City of El Campo Drainage Master Plan Update	Watershed Planning	$750,000

FME ID	Name	Type	Cost
101000211	Jarvis Creek Channel Widening and Regional Detention Project	Project Planning	$150,000
101000212	Louise Internal Drainage Master Plan	Watershed Planning	$400,000
101000213	Wharton County Drainage Master Plan Update	Watershed Planning	$4,000,000
101000214	West Brazoria County Drainage District #11	Watershed Planning	$990,000
101000215*	Hill, Pecan, & Pine Street Drainage Improvements (DMP GB-04)	Project Planning	$600,000
101000216*	Local Storm Drain Improvements Near Piney Creek (DMP PC-04)	Project Planning	$360,000
101000217*	Pecan Street Bypass & Pond Diversion (DMP PC-05)	Project Planning	$1,700,000
101000218*	Pecan, Beech, & Haysel Improvements to Gills Branch (DMP GB-05)	Project Planning	$1,400,000
101000219*	Bastrop CCTV Storm Drain Evaluation (DMP COB-02)	Project Planning	$350,000
101000220*	Water, Spring, & Cedar Street Drainage Improvements (DMP GB-03)	Project Planning	$1,800,000
101000221*	Burnet County Lower Water Crossing Assessment	Project Planning	$150,000
101000222*	Burnet County Modeling and Mapping Update	Project Planning	$4,000,000
101000223*	Caldwell County Flood Early Warning System	Project Planning	$50,000
101000224*	Lytton Springs Creek Near CR 174	Project Planning	$40,000
101000225*	CR175 @ Cedar Creek Trib 1	Project Planning	$40,000
101000226*	City of Hays Drainage Master Plan Update	Project Planning	$200,000
101000228*	Cummins Creek WS SCS Site 1 Dam Flood Management Evaluation	Project Planning	$100,000
101000229*	Needville Wastewater Treatment Plant Floodproofing	Project Planning	$100,000
101000230*	Fairchild Creek Drainage Mitigation Study	Project Planning	$100,000
101000231*	Caldwell Elementary Improvements at Upper Gilleland Creek (DMP GC-01)	Project Planning	$680,000
101000232*	Pflugerville Storm Drain CCTV Evaluation (DMP Pf-03)	Project Planning	$250,000
101000233*	Hidden Lake Drive Improvements at Wilbarger Creek Tributary 200 (DMP WC-02)	Project Planning	$280,000
101000234*	Kennemer Drive Improvements at Wilbarger Creek Tributary 200 (DMP WC-05)	Project Planning	$220,000
101000235*	North Heatherwilde Improvements at Upper Gilleland Creek (DMP GC-02)	Project Planning	$1,200,000
101000237*	Railroad Avenue Improvements at Upper Gilleland Creek (DMP GC-04)	Project Planning	$1,200,000

FME ID	Name	Type	Cost
101000238*	Swenson Farms Improvements at Upper Gilleland Creek (DMP GC-03)	Project Planning	$370,000
101000239*	Weiss Lane Improvements at Wilbarger Creek (DMP WC-01)	Project Planning	$110,000
101000240*	Town of Boling Drainage Master Plan	Project Planning	$150,000
101000241*	Louise Drainage Master Plan	Project Planning	$150,000
101000243*	Colorado River Levee Gate Structure Improvements	Project Planning	$100,000
101000244*	El Lobo Neighborhood Drainage Improvements	Project Planning	$50,000
101000245*	Pecan Valley Phase 2 Preliminary Engineering Report	Project Planning	$100,000
101000246*	Riverwood Drive Improvements at Piney Creek (DMP PC-02)	Project Planning	$160,000
		Total Estimated Cost of FMEs:	**$62,217,500**

**Indicates FME was added in Task 12 and 13 amendments.*

Flood Infrastructure Fund Category 1 Projects

Based on the information provided by TWDB, there are seven Flood Infrastructure Fund (FIF) Category 1 planning projects within the Lower Colorado-Lavaca flood planning region. Information regarding each of these studies can be found in *Table 5.5* below. After performing a high-level review and comparison between these FIF studies and the FMEs recommended in this regional flood plan, there appears to be no overlapping effort; however, this analysis was based on the limited information available regarding the specific scopes of work, tasks, and deliverables involved in each. In areas where the FIF project will generate a master drainage plan or watershed-wide study, it is assumed that any modeling or other data generated by the FIF study would be available and leveraged in the performance of a future FME. It will be the ultimate responsibility of Sponsors of FMEs to ensure that any program or funding requirements of the TWDB are met, including ensuring no duplication of effort, when seeking future state funding for FMEs. It should be noted that some of the new FMEs identified in *Table 5.4* and new FMPs identified in *Table 5.6* were added as a result of the Caldwell County Flood Protection Planning FIF Category 1 Project.

Table 5.5 Flood Infrastructure Fund Category 1 Projects

FIF Project ID	Entity Name	Project Name
40006	Wharton County	Waterhole Creek - Caney Creek Basin Flood Protection Study
40012	Caldwell County	Caldwell County Flood Protection Planning
40015	Jackson County County-Wide Drainage District	Keller Branch - Lavaca River Basin Flood Protection Study Option 2

FIF Project ID	Entity Name	Project Name
40043	Bastrop County	Flood Protection Planning Studies - Phase 6
40060	Austin	Central Texas Regional Floodplain Studies
40077	Hays County	Onion Creek Watershed Study Floodplain and Mapping
40133	Travis County	Master Flood Plan Phase 1

County-Wide Evaluations

The RFPG recognizes that several county-wide evaluations cross into adjacent flood planning regions. These actions are sponsored by an entity that overlaps multiple planning regions; the efforts will not be duplicated, and coordination efforts will continue to adjudicate potential funding or costs. For example, Fort Bend County is sponsoring an FME to study flood early warning systems throughout the county. This regional action will include the portions of Regions 6 and 10 to avoid duplicative effort, and the costs only reflect the costs for the evaluations within Region 10.

Existing Base Level Engineering Models

As outlined in *Chapter 2*, the TWDB has invested significantly in developing base-level engineering (BLE) to provide statewide flood hazard coverage by 2024. Currently, BLE for the lower half of Region 10 is complete, and the upper half of the Region is underway (anticipated release in 2023). BLE modeling and mapping studies develop large-scale (HUC-8) engineering models and approximate flood hazard data. The public and communities can use this data to understand flood risk, and in areas with no or out-of-date studies, the information can be used as the “best available data” for floodplain management. In addition, BLE models can be refined to include more detail to create new flood insurance base maps (FIRMs) and/or to use as the basis for project planning and analysis.

Flood Mitigation Projects (FMPs) Recommendation Approach

For consideration as an FMP, a project must be defined sufficiently to meet the technical requirements of the flood planning project scope of work and the associated Technical Guidelines developed by the TWDB. In summary, the RFPG must be able to demonstrate that each recommended FMP meets the following the TWDB requirements:

1. The primary purpose is mitigation (response and recovery projects are not eligible for inclusion in the Regional Flood Plan)
2. Supports at least one regional floodplain management and flood mitigation goal
3. The FMP is a discrete project (not an entire capital program or drainage master plan)
4. Implementation of the FMP results in:
    a. Quantifiable flood risk reduction benefits
    b. No negative impacts to adjacent or downstream properties
    c. No negative impacts on an entity’s water supply
    d. No overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan

In addition, the TWDB recommends that, minimally, FMPs should mitigate flood events associated with the 1 percent annual chance (100-year) LOS. However, if a 1 percent annual chance (100-year) LOS is not feasible, the RFGP can document the reasons for its infeasibility and still recommend an FMP with a lower LOS.

Updated construction cost estimates and estimates of project benefits must also be available to define a benefit-cost ratio (BCR) for each recommended FMP. The TWDB recommends that proposed projects have a BCR greater than one, but the RFPG may recommend FMPs with a BCR lower than one with proper justification.

All potentially feasible FMPs with the necessary data and detailed modeling results available to populate these technical requirements were considered for recommendation by the RFPG. Pertinent details about the FMP evaluation are provided in the following section.

Initial Evaluation

The scope of work for each FMP was evaluated to ensure that it would support at least one of the regional floodplain management and flood mitigation goals established in *Chapter 3*. The goals associated with each FMP are included in *Chapter 3*. Based on a review of supporting information, it was determined that the primary purpose for each FMP is mitigation (rather than a response or recovery project), they are discrete projects, and they do not have any anticipated impacts to water supply or water availability allocations as established in the most recent adopted State Water Plan.

No Negative Impacts Determination

Each identified FMP must demonstrate that there would be no negative impacts on a neighboring area due to its implementation. No negative impact means a project will not increase the flood risk of surrounding properties. Using the best available data, the increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge. It is recommended that no rise in water surface elevation or discharge should be permissible (without acquiring the affected land or obtaining permission from the effect parties). The analysis extent must be sufficient to prove that the proposed project conditions are equal to or less than the existing conditions.

For the flood planning effort, no negative impact can be determined if a project does not increase the inundation of infrastructures such as residential and commercial buildings and structures. Additionally, the following requirements, per the TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

- Does not increase inundation in areas beyond the public right-of-way, project property, or easement
- Does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity
- Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section
- Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell

- Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

If negative impacts are identified, mitigation measures may be utilized to alleviate such impacts. The Regional Flood Plan may include projects with identified design-level mitigation measures. They could be finalized later to conform to the "No Negative Impact" requirements before funding or execution of a project.

Furthermore, the RFPG has the flexibility to consider and accept additional "negative impact" for requirements one through five based on the engineer's professional judgment and analysis, given that affected entities are informed and accept the impacts. This should be well-documented and consistent across the entire region. However, flexibility regarding negative impact remains subject to TWDB review.

Based on their reported hydrologic and hydraulic model results, a comparative assessment of pre-and post-project conditions for the 1 percent annual chance (100-year) event flood was performed for each potentially feasible FMP. Study results for floodplain boundary extents, resulting in water surface elevations, and peak discharge values were reviewed to verify potential FMPs conform to the no negative impacts requirements. The same studies were used to identify reported flood risk reduction.

Table 20 in *Appendix B* summarizes the no negative impact determination with reference information to relevant engineering reports and hydraulic modeling as appropriate.

Level of Service (LOS) and Benefit-Cost Ratio Evaluation

All the recommended FMPs provide some level of flood reduction benefits which are included based on the available information. When a BCR had been previously calculated in an engineering report or study used to create an FMP, the previously calculated BCR value was utilized for the FMP analysis. For any FMP that did not already have a calculated BCR value, the TWDB BCA Input Spreadsheet was utilized in conjunction with the FEMA BCA Toolkit 6.0 to generate BCR values.

The RFPG considered the above projects and determined that recommending these FMPs is consistent with the overarching goal of the Regional Flood Plan "to protect against the loss of life and property."

Recommended Flood Mitigation Projects (FMPs)

Due to the high level of detail required for consideration as an FMP, only 49 projects were determined to have enough details available for evaluation and potential recommendation as FMPs. All FMPs were recommended by the RFPG, representing a combined total project cost of $378,249,000. The final number and cost of the FMPs reflect the changes from the Tasks 12 and 13 amendments. A summary of the recommended FMPs for inclusion in the Regional Flood Plan is presented in *Table 5.6*. Like the FMEs, FMPs are concentrated in the central and lower portion of the basin. A map of project areas for the recommended FMPs is provided in *Appendix A*. Additionally, the TWDB-required Project Details Spreadsheet, which will be used for evaluation and project ranking by the State, is included in *Appendix B*. Supporting FMP data is also provided in the digital deliverable associated with the hydrologic and hydraulic folder.

Table 5.6 Recommended FMPs

FMP ID	FMP Name	FMP Type	FMP Description	Cost
103000001	Alum Creek - Cardinal Drive Improvements	LWC upgrade	2 box culverts: 4x3 west, 4 box culverts: 4x2 east, 310 LF raised roadway and channel widening adjacent to the roadway	$545,000
103000002	Alum Creek - Cardinal Drive Improvements (Tributary 11)	LWC upgrade	5 box culverts: 7x6, 360 LF raised roadway and channel widening	$719,000
103000003	Alum Creek - Cardinal Drive Improvements (Tributary 87)	LWC upgrade	3 box culverts: 8x6, 100 LF raised roadway and channel widening	$352,000
103000004	Alum Creek - Ponderosa Loop Improvements	LWC upgrade	3 box culverts: 8x5, 192 LF raised roadway	$431,000
103000005	Gills Branch Flood Mitigation Improvements	Channel	5,050 LF channel benching, 175 LF channel improvements, increased capacity at 3 roadway creek crossings, landscape walls	$6,240,000
103000006	FM 685 Crossing Improvements	Channel	Integrated with E. Pflugerville Prkwy improvement, 100 FT wide channel bench 1,700 LF, four 50 FT span bridges, 810 LF raised roadway	$7,660,000
103000007	E. Pflugerville Parkway Crossing Improvements	Channel	Integrated with FM 685 improvement, 100 FT wide channel bench 1,700 LF, four 50 FT span bridges, remove concrete drop structure	$2,860,000
103000008	Highland Park Subdivision Culvert Improvements	LWC upgrade	Add two 8x4 RCBs; grading US overbank; 1.5 FT tall 150 FT long berm to prevent water flowing onto Crater of the Moon Blvd	$533,000
103000009	Cele Road Crossing Improvements	LWC upgrade	Four 50 FT span bridge, 1160 LF raised road	$3,970,000

FMP ID	FMP Name	FMP Type	FMP Description	Cost
103000011	Cameron Road Crossing Improvements	LWC upgrade	Six 50 FT span bridge, 1520 LF raised road, channel grading and widening	$2,860,000
103000023	Sandy Creek/Pecan Park Areas Buyout	Property Acquisition	Acquisition of 11 residential properties located in the regulatory 1% ACE floodplain and floodway on Sandy Creek, Pecan Park area	$1,050,000
103000025	Onion Creek Structure Elevation	Property Elevation	Elevation of 15 residential properties in the 1% ACE floodplain at Arroyo Doble and Onion Creek Meadows neighborhoods	$2,800,000
103000026	Bluff Springs Elevation	Property Elevation	Elevation of 39 residential properties in the 1% ACE floodplain	$6,980,000
103000027	Onion Creek Meadows Elevation	Property Elevation	Elevation of 6 residential properties in the 1% ACE floodplain	$894,000
103000031	South Austin Regional WWTP / Sand Hill Energy Center Flood Reduction	Flood Walls and Levees	Structural flood mitigation measures to protect WWTP	$115,000,000
103000032	Walnut Creek Wastewater Treatment Plant Flood Wall	Flood Walls and Levees	Sheet pile floodwall installation to protect WWTP	$31,462,000
103000033	S Bowie Low Water Crossing - Flood Warning System	Preparedness	Install FEWS with automatic gates & flashers	$28,000
103000034	8 Low Water Crossings - Flood Warning System	Preparedness	Install flood warning signals at 8 identified low water crossings that frequently overtop. Additional flow gauge installments.	$220,000
103000037	Lady Bird Golf Course Low Water Crossing - Flood Warning System	Preparedness	Install FEWS with automatic gates & flashers	$28,000

FMP ID	FMP Name	FMP Type	FMP Description	Cost
103000038	W Travis Low Water Crossing - Flood Warning System	Preparedness	Install FEWS with automatic gates & flashers	$28,000
103000039	Windmill Oaks Subdivision - Flood Warning System	Preparedness	FNI proposes to install FEWS with automatic gates & flashers	$28,000
103000040	Red Bud Trail - Flood Warning System	Preparedness	Install automatic warning system for Ullrich Water Treatment Plant	$28,000
103000041	Davitt St Water Plant Backup Generator	Preparedness	Retrofit plant with backup generator	$826,000
103000042	City of Burnet Veterans of Foreign Wars Backup Generator	Preparedness	Emergency generator for VFW	$83,000
103000043	Beasley City Fire Department Backup Generator	Preparedness	Emergency generator for Fire Department	$83,000
103000044	Emergency Management System Backup Generators	Preparedness	Purchase/install a 30 kW generator to maintain government	$89,000
103000045	City of Edna Safe Room Backup Generator	Preparedness	Purchase/install 100 kW generator for Community Safe Room (triage center)	$150,000
103000046	City of Edna Sewer Lift Station Backup Generator	Preparedness	Purchase/install a 30 kW generator to maintain WWTP	$89,000
103000047	City of Ganado Sewer Lift Station Backup Generator	Preparedness	Emergency generators for sewer lift stations	$89,000
103000048	Jackson County Courthouse Backup Generator	Preparedness	Purchase generator for courthouse	$89,000
103000050	City of Edna Hospital Backup Generator	Preparedness	Purchase a permanent backup generator for the hospital	$500,000
103000051	Various Streets - Flood Warning System	Preparedness	Purchase flood early warning system	$310,000
103000052	Jonestown Flood Warning System	Preparedness	Floodplain early warning system and local response plan	$54,000

FMP ID	FMP Name	FMP Type	FMP Description	Cost
103000053	City of Briarcliff WWTP Backup Generator	Preparedness	Purchase stand-by generator for WWTP	$809,000
103000054	Portable Electronic Signs	Preparedness	Portable electronic signs	$56,000
103000055*	Dalton Lane Low Water Crossing Improvements	LWC upgrade	The project replaces culverts of 2 existing low water crossings (LWC) with new bridges. The LWC flood in the 2-year storm, and the project will prevent the LWCs from overtopping in the 100-year storm. Creek restoration downstream of the crossings to prevent erosion.	$19,138,000
103000056*	Waller Creek - Guadalupe St Flood Risk Reduction Project	Storm Drain	Install new storm drains, detention ponds, and LID	$72,072,000
103000057*	Detention Pond at Hunters Crossing (DMP SB-01)	Detention Pond	Outlet weir structure, berm improvements	$708,000
103000059*	SH-95 Improvements at Gills Branch (DMP GB-01)	LWC upgrade	Addition of culverts at SH-95	$688,000
103000060*	FM 812 at Little Alum Creek	LWC upgrade	Replace existing culvert with bridge and channel benching at FM 812	$8,289,000
103000061*	Piney Creek Mitigation	LWC upgrade	Bridge improvements and channel benching at SH95, Main St, and UPRR	$23,992,000
103000062*	Cedar Creek Channel Improvements Near Christian Drive	Channel	Channel improvements to reduce residential flooding near Christian Drive	$14,654,000
103000063*	CR 170 Low Water Crossing Improvements @ Lytton Creek	LWC upgrade	Upgrade 2 existing low water crossings to include box culverts and channel improvements	$4,877,000
103000064*	CR 172 Low Water Crossing	LWC upgrade	Upgrade existing low water crossing to include box	$4,574,000

FMP ID	FMP Name	FMP Type	FMP Description	Cost
	Improvements @ Lytton Creek		culverts and channel improvements	
103000065*	Creek Street at Barons Creek	LWC upgrade	Upgrade existing low water crossing and channel improvements	$2,027,000
103000066*	Broadway Avenue at Backbone Creek Low Water Crossing	LWC upgrade	This FMP replaces the Broadway Street bridge and makes channel improvements adjacent to the bridge. The existing bridge is approximately 150 feet long. The new bridge length will be increased to approximately 350 feet long and raised 10.5 feet.	$5,235,000
103000067*	Whitman Branch Industrial Area - Regional Detention	Detention Pond	This FMP is regional stormwater detention that controls flows upstream of the Commerce Street area. The solution includes an approximately 36 ft tall earthen dam approximately 1750 feet long on Whitman Branch near Coach Drive.	$28,000,000
103000068*	Immanuel Road/Pecan Park at Upper Gilleland Creek (DMP GC-05)	Flood Walls and Levees	Channel improvements and embankment construction	$4,863,000
103000070*	Peach Creek Channel Improvements	Channel	Channel Benching along lower Peach Creek for approximately 22,900 LF. Easement Acquisition and channel stabilization measures	$2,100,000
			Total Estimated Cost of FMPs:	**$379,160,000**

**Indicates FMP was added in Task 12 and 13 amendments.*

Flood Management Strategies (FMSs) Recommendation Approach

The approach for recommending FMSs adheres to similar requirements as the FMP process except, due to the flexibility and varying nature of RFPG's potential utilization of FMSs, some of these requirements may not apply to certain types of FMSs. In general, the RFPG must be able to demonstrate that each recommended FMS meets the following TWDB requirements as applicable:

1. The primary purpose is mitigation (response and recovery projects are not eligible for inclusion in the Regional Flood Plan)
2. Supports at least one regional floodplain management and flood mitigation goal
3. Implementation of the FMS results in:
    a. Quantifiable flood risk reduction benefits
    b. No negative impacts to adjacent or downstream properties (a No Negative Impact certification is required)
    c. No negative impacts on an entity's water supply
    d. No overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan

In addition, the TWDB recommends that, at a minimum, FMSs should mitigate flood events associated with the 1 percent annual chance (100-year) flood LOS. However, if a 1 percent annual chance (100-year) LOS is not feasible, the RFGP can document the reasons for its infeasibility and still recommend an FMS with a lower LOS.

Although each potentially feasible FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation, no structural FMSs were identified for this region. Therefore, no adverse impacts from flooding or water supply are anticipated.

Recommended Flood Management Strategies (FMSs)

The RFPG identified more than 270 potential strategies from stakeholders within the Lower Colorado-Lavaca Region. Many of the identified strategies were found in existing Hazard Mitigation Action Plans, and noted a lot of similarity and overlap in the strategies. All the strategies can be consolidated into broad regional strategies and initiatives. For these reasons, the planning group decided to create five regional strategies. The main reasons for this decision were to make each strategy inclusive of all communities within the region that choose to pursue them and to encourage collaboration between sponsors, particularly neighboring communities.

For example, many communities identified Flood Awareness and Preparation Education and Outreach strategies. Rather than developing individual programs or material, the RFPG encourages communities within media markets to develop joint programs to consistently and efficiently use resources. A one-page summary for each strategy is included in *Appendix C*.

Table 5.7 Recommended FMSs

FMS ID	FMS Name	FMS Description	Cost
102000001	Floodplain Management and Regulation	This strategy will consist of education, outreach, and direct technical assistance to cities and counties throughout the Lower Colorado-Lavaca Region, with a particular focus on providing targeted assistance to cities that are eligible but not currently participating in the NFIP; and other communities with the identification, evaluation, adoption, and implementation of enhanced floodplain management practices and regulations and land development, land use, and comprehensive drainage regulations.	Unknown
102000002	Flood Awareness and Preparation Education and Outreach	This strategy includes the Lower Colorado-Lavaca RFPG continuing its public outreach and engagement efforts through ongoing TWDB funding. This would include periodic e-mail news blasts, additional public meetings to present the initial Regional Flood Plan, and continuing outreach to key stakeholders (e.g., state and local elected officials, floodplain administrators, and emergency coordinators).	Unknown
102000003	Low Water Crossing Assessment, Prioritization, and Mitigation	There are an estimated 1,354 low-water roadway crossings within the Lower Colorado-Lavaca Region. Many of these crossings experience frequent flooding but may have relatively minor flood risk in terms of public safety and/or the integrity of the roadway. This strategy is for the Lower Colorado-Lavaca RFPG to provide technical assistance to communities assessing flood risk at low water crossings.	Unknown
102000004	Stream Corridor Protection and Restoration	This strategy is focused on encouraging public/private partnerships to enhance the protection and restoration of stream corridors. The essence of this strategy is open space acquisition, either through fee simple purchases of property within stream corridors or through voluntary agreements (i.e., conservation easements) between governmental and/or non-governmental organizations and private landowners.	Unknown

FMS ID	FMS Name	FMS Description	Cost
102000005	Watershed Modeling and Floodplain Mapping	This strategy is intended to address the need for immediate region-wide effort and funding to update watershed models, floodplain mapping, and associated geospatial products needed to understand flood risk and exposure; provide effective floodplain management; identify and evaluate flood risk reduction solutions and enhance flood emergency preparedness and response.	Unknown

Public Comment and Response Period

All the Technical Committee and full RFPG meetings were open to the public, and opportunities for public input were posted. No public comments were received during the meetings. The recommended actions and summary sheets were included in the Draft Regional Flood Plan in August 2022. The public had a minimum 60-day window to provide comments to the RFPG for consideration. A summary of public comments received during the public comment period is provided in *Chapter 10,* with detailed information provided in *Appendix D*. This chapter was updated in response to the public comments. The technical consultant team worked closely with sponsors during the performance of Tasks 12 and 13 to incorporate requested changes and new activities. The Amended Regional Flood Plan was made available for public review and comment for seven days before the RFPG voted to recommend and submit the amended plan to TWDB.

Tasks 11 – 13: Plan Amendment Phase

As the first cycle of regional flood planning progressed, TWDB received additional funding from the Texas Legislature and amended the work scope to include tasks 11, 12, and 13. Task 11 provided additional funds to prepare the initially adopted Regional Flood Plan, specifically to conduct additional stakeholder outreach and data collection to support Tasks 1 through 9. Tasks 12 and 13 represent an extension of the first cycle of regional flood planning, with the outcome being adopting an Amended Regional Flood Plan.

Task 12 focused on performing Flood Management Evaluations (FMEs) to reclassify FMEs to meet the criteria for FMPs. Candidate FMEs for the Task 12 studies were required to be approved by the RFPG and adhere to all relevant TWDB requirements and guidelines, particularly those pertaining to Task 5 - Recommendation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects.

With the assistance of the technical consultants and the RFPG 10 Technical Committee, a process was undertaken to identify candidate FMEs for the Task 12 study. An initial list of 19 candidate FMEs was developed by the consultant using the following selection criteria:

- FMEs are categorized as “Preliminary Engineering”
- Availability of needed hydrologic and hydraulic models available
- Exposure of at-risk structures and populations

- High risk/exposure low water crossings (e.g., depth of inundation, traffic count)
- Critical facilities at risk
- Level of effort (cost) to perform FME relative to the available budget
- Sponsor concurrence

Further screening of the preliminary list of candidate studies was conducted with the input of the RFPG 10 Technical Committee, and ultimately the RFPG approved seven (7) Task 12 studies. Technical memorandums were prepared for each study to document findings, conclusions, and recommendations. These Task 12 technical memorandums are included in *Appendix E*. The Task 12 studies and outcomes are summarized in *Table 5.8.* The recommended actions were approved by the RFPG on June 22, 2023, and are incorporated into the adopted Amended Regional Flood Plan.

Table 5.8 Task 12 Studies and Recommended Outcome

FME Title	County	Sponsor	Recommended Outcome	Action Number	Estimated Action Cost
Edison & Creek Street	Gillespie	Fredericksburg	Revise and retain as FME	101000043	$150,000
Creek Street at Barons Creek	Gillespie	Fredericksburg	Upgrade to FMP	101000065	$2,027,000
Whitman Branch Bypass; Oak Ridge Dr. Creek, including Detention	Burnet	Marble Falls	Upgrade to FMP	101000067	$28,000,000
Broadway Street at Whitman Branch Low Water Crossing	Burnet	Marble Falls	Upgrade to FMP	101000066	$5,234,400
FM 812 at Little Alum Creek	Bastrop	Bastrop Co.	Upgrade to FMP	101000060	$8,288,617
Piney Creek Benching	Bastrop	Bastrop Co.	Upgrade to FMP	101000061	$23,991,550
Wastewater Treatment Plant Floodproofing	Jackson	Edna	Remove	N/A	N/A

Under Task 13, additional TWDB funding was provided for the amendment of the Regional Flood Plan, including additional RFPG and Technical Committee meetings and revisions to portions of the plan and, with prior TWDB approval, other enhancements to the January 2023 Regional Flood Plan. With approval from the TWDB and the RFPG, a significant portion of the Task 13 effort focused on identifying, evaluating, and recommending additional FMEs and FMPs to incorporate into the Amended Regional Flood Plan. The resulting changes to the January 2023 Plan included:

- Addition of 29 new FMEs and 9 FMPs based on the Task 13 sponsor provided information and requests for their inclusion.
- Addition of 5 new FMPs due to the Task 12 reclassification of FMEs to FMPs

All amendments to plan chapters, maps, tables, geospatial data, and supporting data are incorporated into the Amended Regional Flood Plan. It should also be noted that *Tables 5.4* and *5.6* above also include these associated amendments.

Geospatial Data Processing

Per TWDB guidelines[4], all FMPs, FMEs, and FMSs, must be submitted with the geospatial database with all required attributes. To comply with the requirement, the Technical Consultant Team has drawn all FMPs, FMEs, and FMSs into the geodatabase with all applicable information from hazard mitigation plans, drainage masterplans, and stakeholder engagements. The Technical Consultant Team also populated the required attributes from Exhibit D with available information.

The locations and boundaries of FMPs, FMEs, and FMSs are determined from the best information available. Often in this region, a map figure for potential FMPs, FMEs, and FMSs is lacking, and only a brief location description is available. In this case, engineering judgment determines the most probable location of FMPs, FMEs, and FMSs. Occasionally, potential FMPs, FMEs, and FMSs contain a map figure, in which case the geographic extent of the project is directly used for the location and boundary (when applicable as below).

Determining the locations and boundaries of FMPs, FMEs, and FMSs varies depending on the type. For example, the location of a low water crossing improvement FMPs, FMEs, and FMSs are often determined by the creek's name and the crossing road. The boundary of such FMPs, FMEs, and FMSs is the contributing upstream portion of the HUC-12 watershed. In another scenario, an urban drainage FMPs, FMEs, and FMSs location is determined by the best information on the neighborhood. The boundary is the upstream drainage area that leads to the project outlet. Lastly, some FMPs, FMEs, and FMSs are citywide or county-wide, where a city/county boundary is used as the FMPs, FMEs, and FMSs boundary.

After all the FMPs, FMEs, and FMSs have been drawn in, a spatial join process is performed to populate the geospatial parameters required by *Exhibit D 3.10 – 3.12.* Features in other layers containing geospatial information (HUC-12, flood risk types, entities with oversight, etc.) that overlap with the FMPs, FMEs, and FMSs footprint are joined and populated in the FMPs, FMEs, and FMSs geospatial attributes.

[4] Data Submittal Guidelines for Regional Flood Planning, 3.10 – 3.12

Chapter 6: Impact and Contribution of the Regional Flood Plan

Lake Marble Falls

The objective of this task is to assess and summarize the impacts and contributions, in the aggregate, associated with the implementation of this Regional Flood Plan. In previous chapters, existing flood hazard and exposure conditions were assessed based on the 1 percent and 0.2 percent annual chance flood events. In addition, an inventory of existing infrastructure and natural features was compiled for use as a baseline. Flood risk reduction or mitigation needs were identified, leading to the Region Flood Planning Group (RFPG) adoption of recommendations presented in the previous chapter of flood management evaluations, strategies, and mitigation projects. This chapter compares those identified risks with the potential estimated positive and negative benefits of implementing the Regional Flood Plan. Additionally, in the second part of this chapter, potential contributions to and impacts on water supply development and the State Water Plan are assessed.

Task 6A: Impacts of the Regional Flood Plan

Implementing the Regional Flood Plan can be expected to provide numerous benefits to the areas served by local Sponsors and will not negatively impact neighboring areas within or outside of the region. More specifically, implementing recommended flood mitigation projects (FMPs) is expected to reduce the number and/or spatial extent of areas with high flood hazard and exposure. For example, implementing recommended FMPs is expected to remove an estimated 665 at-risk structures from flood-prone areas. However, the benefits will vary across the region due to the highly variable and local nature of most flood hazard areas, as well as with the types of studies, strategies, and projects implemented. Further discussion of the potential benefits of implementing this Regional Flood Plan is provided below.

Floodplain Management and Modeling

Information was compiled during the baseline development of the Regional Flood Plan. As part of the compilation, data gaps were identified within the region. The information and data gaps were found in areas of low to high flood risks that lack floodplain management practices, adequate enforcement of floodplain standards and regulations, detailed hydrologic and hydraulic models, and flood inundation mapping. The existing condition exposure analysis revealed that approximately 5,238 square miles, or 21 percent of the Lower Colorado-Lavaca Region, including an estimated population of 244,664, are currently at risk of flooding. The lack of information hinders local entities' ability to effectively manage floodplain activities, adequately assess flood risks and exposure, evaluate potentially feasible flood risk reduction strategies and solutions, and select a preferred option(s) for implementation. This likely results in population and property being exposed unnecessarily to flood risk. As reported in *Chapter 5*, 184 Flood Management Evaluations (FMEs) are recommended and when implemented will close some data and information gaps and set in motion the process of developing and implementing flood risk reduction solutions. Eight recommended FMEs are specifically focused on watershed modeling and mapping, and the majority of the remaining FMEs include modeling and mapping to identify flood risk, flood mitigation alternatives analysis and feasibility studies, and preliminary engineering studies, among others. The FME study areas, in aggregate, encompass areas and populations with insufficient data covering over 44,500 square miles (study area).

Reduction in Flood-Impacted Areas

Existing and future flood hazard areas were identified and quantified for both 1 percent and 0.2 percent annual chance flood events; however, flood risk is generally defined for the existing condition 1 percent annual chance (100-year) flood event. The tables below show the flood-impacted areas in square miles for both existing and future scenarios based on annual chance flood events and the reduction of impacted areas. A large portion of the areas with defined floodplains includes rural, unpopulated areas. Implementing the Regional Flood Plan, which focuses more on areas with high populations at risk, will reduce areas previously impacted by approximately 0.03 percent, or a reduction of approximately 1.8 square miles.

Table 6.1 Reduction in Existing Flood-Impacted Areas

Annual Chance Event Flood Risk	Area in Floodplain (square miles)	Reduction of Floodplain after Implementation (square miles)	Decrease in Floodplain Impacted
1%	4,515	1.44	0.03%
0.2%	723	0.36	0.05%
Total	**5,238**	**1.80**	**0.03%**

Table 6.2 Reductions in Future Flood-Impacted Areas

Annual Chance Event Flood Risk	Area in Floodplain (square miles)	Reduction of Floodplain after Implementation (square miles)	Decrease in Floodplain Impacted
1%	5,385	1.44	0.03%
0.2%	578	0.36	0.06%
Total	**5,963**	**1.80**	**0.05%**

Benefits to Population and Structures at Risk

The direct beneficiaries of this Regional Flood Plan implementation are the populations that reside in areas with reduced flood risk and public and private assets (e.g., structures, roads, utilities). The estimated population removed from the flood risk area is shown in *Table 6.3*. While the number of potentially avoidable injuries and deaths associated with implementing this plan is not quantifiable, the expected benefits could be significant. Public safety benefits will be a result of changing flood characteristics to reduce flood risk to structures, roads, and property (structural flood mitigation projects) and by changing the way people interact with flood risk (non-structural flood mitigation projects and strategies) through regulatory improvements, educating people about flood risks, and by implementing flood early warning and evacuation measures.

Table 6.3 Population Removed from the Floodplain

Annual Chance Event Flood Risk	Existing At-Risk Population	Reduction of At-Risk Population After Implementation	Decrease in Population Impacted
1%	149,830	2,482	1.7%

Implementing this plan provides benefits by removing existing structures within flood hazard areas. These include inundated structures for short periods and those inundated for extended periods within areas with relatively flat topography, such as the coastal areas. *Table 6.4* shows the estimated number of structures that will be removed after implementing the Regional Flood Plan.

Table 6.4 Structures Removed from the Floodplain

Annual Chance Event Flood Risk	Existing At-Risk Structures	Reduction of At-Risk Structures After Implementation	Decrease in Structures Impacted
1%	67,824	644	1.0%
0.2%	34,477	21	0.06%
Total	**102,301**	**665**	**0.7%**

Critical facilities are generally identified as municipal and other public utilities, governmental facilities, hospitals and care facilities, and schools. *Table 6.5* shows the estimated number of exposed critical facilities and those that will be removed from the floodplain through this plan's implementation.

Table 6.5 Critical Facilities Removed from the Floodplain

Annual Chance Event Flood Risk	Existing At-Risk Critical Facilities	Reduction of At-Risk Critical Facilities After Implementation	Decrease in Critical Facilities Impacted
1%	99	4	4.0%
0.2%	59	0	0.0%
Total	**158**	**4**	**2.5%**

Low Water Crossings and Impacted Roadways

Implementing FMSs and FMPs across the region will significantly impact the number of existing low water crossings and/or the degree of risk at those crossings. As projects are implemented, the number of low water crossings will be reduced. In addition to removing low water crossings, there will be a significant risk reduction of many crossings, reducing the frequency and duration of road closures due to severe flooding. The total number of low water crossings being removed and/or those with reduced flood risk is shown in *Table 6.6*.

Table 6.6 Low Water Crossings Removed

Annual Chance Event Flood Risk	Existing At-Risk Low Water Crossings	Reduction of At-Risk Low Water Crossings After Implementation	Decrease in Low Water Crossings Impacted
1%	1,109	15	1.4%
0.2%	23	0	0.0%
Total	**1,132**	**15**	**1.3%**

In addition to the number of low water crossings being removed, flooded roadways also benefit from implementing the Regional Flood Plan. Information in *Table 6.7* shows transportation infrastructure benefits by reducing the time a roadway is closed or removing it from flooding altogether.

Table 6.7 Removal of Roads from Flood Risks

Annual Chance Event Flood Risk	Existing At-Risk Roadways (miles)	Reduction of At-Risk Roadways After Implementation	Decrease in Roadways Impacted
1%	2,374	19	0.8%

Socioeconomic and Recreational Impacts

Socioeconomic

Implementing the Regional Flood Plan, as shown in the previous sections, benefits the entire region. As part of this effort, socioeconomic impacts were considered to evenly distribute flood risk reduction benefits among all groups across the region as much as practical. The region has a diverse population with wide-ranging economic levels requiring extra attention to improve conditions for everyone. Disadvantaged socioeconomic populations have limited access to resources hindering response and recovery from flood events. Processes in developing the appropriate FMSs, FMPs, and FMEs included reducing the impacts of flood events and improving the lives of all socioeconomic groups ensuring the most disadvantaged were well represented. This can be shown in the locations of FMSs, FMPs, and FMEs identified in the region.

Recreation Impacts

There can be many opportunities to benefit recreation through implementing the Regional Flood Plan. Many parks located along waterfronts are designed to be flooded periodically, with infrastructure minimally impacted. Floodplains and wetlands can support recreation and tourism. Although not specifically identified in this plan, as FMSs and FMPs are implemented that remove structures from floodplains and reduce existing floodplains, new opportunities become available for local sponsors. These areas are often utilized in cities throughout the state for hiking and biking trails. The RFPG will encourage secondary benefits such as recreational opportunities. While the Regional Flood Plan will provide opportunities, it will not negatively impact existing recreation activities throughout the region.

Overall Impacts

Implementing the Regional Flood Plan provides numerous benefits associated with the primary purposes of FMEs, FMSs, and FMPs. Although not readily quantifiable, the benefits will provide greater protection of public health and safety throughout the region. This is accomplished by reducing the frequency and severity of flooding in flood-prone areas, removing populations, structures, and roadways from flooding with expanded, improved warning systems, and providing officials with the tools to effectively manage flood-prone areas.

No major environmental impacts, water quality, erosion, or sedimentation are anticipated by implementing the recommended FMPs in this region. More than half of the recommended FMPs are non-structural projects that do not involve modifications to the watershed or flow of water. Per industry standards for implementing structural flood mitigation projects, detailed evaluations are necessary once configurations and extents of proposed infrastructure are finalized. Such evaluations include but are not limited to impacts to the waters of the U.S., endangered species surveys, cultural resources surveys, water quality best management practices, sediment transport/stream stability studies, and the development of mitigation measures where impacts are anticipated. Implementing the Regional Flood Plan is not anticipated to impact agriculture or navigation of inland or coastal waterways. The recommended structural FMPs primarily include improvements to drainage systems within urbanized areas and roadway culverts and bridges at low water crossings over inland streams.

Task 6B: Contributions to and impacts on water supply development and the State Water Plan

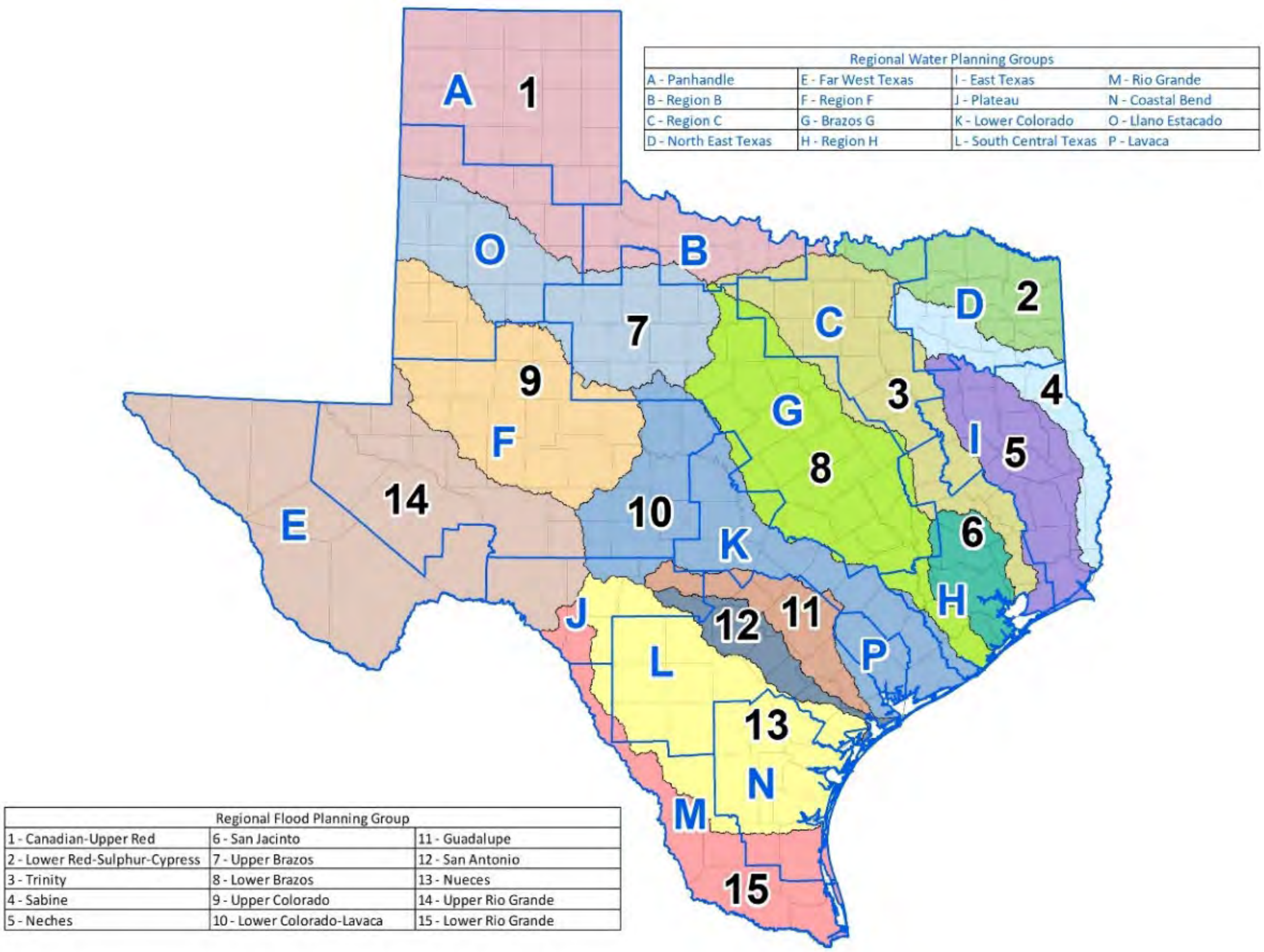
Regional Flood Plans must include a region-wide assessment of the potential contributions and impacts that implementation can be expected to have on water supplies and the State Water Plan. As part of this analysis, each FMS and FMP was reviewed to determine whether there are potential impacts on existing water supplies or the availability of water supplies. Impacts include potential contributions to, as well as reductions in water supply and availability. These impacts, as determined, would be placed in one of the following categories:

- Involves direct impacts on available water supply yield during a drought-of-record, which requires both availability and directly connecting supply to a specific water user group(s)
- Direct benefits (i.e., increases) water availability
- Indirectly benefits water availability
- Has no anticipated impact on the water supply

A coordinated effort with representatives from multiple regional water planning groups occurred to identify water management strategies that could be impacted. Those regional water planning groups include Region F, Region G (Brazos), Region H, Region J (Plateau), Region K (Lower Colorado), Region L (South Central Texas), and Region P (Lavaca).

It was determined that there were no anticipated impacts from the recommended FMSs and FMPs on water supply, water availability, or projects in the State Water Plan based on no anticipated measurable impact. More specifically, no recommended FMPs in this Regional Flood Plan propose to detain or impound stormwater where such detention might benefit or adversely affect the existing water supply. Additionally, most stormwater detention facilities are relatively small and designed to temporarily impound for less than 24 hours.

Figure 6.1 Flood Planning Regions versus Regional Water Plan Boundaries



Chapter 7: Flood Response Information and Activities

Source: Hays County Onion Creek Flood Photo

Overview

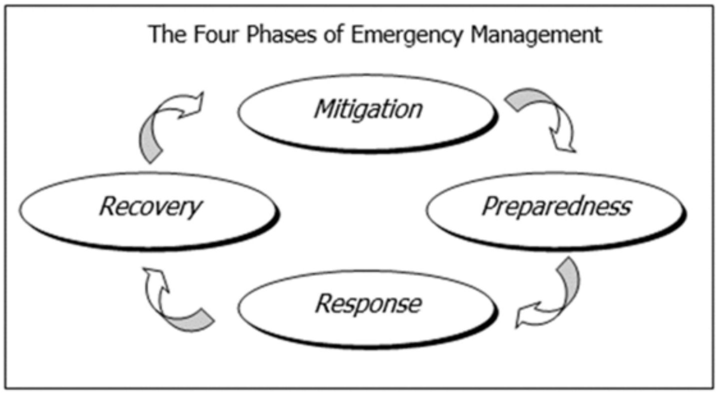
Pursuant to the Texas Water Development Board (TWDB) rules and guidelines for Task 7, this chapter summarizes "...the nature and types of flood response preparations within the flood planning region, including providing where more detailed information is available regarding recovery." This task does not include analyses or other activities related to planning for disaster response or disaster recovery.

Introduction

In 2011, a Presidential Policy Directive[1] was issued establishing a national preparedness goal "...aimed at strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the Nation, including ... catastrophic natural disasters." The directive also established the National Preparedness System, which includes a series of "integrated national planning frameworks" that address prevention, protection, mitigation, response, and recovery. Together these establish an overall institutional framework through which flood response preparedness is planned and implemented at the federal, state, and local levels of government. As depicted in *Figure 7.1,* this national framework for emergency management is organized around four phases: mitigation, preparedness, response, and recovery.

[1] Presidential Policy Directive/PPD-8. National Preparedness. The White House, March 30, 2011. Available at: https://www.dhs.gov/xlibrary/assets/presidential-policy-directive-8-national-preparedness.pdf

Figure 7.1 The Four Phases of Emergency Management



Source: FEMA, 1998

Table 7.1 Definitions and Examples of the Four Phases of Emergency Management

Phase	Definition	Examples
Flood Preparedness	Actions, aside from mitigation, that is taken before flood events to prepare for floods and plan flood response activities	Flood awareness education, emergency management and evacuation plans, and the development of flood early warning systems
Flood Response	Actions taken during and in the immediate aftermath of a flood event	Conduct evacuations, establish and operate shelters, road closures, and operation of flood early warning systems
Flood Recovery	Actions are taken after a flood event involving clean-up, repairs, or other actions necessary to return to pre-event conditions	Restoration of utilities and infrastructure, debris clean-up, insurance payouts, rebuilding resiliently
Flood Mitigation	The implementation of actions, including both structural and non-structural solutions, to reduce flood risk to protect against the loss of life and property	Building floodwalls/seawalls, floodgates, and levees; establishing evacuation routes; elevating structures; property buyouts and relocations; and regulatory measures

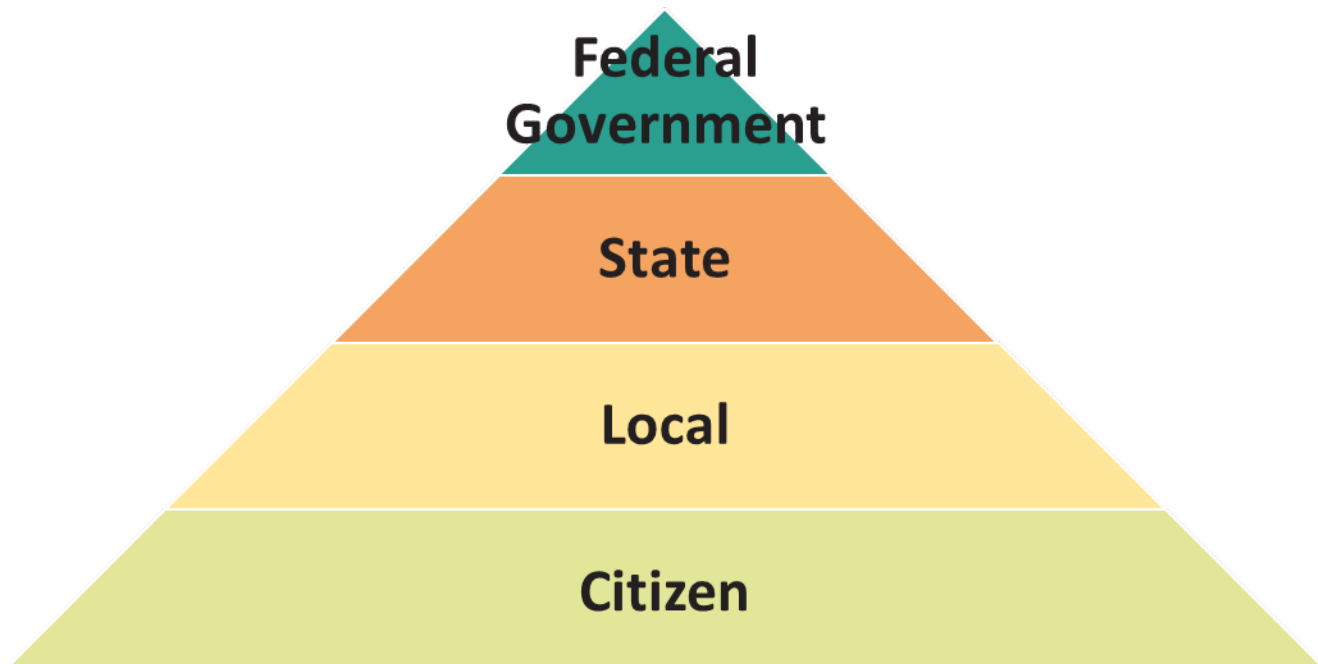
Note: Table adapted from the TWDB Guidance, which was adapted from Animals in Disaster, Module A, Awareness, and Preparedness (FEMA, 1998)

As set out in the TWDB's requirements and guidance for regional flood planning, this chapter is focused on three of the four emergency management phases: preparedness, response, and recovery. Flood mitigation or flood risk reduction is, of course, a primary focus of this Lower Colorado-Lavaca Regional Flood Plan but is not addressed in this chapter. The chapter is organized into three sections: roles and responsibilities for flood emergency preparedness and management, an overview of flood preparedness in the region (i.e., detailed information on flood early warning, flood response, and flood recovery), and an overall concluding state of flood preparedness in the Lower Colorado-Lavaca Region.

Roles and Responsibilities for Flood Emergency Preparedness, Response, and Recovery

Responsibility for flood emergency preparedness, response, and recovery is a shared responsibility between multiple federal agencies, the states (and tribes and territories), and communities (i.e., individuals, businesses, and local government) operating within the national emergency management framework. Additionally, the United States Department of Homeland Security has established the National Incident Management System, which "...provides a consistent nationwide template to enable partners across the Nation to work together to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity."[2]

Figure 7.2 Emergency Management Support



Source: Emergency Management Institute, Are You Ready?

In many respects, the institutional framework for flood emergency preparedness, response, and recovery is "bottom-up." Much of the responsibility and authority for emergency management rests with local government and the communities they serve. This allows emergency management processes and activities to be tailored to only those areas affected by a natural disaster, such as a flood

[2] Federal Emergency Management Agency, National Incident Management System, Third Edition, October 2017.

emergency. That said, federal and state agencies play a critical and central role in coordinating emergency management activities and providing support and assistance to local entities in emergency preparedness planning, emergency response, and post-disaster recovery. Starting with the federal role, the following presents a discussion of the emergency management roles and responsibilities at each level of government.

Federal Emergency Management Responsibilities

Nationally, the Federal Emergency Management Agency (FEMA) and their federal agency partners have legal authorities, technical and financial resources, and programs to assist state and local governments with flood preparedness and emergency response and with flood risk reduction through prevention and mitigation. Below is a brief description of the lead role played by FEMA at the federal level in flood emergency preparedness, response, and recovery.

Federal Emergency Management Agency (FEMA)

FEMA is an agency of the United States Department of Homeland Security (DHS). FEMA's primary focus is to coordinate the response to all types of disasters in the United States and its territories, particularly those of a magnitude that may overwhelm the capabilities and resources of state and local authorities. At the federal level, FEMA plays the central role in helping people before, during, and after disasters.

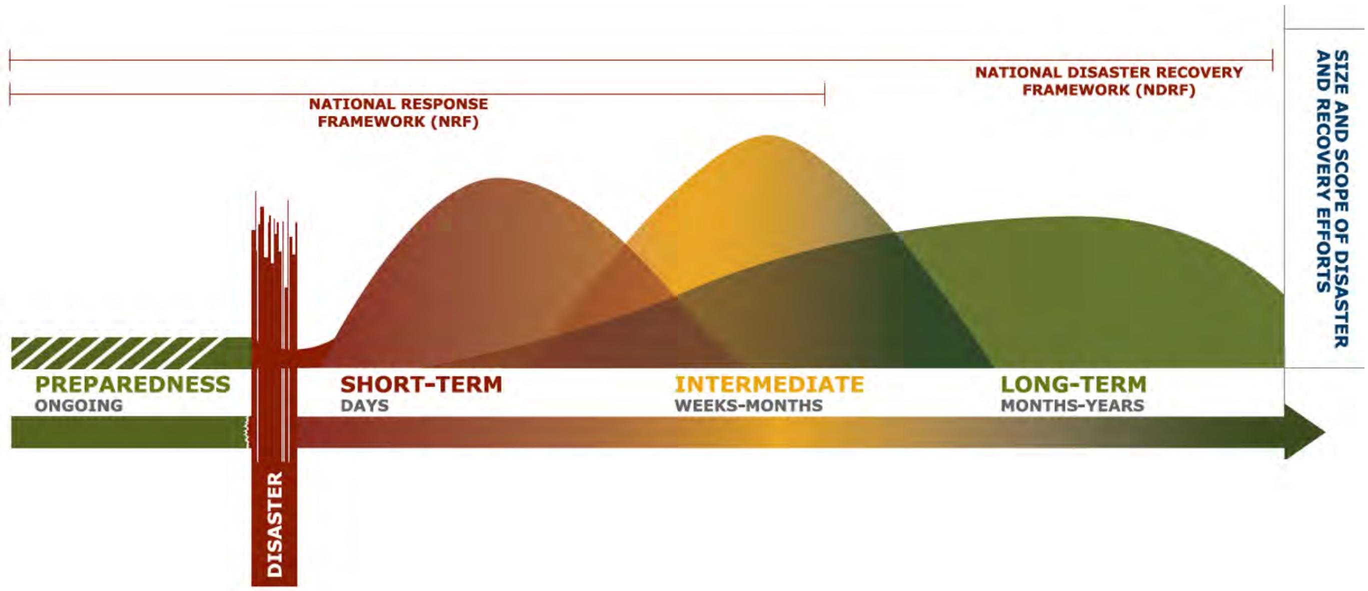
Specifically, FEMA assists with:

- Public outreach and education, through raising flood risk awareness, informing the public and interest groups about flood risk reduction options, and providing technical and financial assistance with flood emergency planning and preparedness;
- Coordination of the federal response to flood disasters and mobilization and management of the federal resources during disasters; and
- Coordination of the federal disaster recovery efforts and provision of resources.

By law, FEMA is tasked with a lead role in disaster prevention, protection, mitigation, response, and recovery, consistent with the agency's statutory authorities. FEMA has incorporated the Presidential Policy Directive into their established emergency management program, focusing on the four-phase *all-hazards* approach to emergency management implemented in partnership with state and local government, private sector entities, and non-governmental organizations (e.g., the American Red Cross). As discussed in some detail in *Chapter 3*, FEMA also plays a key role nationally in flood risk prevention and reduction as the administering agency for the National Flood Insurance Program (NFIP). As noted in *Chapter 3*, nearly all eligible local entities in the Lower Colorado-Lavaca Region are current participants in the NFIP. They, therefore, have adopted and enforced at least the minimum required standards for floodplain management.

FEMA also oversees the National Disaster Recovery Framework to promote disaster effectiveness. A core component of the National Disaster Recovery Framework advances the concept that recovery extends beyond simply repairing damaged structures. It also includes "the continuation or restoration of services critical to supporting the physical, emotional, and financial well-being of impacted community members."[3] In other words, it includes the restoration and strengthening of key systems and assets critical to the community's long-term vitality. One of the key concepts of the National Disaster Recovery Framework is the Recovery Continuum—an acknowledgment that the foundation for a strong recovery starts with effective pre-incident preparedness planning (*Figure 7.3*).

Figure 7.3 National Disaster Recovery Framework (NDRF) Recovery Continuum



FEMA also has the lead role in initiating federal emergency response actions and for mobilizing and coordinating federal resources in "real-time" immediately before and during flood disasters. This involves coordinating with the Governors of affected states and state emergency management agencies, and the Texas Division of Emergency Management (TDEM). State Emergency Managers coordinate with local officials in impacted areas, primarily at the county level, and county officials coordinate and collaborate with the local officials. During the pre-event preparedness and response phases, FEMA's authority and resources may be bolstered by an "Emergency Declaration" by the President, which is one of two types of federal disaster declarations provided for in the federal Stafford Act (42 U.S.C. §§ 5121-5207). For Emergency Declarations, the President can declare an emergency for any occasion or instance where there is a need for federal assistance. Emergency Declarations are generally issued in response to a direct request from the Governor of the affected state and/or upon recommendation of FEMA.

An Emergency Declaration intends to enable the federal government to mobilize resources in real-time to support and supplement state and local efforts to "…provide emergency services, such as the protection of lives, property, public health, and safety, or to lessen or avert the threat of a catastrophe

[3] NRDF. Available at: https://www.fema.gov/sites/default/files/2020-06/national_disaster_recovery_framework_2nd.pdf

in any part of the United States."[4] Once the President issues an Emergency Declaration, FEMA can assist state and local entities with removing debris and implementing emergency protective measures. Before an imminent natural disaster and often in advance of an Emergency Declaration, FEMA may also place federal resources on standby or even pre-position federal personnel and other resources; for example, to have personnel and equipment at the ready to aid in rescue operations and/or to prepare for the recovery phase, such as by pre-positioning of drinking water and food to expedite delivery to impacted areas. The Governor of an affected state may, in some circumstances, request and receive a Pre-Disaster Emergency Declaration, which enables FEMA to assist with emergency protective measures.

The second type of federal disaster declaration is a "Major Disaster Declaration," issued only by the President and considered in the aftermath of a major natural disaster. Major disasters are any natural event (e.g., hurricanes, severe storms, floods, water, tidal waves, etc.) where it has been determined that the damage is of such severity that it is beyond the combined capabilities of state and local government. A major disaster declaration provides for a wide range of federal assistance programs for both impacted individuals, businesses, public infrastructure and for the continuity of local governmental operations. All requests for a presidential declaration of a major disaster are made by the Governor of the affected state or territory.

FEMA plays a central role in issuing Major Disaster Declarations, which are required to fully mobilize federal disaster recovery resources. The process begins with a preliminary damage assessment, often conducted jointly by FEMA and state officials and agencies, such as TDEM, and with the participation of affected local entities. In this step, the extent of the disaster is assessed along with impacts on the public and public facilities. From the assessment, a preliminary determination is made as to the types of federal assistance that may be needed. Typically, the preliminary damage assessment provides the basis for a Governor's request for a Major Disaster Declaration. However, in some cases where the magnitude of the disaster is such that the level of damage and the need for federal assistance is overwhelming and apparent, a Major Disaster Declaration may be requested before the completion of the preliminary assessment.

Other Federal Agency Partners

Several federal agencies partner with FEMA to provide support and assistance before, during, and after flood emergencies and disasters. For example, the United States Army Corps of Engineers often has a lead role as the federal contracting agency for acquiring, pre-positioning, and distributing drinking water, food supplies, equipment, and other goods and services. FEMA may also call upon them and other federal agencies to provide personnel and available equipment for debris removal or other recovery activities. Another example is the Small Business Administration, an agency of the United States Department of Commerce, which is often mobilized to assist impacted businesses with recovery by providing loans or other assistance.

[4] FEMA Declarations. Available at: https://www.fema.gov/disaster/how-declared.

State Emergency Management Responsibilities

As indicated in the above discussion, at the state level, the Governor and the Texas Division of Emergency Management (TDEM) also have central roles in emergency management before, during, and after flood emergencies and disasters. The Governor, for example, has the authority to issue State Disaster Declarations and, in doing so, mobilize and deploy state resources to prepare for and respond to natural disasters. This may include the deployment of state personnel or the National Guard to support public safety activities, such as a large-scale evacuation, as well as the provision of material support, such as the deployment of equipment for clean-up in the immediate aftermath of a disaster and during the recovery phase. Most importantly, as noted, it is the Governor that can make requests for presidential Emergency Declarations and Major Disaster Declarations.

TDEM is an administrative unit of the Texas A&M University System and is the state agency charged with implementing the state's all-hazard emergency management program. A key TDEM responsibility is supporting the Governor with the state and federal emergency declaration and response processes. With this role, TDEM serves as the primary point of contact with FEMA, counties, and other local entities before and during flood emergencies. During the recovery phase, TDEM plays a central role in coordinating the participation of affected state and local entities in conducting preliminary damage assessments. Specifically, TDEM has a lead role in collecting, compiling, and analyzing data and information provided by local authorities regarding the extent of damages to public infrastructure and facilities, impacts on individuals and businesses, and costs for local response and recovery activities. Other responsibilities include disaster preparedness activities, including state and local emergency management planning, hazard mitigation planning, and training local officials and emergency management personnel.

Local Emergency Management Responsibilities

As noted previously, in many respects, emergency management is a bottom-up process with a large portion of the responsibility related to flood emergency preparedness, response, and recovery residing at the local level. In Texas, counties and municipalities are at the frontline of emergency management. The chief executives of these local governmental entities – county judges and mayors – have the authority under state law to declare local disasters and oversee local and/or inter-jurisdictional emergency management functions. As stated in Chapter 418 of the Texas Government Code and Title 37, Part 1, Chapter 7 of the Texas Administrative Code, these officials are authorized to declare local disasters.[5] A local disaster declaration allows public officials to exercise emergency powers to preserve life, property, and public health. For example, county or city officials can order evacuations from and control access to threatened or impacted areas under a local disaster declaration and temporarily suspend certain rules and regulations. Local disaster declarations are very often the first step in the process of requesting state and federal assistance.

[5] TWCA Emergency Management Guidebook. Available at: https://www.twcarmf.org/wp-content/uploads/2018/07/TWCARMF-Emergency_Management_Guide.pdf.

Flood Preparedness

Preparedness is defined by the Department of Homeland Security (DHS) and the Federal Emergency Management Agency (FEMA) as "a continuous cycle of planning, organizing, training, equipping, exercising, evaluating, and taking corrective action to ensure effective coordination during incident response."[6] Beyond actual mitigation, which is the primary focus of the overall State Flood Plan, preparedness is the next most important component. During this stage, a community takes necessary measures to prevent people from being put in harm's way and to ensure they are ready for the next disaster. The next section provides an overview of what communities and entities in the Lower Colorado-Lavaca Region do as part of their flood preparedness activities (e.g., flood early warning, flood response, flood recovery, and public awareness and education).

One of the ways the Lower Colorado-Lavaca Regional Flood Planning Group (RFPG) was able to assess local performance was through a data collection effort in Summer 2021. This input covered a broad spectrum of communities across the rural-to-urban divide. One of the questions asked focused on the types of measures their jurisdiction took related to flood resilience. Several of the responses involved actions related to flood preparedness, response, and recovery. Figure 7.4 highlights that six jurisdictions provided flood readiness and education, nine offered (or participated in) a flood early warning system and 11 undertook flood response planning activities.

Figure 7.4 Measures Taken to Promote Resilience with Flood-Prone Areas

Flood Early Warning

It is widely recognized that an important element of flood preparedness and flood emergency response is the ability to alert or warn threatened and vulnerable populations about potential flood conditions before they occur so that timely actions can be taken "...to ensure their own safety and to minimize

[6] Plan and Prepare for Disasters. DHS. Available at: https://www.dhs.gov/plan-and-prepare-disasters

damage to their homes, businesses, and personal property." Early warning of impending flooding can significantly reduce loss of life and property damage from flooding. Sometimes referred to as Flood Early Warning Systems (FEWS), these "systems" are best viewed as an integration of various components that, in combination, provide the technical and operational capabilities required to warn at-risk populations of impending flood threats. These are flood risk knowledge, real-time data acquisition, monitoring and forecasting, and dissemination of data and warnings. All of these components of early flood warning provide information that is critical for proactive flood emergency response. Each of these elements of flood early warning is briefly discussed below.

Flood Risk Knowledge

Understanding flood risk is the starting point and underpins any approach to flood early warning. In simple terms, it is an understanding of flood hazards, exposures to such hazards and vulnerabilities to flood hazards, all of which have been evaluated in this planning process for the Lower Colorado-Lavaca Region, the results of which are reported in *Chapter 2*. Flood hazard assessment is a product of hydrologic and hydraulic analysis of watersheds, streams, rivers, and floodways using historical rainfall and other pertinent data to establish the stage (the height of water in a stream channel or floodway), the volume of flood flows generated by the contributing watershed(s), the volume and timing of water entering and moving through a stream system, and the use of topographic data to define the geometric characteristics of a stream or river. In combination, this information provides analytical tools (e.g., numerical models and geospatial representations/maps) that inform where flood waters are originating, where they will go, the stage and velocity of flood flow at a given point along a stream or floodway, and zones of inundation. The second essential piece of the flood risk puzzle is understanding what is exposed to flood hazards under varying conditions – people, property, and infrastructure. The third piece is to understand the vulnerability or degree of risk faced by exposed populations, property, infrastructure, etc.

In terms of flood early warning systems, the information provided by a flood hazard-exposure-vulnerability assessment allows emergency management professionals to determine where the greatest threats exist and under what conditions, particularly threats to vulnerable populations in high flood-risk areas. For example, how many occupied structures are located in a 25-year or 100-year floodplain at a given location along a stream corridor. This information enables emergency management professionals to understand where real-time data collection points (e.g., stream gauges, weather stations) are needed and provides an ability to target specific locations and populations for flood warnings.

Real-Time Data Acquisition and Dissemination

A second essential component of flood early warning is the ability to acquire and process relevant real-time weather and hydrologic data. Multiple sources of such data are available from federal, state, regional, and local agencies.

A primary data source is the National Weather Service (NWS), an agency of the National Oceanic and Atmospheric Administration. The NWS's mission is to "Provide weather, water, and climate data, forecasts, warnings, and impact-based support services for the protection of life and property and enhancement of the national economy."[7] In performing its mission, the NWS works in partnership with a host of other federal agencies, such as the United States Geological Survey, the United States Army Corps of Engineers, the Natural Resources Conservation Service, and other organizations.

The NWS provides many weather and water-related products that serve as useful inputs for flood early warning and are well-known to emergency management personnel and other primary users of the products. These include access to real-time rainfall data, rainfall forecasts, and river forecasts at various time scales. For example, the NWS can provide hourly forecasts to guide decisions before and during flash floods and support local flood warning systems. NWS regional river forecast centers also provide river forecasting services and products. The Lower Colorado-Lavaca Region is in the NWS' West Gulf Coast River Forecast Center.

In addition to the weather, water, and climate data and forecasting products it provides, the NWS also administers the Weather-Ready Nation (WRN) program, which has a goal of providing "...forecast information in a way that better supports emergency managers, first responders, government officials, businesses and the public to make fast, smart decisions to save lives and property and enhance livelihoods."[8] This program is a partnership and collaboration between NWS and various external partners – Weather-Ready Nation Ambassadors – such as affiliated industry partners (e.g., the American Weather and Climate Industry Association), the emergency management community, and media partners. WRN Ambassadors in Central Texas include the Central Texas Disaster Action Response Team, the University of Texas at Austin, and the Williamson County Office of Emergency Management. WRN emergency warnings for various weather events are disseminated through a nationwide emergency alert system known as Wireless Emergency Alerts (WEA).

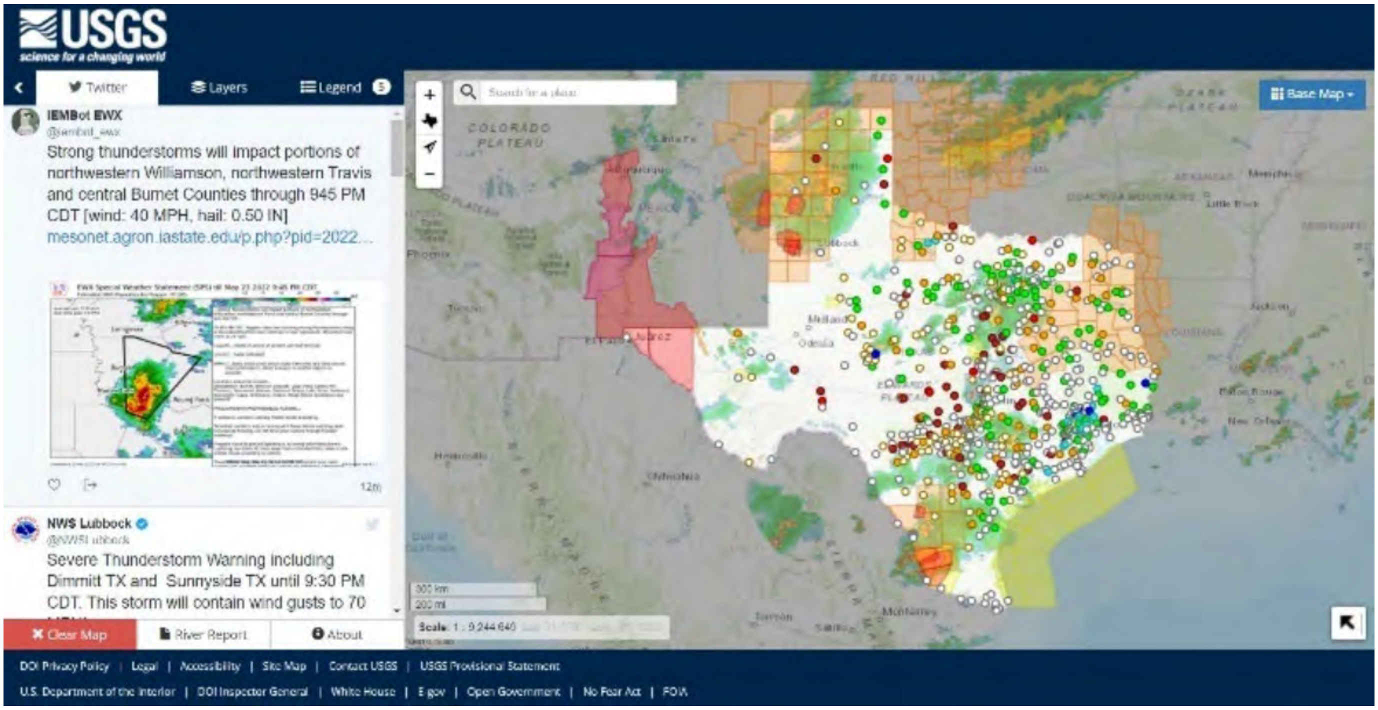
The NWS also administers the StormReady® program, which employs a grassroots approach "to help communities develop plans to handle all types of serve weather" through advanced planning, education, and awareness.[9] Several NWS Water Forecast Offices serve different portions of the Lower Colorado-Lavaca Region.

As noted, the United States Geological Survey (USGS) partners with the NWS to collect and provide access to data used for early warnings of a flood. Notably, the USGS provides the National Water Information System (NWIS) web application, which provides access to real-time and historical surface water, groundwater, water quality, and water-use data collected at approximately 1.5 million sites across all 50 states and territories (*Figure 7.5*). The types of data collected include surface water data such as stream gage height to measure flood stage and streamflow for larger streams, rivers, and reservoirs.[10] The NWIS also ties into real-time weather information. In Texas, the NWIS provides access to 750 "real-time stream, lake, reservoir, precipitation, and groundwater stations in context with current

[7] NWS. Available at: https://www.weather.gov/about/
[8] NWS Weather-Ready Nation. Available at: https://www.weather.gov/wrn/about
[9] NWS StormReady®. Available at: https://www.weather.gov/wrn/collaborate
[10] USGS NWIS. Available at: https://waterdata.usgs.gov/nwis

weather and hazard conditions on both desktop and mobile devices."[11] The data is collected and then disseminated or made available to federal, state and local agencies, public and private utilities, and the public. In Texas, USGS disseminates NWIS data via Twitter at @USGS_TexasFlood and @USGS_TexasRain on current water level and precipitation data during flooding or severe rainfall events.

Figure 7.5 USGS NWIS Texas Water Dashboard [12]



Forecasting and Warnings

The data resources described above are critical inputs to the users of such information, particularly for emergency management personnel and decision-makers, before and during floods. Local emergency managers use the hydrologic and weather data and forecasts derived from such data to decide whether to issue alerts and warnings and whether to mobilize personnel and resources, such as first responders, swift water rescue teams, and personnel and equipment needed for road closures. The NWS and other forecasters use real-time hydrological and weather data as inputs to sophisticated forecasting models to predict where, when, and how much rainfall will likely fall over a given area and for an estimated duration. This forecasting information is then used in predictive models to estimate the stage, discharge, and duration of flood flows at various locations along a receiving stream, river, or reservoir. With this information, along with information about flood hazard areas and exposure information, emergency managers can make informed decisions about when and where impactful flooding can be expected and issue alerts and warnings. Importantly, the NWS data, forecasts, bulletins, alerts, and warnings are

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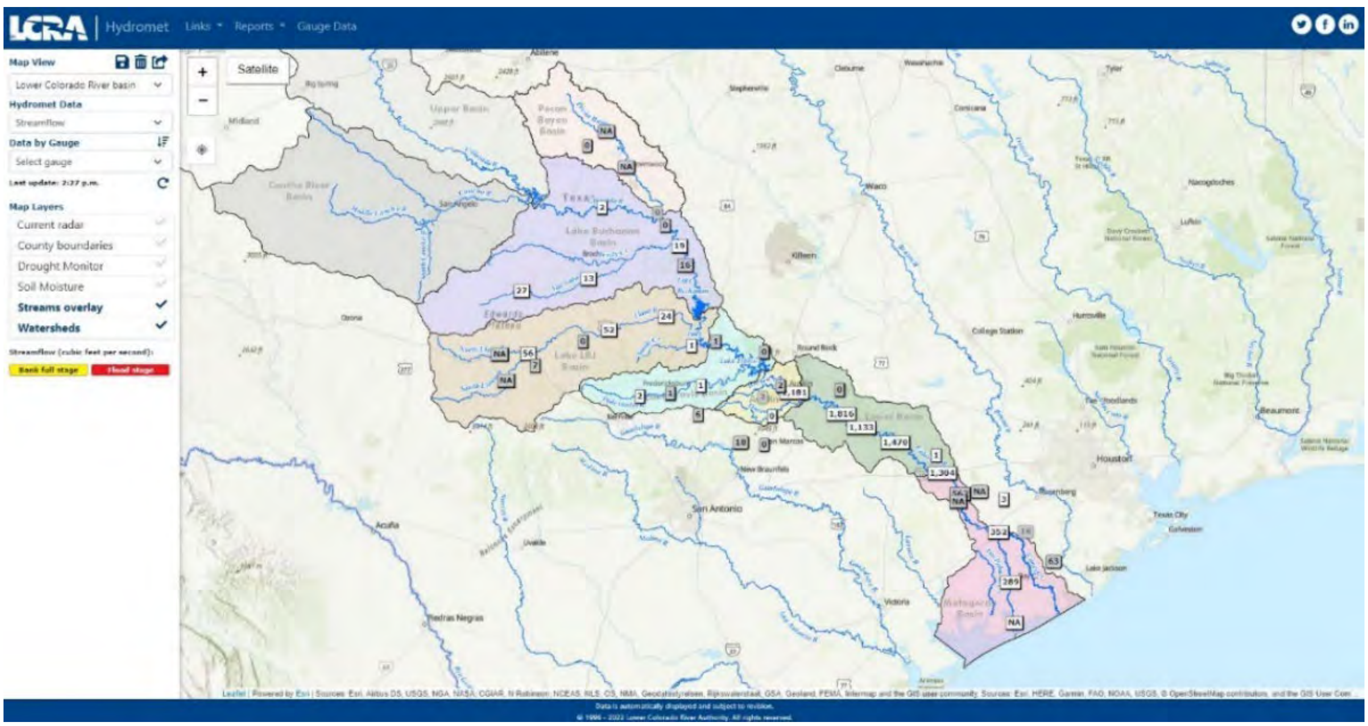
[11] USGS Texas NWIS. Available at: https://waterdata.usgs.gov/tx/nwis/rt
[12] USGS Texas NWIS Dashboard. https://txpub.usgs.gov/txwaterdashboard/index.html

accessible by all state and local jurisdictions, the media, and the public throughout the Lower Colorado-Lavaca Region.

Several entities in the Lower Colorado-Lavaca Region also disseminate flood alerts and warnings, including the Lower Colorado River Authority (LCRA). LCRA's Hydromet (Figure 7.6) network is an early warning system comprised "of more than 380 gauges, including 244 gauges maintained by LCRA, 78 gauges maintained by City of Austin and more than 60 gauges maintained by USGS in cooperation with LCRA, City of Austin and others."[13] The gauges measure hydrological data, including river stage, lake level, and streamflow. It also measures meteorological data such as rainfall, air temperature, and humidity. The data is supplied to the National Weather Service's River Forecast Center in Fort Worth to help forecasters decide whether to issue flood and weather warnings.

Figure 7.6 LCRA Hydromet



During flood events, the hydrologists and engineers in the LCRA River Operations Control Center (ROCC) manage the intensity of flooding downstream by managing the flow of floodwaters through the Highland Lakes system of lakes and dams along the Lower Colorado River. This includes monitoring the dams, lakes, and information provided by the LCRA Hydromet system to understand changing flood risk conditions at their dams and those downstream. This critical information is aggregated and available to anyone who subscribes to LCRA's Flood Operations Notification Service (LCRA FONS). This includes the media, emergency managers, and the public. Notifications are by email, text, and/or recorded phone call and are focused on flood operations of the Highland Lakes system and river flooding conditions downstream of the lakes. LCRA also provides information via floodstatus.lcra.org, in its Flood Operations

[13] LCRA Hydromet. https://hydromet.lcra.org/Faq

Report, on Twitter and Facebook, and on the radio, via the NOAA Weather Radio All Hazards radio rebroadcasts on AM 1610 in the Highland Lakes area and AM 1670 along the Colorado River downstream of Austin.[14]

Another source of information, alerts, and warnings about flooding in a portion of the Lower Colorado-Lavaca Region is the Warn Central Texas service (WarnCentralTexas.org). This is an emergency notification system operated by the Capital Area Council of Governments (CAPCOG), which serves a 10-county area of Central Texas. Much like the LCRA notification system, WarnCentralTexas is a public portal for people to register for a Regional Notification System – a regional emergency and disaster preparedness resource for subscribers.[15] Local jurisdictions in the CAPCOG region generate alerts, warnings, and advisories disseminated through the WarnCentralTexas service via telephone, email, and text. In addition to emergency messages from the local jurisdictions, participants may also receive automated warnings from the National Weather Service for weather events such as tornados, severe thunderstorms, and flash floods.

After devastating floods on the Blanco River in 2015, the Hays County Office of Emergency Services initiated efforts to improve flood monitoring across the county. This resulted in the creation of HaysInformed.com, a new website that provides real-time information on the status of 22 low-water crossings, 10 precipitation gauges, and five monitors on dams along the Blanco River.[16] Public media access to real-time emergency information is provided through the Hays Informed website (haysinformed.com). The Office of Emergency Services also provides a restricted access Hays Informed blog for authorized governmental jurisdictions, including emergency responders, school districts, cities, utilities, and law enforcement.

The City of Austin's Flood Early Warning System (FEWS), which in many respects is state-of-the-art, continuously monitors rainfall, stream water levels and flows, and low water crossings. Their network of gauges includes 130 rain or creek level gauges, flashing lights or automated barricades (at 15 high priority low water crossings), gauge-adjusted radar data, cameras at certain low water crossings, and predictive modeling and mapping.[17] The Austin FEWS, ATX Floods, is interconnected with the much broader LCRA Hydromet system.

It also produces gauge-adjusted radar rainfall measurement data. Additionally, FEWS personnel uses predictive models in real-time during floods for immediate near-term forecasting of when and where

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[14] LCRA Flood Information. Available at: https://www.lcra.org/water/floods/

[15] WarnCentralTexas.org. Available at: https://warncentraltexas.org/

[16] KXAN. Available at: https://www.kxan.com/news/local/hays/hays-county-launches-new-flood-monitoring-website/

[17] City of Austin FEWS. Available at: https://www.austintexas.gov/department/flood-early-warning-system

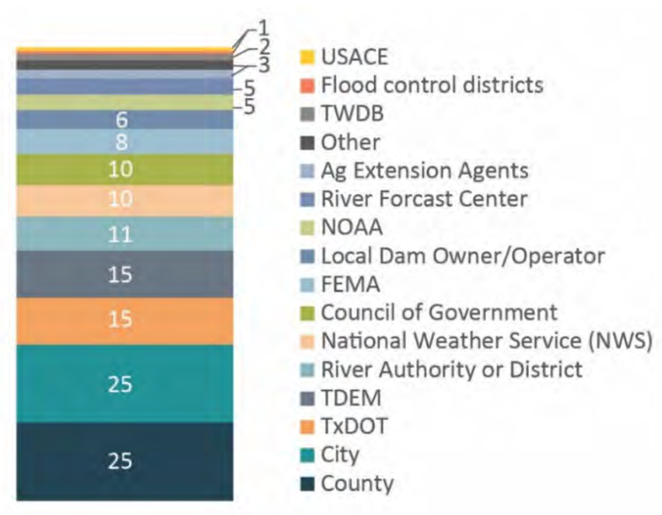
severe stream flooding conditions are expected. The Austin FEWS is maintained and operated by the City's Watershed Protection Department.[18]

The City of Austin FEWS provides essential early warning information, particularly in flash floods where hazardous flooding conditions can develop quickly, and rapid decision-making and emergency response is critical. The City of Austin's FEWS, both its technical capabilities and the personnel that manages the system, are integral to City and Travis County emergency operations immediately before and during flood emergencies. During a flood, FEWS personnel works closely with emergency management decision-makers to provide accurate and timely information and advice about potential flooding in advance of major storms, current real-time conditions, and predictive information about future near-term flooding. This allows for timely decision-making regarding issuing warnings to the public and the media, deployment of first responders, road closures, and evacuations.

Flood Response

Flood response includes those "capabilities necessary to save lives, protect property, and the environment, and meet the basic human needs after an event has occurred."[19] The goal is to rapidly stabilize an incident to save and sustain lives, restore basic human services and community function, and set a foundation for the transition to recovery. Some core components of flood response include planning, multijurisdictional operational coordination, critical transportation, logistics, and supply chain management, among others. Like other components of emergency preparedness, flood response is handled via a myriad of different entities and programs (Figure 7.7).

Figure 7.7 Entities Coordinated with During a Flood Event



[18] City of Austin FEWS. Available at: https://www.austintexas.gov/department/flood-early-warning-system

[19] TWCARMF Emergency Management Guide. Available at: https://www.twcarmf.org/wp-content/uploads/2018/07/TWCARMF-Emergency_Management_Guide.pdf

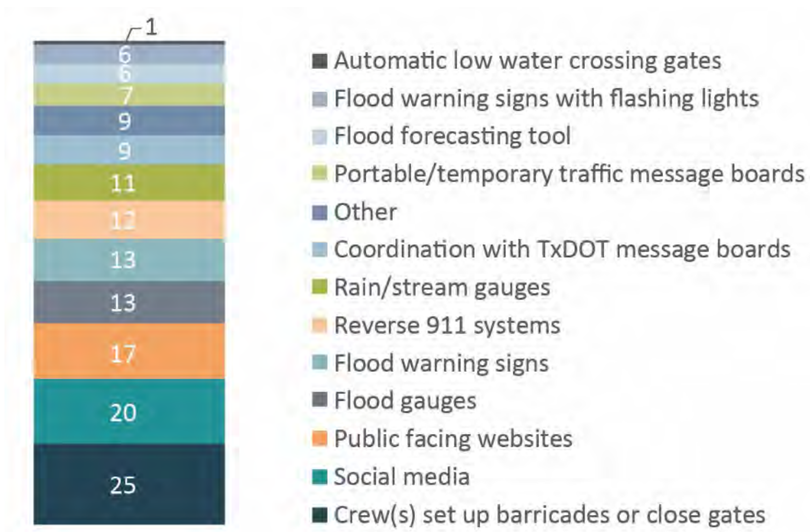
Local Authority

As identified earlier in the roles and responsibilities section of this chapter, in Texas, mayors and county judges serve as emergency management directors. They are responsible for the jurisdiction's emergency management program. In most jurisdictions, these officials appoint an emergency management coordinator to administer the program. The mayor and county judge are authorized by the Texas Disaster Act to declare a local disaster (not to exceed seven days) when conditions exist or when there is an immediate threat, and they do not need the consent of the city council or county commission. During emergencies, local governments are expected to use their own resources first during response operations. If local resources and mutual aid are insufficient, state and federal assistance may be requested.[20]

Emergency Response

Many actions occur as part of state, regional, and local emergency response activities. As indicated in the data collection effort undertaken in the Summer of 2021 (Figure 7.8), respondents in the Lower Colorado-Lavaca Region identified a series of measures they used during emergency response. This included crews setting up barricades or closing gates at low water crossings, disseminating warnings and alerts via social media and public-facing websites, and utilizing flood gauges, warning signs, and reverse 911 systems to warn people about flood risks and dangers. Some of the less used measures included automated low water crossing gates, flood warning signs with flashing lights, and enhanced use of flood forecasting tools.

Figure 7.8 Measures Currently Used for Emergency Response

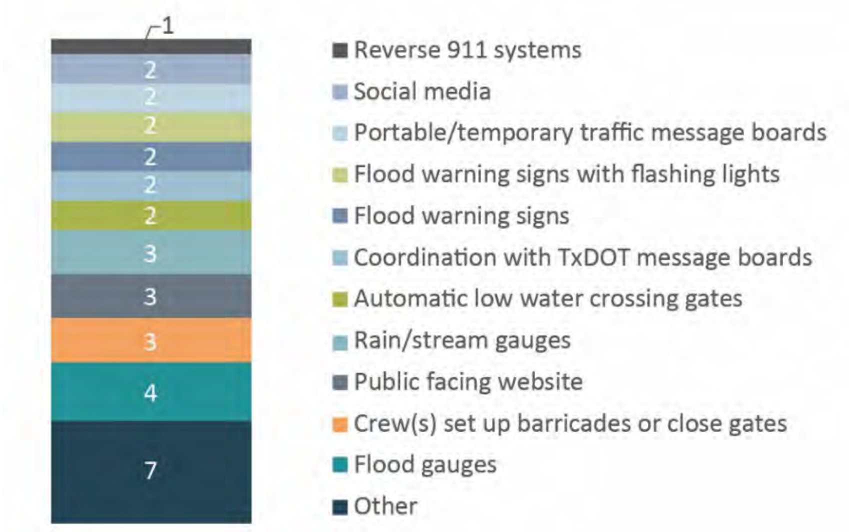


[20] TWCARMF Emergency Management Guide. Available at: https://www.twcarmf.org/wp-content/uploads/2018/07/TWCARMF-Emergency_Management_Guide.pdf

Some jurisdictions have standard operating procedures (SOPs) to guide flood response activities for the deployment of personnel (e.g., the City of Austin) and field operation crews to close roads and the activation of other flood operational responses (e.g., closing the Waller Creek Tunnel).

Moving forward, the same entities identified a series of measures to add to their toolbox to improve their emergency response capabilities in the next five years. These include the establishment of additional flood gauges, adding crews to set up barricades or close gates, and a series of other measures (Figure 7.9).

Figure 7.9 Anticipated Measures to Add to Improve Emergency Response in the Next 5 Years



Flood Recovery

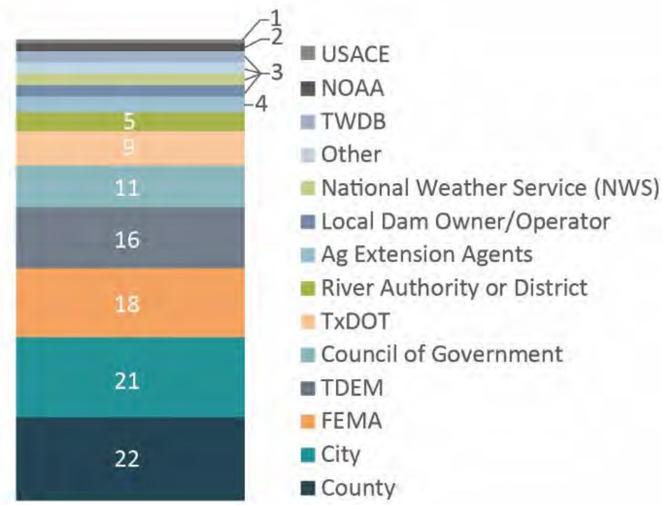
Flood recovery includes those "capabilities necessary to assist communities affected by an incident to recover effectively."[21] Recovery support focuses on the care continuum after the initial emergency response ends. Some core components of flood recovery include planning, economic recovery, health, and social services, longer-term, temporary housing, and infrastructure systems. Some specific activities during flood recovery include debris removal in floodways, clean-up in impacted neighborhoods, and emergency repairs to damaged public infrastructure (e.g., roadway crossings). The City of Austin also sends teams of engineers out to conduct flood damage assessments and collect data such as high water marks, debris lines, and such.

[21] TWCARMF Emergency Management Guide. Available at: https://www.twcarmf.org/wp-content/uploads/2018/07/TWCARMF-Emergency_Management_Guide.pdf

State and Local Recovery

As indicated in the data collection effort undertaken in the Summer of 2021 (Figure 7.10), respondents in the Lower Colorado-Lavaca Region identified a myriad of entities that they coordinated with during flood recovery and clean-up operations.

Figure 7.10 Entities Coordinated with for Flood Recovery and Clean Up



This illustrates that most incidents do not warrant the need for federal assistance. Rather, they are successfully handled at the state and local levels, supported by the assistance of voluntary and private entities. This includes state agencies like TDEM's Recovery and Mitigation Division, and Texas General Land Office (GLO) through their Community Development Block Grant Disaster Recovery (CDBG-DR) and Mitigation (CDBG-Mitigation) funds from the U.S. Department of Housing and Development (HUD), through faith-based organizations, among a myriad of others.[22]

Public Awareness and Education

A critical element of flood emergency preparedness and response is public awareness of flood risks and public education on actions individuals can take in advance of and during floods. In terms of public safety, many factors may determine the number of lives saved or lost when flood disasters occur. One factor is what the community – local government, individuals, businesses, and community organizations – has done to reduce flood risks and prepare for flood emergencies. For example, putting in place plans to evacuate areas threatened by flooding, having properly trained and equipped personnel to control access to high-risk areas (e.g., road closures), or conducting flood rescue operations. A second and often determinant factor is how individuals act or fail to act appropriately during major flood events. Public awareness and education are key to community and individual preparedness and response.

Many governmental and non-governmental entities engage to some degree in flood awareness, flood preparedness, and flood safety outreach and education. For example, and as noted previously, flood risk

[22] Texas Flood. Available at: https://www.texasflood.org/recovery/index.html

awareness, preparedness, and safety messaging are part and parcel of the missions and day-to-day work of many entities in the flood "space" – at the federal level, the National Weather Service, the United States Army Corps of Engineers, the United States Department of Education, the federal Occupational and Safety Administration; in Texas, the Texas Division of Emergency Management, Texas Water Development Board, Texas A&M AgriLife Extension Service; and the Texas Floodplain Management Association, other professional organizations; and many others at the local level and in the private sector. These and many other entities offer flood awareness, preparedness, and safety educational resources, many of which can be easily found and accessed online (tip – search the web for "flood safety education").

Within the Lower Colorado-Lavaca Region, the City of Austin stands out because of the breadth and reach of its flood awareness and flood safety outreach and education programs. Breadth in terms of content and messaging tailored to adult and school-age audiences and their multi-media approach (e.g., broadcast, print, social). Also, the geographic reach of Austin's flood awareness and education efforts is such that a very large portion of the Lower Colorado-Lavaca Region and its population is within the Austin Metropolitan Area regional media market. For example, the "Austin Designated Market Area" in 2022 has a TV Household population of approximately 770,000, including 12 of 43 Lower Colorado-Lavaca Region counties. Combined, these counties represent roughly 90-95 percent of the entire estimated 2019 population of the region. Notably, Travis County (by far the most populous) and several surrounding Hill Country counties lie in the heart of what is commonly known as Flash Flood Alley. Flash Flood Alley is considered the most flash-flood-prone region in North America because of its steep terrain, shallow soils, and periodically high rainfall rates.

Due to the relatively high risk and exposure to flash flooding and its long history and experience with catastrophic flooding with loss of life and widespread property damage, the City of Austin has developed and sustained a comprehensive public outreach and flood awareness campaign and other educational programs. A key goal is to keep flood risk and preparedness messaging front and center in people's minds on an ongoing basis during the often long lapses between major floods, during the spring and fall rainy seasons, and of course, particularly when flooding is imminent or occurring. Another goal is to inform and equip the public, particularly those in flood-prone areas, with actionable information about individual actions to prepare for flooding and minimize risks to personal safety (e.g., Turn Around Don't Drown).

Information about the City of Austin Watershed Protection Department's flood awareness tools and educational resources can be found at www.ATXFloodSafety.com (Figure 7.11). Some of these tools, specifically ATXFloods.com (Figure 7.12) and WarnCentralTexas.org, are described in the previous section of the chapter as they provide real-time information about flood conditions as they occur. Another tool, ATXFloodPro, provides public access to a viewer of floodplain information allowing a property owner or prospective property owner to assess the flood risk of specific parcels. These resources are readily available to other local entities in the Lower Colorado-Lavaca Region and can be used as-is or adapted to local conditions outside the Austin area.

Figure 7.11 ATXFloodSafety.com Website Resources

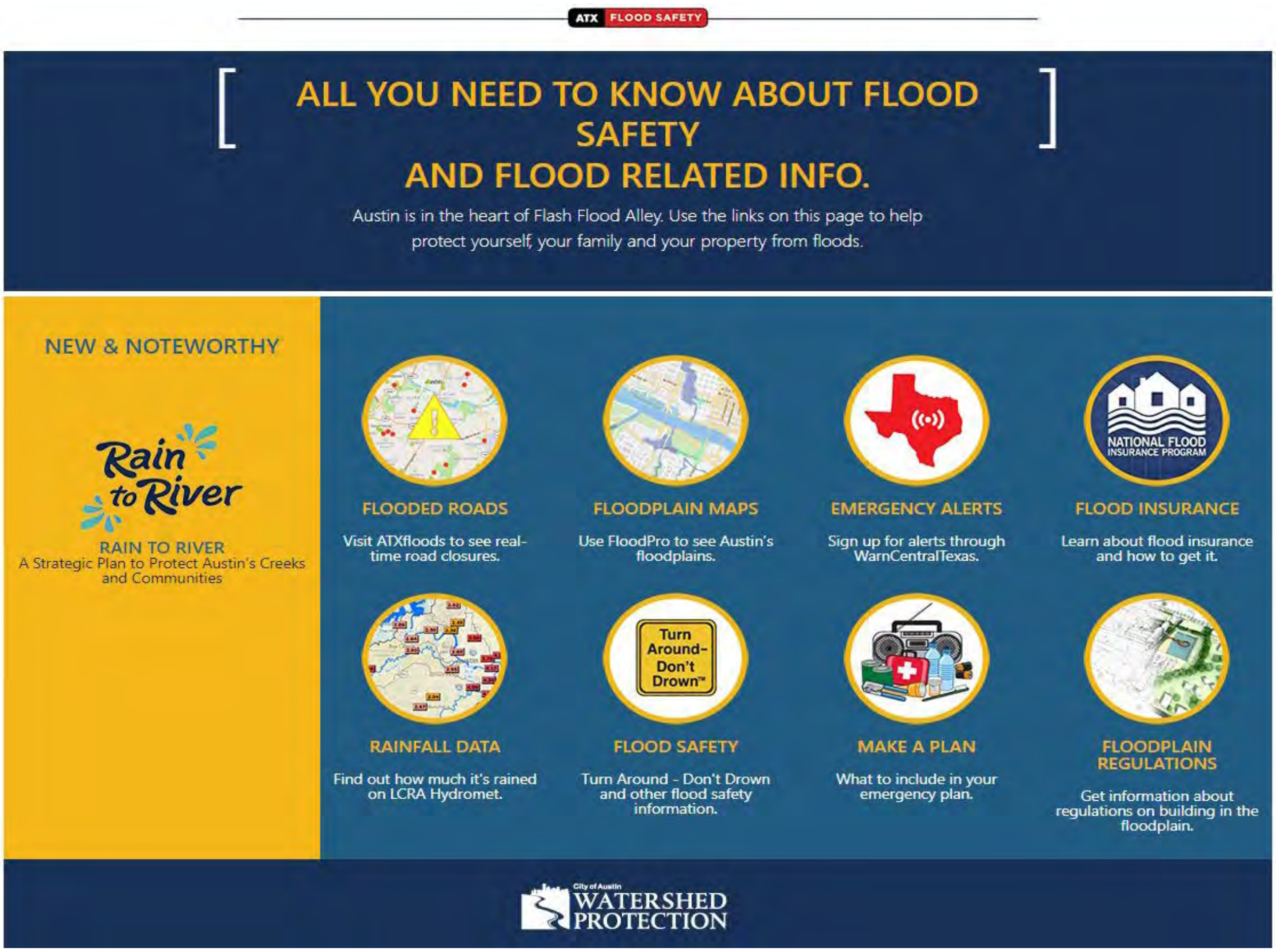
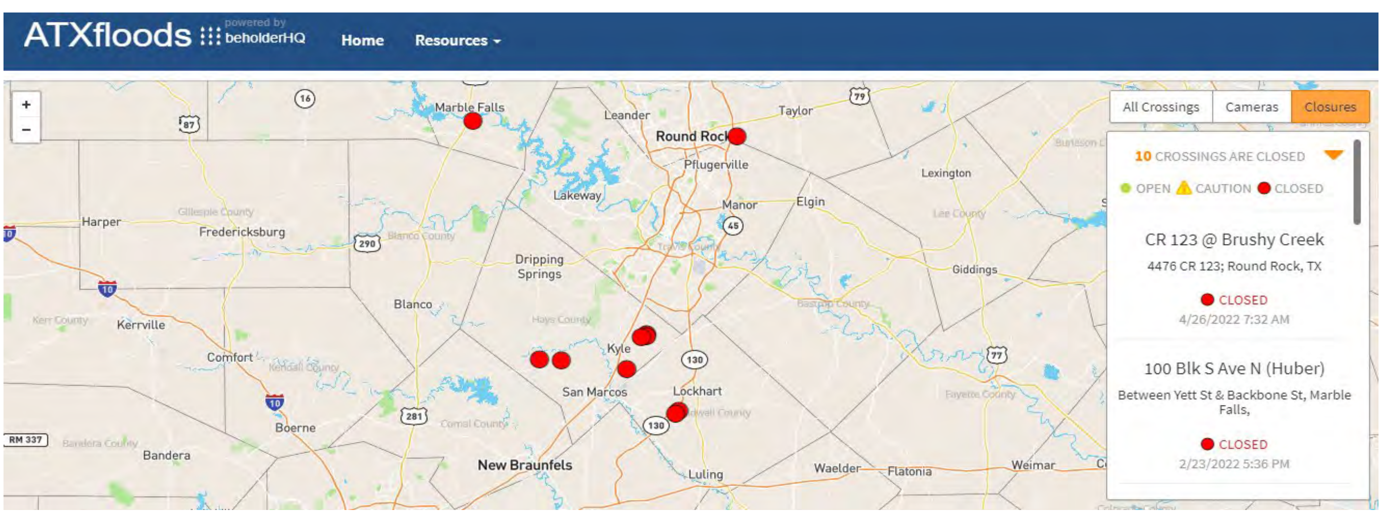


Figure 7.12 ATXFloods.com



The City of Austin also actively engages with the local/regional broadcast media with free and paid advertising (e.g., Turn Around Don't Drown radio spots) during impending or in-progress flood events and through interviews and advisories targeted at broadcast media. Local TV and radio weather forecasters are a particularly effective conduit for disseminating real-time flood information and very often display such information in their live broadcasts. The city also issues press releases and email blasts to subscribers, sponsors an annual "Turn Around Don't Drown" poster contest in public schools, provides in-school presentations on flooding and flood preparedness and offers youth education programs[23] such as Watershed Detectives[24], Earth School,[25] and Earth Camp.[26] (*Figure 7.13, Table 7.2)*

Figure 7.13 Example Advertising and Outreach Campaigns from the City of Austin Watershed Protection Department

Source: City of Austin

[23] City of Austin Youth Education. Available at: https://www.austintexas.gov/department/watershed-youth-education
[24] City of Austin Watershed Detectives. Available at: https://www.austintexas.gov/department/watershed-detectives
[25] City of Austin Earth School. Available at: https://www.austintexas.gov/department/earth-school
[26] City of Austin Earth Camp. Available at: https://www.austintexas.gov/department/earth-camp

Table 7.2 Advertising and Outreach Campaigns from the City of Austin Watershed Protection Department

Campaign	Overview	Timeframe
Flood Safety Campaign	This campaign educates Austin drivers about the dangers of driving through flooded roadways through print, radio, television, social and digital advertising. The campaign runs several times per year, typically during Austin's rainy seasons. The primary theme is "Turn Around Don't Drown," which is promoted widely throughout the U.S.	Mid-May to Mid-June Late Summer/ Early Fall Mid-October to Mid-November
Turn Around - Don't Drown	This campaign focuses on educating school children through an annual Turn Around Don't Drown poster contest. The secondary objective for children is to influence their parents about the dangers of driving across flooded roadways. The campaign is promoted to Austin area art and science teachers through social media and the Austin Watershed Protection Department's Youth Education Programs.	Post Contest: Mid-January to Late March
Floodplain Property Owner Notifications	This campaign includes sending postcards to property owners who own or reside at a property within defined floodplains. The goal is to increase understanding of their risk to potential flooding.	Annually
Safety and Transportation Manager Outreach	This campaign is focused on outreach to emergency and transportation managers in the school districts and charter schools in the Austin area as well as to teachers, parents, students, and school volunteers. The goal is to connect them to established flood preparedness resources like school messaging systems, the Austin Flood Early Warning System (FEWS) email distribution list, ATXFloods, and other regional, state, and federal resources (e.g., the National Weather Service).	Annually
Emergency and Social Media Ads	This campaign is disseminated before and during emergency flooding situations via radio and digital ads and social media promoting ATXfloods.com and real-time information about flooded roads and closures.	Ongoing as Needed

State of Flood Preparedness

Taken as a whole, all of the many topics addressed in this chapter address flood preparedness in one way or another – the national institutional framework for emergency management; established processes and procedures for local, state, and federal disaster declarations; emergency response planning; training of emergency management professionals and first responders; technical professional capabilities needed for advanced warning of impending flooding; and outreach and education about flood risk, safety, and preparedness. Looking at the state of "flood information response and activities" in their entirety for the Lower Colorado-Lavaca Region, it's concluded that the region is well-prepared, in some areas more than others, and always with the potential for improvement. Of particular note from the discussion of flood early warning capabilities and public awareness and education, local entities in the major population center in the region, the Austin Metropolitan Area, have put in place technical and professional capabilities and have other resources that together provide a high level of flood preparedness for a majority of the population of the region, populations that are in areas that are particularly flood-prone. There are already several items of flood preparedness in the central portion of the Lower Colorado-Lavaca Region that local entities in other areas of the region can learn from and build on from their colleagues.

Chapter 8: Administrative, Regulatory, and Legislative Recommendations

Source: Texas Water Development Board

As outlined in the Texas Water Development Board (TWDB) rules and guidelines for regional flood planning, the Regional Flood Planning Groups (RFPG) may adopt recommendations on policy issues related to floodplain management and flood mitigation planning and implementation. Specifically, the RFPGs may adopt:

1. Legislative recommendations are considered necessary to facilitate floodplain management and flood mitigation planning and implementation.
2. Other regulatory or administrative recommendations are considered necessary to facilitate floodplain management and flood mitigation planning and implementation.
3. Any other recommendations that the RFPG believes are needed and desirable to achieve its regional flood mitigation and floodplain management goals.
4. Recommendations regarding potential, new revenue-raising opportunities, including potential new municipal drainage utilities or regional flood authorities, that could fund the development, operation, and maintenance of floodplain management or flood mitigation activities in the Region.

Legislative, regulatory, and administrative recommendations adopted by the Lower Colorado-Lavaca Regional Flood Planning Group follow.

Legislative Recommendations

Some flood-related policy issues require approaches and solutions that require action by the Texas Legislature, either establishing new or amending authorities or programs through statute or new or increased appropriations through the state budget process. *Table 8.1* presents recommendations for flood planning, flood risk mitigation, and funding adopted by the Lower Colorado-Lavaca RFPG that require legislative action.

Table 8.1 Legislative Recommendations

ID Number	Recommendation	Rationale for Recommendation
8.1.1	Extend Local Government Code, Title 13, Subtitle A, Chapter 552 to allow counties to establish drainage utilities and collect drainage utility fees in unincorporated areas.	Municipalities in Texas have the statutory authority to establish public utilities to provide various services to their residents, including drainage. Municipal public utilities can assess and collect user fees to fund operations and maintenance for land acquisition and implement drainage improvement and flood risk reduction problems. By comparison, counties in Texas have floodplain, drainage, and flood mitigation responsibilities but do not currently have the authority to establish drainage utilities. This limits the ability of counties to self-finance flood mitigation and drainage projects and provide adequate ongoing maintenance of drainage and flood mitigation infrastructure.
8.1.2	TWDB should investigate legal impediments and potential legislative or other remedies to the use of local government funds for the elevation and/or floodproofing of privately-owned structures at-risk of severe flooding.	Elevation and/or floodproofing of existing at-risk structures may be preferable to buyouts or other flood risk reduction measures in some situations (e.g., less cost, avoids displacement, no ongoing O&M). However, local entities in Texas cannot use local funds to improve private properties. Local entities can use local resources to assist with implementing FEMA-funded elevation/floodproofing projects, but they cannot directly contribute to local funding. By comparison, municipalities in Texas do have the legal authority to expend local funds to purchase and remove privately-owned structures at risk of flooding, the primary difference being that the local entity owns the property in question and therefore retains the public benefits in perpetuity.

ID Number	Recommendation	Rationale for Recommendation
8.1.3	Establish and provide state budget appropriations and/or assess fees to fund the implementation of a levee safety program similar to the TCEQ dam safety program.	Levees are typically designed and constructed to meet specific standards for FEMA certification under the NFIP. However, unlike dams, there is no state levee safety program, even though levee failures may pose a significant flood risk to the assets they are intended to protect.
8.1.4	Enact legislation updating the state building code to a more recent edition (e.g., the 2018 edition of the International Building Code and International Residential Code).	Without a current mandatory state building code, local entities in Texas do not score competitively for some federal funding programs, such as FEMA's Building Resilient Infrastructure and Communities (BRIC) Grant.
8.1.5	Provide ongoing state appropriations to the TWDB for additional grant funding for Regional Flood Planning Groups to continue functioning during the interim between planning cycles.	It is important that momentum gained in the first regional flood planning cycle be maintained in the interim between planning cycles. Additional ongoing funding would enable the RFPGs to continue to meet and function; conduct ongoing public and stakeholder outreach and engagement thin their respective regions; consider additional FMEs, FMPs, and/or FMSs that may be identified; amend the Regional Flood Plan as needed, and allow RFPGs to implement RFPG-sponsored activities and programs (e.g., a targeted outreach, and technical assistance program to local entities for enhanced floodplain management and floodplain and land use regulation).
8.1.6	Increase state funding and technical assistance to develop accurate watershed models and FEMA Flood Insurance Rate Maps (FIRMs). The TWDB should consider mapping updates as a high priority for future flood planning grants through the Flood Infrastructure Fund.	Accurate floodplain models and maps are essential to effective floodplain management and are a prerequisite for thorough evaluations of flood risk and evaluating flood risk reduction measures. Many local entities that participate in the NFIP or are eligible to participate lack FEMA Flood Insurance Rate Maps (FIRM) or are using outdated maps. Grant funding and technical assistance are available through the FEMA Cooperating Technical Partners (CTP) Program, administered by the TWDB and the City of Austin within the Lower Colorado-Lavaca Region. The TWDB also funds watershed modeling and mapping studies through the Flood Infrastructure Fund (FIF). Additional funding is needed for these recommended Flood Management Evaluations, of which seven (7) are included in the Lower Colorado-Lavaca Regional Plan.

ID Number	Recommendation	Rationale for Recommendation
8.1.7	Establish and fund a state program to assist counties and cities with assessing and prioritizing low water crossings. Funding should also be provided on a cost-sharing basis to implement structural and/or non-structural flood risk reduction measures at high-risk, low water crossings. The design of improvements to reduce roadway crossing risk should consider potential environmental impacts and measures to minimize impacts, particularly impact to aquatic ecosystems, including the plant and animal species that depend on those ecosystems.	An estimated 1,354 low water roadway crossings (LWC) are within the Lower Colorado-Lavaca Region. Many of these crossings experience frequent flooding but may have relatively minor flood risk in terms of public safety and/or the integrity of the roadway. Others, however, are at high-risk and experience flood depths and velocities that pose a significant risk. While there are some historical records of fatalities and other public safety issues at some LWCs, much of the available information is anecdotal, and the risk has not been fully assessed. Furthermore, the cost to mitigate flood risk at high-risk LWC with structural solutions (e.g., bridges) is typically very high and often prohibitive. Therefore, it is important that the flood risk at LWCs be systematically and fully evaluated to prioritize those LWCs needing mitigation, either through structural or non-structural (e.g., closures, reverse 911 notifications) measures. This program could be implemented by TxDOT, TDEM, and/or TWDB independently or in collaboration with one another. Note that this recommendation is a companion to a Flood Management Strategy included in the Lower Colorado-Lavaca Regional Plan. Additionally, there are 48 FMEs and 15 FMPs that are recommended in the Lower Colorado-Lavaca Regional Plan that address high-risk LWCs.
8.1.8	Consider establishing property tax incentives to protect stream corridors by private landowners.	The Lower Colorado-Lavaca RFPG has recommended a regional Flood Management Strategy (FMS) to encourage collaboration among governmental and non-governmental organizations and private property owners to undertake voluntary actions to protect, manage, and restore stream corridors, particularly in rural areas. This strategy complements another regional FMS focused on encouraging the adoption of higher or enhanced floodplain and land development standards and regulations, which could include the protection of stream corridors within urban areas. This recommendation establishes a new special tax assessment category (a property tax exemption) to protect stream corridors on qualified agricultural land. This is envisioned to be similar to current state law, allowing the agricultural appraisal of land used to manage wildlife.

Regulatory and Administrative Recommendations

Other flood-related policy issues will not require legislative action but could be addressed through state agency regulations or administrative actions promulgated or taken under existing statutory authority and implemented with existing and/or increased state agency resources. *Table 8.2* presents recommendations adopted by the Lower Colorado-Lavaca RFPG that involve administrative and/or regulatory action by one or more state agencies.

Table 8.2 Regulatory and Administrative Recommendations

ID Number	Recommendation	Rationale for Recommendation
8.2.1	The TWDB should actively promote the establishment of local drainage utilities, where appropriate, to provide a stable and predictable funding source through assessing drainage fees and to support ongoing operations and maintenance (O&M) of existing flood mitigation and other drainage infrastructure. This should include the provision of technical assistance with the creation of local drainage utilities.	State law (Local Government Code, Title 13, Subtitle A, Chapter 552) allows municipalities to establish local drainage utilities. This included assessment of fees to support drainage utility operations, including administration of floodplain management and implementation and enforcement of floodplain and drainage regulation, and self-finance investments in structural and non-structural flood risk reduction infrastructure. Having a stable and predictable funding source is conducive to long-range planning and the timely development and implementation of flood risk reduction projects. Without creating a drainage utility, local governments typically fund floodplain management and regulatory programs, O&M of drainage, and flood risk reduction infrastructure with general tax revenues and/or municipal bonds secured and serviced with local tax revenues. At present, only three municipalities in the Lower Colorado-Lavaca Region have established a drainage utility, one of which, the City of Austin, encompasses a large portion of the population of the Lower Colorado-Lavaca Region. It is recognized, however, that not all municipalities require or are well-suited to establish drainage utilities, as there is overhead associated with the administration of such utilities. Municipalities best suited to drainage utilities are typically larger communities, communities with extensive networks of aging drainage infrastructure, and communities experiencing high growth and development levels.

ID Number	Recommendation	Rationale for Recommendation
8.2.2	TxDOT should employ roadway design criteria to require all new and reconstructed state roadways to be designed and constructed, to the extent practicable, at elevations at or above the 1% annual chance event water surface elevation. TxDOT should also consider future conditions, such as urbanization and climate variability, in its roadway design criteria for drainage and flood risk reduction.	TxDOT is not a participant in the NFIP and does not, in all cases, design roadways in a manner consistent with minimum NFIP requirements. It is recognized that, by their nature, it is often not feasible or practicable to design and construct roadways to provide a level of flood protection equivalent to or greater than the 1% annual chance storm event (100-year) event. However, concerning policy and practice, TxDOT should strive to meet this standard.
8.2.3	Revise the scoring criteria for funding associated with stormwater and flood-related projects that benefit agricultural and/or rural areas.	Commonly used benefit-cost analysis methods and tools skew towards protecting the high-value public and private assets, those typical of urbanized areas. In terms of benefit versus cost, projects that reduce flood risk to agricultural and/or rural assets do not compare/compete well with projects benefiting urban areas.
8.2.4	The TWDB should continue to include and refine its criteria for evaluating and ranking applications for financial assistance for flood risk mitigation studies and projects, considerations of social vulnerability (SVI scores), and other social, economic, and environmental resilience and sustainability measures. This should include modifying the benefit-cost methodology to account for such factors rather than relying solely on traditional measures of benefit (e.g., avoidance of flood losses to property, the value of infrastructure to be constructed, etc.).	In the first round of funding from the Flood Infrastructure Fund, The TWDB requested information and consideration about the social vulnerability and the socioeconomic attributes of the populations of areas for which funding is being sought. Other TWDB programs also consider such factors (e.g., the Economically Distressed Areas Program, commonly known as the colonias program). This is important as many local entities have a limited ability to self-finance flood risk reduction measures and serve economically disadvantaged populations with relatively low resilience in terms of recovering from flood damages.

ID Number	Recommendation	Rationale for Recommendation
8.2.5	Provide direct technical assistance to economically distressed communities and/or those with high social vulnerability by preparing funding applications for federal and/or state financial assistance for flood planning and implementing flood risk reduction measures.	Currently available federal and state financial assistance programs for flood planning and developing and implementing flood risk reduction measures often require significant effort and specialized technical capabilities to prepare applications for financial assistance. Smaller entities, those considered economically distressed, and those with high social vulnerability typically lack the staff resources, expertise, or funds to hire consultants to develop and compile the information required for funding applications.
8.2.6	Reduce or eliminate barriers to and provide incentives for the planning, funding, and implementing inter-jurisdictional flood risk reduction measures, either structural and/or non-structural.	Flooding occurs within watersheds and does not recognize jurisdictional or political boundaries. Through interlocal agreements and other mechanisms, local entities can collaborate and share the costs of implementing flood management activities and flood risk reduction projects. This should be encouraged and perhaps incentivized by the state. The TWDB and other state agencies should evaluate and take action, as appropriate, to reduce or eliminate barriers to and/or implement measures to encourage and incentivize greater inter-jurisdictional collaboration (e.g., added points in TWDB's project scoring/ranking).

ID Number	Recommendation	Rationale for Recommendation
8.2.7	In collaboration with FEMA, other state agencies, and professional organizations (e.g., ASCE, TFMA), the TWDB should expand its flood-related professional education, training, and technical assistance programs and activities. This should include targeted outreach and technical assistance to entities not currently participating in the NFIP and to participating NFIP communities needing or interested in adopting higher floodplain management and floodplain, drainage, and land use regulations. In delivering such services, consideration should also be given to partnering with and providing funding support to RFPGs to deliver professional education, training, and technical assistance. Also, see Regulatory and Administrative Recommendation 8.2.9.	The TWDB, FEMA, other state agencies, and other organizations (TFMA) each support professional education, training, and technical assistance programs. The audience for these programs is typically elected and professional local officials, particularly those lacking the knowledge, expertise, and resources required to implement effective floodplain management practices and other preventative measures. Communities that are not NFIP participants may not fully understand the benefits of joining the NFIP. Cities and counties may not fully understand their current authority to establish and enforce higher floodplain management and land development standards over and above NFIP minimums.

ID Number	Recommendation	Rationale for Recommendation
8.2.8	Allow small communities to benefit from the TWDB Flood Infrastructure Fund (FIF) incentives for green and nature-based projects by 1) working with the Texas Municipal League, Texas Association of Counties, and Texas Floodplain Management Association to train community officials on the basics of Low Impact Development (LID) and Green Stormwater Infrastructure (GSI); 2) developing model ordinances for use by small communities in establishing LID and GSI regulations, such as green street design standards; 3) publicizing and assisting RFPGs in publicizing successfully implemented GSI projects; 4) adjusting cost-benefit analysis calculations as needed to include environmental values; and 5) by setting aside a percentage of FIF funds for smaller communities that may not be able to otherwise meet FIF incentives for green and nature-based projects.	There are various terms and concepts that are used to describe and characterize “green and nature-based" approaches to flood risk reduction. One such term is Low Impact Development (LID), which the U.S. EPA defines as “systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration, or use of stormwater to protect water quality and associated aquatic habitat.” Further, LID is “...an approach to land development (or re-development) that works with nature to manage stormwater as close to the source as possible”. EPA also uses the term Green Infrastructure (GI) “...to refer to the management of wet weather flows that use these processes, and to the patchwork of natural areas that provide habitat, flood protection, cleaner air, and cleaner water.” Green Stormwater Infrastructure (GSI) is a related concept that typically refers to engineered systems that “...are designed to mimic nature and capture rainwater where it falls.” LID, GI, and GSI practices are often focused on the protection of water quality but can also contribute flood risk reduction.
8.2.9	The TWDB should include consideration of existing and scheduled Watershed Protection Plans (WPPs) in applications for financial assistance for flood risk mitigation studies and projects.	Watershed Protection Plans work to reduce the impact of floods, erosion, and water pollution and often propose environmental solutions outside of the floodplain. Including recommendations from a WPP when evaluating requests for financial assistance for FMSs and FMPs would ensure that the proposed flood mitigation activity integrates with solutions to water quality problems that can occur across multiple jurisdictions.

Flood Planning Recommendations

The first regional flood planning process has been a learning experience for all involved – the TWDB, RFPGs, sponsors, technical consultants, and the public. It is important that lessons learned be captured and, as appropriate, incorporated into the TWDB rules and guidance for regional flood planning to improve the process as we advance into the second planning cycle. *Table 8.3* below presents the Lower Colorado-Lavaca RFPG recommendations pertaining to potential improvements in the regional flood planning process. Additionally, the Lower Colorado-Lavaca RFPG recommends that the TWDB convene a series of lessons-learned workshops, at or near the conclusion of the first regional flood planning cycle, in various areas of the state to obtain feedback from the RFPGs, sponsors, and technical consultants.

Table 8.3 State Flood Planning Recommendations

ID Number	Recommendation	Rationale for Recommendation
8.3.1	Use consistent Hydraulic Unit Code (HUC) reporting requirements throughout the TWDB-required tables.	The RFPG Guidance requires HUC-8 in some tables, HUC-10 in other tables, and HUC-12 in other tables. Some tables require multiple HUCs to be provided. The RFPG recommends that the TWDB require HUC-8 in all TWDB-required tables for consistency and to correspond to FEMA's base level watershed planning spatial granularity.
8.3.2	Use FEMA's Social Vulnerability Index (SVI) instead of the CDC SVI in future planning cycles. SVI should not be the primary component considered when allocating funding.	FEMA's SVI is reasoned to be more directly relevant to flood resiliency and flood risk reduction than the CDC's SVI.
8.3.3	Clarify the phrase "flood-related authorities or entities," what local and regional governmental entities are included, and which are not.	The phrase is used in the TWDB planning documents multiple times and is a central part of *Chapters 1* and *10*. The TWDB originally provided the RFPG with a list of entities thought to have flood-related responsibilities. During the outreach efforts, many of those entities communicated they did not have flood responsibilities and did not believe they should be included in the regional flood planning effort. Note, however, that some political subdivisions of the state, such as water control and improvement districts (WCID) or municipal utility districts (MUD), do have authority to develop and maintain drainage and other related infrastructure, such as stormwater conveyance systems and detention facilities.

ID Number	Recommendation	Rationale for Recommendation
8.3.4	Clarify the distinction between flood mitigation and flood infrastructure and what is more commonly considered as drainage infrastructure.	Many local entities, for example, municipal utility districts, have drainage responsibilities, particularly with respect to the development of land within their jurisdictions and the maintenance of drainage infrastructure, such as storm drain systems. These entities may or may not also develop what might be considered flood risk reduction infrastructure. Also, most local drainage problems and deficiencies in local drainage infrastructure are very localized and sometimes cause what can be characterized as “nuisance” flooding rather than posing significant risk and exposure to people and property. In future planning cycles, it would be helpful to delineate this distinction as best as possible. For example, the TWDB guidance regarding flood exposure and vulnerability could be refined to better emphasize identifying and mitigating significant risks to public safety, property, and public infrastructure.
8.3.5	Streamline the data collection requirements, specifically those identified in *Chapter 1*. Focus on collecting the most useful data for the regional flood plan development.	This first round of regional flood planning revealed that very few local entities collect and maintain data and information prescribed by the TWDB for use in the planning process. This is particularly the case with data available in a digital geospatial format. Also, some required data (e.g., drainage infrastructure) was not available, is of questionable value in the planning process, and is generally unavailable. As noted in the previous recommendation, most problems associated with drainage infrastructure do not present significant flood risk and are best characterized as nuisance flooding.
8.3.6	Update the scope of work, guidance documents, rules, checklists, etc., based on the clarifications, interpretations, and adjustments made during the first regional flood planning cycle.	During the first cycle of the State Flood Plan, multiple amendments, additions, interpretations, clarifications, and adjustments were made to the TWDB requirements and guidance. As appropriate, these adjustments should be incorporated into TWDB requirements and guidance documents for the second regional flood planning cycle.

ID Number	Recommendation	Rationale for Recommendation
8.3.7	Reassess and relax, as appropriate, requirements for potentially feasible Flood Mitigation Projects (FMP) that present impediments to the inclusion of FMPs in regional flood plans.	A significant number of potentially feasible FMPs were required to be developed and included in the regional flood plans as Flood Management Evaluations (FMEs) due mostly to a lack of required data and information, such as cost estimates or benefit-cost analysis. Otherwise, many local entities that have requested or supported the inclusion of their projects in the regional flood plan have identified a “preferred” solution to a flooding problem and intend to proceed with implementation at some point in the future. In addition to resulting in the “downgrade” of some potential FMPs to FMEs, such deficiencies could result in lower scores and rankings when considered for TWDB financial assistance. Overall, the information required for FMPs is more detailed than one might expect for flood planning on a regional scale.
8.3.8	Provide applicable data sources and a methodology to determine infrastructure functionality and deficiencies for use in the next regional flood planning cycle. Consider the lack of readily available local data when developing the methodology.	Most entities do not have information regarding the functionality and deficiency of their flood and drainage infrastructure. Some fields in the tables required by the TWDB require data that is not generally readily available without extensive fieldwork (e.g., mapping, conditions assessments, risk/consequence of failure, etc.).
8.3.9	Include the reimbursement of costs for all pertinent and justified needs associated with conducting RFPG meetings and other meetings (e.g., RFPG committees, public meetings). An example is costs for audio and visual equipment purchases or rentals needed to conduct virtual and/ or hybrid meetings.	Some RFPGs have had to rent or purchase A/V equipment to conduct virtual/hybrid meetings in a manner that conforms with the Texas Open Meetings Act requirements. Given the large geographic areas spanned by the flood planning regions and the availability of technology for virtual/hybrid meetings, many RFPG members prefer not to travel to attend meetings. Virtual/hybrid meetings also increase public and entity participation opportunities in the regional flood planning process. Expenses incurred to conduct virtual/hybrid meetings in a manner compliant with the Open Meetings Act should not have to be absorbed by RFPG sponsors.

ID Number	Recommendation	Rationale for Recommendation
8.3.10	Include a soil scientist representative from the Texas State Soil and Water Conservation Board (TSSWCB) as a nonvoting member of each Regional Flood Planning Group.	TSSWCB soil scientists work with communities to prepare Watershed Protection Plans. They participate in coordinated frameworks for implementing water quality protection and restoration strategies. Their input can help the RFPG to take a wider view to identify appropriate flood mitigation solutions, both structural and non-structural, especially Nature Based Solutions.
8.3.11	Add a requirement in *Chapter 6* of the Regional Flood Plan for a map or maps illustrating existing and scheduled Watershed Protection Plans from the Texas State Soil and Water Conservation Board.	Including a map or maps showing the completed and in-progress WPPs as part of *Chapter 6* emphasizes the importance of coordinating the work of regional flood planning and regional water planning. Flood mitigation efforts and water quality solutions should be aligned to protect unimpaired water bodies from pollution and restore polluted water bodies as well as protect people and property from flooding.

Chapter 9: Flood Infrastructure Financing

Source: Texas Water Development Board

The Texas Water Development Board (TWDB) requires that each Regional Flood Planning Group (RFPG) conduct a survey to assess and report on how Sponsors propose to finance recommended Flood Management Evaluations (FME) and Flood Management Strategies (FMS) and Flood Mitigation Projects (FMP). The objective of the survey is to gain an understanding of the funding needs of Sponsors. The RFPG also provides recommendations on the state's role in financing recommended FMEs, FMSs, and FMPs.

The following sections present an overview of common funding sources for flood mitigation planning, projects, and other flood management efforts, the methodology and results of the financing survey, and recommendations of the Lower Colorado-Lavaca RFPG regarding the state's role in financing flood-related activities and infrastructure. The Lower Colorado-Lavaca RFPG has also adopted several recommendations pertaining to state funding of various specific activities. A recap of these recommendations can be found at the conclusion of this chapter as well as in *Chapter 8: Administrative, Regulatory, and Legislative Recommendations*.

Sources of Funding for Flood Management Activities

Historically in Texas and throughout the United States, the largest share of governmental expenditures for and investments in flood-related activities and drainage and flood infrastructure has been borne by local entities. In a general sense, providing drainage services and mitigating local flood risk is typically a local responsibility and function, much like streets and public safety. However, both the state and federal governments play an important and increasingly important, and sometimes critical role, particularly in financing local and regional flood infrastructure. Historically, at the national level, the federal government has been a primary source of funding for large-scale flood control projects, in some cases providing up to 100 percent of the costs. Examples include large dams and reservoirs that provide large volumes of flood storage, such as Mansfield Dam and Lake Travis, the extensive levee systems and other water control infrastructure along major rivers, flood conveyance, protection of urban areas and agricultural resources, and to protect and improve navigation. Over time the extent of federal funding support has declined as a share of total needs. As flood risk has grown over time with population growth and urbanization, and now with the added uncertainty and risk associated with a changing climate, rainfall patterns specifically, the need for federal and state assistance is greater now than ever and is increasing.

Generally, larger urban communities bear much or even all the costs for flood and stormwater-related activities, such as floodplain management and regulation and developing and implementing flood risk reduction projects, both structural and non-structural. Smaller communities, particularly those in rural areas with a limited tax base, often struggle to fund flood-related activities and projects as those needs compete with other needs for basic services. A combination of increased local capabilities to self-fund flood-related activities and projects and increased funding from state and federal sources are needed to address the flood risk reduction needs identified through this regional planning process and documented in this plan. State funding is particularly needed to provide greater access to funding for small, rural communities, incentivize high-priority projects, bridge gaps that may impede the implementation of needed projects, and improve access to federal funding sources.

Counties and cities in Texas have commonly used various methods and sources to fund and finance flood-related activities and infrastructure. This includes local, state, and federal sources. This section discusses some of the most common methods used by local entities to generate revenue and describes various state and federal financial assistance programs available to Texas communities for flood-related activities and projects. *Table 9.1* provides an at-a-glance overview of local, state, and federal funding methods and sources. Each source of funding is characterized according to three key parameters: first, which state and federal agencies are involved, if applicable; second, whether they offer grants, loans, or both; and third, whether they provide regularly occurring or ongoing funding opportunities or are only available after a flood disaster. It is important to note that the general public cannot access state and federal financial assistance programs directly. Local governments must apply on behalf of their communities to receive and use state and federal funding for flood-related activities and projects.

Local Funding

Through the RFPG's initial outreach efforts, the Lower Colorado-Lavaca RFPG sought to understand the landscape of local funding for flood-related programs and projects in the region. Many communities, particularly smaller and more rural communities, have reported lacking local funding sources for flood risk reduction, including studies to fully assess local flood risks, floodplain management activities, and flood risk reduction infrastructure. Those communities that reported local funding indicated the following primary sources: general fund (taxes); dedicated fees, such as impact and stormwater or drainage utility fees; and bonds (i.e., debt financing).

This section focuses on the funding mechanisms available to municipalities and counties, as nearly all of the Sponsors of recommended FMEs, FMSs, and FMPs are these types of entities. Special purpose districts are briefly discussed as there may be opportunities to create more such districts in the Lower

Colorado-Lavaca Region. This chapter does not discuss funding avenues for other types of local and regional entities, such as river authorities.

Counties and cities in Texas derive general fund revenues primarily from sales and property taxes and perhaps certain types of fees. The general fund is typically the primary source of revenue available to support governmental administration and various local services, such as public safety, parks, libraries, and street maintenance. Due to demands on general revenue funds for such services and local governmental functions, there is little of what might be considered discretionary funding available for drainage and flood infrastructure.

Table 9.1 Common Sources of Flood Infrastructure Funding in Texas

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
Federal	FEMA	TDEM	Hazard Mitigation Grant Program (HMGP)	G	-	D
Federal	FEMA	TWDB	Flood Mitigation Assistance (FMA)	G	-	-
Federal	FEMA	TDEM	Building Resilient Infrastructure and Communities (BRIC)	G	-	-
Federal	FEMA	TCEQ	Rehabilitation of High Hazard Potential Dam Grant Program (HHPD)	G	-	-
Federal	FEMA	*TBD*	Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM)	-	L	-
Federal	FEMA	TDEM	Public Assistance (PA)	G	-	D
Federal	HUD	GLO	Community Development Block Grant – Mitigation (CDBG-MIT)	G	-	D
Federal	HUD	GLO	Community Development Block Grant Disaster Recovery Funds (CDBG-DR)	G	-	D
Federal	HUD	TDA	Community Development Block Grant (TxCDBG) Program for Rural Texas	G	-	-
Federal	USACE	-	Partnerships with USACE, funded through Continuing Authorities Program (CAP), Water Resources Development Acts (WRDA), or other legislative vehicles*	-	-	-
Federal	EPA	TWDB	Clean Water State Revolving Fund (CWSRF)	G**	L	-
State	-	TWDB	Flood Infrastructure Fund (FIF)	G	L	-
State	-	TWDB	Texas Water Development Fund (Dfund)	-	L	-
State	-	TSSWCB	Structural Dam Repair Grant Program	G	-	-

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
State	-	TSSWCB	Operation and Maintenance (O&M) Grant Program	G	-	-
State	-	TSSWCB	Flood Control Dam Infrastructure Projects - Supplemental Funding	G	-	-
Local	-	-	General fund	-	-	-
Local	-	-	Bonds	-	-	-
Local	-	-	Stormwater or drainage utility fee	-	-	-
Local	-	-	Special-purpose district taxes and fees	-	-	-

**Opportunities to partner with USACE are not considered grant or loan opportunities but shared participation projects where USACE performs planning work and shares in the cost of construction.*
***The CWSRF program offers principal forgiveness, similar to grant funding.*

Dedicated fees such as stormwater or drainage fees are another option for local flood-related funding. Municipalities in Texas can establish a stormwater utility (sometimes called a drainage utility), which allows for assessing fees for drainage services. This approach has advantages in providing a stable dedicated funding source for flood/drainage-related programs and drainage and flood infrastructure. However, as reported in *Chapter 3: Floodplain Management Practices and Flood Protection Goals*, at present, only three cities in the Lower Colorado-Lavaca Region have established a stormwater utility. Note that this option is not currently available to counties. Impact fees are another potential source of local funding for flood-related efforts. Such fees are assessed on new development and are used to offset a portion of the cost of the public drainage infrastructure required by the new development.

Creating special districts is another approach to generating local funds to support flood-related activities and infrastructure. Special districts are political subdivisions of the state, typically established to provide specific types of services, such as water supply, wastewater collection and treatment, drainage, and/or sanitation) within a defined geographic area. Types of special districts include Water Control and Improvement Districts (WCID), Municipal Utility Districts (MUD), Special Utility Districts, Public Utility Authorities (PUA), Drainage Districts (DD), and Flood Control Districts (FCD). Each of the different types of districts are governed by different state laws or district-specific enabling statutes, which specify the process for creating a district as well as its duties, powers, and sources of revenue. Districts can be created by various means: the Texas Legislature, the Texas Commission on Environmental Quality, county commissioners' courts, or city councils. Depending on the type of district, the districts may be able to raise revenue through taxes, fees, and/or debt issuance (bond) to fund flood and drainage-related improvements within a district's jurisdiction.

Lastly, municipalities and counties have the authority to issue debt through general obligation bonds, revenue bonds, or certificates of obligation, typically paid back using any of the aforementioned local revenue-raising mechanisms.

Overall, local governments have various options for raising revenue to support local flood-related efforts; however, each presents its own challenges and considerations. Of the communities with access to local funding, the amount available is generally much lower than the total need, leading local communities to seek assistance from state and federal sources.

The following sections present common sources of state and federal financial assistance. Local entities often encounter barriers to accessing alternative funding sources (e.g., state and federal) for flood-related activities and projects. This includes a lack of knowledge of funding sources, a lack of expertise in applying for funding, and a lack of local funds to meet matching or cost-sharing requirements. Complex or burdensome application or program requirements, as well as prolonged timelines, can be barriers to accessing state and federal financial assistance programs. Due to most flood projects not typically generating revenue, communities do not have a steady revenue stream for funding flood projects. Finally, the high demand and competition for state and federal funding assistance, particularly for grants, typically means that some but not all applicants succeed in securing state or federal assistance.

State Funding

Today, communities in Texas have a broader range of state and federal funding sources and programs available to them due to new grant and loan programs that didn't exist even five years ago. Two primary state agencies currently provide state funding for flood projects: the TWDB and the Texas State Soil and Water Conservation Board (TSSWCB). *Figure 9.1* depicts how local communities responded when asked which state and federal funding sources they have accessed to pay for implementing flood-related activities and projects.

The TWDB's Flood Infrastructure Fund (FIF) is a new funding program established by the Texas Legislature and approved by Texas voters through a constitutional amendment in 2019. The program provides financial assistance through low-interest or zero-interest loans and/or grants (cost match varies) to eligible political subdivisions for flood control, flood mitigation, and drainage projects. FIF rules allow for a wide range of flood projects and related activities, including structural and non-structural flood risk reduction projects, planning studies, and preparedness efforts such as flood early warning systems. After the first State Flood Plan is adopted, only projects included in the most recently adopted state flood plan will be eligible for funding from the FIF. FMEs, FMSs, and FMPs recommended in this Regional Flood Plan will be included in the overall State Flood Plan and thus be eligible to access this funding source. Note that the Flood Protection Planning Grant referenced in *Figure 9.1* has been replaced by Flood Infrastructure Fund Category 1 planning grants.

The TWDB also administers the Texas Water Development Fund (Dfund) program, a state-funded streamlined loan program that provides financing to eligible political subdivisions for several types of water-related infrastructure projects. This program enables the TWDB to fund projects with multiple eligible components (water supply, wastewater, or flood control) in one loan at low market rates. Financial assistance for flood control may include structural and non-structural projects, planning efforts, and flood warning systems.

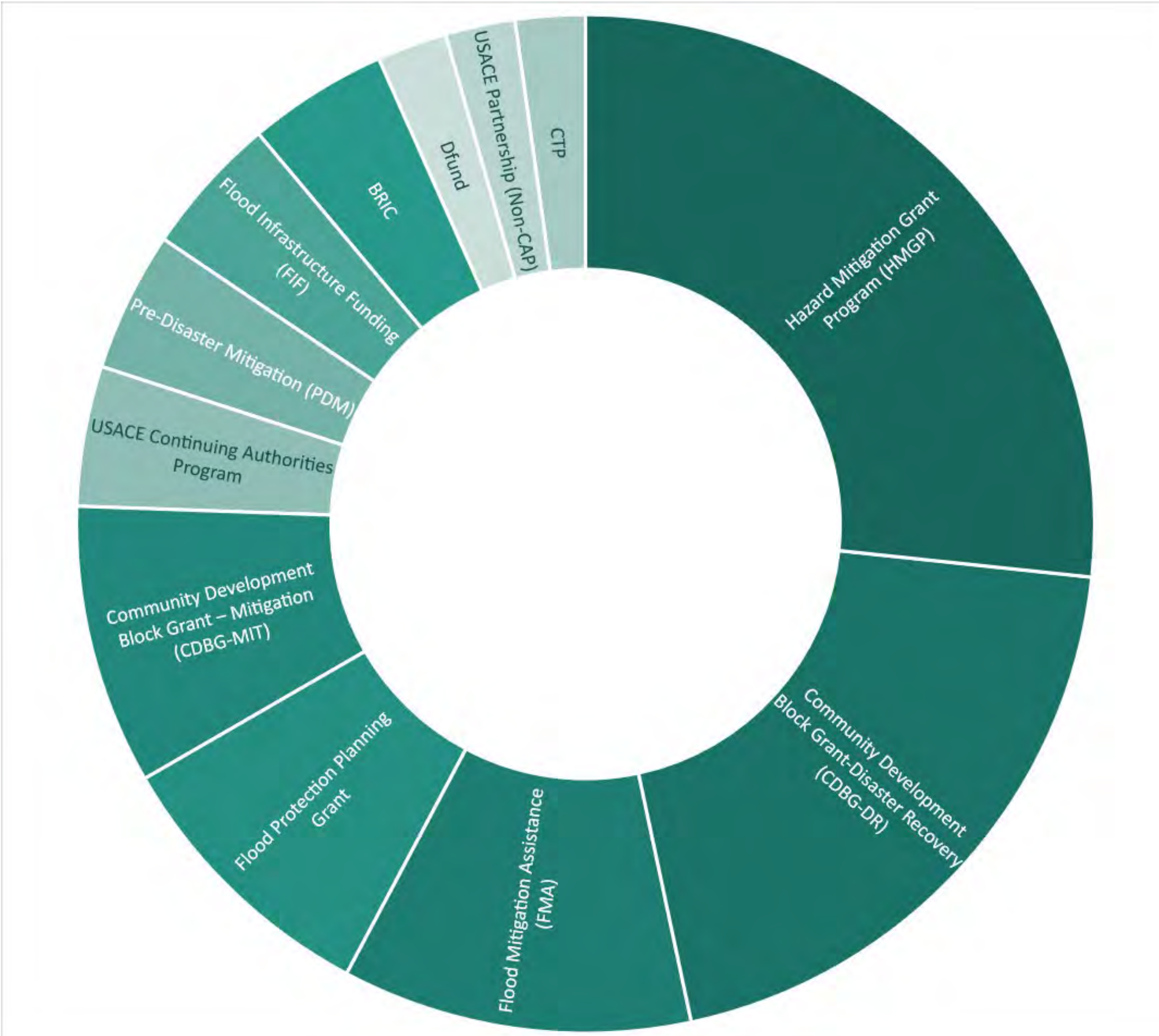
The Texas State Soil & Water (TSSWCB) has three state-funded programs specifically for flood control dams: the Operation and Maintenance (O&M) Grant Program; the Flood Control Dam Infrastructure Projects - Supplemental Funding Program; and the Structural Repair Grant Program. The O&M Grant Program is for local soil and water conservation districts (SWCD) and certain co-owners of small flood control dams. This program reimburses SWCDs 90 percent of the cost of an eligible O&M activity as defined by the program rules; the remaining 10 percent must be paid with non-state funding. The Flood Control Dam Infrastructure Projects - Supplemental Funding program was newly created and funded in 2019 by the Texas Legislature. Grants are provided to local sponsors of flood control dams, including SWCDs, to fund the repair and rehabilitation of the flood control structures to ensure dams meet safety criteria to adequately protect lives downstream. The Structural Repair Grant Program provides state grant funds to provide 95 percent of the cost of allowable repair activities on dams constructed by the United States Department of Agriculture Natural Resources Conservation Service (NRCS), including match funding for federal projects through the NRCS Dam Rehabilitation Program and the NRCS Emergency Watershed Protection (EWP) Program.

Federal Funding

Funding for flood-related activities and projects is available from programs administered by seven different federal agencies and discussed in this section. The funding for these programs originates from the federal government, but for many programs, a state agency partner plays a key role in the management of the program. Each funding program has its own eligibility requirements, applicant and project types, application processes, award timelines, etc. A few examples of eligibility requirements for some of the federal grant programs are: requiring applicants to be participants in the National Flood Insurance Program (NFIP), requiring recipients to have an approved Hazard Mitigation Plan, or requiring a project to have a benefit/cost ratio of 1.0 or greater. More information regarding each program and its unique eligibility requirements and award processes can be found at the Internet web links in this section.

Figure 9.1 depicts how local communities responded when asked which state and federal funding sources they have used to obtain funding for implementing flood management activities and projects.

Figure 9.1 State and Federal Funding Sources Utilized by Local Communities in the Region



Federal Emergency Management Agency (FEMA)

Common FEMA-administered federal flood-related funding programs include Flood Mitigation Assistance (FMA), Building Resilient Infrastructure and Communities (BRIC), Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM), Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program, Hazard Mitigation Grant Program (HMGP), the Public Assistance (PA) program, and the Cooperating Technical Partners (CTP) Program.

Flood Mitigation Assistance (FMA) is a nationally competitive annual grant program that provides funding to states, local communities, federally recognized tribes, and territories. FMA is administered in Texas by the TWDB. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program (NFIP). Funding is typically a 75 percent federal grant with a 25 percent local match. Projects mitigating repetitive loss and severe repetitive loss properties may be funded through a 90 percent federal grant and a 100 percent federal grant, respectively. FEMA's FMA program now includes a disaster initiative called Swift Current. The program was released as a pilot initiative 2022 and explored ways to make flood mitigation assistance more readily available during disaster recovery. Similar to traditional FMA, the program mitigates repetitive losses and substantially damaged buildings insured under the NFIP.

The Building Resilient Infrastructure and Communities (BRIC) is a new nationally competitive non-disaster annual grant program implemented in 2020. The program supports states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC is administered in Texas by the Texas Division of Emergency Management (TDEM). Funding is typically a 75 percent federal grant with a 25 percent local match. Small, impoverished communities may be funded through a 90 percent federal grant and a 100 percent federal grant, respectively.

Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) is a new revolving loan program enacted through federal legislation in 2021 to provide needed and sustainable funding for hazard mitigation projects. The program is designed to provide capitalization grants to states to establish revolving loan funds for projects to reduce risks from disaster, natural hazards, and other related environmental harm. At the time of the publication of this plan, the program does not yet appear to be operational and has not yet been implemented in Texas.

FEMA's Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program, administered in Texas by the Texas Commission on Environmental Quality (TCEQ), provides technical, planning, design, and construction assistance through grants for rehabilitating eligible high-hazard potential dams. The cost-share requirement is typically no less than 35 percent state or local share.

Under the Hazard Mitigation Grant Program (HMGP), FEMA provides funding to state, local, tribal, and territorial governments to rebuild from a recent disaster to reduce or mitigate future disaster losses in their communities. The program is administered in Texas by TDEM. Funding is typically a 75 percent federal grant with a 25 percent local match. While the program is associated with Presidential Disaster Declarations, the HMGP is not a disaster relief program for individual disaster victims or a recovery program that funds repairs to public property damaged during a disaster. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster.

FEMA's Public Assistance (PA) program provides supplemental grants to state, tribal, territorial, and local governments and certain types of private non-profits following a declared disaster so communities can quickly respond to and recover from major disasters or emergencies through actions such as debris removal, life-saving emergency protective measures, and restoring public infrastructure. Funding cost-share levels are determined for each disaster and are typically not less than 75 percent federal grant (25 percent local match) and typically not more than 90 percent federal grant (10 percent local match). In Texas, FEMA PA is administered by TDEM. In some situations, FEMA may fund mitigation measures as part of the repair of damaged infrastructure. Generally, mitigation measures are eligible if they directly reduce future hazard impacts on damaged infrastructure and are cost-effective. Funding is limited to eligible damaged facilities located within PA-declared counties.

The Cooperating Technical Partners (CTP) program is an effort launched by FEMA in 1999 to increase local involvement in developing and updating Flood Insurance Rate Maps (FIRMs), Flood Insurance Study reports, and associated geospatial data in support of FEMA's Risk Mapping, Assessment and Planning (Risk MAP) Program. To participate in the program, interested NFIP-participating communities, state or regional agencies, universities, territories, tribes, or non-profits must complete training and execute a partnership agreement. Working with the FEMA regions, a program participant can develop business plans and apply for grants to perform eligible activities.

Housing and Urban Development (HUD)

HUD administers the following three federal funding programs: Community Development Block Grant – Disaster Recovery (CDBG-DR), Community Development Block Grant – Mitigation (CDBG-MIT), and Community Development Block Grant (TxCDBG) for Rural Texas.

Following a major disaster, Congress may appropriate funds to the Department of Housing and Urban Development (HUD) under the Community Development Block Grant – Disaster Recovery (CDBG-DR) program when there are significant unmet needs for long-term recovery. Appropriations for CDBG-DR are frequently very large, and the program provides 100 percent grants in most cases. The CDBG-DR is administered in Texas by the Texas General Land Office (GLO). The special appropriation provides funds to the most impacted and distressed areas for disaster relief, long term-recovery, restoration of infrastructure, housing, and economic revitalization.

The Community Development Block Grant – Mitigation (CDBG-MIT) is administered in Texas by the GLO. Eligible grantees can use CDBG Mitigation (CDBG-MIT) assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks with typically 100% grants. The primary feature differentiating CDBG-MIT from CDBG-DR is that, unlike CDBG-DR, which funds recovery from a recent disaster to restore damaged services, systems, and infrastructure, CDBG-MIT funds are intended to support mitigation efforts to rebuild in a way that will lessen the impact of future disasters.

The Community Development Block Grant (CDBG) program also provides annual grants on a formula basis to small, rural cities and counties to develop viable communities by providing decent housing and suitable living environments and expanding economic opportunities principally for persons of low- to moderate-income. Funds can be used for public facilities such as water and wastewater infrastructure, street and drainage improvements, and housing. In Texas, the CDBG program is administered by the Texas Department of Agriculture (TDA).

United States Army Corps of Engineers (USACE)

The United States Army Corps of Engineers works with non-federal partners (states, tribes, counties, or local governments) throughout the country to investigate water resources-related needs and opportunities and develops civil works projects that would otherwise be beyond the sole capability of the non-federal partner(s). Partnerships are typically initiated or requested by the local community to their local USACE District office. Before any project or study can begin, USACE determines whether there is an existing authority under which the project could be considered, such as the US Army Corps of Engineers Continuing Authorities Program (CAP), or whether Congress must establish study or project authority and appropriate specific funding for the activity. New study or project authorizations are typically provided through periodic Water Resource Development Acts (WRDA) or another legislative vehicle. Congress will not authorize a project until required studies are completed and a recommendation to Congress is made via a Report of the Chief of Engineers (Chief's Report) or Report of the Director of Civil Works (Director's Report). Opportunities to partner with USACE are not considered grant or loan opportunities but shared participation projects where USACE performs planning work and shares in the cost of construction. USACE also provides technical assistance to state and local governments through their Floodplain Management Services and the Planning Assistance to States programs.

U.S. Environmental Protection Agency (EPA)

The Clean Water State Revolving Fund (CWSRF), administered by the TWDB, provides financial assistance through loans with subsidized interest rates and sometimes partial principal forgiveness for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure projects. Projects can be structural or non-structural. Loans for Low Impact Development (LID) projects are also eligible.

U.S. Department of Agriculture (USDA)

The USDA Natural Resources Conservation Service (NRCS) provides technical and financial assistance to local government agencies through the following programs: Emergency Watershed Protection Program, Watershed Protection and Flood Prevention Program, Watershed Surveys and Planning, and Watershed Rehabilitation. The Emergency Watershed Protection (EWP) program, a federal emergency recovery program, helps local communities recover after a natural disaster by offering technical and financial assistance to relieve imminent threats to life and property caused by floods and other natural disasters that impair a watershed. The Watershed Protection and Flood Prevention Program helps units of federal, state, local, and tribal government protect and restore watersheds; prevent erosion, floodwater, and sediment damage; further the conservation development, use and disposal of water; and further the conservation and proper use of land in authorized watersheds. The Watershed Surveys and Planning Program focuses on funding watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance to identify solutions that use land treatment and non-structural measures to solve resource problems. Lastly, the Watershed Rehabilitation Program helps project sponsors rehabilitate aging dams that are reaching the end of their design lives. This rehabilitation addresses critical public health and safety concerns. The USDA offers various Water and Environmental grant and loan funding programs for water and waste facilities, including stormwater facilities, in rural communities.

Special Appropriations

Occasionally Congress may appropriate federal funds for special circumstances such as recovery from natural disasters or pandemics (COVID-19). A few examples of recent special appropriations from the federal government that can be used to fund flood-related activities are discussed in this section.

In 2021, the American Rescue Plan Act (ARPA) provided a substantial infusion of resources to eligible state, local, territorial, and tribal governments to support their response to and recovery from the COVID-19 pandemic. Coronavirus State and Local Fiscal Recovery Funds, a part of ARPA, delivers $350 billion directly to the state, local, and tribal governments across the country. Some of the authorized uses include improving stormwater facilities and infrastructure. Although not a direct appropriation to local governments like ARPA, the 2021 Infrastructure Investment and Jobs Act, also referred to as the Bipartisan Infrastructure Law (BIL), authorizes over $1 trillion for infrastructure spending across the United States and provides for a significant infusion of resources over the next several years into existing federal financial assistance programs as well as creating new programs.

Flood Infrastructure Financing Survey

This task required obtaining relevant information from Sponsors of the recommended FMEs, FMSs, and FMPs that have capital costs, for example, in the form of a mailed survey or other means of collecting the required information. The primary aim of this survey effort was to understand the funding needs of local Sponsors and then make recommendations as to the state's role in financing FMEs, FMSs, and FMPs. For the Lower Colorado-Lavaca Region, the online survey referenced elsewhere in this plan included questions about local funding needs and sources. Additionally, targeted outreach via phone calls and emails to Sponsors was conducted to gather information on sources and needs for funding for recommended FMEs, FMSs, and FMPs. A follow-up survey via email was also sent to Sponsors to garner additional responses.

A total of 61 Sponsors of recommended FMEs, FMSs, and FMPs with capital costs identified were contacted, and 7 responded. This represents a response rate of approximately 11.5 percent. *Appendix B* presents the survey results for each FME, FMS, and FMP in *Table 19*. The response rate for the survey does not represent a significant percentage of respondents. It, therefore, does not accurately represent the total need for state and federal funding in the Lower Colorado-Lavaca Region. To assess the remaining need, it was estimated that 90 percent of total project costs are required from state and federal sources for those actions where the Sponsor did not respond to the survey. This represents an average of 10 percent of projected local investment in projects. A high percentage of outside needs is supported by the initial outreach, which confirmed that many communities, particularly smaller and more rural communities, do not have adequate local funding available for flood management activities. Those communities that reported having local funding indicated relatively little local funding available in relation to overall needs.

Overall, an estimated $441,377,500 is needed to implement the recommended FMEs, FMSs, and FMPs in this regional flood plan. Approximately $395,348,400 is projected to be needed from state or federal sources, based on the survey data and estimates of remaining need as described above. Since most federal funding programs are dependent on the availability of funds or project selection in a nationally competitive grant program, it is difficult to estimate how much federal funding may be available to implement these studies, strategies, and projects. It is conservatively estimated that as much as the full amount may be needed from state sources. This number does not represent the amount of funding needed to mitigate all risks in the region and solve flooding problems in their totality. This number simply represents the funding needs for the specific, identified studies, strategies, and projects in this cycle of regional flood planning. Future cycles of regional flood planning will continue to identify more projects and studies needed to further flood mitigation efforts in the Lower Colorado-Lavaca Region.

Recommendations – State Role in Flood Infrastructure Finance

As noted at the outset of this chapter, the Regional Flood Planning Groups have an opportunity to offer recommendations as to the role of the state in the financing of flood-related activities and infrastructure. In this regard, the Lower Colorado-Lavaca RFPG offers the following recommendations:

- Generally, the Lower Colorado-Lavaca RFPG believes that the role of the State of Texas in financing flood-related activities, programs, and flood mitigation infrastructure should be expanded. More specifically, ongoing and increased funding for both technical and financial assistance should be made available through the existing financial assistance programs administered by the Texas Water Development Board and the Texas State Soil and Water Conservation Board.
- The Lower Colorado-Lavaca RFPG supports a continuation and expansion of the TWDB's role as an important and sometimes critical source of financial assistance for all water-related planning activities and project implementation, including activities and projects related to flood risk reduction. This role historically has included: 1) providing access to needed funding for economically disadvantaged communities that have limited capacity to self-finance flood-related activities and projects; 2) making financial assistance available and more affordable (e.g., grants, low-interest loans) to any and all eligible entities for flood-related activities and projects; and 3) providing funding to bridge gaps in available and needed funding for implementation of flood risk reduction projects. The latter is often needed to enable such projects to proceed. The assistance should continue to be provided, as appropriate, in the form of grants, with an appropriate level of local cost-share, below-market low-interest-rate loans pegged to the state's high credit rating, subsidized low or zero-interest loans through the Clean Water SRF, or other programs; or a combination of the above.

The Lower Colorado-Lavaca RFPG has also adopted several recommendations pertaining to state funding of various flood-related programs and activities and the administration of such programs. These are found in *Chapter 8: Administrative, Regulatory, and Legislative Recommendations* and summarized below:

- 8.1.3 – Establish and provide state budget appropriations and/or assess fees to fund the implementation of a levee safety program similar to the TCEQ dam safety program.
- 8.1.5 – Provide ongoing state appropriations to the TWDB for additional grant funding for Regional Flood Planning Groups to continue functioning during the interim between planning cycles.
- 8.1.6 – Increase state funding and technical assistance to develop accurate watershed models and FEMA Flood Insurance Rate Maps (FIRMs). The TWDB should consider mapping updates as a high priority for future flood planning grants through the Flood Infrastructure Fund.
- 8.1.7 – Establish and fund a state program to assist counties and cities with assessing and prioritizing low water crossings. Funding should also be provided on a cost-sharing basis to implement structural and/or non-structural flood risk reduction measures at high-risk, low water crossings. The design of improvements to reduce roadway crossing risk should consider potential environmental impacts and measures to minimize impacts, particularly impact to aquatic ecosystems including the plant and animal species that depend on those ecosystems.
- 8.2.3 – Revise the scoring criteria for funding associated with stormwater and flood-related projects that benefit agricultural and/or rural areas.
- 8.2.4 – The TWDB should continue to include and refine its criteria for evaluating and ranking applications for financial assistance for flood risk mitigation studies and projects, considerations of social vulnerability (SVI scores), and other social, economic, and environmental resilience and sustainability measures. This should include modifying the benefit-cost methodology to account for such factors rather than relying solely on traditional measures of benefit (e.g., avoidance of flood losses to property, the value of infrastructure to be constructed, etc.).
- 8.2.5 – Provide direct technical assistance to economically distressed communities and/or those with high social vulnerability by preparing funding applications for federal and/or state financial assistance for flood planning and implementing flood risk reduction measures.
- 8.2.6 – Reduce or eliminate barriers to and provide incentives for the planning, funding, and implementation of inter-jurisdictional flood risk reduction measures, either structural and/or non-structural.
- 8.2.8 – Allow small communities to benefit from the TWDB Flood Infrastructure Fund (FIF) incentives for green and nature-based projects by: 1) working with Texas Municipal League, Texas Association of Counties, and Texas Floodplain Management Association to train community officials on the basics of Low Impact Development (LID) and Green Stormwater Infrastructure (GSI); 2) developing model ordinances for use by small communities in establishing LID and GSI regulations, such as green street design standards; 3) publicizing and assisting RFPGs to publicize successfully implemented GSI projects; 4) adjusting cost-benefit analysis calculations as needed to include environmental values; and 5) by setting aside a percentage of FIF funds for smaller communities that may not be able to otherwise meet FIF incentives for green and nature-based projects.
- 8.2.9 - TWDB should include consideration of existing and scheduled Watershed Protection Plans in applications for financial assistance for flood risk mitigation studies and projects.

The RFPG also offers the following recommendation with regard to local funding of flood-related activities and projects:

- 8.2.1 – The TWDB should actively promote the establishment of local drainage utilities, where appropriate, to provide a stable and predictable funding source through assessing drainage fees and to support ongoing operations and maintenance (O&M) of existing flood mitigation and other drainage infrastructure. This should include the provision of technical assistance with the creation of local drainage utilities.

Chapter 10: Public Outreach and Engagement

Source: City of Austin Lower Shoal Creek Risk Reduction Public Meeting

The objective of this chapter is to address public participation, public meetings, and administrative and technical support activities that were required to complete and submit a draft Regional Flood Plan by August 1, 2022, adopted Regional Flood Plan by January 10, 2023 and an Amended Regional Flood Plan by July 14, 2023. These activities were ongoing from the start to the completion of the regional flood planning process.

Regional Flood Planning Group Meetings (2020–2023)

At the onset of the regional flood planning process, the Texas Water Development Board (TWDB) established 15 flood planning regions based on river basin boundaries and convened Regional Flood Panning Groups (RFPG) for each region. The RFPG's responsibilities include directing the work of technical consultants, soliciting and considering public input, identifying and assessing flood risks, and identifying, evaluating, and recommending Flood Management Evaluations (FME), Flood Management Strategies (FMS), and Flood Mitigation Projects (FMP). To ensure a diversity of perspectives is represented throughout the planning process, the TWDB appointed RFPG members representing 11 interest categories:

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

The Lower Colorado-Lavaca RFPG convened its first meeting in November 2020, at which time it elected a chairperson, a vice-chairperson, a secretary, and two additional RFPG members to serve on an Executive Committee.

At its December 16, 2021 meeting, the RFPG voted to establish a Technical Committee to review, on behalf of the full RFPG, potential FMEs, FMPs, and FMSs for possible inclusion as recommendations in the Regional Flood Plan. Five members of the Lower Colorado-Lavaca RFPG were selected to serve on the Technical Committee. The committee's first meeting was convened in person on January 27, 2022, when the committee elected officers and considered the process and timeline for reviewing FMEs, FMPs, and FMSs. The committee also took action throughout several meetings to approve FMEs, FMPs, and FMSs for subsequent consideration and approval by the full RFPG. A complete chronology of all RFPG and Technical Committee meetings is provided in *Table 10.1*.

The Lower Colorado River Authority (LCRA), the sponsoring agency for the Lower Colorado-Lavaca regional flood planning process, has been responsible for administering the contract with TWDB and a technical consultant for developing the Regional Flood Plan. Additionally, LCRA has been responsible for posting all meetings of the RFPG and its committees on the Texas Secretary of State website and the Lower Colorado-Lavaca Region website. LCRA also distributes agendas and meeting materials via email to all voting and non-voting RFPG members, as well as any person or entity who has requested notice of RFPG meetings and activities. The opportunity to subscribe to receive such notifications is clearly provided on the RFPG website.

All meetings of the Lower Colorado-Lavaca RFPG have been convened either virtually via the Zoom webinar platform or in a hybrid (virtual and in-person) format. All meetings are conducted, as required, following the Texas Open Meetings Act (Chapters 551 and 552, Government Code), Public Information Act, and COVID-related disaster proclamations issued by Governor Abbott—and in accordance with the RFPG’s bylaws. All RFPG meetings must provide at least one opportunity for public comment. Starting in February 2021, the RFPG added a second agenda item for public comment at each meeting, so the public has been provided an opportunity to comment at both the beginning and/or the end of each meeting.

Table 10.1 RFPG, Executive Committee, and Technical Committee Meeting Calendar

Year	Date	Meeting	Highlights
2020	November 2	Planning Group Virtual Meeting	RFPG convening hosted by the TWDB
2020	December 7	Planning Group Virtual Meeting	Planning Group Sponsor (LCRA) hosted
2021	February 8	Executive Committee Virtual Meeting	
2021	February 11[A]	Planning Group Virtual Meeting	Pre-planning public comment
2021	March 25	Executive Committee Virtual Meeting	

Year	Date	Meeting	Highlights
2021	March 29[A]	Planning Group Virtual Meeting	Pre-planning public comment Technical consultant selected/hired
2021	April 19[A]	Planning Group Virtual Meeting	Pre-planning public comment
2021	May 17	Planning Group Virtual Meeting	First meeting for a technical consultant
2021	June 21	Planning Group Virtual Meeting	The technical consultant presented and discussed goals and strategies for public outreach and engagement. Review and discussion of requirements for Tasks 1 and 3.
2021	July 19	Planning Group Virtual Meeting	The technical consultant presented and led the discussion of requirements and processes for Tasks 2, 4, and 5, including an overview of types of FMEs, FMSs, and FMPs. Initiated RFPG goal-setting process. Reviewed requirements and process for Task 8 and discussed the preliminary list of potential policy issues of interest.
2021	August 16	Planning Group Virtual Meeting	Presentation and review a preliminary draft of *Chapter 1*, preliminary draft goal statements, and proposed process for identification, evaluation, and selection of FMEs, FMSs, and FMPs.
2021	October 18[B]	Planning Group Hybrid Meeting	Public comment taken on draft goals and draft process to identify and evaluate potential studies and potentially feasible strategies and projects.
2021	November 15	Planning Group Hybrid Meeting	RFPG approved draft goals and processes for identifying and evaluating potential studies and potentially feasible strategies and projects.
2021	December 16	Planning Group Hybrid Meeting	RFPG approved submitting the Technical Memorandum No. 1 to the TWDB on or before January 7, 2022. RFPG established a technical subcommittee to assist with developing recommendations regarding FMEs, FMSs, and FMPs.
2022	January 27	Technical Committee In-Person Meeting	The first meeting of the Technical Committee. The committee meeting process was discussed; committee officers were elected; the discussion was held on requirements/guidelines for Tasks 4B and 5 with regard to FMEs, FMPs, and FMSs; review standardized templates for FMEs, FMPs, and FMSs.

Year	Date	Meeting	Highlights
2022	January 31	Planning Group Hybrid Meeting	Per RFPG bylaws, RFPG officers and members of the Executive Committee were nominated and elected, followed by a discussion of project status, Technical Memorandum No. 2, Tasks 2A/B, 4B, and 9.
2022	February 17	Planning Group Hybrid Meeting	Reviewed planning progress by Tasks (2A/B, 4A/B/C, 10); Accepted public input on initial flood hazard map(s); RFPG approved submittal of Technical Memorandum No. 2 to the TWDB.
2022	March 9	Technical Committee Hybrid Meeting	Technical consultant presentation and discussion on Task 4B, Identification and Evaluation of Potential Flood Management Evaluations (FME) and Potentially Feasible Flood Management Strategies (FMS) and Flood Mitigation Projects (FMP).
2022	April 7	Planning Group Hybrid Meeting	Discussion of TWDB approval of additional tasks 11, 12, and 13. Update from Technical Committee. Project status from the technical consultant on Tasks 3A/B, 4A/B, 5, 7, and 9.
2022	April 13	Technical Committee Hybrid Meeting	Presentation, discussion, evaluation, and input on template information and formatting for FMSs, FMEs, and FMPs.
2022	April 28	Technical Committee Hybrid Meeting	Presentation of revised templates for all FMSs, FMEs, and FMPs. Technical Committee agreed to recommend 3 FMSs and 21 FMEs.
2022	May 2	Planning Group Hybrid Meeting	Task 8 was discussed. Technical Committee recommended, and RFPG approved 3 FMSs and 21 FMEs. RFPG called for public comment on an initial flood hazard map that may not have been identified previously. No public comment.
2022	May 10	Technical Committee Hybrid Meeting	Presentation and discussion of FMEs, FMSs, and FMPs. Additional comments and suggestions were made to improve FMSs, FMEs, and FMPs templates—no action to recommend.
2022	May 25	Technical Committee Hybrid Meeting	Technical Committee approved the additional recommendation of 93 FMEs and 53 FMPs for RFPG consideration and approval.
2022	June 9	Planning Group Hybrid Meeting	RFPG approved 93 FMEs and 53 FMPs for inclusion in the draft Regional Flood Plan. RFPG also discussed draft policy recommendations (Task 8) and draft recommendations regarding the state's role in flood infrastructure finance (Task 9).

Year	Date	Meeting	Highlights
2022	June 16	Technical Committee Hybrid Meeting	Technical Committee approved the additional recommendation of 7 FMEs, 1 FMS, and 1 FMP for RFPG consideration and approval.
2022	June 30	Technical Committee Hybrid Meeting	Technical Committee approved the recommendation of 1 FMS for RFPG consideration and approval.
2022	July 7	Planning Group Hybrid Meeting	Presentation and discussion of a preliminary draft of the Regional Flood Plan. RFPG approved 7 FMEs, 2 FMSs, and 1 FMP for inclusion in the draft RFP. RFPG approved recommendations for floodplain management practices (*Chapter 3*), approved policy recommendations (*Chapter 8*), and approved recommendations regarding the role of the state in flood infrastructure finance.
2022	July 11	Technical Committee Hybrid Meeting	Technical Committee approved the recommendation of 1 FME for RFPG consideration and approval—approved technical consultant recommendation of FMEs to be performed in Task 12.
2022	July 18	Planning Group Hybrid Meeting	RFPG approved one (1) FME for inclusion in the draft RFP. RFPG adopted the draft Regional Flood Plan and approved it to submit to the TWDB. RFPG approval of preliminary recommendation for FMEs to be performed per Task 12.
2022	August 1	Draft Regional Flood Plan Submitted to the TWDB and posted to the Planning Group website	The public comment period officially opened on August 8, when all hard copies of the RFP were in place at 16 locations throughout the region. Public comment period is set to close on October 17.
2022	September 6	Technical Committee Hybrid Meeting	Considered technical consultant recommendations for FMEs to be performed per Task 12.
2022	September 15	Planning Group Hybrid Meeting	RFPG accepted public comment on the draft Regional Flood Plan at the beginning and end of the meeting, as well as during a specified agenda item for this purpose. RFPG acted to reopen the window for nominations for the vacant water district position. RFPG approved Task 12 funding and analysis of 7 FMEs for possible advancement to FMPs.
2022	November 7	Planning Group Hybrid Meeting	Reviewed and discussed comments received from TWDB and the public on the draft Regional Flood Plan during the public comment period.

Year	Date	Meeting	Highlights
2022	December 1	Technical Committee Hybrid Meeting	Presentation on Task 5 by the technical consultant with recommendations to add 7 FMEs, reclassify 13 FMPs to FMEs (projects to studies), and removal of 6 FMEs and 5 FMPs from the plan per request of the sponsors.
2022	December 15	Planning Group Hybrid Meeting	Reviewed comments from TWDB and the public on the draft RFP and approved responses to those comments. Reviewed and approved Technical Committee's recommendations regarding Task 5 – Flood Management Strategies, Flood Management Evaluations, and Flood Mitigation Projects. Reviewed and approved Task 8 recommendations for administrative, regulatory, and administrative additions.
2022	December 15	Executive Committee Hybrid Meeting	Reviewed and discussed applications for an RFPG member vacancy for the water district category. Prepared to make a recommendation to RFPG at January 5, 2023, RFPG meeting.
2023	January 5	Planning Group Hybrid Meeting	RFPG adopted the final Regional Flood Plan presented by the technical consultant and approved its submission to TWDB on or before January 10, 2023. RFPG approved the Executive Committee's recommendation of Ken Heroy to fill the vacant RFPG position.
2023	April 20	Technical Committee Hybrid Meeting	Presentation on Task 12 and Task 13 by the technical consultant; specifically, the status of the 7 FMEs (studies) to FMPs (projects) for the Amended Regional Flood Plan (RFP); and review of possible additional activities for inclusion in the RFP.
2023	May 15	Technical Committee Hybrid Meeting	Presentation on Task 12 and Task 13 by Technical Consultant. For Task 12, the committee reviewed and approved recommendations from the results studies. For Task 13, the committee reviewed and approved recommendations regarding additions, revisions, and reclassifications of FMEs and FMPs for the Amended Regional Flood Plan. In summary, the recommendations to the RFPG included the addition of 14 FMPs, the removal of 10 FMEs, the addition of 29 FMEs, and no changes to FMSs.

Year	Date	Meeting	Highlights
2023	June 22	Planning Group Hybrid Meeting	RFPG discussed and approved the seven Task 12 studies and Task 13 FME and FMP amendments as recommended by the Technical Committee. RFPG adopted the Amended Regional Flood Plan presented by the technical consultant and approved its submission to TWDB on or before July 14, 2023. Additionally, the RFPG discussed the second regional flood planning cycle, including RFPG members terms, sponsor selection, and other future actions.

[A] Pre-Planning Public Input (Feb, March, April 2021) – Public input regarding suggestions and recommendations as to issues, provisions, projects, and strategies that should be considered during the flood planning cycle and/or input on the development of the Regional Flood Plan (as required per Texas Water Code §16.062(d) and 31 Texas Administrative Code §361.12(a)(4))

[B] October 18, 2021, the meeting initiated a hybrid meeting format with the RFPG Chair and Sponsor organization meeting in a published physical location at LCRA offices in Austin while continuing to offer the Zoom webinar option for members, non-members, and public participants.

Public Outreach Strategies and Tools

Branding the Region

A visual language, style, and color palette was created to provide a consistent look and feel in all public and interest group communications and outreach activities. This established a "brand" for the Lower Colorado-Lavaca Flood Planning Region, which helped draw public attention to the planning process.

Figure 10.1 below presents the logo and color palette developed for the region's website and public communications.

Figure 10.1 Lower Colorado-Lavaca Region Logo

Lower Colorado-Lavaca
REGIONAL FLOOD
PLANNING GROUP
REGION 10

Commitment to Plain Speak

The Lower Colorado-Lavaca RFPG and the technical consultant have committed to using "plain speak" whenever possible to avoid language and technical jargon that is not readily accessible to the general public. An acronym-decoder and a glossary of flood planning and hydrologic terms are included on the RFPG's website. There is also a consistent and concerted effort to use more "familiar" terms rather than terms prescribed in the TWDB rules and guidelines. For example:

- Flood Mitigation Evaluation (FME) = Study
- Flood Mitigation Project (FMP) = Project
- Flood Management Strategy (FMS) = Strategy

Website: Robust and User-Friendly

The LCRA established and maintained the required website on behalf of the Lower Colorado-Lavaca RFPG in January 2021 under the domain name LowerColoradoLavacaFlood.org using the Square Space hosting platform. The technical consultant came on board in May 2021 and immediately undertook branding enhancements and buildout of the website to provide more information about the Lower Colorado-Lavaca Regional Flood Planning Area and the regional flood planning process, as well as information and educational materials about flood planning-related topics. The website was also enhanced to allow easy access for the public and entities to provide input and to access draft deliverables (e.g., flood mitigation and floodplain management goals) for review and comment. The enhanced website went live in June 2021. Currently, there are several locations on the website where active links can be found for public engagement on the website:

- Subscribe to Notifications (top of the Home page, on the Contact Us page, and within the Footer)
- Documents for the Public View page
- Stakeholder Survey page for public and community interest groups
- Submit Comments on the Contact Us page for written comments before or after meetings

As of June 7, 2023, 100 subscribers have registered on the website to receive notifications and information pertaining to regional planning activities. The table below provides additional website analytics.

Table 10.2 Website Analytics

Date	Total Visits	Unique Visitors	Page Views
January 1, 2021 through June 7, 2023	9,900	6,600	18,000

Of note, the visitors to the Region 10 RFPG website came from the following sources:

- 77 percent direct visits
- 10 percent TWDB website
- 9 percent search engines
- 4 percent social media

Direct Email Blasts

The technical consultant introduced Mail Chimp to communicate directly with the public and community interest groups. An email contact list was developed for a targeted audience with 518 contacts and included the following tags:

- Municipalities
- Counties
- County Judges
- Floodplain administrators
- Directors of development
- Other Districts
- Subscribers through website
- Chambers of Commerce
- Libraries
- NGOs
- RFPG members
- Halff team

Forty email blasts were sent to audiences between June 21, 2021, and June 15, 2023, with a click-to-open average rate of over 30 percent. For perspective, a click-to-open average rate between 20-30 percent is generally considered a good response. The email audience included 529 contacts with tags for municipalities, counties, public libraries, non-government organizations, and almost 100 contacts who signed up through the Region 10 RFPG website.

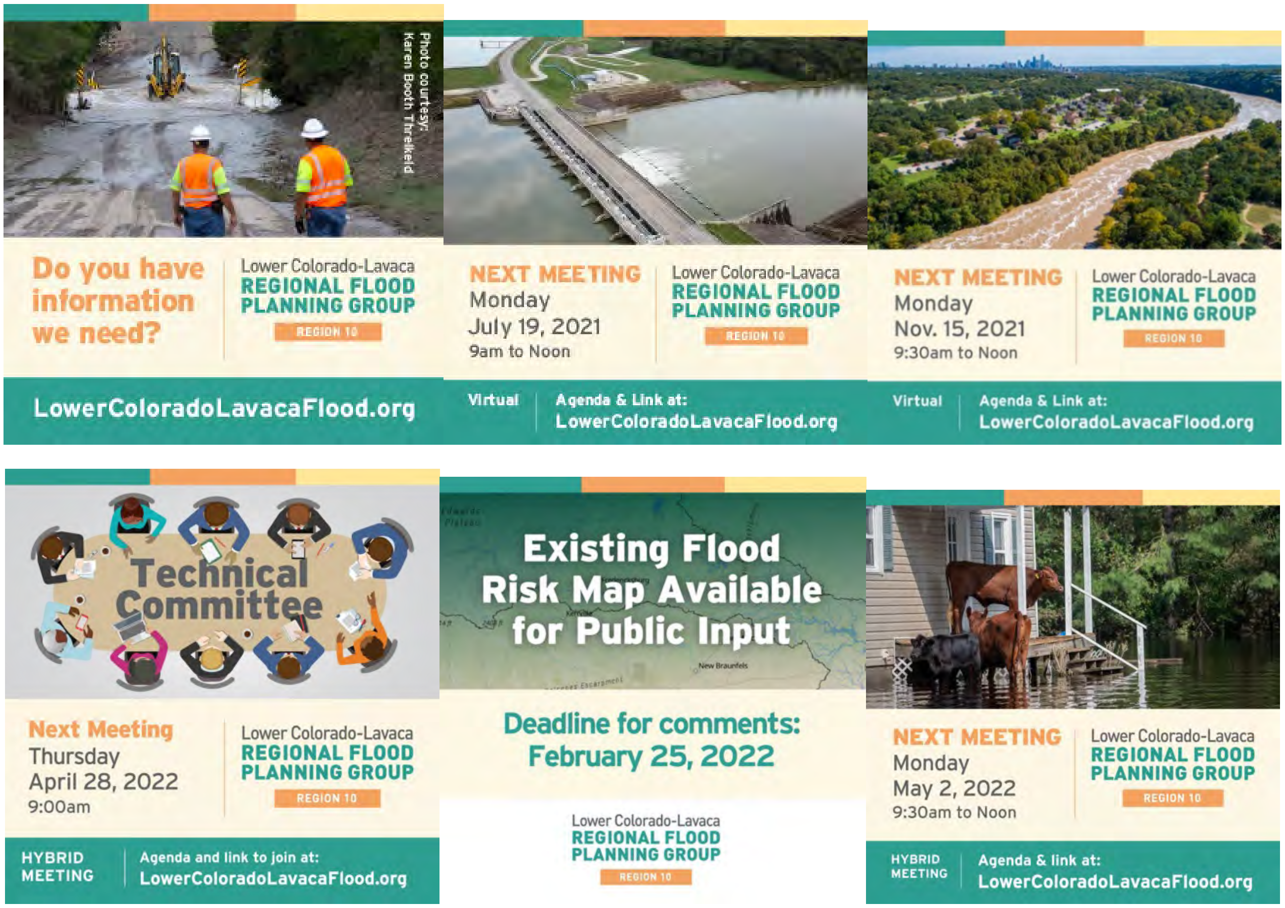
News Media

With the help of the Texas Press Association and the Texas Association of Broadcasters, the technical consultant built a media list including 110 newspapers and 70 radio stations within the Lower Colorado-Lavaca Region. To reach all interest groups through local news media, the technical consultant sends Media Alerts in advance of each RFPG meeting. In July 2021, the technical consultant provided a 30-second public service announcement (Live DJ read) to all regional radio stations regarding the flood planning process.

Social Media and Other Media

Facebook has been the primary social media platform used for public outreach within the Lower Colorado-Lavaca Region, with all meetings posted and promoted and key elements of flood planning in the news media or on the TWDB website. The Lower Colorado-Lavaca Region Facebook page can be accessed at: https://www.facebook.com/LowerColoradoLavacaFlood.

Figure 10.2 Sample Facebook Post Graphics



Members of the Lower Colorado-Lavaca RFPG and the public indicated early in the process that a digital flyer that could be easily printed would be a useful communications tool. In response, the technical consultant developed flyers in both English and Spanish, which are available on the Lower Colorado-Lavaca Region website and shown in *Figure 10.3*.

Figure 10.3 Sample Digital Flyers (English/Spanish)

Public Hearing and Outreach for Draft Regional Flood Plan

Above and beyond

Upon submittal of the Draft Regional Flood Plan, the RFPG initiated a formal public comment process per TWDB requirements. Because the Lower Colorado Lavaca Flood Planning Region is geographically large – encompassing two major river basins, all or portions of 43 counties, 24,380 square miles, and a population of more than 1.8 million, the RFPG decided to not only meet but significantly exceed the TWDB notice public meeting requirements. Below is a summary of these requirements, followed by a summary of RFPG-approved outreach activities conducted by LCRA and the technical consultant team to obtain public input on the draft Regional Flood Plan.

Rule §361.21 Draft Plan Notice Requirements

For meetings at which the RFPG is to take public input related to the RFPG's draft Regional Flood Plan per TWC 16.062(f–g), the following additional public notice provisions must be met:

- The draft Regional Flood Plan must be made available for public inspection online for 30 days prior to the first meeting, if more than one meeting is held and 30 days following the first meeting

- At a minimum, notice must be provided at least 30 days prior to the first meeting
- Notice must be provided to all adjacent RFPGs
- Notice of the meeting must include a summary of the Regional Flood Plan
- Notice must include information on how the public may submit comments
- A hard copy of the draft Regional Flood Plan must be made available for public inspection in at least three publicly accessible locations within the flood planning region for at least 30 days prior to the first meeting and 30 days following the first meeting
- Written comments must be accepted for consideration for at least 30 days prior to the first meeting and at least 30 days following the first meeting for consideration and response prior to adoption of the final plan under §361.50 of this title and oral comments must be accepted during the required meeting

Public Engagement and Outreach Plan for the Public Comment Period

According to the requirements above, the Lower Colorado-Lavaca RFPG posted the Draft Regional Flood Plan on August 1, 2022, the same day it was submitted to TWDB and online at: www.lowercoloradolavacaflood.org.

Printed and bound copies of the Regional Flood Plan were in place by August 8, 2022, at 16 publicly accessible locations, as noted below:

- Upper Basin (5 locations): Llano County Public Libraries at Llano and Kingsland locations, Mason County Library, Brownwood Public Library, Gillespie County Courthouse
- Mid-Basin (7 locations): LCRA Redbud Center, Austin Public Library, Ruiz Branch Public Library, Southeast Branch Public Library, Manchaca Road Branch Public Library, East Travis Gateway Library, Bastrop Public Library
- Lower Basin (2 locations): Wharton County Courthouse, Bay City Public Library
- Lavaca River Basin (2 locations): Lavaca Navidad River Authority offices, Friench Simpson Memorial Library in Hallettsville

The official Public Meeting of the RFPG to accept oral comments from the public on the draft Regional Flood Plan was set on September 15, 2022. The meeting took place in a hybrid format (online via Zoom and in person). It was publicized via three Mail Chimp blasts to the full audience, media alerts to the full media list, and direct emails from LCRA to all subscribers, members, and support organizations.

September 15, 2022; 9:30 am
LCRA Redbud Center
3601 Lake Austin Blvd
Austin, TX 78703

Three Open House Meetings

In addition to the official public meeting, the project sponsor (LCRA) and the technical consultant hosted three in-person "Open Houses" to present the summary of the Regional Flood Plan, answer questions, and take public comments. A hard copy of the draft Regional Flood Plan, large format map boards, a printed handout with an executive summary, and comment forms were available at open house events.

Instructions for submitting public comments after the public hearing and open houses were also provided.

Dates, locations, and attendee count for Open House events are provided below. All Open House meetings took place in the evening after standard work hours (5:30-7 pm), and were promoted via email, the planning region website, and alerts to local media.

- September 8, 2022: Upper Basin – Llano Public Library, 102 E. Haynie St, Llano, Texas (18 attendees)
- September 13, 2022: Lavaca River Basin – Lavaca Navidad River Authority offices at 4631 FM 3131, Edna, Texas (3 attendees)
- September 21, 2022: Lower Basin – Wharton County Courtroom Annex, 309 Milam Street, Wharton, Texas (8 attendees)

Promotional Tactics to Reach the Public for Awareness and Comment Opportunities

The following tools were created, and activities were undertaken to engage and make the public aware of the Draft Regional Flood Plan, public hearings, open house events, and the 70-day public comment opportunity.

Figure 10.4 Fliers Promoting Events and Opportunities for Public Comment

Table 10.3 Promotional Tactics

Tactic	Activity
Media	Media alerts to local news outlets in areas where meetings were held General media release regarding Draft Regional Flood Plan and public comment opportunities.
Email	A series of Mail Chimp email blasts to the audience of interest groups Direct emails to key interest groups, including local elected and floodplain administrators
Website	Draft Regional Flood Plan posted on the Lower Colorado-Lavaca Region's website (https://www.lowercoloradolavacaflood.org/) A public comment link on the website for the Regional Flood Plan
Hard copies	Sixteen (16) publicly accessible locations were selected throughout the region to display a printed, bound hard copy of the draft RFP
RFPG Members, Project Sponsor, Technical Consultant Team	Fliers and communication tools provided for personal ease of targeting and sharing

Public Comment Period

During the official 70-day public comment period, August 8 through October 17, 2022, public comments were accepted via:

- Oral comments made at the official RFPG meeting on September 15, 2022
- Written or verbal comments in person at open house meetings
- Written comments emailed to: LowerColoradoLavacaFlood@lcra.org
- Written comments submitted online at Lower Colorado-Lavaca Region's website: www.lowercoloradolavacaflood.org

TWDB and Public Comments on the Draft Regional Flood Plan

As directed by TWDB, the purpose of the process of publishing a complete first draft of the Regional Flood Plan was to receive input from interested parties, sponsors of recommended studies and projects, governmental and non-governmental organizations, individuals among the general public, and the TWDB itself. A compendium of both TWDB and public comments and responses can be found in *Appendix D*, and below is a general explanation of comment types and the Planning Group response for the initial Regional Flood Plan. As a reminder, this final Regional Flood Plan represents the completion of the first cycle of the regional flood planning program that will be repeated on a five-year cycle.

TWDB Comments

On October 10, 2022, the TWDB commented on the draft Lower Colorado-Lavaca Regional Flood Plan. There were 39 Level 1 comments that must be satisfactorily addressed to meet specific statutory, rule, or contract requirements, and there were 36 Level 2 comments for consideration to improve the readability and/or overall understanding of the plan. On March 28, 2023, the TWDB commented on the Lower Colorado-Lavaca Regional Flood Plan. There were 20 Level 1 comments that must be satisfactorily addressed to meet specific statutory, rule, or contract requirements, and there were 9 Level 2 comments for consideration to improve the readability and/or overall understanding of the plan. Response to the comments generally included minor updates to chapter text, tables, maps, and spatial data. A more detailed summary of TWDB comments and the associated response is included in *Appendix D*.

Public Comments

Fifty-one comments were received from 31 individuals and 11 governmental and non-government organizations during the public comment period for the draft Regional Flood Plan. Broadly, comments received from the "public" fall into four areas: 1) requests from local entities to add or revise recommended FMEs and FMPs; 2) concerns about the protection of private property rights and private groundwater ownership; 3) comments expressing strong support for nature-based flood risk reduction measures, often referred to as Nature-Based Solutions (NBS); and 4) proposed additions to administrative and regulatory policy recommendations. A summary of each of these areas is provided below, along with a more detailed summary of public comments can be found in *Appendix D*.

Requests for New FMEs and FMPs

Several local entities submitted requests during the comment period requesting the addition of new Flood Management Evaluations, reclassification of Flood Mitigation Projects to studies, or removal of a recommended action. The RFPGs Technical Committee considered these requests on December 1, 2022, and subsequently approved them for inclusion in the final Regional Flood Plan by the RFPG on December 15, 2022. Accordingly, these FMEs, FMPs, and associated plan revisions have been incorporated into *Chapters 5, 6*, and *9* and in related appendices and spatial data. Also, additional potential FMEs and FMPs have been identified through ongoing engagement with local entities. They are expected to be considered by the RFPG for inclusion in the Regional Flood Plan during the plan amendment process in 2023.

Protection of Private Property Rights and Private Groundwater Ownership

Several individuals submitted comments expressing concerns about the potential infringement of private property rights and private ownership of groundwater, including metering of groundwater withdrawals. These commenters indicated that their concerns stem from a perception that the state and regional flood planning processes, and this regional flood plan, is an outgrowth of *United Nations Agenda 21 Goals for Sustainable Development*. *United Nations Agenda 21* goals, which were reaffirmed and adopted by all United Nations member nations in the *2030 Agenda for Sustainable Development*, is a non-binding "…comprehensive plan of action to be taken globally, nationally, and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which humans impact on the environment”.[1] Those expressing these concerns are staunchly opposed to any governmental infringement on private property rights, in Texas specifically, and landowner rights to groundwater. Accordingly, several commenters requested that specific guarantees of private property rights and groundwater rights be included in the final Regional Flood Plan.

In response to these concerns, the Lower Colorado-Lavaca RFPG adopted the following:

> The Lower Colorado-Lavaca Regional Flood Plan is the result of a process established by a state law enacted by the Texas Legislature and signed by the Governor in 2019. The planning processes are further prescribed by rules and guidelines adopted by the administering agency, the Texas Water Development Board (TWDB). The all-volunteer members of the Lower Colorado-Lavaca Regional Flood Planning Group (RFPG) were appointed to oversee and guide the regional flood plan development process. The RFPG only has the authority to recommend flood management studies and strategies, flood mitigation projects, and administrative, regulatory, and legislative policies related to flood risk reduction. The RFPG has no authority or resources to implement said recommendations or to compel implementation. Implementation of the recommendations included in the plan will fall mostly to local governmental entities (sponsors) and local and state policymakers. Further, nothing in the enabling statute, TWDB rules or guidelines, or in the Lower Colorado-Lavaca Regional Flood Plan provides the RFPG jurisdiction over private property rights or private ownership of groundwater. In conclusion, the RFPG proposes no changes to the final Regional Flood Plan in response to these comments and concerns.

Nature-Based Flood Risk Reduction Strategies

The Texas Parks and Wildlife Department (TPWD), along with several non-profit environmental organizations, submitted comments expressing their strong interest in and support for green or “nature-based” flood risk reduction solutions (NBS). The non-profit organizations are the Hill County Alliance, the Greater Edwards Aquifer Alliance, and the National Wildlife Federation. Comments from TPWD and the other organizations were general and mostly not specific to the Lower Colorado-Lavaca Regional Flood Plan. The comments were generally broad recommendations pertaining to the overall state and regional flood planning processes. Common themes expressed in the comments include:

- Recognize that flooding is a natural process that has beneficial effects.
- Include ecological and societal benefits of flooding in education programs.
- Encourage the use of NBS where possible.
- Provide training and technical resources to advance understanding and adoption of NBS and best practices for protecting floodplains and other natural flood mitigation features.
- Prioritize nonstructural flood risk management strategies before structural (e.g., policy, land management, emergency preparedness, etc.).
- Prioritize funding for preventative flood mitigation strategies, protection of natural infrastructure, and implementation of NBS.

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[1] United Nations Sustainable Development Goals Knowledge Platform

- Concern about a lack of Texas-specific data regarding the benefits and effectiveness of NBS for flood risk mitigation. Studies are needed to develop Texas-specific data.

Given the broad and general nature of the comments received pertaining to NBS, no specific revisions have been made to the adopted Regional Flood Plan. The Lower Colorado-Lavaca RFPG would, however, like to emphasize its support for NBS where feasible and as a complement to other flood risk reduction strategies. The RFPG's commitment to NBS is demonstrated in this Regional Flood Plan in the following:

- Floodplain management recommendations (*Chapter 3*) encourage universal participation in the National Flood Insurance Program (NFIP) and local adoption of enhanced or high floodplain and land development standards and regulations. Effective floodplain management can be viewed as a type of nature-based strategy that prevents inappropriate development in high-risk areas while preserving the natural features and functions of floodplains. Of note, a large majority of communities in the region are NFIP participants, and nearly the entirety of the population of the region resides in these communities.
- Several goals were adopted by the RFPG that are relevant to NBS. These include goals supporting the update of watershed models and floodplain maps, particularly in areas affected by Atlas 14; support for more in-depth evaluation of flood risk and prioritization of flood risk reduction measures by cities and counties; support for nonstructural approaches to flood risk reduction (e.g., buyouts and/or flood-proofing of at-risk structures); and increasing the amount of protected open space to preserve the flood risk reduction benefits of natural features (e.g., floodplain and stream riparian areas).
- Several policy recommendations are included in *Chapter 8* that address NBS directly or indirectly. Pertinent legislative recommendations include increased state funding assistance for updates of Flood Insurance Rate Maps and establishing property tax incentives to protect stream corridors by private landowners. Relevant administrative and regulatory recommendations include prioritization of technical assistance and access to funding for small communities, including training on Low Impact Development (LID) and Green Stormwater Infrastructure (GSI), development of model ordinances for LID and GSI regulations, adjusting cost-benefit analysis calculations to capture environmental values, and setting aside a percentage of FIF funds for smaller communities that may not be able to otherwise access Flood Infrastructure Funding incentives for green and nature-based projects.
- There are a number of recommended nonstructural Flood Mitigation Projects. These include projects to flood-proof critical facilities, improve flood warning and notification systems and buyouts of at-risk structures. Notably, buyouts often include some degree of restoration of natural floodplain features and functions once at-risk structures are removed.

Other Public Comments

Comments were also received from the Texas Department of Transportation (TxDOT) and the U.S. Army Corps of Engineers (USACE). These general comments are not specific to the Lower Colorado-Lavaca Regional Flood Plan. These comments are summarized below.

TxDOT noted that the agency does not specifically use transportation projects for flood risk mitigation but that drainage and flooding issues are addressed in their projects. The commenter did note that the agency is able and receptive to partnering and cost-sharing with local entities to include enhanced flood-related features in their transportation projects. Also, a TxDOT-sponsored research project is underway to identify and assess roadway flooding problems statewide. Once available, this information could point to locations where coordination and collaboration with local entities would be beneficial.

Comments submitted by USACE were also general and included legislative recommendations such as establishing non-regulatory regional flood control or drainage districts and land use plans in rapidly growing urban areas; clarification of the statutory authority of counties to regulate floodplains; and maintenance of flood infrastructure. USACE comments also included recommendations pertaining to technical guidelines from regional and state flood planning, including:

- Use stream channel conditions that would result if a channel for a project is not adequately maintained,
- Prevent the loss of valley storage at the 0.2 percent annual chance (500-year) event flood level and allow spatial redistribution of valley storage,
- Use projected fully developed conditions for floodplain regulation and in the development of flood mitigation projects,
- For large urban centers establish a regional approach to develop future condition flood risk,
- Encourage storm shifting/centering to validate the 1 percent annual chance (100-year) event flood and flood risk, and
- Update watershed hydrology assessments (e.g., hydrology and hydraulic modeling) as new precipitation data becomes available.

Given the broad and general nature of TxDOT and USACE comments, no specific revisions have been made to the final Regional Flood Plan in response. However, TWDB is encouraged to consider this input in potential planning process improvements for the subsequent cycles of regional flood planning.

Proposed Additional Administrative and Regulatory Recommendations

A member of the Lower Colorado-Lavaca RFPG, Ann Yakimovicz, submitted a comment suggesting that watershed protection planning be aligned with state and regional flood planning to ensure the water quality and flood risk reduction are considered together. Subsequently, Ms. Yakimovicz proposed additions (8.2.9, 8.3.10 and 8.3.11) to the administrative and regulatory recommendations adopted by the RFPG and included in *Chapter 8*.

Tasks 11-13: Plan Amendment Phase

The first cycle of the regional flood planning process was extended by TWDB with an amendment phase and additional funding provided for Tasks 11, 12, and 13. TWDB established a July 14, 2023 deadline for submitting the adopted Amended Regional Flood Plans. Public outreach and engagement activities described above were continued during this amendment phase. An index of plan amendments from the January 2023 plan can be found in *Appendix E.* Per TWDB requirements, a draft of the amended Regional Flood Plan was posted for public review seven days before the June 22, 2023 RFPG meeting and opportunity was provided to receive public input on the draft at that meeting. While submittal of the adopted and amended Regional Flood Plan represents the conclusion of the first regional flood planning cycle, regular communications to interested parties and the public will continue as appropriate into the second five-year planning cycle.

Guidance Principles for State and Regional Flood Planning

Administrative rules (31 TAC §362.3) for both state and regional flood plans require that the preparation of such plans be guided by 39 "guidance principles." The manner in which the adopted flood plan for the Lower Colorado-Lavaca Region has adhered to these principles is summarized in the table below:

Table 10.4 Guidance Principles and Regional Flood Planning Group Response Satisfying Said Principles

Principle Number	Principle Description	Explanation of Plan Addresses Principle
1	shall be a guide to state, regional, and local flood risk management policy	Addressed throughout the regional flood planning process and incorporated throughout the adopted regional flood plan
2	shall be based on the best available science, data, models, and flood risk mapping	Incorporated in analyses, findings, and conclusions presented in ***Chapters 2, 4, 5, 6*** and ***9***
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	Addressed in ***Chapters 2, 3, 4*** and ***5***
4	shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2% annual chance storm event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historical flood events	Addressed in analyses presented in ***Chapter 2***
5	shall, when possible and at a minimum, evaluate flood risk to life and property associated with a 1% annual chance storm 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% annual chance storm event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historical flood events	Addressed in analyses presented in ***Chapters 2, 3,*** and ***5***; ***TWDB-Required Tables 15, 16*** and ***17***

Principle Number	Principle Description	Explanation of Plan Addresses 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 the adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk	Considered and addressed in ***Chapter 3***
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	Considered and addressed in ***Chapters 2, 3, 4*** 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	Considered and addressed in ***Chapters 2, 4, 5*** 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	Addressed in ***Chapter 5*** and ***TWDB-Required Tables 15, 16*** 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	Considered and addressed in ***Chapters 4, 5*** and ***6***
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	Addressed in ***Chapters 2*** 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	Addressed in ***Chapters 4*** and ***5*** and ***TWDB-Required Tables 12, 13, 14, 15, 16*** and ***17***

Principle Number	Principle Description	Explanation of Plan Addresses Principle
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	Addressed in ***Chapter 7***
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	Addressed in ***Chapters 5*** and ***9*** and ***TWDB-Required Tables 15, 16, 17*** and ***19***
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	Participated in 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 economic management of flood risk to people, properties, and communities, and associated environmental benefits	Addressed in **Chapters *5*** and ***6***
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	Addressed in ***Chapters 4*** and ***5*** and ***TWDB-Required Tables 13, 14, 16*** and ***17***
18	shall contribute to water supply development where possible	Addressed in ***Chapter 6***
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	Addressed in ***Chapter 6***
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	Considered and addressed in ***Chapter 10***
21	shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation	Addressed in ***Chapter 10*** and **RFPG bylaws** (available on the RFPG website)
22	shall include flood management strategies and projects recommended by the RFPGs that are based upon the identification, analysis, and comparison of all flood management strategies the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals	Addressed in ***Chapter 5*** and ***TWDB-Required Tables 16*** and ***17***

Principle Number	Principle Description	Explanation of Plan Addresses Principle
23	shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals	Considered and addressed in ***Chapter 3*** and ***TWDB-Required Tables 6*** and ***10***
24	shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services	Considered and addressed in ***Chapters 1, 3, 4*** 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	Addressed in ***Chapter 3*** and ***TWDB-Required Table 6***
26	shall emphasize the fundamental importance of floodplain management policies that reduce flood risk	Addressed in ***Chapter 3*** and ***TWDB-Required Table 6***
27	shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains	Addressed in ***Chapter 5*** and ***TWDB-Required Table 16***
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	Addressed in ***Chapter 6***
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	Addressed in ***Chapters 3, 8*** 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	Addressed in ***Chapters 5*** and ***9*** and ***TWDB-Required Tables 15, 16, 17*** and ***19***
31	shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction	Addressed in ***Chapter 1*** and ***TWDB-Required Table 2***
32	shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property	Addressed in ***Chapter 8***
33	shall be based on the coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals	Addressed in ***Chapters 1, 3, 5, 9,*** and ***10*** and ***TWDB-Required Tables 16*** and ***17***
34	shall be following all existing water rights laws, including but not limited to Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties	Addressed in ***Chapter 6***

Principle Number	Principle Description	Explanation of Plan Addresses Principle
35	shall consider the protection of vulnerable populations	Considered and addressed in ***Chapters 1*** and ***5*** and ***TWDB-Required Tables 3, 13*** and ***16***
36	shall consider the benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation as appropriate	Considered and addressed in ***Chapter 6***
37	shall minimize adverse environmental impacts and follow adopted environmental flow standards	Addressed in ***Chapter 6***
38	shall consider how long-term maintenance and operation of flood strategies will be conducted and funded	Considered and addressed in ***Chapters 4*** and ***6***
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	Considered and addressed in ***Chapters 5, 6, 8*** and ***9***

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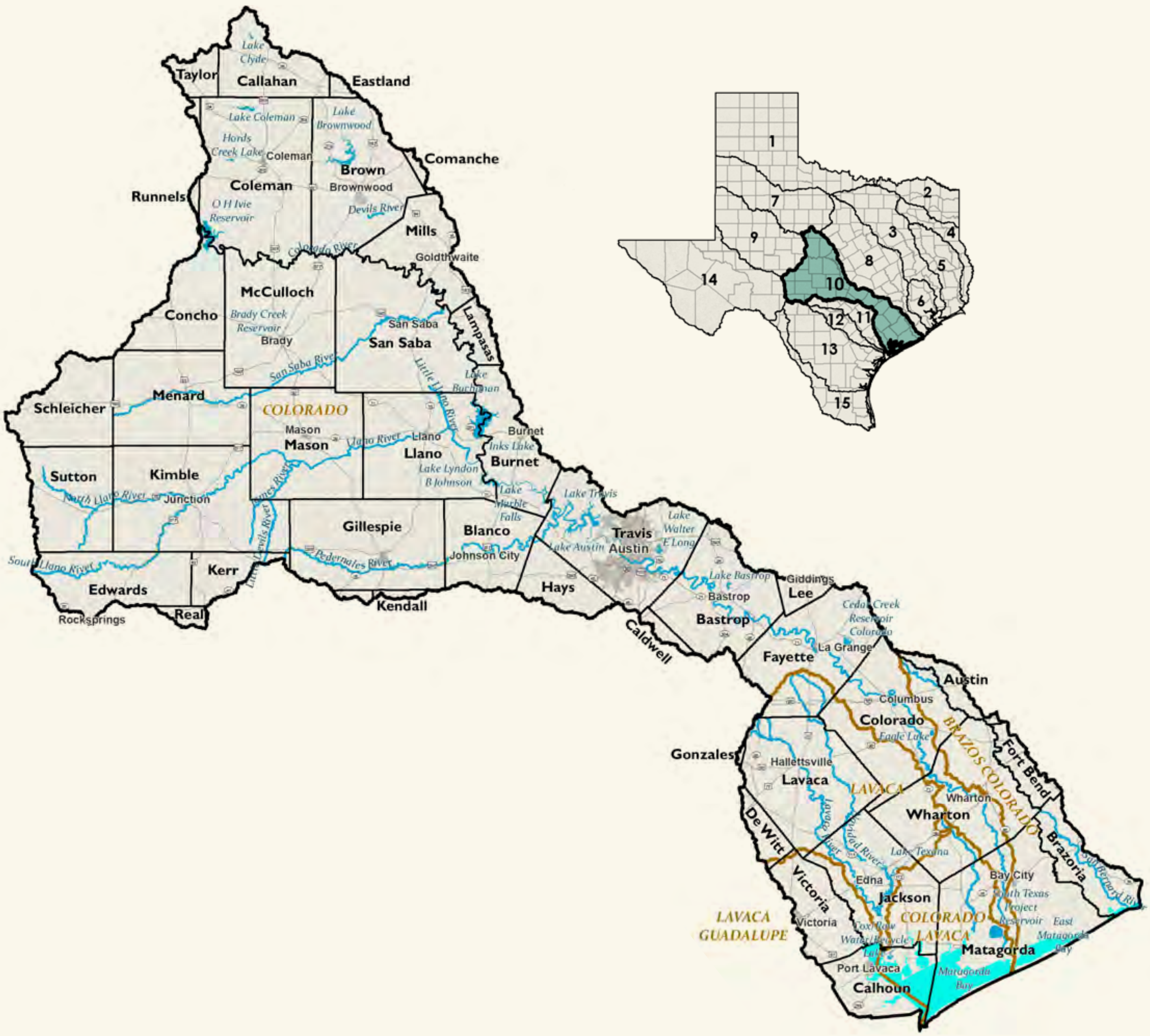
Lower Colorado-Lavaca Regional Flood Planning Area Region 10



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