REGION 1 CANADIAN UPPER RED REGIONAL FLOOD PLANNING GROUP

2023 REGIONAL FLOOD PLAN

REGION 1

CANADIAN–UPPER RED

JANUARY 2023

PREPARED FOR REGION 1 CANADIAN–UPPER RED
REGIONAL FLOOD PLANNING GROUP

2023 REGIONAL FLOOD PLAN

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Annual Chance Event	**FMA**	Flood Mitigation Assistance
ARPA	American Rescue Plan Act	**FME**	Flood Management Evaluation
ASAPP	Amarillo Simulation Analysis of Playa Performance	**FMP**	Flood Mitigation Project
BCA	Benefit-Cost Analysis	**FMS**	Flood Management Strategy
BCR	Benefit-Cost Ratio	**FNI**	Freese and Nichols, Inc.
BFE	Base Flood Elevation	**FPR**	Flood Planning Region
BLE	Base Level Engineering	**GIS**	Geographic Information System
BRIC	Building Resilient Infrastructure and Communities	**GLO**	General Land Office
CAP	Continuing Authorities Program	**GO**	General Obligation
CDBG-DR	Community Development Block Grant - Disaster Recovery Funds	**H&H**	Hydrologic and Hydraulic
CDBG-MIT	Community Development Block Grant- Mitigation	**HHPD**	High Hazard Potential Dam
CDC	Centers for Disease Control and Prevention	**HMAP**	Hazard Mitigation Action Plan
CFR	Code of Federal Regulations	**HMGP**	Hazard Mitigation Grant Program
CIP	Capital Improvement Plan	**HUC**	Hydrologic Unit Code
CO	Certificates of Obligation	**HUD**	Housing and Urban Development
CRS	Community Rating System	**ICLUS**	Integrated Climate and Land Use Scenarios
CTP	Cooperating Technical Partners	**IPCC**	Intergovernmental Panel on Climate Change
CWSRF	Clean Water State Revolving Fund	**LOD**	Level of Detail
Dfund	Texas Water Development Fund	**LOS**	Level of Service
EPA	Environmental Protection Agency	**LWC**	Low Water Crossing
ESRI	Environmental Systems Research Institute	**MS4**	Municipal Separate Storm Sewer System
ETJ	Extraterritorial Jurisdiction	**MUD**	Municipal Utility District
EWP	Emergency Watershed Protection	**NFHL**	National Flood Hazard Layer
FAFDS	First American Flood Data Services	**NFIP**	National Flood Insurance Program
FEMA	Federal Emergency Management Agency	**NHD**	National Hydrologic Dataset
FIF	Flood Infrastructure Fund	**NOAA**	National Oceanic and Atmospheric Administration
FIRM	Flood Insurance Rate Map	**NRCS**	Natural Resources Conservation Service

List of Acronyms and Abbreviations (cont.)

FIS	Flood Insurance Study	**NWS**	National Weather Service
PRPC	Panhandle Regional Planning Commission	**O&M**	Operation and Maintenance
RFP	Regional Flood Plan	**PA**	Public Assistance
RFPG	Regional Flood Planning Group	**TAC**	Texas Administrative Code
RWP	Regional Water Plan	**TCEQ**	Texas Commission on Environmental Quality
RWPA	Regional Water Planning Area	**TDA**	Texas Department of Agriculture
RWPG	Regional Water Planning Group	**TDEM**	Texas Division of Emergency Management
SB	Senate Bill	**TFMA**	Texas Floodplain Managers Association
SFHA	Special Flood Hazard Area	**TPWD**	Texas Parks and Wildlife Department
SFP	State Flood Plan	**TSSWCB**	Texas State Soil and Water Conservation Board
STORM	Safeguarding Tomorrow through Ongoing Risk Mitigation	**TWDB**	Texas Water Development Board
SVI	Social Vulnerability Index	**TxCDBG**	Community Development Block Grant Program for Rural Texas
SWMM	Storm Water Management Model	**TxDOT**	Texas Department of Transportation
SWP	State Water Plan	**USACE**	United States Army Corps of Engineers
WRDA	Water Resources Development Act	**USDA**	United States Department of Agriculture
WUG	Water User Group	**USGS**	United States Geological Survey

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The development of the 2023 Regional Flood Plan was a new process for the State of Texas, Regional Flood Planning Group members, technical consultants, the Texas Water Development Board, and regional stakeholders. The process required communication, collaboration, and problem solving from these various groups in order to represent the diverse needs of the Canadian–Upper Red Region. We thank each contributor for his or her hard work and dedication to meeting the planning objectives and the compressed timeline for the first planning cycle.

Executive Summary

In 2019, the 86th Texas Legislature passed Senate Bill (SB) 8 that authorized and established the regional and state flood planning process. The legislature assigned the responsibility of the regional and state flood planning process to the Texas Water Development Board (TWDB). This investment and massive planning effort represent an important step for Texas because:

- Flood risks, impacts and mitigation costs have never before been assessed at a statewide level for Texas
- Flood risks pose a serious threat to lives and livelihoods across the state
- Much of the flood risk in Texas is unmapped, or is based on out-of-date maps.

This report presents the Region 1 Canadian–Upper Red Regional Flood Plan (RFP), which represents the first-ever region-wide flood plan for the Canadian–Upper Red Region. Region 1 is one of 15 Regional Flood Planning Groups (RFPGs) across Texas tasked with developing a RFP. The RFP consists of 10 tasks, with primary objectives and results summarized below.

Task 1. Planning Area Description

The objective of this task was to describe the flood planning region (FPR), including natural and constructed flood infrastructure, and to describe proposed or on-going flood mitigation projects.

Encompassing the Texas Panhandle and stretching into portions of North Texas along the Oklahoma border, the Canadian–Upper Red FPR includes a wide variety of landscapes and communities. The region is served by a vast network of natural and constructed flood infrastructure, including approximately 65,980 stream miles, as well as an expansive system of playas, dry washes, and urban drainage systems. The FPR is shown in **Figure ES-1**.

While this region is mostly arid and often drought-stricken – with annual rainfall totals ranging from 19 inches in Amarillo to 31 inches in Wichita Falls – rainfall can bring destructive flooding. This task describes the social and economic character of the region and provide a high-level evaluation of the flood infrastructure protecting communities from the adverse effects of flooding.

Figure ES-1: Canadian–Upper Red Region Overview

Population, Future Growth, and Economics

Region 1 encompasses more than 34,600 square miles, making it one of the state's largest planning regions by area. Conversely, Region 1 is one of Texas' least populated flood planning areas, with an estimated 625,000 people in 2021–about 2% of Texas residents–living in the area (U.S. Census Bureau). The region is comprised of 44 counties or portions of counties, containing 90 incorporated communities.

The Canadian–Upper Red Region is a large, geographically diverse region where the needs of rural stakeholders must be balanced with those of the urban population centers. The flood risks faced by communities and landowners also vary across the region.

Region 1 is 95% rural by land area, covering approximately 33,000 square miles of agricultural property, including ranchland. The region contains only two census-designated urbanized areas, Amarillo and Wichita Falls, that are home to an estimated 302,700 residents or nearly 50% of the region's population. The population of the five counties surrounding Amarillo and Wichita Falls account for nearly two-thirds

of the region's total population. Smaller towns and unincorporated communities are vital to the character of the region.

Assessment of Condition and Functionality of Existing Infrastructure

Participants in the Canadian–Upper Red data collection survey provided information about the condition and functionality of drainage infrastructure to supplement information provided by TWDB. Generally, throughout Texas, flood infrastructure is rapidly aging and in need of repair. Per TWDB guidance, infrastructure is considered to be non-functional when it is not providing its intended or design level of service, and deficient when the infrastructure or natural feature is in poor condition and needs replacement, restoration, or rehabilitation. These features are unlikely to become fully functional without funding.

Of the communities that responded to the survey, over 50% noted that at least 25% of their flood infrastructure was non-functional, and over 60% noted that at least 25% was deficient for current flood mitigation needs. **Map 3** in **Appendix A-1** shows the locations of where these survey participants have said their infrastructure or features are non-functional or deficient.

Proposed or Ongoing Flood Mitigation Projects

Only two proposed or ongoing projects were identified in Region 1: Martin Road Playa Improvements in Amarillo and Quail Creek in Wichita Falls. Eight additional entities identified themselves as having proposed or ongoing projects as a part of the outreach survey, but not enough information was provided to include them in the list for Region 1 at this time. These entities were Timbercreek Canyon, Ogallala Commons, Perryton, Hale County SWCD, Palisades, Fritch, Spearman, and Iowa Park.

Task 2. Flood Risk Analysis

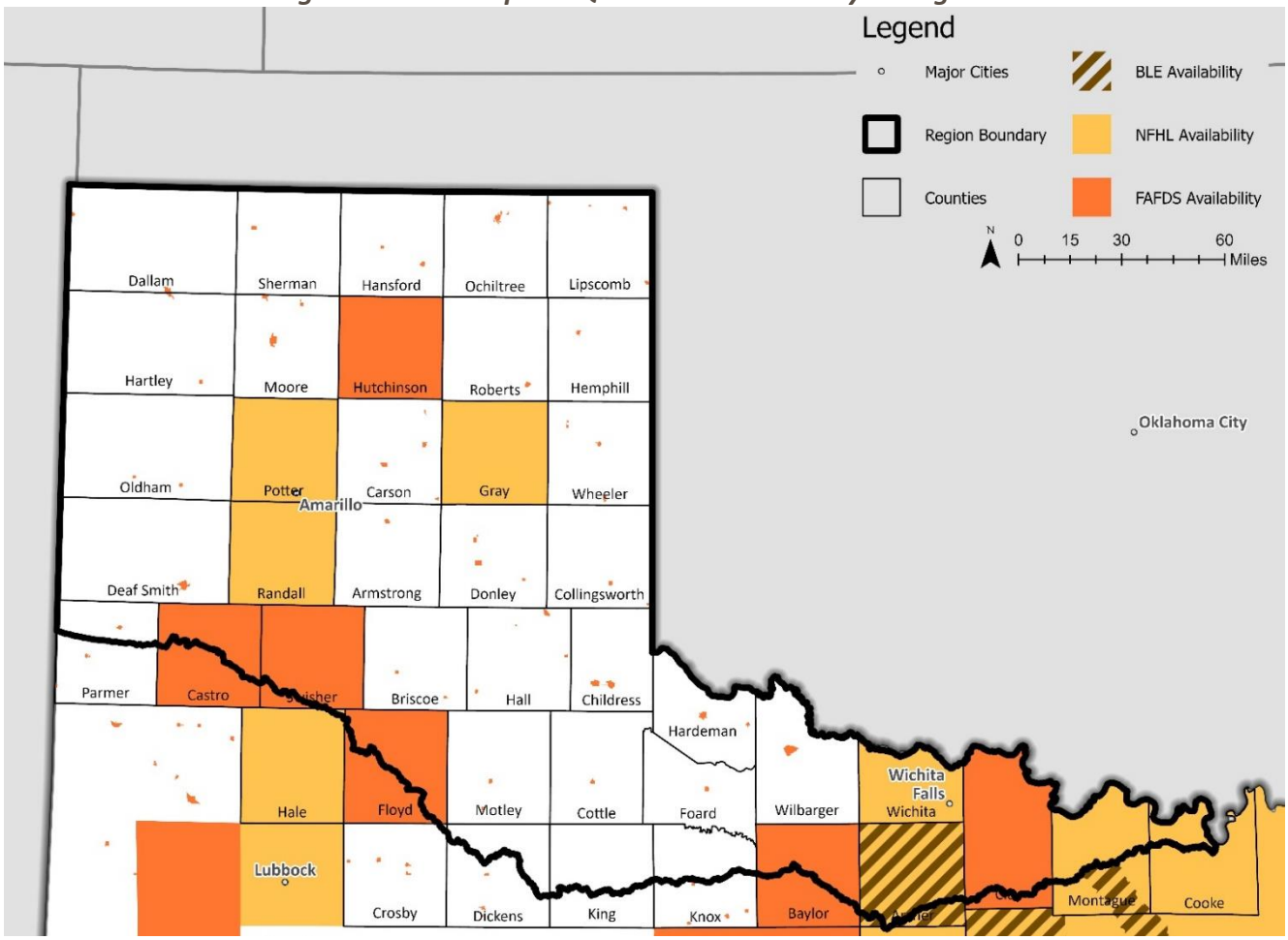
The objective of this task was to perform a comprehensive and cohesive flood risk analysis for the region. Flood risks were assessed for the 1% and 0.2% annual chance events (ACEs), also commonly referred to as 100-year and 500-year floods, respectively. The analysis was performed for existing conditions of the region, as well as a "no action" future condition scenario that considers changes in flood hazards over the 30-year planning horizon.

The region is subject both to the danger of swift-moving flood waters in riverine areas and to standing water associated with flooded playas and lakes. Urban flooding is also a source of significant flooding exposure, particularly in the cities of Amarillo and Wichita Falls. Much of the flood risk in Region 1 is unmapped or based on out-of-date maps and, as a result, most of the flood risk across the region is not well quantified, meaning that people and their property may be unknowingly in harm's way.

To assist RFPGs with the flood risk analysis, TWDB prepared a statewide, geographic information system (GIS) dataset – the "floodplain quilt" – with the most recent, publicly-available flood-hazard data in Texas. The floodplain quilt is comprised of data from several sources, including First American Flood Data Services (FAFDS) flood zone determinations, Federal Emergency Management Agency (FEMA) National Flood Hazard Layer (NFHL) information developed from detailed and approximate flood

studies, and FEMA Base Level Engineering (BLE) data. **Figure ES-2** summarizes the floodplain quilt data available within Region 1.

Figure ES-2: Floodplain Quilt Data Availability in Region 1



Source: TWDB Flood Quilt (TWDB Data Hub)

While an important and valuable source of data, floodplain quilt data provided limited coverage in Region 1. A secondary source of commercially available "cursory floodplain data" was utilized to help fill in the remaining gaps. The cursory floodplain data was generated through 2D rain-on-grid hydraulic modeling performed by Fathom, a company focused on providing large-scale flood models to data-scare areas. The cursory floodplain data was used to develop flood hazard areas for the majority of the region, supplemented by NFHL detailed study (Zone AE) data, where it was available.

In a related effort, TWDB is making an aggressive push to expand the availability of floodplain mapping information in Texas through the development of FEMA BLE data. While very few areas in Region 1 have BLE data currently, full BLE coverage for the region is expected in 2023. Therefore, future flood planning cycles will be able to incorporate this BLE data for more accurate results. **Figure ES-3** depicts the gaps in flood mapping across the region, summarized on a Hydrologic Unit Code (HUC) 12 watershed basis. **Figure ES-4** shows the existing flood hazard area for the region for the 1% and 0.2% ACE.

Figure ES-3: Gaps in Existing Flood Mapping

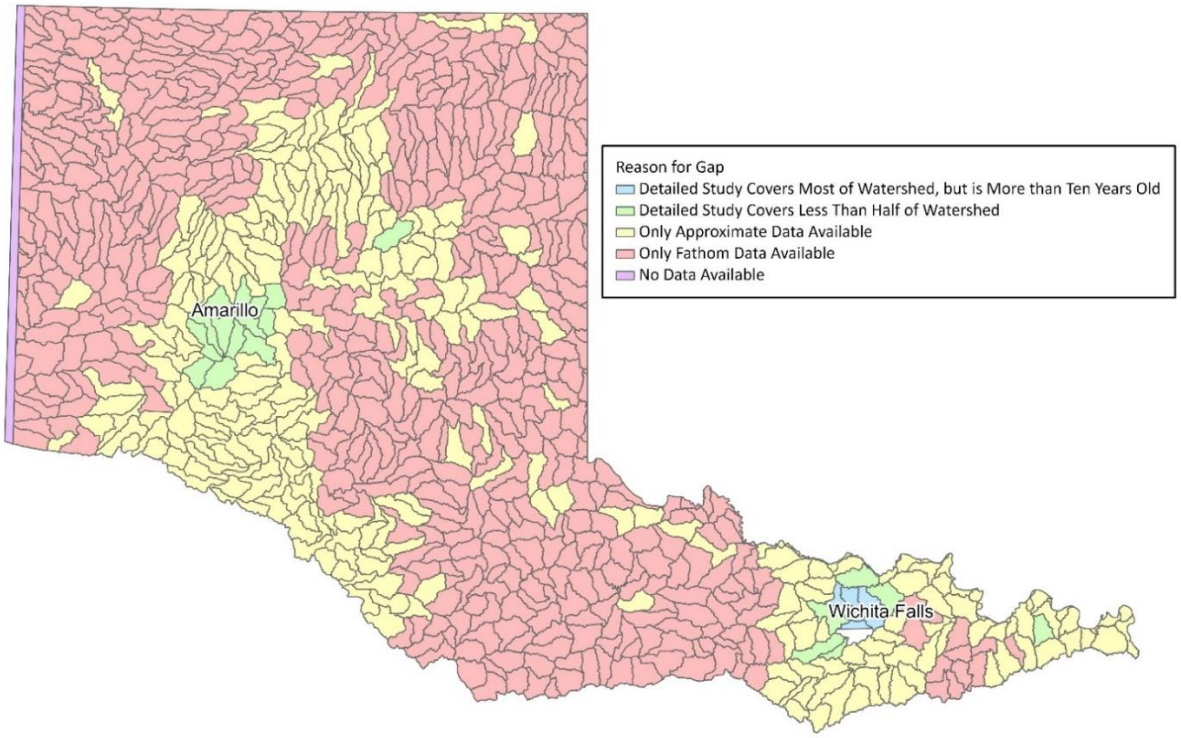
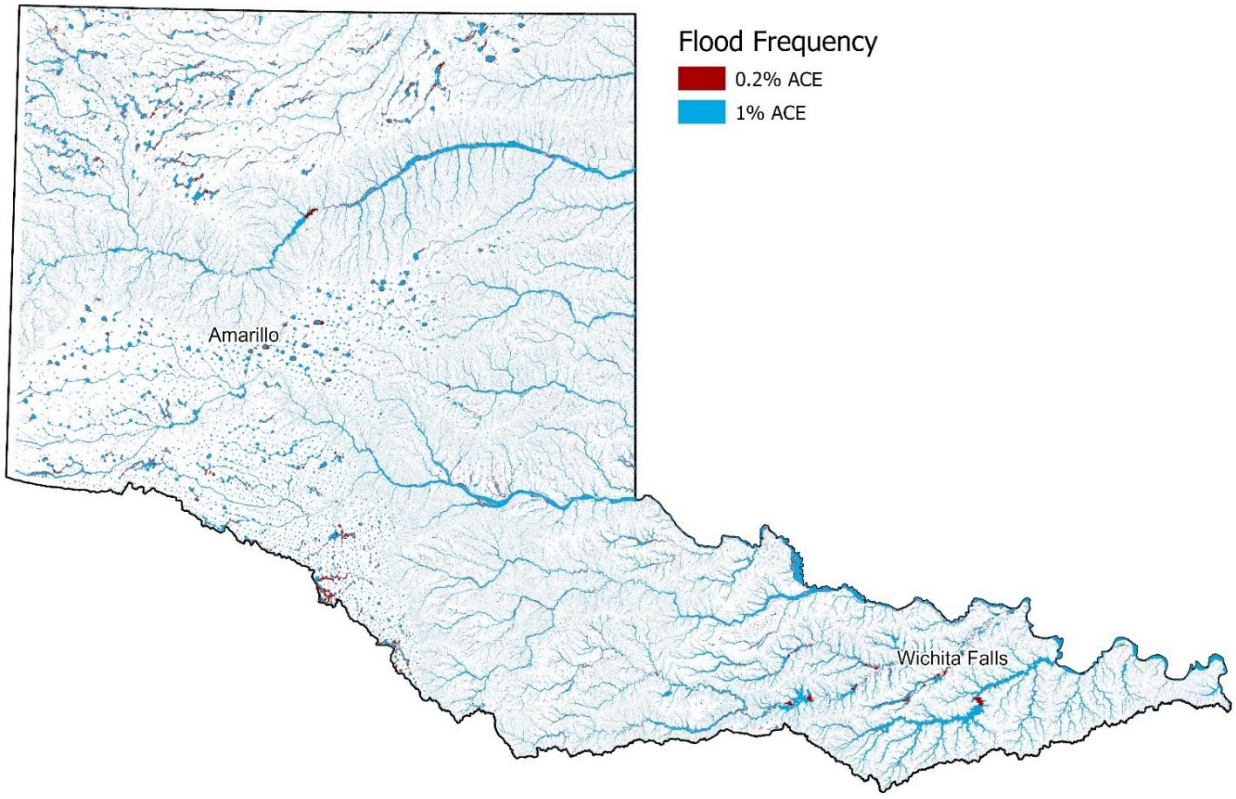


Figure ES-4: Existing Flood Hazard Area



Task 2A. Existing Condition Flood Risk Analysis

The flood hazard analysis identifies who and what might be harmed within the region by the 1% and 0.2% ACE, and is based on existing flood hazard data. A regional summary of flood exposure by feature type is presented in **Table ES-1.**

Table ES-1: Existing Flood Exposure Summary

Exposure Feature Type	Number of Features by Flood Hazard Area			
	1% ACE	0.2% ACE	Unknown	Total
Structures (#)	11,544	12,170	88	**23,802**
Population (#)	29,996	38,834	161	**68,991**
Critical Facilities (#)	160	128	0	**288**
Roadway Segments (miles)	2,299	1,042	8	**3,349**
Roadway Stream Crossings (#)	4,981	945	164	**6,090**
Agricultural Areas (sq. miles)	3,789	858	0	**4,647**

Task 2B. Future Condition Flood Risk Analysis

In addition to quantifying the current flood risk, it is helpful to consider the change in flood risk over the course of the planning horizon to help communities plan ahead for new or increased risks. With this concept in mind, a future condition flood risk analysis was performed for the region. Flood hazards tend to increase over time in populated areas due to increases in impervious cover, anticipated sedimentation in flood control structures, and other factors that result in increased or altered flood hazards. As a result, expected increases in flooding extents and magnitude across the region defined the future condition flood hazard area.

Estimated changes in flood hazard extents are meant to represent the "30-year, no action" scenario for the purpose of evaluating the potential magnitude for future flood risk. This information will in no way be used for floodplain mapping for regulatory purposes, such as local floodplain management and development regulation, or in any way by FEMA or the National Flood Insurance Program(NFIP). This is simply a planning level analysis for the purpose of supporting the regional flood planning process. The future condition flood hazard layer was developed according to the *Technical Guidance* and is described further in **Chapter 2**.

A comparison of the existing and future flood hazard area is presented in **Table ES-2**. The future condition 1% ACE flood hazard area is equal to the total combined flood hazard area under existing conditions because the 0.2% ACE flood hazard area was chosen to estimate the extents for the future 1% ACE flood. An additional 1,632 square miles of flood hazard area is added to estimate the extents of 0.2% flooding.

Table ES-2: Flood Hazard Area Comparison

Flood Hazard Area	Total Existing Area (Sq. Miles)	Total Future Area (Sq. Miles)	Area Change (Sq. Miles)	Area Change (%)
1%	4,305	5,232	927	22%
0.2%	930	1,632	702	75%
Total	5,235	6,864	1,629	31%

A regional summary of future conditions flood exposure by feature type is presented in **Table ES-3**. With the increase in size of the flood hazard areas in future conditions, exposure also increases for all feature types.

Table ES-3: Future Flood Exposure Summary

Exposure Feature Type	Number of Features by Flood Hazard Area			
	1% ACE	0.2% ACE	Unknown	Total
Structures (#)	23,718	17,480	78	41,276
Population (#)	66,927	39,356	139	106,422
Critical Facilities (#)	288	241	0	529
Roadway Segments (miles)	3,342	2,010	7	5,359
Roadway Stream Crossings (#)	6,277	4,448	124	10,849
Agricultural Areas (sq. miles)	4,606	1,538	0	6,144

Task 3. Floodplain Management Practices and Flood Protection Goals

This task included evaluating and recommending floodplain management practices (Task 3A) and flood mitigation goals (Task 3B) within the region.

Task 3A. Evaluation and Recommendations on Floodplain Management Practices

During discussions, the RFPG generally was reluctant to impose additional regulations and requirements on communities and recognized the current lack of available flood hazard information. The reasoning is the belief that such requirements would impose an undue burden on communities to develop the hydrologic and hydraulic (H&H) analyses necessary to enforce these requirements. Therefore, the Canadian–Upper Red RFPG **recommends, but does not adopt,** the following minimum standards for the region.

1. A developer should be required to submit a study, based on both existing and proposed conditions, and demonstrate no adverse flood impact due to the development.
2. Structures should be required to be elevated 1 foot above the BFE, top of curb, or adjacent grade, whichever is highest based on available data.

3. The design of roadway riverine crossings should adhere to the following criteria based on roadway classification:
    a. Local/Collector – No overtopping by the 10% ACE (10-year); no inundation of adjacent structures.
    b. Arterial – No overtopping by the 4% ACE (25-year); no inundation of adjacent structures.
    c. Thoroughfare/Freeway/Emergency Access – No overtopping by the 1% ACE (100-year); no inundation of adjacent structures.
4. Developers wishing to fill in a playa floodplain should provide compensatory storage and maintain equivalent hydrologic function, and adhere to the following requirements:
    a. Natural areas should be preserved to promote natural infiltration and evaporation.
    b. High-maintenance infrastructure, such as pumps, should be avoided.
    c. Natural areas should be acquired or protected by public easements.
    d. A flood study should be required to demonstrate no adverse flood impact.
    e. Freeboard requirements for nearby structures should also apply.

Task 3B. Flood Mitigation and Floodplain Management

The RFPG discussed potential goals for the RFP over a series of four meetings from June to September 2021. The adopted goals are listed in **Table ES-4**. These goals guided the recommendation of evaluations, projects, and strategies to identify and mitigate flood risk across the region as part of Tasks 4 and 5.

Table ES-4: Adopted Flood Mitigation and Floodplain Management Goals

Short-Term (10 year)	Long-Term (30 year)
Evaluate watersheds to confirm/refine flood risk for 50% of habitable structures identified within the planning region's 1% existing flood hazard area.	Evaluate watersheds to confirm/refine flood risk for 100% of habitable structures identified within planning region's 1% existing flood hazard area.
Reduce number of habitable structures within the planning region's 1% existing flood hazard area by 20%.	Reduce number of habitable structures within the planning region's 1% existing flood hazard area by 50%.
Improve safety at 20% of Low Water Crossings (LWCs) in the planning region through structural improvements or warning/signage systems.	Improve safety at 50% of LWCs in the planning region through structural improvements or warning/signage systems.
Develop a baseline understanding of the risks associated with high-hazard dams and levees within the planning region.	Bring 100% of deficient high-hazard dams and levees in the planning region up to current state and/or federal standards.

Short-Term (10 year)	Long-Term (30 year)
Increase NFIP participation or adoption of equivalent standards to 90% of municipalities and 75% of counties in the planning region.	Increase NFIP participation or adoption of equivalent standards to 100% of municipalities and 100% of counties in the planning region.
Increase percentage of communities in the planning region with dedicated funding sources for operations and maintenance of storm drainage system to 25% of municipalities and 10% of counties.	Increase percentage of communities in the planning region with dedicated funding sources for operations and maintenance of storm drainage system to 50% of municipalities and 30% of counties.
Consider and incorporate nature-based practices in 50% of Flood Mitigation Projects (FMPs) and Flood Management Strategies (FMSs) recommended in the RFP.	N/A

Task 4. Assessment and Identification of Flood Mitigation Needs

The objective of Task 4 was to conduct a high-level analysis of flood risk knowledge gaps and flood risk mitigation needs across the region. The results of the analysis were used to identify a set of potential flood mitigation actions to address the identified needs. These actions were evaluated for recommendation under Task 5.

Task 4A. Flood Mitigation Needs Analysis

The RFPG conducted a flood mitigation needs analysis that considered a variety of criteria, including flood risk exposure to buildings, LWCs, critical infrastructure, agricultural areas, and other resources; NFIP participation; gaps in flood mapping information; lack of H&H models; emergency need; existing flood risk mitigation plans; FMPspreviously identified; historic flooding reports; and social vulnerability of communities. The factors considered as part of the needs analysis and the relative weighting of each factor were determined by the RFPG over the course of several meetings. **Figure ES-5** summarizes the results of the flood mitigation needs analysis on a watershed basis for the greatest gaps in flood risk information, while **Figure ES-6** summarizes the region for the locations of the greatest flood risk.

Figure ES-5: Needs Analysis Results for Greatest Gaps in Flood Risk Information

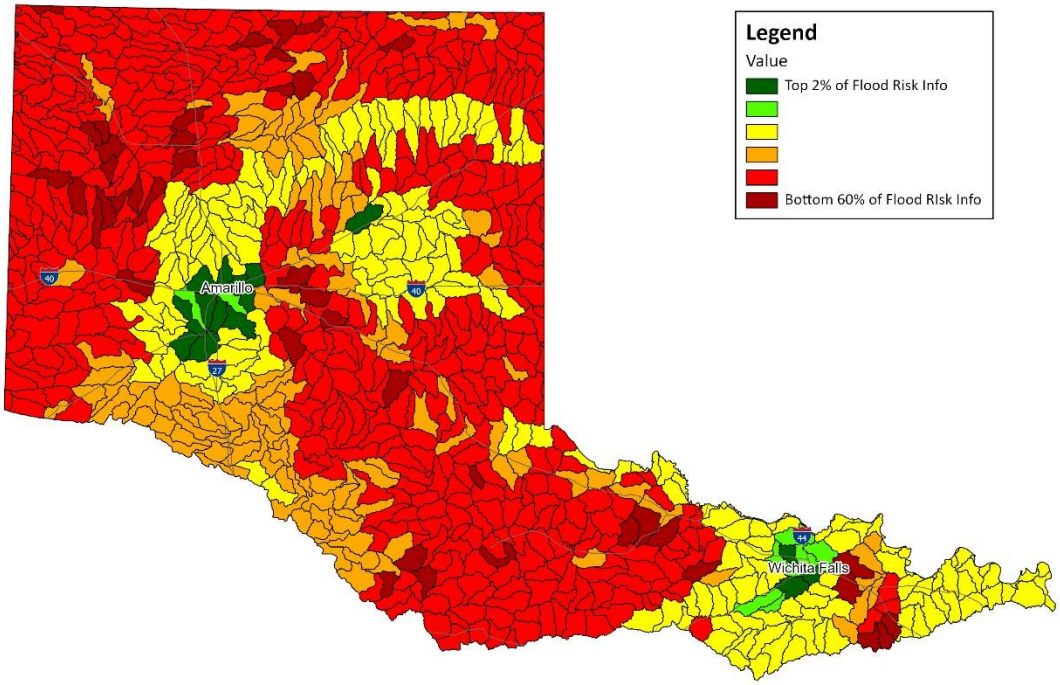
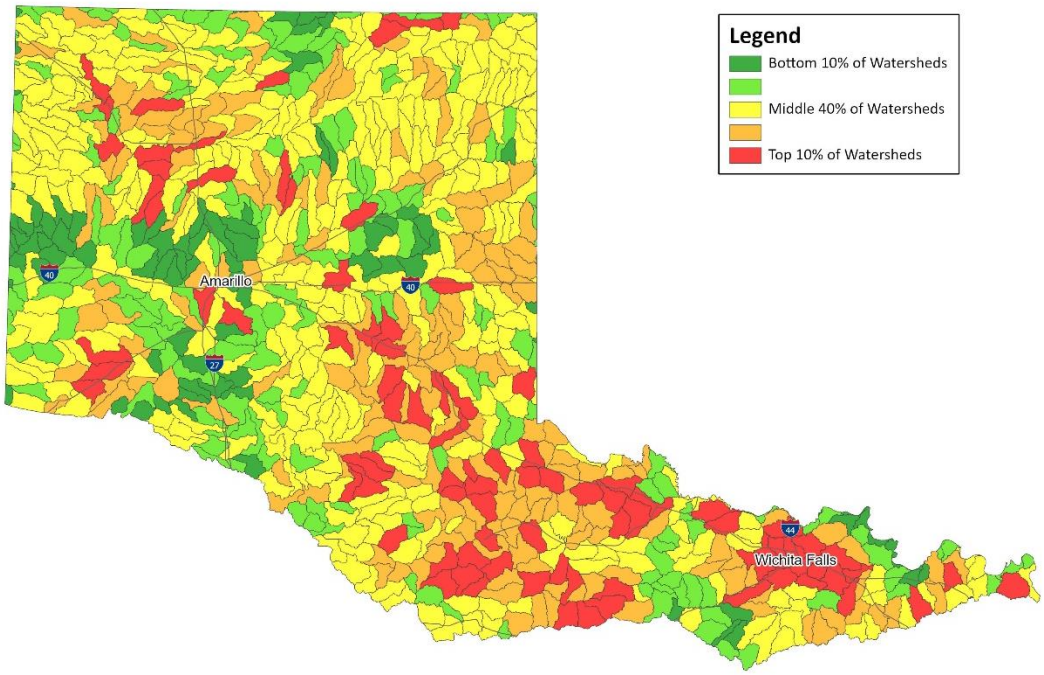


Figure ES-6: Needs Analysis Results for Greatest Flood Risk



Task 4B. Identification and Evaluation of Potential Flood Management Evaluations, Potentially Feasible Flood Management Strategies, and Flood Mitigation Projects

The goal of Task 4B was to define and evaluate a wide range of potential actions to identify and mitigate flood risks across the region. These actions have been broadly categorized into three distinct types, defined as follows:

- **Flood Management Evaluation (FME)**: 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
- **Flood Mitigation Project (FMP)**: A proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and, when implemented, will reduce flood risk or mitigate flood hazards to life or property
- **Flood Management Strategy** (**FMS**): A proposed plan to reduce flood risk or mitigate flood hazards to life or property

Based on the results of the flood mitigation needs analysis, several sources of data were used to develop a list of potential flood risk reduction actions that may address the region's needs. The list of potential FMEs and potentially feasible FMSs and FMPs for the RFP were compiled based on contributions from the RFPG and other regional stakeholders whose sources included previous flood studies, drainage master plans, flood protection studies, and capital improvement plans. The process for identifying and evaluating potential FMEs and potentially feasible FMSs and FMPs was voted on by the RFPG during the September 13, 2021 meeting.

Task 5. Evaluation and Recommendation of Flood Management Evaluations, Flood Management Strategies, and Associated Flood Mitigation Projects

As part of Task 5, FMEs, FMSs, and FMPs were further evaluated in order to compile the necessary technical data for the RFPG to decide whether to recommend these actions or a subset of these actions.

The RFPG considered recommendations on flood mitigation actions through a multi-step process. The general methodology included a screening of all potential flood mitigation actions while considering TWDB requirements for inclusion in the RFP. The reasons for not recommending a particular flood mitigation action were clearly documented as part of the evaluation and recommendation process.

Description and Summary of Recommended Flood Management Evaluations

The RFPG identified and evaluated 185 potential FMEs, recommending 184 that represented $84.4 million of need across the region. The only FME that was not recommended was the Borger City Drainage Master Plan because the sponsor indicated that the proposed study is in progress. From 45 Project Planning FMEs with associated construction costs, an additional $70.9 million of need was identified to construct improvements if FMPs are recommended after these FMEs are performed.

The number and types of projects recommended by the RFPG are summarized in **Table ES-5**.

Table ES-5: Summary of Recommended FMEs

FME Type	Description	Number of Potential FMEs Identified	Number of FMEs Recommended	Total Cost of Recommended FMEs
Watershed Planning	FEMA mapping, drainage master plans, watershed evaluations, river modeling	120	119	$68,737,000
Project Planning	Project design development	49	49	$12,691,000
Preparedness	Pump station rehabilitation	1	1	$125,000
Other	GIS development, dam evaluations, data collection systems	15	15	$2,885,000
	Total:	**185**	**184**	**$84,438,000**

Description and Summary of Recommended Flood Management Strategies

The RFPG identified and evaluated a wide variety of FMS types, identifying 62 potentially feasible FMSs and recommending 60 for the RFP. One FMS to assist a community with joining the NFIP was not recommended at the direction of the sponsor. Generally, these FMSs recommend city-wide and county-wide strategies and initiatives that represent a total cost of $13.6 million. These FMSs support several of the regional floodplain management and flood mitigation goals established in **Chapter 3**.

The number and types of projects recommended by the RFPG are summarized in **Table ES-6**.

Table ES-6: Summary of Recommended FMSs

FMS Type	Description	Number of Potential FMSs Identified	Number of FMSs Recommended	Total Cost of Recommended FMSs
Property Acquisition and Structural Elevation	Acquiring properties and creating regulation to raise future structures	1	1	$6,000,000
Infrastructure Projects	Gates at LWCs	1	1	$1,000,000
Education and Outreach	Public education programs	2	2	$200,000
Flood Measurement and Warning	Warning systems and gauges	3	3	$750,000
Regulatory and Guidance	NFIP participation, Community Rating System (CRS), stormwater utility fee development	54	52	$5,300,000
Other	Maintenance	1	1	$100,000
	Total:	**62**	**60**	**$13,350,000**

Description and Summary of Recommended Flood Mitigation Projects

The RFPG identified 18 potential FMPs, and nine have been recommended for inclusion in the RFP. These projects are located in the cities of Amarillo, Canyon, and Wichita Falls, and they represent a total construction cost of $92.3 million. Two FMPs for the City of Wichita Falls were not recommended based on a sponsor request to not include them in the RFP. The other seven FMPs not recommended were alternatives for the City of Canyon Flood Mitigation Project. These were not recommended because they did not have the necessary technical data for evaluation as an FMP and because the sponsor preferred a combined detention and channel improvement alternative, which was ultimately recommended for inclusion. Each of the FMPs were evaluated to confirm they have no negative impacts per TWDB guidance.

A summary of the recommended FMPs for inclusion in the RFP is presented in **Table ES-7.**

Table ES-7: Summary of Recommended FMPs

FMP Name	Description	Sponsor	Total Cost of Recommended FMPs
T-Anchor Lake Watershed Drainage Improvements	Four-phase playa excavation and storm drain improvements	Amarillo	$31,300,000
Rhea Road Drainage Project	Install storm drain system with curb and gutter	Wichita Falls	$2,995,000
Brenda Hursh Enhancement Project	Construct storm system diversion to channel through golf course	Wichita Falls	$4,151,000
City of Canyon Flood Mitigation Project	Construct offline detention facilities along Palo Duro Creek, construction diversion channel through golf course, and upgrade LWCs	Canyon	$37,238,000
Wichita Gardens Drainage Improvements	Install storm drain system with curb and gutter	Wichita Falls	$10,008,000
Echo/Neta Lane Drainage Project	Install storm drain system with curb and gutter	Wichita Falls	$2,853,000
Hirschi–Huskie Drainage Project	Extend existing storm drain system and acquire properties	Wichita Falls	$632,000
Landon, Duty, and Sunset Streets Drainage Project	Install storm drain system with curb and gutter and an outfall to a drainage channel	Wichita Falls	$2,120,000
Spanish Trace Drainage Project	Regrade irrigation canal to convey flow north	Wichita Falls	$1,043,000
		Total:	**$92,343,000**

Task 6. Impact and Contribution of the Regional Flood Plan

Task 6A. Impacts of the Regional Flood Plan

The goal of Task 6A was to summarize the overall impacts of the RFP. This includes potential impacts to areas at risk of flooding, structures and populations in the floodplains, number of LWCs impacted,

impacts to future flood risk, impact to water supply (details provided in **Task 6B**), and overall impact on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

Table ES-8 summarizes the benefits from the recommended FMPs to structures, population and LWCs**.** This shows the impacts of the new 1% ACE after structural projects are implemented that reduce flood risk.

Table ES-8: Summary of Impacts from FMPs for the 1% ACE

	Existing Conditions	After FMP Implementation	Exposure Reduction from FMPs
Exposed Structures	858	145	713
Exposed Population	2,574	483	2,091
Exposed LWC	9	6	3

The impacts from FMEs and FMSs are more qualitative in nature and are summarized in **Chapter 6**. Until the FMEs are completed, their specific benefits cannot be quantified; however, there are an estimated 11,550 structures located in the 1% ACE floodplain, with 12,170 in the 0.2% ACE floodplain. These structures represent a population of nearly 41,800 and 54,020 people, respectively. Tens of thousands more are exposed to risk as they travel across flooded roadways and LWCs. These FMEs will help reduce the risks to these people and help prevent additional flood exposure by providing more accurate information on the flood risks, empowering communities to keep citizens and their property out of harm's way.

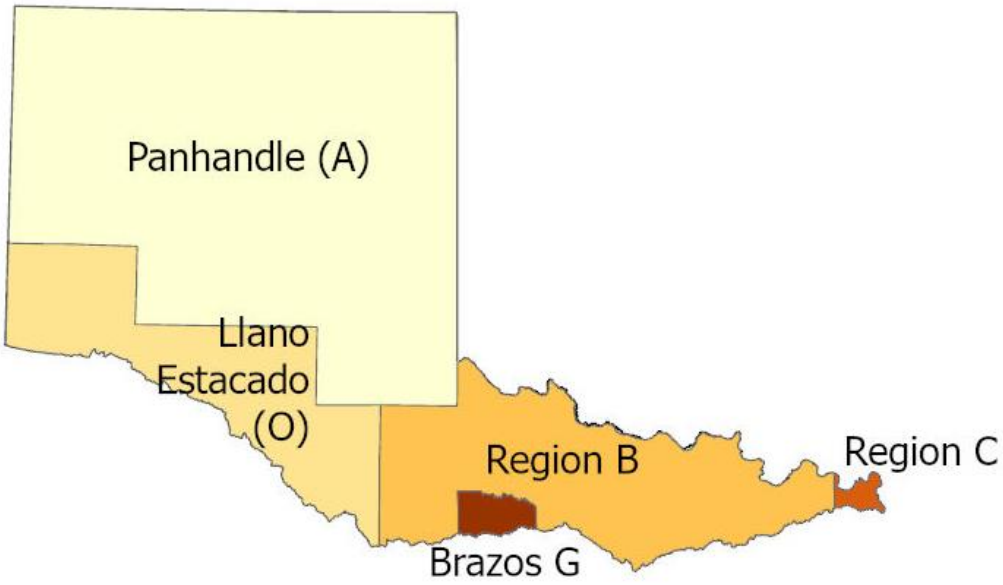
By implementing the recommended FMSs, impacts from flooding is likely to be less severe, and anticipated increases in future flood exposure are likely to be reduced. The recommended FMSs are expected to reduce the number of injuries and deaths due to flooding by educating people about the risks of flooding, providing warnings of current and potential flooding, and reducing the frequency and severity of flooding of roads and structures. While the number of injuries and deaths prevented by these FMSs could not be readily quantified, they have the potential to be significant. However, these positive impacts will only be realized if communities are able to enact these strategies and enforce these policies.

Task 6B. Contribution to and Impacts on Water Supply Development and the State Water Plan

TWDB is responsible for overseeing Texas' regional water planning process in 16 regional water planning areas (RWPA), with appointed members who represent key public interests to the regional water planning groups (RWPG). A model for the state's flood planning process, the RWPGs evaluate region-specific risks, uncertainties, and potential water management strategies. The Region 1 flood planning area includes all or part of the following RWPAs, as shown in **Figure ES-7**: Region A, Region B, Region G, Region O, and Region C.

The goal of Task 6B was to evaluate potential impacts of the RFP on water supply development and the State Water Plan (SWP). It was determined that none of the FMPs or FMSs in this RFP has an impact on water supply, water availability, or projects in the SWP.

Figure ES-7: Region 1 Overlap with Water Planning Regions



Source: Water Planning Areas (TWDB Data Hub)

Task 7. Flood Response Information and Activities

This task provided an overview of flood emergency management and focused on the preparedness, response, and recovery phases of flood emergencies specific to the Canadian–Upper Red Region. Its information relied upon survey responses, oral testimony of entities and citizens from the region, and local knowledge of the technical consultants to present flood response information and activities specific to this region.

Aside from preparedness activities related to flood mitigation, the region currently lacks dedicated flood preparedness, such as emergency planning documents, staff, equipment, and systems for flooding emergencies. Community officials largely rely on publicly available data from the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), United States Geological Survey (USGS), and Texas Department of Transportation (TxDOT) when preparing for flood events. Cities and counties carry most of the burden for flood response, including road closures and evacuations.

The most common flood recovery activity within the region is debris removal at culvert entrances and bridges that, if not remedied, compounds the next flood emergency. This activity is primarily conducted by cities, counties, and TxDOT. A lack of coordination among the responsible entities for debris removal at these facilities is a commonly reported problem by cities and counties.

Task 8. Administrative, Regulatory and Legislative Recommendations

This task provided an opportunity for the RFPG to make recommendations to the State of Texas to improve floodplain management and mitigation within the region. The Canadian–Upper Red RFPG discussed draft recommendations during the April 14, 2022, May 11, 2022, and June 22, 2022 meetings. A total of 32 recommendations were developed and are summarized in **Table ES-9** and **Table ES-10** . Additional explanation and rationale for each recommendation are included in **Chapter 8**.

Table ES-9: Administrative Recommendations

Administrative Recommendations	
8.1.1	Develop model standards and ordinances for general law cities, such as building codes and subdivision regulations.
8.1.2	Develop model floodplain management standards for varied levels of floodplain management practices (low, medium, high) to encourage increased levels.
8.1.3	Compile research and develop standards for flood management inside and adjacent to playas. This would include best practices for dealing with the unique hydrology of playas.
8.1.4	Provide ongoing training targeted to non-technical floodplain administrators to promote a higher level of floodplain management in communities across the state that may not have the necessary resources or technical expertise to perform these functions themselves.
8.1.5	Provide funding and/or technical assistance to smaller jurisdictions to assist them in dealing with flood planning and management, and encourage interjurisdicational cooperation.
8.1.6	Develop alternatives to a traditional Benefit-Cost Ratio (BCR) when ranking projects within the State Flood Plan (SFP) that benefit agricultural and energy activities.
8.1.7	Expand consideration for projects that do not provide 1% ACE (100-year) flood Level of Service (LOS) but can demonstrate substantial benefit during higher-frequency (smaller) events.
8.1.8	Develop a publicly available, statewide database and tracking system to document flood-related fatalities. This could be an addition to the Flood Plan Data Hub to capture existing data from TxDOT, NOAA, or others.
8.1.9	Partner with Texas Floodplain Managers Association (TFMA) to promote public education and outreach about flood awareness and flood safety, and provide outreach materials to communities.
8.1.10	Maintain a flood hazard area map on a public web map platform, potentially integrated with the existing Water Data interactive site.

Administrative Recommendations	
8.1.11	Provide outreach information that varies geographically and is tailored to a wide variety of flood situations.
8.1.12	Develop a model-based future conditions flood hazard data layer using BLE data, and provide it for use by RFPGs and the technical consulting teams during the next flood-planning cycle (2029).
8.1.13	Incentivize voluntary buy-out programs, turning previously flooded properties and neighborhoods into green space and parkland as an alternative to large-scale construction projects.
8.1.14	Provide training to state agencies, local governments, engineers, and planners in the use of natural floodplain preservation/conservation techniques.
8.1.15	Identify and eliminate barriers that prevent jurisdictions from working together to provide regional flood mitigation solutions, and identify process that would encourage greater regional cooperation.
8.1.16	Provide funding to support multijurisdictional cooperation on FMEs, FMSs and FMPs.

Table ES-10: Regulatory and/or Legislative Recommendations

	Regulatory and/or Legislative Recommendations
8.2.1	TWDB and TFMA should encourage communities to adopt 2015 or 2018 versions of International Building Code and International Residential Code as State Building Standards. Additionally, TWDB and TFMA should recommend to FEMA updating the Building Resilient Infrastructure and Communities (BRIC) scoring criteria to better capture the disparate needs of Texans across the State.
8.2.2	TWDB and TFMA should recommend (not adopt or require) a statewide building standard of a minimum floor elevation equal to the BFE plus freeboard.
8.2.3	TxDOT should review and update its design criteria to identify opportunities to improve consideration for flood safety to better align with the goals and objectives of the regional flood planning criteria.
8.2.4	TxDOT should review and update its design criteria to require no adverse flood impacts on adjacent or downstream properties for proposed road projects.
8.2.5	TxDOT should review and update its design criteria to require design for future land use and development conditions.

	Regulatory and/or Legislative Recommendations
8.2.6	TWDB and TFMA should encourage FEMA to streamline the CRS application process.
8.2.7	The Texas Legislature should allocate funding for recurring biennial appropriations to the Flood Infrastructure Fund (FIF) for study, strategy, and project implementation.
8.2.8	The Texas Legislature should allocate funding for a dedicated funding mechanism for TxDOT to improve the flood safety of transportation facilities.
8.2.9	The Texas Legislature should allocate funding for a state levee-safety program similar to the Texas Commission on Environmental Quality (TCEQ) dam safety program.
8.2.10	The Texas Legislature should allocate funding for a program to assist private dam owners and agencies owning former National Resources Conservation Service (NRCS) dams with the costs associated with evaluation, repair and maintenance of those structures.
8.2.11	The Texas Legislature should allocate funding for incentives for establishment of dedicated drainage funding.
8.2.12	The Texas Legislature should provide guidance for use of public funds to improve private properties for flood risk reduction.
8.2.13	The Texas Legislature should provide counties with legislative authority to establish drainage utilities and assess drainage fees under similar conditions to those authorized for municipalities under Local Government Code, Title 13, Subtitle A, Chapter 552.
8.2.14	The Texas Legislature should provide counties with expanded regulatory authority to manage new development to reduce future flood risk and benefit water supplies.
8.2.15	The Texas Legislature should provide clarity on roles and responsibilities within extraterritorial jurisdiction (ETJ) areas related to floodplain management activities.
8.2.16	The Texas Legislature should increase cooperative funding with the USGS to expand the stream gauging network in Texas to provide better information for flood planning and response, and improve information available for regional water supply planning.

Task 9: Flood Infrastructure Financing Analysis

The Region 1 RFPG has recommended a total of 253 flood mitigation actions to address flood risk across the planning region. Combined, these flood mitigation actions are anticipated to cost $261 million to implement, as shown in **Table ES-11**. Note that the total cost for FMEs includes the anticipated construction cost of FMPs developed by project planning FMEs.

Table ES-11: Total Cost of Recommended Flood Mitigation Actions

Action Type	Number Recommended	Anticipated Total Cost
FME	184	$155.3 M
FMP	9	$92.3 M
FMS	60	$13.3 M
Total	**253**	**$261 M**

Stormwater infrastructure and floodplain management activities are historically underfunded programs compared to other infrastructure types, and this is a continued challenge that local entities documented through their initial survey responses. Lack of funding was indicated as a primary cause of inadequate or deficient drainage infrastructure in nearly all of the surveys received.

The RFPG surveyed sponsors to determine how much local funding is available to contribute to these actions. Overall, there is an estimated $203 million of funding needed to implement the recommended FMEs, FMSs, and FMPs in this RFP beyond what is anticipated to be funded by local sponsors. This figure represents 78% of the total cost of the flood mitigation actions identified in this RFP.

This number does not represent the amount of funding needed to mitigate all risks in the region nor to solve flooding problems in their totality. This number simply represents the funding needs for the specific, identified evaluations, 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 Canadian–Upper Red Region.

Task 10: Public Participation and Plan Adoption

The Region 1 RFPG employed multiple methods to engage the public and stakeholders in this initial RFP development. The Region 1 RFPG gave the public access to a survey through their project webpage. The public was also given access to an interactive map hosted on the website, where they were able to identify areas of flood risk in their region, use a portal to upload their own data to contribute to the planning process, and provide information on flood projects in their community. The website also hosted an interactive data dashboard that displayed the GIS data developed during the planning process.

From October 2020 to December 2022, the Region 1 RFPG held 19 formal meetings. The Region 1 RFPG meetings were conducted both online via GoToWebinar and in-person at the TxDOT Childress District Office keeping in mind concerns for the COVID-19 pandemic. All meetings were conducted in accordance with the Texas Open Meetings Act. Public attendance and comments were encouraged at each meeting.

The final RFP was adopted on December 7, 2022. The RFP was prepared in accordance with the rules and guidance principles provided by TWDB. **Table 10-3** in **Chapter 10** indicates which portion of the RFP addresses each guidance principle.

The Regional Flood Plan in Context

Overview of the Establishing Act

In 2019, in the wake of historic flooding in Texas, the State Legislature passed Senate Bill (SB) 8, which established the first-ever regional and state flood planning process for Texas. The Texas Water Development Board (TWDB) was charged with overseeing flood planning for Texas and providing funding for investments in flood science and mapping efforts to support plan development.

This investment and massive planning effort represent an important step for Texas because:

- Flood risks, impacts and mitigation costs have never before been assessed at a statewide level for Texas
- Flood risks pose a serious threat to lives and livelihoods across the state
- Much of the flood risk in Texas is unmapped, or is based on out-of-date maps.

RFPs are required to be based on the best available science, data, models, and flood risk mapping. The plans focus both on reducing existing risk to life and property and on enhancing floodplain management to avoid increasing flood risk in the future. The guiding principles of the plan are described in 31 Texas Administrative Code (TAC) §362.3, and include a focus on additional benefits such as water quality, recreation, and ecosystem function as well.

Overview of the Planning Process

Given the diverse geography, culture and population of the state, the planning effort is being carried out at a regional level. TWDB established 15 FPRs which are based on major river basin boundaries. Region 1 is designated as the Canadian–Upper Red FPR. The boundaries for each FPR are shown in **Figure A-1**. A summary of project milestones is presented in **Table A-1**. The first RFP was submitted to TWDB January 10, 2023. The Regional Flood Planning Group (RFPG) also has the opportunity to apply supplemental funding to enhance the first RFP by providing an amended RFP by July 14, 2023. TWDB will compile these RFPs into a single statewide flood plan and will present it to the Legislature in 2024. An updated version of the State Flood Plan (SFP) will be due every five years thereafter. Projects listed in the plan will be eligible for state funding, and the comprehensive view of flood risk in Texas will allow policymakers to make informed decisions on funding allocation for flood risk reduction projects and policies.

Figure A-1: Flood Planning Region Boundaries

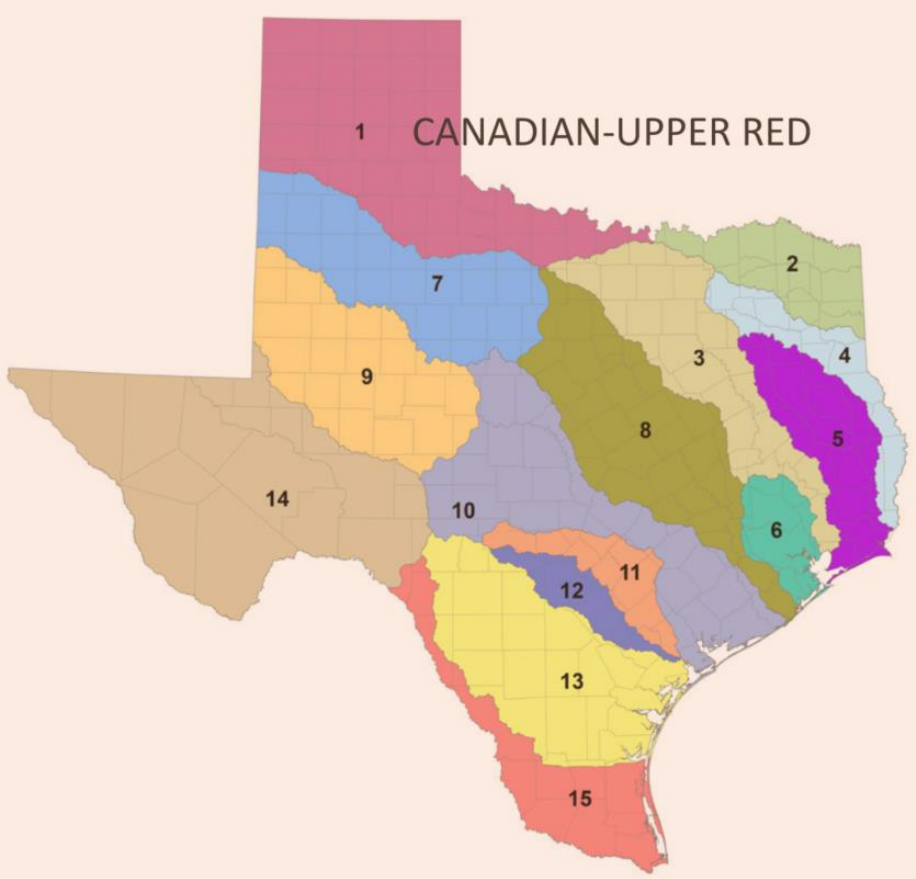


Table A-1: First Planning Cycle Deadlines

Plan Deliverable	Deadline
Draft RFP	August 1, 2022
Final RFP	January 10, 2023
Amended RFP	July 14, 2023
Final SFP	September 1, 2024

RFPG Organization

TWDB has appointed a RFPG for each region and has provided them with funding to prepare their RFPs. The Region 1 RFPG was established by TWDB on October 1, 2020 to manage the flood planning efforts for the Canadian–Upper Red FPR. The RFPG performs the functions defined in Texas Water Code Chapter 16 and in Title 31 of the TAC Chapters 361 and 362. The enabling legislation and TWDB planning rules and guidelines established the basis for the creation and composition of the RFPGs. The statute listed 12 required interest groups that must be represented at all times by the planning group. The interest groups represented by the 15 voting members of the RFPG are listed below:

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

In addition to the 15 voting members, the RFPG has seven key state resource agency stakeholder positions represented as non-voting members. The RFPG also designated an eighth non-voting position to represent transportation authorities. Finally, each RFPG has designated a non-voting member liaison to represent portions of major river basins that have been split into more than one FPR. In Region 1, the liaison coordinates between the Canadian–Upper Red (Region 1) and Lower Red-Sulphur-Cypress (Region 2) FPRs.

The members of the Region 1 RFPG for the first flood planning cycle are listed in **Table A-2**. TWDB selected the initial members from a nominating process. Each member is recognized for his or her valuable contributions to the 2023 RFP.

Table A-2: Region 1 RFPG Membership

Member Name	Interest Category/Title	Organization/Entity	Voting Member
Chandler Bowers	Agricultural Interests	Self	Yes
Layne Chapman	Agricultural Interests	Texas Farm Bureau	Yes
Jeff Watts	Counties (*Executive Committee*)	Wichita County	Yes
Ronnie Gordon	Counties	Hartley County	Yes
Glen Green	Electric Generating Utilities	Xcel Energy	Yes
Nathan Howell	Environmental Interests	West Texas A&M University	Yes
Carolann Corado	Flood Districts	Farmers Creek Watershed Authority	Yes
Don Davis	Industries	Self	Yes
Kyle Schniederjan	Municipalities (*Secretary*)	City of Amarillo	Yes
Russell Schreiber	Municipalities	City of Wichita Falls	Yes
Jane Ketcham	Public	Self	Yes
Randy Whiteman	River Authorities	Red River Authority of Texas	Yes
Joseph Shehan	Small Businesses (*Vice Chairman*)	J. Shehan Engineering, P.C.	Yes
Tracy Mesler	Water Districts (*Executive Committee*)	Upper Trinity Groundwater Conservation District	Yes
Floyd Hartman	Water Utilities (*Chairman*)	City of Amarillo	Yes
Brad Simpson	Natural Resources Specialist	Texas Parks and Wildlife Department	No
Brian Hurtuk	Hazard Mitigation Planner	Texas Division of Emergency Management	No
Carol Faulkenberry	Field Representative	Texas Department of Agriculture	No
Bob Gruner	Field Representative	Texas State Soil and Water Conservation Board	No
Trey Bahm	Management Analyst	General Land Office	No
Nellie Bennett	Environmental Coordinator	Texas Department of Transportation	No
Anita Machiavello	Regional Flood Planner	Texas Water Development Board	No
Melinda Torres	Assistant Homeland Security Coordinator	Texas Commission on Environmental Quality	No
Clark Crandall	River Basin Liaison	Region 2 Lower Red-Sulphur-Cypress RFPG	No

Roles and Responsibilities

The RFPG performs several important functions including support of and coordination with TWDB and performing all technical and administrative support activities necessary to deliver the draft and final RFPs. The RFPG responsibilities are outlined in 31 TAC §361.12. Specifically, the RFPG is responsible for performing the following activities each planning cycle:

1. Designate a political subdivision as a planning group sponsor of the RFPG – for the first cycle, the planning group sponsor was Panhandle Regional Planning Commission (PRPC).
2. Select a technical consultant(s) to be procured by the planning group sponsor – for the first cycle, the technical consultant was Freese and Nichols, Inc. (FNI).
3. Hold at least one public meeting, to determine what, if any, additional public notice the RFPG determines is necessary to ensure adequate public notice in its own FPR – this meeting was held on October 26, 2020.
4. Hold public meetings at central locations readily accessible to the public within the FPR – see details in **Chapter 10.**
5. Approve the contract(s) and any subsequent amendments thereto between the planning group sponsor and the technical consultant or TWDB Scope(s) of Work or budgets in open meetings – the initial contract was approved and executed on April 28, 2021. Additional contract amendments were executed as necessary and are documented in the meeting minutes available on the RFPG website.
6. Hold regular RFPG meetings, at a minimum, annually – see details in **Chapter 10**.

Funding Sources

To fund projects identified by these RFPs, the Legislature created a new Flood Infrastructure Fund (FIF) and charged TWDB with administering the fund. The Texas Infrastructure Resiliency Fund is being used to finance the preparation of these RFPs, and will also be used to finance flood-related projects. Entities with identified flood mitigation solutions that are included in the RFP may be eligible for future financial assistance in the form of grants and/or loans from TWDB.

Chapter 1. Planning Area Description

The objective of this task was to describe the FPR, including natural and constructed flood infrastructure, and describe proposed or ongoing flood mitigation projects. Encompassing the Texas Panhandle and stretching into portions of North Texas along the Oklahoma border, the Canadian–Upper Red FPR includes a wide variety of landscapes and communities. The region is served by a vast network of natural and constructed flood infrastructure, including approximately 65,980 stream miles, as well as an expansive system of playas, dry washes, and urban drainage systems. The FPR is shown in **Figure 1-1**.

Figure 1-1: Canadian–Upper Red Region Overview

While this region is mostly arid and often drought-stricken–with annual rainfall totals ranging from 19 inches in Amarillo to 31 inches in Wichita Falls–rainfall can bring destructive flooding. This task describes the social and economic character of the region and provides a high-level evaluation of the flood infrastructure protecting communities from the adverse effects of flooding.

1.1 Social and Economic Character of the Planning Area

1.1.1 Population, Future Growth, and Economics

Region 1 encompasses more than 34,600 square miles, making it one of the largest planning regions by area. Conversely, Region 1 is one of Texas' least populated flood planning areas, with an estimated 625,000 people in 2021 – about 2% of Texas residents – living in the area (U.S. Census Bureau). The region is comprised of 44 counties or portions of counties, containing 90 incorporated communities.

The Canadian–Upper Red Region is a large, geographically diverse region where the needs of rural stakeholders must be balanced with those of the urban population centers. The flood risks faced by communities and landowners also vary across the region. To better understand the nature of that flood risk, this section discusses the people, type and location of development, economic activities and sectors at greatest risk of flood impacts.

1.1.1.1 Current Development Conditions

Region 1 is 95% rural by land area, covering approximately 33,000 square miles of agricultural property, including ranchland. The region contains only two census-designated urbanized areas, Amarillo, in Potter and Randall Counties, and Wichita Falls, in Wichita, Clay, and portions of Archer County. These two cities are home to an estimated 302,700 residents, or nearly 50% of the region's population. The population of the five counties surrounding Amarillo and Wichita Falls account for nearly two-thirds of the region's total population.

Smaller towns and unincorporated communities are vital to the character of the region, with several located along the major transportation corridors of US 287 and IH-40. Only eight other cities in the region have populations exceeding 10,000, with none exceeding 20,000 except for Amarillo and Wichita Falls, as listed in **Table 1-1**.

Table 1-1: Cities in the Canadian–Upper Red Region with Population Greater than 10,000

City	Population	City	Population
Amarillo	200,393	Canyon	14,836
Wichita Falls	102,316	Dumas	14,501
Gainesville*	17,394	Borger	12,551
Pampa	16,867	Burkburnett	10,939
Hereford	14,972	Vernon	10,078

Source: 2020 Census Redistricting (census.gov)
**A small portion of Gainesville is within the Region 1 boundary.*

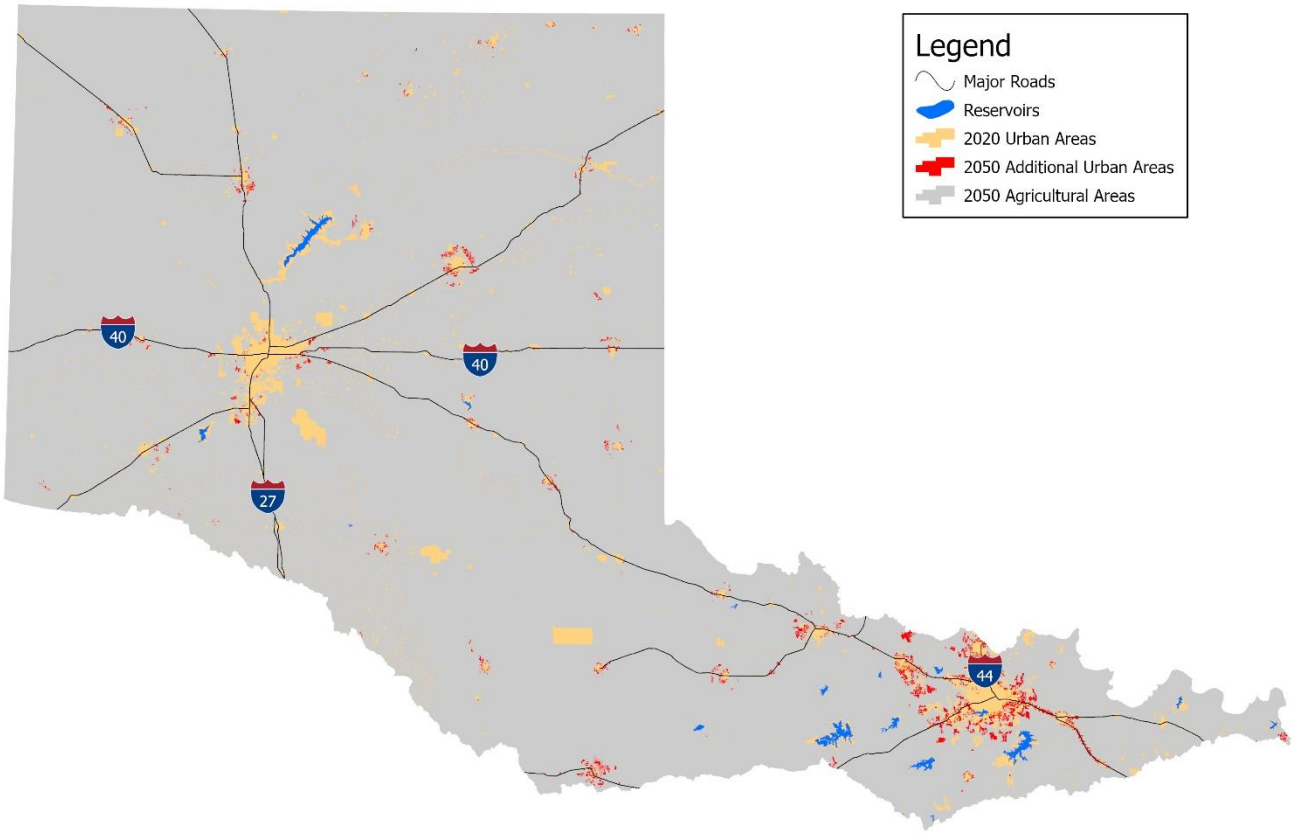
1.1.1.2 Projected Growth Within the Region

The 2020 census documented a decade of explosive growth in the State of Texas, the fastest growing state in the nation. The population is expected to continue to increase at a rapid rate across the state in the future. However, most of this growth is expected to occur in the state's largest cities and their surrounding counties, namely the corridors connecting Dallas-Fort Worth, Austin, and Houston (Murdock and Cline). In fact, several counties decreased in population over the last decade, especially in the Texas plains and Panhandle region, as the population in Texas has become increasingly urbanized.

Despite expected population decreases in rural areas, Region 1 as a whole is expected to grow over the 30-year planning horizon. From 2020 to 2050, the population within Region 1 is expected to increase 24% to nearly 805,000 residents, based on the Water User Group (WUG) and Hydrologic Unit Code (HUC) 8 population projections provided by TWDB. The United States Geological Survey (USGS) delineates watersheds nationwide using a hierarchical HUC system consisting of 2 additional digits for each increasing level of definition. A HUC 8 subbasin is identified with eight digits, HUC 10 watersheds are identified with 10 digits, and HUC 12 sub-watersheds with 12 digits. As noted, these increases are expected to be centralized within cities and towns that will add areas of new development and see some redevelopment of existing areas to provide housing and businesses to support the growing population.

The Integrated Climate and Land Use Scenarios (ICLUS) land cover projections developed by the United States Environmental Protection Agency (EPA) were used to evaluate existing and future land use conditions across the region. The existing and future development conditions are depicted in **Figure 1-2.** Despite the population increase, the land use in the region is still expected to be over 92% rural by the end of the 30-year planning horizon.

Figure 1-2: Urban Development Changes



Source: ICLUS Land Cover Projections Dataset (US EPA)

1.1.1.3 Economic Activity

In order to understand the economic risk that the region faces from flood events, this report identifies the most significant industries within the region by two factors:

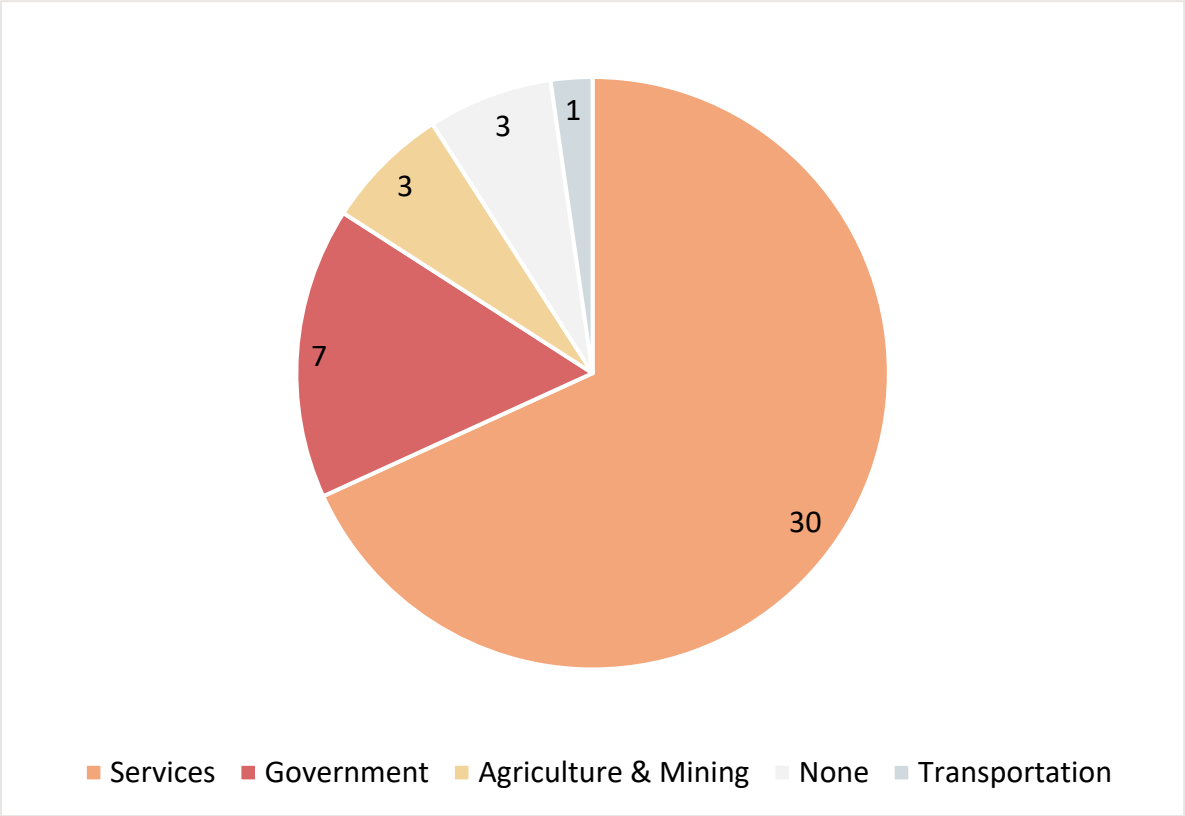
- Number of establishments
- Number of employees

The analysis utilized data from the Environmental Systems Research Institute (ESRI) Business Analyst. Through ESRI Business Analyst, only the areas within the region are considered for analysis, even if the county or census tract extends into neighboring regions. Therefore, some analyses produce results of "none" or "0" for counties where most of the development occurs outside the Region 1 boundary.

Industries were divided in accordance with the Standard Industrial Classification system, which classifies all business establishments to facilitate the publication of statistical data related to the United States economy. This section of the report identifies the largest industry per county, as measured by the two factors above. By identifying the dominant industries in each category, the figures within this section identify the economic sectors with the highest potential economic impacts in the event of a flood.

Figure 1-3 shows the major industry of each county based on the number of establishments. To determine this, the number of establishments in each category was counted per county to determine that county's top category. Those top categories were listed, one per county, to illustrate the most common establishments in the region. The most common industry is services. Services includes establishments like hotels, health services, legal services, educational institutions, and others. The second most common is government. The three counties with "none" listed are Crosby, Hale, and Young Counties, which only have small portions of the county within the Region 1 boundary.

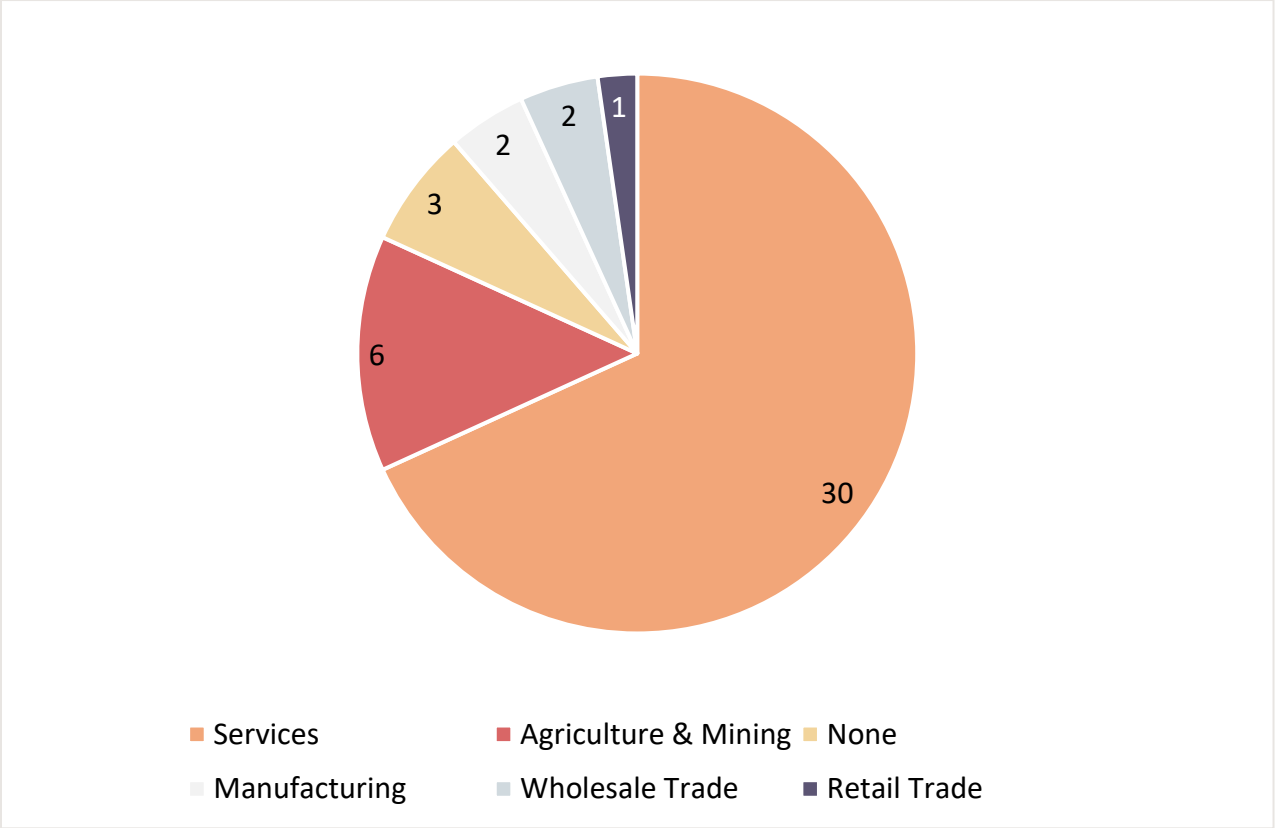
Figure 1-3: Major Industry per County by Number of Establishments



Source: 2021 ESRI Business Analyst

Figure 1-4 shows the major industry of each county by the number of employees working in that sector. The representation of the services industry is fairly similar to the graph of number of establishments; however, government is no longer the major industry in any county. This indicates that, while there are many governmental establishments within the region, none of them are major employers. Instead, the second most common industry is agriculture & mining.

Figure 1-4: Major Industry per County by Number of Employees



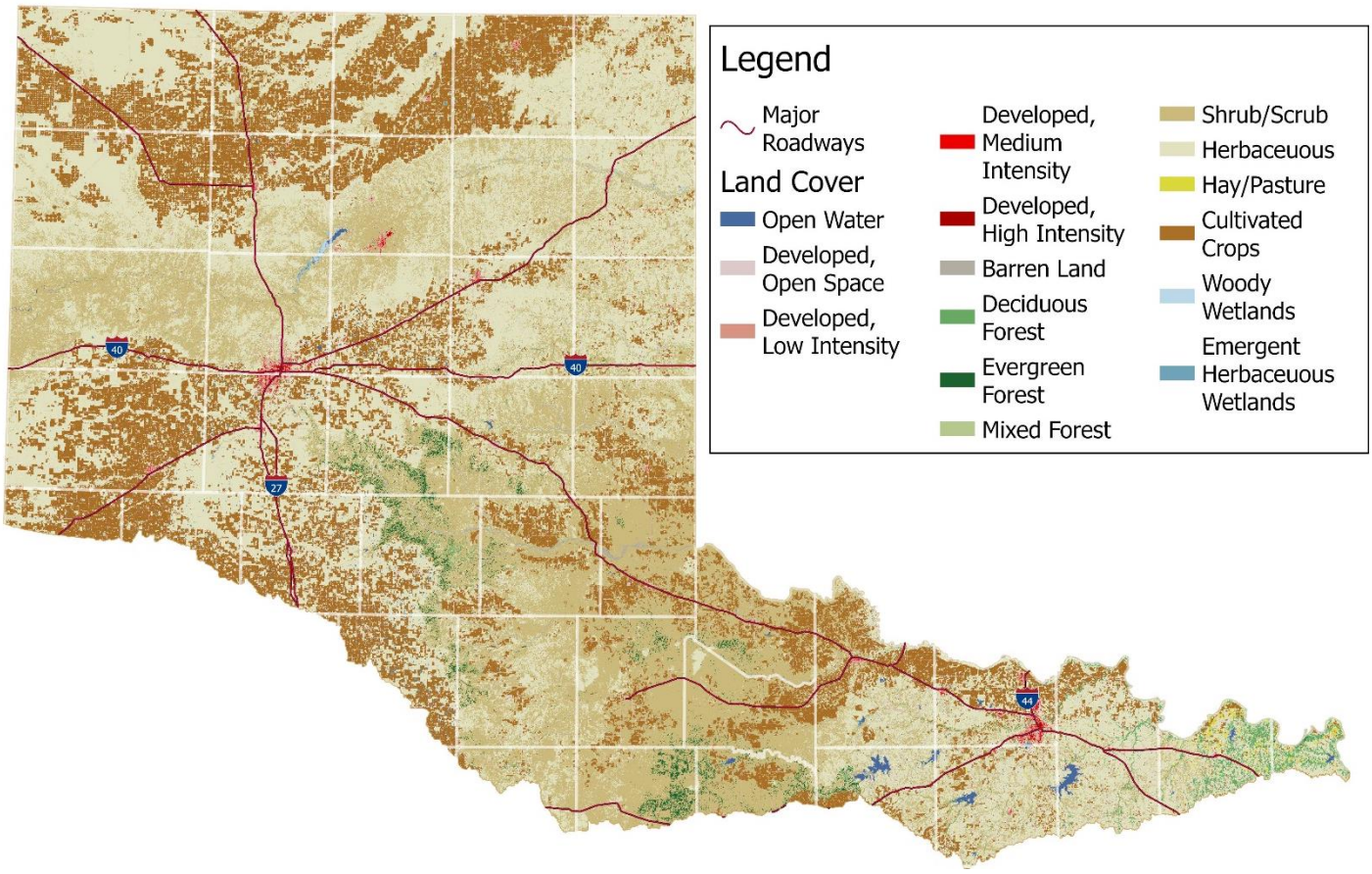
Source: 2021 ESRI Business Analyst

Agriculture/Ranching

The Texas Panhandle is an extremely productive agricultural region with a rich farming and ranching heritage. Although fewer individuals are exposed to flood hazards in rural areas, the impact of flooding on agriculture and ranching can be severe. Floods can delay planting and ruin crops, kill livestock, and damage barns or other structures, causing significant economic hardship to the farmers and ranchers.

Land cover variation across the region is shown in **Figure 1-5**. Ranching (shrub/scrub and herbaceous land cover) is the predominant agricultural use of working lands across Region 1**.** Cropland (cultivated crops) is also common across the region.

Figure 1-5: Land Cover



Source: USDA CropScape 2020 Cropland Data Layer

According to the United States Department of Agriculture (USDA), the region's major crops between 2015 and 2019 include corn, soybeans, wheat, and cotton. **Table 1-2** summarizes the total value of crops for the counties in Region 1 between 2015 to 2019 in 2021 dollars, adjusting for inflation. These values are provided at a county level and were not adjusted to reflect the portion of the county that is contained within the region. As a result, the total value for the crops in Region 1 is slightly overrepresented by the figures provided.

Table 1-2: Major Crop Types by Crop Value (2015 through 2019)

Crop Name	Total Crop Value (2021 $)	Crop Name	Total Crop Value (2021 $)
Corn	$4,467,900,000	Flue Cured Tobacco	$92,100,000
Soybeans	$2,672,900,000	Sugar Beets	$86,700,000
Wheat	$1,564,900,000	Canola	$86,500,000
Cotton	$1,190,500,000	Grapes	$83,900,000
Pasture, Rangeland, Forage	$304,400,000	Dry Peas	$82,600,000
Grain Sorghum	$256,500,000	Annual Forage	$78,000,000
All Other Crops	$239,500,000	Peanuts	$70,600,000
Apples	$132,600,000	Almonds	$65,700,000
Rice	$125,600,000	Oranges	$64,100,000
Cherries	$115,200,000	Sunflowers	$59,800,000

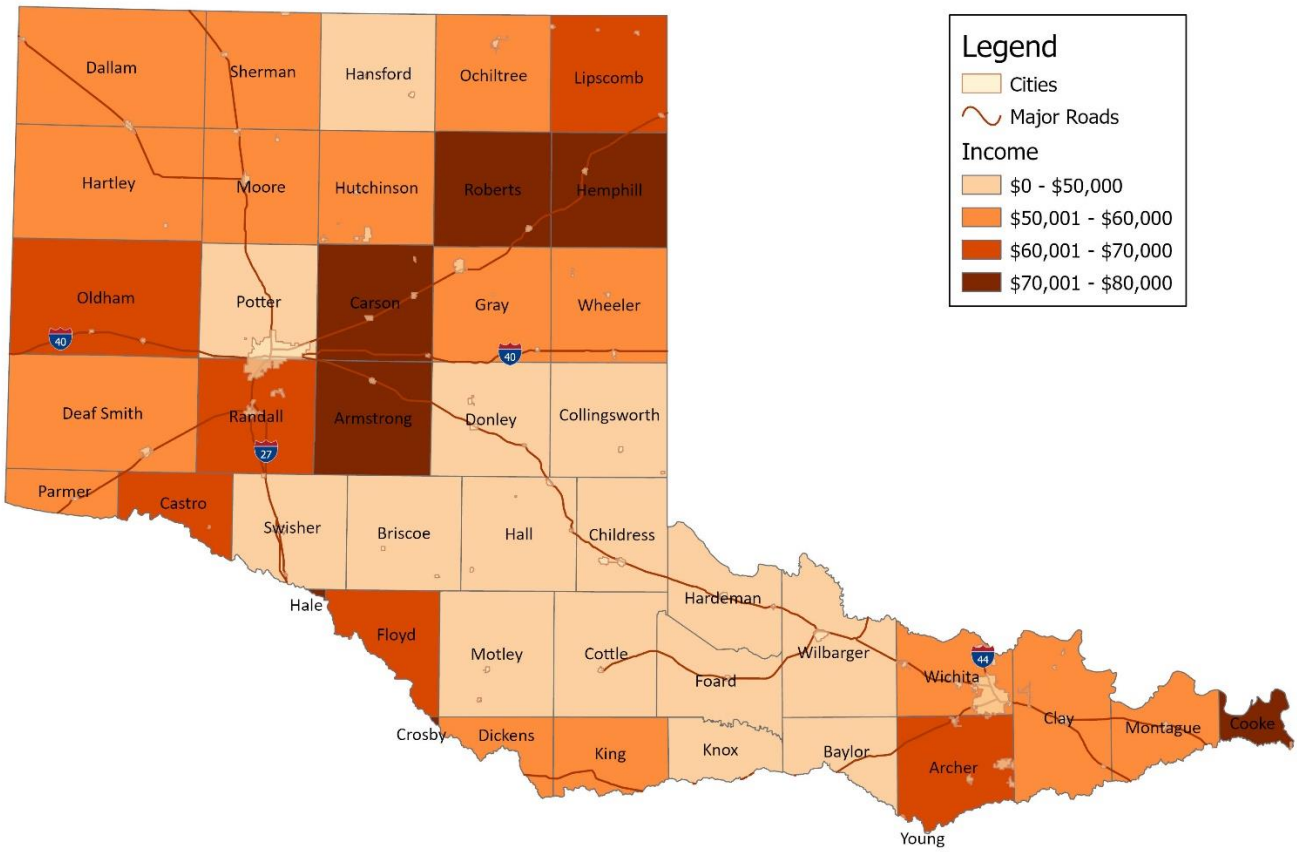
Source: USDA State/County/Crop Summary of Business

1.1.1.4 Economic Status of Population

The median household income provides a good comparison for income levels across the region. Variation of median household income of each county in the region is shown in **Figure 1-6**. Through an analysis using ESRI Business Analyst, which only considers portions of the county within the regional boundary, the highest median household incomes were found in Cooke, Carson, Roberts, Hale, and Armstrong Counties. The counties with the lowest median incomes are Cottle, Hall, Potter, Hansford, and Swisher Counties.

Within the region, the median household income is $53,228. This figure is less than the Texas median of $63,524 and the US median of $64,730. Median household incomes can be affected by many factors, including education levels, opportunity of employment, and location. Overall, the lower median household income in Region 1 indicates that average individuals affected by floods in this region may be at a financial disadvantage compared to their state or national counterparts. Even within the region, individuals with higher income levels may be able to recover faster and more fully than their lower-income neighbors.

Figure 1-6: Median Household Income by County



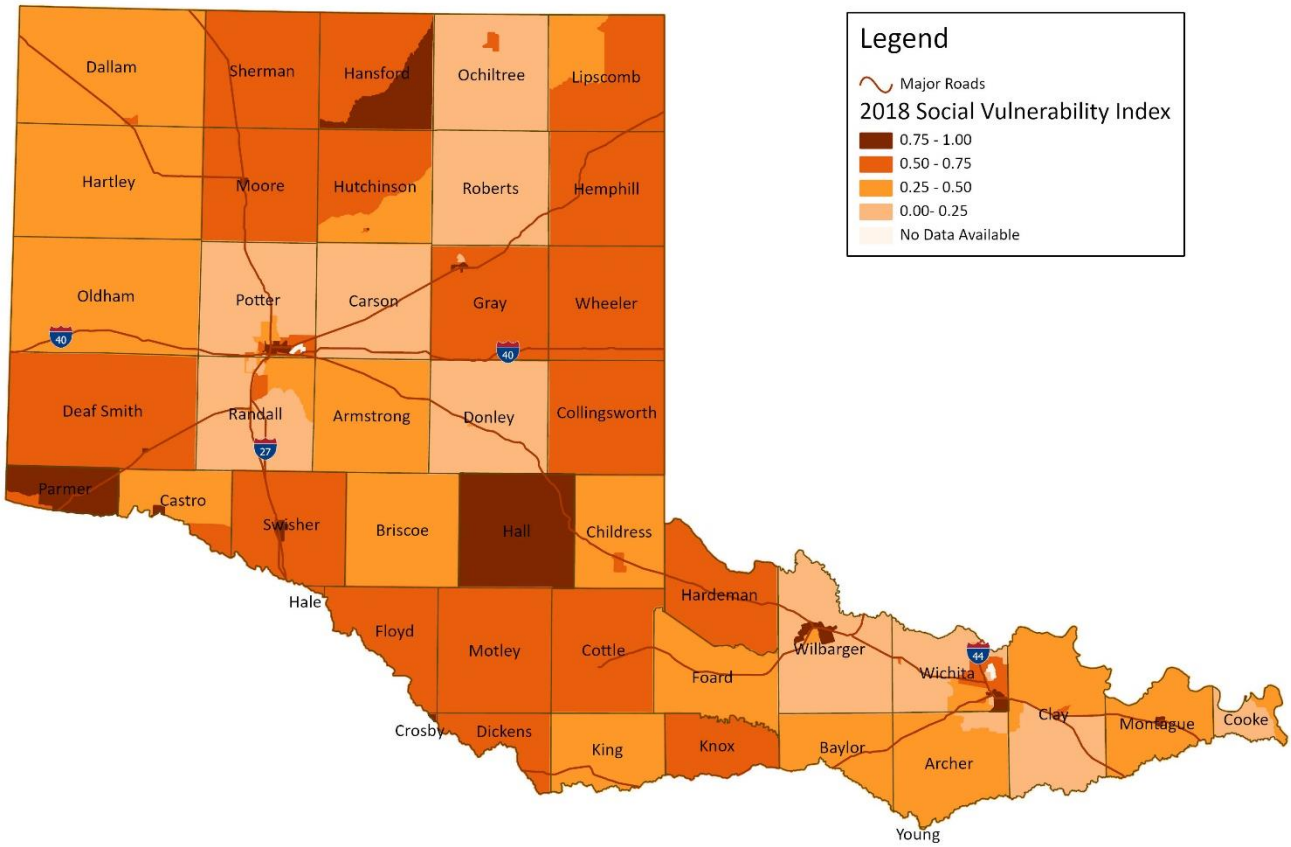
Source: US Census Bureau, ESRI Business Analyst

1.1.1.5 Social Vulnerability Index

When anticipating the likely extent of damages to a community from catastrophic floods, this assessment first considers "exposure" based on geographic location of people and property. Another important dimension to consider is each community's relative "vulnerability" to floods when they do occur. Disasters affect different people or groups in different ways, which range from their ability to evacuate an area in harm's way, to the likelihood of damage to their homes and properties, to their capacity to marshal the financial resources needed to recover and rebuild after a storm.

Several factors are evaluated to determine an area's Social Vulnerability, which measures a person's or group's "capacity to anticipate, cope with, resist and recover from the impacts of a natural hazard," based on their relative vulnerability (Wisner, Blaikie and Cannon). The Social Vulnerability Index (SVI) is a standard system developed by the Centers for Disease Control and Prevention (CDC) for assigning a Social Vulnerability score at a census-tract basis. Knowledge of a community's SVI allows planners to better prepare for emergency events including disease outbreaks, hurricanes, flood events, and exposure to dangerous chemicals, among other emergency events (Centers for Disease Control). A score of 0.75 or greater indicates that a community is highly vulnerable to impacts from a natural disaster.

Figure 1-7: SVI by Census Tract



Source: CDC

Figure 1-7 shows variations in SVI by census tract. Within Region 1, there are 34 census tracts with an SVI index greater than 0.75, containing over 104,000 residents, according to 2018 census data. These areas lie in both urban centers and rural parts of the region, indicating that different strategies will be needed to meet the varying needs of the population at risk across the region.

1.1.2 Flood Basics

By simple definition, a flood is a condition in which water inundates an area that is normally dry. The sources of floodwaters can vary, but the most common cause is excess precipitation from a heavy or sustained rainfall event. When it rains, a portion of the water is absorbed by the ground surface or otherwise lost through natural processes including evaporation. The portion of rainfall that cannot be stored or absorbed becomes surface water runoff. If surface water runoff accumulates, it can cause flooding. Flooding is a natural process, and natural floodplains exist and function to temporarily store floodwaters. However, when flooding occurs in an area of development, be it urban or rural, the effects to lives and property can be detrimental and even deadly.

The frequency and severity of flooding are impacted by human activities. Urban development tends to increase the amount of runoff that is expected for a given rainfall event, because rainwater that falls on impervious surfaces like roads, parking lots, and roofs cannot infiltrate into the ground. Flooding is also

affected by climate variability. In warmer conditions, air can hold more moisture, so it will pull more from water bodies and soil, and release more during rainfall, leading to higher intensity storms and more severe dry weather (Fecht). The flood hazard analysis within this RFP is generally conducted at the 0.2% and 1% annual chance events (ACEs), which may not fully capture areas impacted by flash flooding or other lower interval storm events. However, public feedback on commonly flooded areas was collected, and may include areas outside of the central storm events for the RFP.

Understanding the causes of flooding and the areas most likely to flood can help a community mitigate flood risk to people and property by adopting responsible development policies, implementing projects and strategies to manage floodwaters, and preparing emergency action plans to respond during a flood. The following sections provide a high-level summary of flood risk across the region, including historical data about past flooding events and the extent to which entities in the region have policies in place to manage flood risks. Quantification of flood risk in Region 1 is the focus of **Chapter 2** of this report.

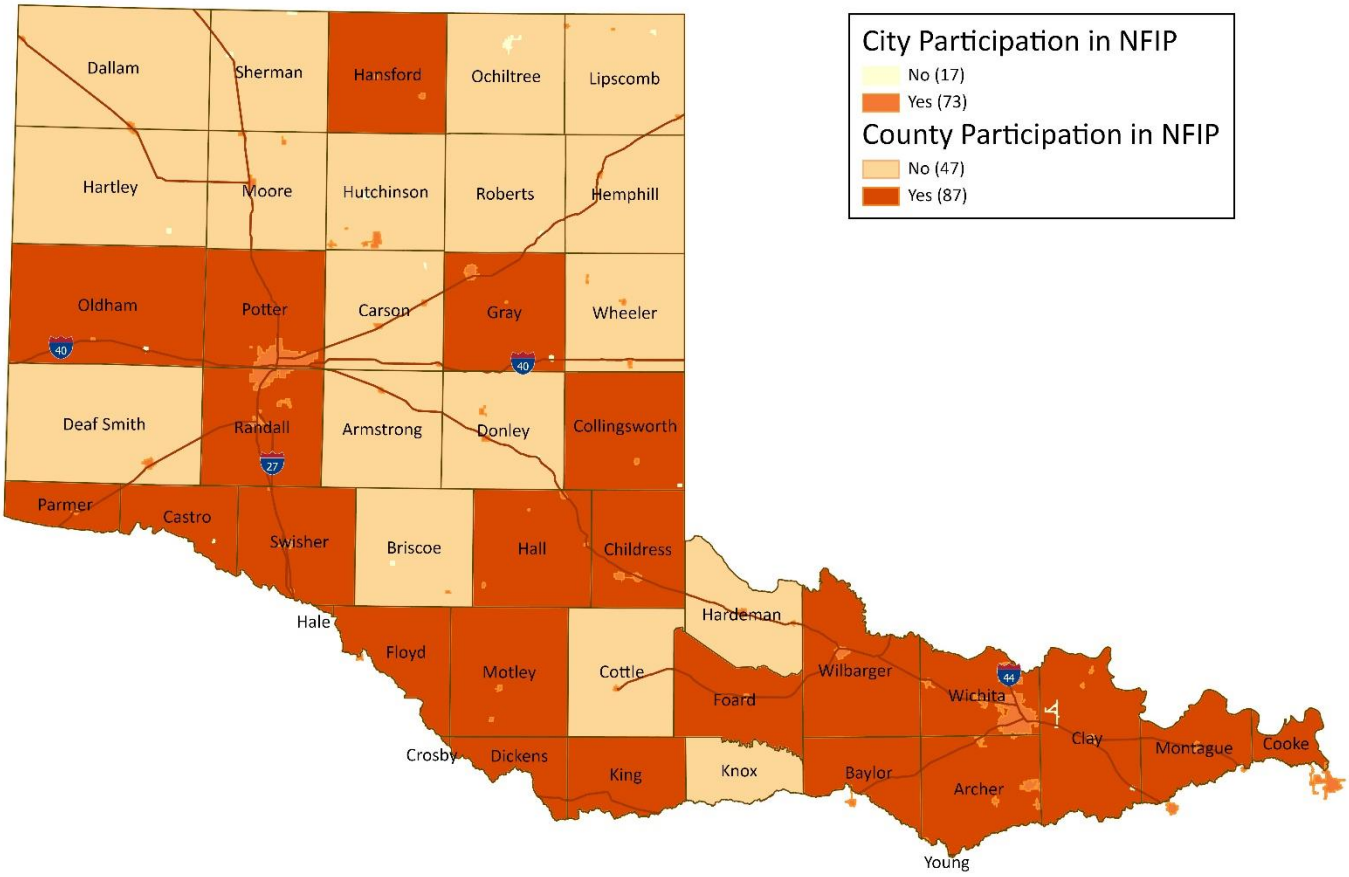
1.1.3 Flood Prone Areas and Flood Risks to Life and Property

As Texas seeks to better manage flood risk in order to mitigate loss of life and property from flooding, this section establishes a baseline of what is known with respect to the area's exposure to flood hazards, as well as the vulnerability of the communities within the Canadian–Upper Red Region.

Today, a patchwork quilt of plans, regulations, and infrastructure are in place to try to address flood hazards in Texas. This planning largely takes place at a local level, with an inconsistent set of standards from community to community and a lack of available floodplain mapping that makes it very difficult to quantify risk across the state. This is also true within Region 1.

Figure 1-8 depicts the communities currently listed as participants in the National Flood Insurance Program (NFIP) within the region, which allows property owners to purchase flood insurance and regulates development in the floodplain. Approximately two-thirds of the communities in Region 1 have implemented ordinances making them eligible to participate in the NFIP, administered by the Federal Emergency Management Agency (FEMA). However, entities have indicated varying levels of knowledge about and enforcement of floodplain regulations, even in NFIP-participating communities. NFIP participation and floodplain management policies in general are further discussed in **Chapter 3**.

Figure 1-8: NFIP Participating Communities



Source: FEMA Community Status Book Report

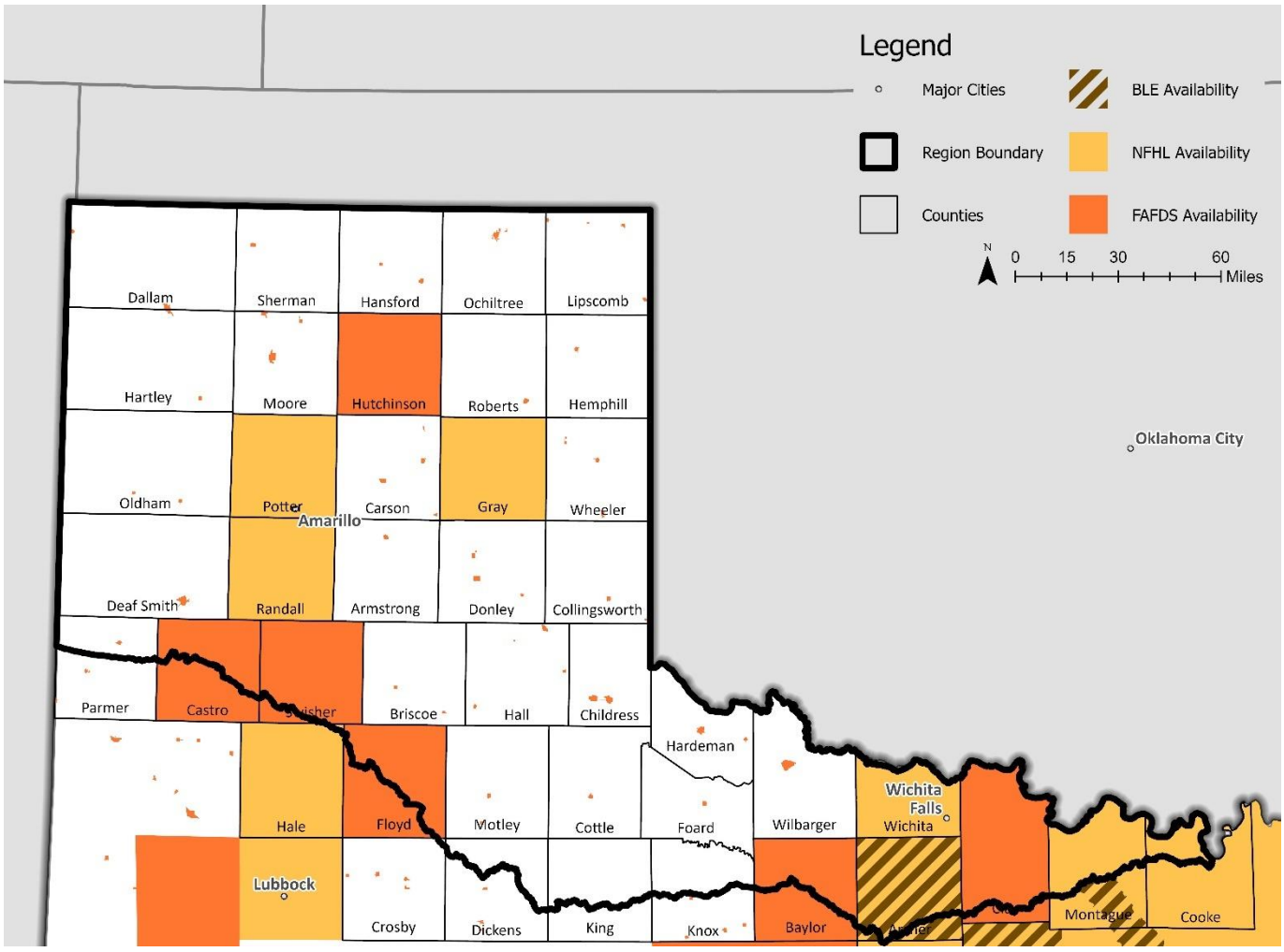
Participation in the NFIP improves a community's prospects for economic recovery in the event of a major flood. However, public input has indicated that many of the eligible participants are not actively engaging in floodplain management. Even among participating communities, many maps identifying flood risk are decades old and may only tell part of the story about a community's flood risk. These maps may not reflect changing patterns of development and often fail to identify flood risks associated with changes in the topography and environment.

1.1.3.1 Identification of Flood Prone Areas

Identification of flood prone areas is complicated by the lack of investment in floodplain mapping data in the region. Nearly 86% of the region is lacking regulatory floodplain mapping. Of the regulatory flood mapping studies that have been performed in the region, only one, in Archer County, was completed within the last 10 years.

In the absence of a cohesive, up-to-date flood map that applies across the region, TWDB has developed a flood quilt from various sources of existing statewide flood hazard information. **Figure 1-9** summarizes the floodplain quilt data available within Region 1.

Figure 1-9: Floodplain Quilt Data Availability in Region 1



Source: TWDB Flood Quilt (TWDB Data Hub)

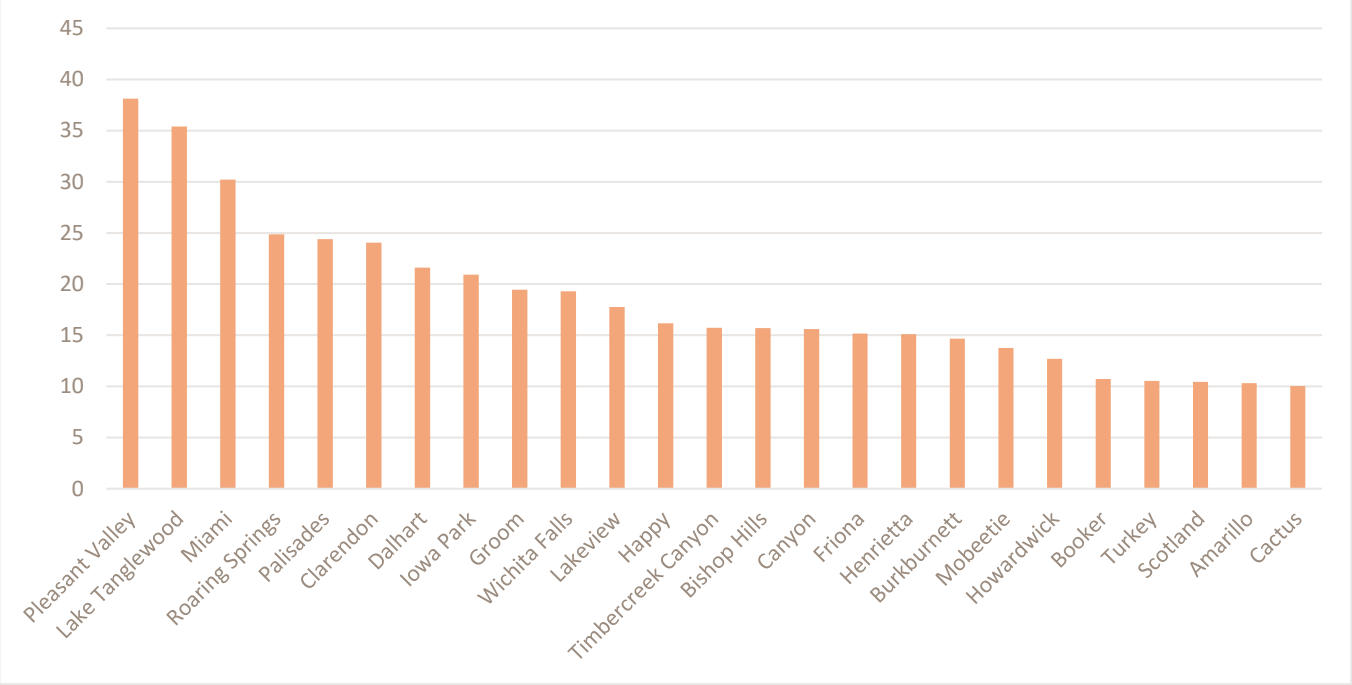
In a related effort, TWDB is making an aggressive push to expand the availability of floodplain mapping information in Texas through the development of FEMA Base Level Engineering (BLE) data. Several watersheds across the state have already benefited from the availability of BLE data, which can be incorporated into the 2023 RFPs. However, Region 1 is not expected to receive comprehensive BLE data until 2023, meaning none of this data will be able to be incorporated into the flood risk analyses for this first round of planning. As a result, identification of flood prone areas for this initial RFP relies heavily on the commercially available cursory floodplain dataset prepared by Fathom and furnished by TWDB.

Using these various data sources, it is estimated that approximately 4,305 square miles, or 12.4% of the region, is subject to flooding due to the 1% ACE. The 1% annual chance floodplain is the boundary of the flood that has a 1% chance of being equaled or exceeded in any given year. Historically, this has been referred to as the 100-year floodplain.

While much of the flooding occurs outside of population centers, there are an estimated 11,544 properties within the 1% ACE floodplain across the region, 68% of which are contained within

incorporated communities. Eight communities have been identified as having over 20% of their land area located in the 1% floodplain. Communities with the largest percentage of their land within the floodplain are shown in **Figure 1-10**. However, even in undeveloped areas, flooding represents an existing hazard, particularly for farm and ranch damages, as well as a constraint to future development. **Chapter 2** of this report catalogs in more detail the people, places, and facilities most impacted by flooding.

Figure 1-10: Percentage of Land Area in 1% ACE Floodplain

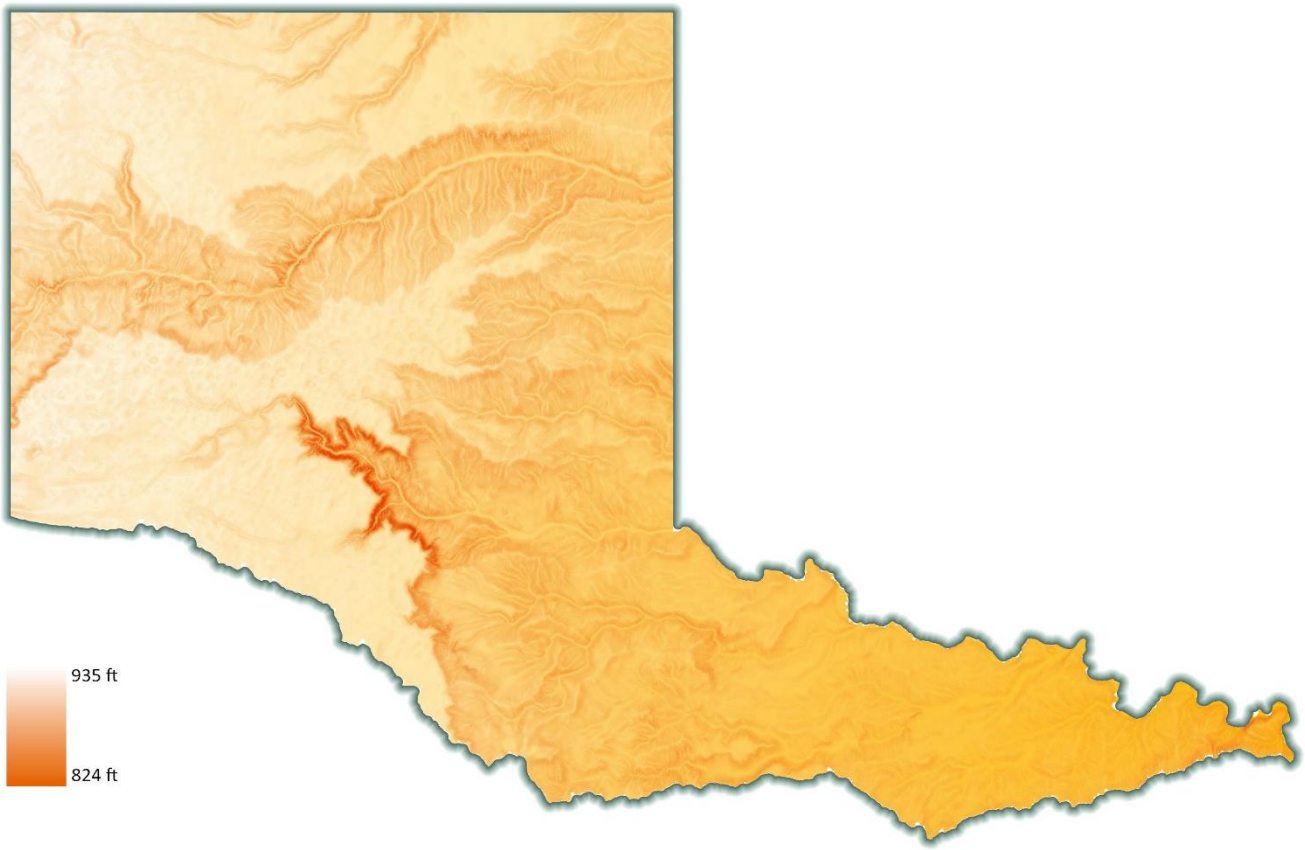


Source: TWDB Flood Quilt, TWDB Cursory Floodplain Dataset, Texas Department of Transportation City Boundaries

1.1.3.2 *Types of Major Flood Risks*

Figure 1-11 shows the varying elevations within the region, which highlights the flatter areas of caprock where playa flooding is more common, while riverine areas are noticeably more entrenched. Region 1 is subject to the dangers of swift-moving flood waters in riverine areas, as well as to standing water associated with flooded playas and lakes. Urban flooding, which is the accumulation of floodwaters when the capacity of an urban drainage system is exceeded during a rainfall event, is likely also a source of significant flooding exposure, particularly in the cities of Amarillo and Wichita Falls. However, this type of flooding was not specifically defined in the available hazard datasets and has not been discretely identified for the first planning cycle.

Figure 1-11 Topography in Region 1



1.1.4 Key Historical Flood Events

Flooding is the nation's most frequent severe weather threat and the costliest type of natural disaster in the United States. Ninety percent of all natural disasters in the United States involve flooding of some kind. Some of the most significant events that have occurred in Region 1 are listed in **Table 1-3**. Since 2000, there have been 15 major flood-related Presidential Disaster Declarations within the Canadian–Upper Red Region. The number of Disaster Declarations by county is summarized in **Figure 1-12**.

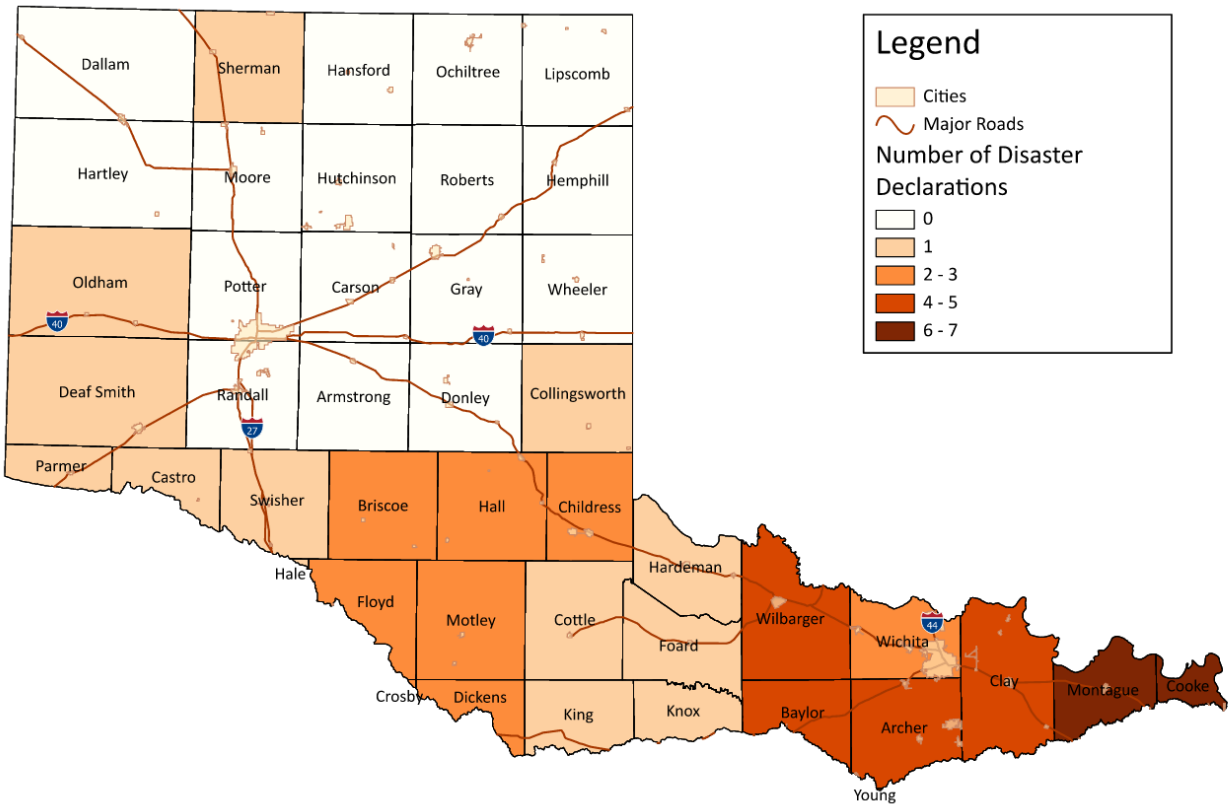
The issuance of a Disaster Declaration allows public officials to exercise emergency powers to preserve life, property, and public health following a disaster. A Federally-Declared Disaster also provides a means for affected communities and individuals to receive payment to recover from a disaster through FEMA's Public and Individual Assistance programs. Nearly $30 million in public assistance have been paid to communities in Region 1 since 1981. The values shown were the documented values for each event.

Table 1-3: Historical Flood Disaster Declarations with Non-Zero FEMA Claims

FEMA Declaration String	Date	Disaster Title	Counties Impacted	FEMA Public Assistance Claim Values
DR-648-TX	10/1981	Severe Storms & Flooding	Cooke, Montague	$63,000
DR-659-TX	5/1982	Severe Storms & Flooding	Wichita	$5,816,000
DR-828-TX	5/1989	Severe Storms, Tornadoes, & Flooding	Archer, Baylor, Clay, Cooke, Donley, Hale, Hall, Hutchinson, Knox, Montague, Ochiltree, Potter, Randall, Sherman, Wichita, Young	$210,000
DR-863-TX	5/1990	Severe Storms, Tornadoes, & Flooding	Archer, Clay, Cooke, Cottle, Hansford, Montague, Motley, Ochiltree, Wichita, Young	$108,000
DR-1709-TX	6/2007	Severe Storms, Tornadoes, and Flooding	Archer, Baylor, Cooke, Cottle, Montague, Wichita, Wilbarger	$4,170,000
DR-4223-TX	5/2015	Severe Storms, Tornadoes, Straight-line Winds and Flooding	Archer, Baylor, Clay, Collingsworth, Cooke, Dickens, Hall, Hartley, Montague, Wichita, Young	$2,438,000
			TOTAL:	$12,805,000

Source: FEMA Declared Disasters

Figure 1-12: Historical Flood Disaster Declarations by County (1981 – 2021)



Source: FEMA Declared Disasters

The following photos are from the May 2015 floods in Wichita Falls, photographed by the Wichita Falls Times Record News.

Figure 1-13: Flooded Roads at the Entrance of Lucy Park

Figure 1-14: Red River Flowing Strongly Near the Texas-Oklahoma State Line

Figure 1-15: Texas Game Wardens Rescue People From Pickups Washed Off the Road

1.1.4.1 Past Casualties and Property Damage

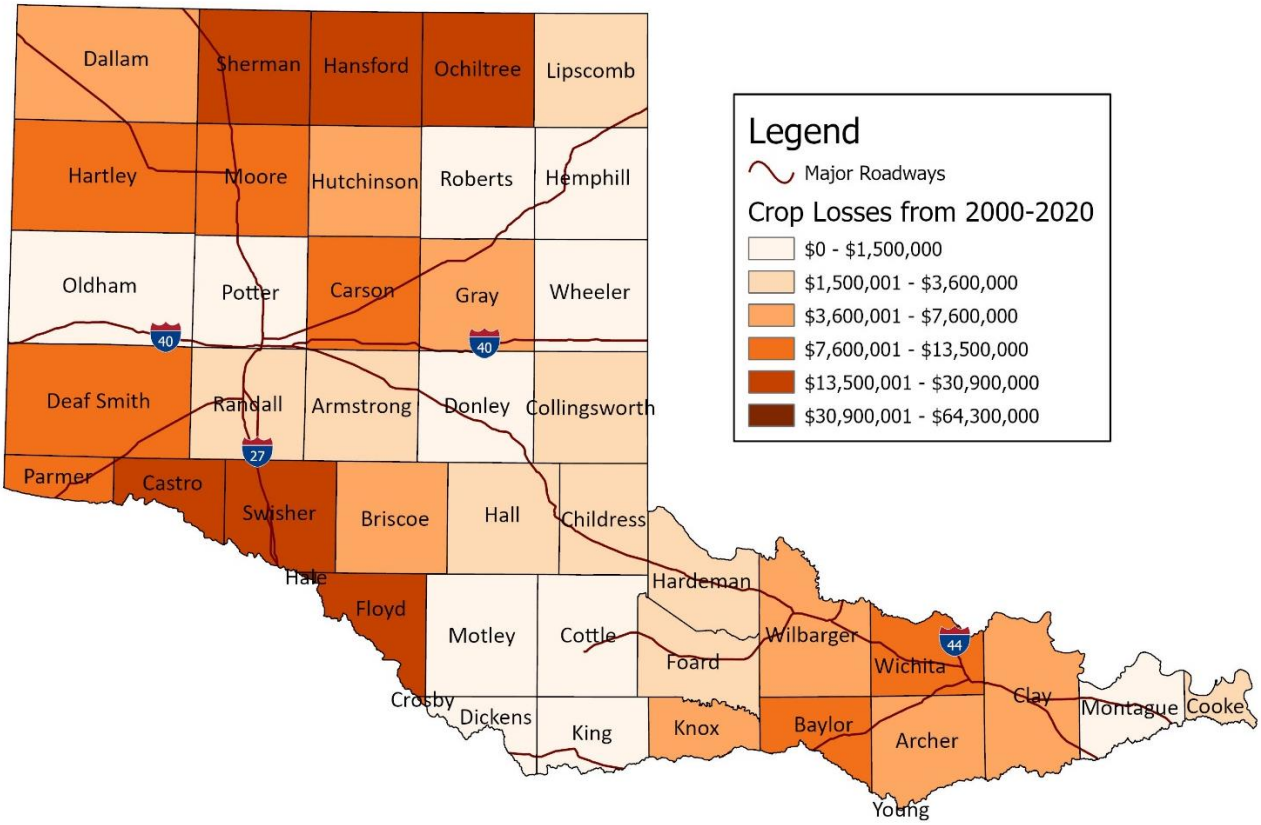
A major flood event often causes loss of life and property. Centralized statistics regarding loss of life due to flood events are difficult to obtain. In Region 1, there have been a total of eight recorded losses of life and four injuries from 2000 to 2020 reported as being direct results of a flood event according to the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database, which is not considered to be a comprehensive record. These recorded losses of life and injuries took place in Cooke, Hemphill, and Potter Counties.

Another way that FEMA provides flood recovery assistance is through the payment of flood insurance claims to individuals who experience property losses during a flood through the NFIP. Within the same flooding events as the casualty and injury records, there were multiple reported losses to property. Total property losses throughout the region amounted to $109 million between 2000 and 2020 in 2021 dollars.

1.1.4.2 Past Losses for Farming and Ranching

The Canadian–Upper Red Region accounts for much of the agricultural production in the State of Texas. The cumulative reported losses of crops due to flooding in the region from 2000 to 2020 amounted to $361 million in 2021 dollars. The total value of crop losses for each county is depicted in **Figure 1-16**. Hale County experienced the highest total losses, but only a small portion of the county lies within Region 1. Sherman, Hansford, and Ochiltree are the counties contained entirely within the region that have experienced the highest crop losses.

Figure 1-16: Total Value of Crop Losses Due to Flooding by County, 2000 – 2020



Source: USDA Cause of Loss Historical Data

1.1.4.3 Location of Critical Facilities

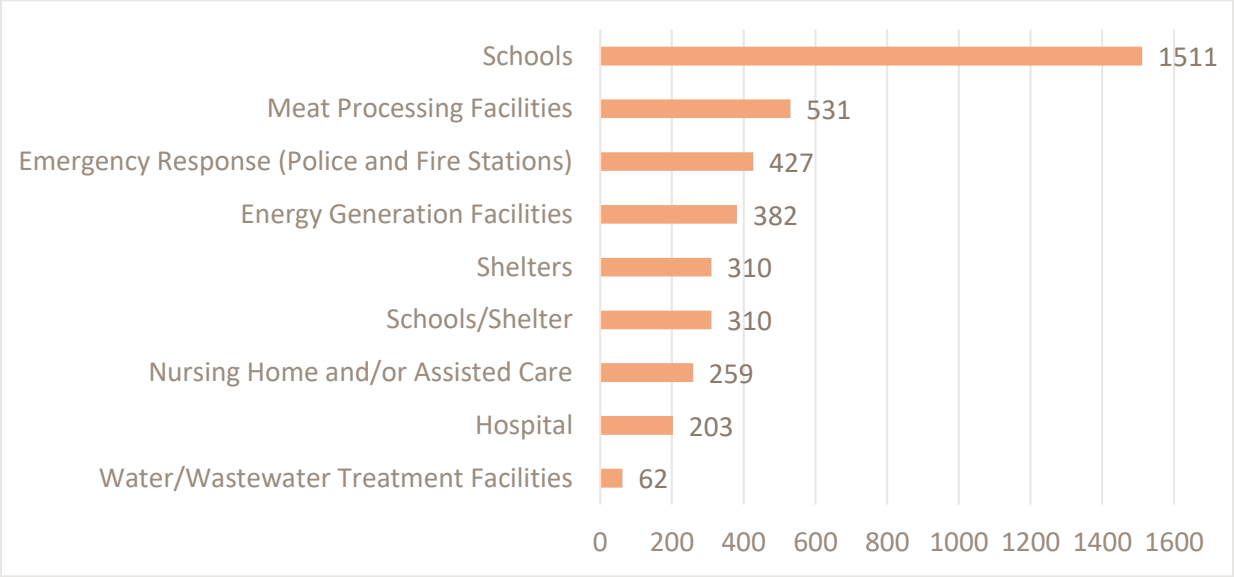
Critical facilities include schools, hospitals, fire stations, feed lots and meat processing plants, shelters, nursing homes and assisted care facilities, water and wastewater treatment plants, and energy facilities. Information for fire stations, hospitals, shelters, and schools was provided by TWDB, while additional facilities were added based on input from the RFPG. **Table 1-4** summarizes the type of critical facility and the source used to identify it in the Canadian–Upper Red Region.

Table 1-4: List of Critical Facility Types and Sources

Critical Facility Type	Source
Fire Stations	TWDB Data Hub
Hospitals	TWDB Data Hub
National Shelter System	TWDB Data Hub
Schools	TWDB Data Hub
Police Stations	Manual identification; only performed in major urban areas
Water and Wastewater Treatment Plants	U.S. Environmental Protection Agency Facility Registry Service
Meat Processing Facilities and Feed Lots	U.S. Department of Agriculture Meat, Poultry and Egg Inspection Directory
Nursing Homes and Assisted Care Facilities	Homeland Infrastructure Foundation Level Data
Energy Facilities	U.S. Energy Information Administration

These assets or facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. The majority of these critical facilities are concentrated around Amarillo and Wichita Falls. **Figure 1-17** provides the number of critical facilities by type within the Canadian–Upper Red Region. Some structures provide dual critical functions, such as schools that double as shelters.

Figure 1-17: Critical Facilities by Type



1.1.5 Political Subdivisions with Flood-Related Authority

This section discusses the range of political subdivisions with flood control authority in the Canadian–Upper Red Region, including their overlapping and/or joint responsibilities. 1 TAC §20.1 defines a political subdivision as a "county, city, or school district or any other governmental entity that embraces a geographic area with a defined boundary, existing for the purpose of discharging functions of government, and possesses authority for subordinate self-government through officers selected by it".

State law also provides for limited purpose Water Supply and Utility Districts, (known variously as Municipal Utility Districts (MUDs), Municipal Water Districts, Fresh Water Supply Districts, Special Utility Districts). These districts may be located in or adjacent to cities or in the county and may be involved in land reclamation and stormwater drainage management.

The number of each type of political subdivision identified in Region 1 is listed in **Table 1-5**. Of the political subdivisions referred to above, the majority are municipal or county governments, both of which exercise authority to set policy to mitigate flood risk. The data collection effort for this RFP identified 90 cities and 44 counties within the region. An additional 27 entities with varying degrees of potential flood control authority were also identified. Participation in NFIP indicates flood management engagement by the entity. Additional information on entity participation in planning and mitigation can be found in **Chapter 3**.

Table 1-5: Political Subdivisions with Flood-Related Authority

Type of Political Subdivision	Number of Jurisdictions	NFIP Participants
Municipality	90	62
County	44	26
River & Watershed Authorities	4	N/A
Water Supply & Utility Districts	23	N/A

Source: FEMA Community Status Book Report; TWDB Entities

1.1.6 Local Regulation and Development Codes

Using policies and regulations to reduce the exposure of people and properties to flood risk are forms of non-structural flood mitigation. By encouraging or requiring communities to avoid developing in flood prone areas altogether, or to take precautions such as increasing building elevation, preserving overflow areas through buffering and avoiding sensitive natural areas such as wetlands, communities can reduce the likelihood and extent of damages to new and existing development. Local regulations and development codes pertaining to flooding include:

- **Floodplain Ordinances** – Floodplain ordinances regulate development and the impact new development has on a community's floodplain. Community regulations are typically based on FEMA provided flood hazard information but can be based on other local sources of data as well. Participation in the NFIP requires a community to have adopted a floodplain ordinance with minimum requirements established by FEMA.

- **Building Standards** – Building standards may include special considerations for structures located within a floodplain, including minimum finished floor elevations and flood proofing requirements. NFIP requirements also set standards for property owners seeking to renovate structures in a floodplain including those that experience repetitive or severe flood losses.
- **Drainage Design Standards** – Adopted drainage design standards set the minimum standards for stormwater management that must be met prior to the approval of new construction plans. Drainage criteria in the region are typically adopted by municipalities but are also used by counties.
- **Zoning and Land Use Policies** – Planning and zoning ordinances regulate acceptable types of land uses within a community to promote appropriate development, safety, and general welfare. Some communities use zoning and land use ordinances to establish open space requirements, conservation easements, and minimum setbacks from creeks and wetlands to preserve floodplain function and promote sustainable and resilient development.

A summary of existing floodplain regulations adopted by entities in the region are summarized in **Table 1-6**. Local regulations and development codes, as well as their prevalence in Region 1, are discussed in greater detail in **Chapter 3**.

Table 1-6: Summary of Existing Flood Plans and Regulations

Type of Regulation	Count
Floodplain Ordinances	88*
Zoning and Land Use Policies	22
Drainage Design Standards	2

**Estimated based on NFIP participation*

Source: Various Sources

1.1.7 Existing Local and Regional Flood Plans Within the Flood Planning Region

Local and regional flood plans analyze a community's flood risk and present how that entity will improve its resiliency. Drainage master plans describe a community's physical and institutional planning environment and establish interjurisdictional roles and responsibilities when many drainage entities are present. Capital improvement plans (CIP) identify capital project alternatives for an entity, provide economic analyses for alternatives, and often rank alternatives based on feasibility.

This RFP represents an important step forward in evaluating and addressing flood risk across the region, because to this point, no large-scale flood plan has been developed. There are select examples of cities developing drainage master plans and CIPs, as is the case for the City of Wichita Falls and the City of Amarillo. There are also several existing county-wide or regional Hazard Mitigation Action Plans (HMAPs), which propose high-level actions to address a wide variety of hazards, including floods. Relevant content from existing CIPs and HMAPs has been incorporated into the recommendations of this report. A list of previous studies that were considered relevant for the RFP is shown in **Table 1-7.**

Table 1-7: List of Previous Studies Relevant to the RFP

Report Title	Study Area	Sponsor Entity	Date
Archer County Flood Insurance Study (FIS)	Archer County	FEMA	2021
Cooke County FIS	Cooke County	FEMA	2008
Gray County FIS	Gray County	FEMA	2010
Hale County FIS	Hale County	FEMA	2011
Montague County FIS	Montague County	FEMA	2011
Potter County FIS	Potter County	FEMA	2010
Randall County FIS	Randall County	FEMA	2010
Wichita County FIS	Wichita County	FEMA	2010
Canyon Flood Mitigation Study	City of Canyon, Randall County	U.S. Army Corps of Engineers (USACE)	2011
Corps Water Management System Report	Canadian River Basin	USACE	2017
Corps Water Management System Report	Red River Basin	USACE	2017
Archer County HMAP	Archer County	Archer County	2019
Armstrong County HMAP	Armstrong County	Armstrong County	2018
Baylor County HMAP	Baylor County	Baylor County	2020
Briscoe County HMAP	Briscoe County	Briscoe County	2018
Carson County HMAP	Carson County	Carson County	2014
Carson County HMAP	Carson County	Carson County	2018
Childress County HMAP	Childress County	Childress County	2018
Clay County HMAP	Clay County	Clay County	2020
Collingsworth County HMAP	Collingsworth County	Collingsworth County	2017
Cooke County HMAP	Cooke County	Cooke County	2018
Dallam and Hartley County HMAP	Dallam and Harley Counties	Dallam and Harley Counties	2018
Deaf Smith County HMAP	Deaf Smith County	Deaf Smith County	2018
Dickens County HMAP	Dickens County	Dickens County	2017
Donley County HMAP	Donley County	Donley County	2018
Gray County HMAP	Gray County	Gray County	2018
Hall County HMAP	Hall County	Hall County	2019
Hansford County HMAP	Hansford County	Hansford County	2018
Hemphill County HMAP	Hemphill County	Hemphill County	2018
Hutchinson County HMAP	Hutchinson County	Hutchinson County	2017
Lipscomb County HMAP	Lipscomb County	Lipscomb County	2018

Report Title	Study Area	Sponsor Entity	Date
Montague County HMAP	Montague County	Montague County	2020
Ochiltree County HMAP	Ochiltree County	Ochiltree County	2018
Oldham County HMAP	Oldham County	Oldham County	2019
Parmer County HMAP	Parmer County	Parmer County	2018
Potter and Randall County HMAP	Potter and Randall Counties	Potter and Randall Counties	2015
Roberts County HMAP	Roberts County	Roberts County	2018
Sherman County HMAP	Sherman County	Sherman County	2017
Swisher County HMAP	Swisher County	Swisher County	2018
Wheeler County HMAP	Wheeler County	Wheeler County	2018
Wilbarger County HMAP	Wilbarger County	Wilbarger County	2020
Young County HMAP	Young County	Young County	2020
Canyon HMAP	City of Canyon	City of Canyon	2021
Our Canyon: A Comprehensive Plan	City of Canyon	City of Canyon	2018
Assessment of Channel Changes, Models of Historical Floods and Effects of Backwater on Flood Stage, and Flood Mitigation Alternatives for the Wichita River at Wichita Falls, Texas	City of Wichita Falls	USGS	2011
Amarillo Drainage Master Plan (DMP)	City of Amarillo	City of Amarillo	2019
T-Anchor Drainage Study	City of Amarillo	City of Amarillo	2014
Amarillo Drainage Utility Report	City of Amarillo	City of Amarillo	2011
Storm Water Management Master Plan	City of Amarillo	City of Amarillo	1993
Quail Creek DMP	City of Wichita Falls	City of Wichita Falls	2018
Wichita River Floodplain Model	City of Wichita Falls	City of Wichita Falls	2016
Wichita Falls DMP	City of Wichita Falls	City of Wichita Falls	2011
Buck Creek Watershed Protection Plan	Buck Creek	Texas State Soil and Water Conservation Board (TSSWCB)	2014

1.1.8 Agricultural and Natural Resources

As a major agricultural area comprised of over 90% open space, the Canadian–Upper Red Region has seen major impacts to agricultural lands and natural resources as a result of flooding. While some of these impacts have been quantified in previous sections, there are several qualitative impacts that are discussed in the following sections.

1.1.8.1 Farming

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

1.1.8.2 Ranching

Ranching activities in the region are also impacted by flooding. Livestock can be swept away, drowned, or injured by flash floods. Livestock exposed to contaminated flood waters can experience health issues such as pneumonia or foot rot. Livestock could also be exposed to disease carrying mosquitoes during flood events. Flood events can cause delays in building back livestock herds. Damages to feed crops can also reduce ranching capabilities (Smith).

1.1.8.3 Natural Resources

Public education and outreach surrounding flooding often focus on its negative impacts on the built environment. However, in natural systems, floods play an important role in maintaining ecosystem functions and biodiversity, increasing connectivity between aquatic habitats and transporting sediment and nutrients to different parts of the landscape.

The Texas Conservation Action Plan is a guiding document for conservation in the State of Texas, with the goals of realizing conservation benefits, preventing species listings, and preserving our natural heritage for future generations. Species of Greatest Conservation Needs include numerous aquatic species such as fish, freshwater mussels, and salamanders. Six types of priority habitats have been identified, three of which are aquatic: water resources; riparian and floodplains; and caves and karst.

These natural resources can be negatively impacted by flood events. As with livestock, wildlife can be injured or killed by flash floods. Severe flood conditions can degrade stream health and negatively impact ecosystems in the region. Flooding can cause an imbalance of aquatic and riparian ecosystems by causing loss of habitat, the release of pollutants, loss of wetland function through impoundments and dam operations, and excess sedimentation that negatively affects water quality.

1.2 Assessment of Flood Infrastructure

This section provides an overview of natural and constructed flood infrastructure in the Canadian–Upper Red Region that contribute to lowering the flood risk. Flood infrastructure in the region includes built features which are owned and managed by stakeholders ranging from the the Texas Parks and Wildlife Department (TPWD) to individual farmers and ranchers, as well as natural areas that provide flood mitigation function but are not actively maintained for this purpose. This RFP considers both the natural and manmade features that contribute to risk reduction, which may include:

- dams that provide flood protection
- detention and retention ponds
- levees
- rivers, tributaries, and functioning floodplains
- storm drain systems
- playa lakes
- wetlands
- *sinkholes*
- *alluvial fans*
- *vegetated dunes*
- *sea barriers, walls, and revetments*
- *tidal barriers and gates*
- *stormwater tunnels*
- *stormwater canals*
- *weirs*

Note: Features in italics have not been identified in the Canadian–Upper Red Region.

TWDB provided several data sources to assist with the identification of flood management infrastructure in the Flood Data Hub. In order to gain more insight into the current status of flooding and flood regulation in the region, a survey was shared with stakeholders asking about topics including infrastructure, current projects, and standards. There were a number of questions posed in the survey that were used to complement the information provided by existing data sources to create a more complete picture of how communities in the region protect themselves from flood risk.

An inventory table of existing flood infrastructure is provided as TWDB-required **Table 1**, included in **Appendix A-2**. This inventory serves as the basis for the information presented in this section. The inventory includes only major flood infrastructure, for example regional detention facilities but not small stock ponds serving individual properties. The determination as to what constitutes major infrastructure was made on a case-by-case basis for each infrastructure type, with a goal to manage the size of the dataset and to help prioritize infrastructure that is most likely to provide flood control benefit at a regional scale. This table also summarizes all identified low water crossings (LWCs) in the region.

A series of maps have been provided showing the location of different types of flood infrastructure within the region. Together, these maps serve as TWDB-required **Map 1**. These maps are presented as **Appendix A-1**.

1.2.1 Natural Features

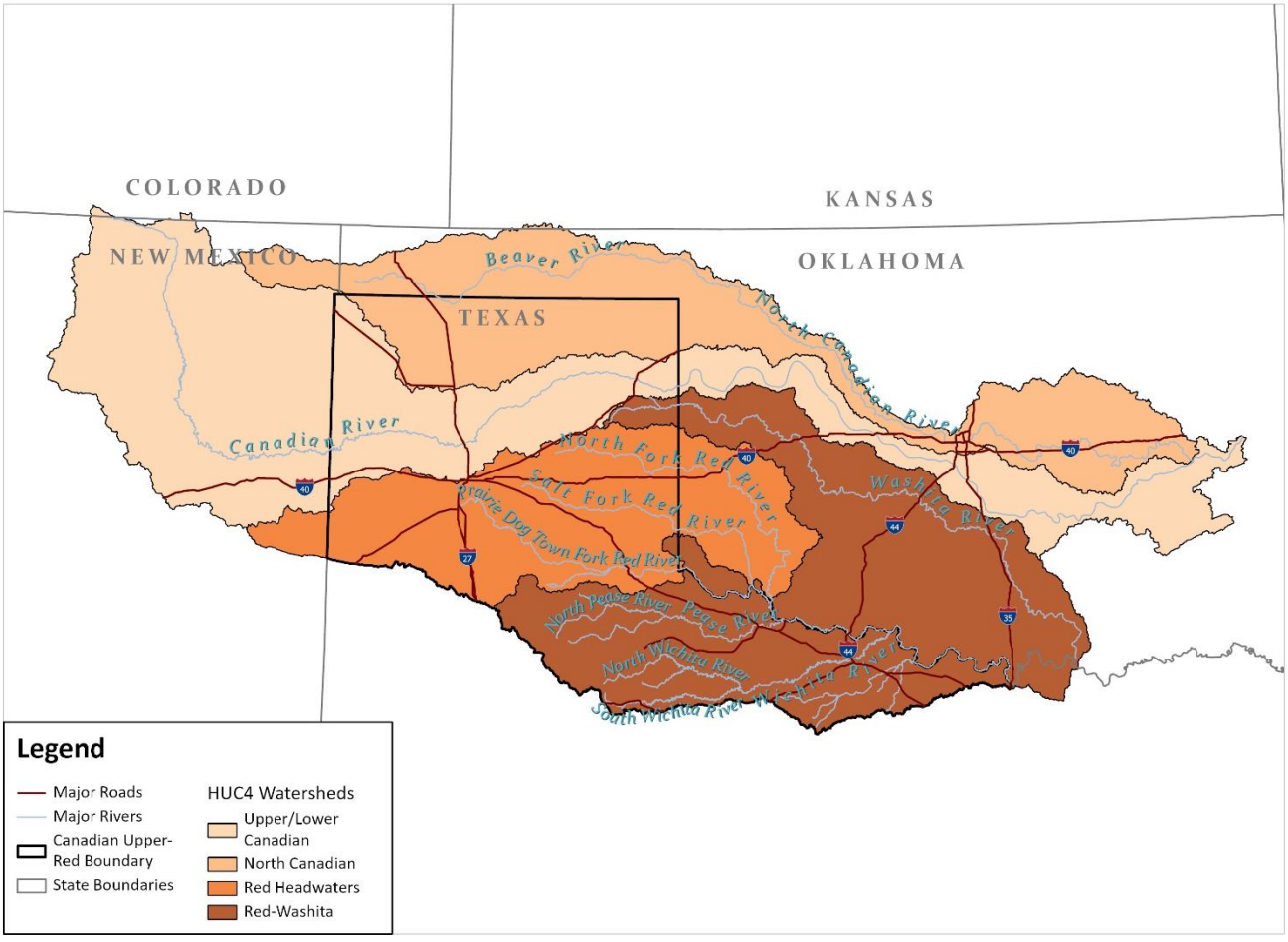
Natural features serve an important role in managing stormwater precipitation and runoff. Transport features such as rivers and streams carry excess runoff towards downstream receiving waters. Storage features such as ponds, lakes, and playas hold water, allowing natural evaporation and infiltration

processes to occur. Much of the stormwater in the region is captured through groundwater recharge by the Ogallala and Seymour aquifers, vital sources of drinking water for people and animals in West Texas. The following sections explore the vast and complex system of natural drainage features in the Canadian–Upper Red Region.

1.2.1.1 Rivers, Tributaries and Functioning Floodplains

The Canadian–Upper Red RFP is comprised of two primary river basins and their floodplains. For the purpose of summarizing this infrastructure class for this assessment, rivers were compiled using the National Hydrologic Dataset (NHD) layer and considering streams of stream order 1 and 2, which represents main stems and primary tributaries. The Canadian–Upper Red Region is named for the two major river basins located in the FPR. The major rivers and HUC 8 watershed boundaries in Region 1 are shown in **Figure 1-18**.

Figure 1-18: Major Rivers and Watersheds



The Red River is the second-largest river basin in the southern Great Plains. From its headwaters in New Mexico, the Red River courses through three primary forks in Texas: the North Fork, Salt Fork, and Prairie Dog Town Fork. These rivers continue through portions of Oklahoma until they reach the Red River's main stem, which forms the boundary between Texas and Oklahoma as well as the northern edge of the planning region. Other major tributaries to the Red River include the Pease River and the Wichita and Little Wichita Rivers in the southeastern portion of the region. The following photos are provided by West Texas A&M University.

Figure 1-19: North Fork Red River

The Canadian River originates in Colorado and travels through New Mexico before cutting across the Texas Panhandle and flowing into Oklahoma on its course to the Arkansas River. The second major river basin in the region, the Canadian River captures drainage from the northernmost portion of the Texas Panhandle.

Figure 1-20: Canadian River

Functioning floodplain is a broad term used to describe a natural area susceptible to flooding that provides a broad range of ecological and hydrological functions, including flood storage, water quality benefits, and groundwater recharge (FEMA). There is no comprehensive dataset for functioning floodplain areas, and it is challenging to make this designation on a regional basis. As a result, the dataset does not contain any designated functioning floodplains as part of the flood infrastructure. Much of what can be considered functioning floodplain is captured by the wetlands feature class described below.

1.2.1.2 Wetlands

A wetland is an ecosystem that is flooded by water, either permanently, seasonally, or after discrete rainfall events. Wetlands provide an important ecosystem for aquatic plants and animals, as well as significant flood storage. While the Canadian–Upper Red Region is generally considered arid, it contains

over 193,000 acres of freshwater wetlands concentrated within its major floodplains. These wetland features were compiled from the National Wetlands Inventory (NWI) dataset.

1.2.1.3 Ponds and Lakes

While almost all well-known lakes in Texas are manmade, ponds and lakes are generally considered to be natural flood infrastructure features. As a distinction, major reservoirs with significant flood control or water supply function are discussed in **Section 1.2.2**. These non-major ponds and lakes were compiled from the NHD waterbodies dataset, filtering out features less than 0.25 acres in size that are unlikely to have significant flood control benefit. Across the region, ponds and lakes encompass over 25,000 distinct features and upwards of 32,500 acres of land area. Many of these features likely provide some flood protection during small rainfall events but are unlikely to provide any regional benefit.

1.2.1.4 Playas

The western portion of the Canadian–Upper Red Region is home to a vast system of playas, some of the most unique and important hydrologic features in the Southern High Plains. Playas are shallow wetlands that form after a rainfall and serve as an important source of groundwater recharge for the Ogallala Aquifer. A dataset developed by the Playa Lakes Joint Venture was used to identify playas, and features less than 1 acre were removed as they were not considered to have major flood control function. An estimated 30,000 individual playa lakes are found in the Southern High Plains, and over 9,300 individual features, accounting for over 200,000 acres of surface area, were identified in the Canadian–Upper Red FPR.

1.2.2 Constructed Flood Infrastructure

Constructed flood infrastructure ranges from major facilities such as reservoirs, dams, and levees, to municipal drainage systems comprised of constructed channels and ditches and closed storm drain systems. While generally the most underfunded sector of public infrastructure, each piece plays an important role in protecting Texas communities from flooding.

1.2.2.1 Dams, Reservoirs, Levees, and Weirs

Impounded water features such as reservoirs serve many purposes including recreation, flood risk mitigation, irrigation, water supply and fire protection, among others. The dataset used to identify major reservoirs is maintained by TWDB. Additional information was compiled from the latest regional water plans (RWPs). Twenty-nine reservoirs were identified in the Canadian–Upper Red Region. There are 19 reservoirs with known flood control function identified in **Table 1-8**.

Several other dams were identified on smaller impoundments across the region, compiled from various sources of data ownership, including USACE, TSSWCB, and the Texas Commission on Environmental Quality (TCEQ). While many of the dams across the region were constructed by the Natural Resources Conservation Service (NRCS – formerly the Soil Conservation Service), the origin and purpose of most of the other dams are not well documented. As a result, all identified dams have been included as part of this inventory since they potentially serve a flood control function or provide ancillary flood control benefits. Overall, there were over 600 dams identified in the region, with nearly 20% of those dams

serving a known flood control function. There were no individual weir structures identified from any open-source datasets, but elements of other infrastructure types such as dam spillways operate as weirs during overtopping events.

Table 1-8: List of Flood Control Reservoirs in Region 1

Reservoir Name	Location (County)
Bowie Lake	Montague
Buffalo Lake	Randall
Lake Arrowhead	Archer, Clay
Lake Cooper	Archer
Lake Diversion	Archer, Baylor
Lake Electra	Wilbarger
Lake Fryer	Ochiltree
Lake Kemp	Baylor
Lake Kickapoo	Archer
Lake Mackenzie	Briscoe
Lake Marvin	Hemphill
Lake McClellan	Gray
Lake Meredith	Hutchinson, Potter, Moore
Lake Olney	Archer
Lake Pauline	Hardeman
Lake Wichita	Archer, Wichita
N. Fork Buffalo Creek Reservoir	Wichita
Rita Blanca Lake	Hartley
Santa Rosa Lake	Wilbarger

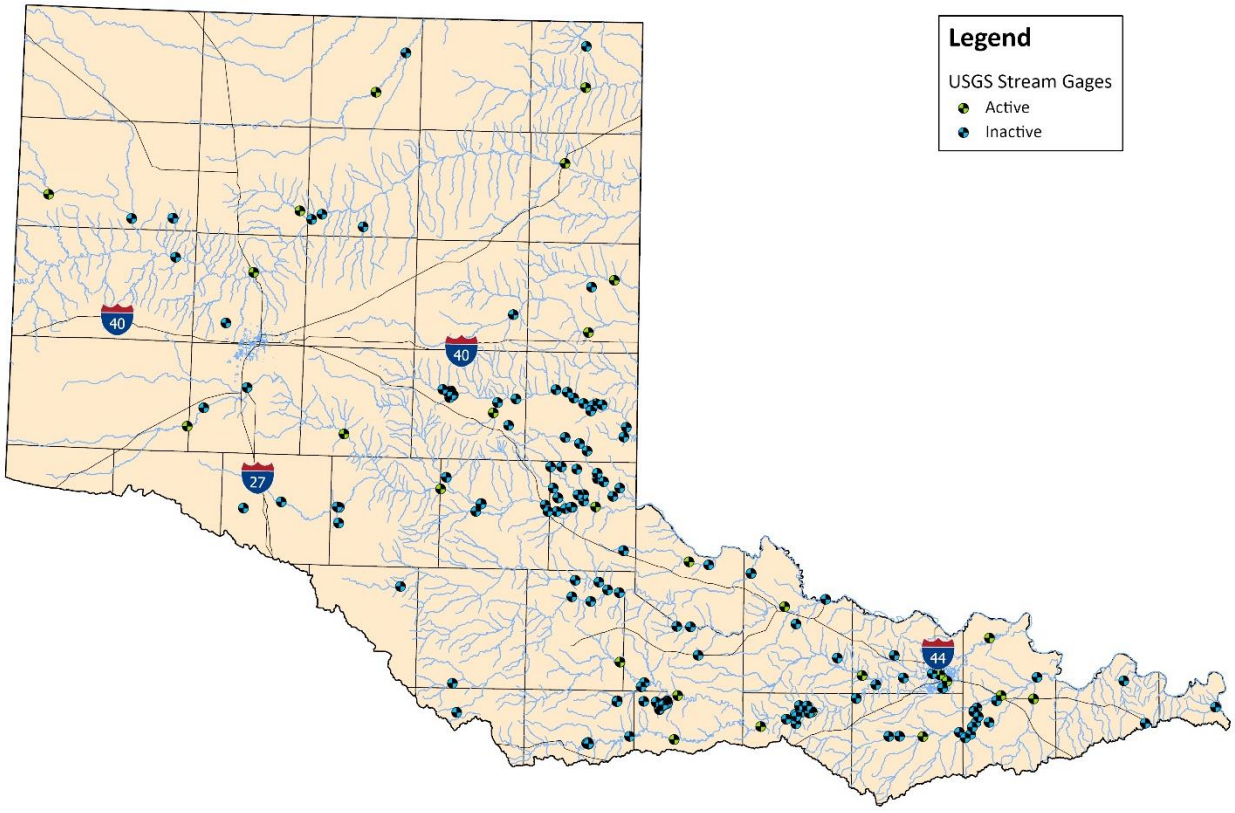
Source: TWDB Texas Lakes & Reservoirs

Levees are manmade embankments that artificially contain flood flows to a restricted floodplain. More than one million Texans and $127 billion dollars' worth of property are protected by levees, including 51 USACE levee systems. However, there were only two minor levee systems identified in Region 1. These include Armstrong East Levee and Armstrong West Levee, agricultural levees located in the northeastern part of unincorporated Armstrong County near the cities of Claude and Groom, as well as a levee system in Wichita Falls that contributes to the impoundment of Lake Wichita and protects urban and residential areas along Holliday Creek.

1.2.2.2 Stream Gages

Stream gages measure and record the amount of water flowing in a stream at a given time. This information can be especially useful in times of flooding, allowing emergency responders and decision-makers to track and predict flooding and issue warnings and evacuation orders to citizens. The USGS maintains a vast network of stream gages nationwide. Stream gages are considered active if they have collected time-series data within the last six months or have collected manual data within the last 13 months. **Figure 1-21** shows the locations of USGS stream gages across the region. In total, there are 190 stream gages in the region, 31 of which are listed as active.

Figure 1-21: Gage Locations



Source: USGS

1.2.2.3 Stormwater Management Systems

Stormwater management systems serve to manage both the quantity and quality of the water that drains into natural waterways. The TCEQ regulates the discharge of municipal separate storm sewer systems (MS4) through the two sets of permits administered under the Texas Pollutant Discharge Elimination System, known as Phase I (large) or Phase II (small) MS4 permits. To be subject to MS4 permit requirements, a community must own and operate storm drainage infrastructure.

Phase I MS4s are cities that had populations exceeding 100,000 as of the 1990 census. The City of Amarillo is the only Phase I MS4 in the Canadian–Upper Red FPR. A handful of other municipalities in the

region are subject to the Phase II MS4 permit, which applies to communities of any size located at least partially within a census-designated urbanized area. The cities of Lakeside City and Wichita Falls, as well as Archer, Potter, Randall, and Wichita Counties are all subject to Phase II MS4 requirements, and thus own and operate storm drainage infrastructure.

While it is likely that most communities maintain a limited amount of storm drainage infrastructure, there is no publicly available dataset of all municipal storm drain systems within Texas. As a result, collection of spatial data for this RFP relied on survey responses. Survey respondents provided information indicating they maintain public drainage systems; however, most respondents did not have spatial data to include in the digital inventory. These responses are summarized in **Table 1-9**. A dash does not signify that there is none of that infrastructure type, simply that the entity did not list or provide any information about it.

Table 1-9: Non-Spatial Stormwater Management System Information

Entity Name	Stormwater Tunnels	Stormwater Canals	Flood Protection Dams	Detention/ Retention Ponds	Storm Drain Systems
Archer County	-	-	X	-	-
Farmers Creek Watershed Authority	-	-	X	-	-
Hall County	-	-	X	-	-
City of Pampa	X	X	-		X
City of Perryton	-	-	-	X	X

Source: Region 1 Stakeholder Survey Responses

Digital asset information was received from the communities of Amarillo, Pampa, and Wichita Falls. A summary of the storm drainage infrastructure information provided by these communities is included in **Table 1-10**.

Table 1-10: Summary of Constructed Storm Drainage Infrastructure

Entity Name	Storm Drain (mi)	Stormwater Inlets (#)	Channels/ Ditches (mi)
Amarillo	184	3,775	-
Pampa	-	304	-
Wichita Falls	145	4,593	67

Source: Region 1 Stakeholder Survey Responses

1.2.2.4 Low Water Crossings

LWCs are roads that pass over water that are frequently flooded with water levels rise. These can include both bridges and culverts. These locations are where the majority of loss of life occurs during flooding events, as drivers misjudge risk and attempt to cross. This can lead to floods sweeping vehicles off of roads and engines stalling, trapping travelers in waterways. To analyze LWCs for the region, two sources were used. One was the provided dataset from TWDB, which listed many LWCs across the region. The second was historical flooding data from Texas Department of Transportation (TxDOT), which was intersected with streams to find the likely source of flooded roadway concerns.

1.3 Assessment of Condition and Functionality of Existing Infrastructure

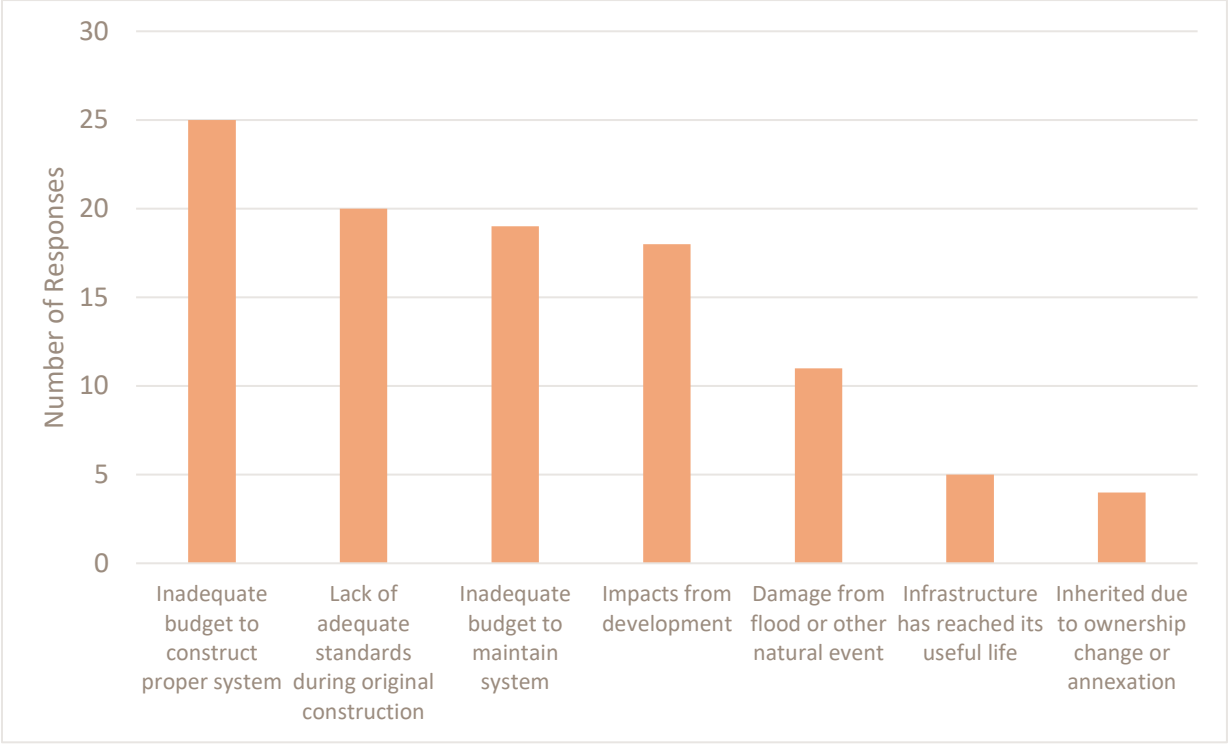
TWDB Flood Data Hub and other sources provided little information about the condition of the region's flood infrastructure. Participants in the Canadian–Upper Red data collection effort provided some information that could supplement the information provided by TWDB. However, throughout Texas, flood infrastructure is rapidly aging and in need of repair. Per TWDB guidance, infrastructure is considered to be non-functional when it is not providing its intended or design level of service, and deficient when the infrastructure or natural feature is in poor condition and needs replacement, restoration, or rehabilitation. These features are unlikely to become fully functional without funding.

Of the communities that responded to the survey, over 50% noted that at least 25% of their flood infrastructure was non-functional, and over 60% noted that at least 25% was deficient for current flood mitigation needs. **Map 3** in **Appendix A-1** shows the locations of where these survey participants have said their infrastructure or features are non-functional or deficient.

In the survey, participants could select multiple reasons as to why their infrastructure was non-functional or deficient. As shown in **Figure 1-22**, there were two common reasons given for non-functional and deficient infrastructure. The first is lack of funding. Unlike water and wastewater utilities, which receive funding through a dedicated utility fund, many municipalities lack a dedicated funding source for stormwater projects, operations, and maintenance. Texas state law does provide a mechanism for municipalities to establish a dedicated revenue source for drainage through the implementation of a stormwater utility fee. However, only four cities in Region 1 are known to have these fees in place: Amarillo, Burkburnett, Vernon, and Wichita Falls. Additionally, state law does not currently allow counties or other drainage operators to establish similar programs.

Another common reason cited for inadequate drainage infrastructure is higher standards since the construction of existing drainage systems. As cities continue to develop, the requirements for infrastructure functionality increase due to greater consequences of failure. Additionally, better rainfall data has been established in recent years that often indicates that higher storm intensities should be expected for a given design rainfall event. When coupled together, these two factors quickly mean that stormwater infrastructure constructed in previous decades is inadequate to meet the current needs as we understand them today.

Figure 1-22: Reason for Non-Functional/Deficient Infrastructure



Source: Region 1 Stakeholder Survey Responses

1.4 Proposed or Ongoing Flood Mitigation Projects

The flood infrastructure inventory also collected information about proposed or ongoing FMPs in the FPR, including:

- Structural FMPs currently under construction
- Non-structural FMPs currently being implemented
- Structural and non-structural FMPs with dedicated funding to implement, and the expected year of completion

This portion of the inventory is summarized in TWDB-required **Table 2** included in **Appendix A-2**, and on **Map 2** in **Appendix A-1.** The purpose of this exercise was to identify and consider the impacts of these flood projects on future flood conditions and to prevent a project from being listed in the RFP if it has already established funding for implementation. In Region 1, projects listed on a CIP were not considered to have dedicated funding for implementation unless an engineering or construction contract had been executed, since municipal budgets are subject to change from year to year. Only two qualifying projects were identified in Region 1: Martin Road Playa Improvements in Amarillo and Quail Creek in Wichita Falls. Eight additional entities identified themselves as having proposed or ongoing projects as a part of the outreach survey, but not enough information was provided to include them in the list for Region 1 at this time. These entities were Timbercreek Canyon, Ogallala Commons, Perryton, Hale County Soil and Water Conservation District, Palisades, Fritch, Spearman, and Iowa Park.

Martin Road Playa Improvements includes excavation of the playa, replacing the existing pump, and increasing the size of several pipes in the system. The construction is anticipated to finish in 2023 and will cost a total of $12.3 million, funded by Amarillo stormwater utility fees. Once complete, it will reduce flood risk and provide recreation opportunities for fishing or walking along trails.

The Quail Creek project in Wichita Falls consists of five phases, with the final construction date anticipated in 2025. The total construction cost for all five phases is $16.7 million and is funded by Wichita Falls stormwater utility fees. The project consists of a variety of actions, including channel improvements and expansions, culvert modifications, removing weirs and dams, and increasing storage volume in basins. Once complete, the project will reduce flood risk for its project area.

Chapter 2. Flood Risk Analysis

The objective of this task was to perform a comprehensive and cohesive flood risk analysis for the region. Flood risks were assessed for the 1% and 0.2% ACEs. The analysis was performed for existing conditions of the region, as well as a future-condition scenario that considers changes in flood hazards over the 30-year planning horizon. The overall flood risk analysis is comprised of three separate but related evaluations, including:

- Flood Hazard Analyses – to characterize location, magnitude, and frequency of flooding.
- Flood Exposure Analyses – to identify who and what might be harmed within the region.
- Vulnerability Analyses – to identify vulnerabilities of communities and critical facilities.

This chapter describes the process that was undertaken to determine and quantify flood hazards in the region and presents the results of the evaluation, including a summary of the types and magnitude of flooding and the communities most susceptible to its harmful effects. This information was then used to recommend flood mitigation actions within the region. TWDB-required **Tables 3** and **5** summarize the quantitative results of this analysis by county and are included in **Appendix B-2**. The maps, charts, figures, and other visuals presented in this chapter are drawn from the data in these tables.

A rainfall event can be described in terms of ACE, which describes how likely an event is to occur in a given year. This probability has classically been presented inversely as a return period, giving the estimated time interval between events of a similar size or intensity. For example, the “100-year storm” return period equates to a 1% ACE. This does not mean that a storm of this duration or intensity occurs every 100 years—instead, it means that, in any given year, there is a 1% chance of such an event occurring.The equivalents of ACEs and recurrence intervals are shown in **Table 2-1.** A lower ACE indicates a less frequent but more severe storm.

Table 2-1: Recurrence Interval and % ACE Equivalent

Recurrence Interval	% ACE
1000-year	0.1% ACE
500-year	0.2% ACE
100-year	1% ACE
50-year	2% ACE
25-year	4% ACE
10-year	10% ACE
5-year	20% ACE
2-year	50% ACE

2A. Existing Condition Flood Risk Analysis

2A.1 Existing Condition Flood Hazard Analysis

The purpose of the existing condition flood hazard analysis was to compile a comprehensive outlook of existing flood hazards in the region. To date, no full-coverage evaluation of flood risk has ever taken place in the region or in the State of Texas. In addition, much of the flood risk in Region 1 is unmapped or based on out-of-date maps and, as a result, most of the flood risk across the region is not well quantified, meaning that people and their property may be unknowingly in harm's way.

The output of the flood hazard analysis is a map of flood hazard areas that are subject to flooding during the 1% and 0.2% ACEs. This effort is not regulatory in nature, and the results of this evaluation do not have an impact on NFIP insurance requirements or premiums. Rather, this exercise is intended to gather a single, comprehensive set of best available information on actual flood risk in the region to help communities understand their current risks and better prepare them.

2A.1.1 Types of Flood Hazards in the Region

To plan for a flood, it is important to understand the types of flooding an area faces. Each type of flooding is different in how it occurs, how it is forecast, and the damage it can cause. This evaluation considered several different types of flooding in the development of the flood hazard areas.

- **Riverine Flooding:** Riverine flooding is caused by bank overtopping when the flow capacity of rivers is exceeded. Rising water generally originates from high-intensity rainfall creating soil saturation and large volumes of runoff to the receiving waters, either locally and/or in upstream watershed areas.
- **Playa Flooding:** Playa flooding occurs when playas overtop and flood surrounding areas. In Texas, this type of flooding is unique to the Panhandle.
- **Playa and Riverine Flooding:** In some instances, areas may be classified as both playa and riverine flooding, such as land between interconnected playas where flow travels.
- **Pluvial Flooding including Urban Flooding:** One of the common misconceptions about flooding is that you must be located near a body of water to be at risk. Yet pluvial, or "urban" floods are not caused by swelling rivers. Urban floods can occur when the inflow of stormwater in urban areas exceeds the capacity of drainage systems, causing flooding out into streets and nearby structures.
- **Coastal Flooding:** Coastal flooding occurs when normally dry, low-lying land is flooded by seawater. Since Region 1 is contained entirely inland, this type of flooding does not occur in the region.
- **Flash Flooding:** Flash flooding occurs following a heavy rainfall when high velocity surface waters sweep through low-lying areas. Flash flooding is particularly dangerous because since the flooding occurs quickly, it often catches people off-guard.

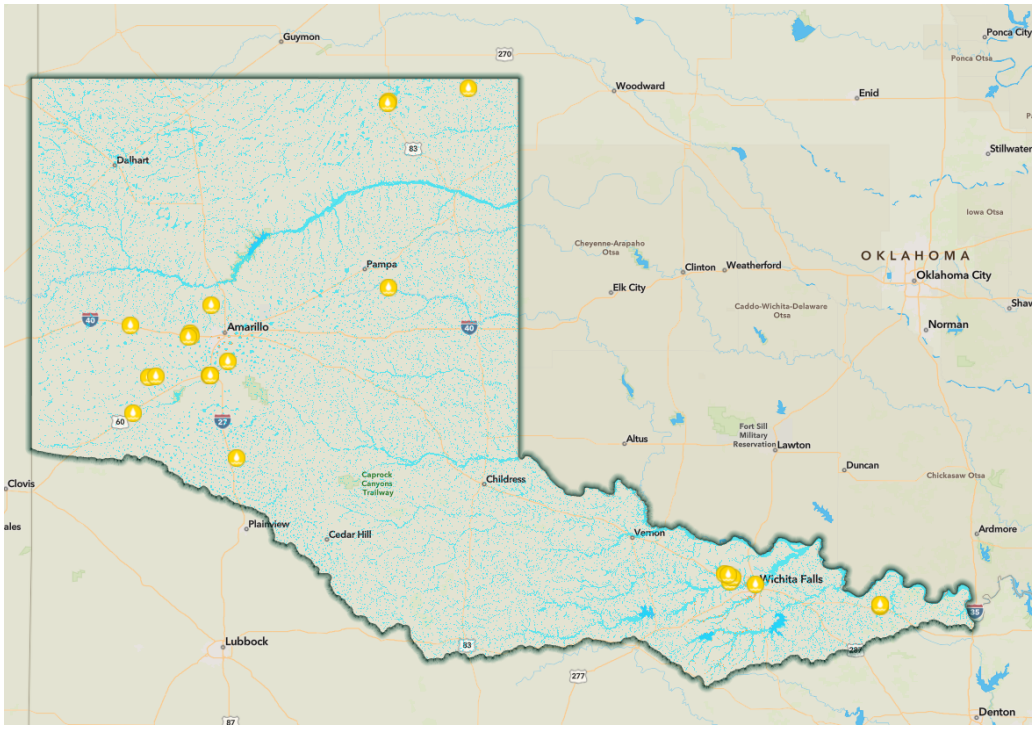
- **Possible Flood Prone Areas:** This analysis also considers potentially flood prone areas that the RFPG identifies outside of previously mapped flood hazard areas. They can be identified through the location of hydrologic features, historic flooding, and/or local knowledge. Since the cause and recurrence of flooding in these areas is uncertain, separate flood hazard areas have been developed and are listed with "unknown" flood frequency in this analysis.

The region is subject both to the danger of swift-moving flood waters in riverine areas and to standing water associated with flooded playas and lakes. The distribution of these types of flooding in the region can be seen in **Map 4** in **Appendix B-1**. Urban flooding is likely also a source of significant flooding exposure, particularly in the cities of Amarillo and Wichita Falls. However, this type of flooding was not specifically defined in the available hazard datasets and has not been discretely identified for the first planning cycle.

Additionally, possible flood prone areas were identified through two sources of data. The first was through an evaluation of the region's LWC data compared to known flood hazard areas. LWC points outside of the 1% and 0.2% annual chance flood hazard area were delineated as possible flood prone areas, since their status as LWCs indicates that there is likely flooding occurring at these locations, even if it is not mapped.

The second source of data was comments on an ArcGIS Online web map where the public could report areas of flooding. This web map was shared on the RFPG website, as well as emailed to community officials in the region. Points that were outside of the 1% and 0.2% flood hazard area were delineated as possible flood prone areas based on the description included in the comment. The web map with possible flood prone areas indicated with yellow markers is included as **Figure 2-1**.

Figure 2-1: Survey Web Map Used to Develop Flood Prone Areas



2A.1.2 Existing Hydrologic and Hydraulic Model Availability

The development of the flood hazard areas relied on floodplain modeling and mapping information from existing sources, rather than the development of new flood hazard information. Eight counties have existing FEMA FISs, with associated models that were used to develop regulatory maps for the NFIP and are represented in the developed flood hazard layer. Other models from the listed studies were not readily available for use in development for the hazard layer. These studies and their associated models are listed in **Table 2-2**.

Table 2-2: Identified Existing Hydrologic and Hydraulic Models

Model/Report Title	Software/Method	Study Area	Sponsor Entity	Date
Archer County FIS	HEC-HMS, HEC-RAS	Archer County	FEMA	2017
Cooke County FIS	HEC-1, HEC-RAS	Cooke County	FEMA	2002
Gray County FIS	HEC-HMS, HEC-RAS	Gray County	FEMA	2009
Hale County FIS	HEC-1, HEC-2	Hale County	FEMA	2009
Montague County FIS	HEC-1, HEC-2	Montague County	FEMA	1988
Potter County FIS	HEC-HMS, HEC-RAS	Potter County	FEMA	2006
Randall County FIS	HEC-1, HEC-2, HEC-RAS	Randall County	FEMA	2006
Wichita County FIS	HEC-1, HEC-2	Wichita County	FEMA	1981, 1989
Canadian River Basin Corps Water Management System Report	HEC-HMS, HEC-RAS	Canadian River Basin	USACE	2017
Red River Basin Corps Water Management System Report	HEC-HMS, HEC-RAS	Red River Basin	USACE	2017
City of Canyon & Randall County, Texas FIS	HEC-HMS, HEC-RAS	City of Canyon	USACE	2011
East Plum Creek	HEC-HMS, HEC-RAS	East Plum Creek	City of Wichita Falls	2012
Holliday Creek	HEC-HMS, HEC-RAS	Holliday Creek	USACE	1996
Wichita Falls Drainage Master Plan	HEC-HMS, HEC-RAS, EPA SWMM	City of Wichita Falls	City of Wichita Falls	2011
Wichita River Floodplain Model	HEC-HMS, HEC-RAS	Wichita River	City of Wichita Falls	2016
USGS Study of the Wichita River	HEC-HMS, HEC-RAS	Wichita River	USGS	2011
City of Amarillo DMP Rain on Grid Rapid Assessment Model	HEC-HMS, HEC-RAS	City of Amarillo	City of Amarillo	2019

Model/Report Title	Software/Method	Study Area	Sponsor Entity	Date
Amarillo Simulation Analysis of Playa Performance (ASAPP)	ASAPP	City of Amarillo Playa Lakes	City of Amarillo	1993
Bivins Lake Dam Breach Model	HEC-RAS	Bivins Lake Dam	City of Amarillo	2013
Thompson Park Dam No. 3 Breach Analysis	HEC-RAS	Thompson Park Dam	City of Amarillo	2013
Farmers-Mud BLE	HEC-RAS	Parts of Clay, Montague, and Cooke Counties	FEMA	2021*
Archer County BLE	HEC-RAS	Archer County	FEMA	2018
Washita Headwaters BLE	HEC-RAS	Parts of Hemphill, Roberts, Gray, and Wheeler Counties**	FEMA	N/A

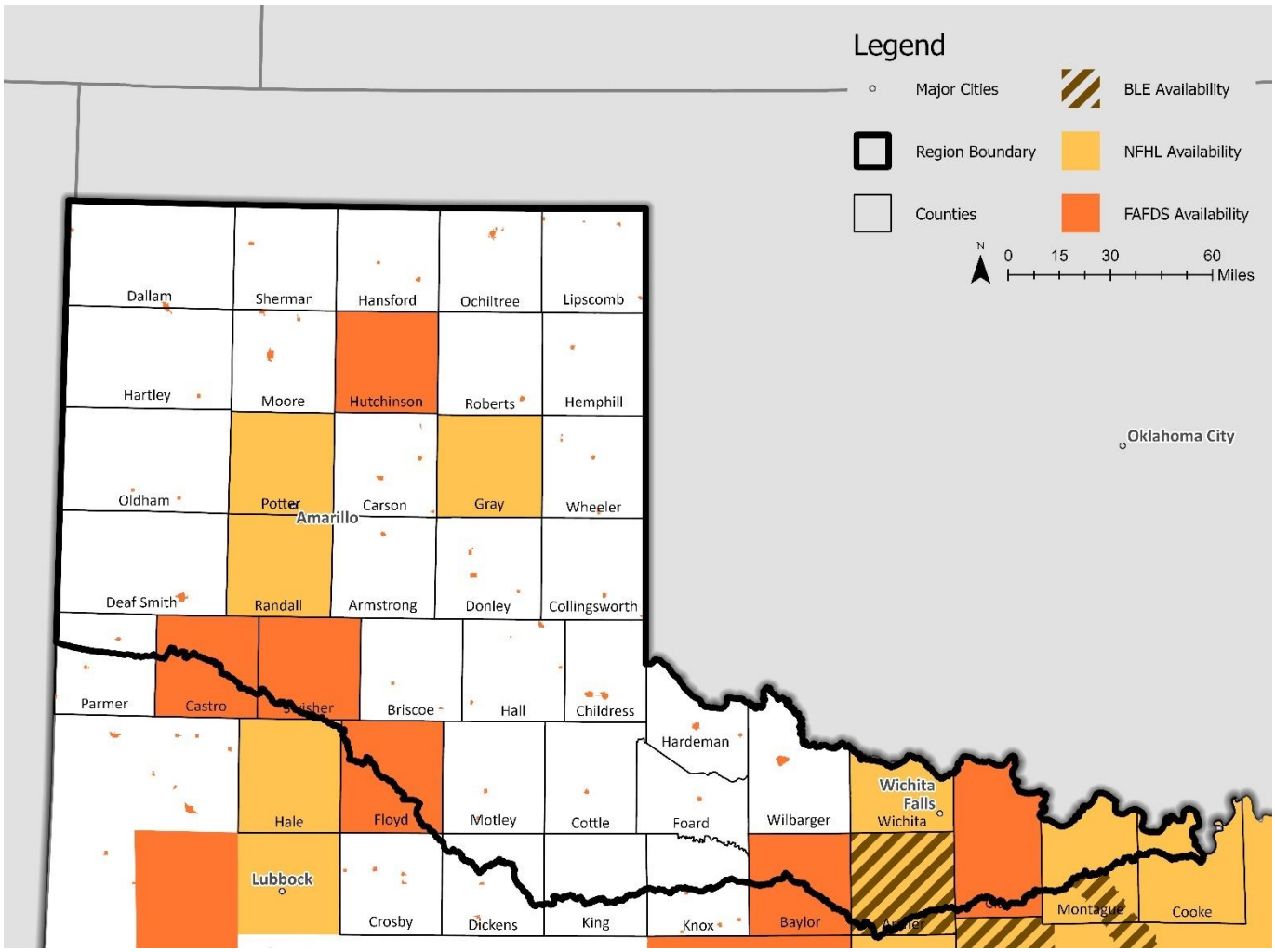
**Became available after the development of the flood hazard layer*
***No flood elevations within Texas available for this watershed*

A handful of other models exist from past studies to evaluate flood risk and develop conceptual design alternatives for the communities of Amarillo, Canyon, and Wichita Falls. These models are listed in the table but were not used to develop existing flood hazard information, unless they provided floodplain information for an area that is impacted by a specific FMP included in this RFP. Impacts from FMPs with dedicated construction funding with anticipated completion prior to the adoption of the next SFP were also not included, since impacts from those projects cannot be concretely identified at this time and will have minor, local benefits.

2A.1.3 Best Available Data Determination

To assist RFPGs with the flood hazard analysis, TWDB prepared a statewide geographic information system (GIS) dataset – the "floodplain quilt" – with the most recent flood-hazard data in Texas. The floodplain quilt is comprised of data from several sources, First American Flood Data Services (FAFDS) flood zone determinations, FEMA National Flood Hazard Layer (NFHL) information developed from detailed and approximate flood studies, and FEMA BLE data. **Figure 2-2** summarizes the floodplain quilt data available within Region 1.

Figure 2-2: Floodplain Quilt Data Availability in Region 1



Source: TWDB Flood Quilt (TWDB Data Hub)

While an important and valuable source of data, floodplain quilt data provided limited coverage in Region 1. A secondary source of commercially available "cursory floodplain data" was utilized to help fill in the remaining gaps. The cursory floodplain data was generated through 2D rain-on-grid hydraulic modeling performed by Fathom, a company focused on providing large-scale flood models to data-scare areas. The data was made available by TWDB through two separate deliverables in July and October of 2021. The primary differences between the deliverables were the data source and resolution for the terrain model, as well as the recurrence intervals evaluated. The cursory floodplain datasets used in this analysis are summarized in **Table 2-3**.

Table 2-3: Cursory Floodplain Data Summary

#	Deliverables	Terrain Source	Modeling Terrain	Mapping Terrain	Recurrence Intervals (years)	Deployment
1	Draft Cursory Floodplain (raster only)	Digital Elevation Model (DEM)	30M DEM	30M DEM	10, 100, 1000	July 2021
2	Cursory Floodplain	Light Detection and Ranging (LiDAR) Data	30M LiDAR	3M LiDAR	5, 10, 100, 500	October 2021

Source: Cursory Floodplain Dataset (TWDB Data Hub)

The development of flood hazard areas is required to be based on "best available" data as determined by the RFPG. To assist with this determination, the various data sources were organized by TWDB into an initial hierarchy based on the relative quality and extent of coverage of the data. The initial hierarchy developed by TWDB is presented in **Table 2-4**.

Table 2-4: TWDB Best Available Data Hierarchy

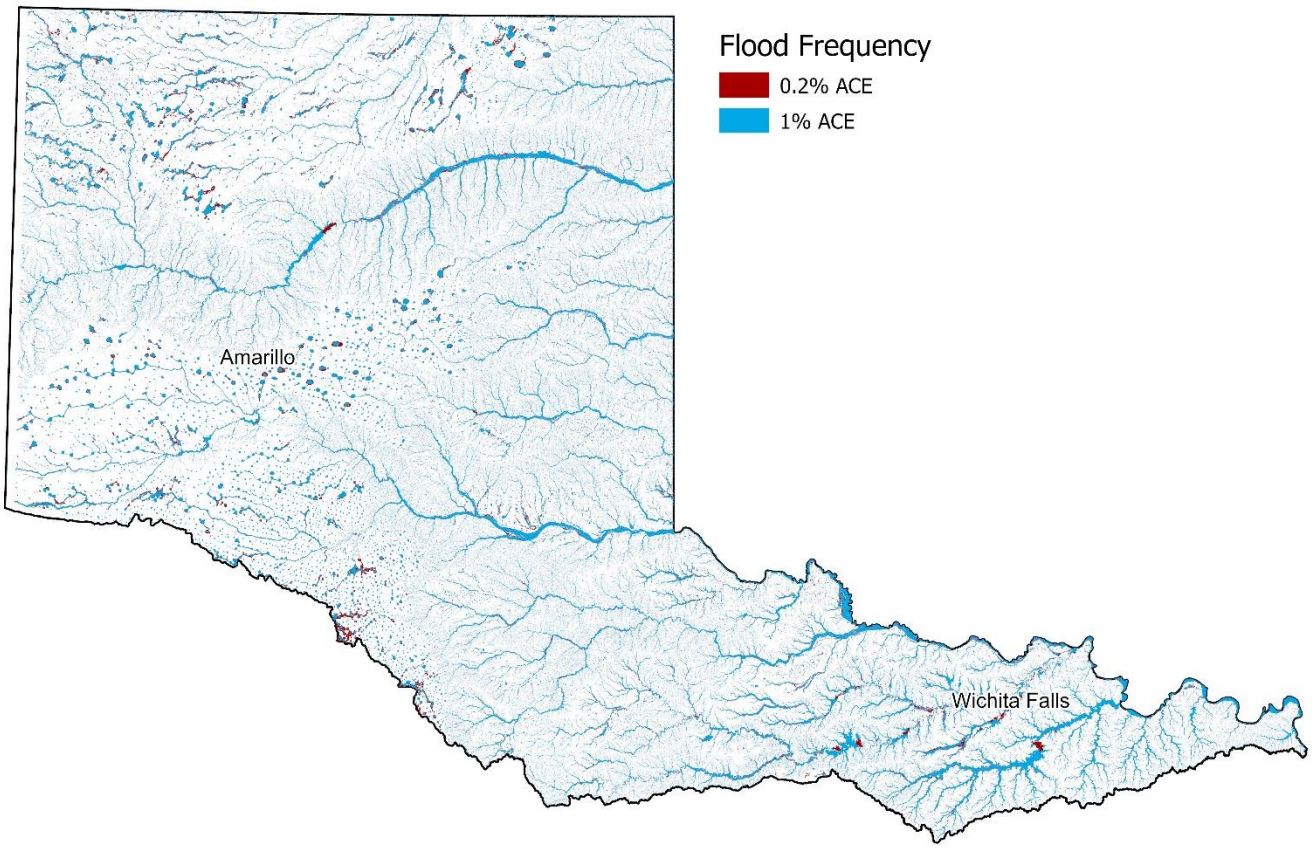
Rank	Data Source and Classification
1	NFHL – Pending Data
2	NFHL – Preliminary Data
3	NFHL – Effective Data (Detailed Study Areas only)
4	BLE
5	NFHL – Effective Data (Approximate Study Areas only)
6	FAFDS
7	Other Potential Data Sources – includes Cursory Floodplain Data (Fathom)

Source: TWDB Technical Guidance

Region 1 currently only has floodplain mapping data available from categories 3, 4, 5, 6, and 7. However, the majority of the available data is more than ten years old and/or is only available for the 1% ACE, with no corresponding 0.2% ACE floodplain. Therefore, it was determined that the cursory floodplain data would be a better source of data than NFHL and FAFDS data in many cases, due to more recent mapping and more comprehensive coverage. As a result, cursory floodplain data was used to develop flood hazard areas for the majority of the region, supplemented by NFHL detailed study (Zone AE) data, where it was available. This decision also allowed for internal consistency between the 1% and 0.2% flood hazard boundaries, rather than producing a feature class with gaps as the result of mixing and matching data sources.

It is recognized that the cursory floodplain data is limited in precision due to the low level of detail (LOD) required to provide flood mapping data at such a large scale. However, the availability and use of the cursory floodplain data represents an important step in developing flood hazard information in this region, in which floodplain boundaries remain largely unmapped. In a related effort, TWDB is making an aggressive push to expand the availability of floodplain mapping information in Texas through the development of FEMA BLE data. While few areas in Region 1 have BLE data currently, full BLE coverage for the region is expected in 2023. Therefore, future flood planning cycles will be able to incorporate this BLE data for more accurate results. For the existing flood hazard layer, data from the TWDB quilt was combined with the cursory floodplain data. Since the Farmers-Mud BLE was available after the quilt was provided to regions, it was not incorporated into this flood hazard layers due to the compressed timeline. Archer County has BLE, but it is older than the FIS data for the county, so the FIS data was used instead for that area of the region. **Figure 2-3** shows the existing hazard extents for the region for the 1% ACE.

Figure 2-3: Existing Flood Hazard Extents



2A.1.4 Identified Existing Flood Hazard Areas

Appendix B-1 contains a series of flood hazard area maps under existing conditions. Combined, these maps serve as TWDB-required **Map 4**. These floodplains cover over 5,230 square miles and 15% of the

land area of Region 1. Of the mapped flood hazard area, 4,305 square miles are inundated during the 1% ACE, and an additional 930 square miles are inundated during the 0.2% annual chance floodplain. Potentially flood prone areas of unknown flood frequency account for less than 1 square mile of total area across the region.

Figure 2-4 presents the total flood hazard area by county. Counties with total flood hazard area in Region 1 less than 2 square miles are excluded for clarity. This includes the counties of Crosby, Hale, and Young, which lie mostly in bordering FPRs. Overall, the counties of Dallam, Wilbarger and Clay have the highest total flood hazard area, with over 200 square miles of flood hazard area per county. **Figure 2-5** presents the total area of flood hazard by type. Riverine flooding accounts for the majority of flood hazards in the region. Additionally, there are portions of the watershed that are considered to be subject to riverine and playa flooding, such as areas in the overland flowpath of interconnected playas.

Figure 2-4: Total Existing Condition Flood Hazard Area by County (Sq. Mi.)

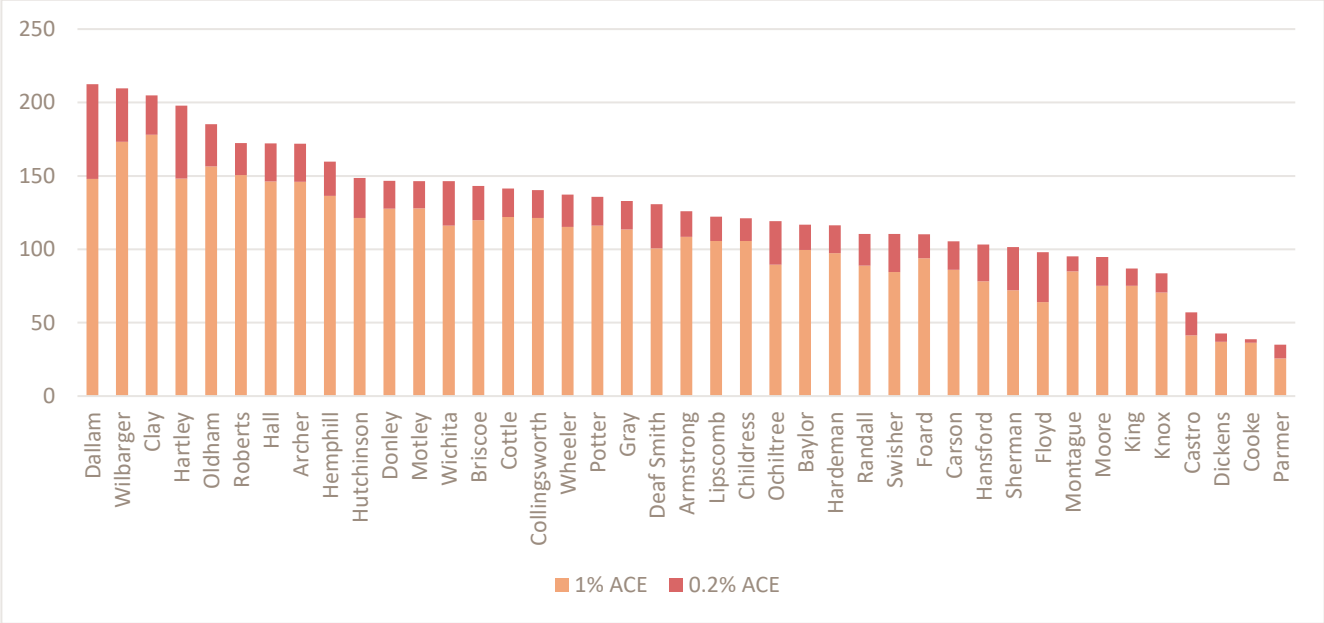
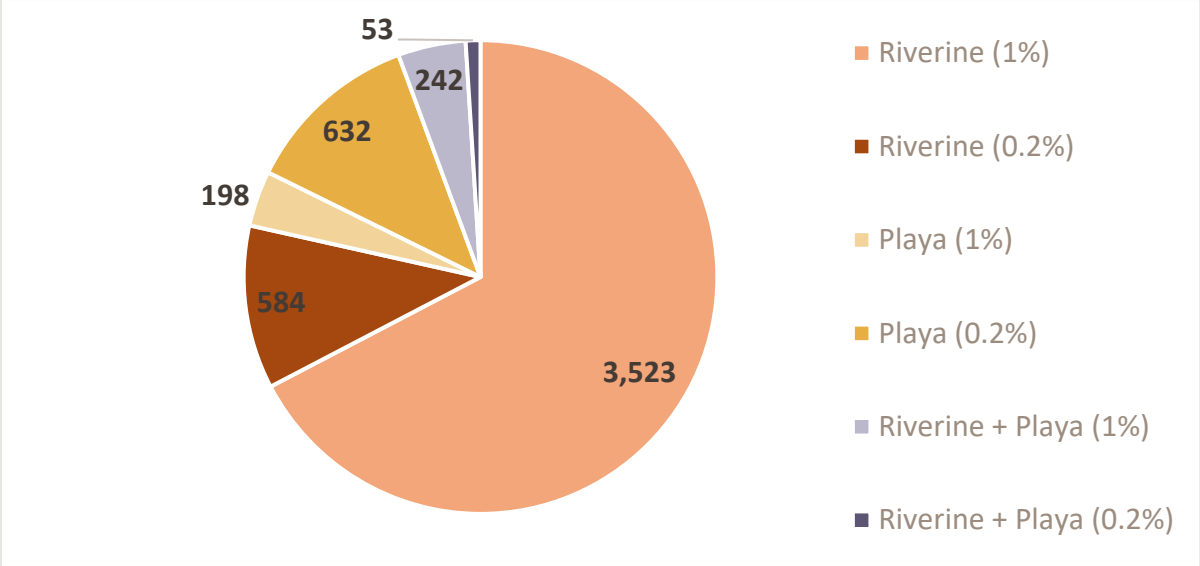


Figure 2-5: Existing Condition Type of Flooding by Total Area (Sq. Mi.)

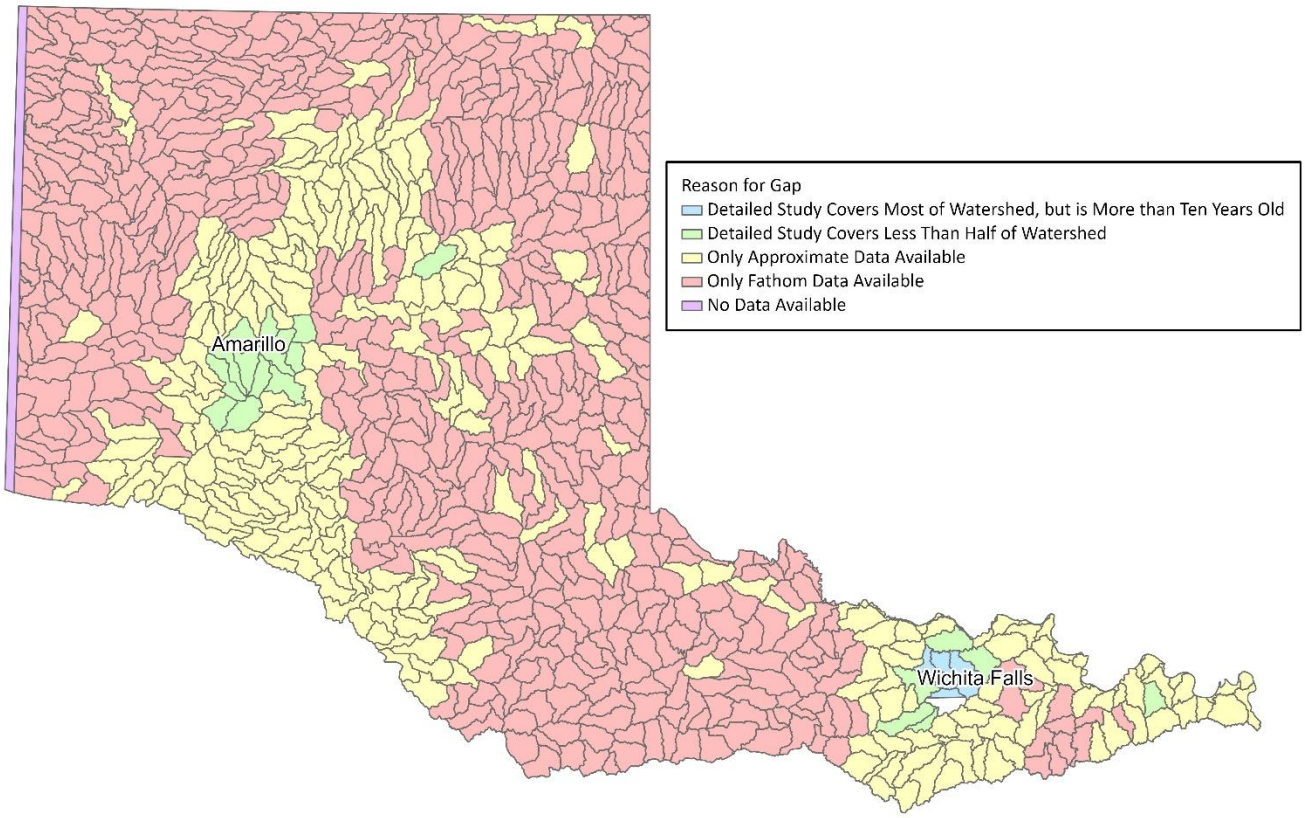


2A.1.5 Existing Condition Data Gaps

As previously described, the majority of Region 1 is lacking flood mapping information, and the areas that are mapped are generally decades old. For the gap analysis, the RFPG determined that anything other than detailed study information less than 10 years old was considered a data gap. This results in almost the entire region being listed as a gap, though this was further refined based on the severity of the gap, such as an area that has old mapping information versus an area that has had no mapping performed. Additionally, the very western portion of the region has no cursory floodplain data available, so a separate gap type was created for this area.

This information is presented visually in **Map 5** in **Appendix B-1** and in **Figure 2-6,** which breaks down the data gaps by HUC 12. The southern portion of the Middle Holliday Creek watershed in Wichita Falls had a detailed study completed in February 2021 and is the only watershed considered to have sufficient flood mapping information. The majority of the watershed that remains was considered for potential Flood Management Evaluations (FMEs) in **Tasks 4** and **5**.

Figure 2-6: Gaps in Existing Flood Mapping



2A.2 Existing Condition Flood Exposure Analysis

Once the existing condition flood hazard areas were completely defined, the existing condition flood exposure analysis was performed to identify the people and property at risk. This analysis was completed using an automated GIS process that intersected various data sources with the flood hazard area boundaries to create various flood exposure feature classes for different feature types. The analysis considered exposure of different types of existing development within the flood hazard area, including:

- **Buildings:** residential and non-residential structures, those structures identified as critical facilities, and the associated population at risk. The population at risk evaluated both the day and night population estimates for each structure, with the higher of the two values being used to estimate the population in the flood hazard area.
- **Roadways:** estimated number of road crossings and total roadway length inundated by flooding. Those road crossings identified as LWCs were specifically identified, as these crossings are generally overtopped by floodwaters more frequently.
- **Agricultural Areas:** the total area of farming and ranching lands within the flood hazard area.

2A.2.1 Flood Exposure Due to Existing Levees or Dams

The analysis also required the consideration of population and property located in areas where existing levees or dams do not meet FEMA accreditation as inundated by flooding without those structures in place. No dams or levees in the region were specifically identified as not meeting FEMA accreditations. Therefore, it was assumed that the current floodplain limits properly reflect the flood protection benefits of these structures.

2A.2.2 Existing Flood Exposure Summary

This section describes the results of the existing flood exposure analysis through a series of maps for each type of exposure evaluated and are summarized at a county level. The figures and counts all refer to the total exposure in the county, including 1% ACE, 0.2% ACE, and unknown flood frequency areas. A regional summary of flood exposure by feature type is presented in **Table 2-5**.

Table 2-5: Existing Flood Exposure Summary

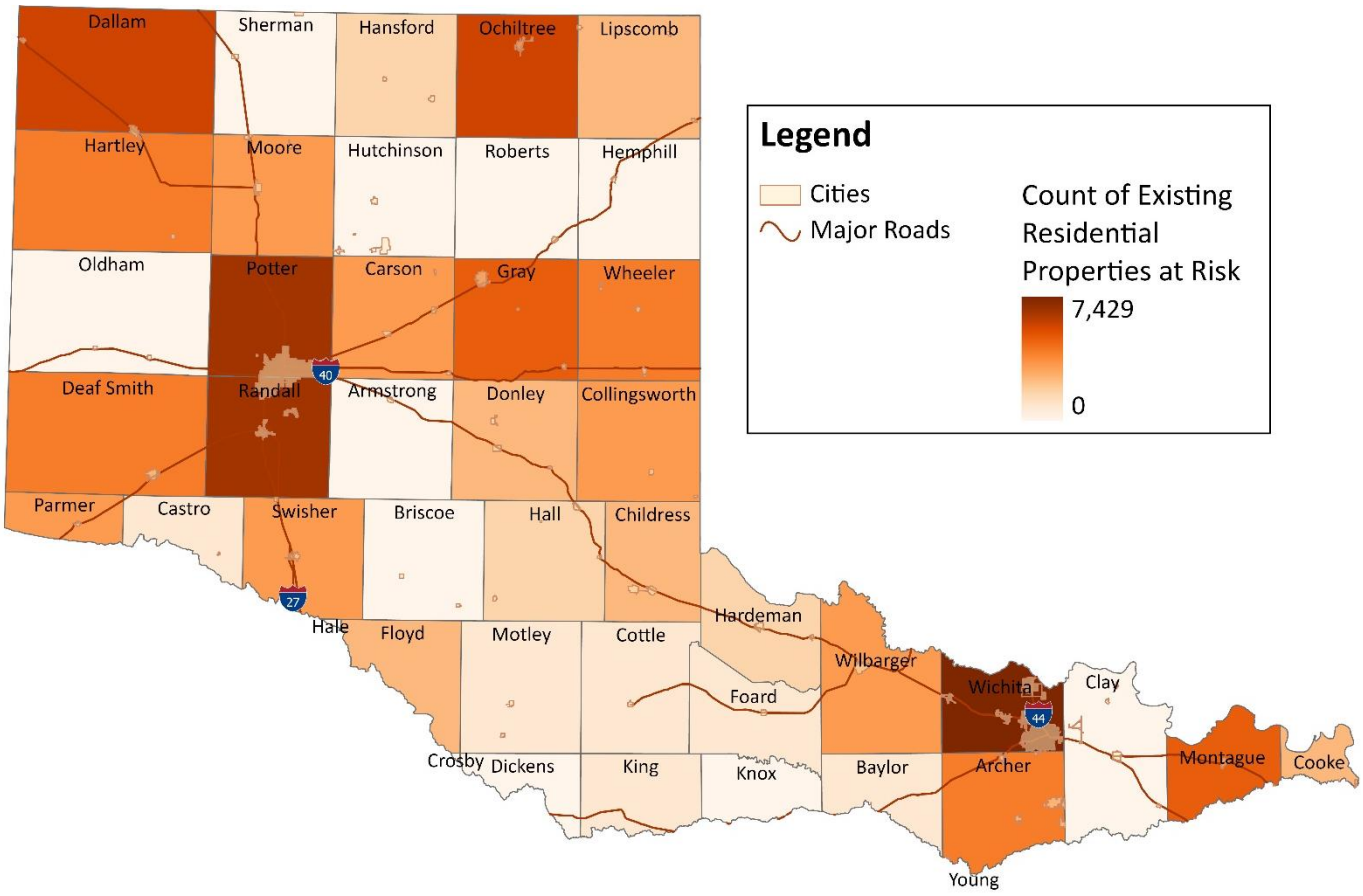
Exposure Feature Type	Number of Features by Flood Hazard Area			
	1% ACE	0.2% ACE	Unknown	Total
Structures (#)	11,544	12,170	88	**23,802**
Population (#)	29,996	38,834	161	**68,991**
Critical Facilities (#)	160	128	0	**288**
Roadway Segments (mi.)	2,299	1,042	8	**3,349**
Roadway Stream Crossings (#)	4,981	945	164	**6,090**
Agricultural Areas (sq. mi.)	3,789	858	0	**4,647**

Additionally, **Map 6 (Appendix B-1)** is presented as a heat map identifying areas of concentrated exposure features across the region with a series of maps displaying a more detailed look at exposures. Unsurprisingly, the urban centers of Amarillo and Wichita Falls have the highest concentration of flood exposure in the region, due to the density of development and total population in these areas. However, flooded roadways and agricultural areas are found throughout the region, and the impacts due to the loss of function in these areas should not be understated.

Residential Properties

The three counties with the highest number of residential properties in the flood hazard area are Wichita, Randall, and Potter, which contain the Cities of Wichita Falls and Amarillo. Outside of these metro areas, the next highest residential property count is in Dallam, due to flooding in Dalhart. The remaining counties have drastically lower counts compared to these top four, with nine counties containing no residential structures in the flood hazard area in Region 1. The number of residential properties in the existing flood hazard area is summarized in **Figure 2-7**.

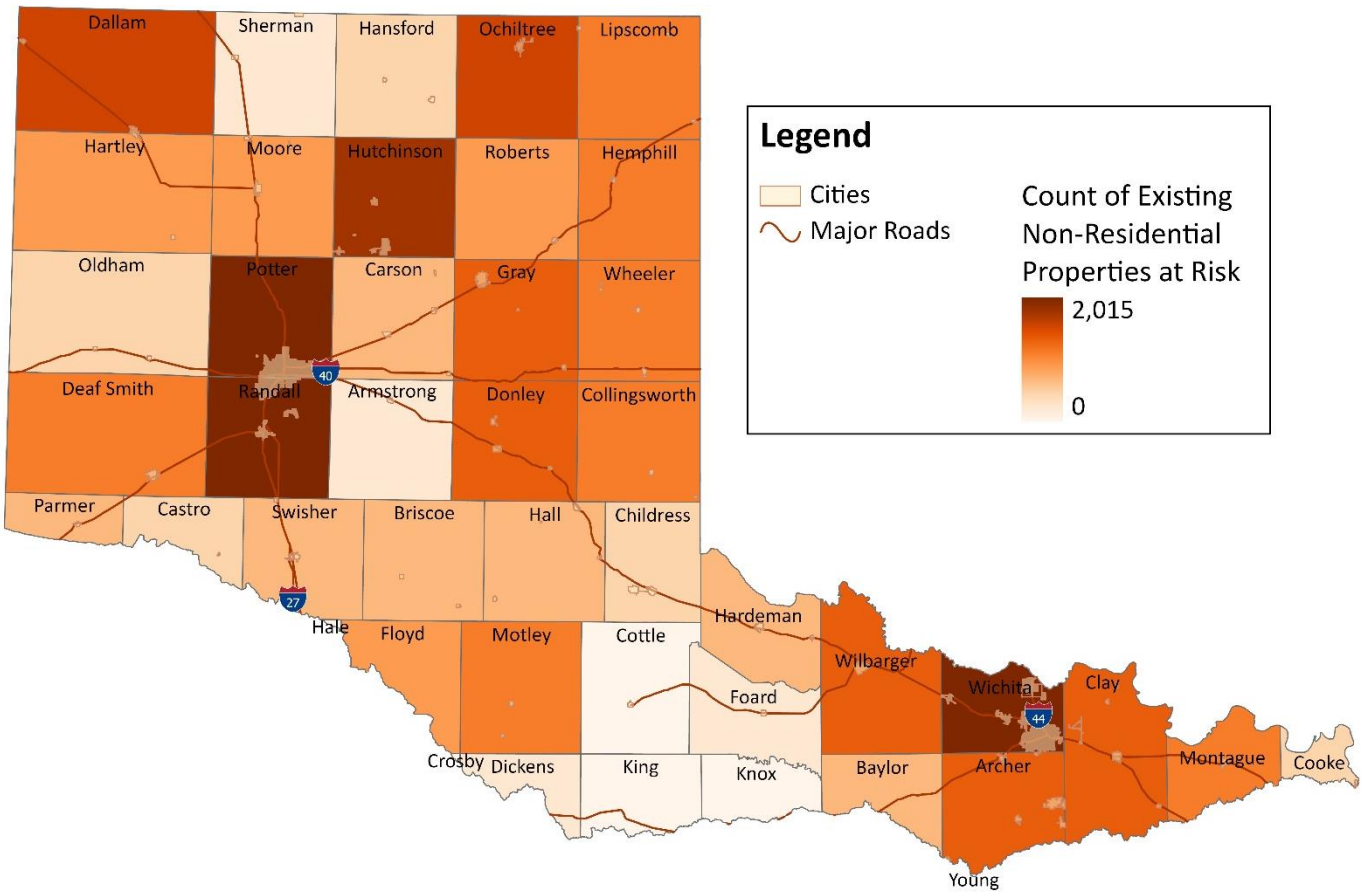
Figure 2-7: Total Existing Exposure Summary - Residential Structures



Non-Residential Properties

Non-residential properties within the flood hazard area follow a similar exposure pattern as residential structures. Wichita, Randall, and Potter Counties have the highest numbers of structures, but Hutchinson County is ranked fourth overall, despite having no residential buildings in the floodplain. After evaluation, this is likely an artifact of the dataset used to complete the analysis, as 99.91% of all buildings within Hutchinson are listed as vacant or unknown. As a result, the number of residential structures within the county and region overall is likely being undercounted. A refined building dataset should be developed for the next cycle to address this discrepancy and ensure an accurate reflection of the population at risk. The number of non-residential structures in the existing flood hazard area is summarized in **Figure 2-8**.

Figure 2-8: Total Existing Exposure Summary - Non-Residential Structures



Public Infrastructure

Public infrastructure is a broad term that includes roads; public water collection, treatment, and distribution facilities; gas and electrical facilities; and other public utilities. These facilities often perform essential functions that require enhanced levels of flood protection so that they may continue to function and provide services during and after a flood. As a result, a concentrated effort to identify "critical facilities" was performed in the flood exposure analyses. Examples of critical facilities include hospitals, fire stations, police stations, power generation facilities, and schools. Of the 847 buildings marked as public infrastructure within the FPR, 167 have been identified as critical facilities.

Roadway impacts are also evaluated under a separate subcategory of analysis. Flooded roadways pose a substantial risk to motorists, as over half of all flood-related drownings occur when vehicles are driven into hazardous flood waters. Functioning roadways serve a critical function during flood events, providing access to first responders and clear routes to safety in the case of an evacuation.

Other impacts to public infrastructure are not specifically quantified in this analysis, due to the lack of publicly available data for most of these infrastructure types. However, some general impacts and expected loss of function for these infrastructure types are outlined in **Section 2A.2.3**.

Major Industrial and Power Generation Facilities

There are 918 buildings in the existing flood hazard area that are marked as industrial, including 28 critical facilities. Within the flood hazard area, there are 16 facilities associated with power generation. Seven are natural gas processing plants, six are petroleum refineries, and three are power plants. These facilities are in Gray, Moore, Roberts, Wichita, and Wilbarger Counties and are summarized in **Table 2-6**.

Table 2-6: Existing Exposure Summary - Power Generation Facilities

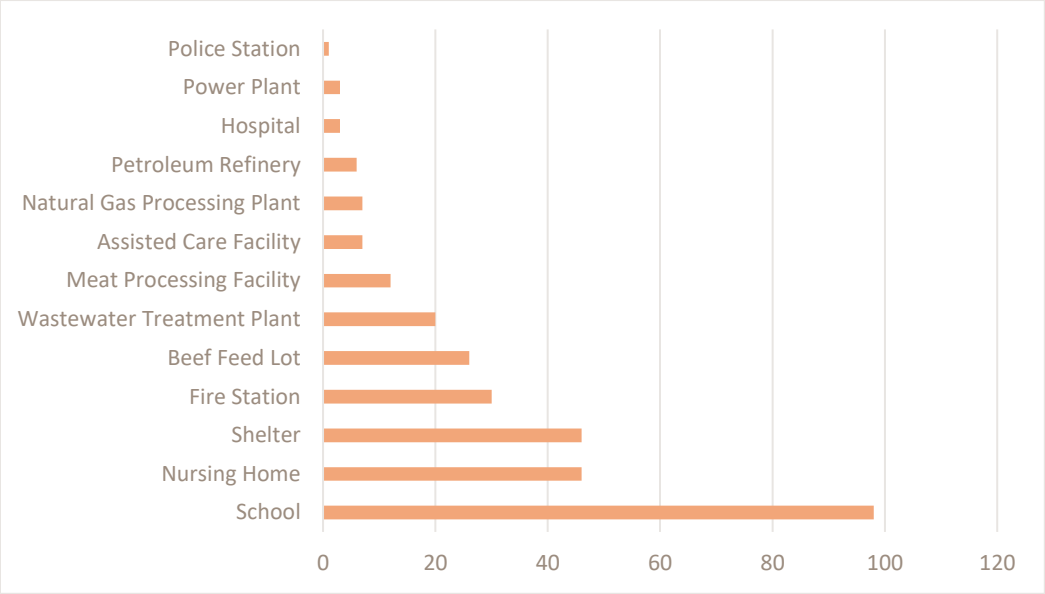
Critical Facility Type	County	Structures (#) in the Flood Hazard Area	
		1% ACE	0.2% ACE
Natural Gas Processing Plants	Gray	1	4
Petroleum Refineries	Moore	4	2
Natural Gas Processing Plants	Roberts	2	0
Power Plants	Wichita	1	0
Power Plants	Wilbarger	1	1

Critical Facilities

There are 288 critical facilities total within the existing flood hazard area. While some are marked public, other facilities such as power generation and meat processing are marked industrial. **Figure 2-9** shows a count for each type of critical facility. The two most common types of facilities within the flood hazard area are schools and nursing homes. A map of these critical facilities is included as **Figure 2-10**. The majority lie within Wichita Falls and Amarillo, but other major clusters include Dalhart, Timbercreek Canyon, Vernon, Borger, and Perryton.

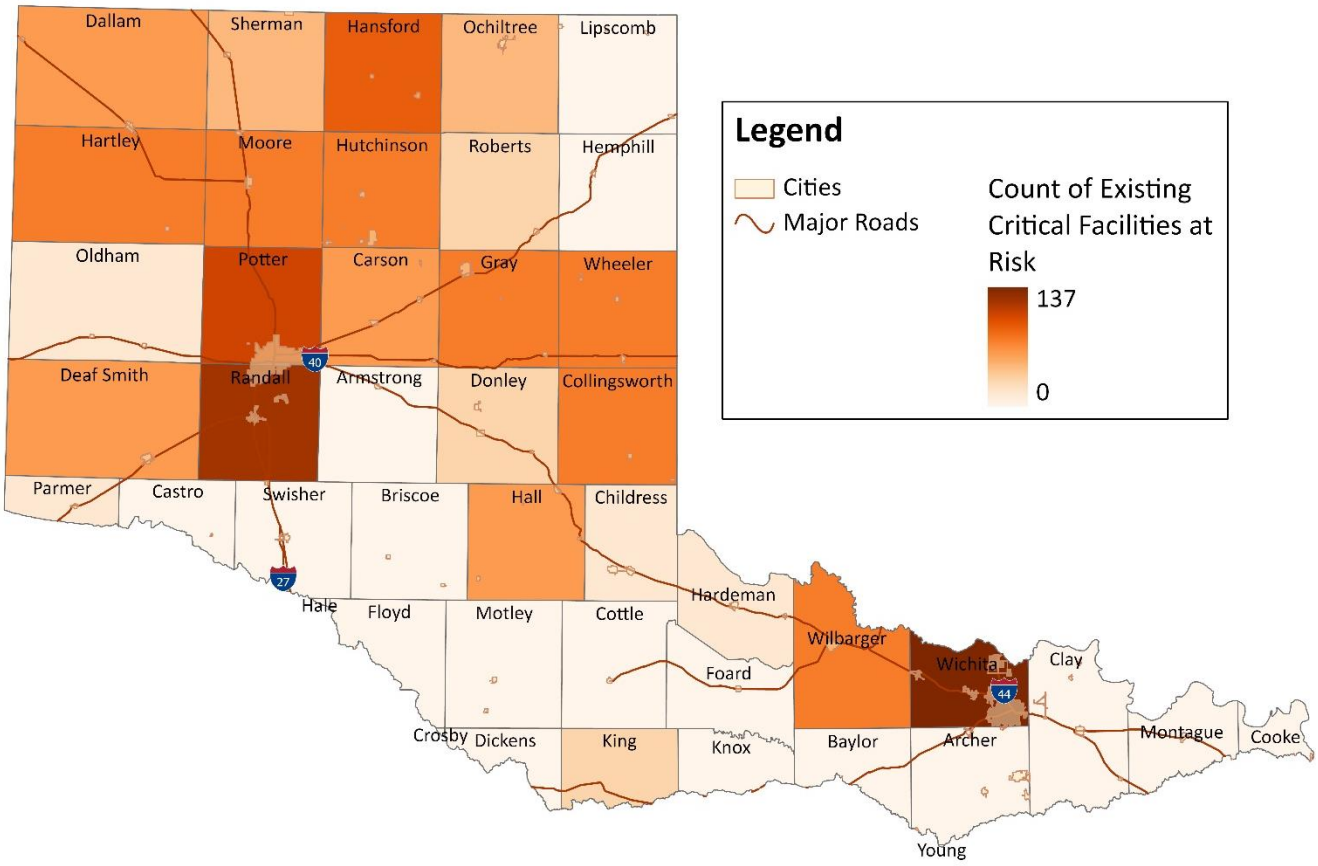
The vulnerability of a critical facility to flooding is impacted by several factors, such as the proximity of the critical facility to a floodplain or other bodies of water, the location of critical systems like primary and back-up power, past flooding issues, and the quality and availability of emergency management plans. Since this level of analysis only identified critical facilities in known flood hazard areas, it is likely that other critical facilities exist in the region that are vulnerable to flooding but are not represented in this report. For example, a critical facility would be impacted by flooding if access to the facility is limited during a flood, even if the facility itself is not flooded.

Figure 2-9: Total Existing Exposure Summary - Critical Facilities by Type



**Note: In the case that a facility serves multiple uses, both classifications have been counted.*

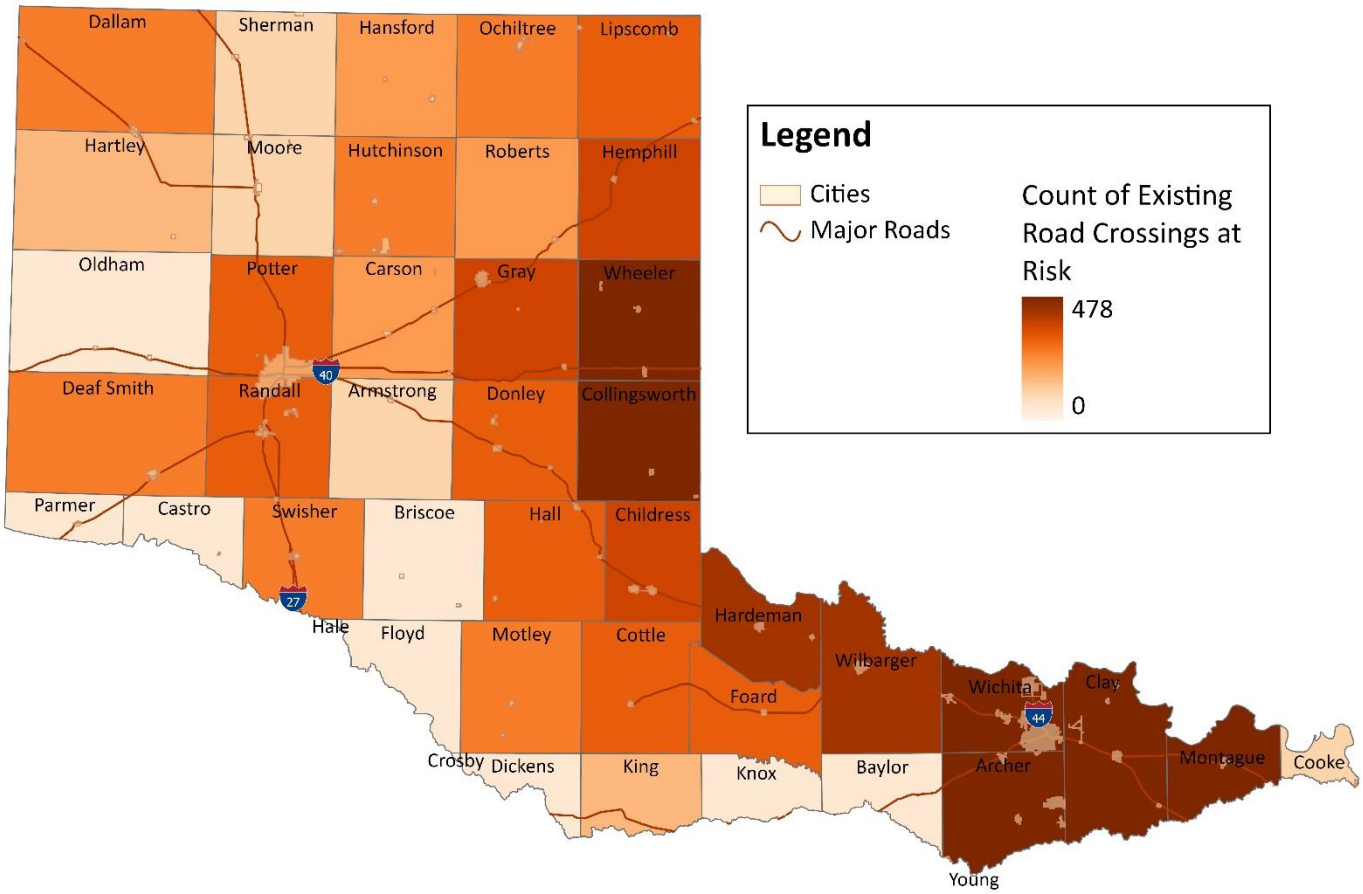
Figure 2-10: Total Existing Exposure Summary - Critical Facilities



Roadway Crossings

For this analysis, all road and stream intersections were considered, not just LWCs. Since regional data on deck height and water surface elevations for these crossings are not available, a flooding depth was not able to be associated with each crossing. The counties with the highest number of roadway stream crossings are Wichita and Clay, centered around Wichita Falls and surrounding cities. This area is the major transition point between North Texas and the far reaches of the Panhandle, with several major roadways and arterials converging through downtown Wichita Falls. Additionally, this portion of the watershed contains the Wichita River and its vast network of tributaries, meaning several major river crossings are found along these transportation corridors. **Figure 2-11** shows relative density of roadway stream crossings for each county.

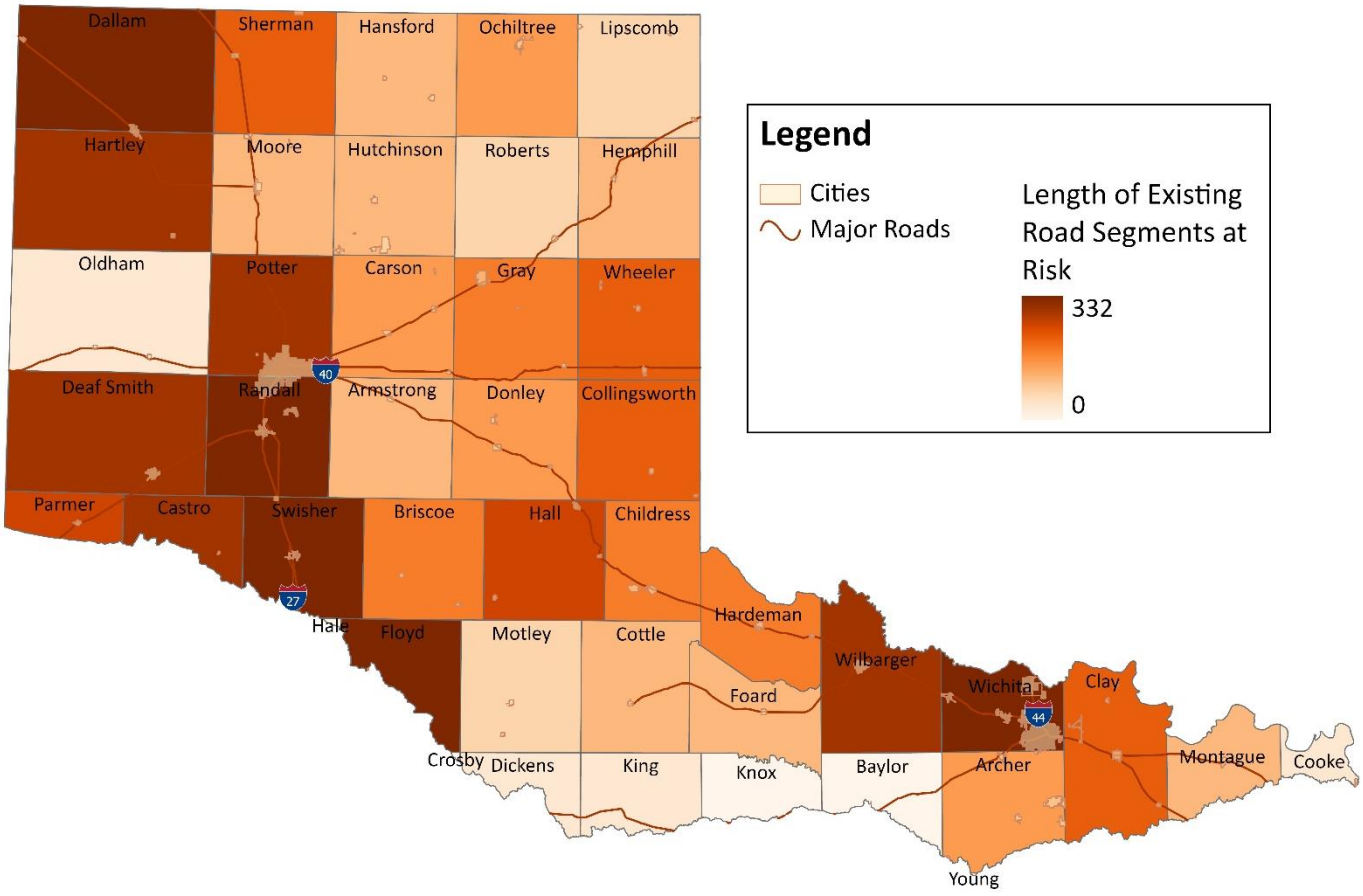
Figure 2-11: Total Existing Exposure Summary - Roadway Crossings



Roadway Segments

Wichita County has the most miles within the floodplain due to a large number of roads within Wichita Falls, Electra, Iowa Park, and Burkburnett, as well as flooding along the major thoroughfares of US 287, US 277, and I-44. The three other counties with more than 200 miles within the floodplain are Swisher, Dallam, and Randall. Swisher County includes flooding within the cities of Tulia and Happy, as well as along I-27. Dallam County includes Dalhart, US 87, and US 54. Randall County contains the southern half of Amarillo, Canyon, Timbercreek Canyon, Palisades, and Lake Tanglewood, which all contain roads, as well as US 60 and I-27. **Figure 2-12** summarizes the length of roadway segments impacted by flooding for each county.

Figure 2-12: Total Existing Exposure Summary - Roadway Segments

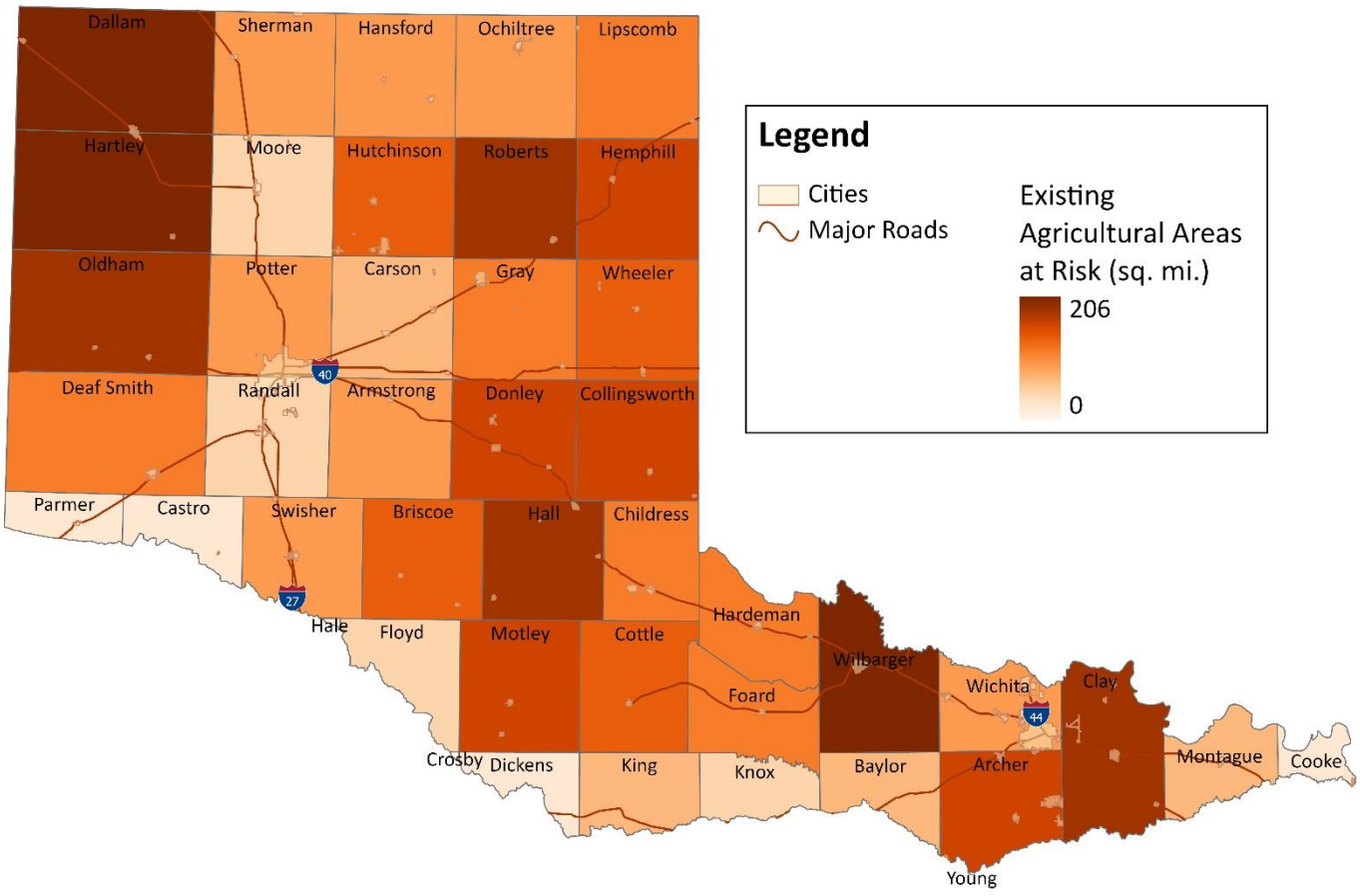


Agricultural Areas

The county with the most agricultural areas within the floodplain is Dallam County, with Wilbarger and Hartley Counties rounding out the top three. This metric emphasizes areas with more agriculture and less urban development. Wichita, Randall, and Potter Counties fall further down on this list than other metrics, because they are the most urban, as shown in **Figure 2-13**.

In order to evaluate the value of land exposed, average values for agricultural land in Texas were identified using the 2020 USDA Land Values Summary. This summary included an average value of $2,030/ac for cropland and $1,680/ac for pasture. Within the entire region, there are 8,998 square miles of cropland and 23,879 square miles of ranchland. From these values, a weighted average cost for agricultural land was identified as $1,775.8/ac. Within the entire flood hazard area, there is $5.28 billion worth of crops and pasture exposed to the 1% and 0.2% ACE.

Figure 2-13: Total Existing Exposure Summary - Agricultural Areas



2A.2.3 Expected Loss of Function

The impacts of flooding on lives and livelihoods are often felt not just during a flood event but long afterwards as well. As communities assess damages after a flood, several different types of impacts must be evaluated. Historical flood impacts, including dollar values of damages and known injuries and losses

of life are quantified in **Chapter 1**. This section presents a qualitative assessment of the types of flood impacts and the expected losses of function in both the public and private sectors.

Inundated Structures

Structural flooding can be devastating to property owners and communities as a whole. Structural flooding can cause water damage to the building as well as the contents inside. Often times, this leads to costs due to families being displaced from their homes. Businesses may also lose inventory that is damaged during a flood and may not be able to operate while repairs are being made. In extreme cases, the flood damages can be so severe that the structure and contents constitute a total loss. These impacts are lessened at lower flood elevations, which is why it is important to consider depth when evaluating flood impacts on structures.

Health and Human Services

Health impacts from flooding can be both direct and indirect. The two-thirds of flood-related deaths worldwide are due to drowning, but other impacts can also have negative implications for human health (World Health Organization, 2014). Direct effects of flooding include heart attacks, drowning from traveling through flood waters, injuries from flood conditions, and disease. Indirect impacts include damage to health care infrastructure, water shortages and contamination, disruption of food supplies, population displacement, and disruption of livelihoods. Hospital preparedness is important during flooding. Natural disasters can cause both damage to existing infrastructure and increase the number of patients who need assistance.

Water Supply and Wastewater Treatment

Water treatment plants can be particularly at-risk during flooding events, as many are located next to rivers or other water sources. Failure of water supply systems results in both direct costs (repairing pipes, contamination of the network) and indirect costs (service disruptions impacting people outside of flood waters) (Arrighi, Tarani, Vicario, & Castelli, 2017). The indirect impacts can reach up to three times as many people as were directly flooded.

Flooding can also negatively affect water quality. In 2018, flooding caused high turbidity in the water flowing into water treatment plants in Austin, Texas (FOX 7 Austin Digital Team, 2021). This resulted in a weeklong boil water advisory as the treatment plants struggled to remove high levels of silt and reduce turbidity levels.

There are also several impacts from flooding on wastewater systems. For houses using septic tanks, sewage can be carried back into the house through piping in some flood events, which will cause physical damage and could introduce disease-causing bacteria and viruses (Heger & Anderson, 2018). This is particularly a concern in rural areas that often do not have a community wastewater collection system. Flooding can also damage the wastewater system, and if untreated wastewater is released, there can be environmental and water quality damage. Wastewater treatment plants can be impacted by flooding through loss of power, damage to the plant, and personnel being unable to safely reach the plant (Nielsen, 2018). If systems are damaged in a flood, people can be left without adequate wastewater management systems until they can be repaired.

Utilities and Energy Generation

Damage to power lines and electricity distribution equipment from floating debris and inundation are some of the direct impacts of flooding on utilities and energy (U.S. Environmental Protection Agency, n.d.). Due to road impacts, maintenance and repairs can also be delayed. Electricity disruptions have impacts on other aspects of energy production as well, as oil and gas pipeline disruptions are often due to power outages after severe weather events.

Transportation and Emergency Services

Flooding can cause immediate impacts to transportation systems by causing delays or disruptions due to inundated and damaged infrastructure (Rebally, Valeo, He, & Saidi, 2021). On a greater scale, these conditions impact the economics of the region as a whole. Due to roads being unsafe for travel, closed, or submerged, connectivity is reduced, deviated, or canceled for people, goods, and services. For these reasons, flood impacts on transportation infrastructure have consequences throughout the region, in both flooded and dry areas.

Flooding has a negative impact on emergency services. Due to inaccessible roads and increased traffic congestions, it can take a longer time to get to people in need (Loughborough University, 2020). Within England, researchers found that 84% of the population can be reached within 7 minutes for emergency situations, however, in a 33% ACE flood, it drops to 70%, and in the 1% ACE, it drops even lower to 61%.

2A.3 Existing Conditions Vulnerability Analysis

Once the flood exposure analysis was complete, the populations and structures exposed to flooding within the identified flood hazard area were analyzed to determine their vulnerability to flooding. Vulnerability was assessed using SVI. The CDC uses SVI as an indicator of a community's need for support before, during, or after a disaster. SVI is provided as a decimal value from 0.00 to 1.00; the higher the SVI, the more assistance a community is likely to need. An extended discussion on SVI is included in **Chapter 1**.

TWDB provided a building dataset that included SVI values for each building. SVI was also assigned to the other exposure features (such as LWCs and critical infrastructure) based on the average SVI of the surrounding census tract. Based on the exposure features in the existing condition flood hazard area, an average SVI of the exposed area was computed for each county. Using these results, vulnerable portions of the region were identified.

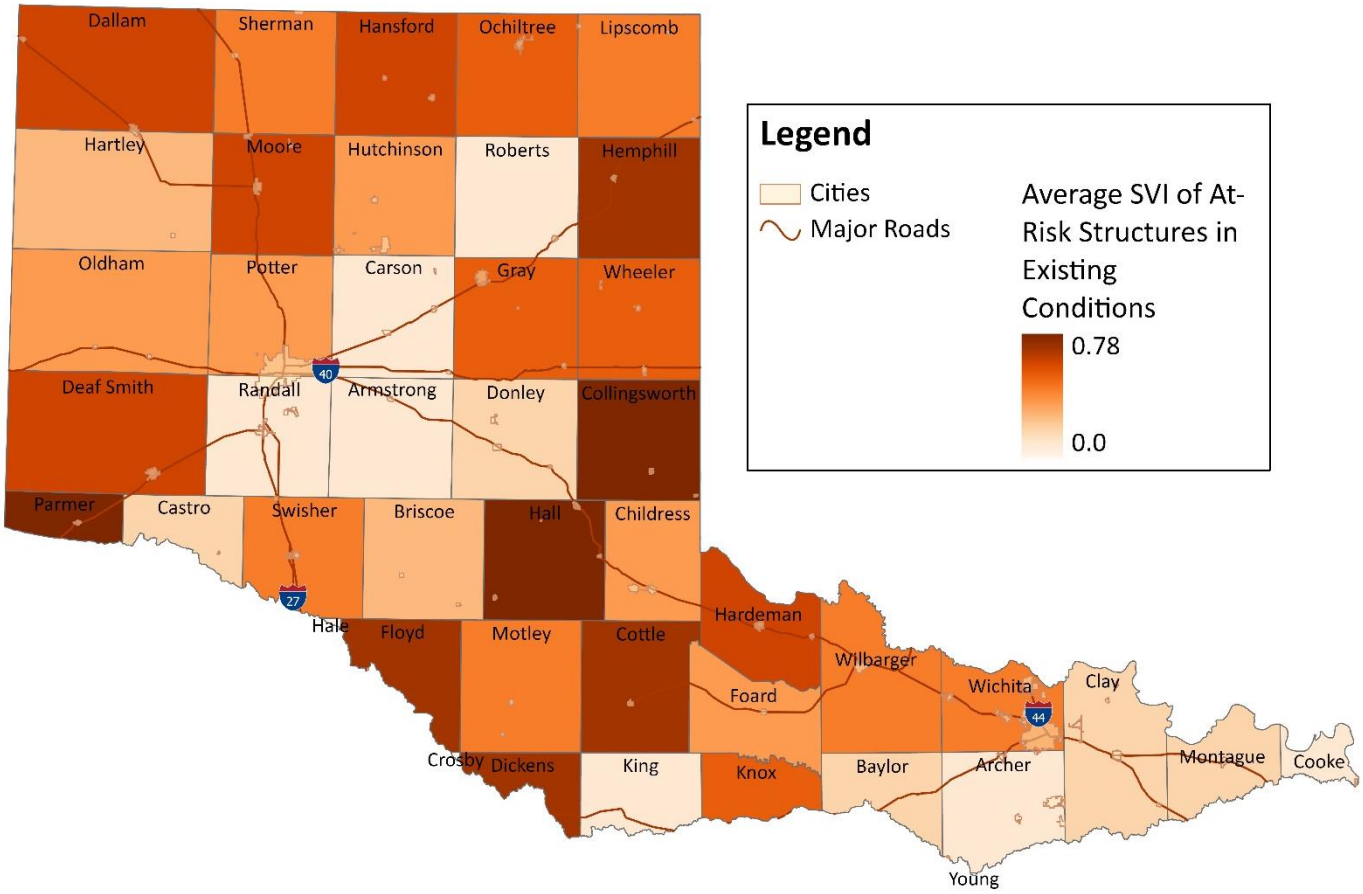
The results of the analysis are summarized in **Map 7 (Appendix B-1)**. **Map 7** also includes the location of critical facilities in the region color-coded by their SVI. As a reminder, an SVI value of 0.75 or greater indicates a high vulnerability to the effects of a disaster.

2A.3.1 Resiliency of Communities

Within the Canadian–Upper Red Region, 34 census tracts have an average SVI value higher than 0.75. These communities are overwhelmingly found in Potter and Wichita Counties, but vulnerable communities are found outside of these areas as well. Overlaying this information with the flood hazard

area, the RFPG was able to assess which portions of the exposed population would be most vulnerable. **Figure 2-14** maps vulnerability based on the average SVI of the exposure features within each county. These SVI values are generally similar to the SVI for the county as a whole, but having more exposure in higher SVI areas, such as urban areas, would increase the SVI for the county presented in this metric.

Figure 2-14: Existing Vulnerability Summary - Average SVI by County



2A.3.2 Vulnerabilities of Critical Facilities

Map 7 shows the location of critical facilities with associated SVI values. Of the 288 critical facilities within the existing flood hazard area, 34 facilities have an SVI value higher than 0.75. The county with the most critical facilities with SVI values over 0.75 is Wichita County, with 13. This indicates that in addition to the high flood exposure in Wichita County, the exposed communities are highly vulnerable.

A high SVI value indicates that if these critical facilities go offline as the result of a flood, they may lack the necessary resources to restore services or rebuild quickly, prolonging the disruption to the surrounding communities. It is also noteworthy that of these 34 facilities, 16 are in the 1% annual chance flood hazard area and 18 are in the 0.2% annual chance flood hazard area. Generally, a higher Level of Service (LOS) is recommended for critical facilities to prevent damage or disruption of services during a flood. The results of this analysis should drive decision making regarding improvements to these facilities, including flood proofing or relocation out of the floodplain.

Other factors, such as past flooding issues, emergency management plans, and the location of critical systems like primary and back-up power, can also impact a critical facility's vulnerability. Due to the scale of the region, facilities were not discretely evaluated for these potential issues, but they should be considered when preparing critical facilities for hazardous situations.

2B. Future Condition Flood Risk Analysis

In addition to quantifying the current flood risk, it is helpful to consider the change in flood risk over the course of the planning horizon to help communities plan ahead for new or increased risks. With this concept in mind, a future condition flood risk analysis was performed for the region.

The future condition flood risk analysis included two components: projected increases in flood hazard and additional exposure and vulnerability. The first step was to define a future flood hazard area boundary to identify areas of existing development that, while not currently at risk of flooding during the 1% or 0.2% chance events, may be at risk of flooding during these events in the future. The second step was to identify areas that face an increase in future flood risk due to new development or redevelopment that may occur in these areas. The methods employed to evaluate future risk and the results of the analysis are explored in the following sections.

2B.1 Future Condition Flood Hazard Analysis

History has demonstrated that flood hazards tend to increase over time in populated areas due to projected increases in impervious cover, anticipated sedimentation in flood control structures, as well as other factors that result in increased or altered flood hazards. As a result, the future condition flood hazard area was defined based on an expected increase in flooding extents and magnitude across the region.

TWDB provided options for the RFPG to choose from various methods to determine the future flood hazard layer. The first step of this task is to identify areas within the region where future condition hydrologic and hydraulic (H&H) model results and maps already exist. For the Canadian–Upper Red Region, no large-scale, regionally relevant future conditions models exist. Due to the large size of Region 1, time constraints to meet statutory requirements, and the large variety of flood risks experienced across the region, models were not modified for future conditions. For future rounds, BLE will be available, which will increase data availability for existing and future conditions analysis. Therefore, the RFPG developed a method for estimating the extent of the future condition floodplain as defined in the following sections.

2B.1.1 Future Condition Based on "No Action" Scenario

These estimated changes in flood hazard extents are meant to represent the "30-year, no action" scenario for the purpose of evaluating the potential magnitude for future flood risk. This information will in no way be used for floodplain mapping for regulatory purposes, such as local (municipal) floodplain management and development regulation, or in any way by FEMA or the NFIP. This is simply a planning level analysis for the purpose of supporting the regional flood planning process.

A “no action” scenario represents the worst-case scenario. This entails no regulation towards development in or impacting the floodplain, making flood risk increasingly common. While environmental considerations mean that not all future increases can be mitigated, future increases can be lessened through proactive, flood-focused decision making. These ideas are further discussed in **Chapter 3.**

Several items can be considered when developing a “no action” scenario. Some, such as anticipated sea level rise and subsidence, are not relevant to the land locked region. Factors like anticipated sedimentation and geomorphic changes, changes to the functionality of the existing floodplain, and completion of FMPs under construction or having dedicated construction were evaluated and determined to have little impact on future floodplains at a regional scale. The impacts from the two main factors, land use changes and population growth, are the focus of the method described below. The method is conservative and will account for all factors considered in a “no action” scenario, without requiring separate analysis.

2B.1.2 RFPG Method for Developing the Future Flood Hazard Layer

For the future 1% flood hazard extents, the existing 0.2% annual change flood hazard extents were used as a proxy, consistent with methodology described in the *Technical Guidance*. For the future 0.2% ACE, the RFPG proposed to use the 0.1% ACE cursory floodplain data released in July 2021 in conjunction with the 0.2% ACE cursory floodplain data released in October 2021 as a proxy. The cursory floodplain data released in October 2021 was utilized for the existing flood hazard analysis. These two data sources use different topography sources and sampling densities for modeling and mapping, so discrepancies in flooding location were observed. Therefore, when comparing the 0.2% ACE and the 0.1% ACE, the larger was used as the outer boundary of the new flood hazard area. This ensures that the future 0.2% annual chance flood hazard area will always be equal to or larger than the future 1% annual chance flood hazard area boundary.

Use of the larger boundary from the 0.2% or 0.1% events is reasonable due to the significant amount of overlap of the 90% confidence limits for the estimated rainfall depths. The 90% confidence interval for Atlas-14 24-hour rainfall depths in Childress, Texas gives a range of 6.83 in to 14.3 in for the 500-year event, while a 1,000-year event has a confidence interval of 7.47 in to 16.4 in. Between these two storm events, much of the confidence interval overlaps. This demonstrates that the methodology is a reasonable, data-based approach for estimating the future 0.2% flood hazard.

Table 2-7: Future Condition Flood Hazard Data Summary

Future Flood Hazard Area	Source
1% ACE	Existing 0.2% ACE
0.2% ACE	Existing 0.1%/0.2% ACE merged

The RFPG approved of this approach on December 9, 2021, with the primary comments being related to distinguishing this planning information from regulatory floodplain information. The method was approved by TWDB on January 21, 2022.

2B.1.3 Identified Future Flood Hazard Areas

Using the method described earlier, the maps for the 1% and 0.2% annual chance future flood hazard areas were developed in GIS. **Appendix B-1** contains a series of flood hazard area maps under future conditions. Combined, these maps serve as TWDB required **Map 8**.

A second series of maps is included in **Appendix B-1** that serves as **Map 10.** A comparison of the existing and future flood hazard area is presented tabularly in **Table 2-8.** The future condition 1% annual chance flood hazard area is equal to the total combined flood hazard area under existing conditions, because the 0.2% annual chance flood hazard area was chosen to estimate the extents for the future 1% annual chance flood. Overall, 1,632 square miles of land area in Region 1 are projected to be newly exposed to flood hazard under the future conditions. As with existing conditions, the possible flood prone areas with unknown flooding frequency represent less than 1 square mile of flood hazard area and are excluded from this summary for clarity.

Table 2-8: Flood Hazard Area Comparison

Flood Hazard Area	Total Existing Area (Sq. Mi.)	Total Future Area (Sq. Mi.)	Area Change (Sq. Mi.)	Area Change (%)
1%	4,305	5,232	927	22%
0.2%	930	1,632	702	75%
Total	5,235	6,864	1,629	31%

The total future condition flood hazard area is summarized by county in **Figure 2-15.** As with existing conditions, Dallam, Hartley, Wilbarger, and Clay are the counties with the highest total area, though the order within these four counties is changed due to differing levels of additional area added under future conditions. Each county experienced an increase in flood hazard area extents under future conditions, though not proportionally. Of the counties located primarily in Region 1, the flood hazard area increased the most in Dallam, Hartley, Sherman, and Wilbarger Counties. All of these counties are located in the northern part of the Panhandle. This portion of the region is very flat, meaning that a small increase in water surface elevation leads to a relatively large increase in horizontal flood hazard extents.

Figure 2-15: Total Future Condition Flood Hazard Area by County (Sq. Mi.)

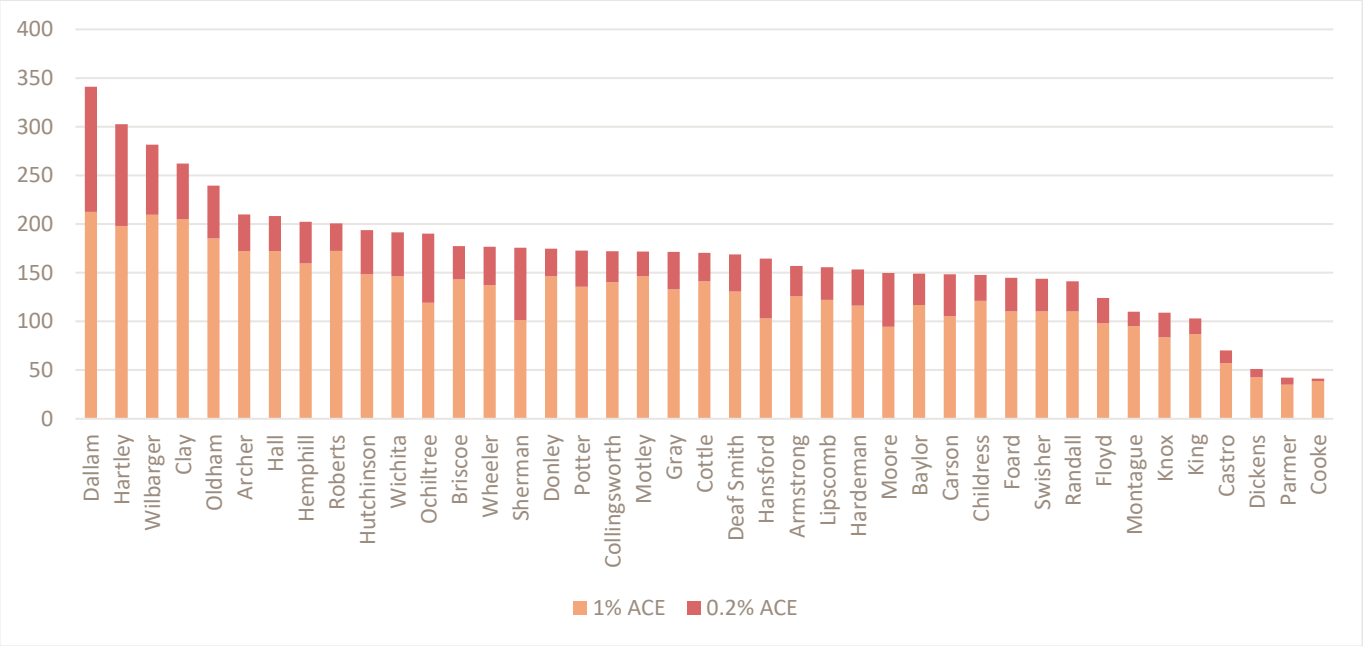
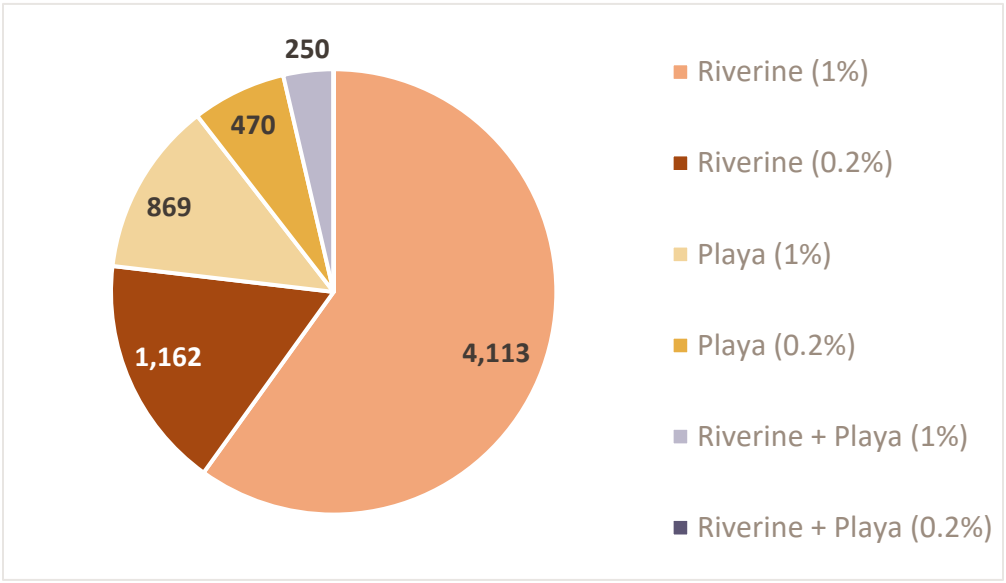


Figure 2-16 presents the total area of flood hazard by type. As with existing conditions, riverine flooding accounts for the majority of flood hazard in the region under future conditions.

Figure 2-16: Future Condition Type of Flooding by Total Area (Sq. Mi.)



2B.1.4 Future Conditions Possible Flood Prone Areas

In the development of possible flood prone areas for future conditions, the same flood prone areas used in the existing conditions flood hazard layer were used for future conditions. Parts of the flood prone

areas that were covered by the future flood hazard layer were assigned the flood recurrence frequency associated with that portion of the hazard layer. As a result, the total area of "unknown" flood hazard is slightly reduced. Generally, these possible flood prone areas encompass less than one square mile of total area in existing and proposed conditions and do not have a substantive impact on the flood risk analyses.

2B.1.5 Future Conditions Data Gaps

No large scale, regionally relevant hydrologic or hydraulic models were identified for future conditions. As a result, the entire region is considered to be a data gap under future conditions. A portion of the region missing cursory floodplain data is called out as a separate gap, since no data exists to estimate future flood hazard in this area. TWDB-required **Map 9**, which shows future condition data gaps, is included as **Appendix B-1**.

2B.2 Future Condition Flood Exposure Analysis

The same flood exposure analysis procedure was followed to quantify exposure under future conditions. This exposure was only quantified for existing development as it compared to the future condition flood hazard area. It is difficult to quantify exposure of future development due to the inherent uncertainty in the exact location of development and changes in population. However, an effort was made to evaluate areas of future development and provide qualitative information regarding potential exposure in these areas.

2B.2.1 Future Flood Exposure Summary

The following sections describe the results of the future flood exposure analysis through the same series of maps that is presented for existing flood exposure. The figures and counts all refer to the total exposure in the county, including 1% ACE, 0.2% ACE, and unknown flood frequency areas. Additionally, a sensitivity bubble is included for each county to represent the relative increase in change in exposure as compared to existing conditions. A larger bubble indicates that exposure increases more dramatically for a given exposure type within that county. A regional summary of flood exposure by feature type is presented in **Table 2-9**.

Table 2-9: Future Flood Exposure Summary

Exposure Feature Type	Number of Features by Flood Hazard Area			
	1% ACE	0.2% ACE	Unknown	Total
Structures (#)	23,718	17,480	78	41,276
Population (#)	66927	39356	139	106,422
Critical Facilities (#)	288	241	0	529
Roadway Segments (mi.)	3,342	2,010	7	5,359
Roadway Stream Crossings (#)	6,277	4,448	124	10,849
Agricultural Areas (sq. mi.)	4,606	1,538	0	6,144

Map 11 (Appendix B-1) is presented as an additional heat map identifying areas of concentrated exposure features across the region, as well as a series of maps that provides more detail about exposure. Amarillo and Wichita Falls continue to have a high concentration of flood exposure in the region. However, other portions of the region see a greater density of flood exposure as compared to existing conditions.

Residential Properties

Figure 2-17 summarizes residential property exposure by county. In almost half of the counties in Region 1, the number of impacted residential structures more than doubles with future flood risk. The highest increase is seen in Armstrong County, but Moore and Foard Counties also have increases of more than ten times the original amount. The increase of potentially impacted residential buildings in Armstrong County is due to an area in the western side of the City of Claude being inundated in the future floodplain. Increased flooding in the City of Crowell and the community of Thalia drive the rise in the number of impacted residential buildings in Foard County, while the City of Dumas is where most of the increase is in Moore County, with some smaller increases in the cities of Cactus and Sunray.

Non-Residential Properties

Figure 2-18 summarizes non-residential property exposure by county. While the total number of non-residential properties contained in the future flood hazard area did not increase as dramatically as residential properties, all but three counties in the region saw an increase. Moore and Foard Counties, which saw high residential building increases, are also represented in some of the highest increases of non-residential properties in the same areas. The highest increase was in Knox County, where most new buildings were located in the center of the county, and Sherman County, where the increase was largely centered in the community of Lautz and the City of Stratford.

Figure 2-17: Total Future Exposure Summary - Residential Structures

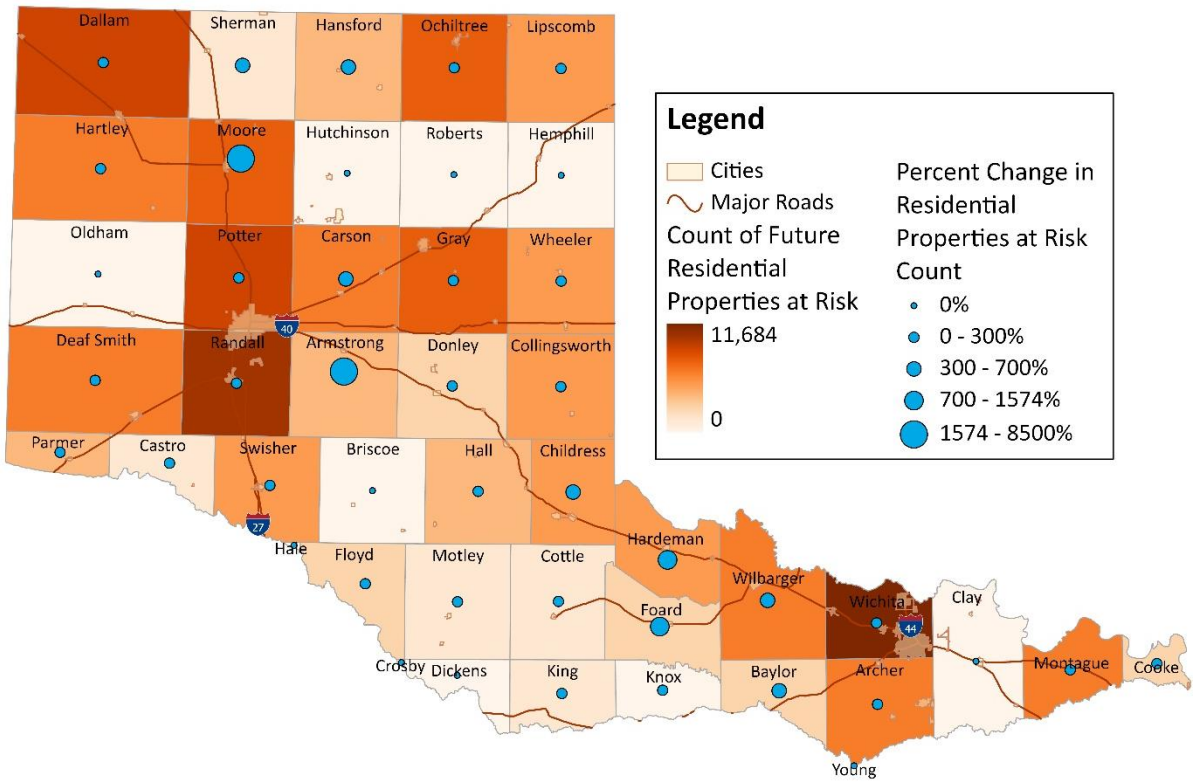
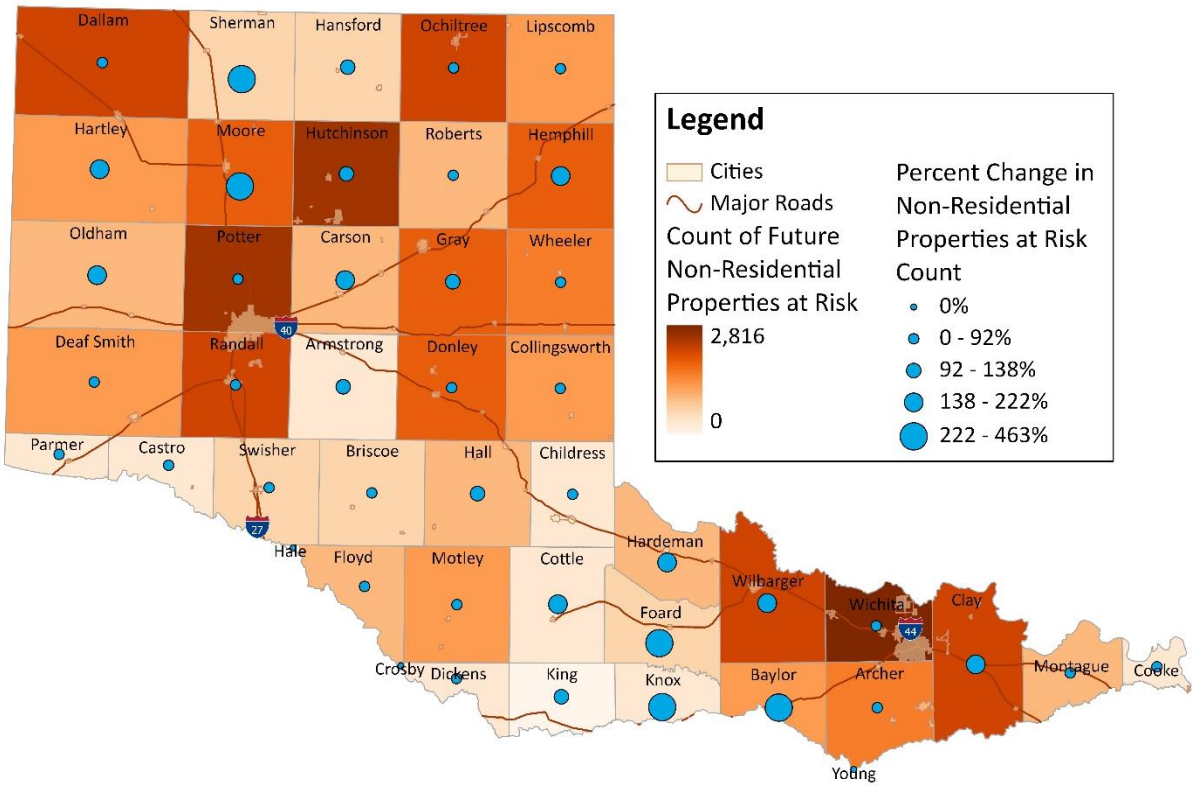


Figure 2-18: Total Future Exposure Summary - Non-Residential Structures



Public Infrastructure

There are 1,489 buildings marked as public infrastructure within the future flood hazard area, 642 more than in the existing flood hazard area. Within this group, 300 buildings are critical facilities and discussed further below. Most of these buildings are located within municipalities, particularly Wichita Falls and Amarillo.

Major Industrial and Power Generation Facilities

There are 1,384 buildings in the future flood hazard area that are marked as industrial, 466 more than in the existing mapped flood hazard. Of those, 43 are marked as critical facilities.

Within the future flood hazard area, there are 52 power generation facilities, 36 more than in the existing flood hazard area. The vast majority of this increase comes from the Gray County Plant, which lies almost entirely within the future flood hazard layer. The other additions are petroleum refineries in Moore County and power plants in Wilbarger and Oldham Counties. **Table 2-10** summarizes the power generation facilities exposed to flooding under future conditions.

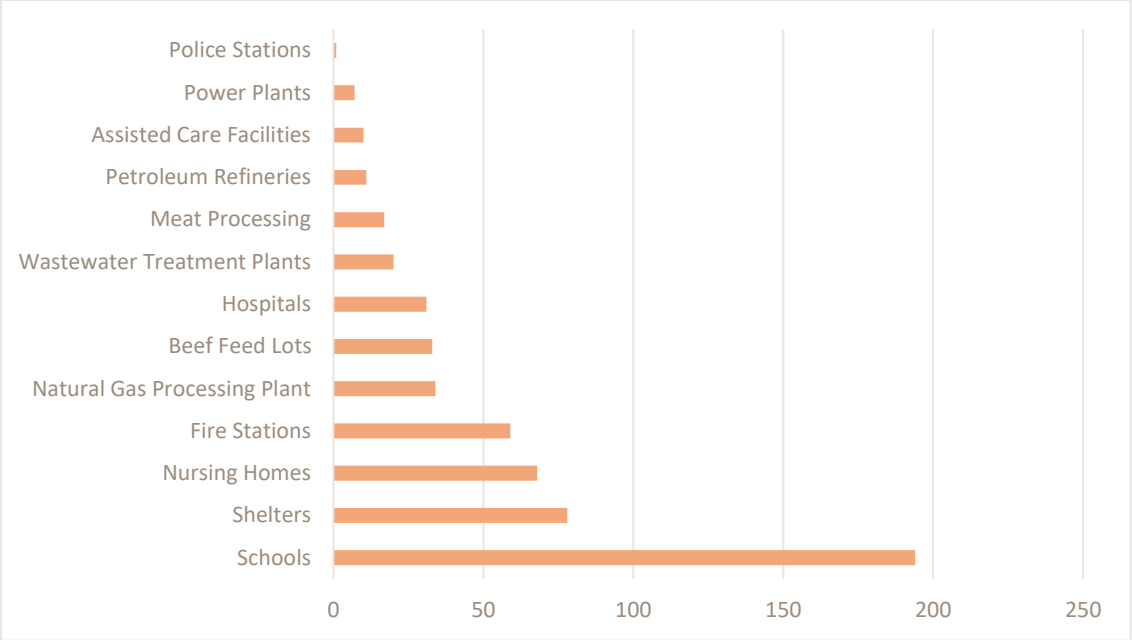
Table 2-10: Future Exposure Summary – Power Generation Facilities

Type	County	Count
Natural Gas Processing Plants	Gray	32
Natural Gas Processing Plants	Roberts	2
Petroleum Refineries	Moore	11
Power Plants	Oldham	1
Power Plants	Wichita	1
Power Plants	Wilbarger	5

Critical Facilities

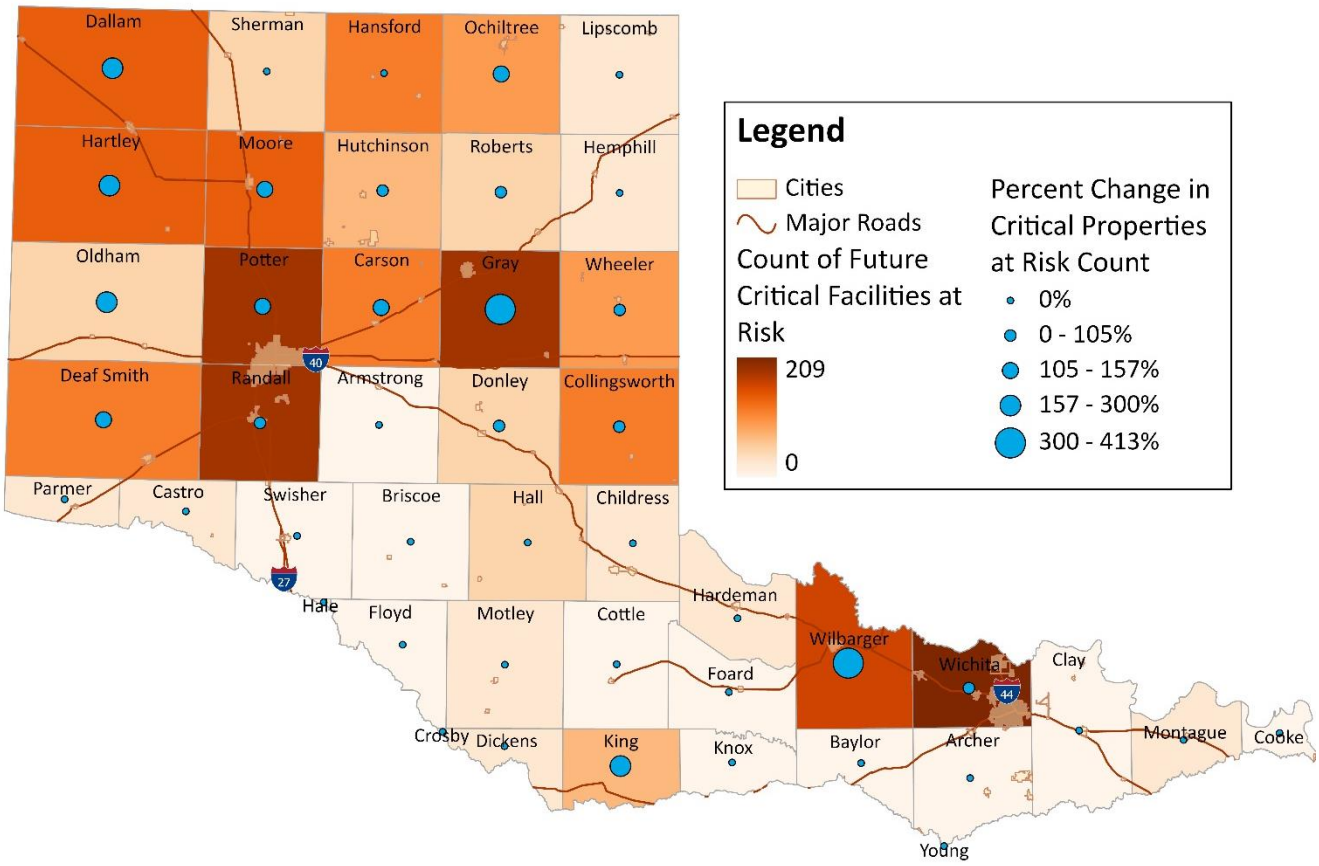
There are 529 critical facilities in the future flood hazard area, 241 more than in the existing flood hazard area. The number and types of each critical facility are listed in **Figure 2-19**. Similar to the existing conditions, most critical facilities are located in Amarillo and Wichita Falls. **Figure 2-20** shows the location of critical facilities exposed to future condition flood hazards and the relative exposure of the counties in Region 1.

Figure 2-19: Total Future Exposure Summary - Critical Facilities by Type



**Note: In the case that a facility served multiple uses, both classifications have been counted.*

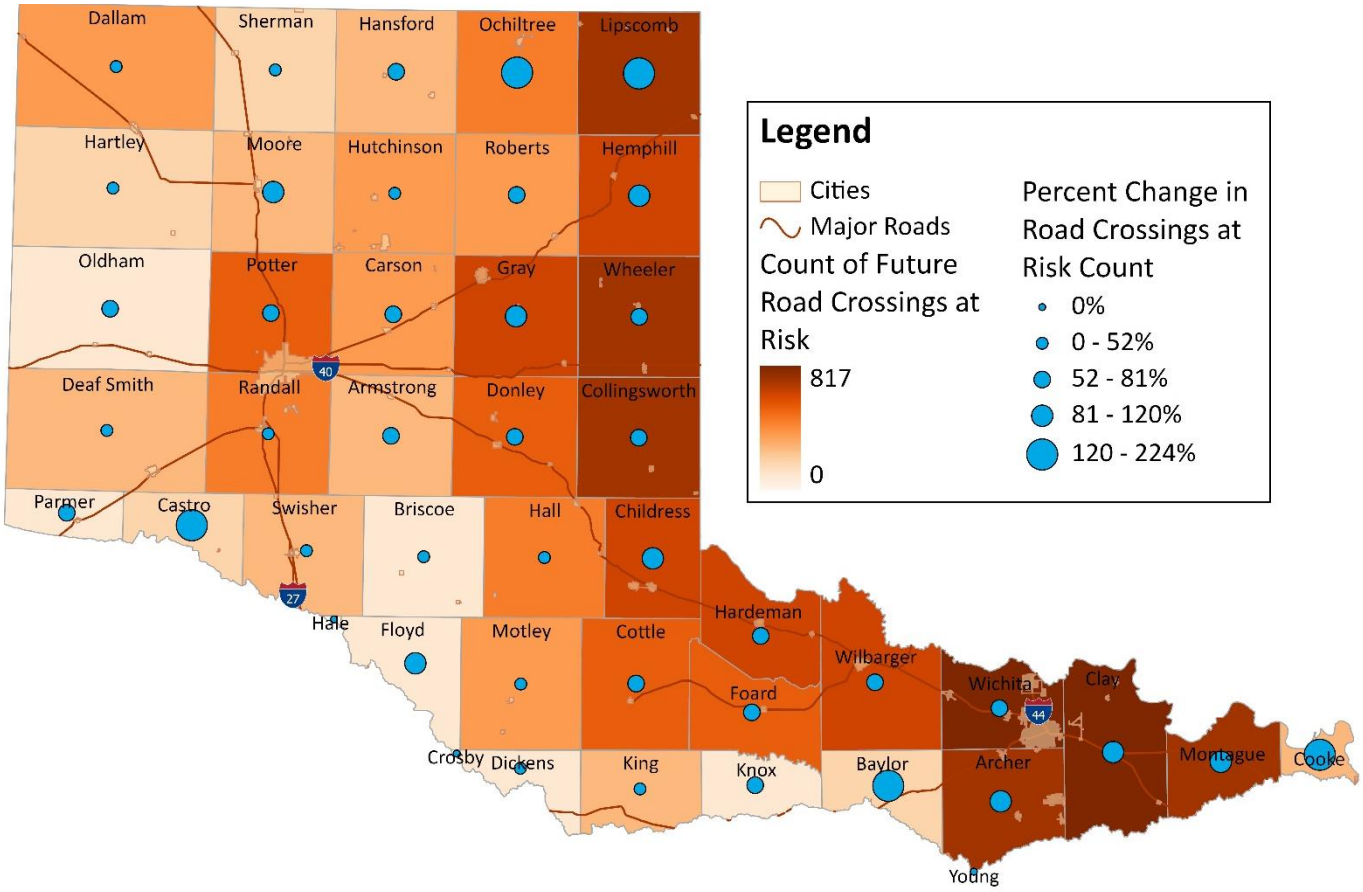
Figure 2-20: Total Future Exposure Summary - Critical Facilities



Roadway Stream Crossings

Figure 2-21 represents the relative number of roadway crossings exposed to flooding under future conditions by county. Overall, roadway stream crossings increased by 66% through the region. Four counties saw the number more than double: Baylor, Lipscomb, Ochiltree, and Gray Counties. In Baylor County, much of this increase is along US 277, US 183, and FM 1919. In Lipscomb County, most of the increase is in the northern part of the county, particularly near the municipalities of Booker and Follett, along Highway 15. In Ochiltree County, many of the additional roadway stream crossings are identified along US 83. Finishing the top four of increases, in Gray County, many of the additional points are in the City of Pampa and around the City of McLean on I-40.

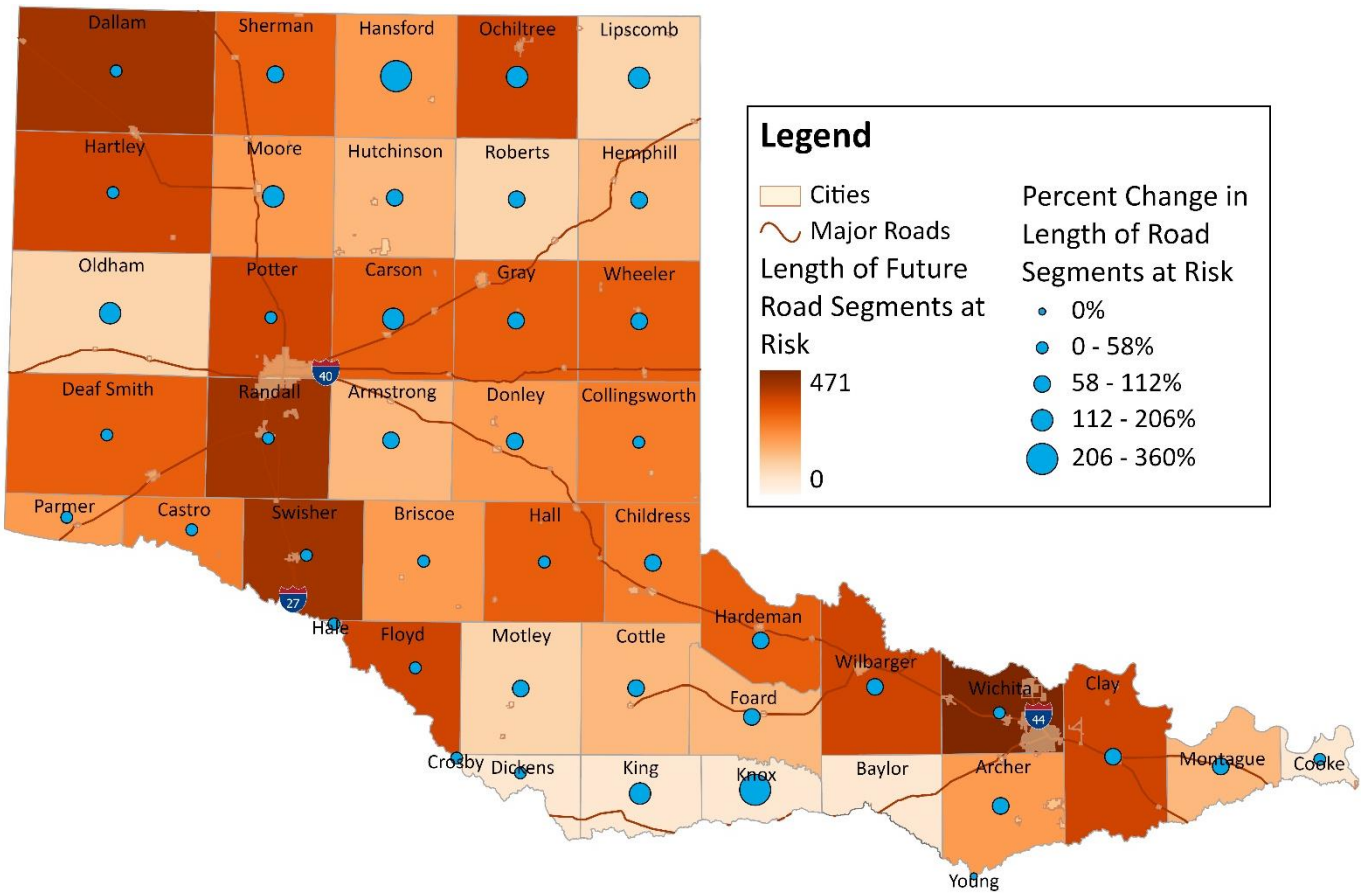
Figure 2-21: Total Future Exposure Summary - Roadway Crossings



Roadway Segments

Figure 2-22 illustrates the relative number of road miles potentially inundated by flooding under future conditions by county. For the future flood hazard area, the number of miles in the flood hazard area increased by 60%. Baylor County had the highest percent increase and had the highest increase in roadway stream crossings. Four counties increased more than triple from their existing flood condition inundation. Most of the increase in Baylor County occurred in the southern part of the county within the region, and along FM 1919 and US 277. The increases in Hansford County are throughout the county, with concentrations around the City of Spearman and in the northern part of the county along Hackberry Creek. In Knox County, much of the roadway flooding lies along FM 267, FM 6, and FM 1756. In Oldham County, almost all the additional inundation is in the southern part of the county, along I-40.

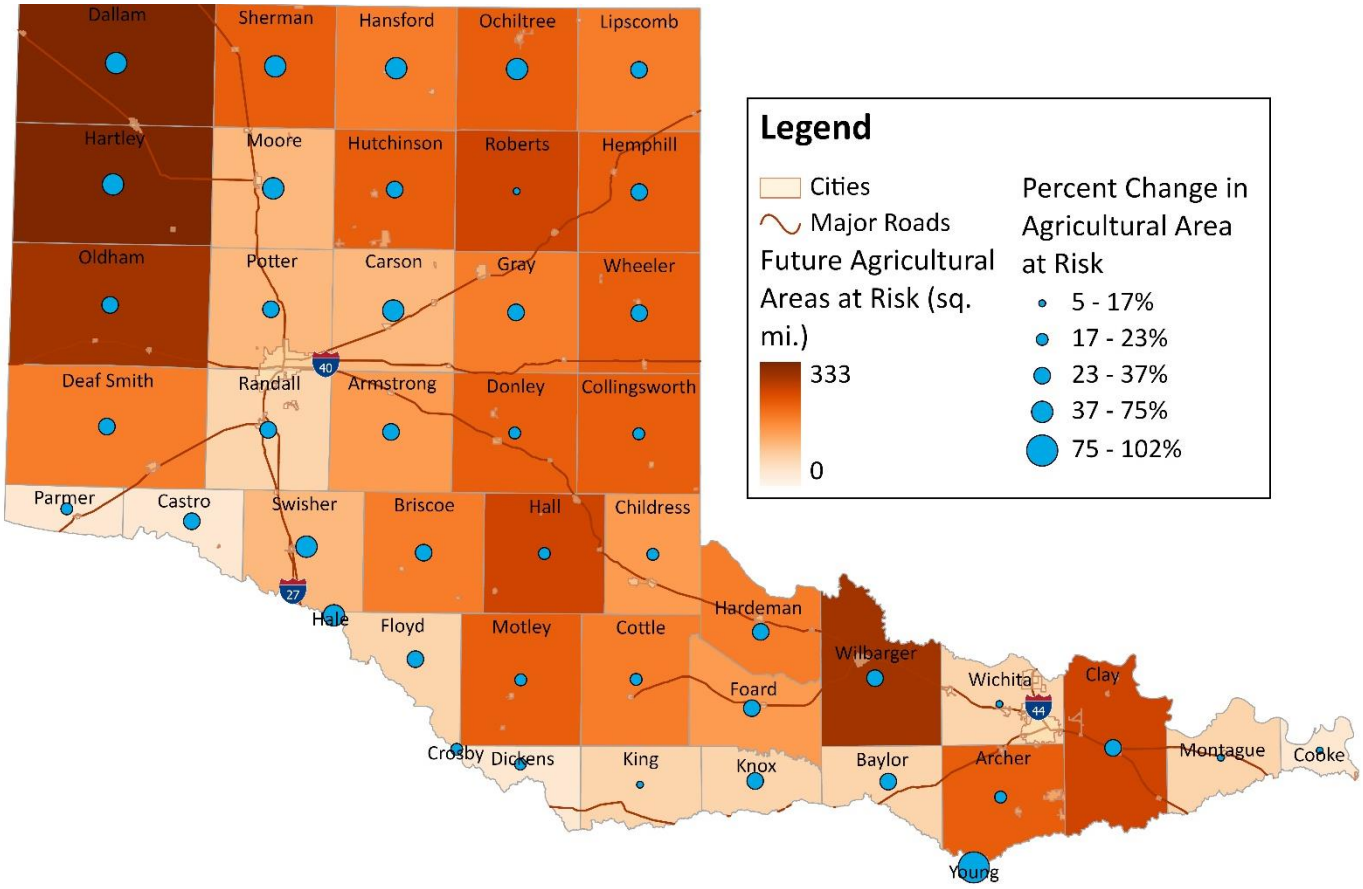
Figure 2-22: Total Future Exposure Summary - Roadway Segments



Agricultural Areas

Figure 2-23 represents the relative number of agricultural areas inundated by flooding under future conditions by county. The amount and value of agricultural areas impacted by flooding increased by 32% in the future flood hazard condition to 11,880 acres and $6.98 billion. The counties with the highest percent increase in Region 1 are located in the northwest area of the Panhandle. These areas saw large increases in overall floodplain size and are largely agricultural in land use, so this increase is expected for the area's characteristics.

Figure 2-23: Total Future Exposure Summary - Agricultural Areas

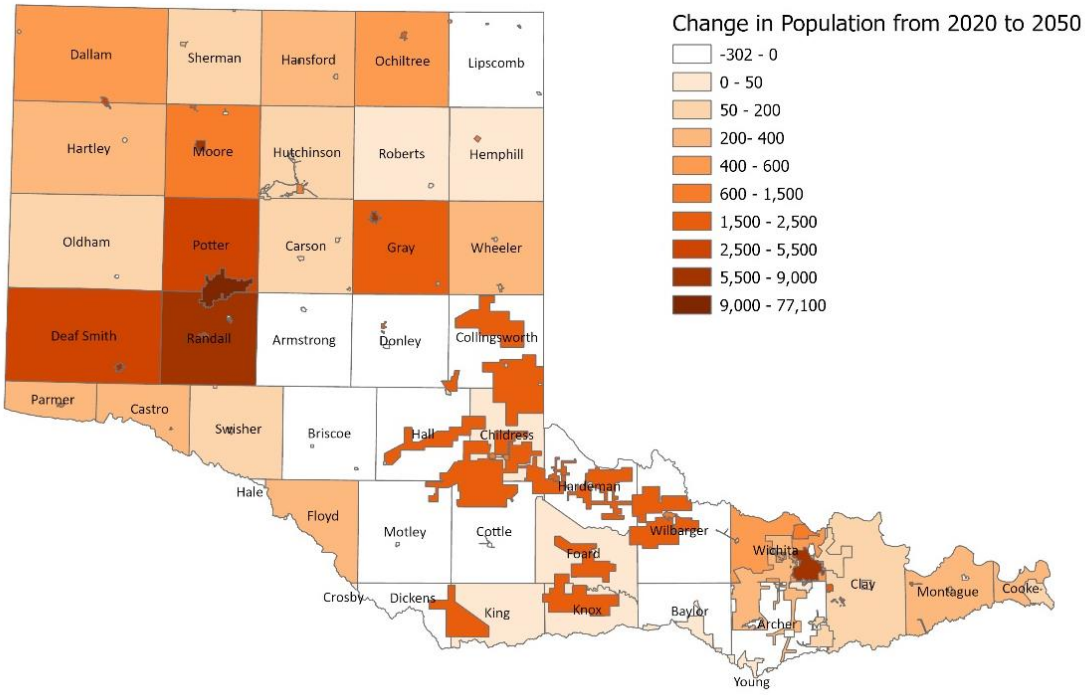


2B.2.2 Future Developments Within the Future Conditions Floodplains

To identify areas of future development, the EPA ICLUS dataset was used. This dataset uses the Intergovernmental Panel on Climate Change (IPCC) scenarios to create spatially projections of population and land use (U.S. Environmental Protection Agency, 2020). From the IPCC, social, economic, and demographic storylines were created for the United States, and then population projections were developed using different assumptions about fertility, mortality, and immigration (U.S. Environmental Protection Agency, 2020). Using that information, annual movement of people was modeled, and new demand for residential land was created to develop future land use (U.S. Environmental Protection Agency, 2020).

A map of the changes in land use is included in **Chapter 1**. Based on this model, Region 1 sees most of its development around Wichita Falls, especially along I-287. Pockets of development are also predicted around Amarillo, Canyon, Guthrie, Pampa, and other existing incorporated communities. These predictions are similar to what the State Water Plan (SWP) has predicted for population increases based on Water User Group (WUG), shown in **Figure 2-24**. If development occurs without consideration of future flood hazard conditions, these areas could see additional increases in flood exposure that are not reflected in the data presented in this report.

Figure 2-24: Population Projection Changes based on Water User Group



While the exact nature, location, and extent of future development is uncertain, the future flood hazard area was compared to the land use predictions from ICLUS to identify areas of future development that may be at risk of future flooding. The Wichita Falls area sees both a large increase in flood hazard area and a large amount of anticipated urban development. The cities of Pampa, Dumas, and Vernon are also expected to expand, including in areas that are within the future flood hazard boundary. In contrast, Amarillo's development is expected to be primarily in areas that are already designated as urban land use, concentrating risk within areas of existing development.

While development and increases in flood risk often go hand in hand, it is possible to mitigate flood impacts due to development and to prevent development from occurring in an area that is likely to be at risk in the future. Increased knowledge of flood risk and proactive planning through development regulation is one way to mitigate these increases. However, these outcomes ultimately rely on the implementation of protective drainage design standards, floodplain management ordinances, and land use policies by the cities and counties overseeing development. These ideas and city-specific information are explored in more detail in **Chapter 3**.

2B.2.3 Potential Flood Mitigation Projects

The future condition flood exposure analysis also required the consideration of impacts from FMPs in progress with dedicated construction funding that are scheduled for completion prior to the adoption of the next SFP. At this point, only two projects meeting this criterion have been identified in Region 1, a playa excavation project in the City of Amarillo and a channel project in the City of Wichita Falls. However, the benefits will be negligible on a regional scale. As a result, no potential FMPs were considered in the creation or analysis of the existing flood hazard layer.

Major cities within the region have CIPs and stormwater fees, which may lead to the implementation of some local stormwater projects. However, these projects do not have existing budget allocations, so they were not considered in the development of the future flood hazard layer since their construction is not guaranteed. Additionally, these projects will have a small-scale impact on the floodplain and will not result in major impacts on regional flood risk.

2B.3 Future Condition Vulnerability Analysis

The vulnerability analysis for future conditions was performed in the same manner as the existing analysis but considering the future condition flood exposure features. The results of the analysis are summarized in **Map 12 (Appendix B-1)**. **Map 12** also includes the location of critical facilities in the region color-coded by their SVI.

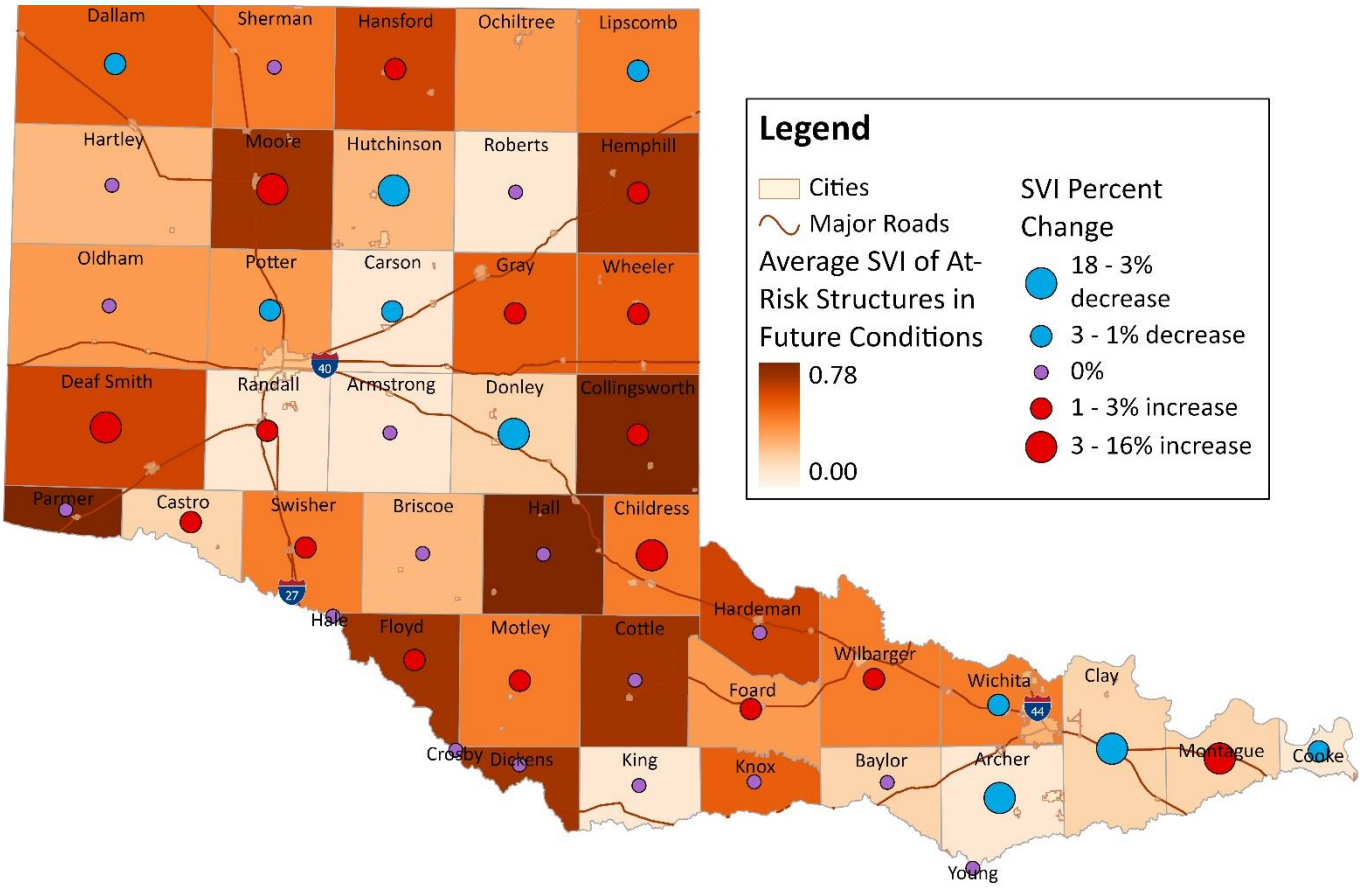
2B.3.1 Resiliency of Communities

The average SVI of features exposed to flood risk within each county is depicted on **Figure 2-25**. Projections for SVI were not available for use in this analysis, and instead current day SVI values were combined with the future flood conditions. Changes in SVI are due to increased or decreased exposure in census tracts of varying SVIs within the county. The counties with the highest SVIs, Parmer and Hall, remain unchanged compared to existing conditions. The largest percent change is in Ochiltree, where the average SVI decreases by 17.7%, and the second largest percent change is in Childress, which increased by 15.9%. Generally, the average SVI values for future exposure were fairly similar when compared to existing conditions. This indicates that while the total exposure has significantly increased, the vulnerability of the communities exposed to flooding is largely the same.

2B.3.2 Vulnerabilities of Critical Facilities

Of the 529 critical facilities within the future flood hazard area, 56 facilities have an average SVI higher than 0.75. This is 22 more than in the existing flood hazard area. As described in previous sections, critical facilities within the flood hazard area should be evaluated for potential flood risk reduction alternatives to ensure continued functionality in the event of a flood. Those evaluations can include past flooding issues, emergency management plans, and primary and back-up power locations. As noted in **Section 2A.3.2**, these factors were not discretely evaluated due to the scale of the planning exercise.

Figure 2-25: Future Vulnerability Summary - Average SVI by County



Chapter 3. Floodplain Management Practices and Flood Protection Goals

The Canadian–Upper Red RFPG was tasked with evaluating and recommending floodplain management practices (Task 3A) and flood mitigation goals (Task 3B) within the region. The intent of regional flood planning is twofold:

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

Floodplain management, land use, infrastructure design and implementation, and other practices play a key role in accomplishing these intents, specifically in preventing additional flood risk in the future.

This chapter describes the processes undertaken by the RFPG to make recommendations on floodplain management practices and to establish flood mitigation goals for the region.

3A. Evaluation and Recommendations on Floodplain Management Practices

Floodplain management is a community-based effort to prevent or reduce the risk of flooding. Community officials responsible for protecting their communities from flooding carry out floodplain management functions including zoning, building codes, enforcement, education and other tasks. Communities have different levels of floodplain management standards – some do not take an active role in regulating floodplain development, whereas others have adopted a robust program of standards for reducing flood impacts due to development and keeping citizens and property out of harm's way. The effectiveness of such standards also relies on a community's ability to enforce their requirements.

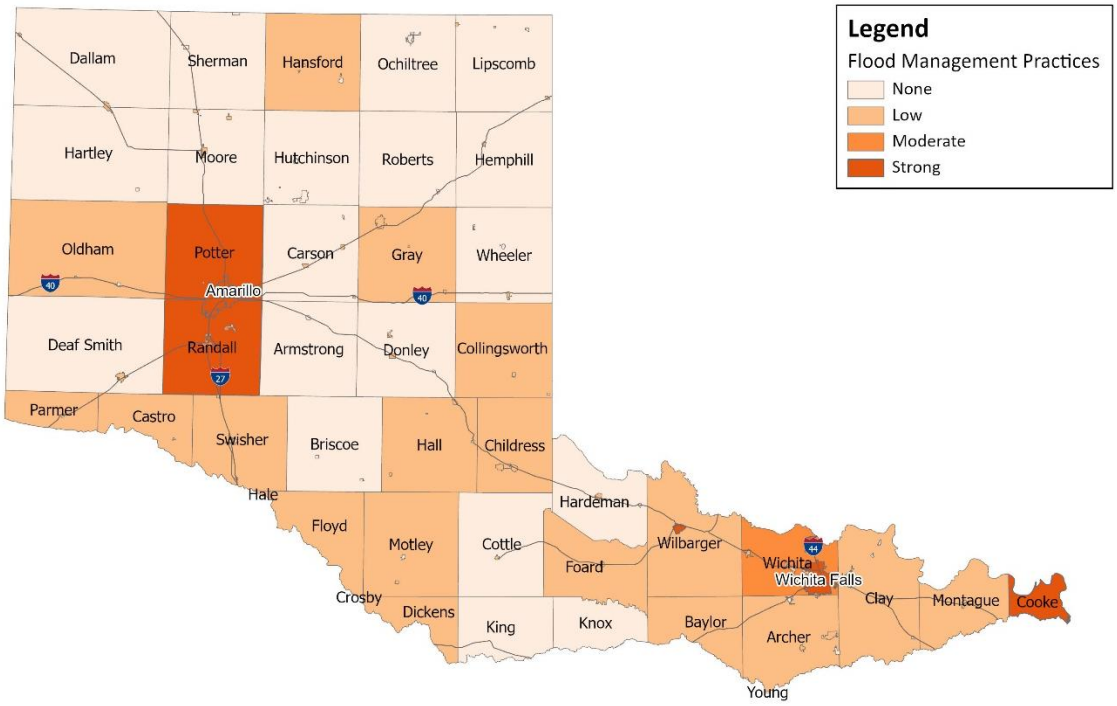
3A.1 Extent to Which Current Floodplain Management and Land Use Practices Impact Flood Risks

The initial effort under Task 3A was to collect data to perform a qualitative assessment of current floodplain management regulations within the region (such as floodplain ordinances, court orders, drainage design standards, and other related policies). Floodplain management regulations that were readily available on the regulatory entity's websites were first collected. Parallel to this effort, a web-based survey was sent out to each regulatory entity in the region to gather additional information.

Based on the data collected in this effort, a total of 27 out of 44 counties (61%) and 61 out of 90 cities/towns (68%) within the region are involved in some form of floodplain management activity (see **Table 6, Appendix C-2**).

The level of floodplain management regulations varies between counties and cities, as shown in **Figure 3-1**. In general, population centers with greater flood exposure and a larger population have more robust floodplain management regulations. Overall, the increased awareness of flood risk and the succinct set of recommended floodplain management standards developed through the regional flood planning process is likely to increase the level of floodplain management regulations throughout the region.

Figure 3-1: Floodplain Management Regulations by Communities in Region 1

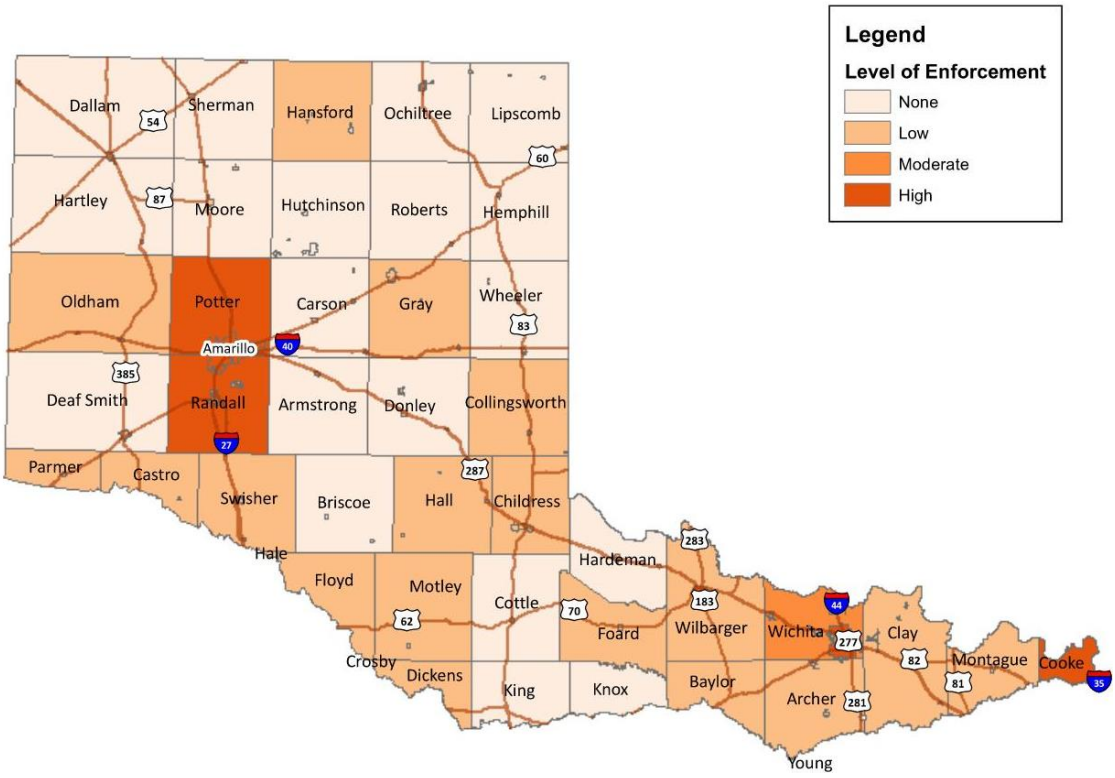


The level of enforcement of floodplain regulations also varies between communities, as shown in **Figure 3-2**. This information is also shown in **Map 13** in **Appendix C-1**. Level of enforcement was assigned based on the following definitions:

- High – actively enforces the entire ordinance, performs many inspections throughout construction process, issues fines, violations, and Section 1316s where appropriate, and enforces substantial damage and substantial improvement.
- Moderate – enforces much of the ordinance, performs limited inspections and is limited in issuance of fines and violations.
- Low – provides permitting of development in the floodplain, may not perform inspections, may not issue fines or violations.
- None – does not enforce floodplain management regulations.

Where this information was not readily available, communities were assigned a “Low” level of enforcement, consistent with the fact that in much of the region, flood hazard information may not be available to perform all the enforcement mechanisms available through the ordinance provisions.

Figure 3-2: Level of Enforcement of Regulations by Communities in Region 1



3A.1.1 National Flood Insurance Program

Congress established the NFIP through the National Flood Insurance Act of 1968 to provide federally subsidized flood insurance protection. The program has been updated multiple times to provide fiscal soundness, inform the public of flood risk through insurance rate maps, and otherwise strengthen the program. Title 44 of the Code of Federal Regulations (CFR) includes the rules and regulations of the program. 44 CFR Part 60 establishes the minimum criteria that FEMA requires for participation in the NFIP, which includes identifying special flood hazard areas (SHFAs) within the participating community.

FEMA develops Base Flood Elevations (BFEs) and SFHAs along rivers, creeks, and large tributaries that are shown on Flood Insurance Rate Maps (FIRMs). The BFE is the elevation of the water surface resulting from a flood that has a 1% chance of occurring in any given year. The BFE typically is determined from FEMA FIRMs (maps) based on (H&H) models developed during FISs. However, the BFE can be based on localized data developed by the community that may or may not be incorporated into a FEMA mapping product. A SFHA is an area having special flood, mudflow, or flood-related erosion hazards.

Communities use the FIRM, BFE, and SFHA data in their floodplain management processes as a requirement for participating in the NFIP. Insurance agents use FIRMs to determine flood risk, which

determines the flood insurance rate for individual properties. Knowledgeable property owners also use FIRMs to determine their specific flood risk.

Cities and counties have the authority to establish their own policies, standards, and practices to manage land use in and around areas of flood risk. Participating communities have the responsibility and authority to permit development that is reasonably safe from flooding. They can adopt and enforce higher standards than the FEMA NFIP minimum standards to better protect people and property from flooding. FEMA offers discounts for all flood insurance policies in communities that adopt higher standards and participate in the Community Rating System (CRS).

The NFIP offers residents in participating communities the opportunity to purchase flood insurance to reduce the socio-economic impacts of floods, as well as making the community eligible for certain disaster assistance programs following a flood event (FEMA, 2021).

3A.1.2 Types of Floodplain Management and Land Use Practices

Flood risks are mitigated by floodplain management and land use practices enacted through regulations and policies adopted by communities and counties. The regulations and policies take several forms, all of which mitigate the risk of property damage and loss of life from flooding. The three general forms of regulations and policies include floodplain ordinances, building standards, and zoning and land use policies.

Development-Related Ordinances

Floodplain ordinances regulate development within a floodplain and the impact new development has on the floodplains with a community. These ordinances frequently stipulate minimum finished floor elevations of buildings above an established flood level and may also regulate the allowable impacts new development can have on flooding.

Many communities have enacted **building standards** for construction within or adjacent to a floodplain. These standards frequently include requirements for flood proofing of structures and are another means to regulate finished floor elevations.

Zoning and land use policies can be used by communities to regulate the types of land use that are acceptable within and adjacent to flood prone areas to promote safety by directing development away from these areas.

Participation in the NFIP requires that communities adopt regulations that meet the minimum standards required by FEMA, which include floodplain ordinances and building standards to mitigate flood risks within the community.

Drainage Design Standards

Communities can adopt minimum standards for the design of stormwater management facilities and transportation infrastructure such as bridges and culverts to ensure that new construction is designed to be resilient and not increase flood risk to existing development within the community.

Flood Plans

Communities and counties can develop local and regional flood and drainage master plans to identify flood risks and plan infrastructure improvements to reduce those flood risks across the community. These plans allow communities to address existing and future flood risks by developing CIPs that prioritize projects according to flood losses and funding constraints. As of November 2021, three entities within Region 1 have completed some form of city or county drainage master plan.

3A.1.3 Variation of Floodplain Management Practices Across the Region

While FEMA manages the NFIP and provides minimum standards for development in and around the floodplain in participating communities, floodplain management and land use practices can vary widely from one entity to another. Communities that are part of the NFIP are required to enact regulations that meet the **minimum** standards required by FEMA but are encouraged to adopt more stringent standards. According to the data collected as part of Task 3A, six cities and four counties with floodplain management regulations within the region have adopted floodplain ordinances with higher standards, as shown in **Table 3-1**.

Table 3-1: Cities and Counties with Standards Adopted Higher than NFIP Minimum Requirements

Name	Type of Higher Standard Adopted
Amarillo	No increase in BFE Lowest floor at least 2 feet above BFE
Burkburnett	No increase in BFE Lowest floor at least 2 feet above BFE
Canyon	Lowest floor at least 1 foot above BFE
Gainesville	Lowest floor at least 2 feet above BFE
Vernon	No increase in BFE Lowest floor at least 1 foot above BFE
Wichita Falls	No increase in BFE Lowest floor at least 1 foot above BFE
Cooke County	No increase in BFE
Potter County	No increase in BFE
Randall County	No increase in BFE
Wichita County	Lowest floor at least 1 foot above BFE

Source: Various Sources

Drainage design standards can also vary across the region, as exhibited by differences in bridge design criteria of the two region's two largest municipalities, Amarillo and Wichita Falls. The *Amarillo*

Stormwater Management Criteria Manual (2008) requires that overtopping of arterial streets at bridge and culvert crossings not exceed 12 inches during the 1% ACE flood event, whereas the *Wichita Falls Stormwater Design Manual* (2011) requires bridges to pass the 1% ACE with 12 inches of freeboard.

3A.1.4 Risks to Existing Population and Property

Multiple resources were considered in determining the extent to which current floodplain management and land use practices impact flood risk to existing population and property. Cities and counties have the ability to approve floodplain ordinances or court orders, respectively. Therefore, the NFIP participants are limited to these entities, and the results included in this section of the report are limited to cities and counties that have the opportunity to participate in the NFIP.

NFIP minimum standards require buildings to be constructed at or above the BFE, provide for floodproofing options for nonresidential buildings, and mandate provisions specific to the elevation and anchoring of manufactured houses. As of October 2021, 26 counties (61%) and 62 cities (65%) in the Canadian–Upper Red Region participate in the NFIP and have floodplain ordinances that meet or exceed the NFIP minimum standards.

Note that the minimum standards are based on maps that represent "current" conditions, which may be based on outdated topographic and hydrologic data. Additionally, there is a great deal of uncertainty in precipitation depths associated with the 1% ACE event, which often results in flooding that exceeds expected depth and extents. In these instances, the minimum standards may offer limited protection from flood damages. The use of updated and modified precipitation estimates including NOAA Atlas 14 information and storm shifting based on the USACE led Texas Storm Study to validate precipitation estimates may help to provide a broader and more accurate understanding of flood risk.

In addition, 15 communities and counties in the region that participate in the NFIP do not have regulatory floodplain maps available to assist with floodplain regulation, as shown in

Table 3-2. Without maps, these communities can participate in the NFIP but may not have a clear picture of where areas of flood risk exist and may find it difficult to regulate development.

Table 3-2: NFIP Participants Without Flood Insurance Rate Maps

Dumas	Hall County
Higgins	Hansford County
Texline	King County
Childress County	Motley County
Collingsworth County	Oldham County
Crosby County	Parmer County
Dickens County	Wilbarger County
Foard County	

Source: Community Status Report Book, "Communities Participating in the National Flood Program". This table identifies entities in Region 1 with no date for a current effective rate map.

The region has a relatively low level of NFIP participation. This increases flood risk in those counties and communities because existing flood risks are not documented, regulations do not exist to limit development in flood-prone areas, and residents have no access to flood insurance available through the NFIP. The State of Texas and FEMA have noted this issue and have started to make substantial investment in developing flood risk data in Region 1 and other regions across the state. Increasing the level of participation in the NFIP is a stated goal of the Canadian–Upper Red RFPG; the Canadian–Upper Red RFPG has identified 47 NFIP-related Flood Management Strategies (FMSs) for the region which are discussed in **Chapter 4**.

3A.1.5 Risks to Future Population and Property

The Canadian–Upper Red Region is projected to experience a population increase of about 24% from 2020 to 2050. Some of the existing floodplain ordinances and court orders with higher standards may continue to protect future population and property if they are enforced. However, the gap in key floodplain management practices across the region poses an increasing level of flood risk as the population continues to increase. Local floodplain regulations with higher standards need to be adopted and enforced to better protect future population and property. The Canadian–Upper Red RFPG encourages those cities and counties without floodplain ordinances or court orders to participate in the NFIP and to develop, adopt, implement, and enforce floodplain regulations that meet or exceed the NFIP minimum standards.

Future hydrology will likely differ from historical observations, and therefore it is anticipated that future floodplains will look different from existing floodplains in some areas within the region. Ideally, the H&H models used to generate floodplain maps would be updated regularly with new topography, survey, precipitation, runoff, and other data as development occurs in and around floodplains. However, funding limitations have constrained development of updated flood risk information in many areas.

Additionally, maintenance of existing stormwater storage and conveyance facilities such as clearing vegetation, dredging, and debris removal is critical to ensuring facilities continue to provide positive drainage and meet their design level of service. However, these routine maintenance activities are frequently underfunded and underperformed, resulting in increased flooding.

The future BFE will likely increase at many locations and will expand floodplain areas, as explored in **Chapter 2**. Cities and counties typically develop their future land use plans considering areas of anticipated population growth and development within their communities. However, future land use plans and zoning generally do not extend outside of incorporated areas or the Extraterritorial Jurisdiction (ETJ). The future land use data developed for the future flood hazard evaluation (Task 2B) may be a helpful starting point to develop future land use data for all developing areas at a regional scale to better account for modified watershed conditions and expanded floodplains.

Additionally, the existing and future floodplains are not always a component of the future land use plan. Incorporating the existing and future floodplains into community planning will provide cities and counties with additional direction as to where development should be directed to protect people and property. Cities and counties could incorporate requirements where H&H analyses will be based on fully

developed land use conditions. Entities who currently use future flood conditions as part of their design criteria provide a factor of safety that reduces future flood hazard exposure for new and existing developments.

Another factor of safety that can be implemented to reduce future flood hazard exposure is to adopt freeboard requirements to provide additional height above the BFE. Because the BFE is likely to increase in the future, the freeboard will increase the likelihood that a structure will remain above anticipated future (higher) BFEs.

Detention and retention ponds are often required to mitigate the impacts that impervious surfaces and modified flow patterns have on the runoff from a developed property. The standard engineering design requirement is to detain or retain runoff from a property so that discharges from the developed property remain at or below the rate of existing (undeveloped) discharges. Incorporating detention or retention requirements mitigate increased runoff in the future and prevent increases in future flood hazard exposure.

Areas without maps and models or with outdated maps and models are at greater risk in terms of future population and property development within the floodplain. Entities need comprehensive and updated maps to direct development away from flood-prone areas. Floodplain maps and models are anticipated to be updated with higher resolution data and advanced modeling techniques. Reducing floodplain mapping gaps within the region and increasing mapping accuracy should reduce flood risk uncertainty and better protect life and property in the future.

3A.2 Consideration of Recommendation or Adoption of Minimum Floodplain Management and Land Use Practices

The Canadian–Upper Red RFPG was required to consider the possibility of recommending or adopting consistent minimum floodplain management standards and land use practices for the entire region. Recommending practices **encourages** entities with flood control responsibilities to establish minimum floodplain management standards over the next several years, whereas the adoption of minimum standards **requires** entities to have adopted the minimum standards before their FMEs, FMSs and FMPs could be considered for potential inclusion in the RFP.

The Canadian–Upper Red RFPG considered all the information gathered and analyzed as part of Task 3A and deliberated on whether to “recommend” or “adopt” minimum floodplain management standards for the region. This topic was first introduced during the June 10, 2021 RFPG meeting, during which TWDB example standards were considered. During the September 3, 2021 RFPG meeting, an interactive web-based polling session was conducted to gather feedback from the RFPG and members of the community with regards to the following topics:

- Categories of minimum standards the RFPG should adopt or recommend
- Types of standards the RFPG should adopt or recommend
- Types of higher standards the RFPG should adopt or recommend

- Types of infrastructure protection standards the RFPG should adopt or recommend
- Appropriate annual risk of flooding for various types of structures
- Types of elevation standard should be considered for structures (BFE or freeboard) and roadways
- Types of regulations should apply to retrofits of existing structures
- Type of land use and flood condition (existing or fully developed) should be considered for development

The results of the polling are included in **Appendix C-3**.

The assessment of current floodplain management regulations and the results of this initial survey served as a guide to compile the following set of minimum standards, which were discussed and accepted by consensus during the November 10, 2021 RFPG meeting.

During discussions, the RFPG generally was reluctant to impose additional regulations and requirements on communities and recognized that the current lack of available flood hazard information would impose a burden on communities to develop the H&H analyses necessary to enforce these requirements. Therefore, the **Canadian–Upper Red RFPG recommends, but does not adopt**, these minimum standards for the region.

1. A developer should be required to submit a study, based on both existing and proposed conditions, and demonstrate no adverse flood impact due to the development. This will limit the negative impacts of development by requiring developers to mitigate impacts to peak flows, velocities, volumes, and flood storage and provide regulatory authorities the information needed to manage floodplains more effectively.

2. Structures should be required to be elevated 1-foot above the BFE, top of curb, or adjacent grade, whichever is highest based on available data. This will protect structures by providing a 1-foot freeboard to hedge against future increases in flood levels.

3. The design of roadway riverine crossings should adhere to the following criteria based on roadway classification:

    a. Local/Collector – no overtopping for the 10% ACE (10-year); no inundation of adjacent structures
    b. Arterial – no overtopping by the 4% ACE (25-year); no inundation of adjacent structures
    c. Thoroughfare/Freeway/Emergency Access – no overtopping by the 1% ACE (100-year); no inundation of adjacent structures

    This will help ensure the safety of the traveling public and will help protect existing structures from flooding caused by roadways obstructing flows.

4. Developers wishing to fill in a playa floodplain should provide compensatory storage and maintain equivalent hydrologic function, and adhere to the following requirements:

a. Natural areas should be preserved to promote natural infiltration and evaporation.
b. High maintenance infrastructure such as pumps should be avoided.
c. Natural areas should be acquired or protected by public easements.
d. A flood study should be required that demonstrates no adverse flood impact.
e. Freeboard requirements for nearby structures should also apply.

This will help maintain the natural flood attenuation benefits provided by the playas and will promote naturally occurring processes within playas.

These recommended minimum standards were compiled in parallel with the flood mitigation and floodplain management goals developed as part of Task 3B. Therefore, the recommended minimum standards also reflect the vision and objectives that were captured in the goals for the region. In other words, the standards, if implemented across the region, are expected to allow the region to meet the goals laid out in Task 3B.

The RFPG recognizes the importance of increasing and improving floodplain mapping coverage across the region to reduce flood risk uncertainty and improve the tools for regulating development within the floodplain. As development continues within the region, it is important to leverage best available data and modeling tools to establish BFEs, update approximate floodplain boundaries (FEMA Zone A), and create floodplain maps where none exist.

3B. Flood Mitigation and Floodplain Management Goals

A critical component of the regional planning process was the development of flood mitigation and floodplain management goals. The objective of Task 3B is to define and select a series of goals that will drive the regional flood planning effort. As such, the Canadian–Upper Red RFPG spent substantial time exploring values and discussing what they considered the best goals for the region.

The overarching goal of all RFPs must be "to protect against the loss of life and property" as set forth in the *Guidance Principles (31 TAC §362.3)*. This is further defined to:

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

The RFPG must identify goals that are specific and achievable and, when implemented, will demonstrate progress towards the overarching goal set by the state. Per TWDB requirements and guidelines, the goals selected by the RFPG must include the information listed below:

- Description of the goal
- Term of the goal 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 categories

The RFPG utilized the existing and future condition flood risk analyses from Task 2, and the assessment of current floodplain management and land use practices from Task 3A, as guides for developing and defining the goals for the Region. The process for selecting these goals and the RFPG's understanding of the benefits and residual risk are described in **Sections 3B.1** and **3B.2**.

3B.1. Flood Mitigation and Floodplain Management Goal Selection Process

The RFPG deliberated over appropriate goals during several RFPG meetings between June and September 2021.

- **June 10, 2021:** The RFPG initiated the process for developing flood mitigation and floodplain management goals with an introduction to floodplain management strategies and goals.
- **July 22, 2021:** The RFPG participated in an interactive goal development session and identified several different "categories" of goals to consider.
- **August 18, 2021:** The RFPG discussed several draft floodplain management goals.
- **September 13, 2021:** The RFPG discussed and adopted the floodplain management goals for the Canadian–Upper Red Region that are summarized in **Table 3-3**. Minor clarifications in wording of goals were incorporated in response to informal comments received from TWDB on the January Technical Memorandum. These changes were approved by the RFPG with the Draft RFP. Additional information for each goal is presented as **Table 11** in **Appendix C-2**.

During the goal selection process, the RFPG was asked to provide feedback concerning several different aspects of flood planning, including:

- Express in one word your top priority for the Regional Flood Planning effort.
- Does your interest category consider these issues an impediment to effective floodplain management?
  - Lack of funding
  - Lack of consistent policies/regulations
  - Lack of staff/resources
  - Inadequate floodplain maps
  - Limited access to flood insurance
  - Outdated design standards
- Select your top three flooding concerns for your interest category in Region 1
  - Flooded roadways
  - Flooding of critical facilities
  - Impacts to economic and agricultural production
  - Damages to private property
  - Potential for loss of human lives
  - Unregulated development

  - Inadequate infrastructure
  - Lack of flood risk data

- How important are the following outcomes for a successful RFP?
  - Achieving policy/regulations improvements
  - Increased participation in NFIP
  - Securing funding for evaluations and projects
  - Regional collaboration for large scale projects
  - Better flood risk data
  - Reducing risk to life and property

During the process, the RFPG identified four general categories of goals that could be developed, and discussed specific goals that could be identified related to several broad topics, including:

- Loss of life
- Property damage
- Floodplain management
- Funding

Seven proposed general goals were identified and discussed for the benefits they might provide the region, including:

1. **Perform FMEs to Confirm Flood Risk**

   Additional evaluation of flooding sources will increase local and regional knowledge of flood risks to communities in Region 1 and will allow floodplain managers to better manage and regulate developments in and around flood prone areas.

2. **Reduce Number of Structures in 1% Existing Floodplain**

   Reducing the number of structures at risk to flooding will protect life and reduce damages.

3. **Improve Safety at Low Water Crossings**

   Safer LWCs, either through warnings and barriers or removal of the LWC will decrease the risk for loss of life during floods and reduce loss the inefficiencies inherent when the traveling public is prevented from passage during a flood event.

4. **Improve Data and Safety at Dams and Levees**

   Much is unknown regarding the condition and relative safety of dams and levees in the region. Increasing knowledge of the condition of these structures' conditions and the inherent risk to downstream communities will allow for better allocation of resources for maintenance to reduce future risk.

5. **Enhance Floodplain Management Standards**

   Enhancing the standards by which floodplains are currently managed in some areas of the region will reduce the amount of development located inappropriately in flood prone areas, protecting both current and future structures. This would include increasing participation in the NFIP.

6. **Create Dedicated Funding Sources**

   Dedicated funding sources targeted at flood risk mitigation would provide much needed funding to assist floodplain administrators in reducing risks to life and property.

7. **Consider Nature Based Solutions**

   Flood management solutions that utilize solutions that allow rivers and streams to remain in a more natural state to improve the environment and promote more recreational uses of our rivers and streams.

After careful consideration of these general goals, the Canadian–Upper Red RFPG adopted the more focused flood mitigation and floodplain management goals summarized in **Table 3-3**. These specific goals were reviewed and approved by the Canadian–Upper Red RFPG on September 13, 2021, during the RFPG public meeting. These adopted goals apply to the entire FPR; no sub-regional goals were identified. The information requirements listed above are presented for each goal in **Table 11**.

To develop a RFP that addresses these goals specifically, each FME, FMS and FMP recommended in the RFP must be tied to achieving at least one of the regional goals; therefore, these selected specific goals have guided the development of the FMEs, FMSs, and FMPs for the Canadian–Upper Red Region. The goals build upon 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. However, the RFPG has no authority to implement actions toward achieving these goals and there are no penalties incurred for not achieving these goals within the specific timeframes.

Table 3-3: Adopted Flood Mitigation and Floodplain Management Goals

Short Term (10 year)	Long Term (30 year)
Evaluate watersheds to confirm/refine flood risk for 50% of habitable structures identified within the planning region's 1% existing flood hazard area.	Evaluate watersheds to confirm/refine flood risk for 100% of habitable structures identified within planning region's 1% existing flood hazard area.
Reduce number of habitable structures within the planning region's 1% existing flood hazard area by 20%.	Reduce number of habitable structures within the planning region's 1% existing flood hazard area by 50%.
Improve safety at 20% of LWCs in the planning region through structural improvements or warning/signage systems.	Improve safety at 50% of LWCs in the planning region through structural improvements or warning/signage systems.

Short Term (10 year)	Long Term (30 year)
Develop a baseline understanding of the risks associated with high-hazard dams and levees within the planning region.	Bring 100% of deficient high-hazard dams and levees in the planning region up to current state and/or federal standards.
Increase NFIP participation or adoption of equivalent standards to 90% of municipalities and 75% of counties in the planning region.	Increase NFIP participation or adoption of equivalent standards to 100% of municipalities and 100% of counties in the planning region.
Increase percentage of communities in the planning region with dedicated funding sources for operations and maintenance of storm drainage system to 25% of municipalities and 10% of counties.	Increase percentage of communities in the planning region with dedicated funding sources for operations and maintenance of storm drainage system to 50% of municipalities and 30% of counties.
Consider and incorporate nature-based practices in 50% of FMPs and FMSs recommended in the RFP.	N/A

3B.2 Benefits and Residual Risk After Goals Are Met

The adopted goals were developed in a manner to allow specific actions to be quantified and measured in future regional and state flood planning cycles. Future data collection efforts or implementation of evaluations, strategies, and/or projects may be used to establish baseline data for future measurements to quantify progress toward achieving the goals. Implementation efforts will also demonstrate progress toward meeting the overall purpose and intent of the regional flood planning process and will benefit individuals, communities, and the region as a whole. Achieving the adopted goals will reduce current and future levels of flood risk in the region.

However, it is not possible to protect against all potential flood risks. In selecting the flood risk reduction goals, the RFPG is inherently determining the accepted residual risk for the region. The residual risk for each of the specific goals adopted for the Canadian–Upper Red Region are presented in **Table 11** in **Appendix C-2**. In general, residual risks for flood risk reduction goals can be characterized as follows:

1. While a new development may be constructed outside the 1% annual chance floodplain, flood events of greater magnitude will inundate areas beyond those identified as a floodplain.
2. Flood events may exceed the LOS for which infrastructure is designed.
3. Communities depend on future funding and program priorities to maintain, repair, and replace flood protection assets. Routine maintenance of infrastructure is required to maintain its design capacity. Maintenance is sometimes neglected due to budget, staff, and time constraints.
4. Policies, regulations, and standards reduce, but do not eliminate, adverse impacts associated with development activity.

5. The lack of local enforcement of floodplain regulations creates risk.
6. Future changes in policy could adversely impact budgets, prior plans, assets, and standards.
7. Practical (time and money) constraints and limited precision associated with studies, models, and plans can limit understanding of potential flood risks.
8. Human behavior is unpredictable, and people may choose to ignore flood warning systems or cross over flooded roadways for a variety of reasons.

Chapter 4. Assessment and Identification of Flood Mitigation Needs

4A. Flood Mitigation Needs Analysis

This chapter describes the process adopted by the RFPG to conduct the flood mitigation needs analysis to identify the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk and mitigation needs. The Task 4A process is a big picture assessment that helps guide the subsequent Task 4B effort of identifying FMEs, FMPs, and FMSs. **Table 4-1** provides a summary of the TWDB guidance and factors that were considered in the flood mitigation needs analysis.

Table 4-1: TWDB Guidance and Factors to Consider

Guidance	Factors to Consider
1. Most prone to flooding that threatens life and property	• Buildings within 1% ACE floodplain • LWCs • Agricultural and ranching areas in 1% ACE floodplain • Critical facilities in 1% ACE floodplain
2. Locations, extent and performance of current floodplain management and land use policies and infrastructure	• Communities not participating in NFIP • Disadvantaged / Underserved communities • City / County design manuals • Land use policies • Floodplain ordinance(s)
3. Inadequate inundation mapping	• No mapping • Presence of BLE/FEMA Zone A/cursory flood risk data • Detailed FEMA models older than 10 years
4. Lack of H&H models	• Communities with zero or limited models
5. Emergency need	• Damaged or failing infrastructure • Other emergency conditions
6. Existing modeling analyses and flood risk mitigation plans	• Exclude flood mitigation plans already in implementation • Leverage existing models, analyses, and flood risk mitigation plans
7. Previously identified and evaluated FMPs	• Exclude FMPs already in implementation • Leverage existing FMPs

Guidance	Factors to Consider
8. Historic flooding events	• Flood insurance claim information • Areas with a history of flooding according to survey responses • Other significant local events
9. Previously implemented FMPs	• Exclude areas where FMPs have already been implemented unless significant residual risk remains
10. Additional other factors deemed relevant by RFPG	• SVI

4A.1 Process and Scoring Criteria

The main objectives of the flood mitigation needs analysis are to identify:

- the areas where the greatest flood risk knowledge gaps exist
- the areas of greatest known flood risk.

This analysis was based on a geospatial process that combines information from multiple datasets representing several of the factors listed in **Table 4-1**. The analysis was developed in GIS and was based on the data collected in Tasks 1 through 3. A variety of data sources were used in this process, including GIS data collected directly from stakeholders during outreach efforts. During the data collection phase, stakeholders participated in an online survey where they were able to respond geographically on a map about frequently flooded areas in their community. The stakeholder responses, as of November 17, 2021, were directly applied to this analysis.

The geospatial process was prepared at a HUC 12 watershed level, which provides a level of resolution that was considered suitable for performing the analysis at a regional scale. The Canadian–Upper Red Region has a total of 895 HUC 12 watersheds, with an average size of 40 square miles.

A total of 13 data categories were used in the geospatial analysis. A scoring range was determined for each data category based on the statistical distribution of the data. A uniform scoring scale of 0 to 5 was adopted and each watershed was assigned an appropriate score for each category. The scoring ranges vary for each category based on the watersheds with the smallest and largest quantity. A normal distribution model was used to help guide determination of scoring limits, but best judgment considering the overall context was used to make final decisions. The scores for each category were then added to obtain a total score for each watershed that was used to quantify the level of known flood risk. The watershed with the highest combined scores indicate areas of greatest known flood risk.

A subset of criteria was used as the basis for determining the areas where the greatest flood risk knowledge gaps exist. The categories of inadequate inundation mapping, reported flood concerns, and areas without H&H models were selected, since they correspond to specific gaps in modeling and mapping, as well as indicate areas that are experiencing flooding based on historical data.

The following sections provide a brief description of the data categories included and how each watershed was scored. To accurately characterize factors most important to the region, the RFPG performed a weighting exercise of assigning points to each category based on relative importance during the October 2021 RFPG meeting. Each category was then weighted based on the cumulative point total normalized by 100. The weight assigned for each criteria is shown below in **Table 4-2.** The score for each category was multiplied by the weight and then summed to get the total score for the watershed

Table 4-2: Needs Analysis Criteria Weighting

Evaluation Criteria	Weight
Critical Facilities in the Floodplain	15.7
Buildings in the Floodplain	14.8
LWCs in the Floodplain	9.8
Agricultural Areas in the Floodplain	8.8
Inadequate Floodplain Mapping	7.4
Prior FEMA Claims	7.1
Miles of Road in the Floodplain	6.3
NFIP Participation	6.3
Number of Disaster Declarations	5.8
Areas Lacking H&H Models	5.5
SVI	4.9
Areas Lacking HMAPs	4.8
Number of Flood Prone Areas	2.8
Total:	**100**

In the following sections, each factor that was considered the in the scoring for the needs analysis is explained, with relevant information on data sourcing, an overview of trends in the region, and the scoring break down. These metrics are taken from the "factors to consider" table, shown in **Table 4-2**, and different subsets of data are analyzed for each factor, as described in the following sections.

4A.1.1 Areas Most Prone to Flooding that Threatens Life and Property

Number of Buildings in the 1% Annual Chance Event Floodplain

Data for building footprints was provided by the TWDB. After identifying buildings in the 1% ACE floodplain as a part of the flood exposure analysis (see **Chapter 2**), point values were assigned based on the number of inundated buildings in each watershed. This count ranged widely through the region, with some rural watersheds having no buildings in the floodplain, while some urban watersheds have more than 2,000 in the floodplain. The points breakdown for this metric is shown below in **Table 4-3**.

Number of Low Water Crossings

Two sources of data were used to identify LWCs. The first was the dataset provided by the TWDB. The second was developed by intersecting flooding incident reports from TxDOT and NHD streams to find

additional potential LWCs. This metric is not intersected with the floodplain, and instead, all LWCs within a watershed are considered. The distribution of points is shown in **Table 4-3**.

Total Agricultural Area at Risk of Flooding

Information on agricultural and ranching land use was obtained from the Cropland Data Layer, hosted on CropScape, through the USDA. Impacted agricultural and ranching areas are those intersecting the 1% ACE floodplain (see **Chapter 2**). The total area in each watershed was considered and given points. This metric gives emphasis to rural areas, where agriculture and ranching are more prominent. The points breakdown for this metric is shown in **Table 4-3**.

Number of Critical Facilities at Risk of Flooding

Critical facilities include schools, hospitals, fire stations, feed lots and meat processing plants, shelters, nursing homes and assisted care facilities, water and wastewater treatment plants, and energy generation facilities. These facilities are described further in **Section 1.3**. These critical facilities were identified within the building dataset provided by TWDB, and impacted structures during the 1% annual chance flood event were identified in the flood exposure analysis (see **Chapter 2**). This category was scored based on the number of critical facilities within the floodplain in each watershed. **Table 4-3** shows the points breakdown for this metric.

Locations Where the Road Floods

Based on roadways from TxDOT, this is the total number of miles of road inundated by the 1% ACE floodplain in each watershed (see **Chapter 2**). This dataset includes major highways, county roads, and local roads. Although this factor primarily addresses water over roadways, it also represents potential urban flooding scenarios. Values range from no miles of road in the floodplain in rural areas to more than 70 miles in urbanized areas. The points breakdown for this metric is shown in **Table 4-3**.

Table 4-3: Task 4A Scoring Range – Areas Most Prone to Flooding that Threatens Life and Property

Score (points)	0	1	2	3	4	5
Number of Buildings	0	1-10	11-20	21-100	101-500	500+
Number of LWCs	0	1-5	6-10	11-20	21-50	51+
Total Agricultural Area (sq mi)	0	0.1-1.3	1.3-3	3.1-4.6	4.7-7.2	7.2+
Number of Critical Facilities	0	1-5	6-10	11-15	16-20	20+
Total Length of Roads (mi)	0	0.1-5	5.1-10	10.1-20	20.1-40	40+

4A.1.2 Current Floodplain Management and Land Use Policies and Infrastructure

Communities Not Participating in the NFIP

Participation in the NFIP was considered as a proxy for having adequate floodplain management regulations in a given community. The NFIP participation status for each community is presented in **Chapter 3** (**Section 3A.1**). Non-participating communities are not eligible for flood insurance under the NFIP. Furthermore, if a presidentially declared disaster occurs due to flooding, no federal financial assistance can be provided to non-participating communities for repairing or reconstructing insurable

buildings in SFHAs. Therefore, this analysis considered non-NFIP communities as being more vulnerable to flooding risks. Watersheds that intersected these communities, regardless of also intersecting a NFIP participatory community, were given five points, as this indicates a lack of preparedness and therefore, greater need. Otherwise, no points were allocated (**Table 4-4**).

Table 4-4: Task 4A Scoring Range – Current Floodplain Management and Land Use Policies and Infrastructure

Score (points)	0	1	2	3	4	5
Community	NFIP Participant					Non-NFIP Participant

4A.1.3 Areas Without Adequate Inundation Maps

Inadequate Inundation Mapping

This analysis was completed based on the information gathered for the existing flood hazard gaps data analysis. Based on the definitions of the source data from TWDB, only NFHL Effective Data (zones AE, AH, OH, and VE) was considered an adequate inundation mapping source. NFHL Zone A and cursory floodplain data were considered inadequate inundation mapping data in this assessment as they only provide approximate inundation boundaries.

In 2018, NOAA released *Atlas 14, Volume 11* which contained updated precipitation frequency values for Texas based on a greater period of record and including precipitation totals for record-breaking rainfall events, including Hurricane Harvey. In portions of central Texas and the Texas Gulf Coast, rainfall totals increased by upwards of six inches for the 100-year event compared to previous estimates on which much of the floodplain mapping was based. These areas are undergoing a rapid and significant remodeling effort to incorporate this enhanced dataset.

Across West Texas, the impact of the revised rainfall totals was less significant. Even so, the forthcoming BLE models for Region 1 will use *Atlas 14* rainfall totals. With these two considerations in mind, models were not considered "inadequate" if they do not utilize *Atlas 14* data. The points breakdown for this metric is shown in **Table 4-5** and it considers the flood quilt data prioritization ranking established by the TWDB.

Table 4-5: Task 4A Scoring Range – Areas Without Adequate Inundation Maps

Flood Mapping Gap Status	Score (points)
Only cursory floodplain data available/no data available	5
Only approximate data available (NFHL Zone A)	4
Detailed study (NFHL effective data) covers less than half of watershed	3
Detailed study covers most of watershed but is more than 10 years old	2
Detailed study covers most of watershed and is less than 10 years old	1

4A.1.4 Areas Without Hydrologic & Hydraulic Models

The existing H&H models that were identified for the Canadian–Upper Red Region are listed under **Section 2A.1.b**. Watersheds containing these models were marked as having models, without consideration of how much of the watershed was covered in the model due to the high level of analysis, and all others were marked as not. Most models are located in and around Amarillo and Wichita Falls. Locations without models have more risk associated with them since flood risks are not well-known for these areas, so communities are less prepared to take actions related to flood preparedness, floodplain management, and flood mitigation. Therefore, locations without modeling receive 5 points, and locations with modeling receive 0 points (**Table 4-6**).

Table 4-6: Task 4A Scoring Range – Areas Without Hydrologic and Hydraulic Models

Score (points)	0	1	2	3	4	5
Model status	Yes					No

4A.1.5 Areas with Emergency Needs

An emergency need has been defined as infrastructure in immediate need for repair or construction, particularly following a natural disaster or other destructive event. No emergency need has been identified for Region 1; therefore, points were not assigned for this category for the first flood planning cycle.

4A.1.6 Existing Flood Risk Mitigation Plans

HMAPs were identified for several counties within the region. Watersheds that intersected a county without a HMAP were given points for this criterion, as this indicates a lack of preparedness for flooding events. This score breakdown is shown in **Table 4-7**.

Table 4-7: Task 4A Scoring Range – Areas Without HMAPs

Score (points)	0	1	2	3	4	5
HMAP status	Yes					No

4A.1.7 Flood Mitigation Projects Previously Identified

Within the region, there are no current FMPs that would impact the level of flood risk at a HUC 12 watershed level. Therefore, points were not assigned for this category in the analysis.

4A.1.8 Historic Flooding Events

Reported Flood Concerns

This category was generated by the community responses to the survey in **Task 2**. Responses received on or before November 17, 2021 were incorporated into this metric. As a part of the survey, people were able to report places that were known to flood. TxDOT records for roadways that had to close due to flooding were also used to supplement this category. Reported areas already located within the flood inundation boundary were not included, since data exists that shows that area is at risk for flooding. Therefore, this category is a way to identify areas of concern outside of the existing flood mapping data.

For this criterion, the number of places with a history of flooding in each watershed was tallied and assigned points as shown **Table 4-9**.

FEMA Claims

This criterion takes into consideration FEMA flood claims paid within the region. Because FEMA claims are protected by federal privacy laws, only redacted claim information is available that provides aggregated claim information at a zip code and census tract level. Since claims are not at their exact location of the incident, census tracts and zip codes were intersected, and claims were located based on those parameters. Then they were intersected by watershed, after which a weighted value was calculated for census and zip code tracts that covered multiple watersheds. These weighted values assumed an equal distribution of count and value across the area. Claims within a watershed were then summed to find the total value of FEMA flood claims paid within each one. The values used were the documented values for each event. Points were distributed as shown in **Table 4-9**.

Historic Storm Events

After disaster strikes, the State of Texas is able to request assistance from the federal government under the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Within the region, there have been 15 recorded Presidential Disaster Declarations related to flooding, summarized in **Table 4-8**.

Table 4-8: Historical Presidential Disaster Declarations

FEMA Declaration String	Date	Disaster Title	Counties Impacted
DR-199-TX	6/1953	Tornadoes & Flooding	Hale
DR-218-TX	5/1966	Severe Storms & Flooding	Cooke
DR-246-TX	7/1968	Severe Storms, High Winds, & Flooding	Collingsworth
DR-286-TX	5/1970	Tornadoes, Windstorms, & Flooding	Briscoe, Donley, Gray, Hale, Parmer, Swisher
DR-454-TX	11/1974	Severe Storms & Flooding	Cooke
DR-561-TX	8/1978	Severe Storms & Flooding	Young
DR-648-TX	10/1981	Severe Storms & Flooding	Cooke, Montague
DR-659-TX	5/1982	Severe Storms & Flooding	Wichita
DR-828-TX	5/1989	Severe Storms, Tornadoes, & Flooding	Archer, Baylor, Clay, Cooke, Donley, Hale, Hall, Hutchinson, Knox, Montague, Ochiltree, Potter, Randall, Sherman, Wichita, Young
DR-863-TX	5/1990	Severe Storms, Tornadoes, & Flooding	Archer, Clay, Cooke, Cottle, Hansford, Montague, Motley, Ochiltree, Wichita, Young
DR-1709-TX	6/2007	Severe Storms, Tornadoes, and Flooding	Archer, Baylor, Cooke, Cottle, Montague, Wichita, Wilbarger

FEMA Declaration String	Date	Disaster Title	Counties Impacted
DR-4223-TX	5/2015	Severe Storms, Tornadoes, Straight-line Winds and Flooding	Archer, Baylor, Clay, Collingsworth, Cooke, Dickens, Hall, Hartley, Montague, Wichita, Young
DR-4255-TX	2/2016	Severe Winter Storms, Tornadoes, Straight-line Winds, and Flooding	Castro, Childress, Collingsworth, Cottle, Crosby, Deaf Smith, Dickens, Donley, Floyd, Foard, Hall, Hardeman, King, Knox, Motley, Parmer, Wheeler, Wilbarger
DR-4272-TX	6/2016	Severe Storms and Flooding	Hall
DR-4416-TX	2/2019	Severe Storms and Flooding	Archer, Baylor, Knox

The number of disaster declarations occurring within each watershed was tabulated, and scores were assigned according to the points breakdown shown in **Table 4-9**.

Table 4-9: Task 4A Scoring Range – Historic Flood Events

Score (points)	0	1	2	3	4	5
Number of Flood Concerns	0	1	2	3	4	5+
Number of Disaster Declarations	0	1	2	3	4-5	6-7
Value of FEMA Claims	$0	$0-$10,000	$10,000-$50,000	$50,000-$100,000	$100,000-$500,000	$500,000+

4A.1.9 Previously Implemented Flood Mitigation Projects

No previously implemented FMPs were identified. Therefore, points were not assigned for this category in the analysis, as residual flood risk remained even in communities with implemented projects.

4A.1.10 Other Factors

Social Vulnerability Index

SVI refers to the ability of a community to overcome potential negative effects caused by external stresses on human health. Such stresses include natural or human-caused disasters, or disease outbreaks. SVI values for the State of Texas were downloaded from the TWDB Flood Data Hub which references the Agency for Toxic Substances and Disease Registry (ATSDR) website (Centers for Disease Control, 2021). The most recent SVI values published on the website (2018) were used in this assessment. SVI values are assigned per census tract, which needed to be converted to SVI per watershed.

SVI values were assigned to each watershed based on an area-weighted average. The percent of a census tract that intersects a watershed was multiplied by the SVI for the census tract. This procedure is followed for all census tracts intersecting a watershed boundary, and those weighted SVI values are added together to produce one SVI value for each watershed. The SVI ratings vary between 0-1 and were scored according to **Table 4-10**. The higher the SVI, the higher the vulnerability of a community; the lower the SVI, the higher the resilience.

Table 4-10: Task 4A Scoring Range – SVI Ratings

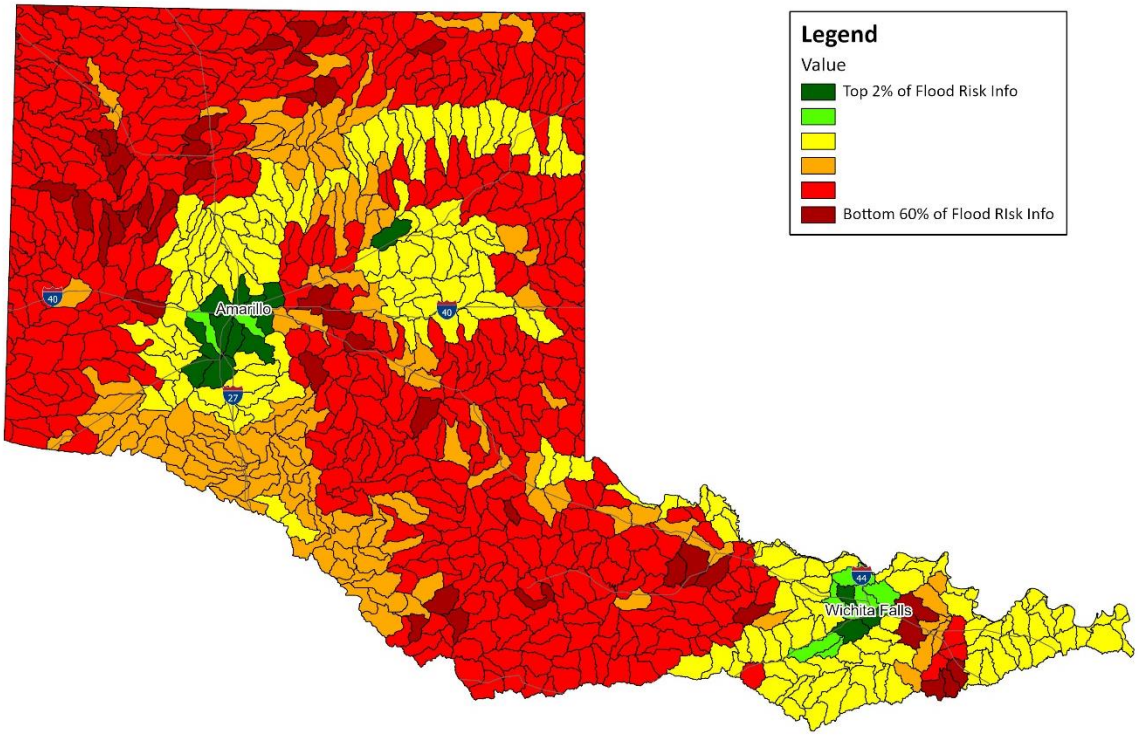
Score (points)	0	1	2	3	4	5
SVI rating	0	0.01-0.20	0.21-0.40	0.41-0.50	0.51-0.65	0.65+

4A.2 Analysis and Results

The process and scoring methodology described above was implemented across the entire Canadian–Upper Red Region. As previously discussed, this assessment was performed to address the two goals of the flood mitigation needs analysis. The first goal is to identify the areas where the **greatest gaps in flood risk information** exist (**Map 14** in **Appendix D-1**). The inadequate inundation mapping, reported flood concerns, and areas without H&H models categories were selected as the basis for identifying these areas.

As shown in **Map 14** and in **Figure 4-1**, areas marked as red are ones that have no existing hydrologic or hydraulic models and only have cursory floodplain data available. This covers 61% of the region. Within the red, the darker red shows areas that also have reported flood concerns, indicating that that there is a greater need for mapping at these locations. The orange indicates that those areas have no existing modeling, but some approximate mapping data is available. Yellow indicates areas with existing mapping and approximate mapping data. The areas with the most flood risk information are shown in green, as they have detailed studies and models. These are found around Amarillo, Wichita Falls, and Pampa. However, the light green shows areas where there are reported flood concerns, so further study might be needed in these areas to refine flood boundary extents. Dark green are areas with the most detailed studies, and therefore, best flood inundation boundary mapping.

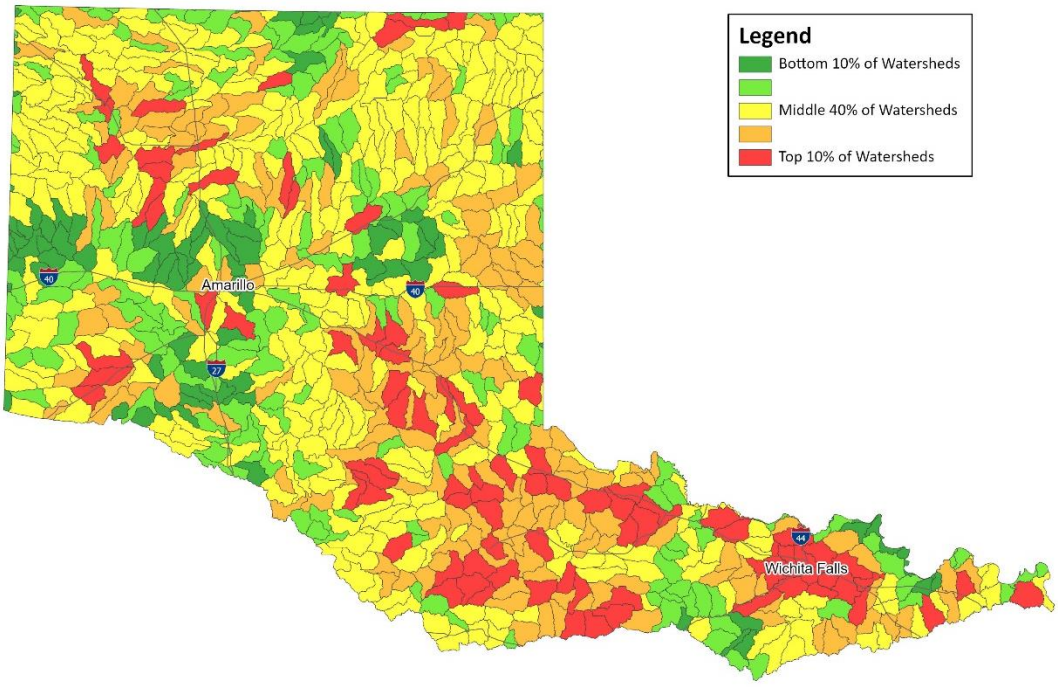
Figure 4-1: Greatest Gaps in Flood Risk Information



The second goal is to determine the areas of **greatest flood risk** and flood mitigation needs. The score from each of the 13 categories were added to obtain a total score for each watershed in the region. Each category was weighted based on relative importance as determined by the RFPG, shown in **Table 4-2**. This analysis also included the metrics used to identify greatest flood risk knowledge gaps (inadequate inundation mapping, reported flood concerns, and areas without H&H models) because uncertainty itself is a risk. The combination of different factors helped determine if a given watershed has a higher level of flood risk relative to the others in the region.

Based on the distribution of the final scores in this assessment, the top 10% were colored red to highlight the areas with the greatest known flood risks (**Map 15** in **Appendix D-1** and **Figure 4-2**). It is important to note that the fact that a watershed resulted in a low score does not necessarily mean that there is no flood risk in this area, only that this risk is relatively low compared to the others in the region. Additionally, each flood planning region involved in the RFP process will have approached this process differently, so direct comparisons between regions cannot be made.

Figure 4-2: Greatest Flood Risk



It can be observed from **Map 15** and **Figure 4-2** that areas with a relatively high population, such as Wichita Falls and its surrounding municipalities, Vernon, Clarendon, Electra, and Dalhart, were identified as those with the greatest known flood risks (red watersheds). The areas with the second highest level of known flood risk (orange watersheds) are mainly located in the surrounding areas of these population centers, but several are scattered throughout the region, particularly along major roadways.

The ten watersheds with the highest scores for flood risk are shown in **Table 4-11**. In general, the highest level of known flood risk was found in the more densely populated southeastern part of the region, while lower levels of known flood risk were found towards the north, within the more rural Panhandle.

The maps resulting from the flood mitigation needs analysis served as a guide to the RFPG's subsequent efforts to identify potential FMEs and potentially feasible FMPs and FMSs (**Task 4B**). The red and orange watersheds in **Map 14** highlight the areas in the Canadian–Upper Red Region where potentially feasible FMEs should be considered. From this needs analysis, several drainage master plans were suggested as FMEs that could target these high-risk areas.

The red and orange watersheds in **Map 15** emphasize watersheds where the RFPG should strive to identify FMSs and FMPs to reduce the known flood risks within those areas. Since the number of projects with enough data to be considered as FMPs is very low in the Canadian–Upper Red Region, only the areas around Wichita Falls, Amarillo, and Canyon will have FMPs listed in the RFP. Therefore, other areas in red will need to be considered for future cycles as FMEs are completed in order to address flood risk.

Table 4-11: Highest Need Watersheds based on Flood Risk Factors

HUC12	Location	Weighted Score
111302060407	Wichita Falls, Wichita County	366.9
111302060501	Wichita Falls, Wichita and Clay Counties	348.2
111302060304	Wichita Falls, Wichita and Archer Counties	314.6
111301050206	Vernon, Wilbarger and Hardeman Counties	279.6
111302060303	Wichita Falls, Archer and Wichita Counties	274.8
111202010204	Clarendon, Donley County	256.8
111301020304	Burkburnett, Wichita County	250.5
111302090504	Jolly, Clay County	246.1
111302060404	Iowa Park, Wichita County	245.4
111301020203	Electra, Wichita and Wilbarger Counties	243.0

4B. Identification and Evaluation of Potential Flood Management Evaluations, Potentially Feasible Flood Management Strategies, and Flood Mitigation Projects

4B.1 Process to Identify Flood Management Evaluations, Flood Management Strategies, and Flood Mitigation Projects

The goal of Task 4B is to define and evaluate a wide range of potential actions to identify and mitigate flood risks across the region. The process to evaluate potential actions as described in the following sections was approved by the RFPG by a simple majority of voting members at a meeting held on September 13, 2021 and was documented in the January Technical Memorandum submitted to TWDB. A few minor clarifications of the process were incorporated into the description to follow in response to informal received from the TWDB. The RFPG approved these revisions with the approval of the Draft RFP.

These actions have been broadly categorized into three distinct types, as defined below:

- **Flood Management Evaluation (FME)**: a proposed flood study of a specific, flood prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.
- **Flood Mitigation Project (FMP)**: a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring costs and, when implemented, will reduce flood risk or mitigate flood hazards to life or property.
- **Flood Management Strategy (FMS)**: a proposed plan to reduce flood risk or mitigate flood hazards to life or property.

Identification of potential FMEs and potentially feasible FMPs and FMSs begins with the execution of the Flood Mitigation Needs Analysis to identify the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk. This process and its outputs have been described previously in **Task 4A**. Based on the results of this analysis, several sources of data were used to develop a list of potential flood risk reduction actions that may address the region's needs. The data includes information compiled under previous tasks, including:

- Existing flood infrastructure, FMPs currently in progress, and known flood mitigation needs (**Task 1**).
- Existing and future flood risk exposure and vulnerability (**Tasks 2A** and **2B**).
- Floodplain management and flood protection goals and strategies developed by the RFPG for the Region (**Task 3A** and **3B**).
- Stakeholder input.

These actions were identified and evaluated through initial screening and data gathering under **Task 4B**. As part of **Task 5**, FMEs, FMSs, and FMPs were further evaluated in order to compile the necessary technical data for the RFPG to decide whether or not to recommend these actions, or a subset of these actions.

This first Regional Flood Planning cycle relies primarily on compiling readily available information to determine appropriate flood mitigation actions to recommend for inclusion in the draft RFP, rather than performing technical analysis to identify new actions. The list of potential FMEs and potentially feasible FMSs and FMPs for the Draft RFP were compiled based on contributions from the RFPG and other regional stakeholders from sources including previous flood studies, drainage master plans, flood protection studies, and CIPs. The specific list of previous flood studies and models relevant to flood plan development for Region 1 are provided in **Chapter 1**, and **Map 22** in **Appendix D-1** shows the locations of relevant models.

4B.2 Classification of Potential FMEs and Potentially Feasible FMSs and FMPs

The *Technical Guidance* included a summary of different general action types, listed in **Table 4-12**. Once potential flood risk reduction actions were preliminarily identified using this list, a high-level screening process was used to confirm that potential actions had been sorted into their appropriate categorization. The screening process is shown in **Figure 4-3.**

Figure 4-3: Potential Flood Risk Reduction Action Screening Process

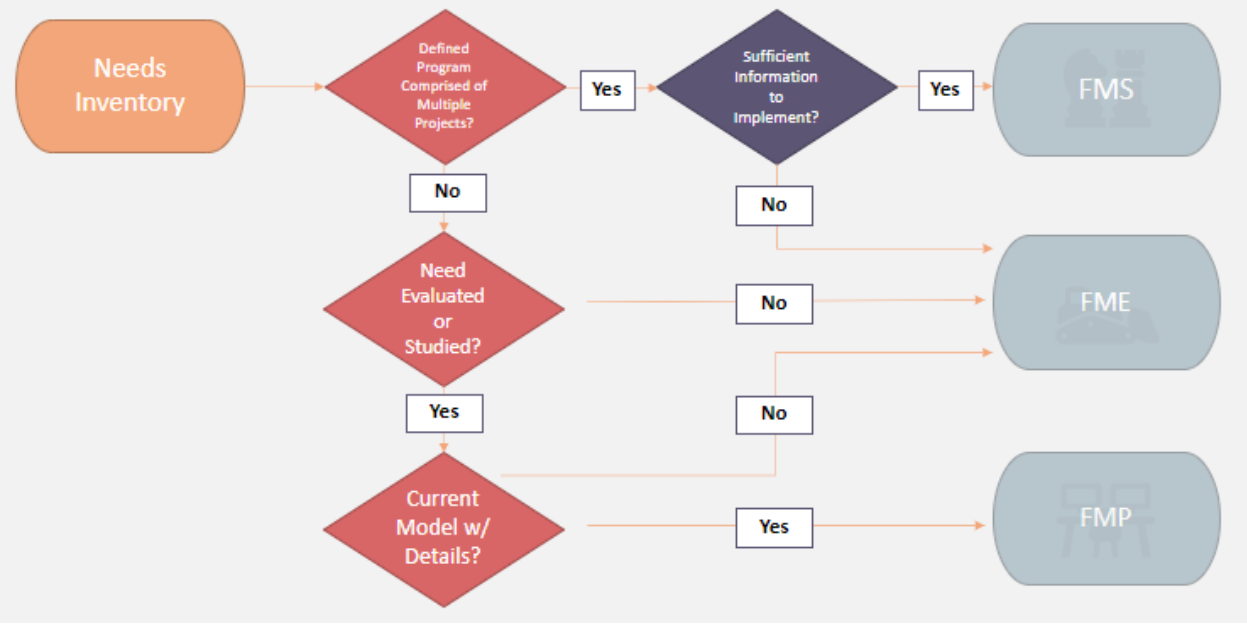


Table 4-12: General Flood Risk Reduction Action Types

Flood Risk Reduction Action Category	Action Types
FME	a. Watershed Planning i. H&H Modeling ii. Flood Mapping Updates iii. Regional Watershed Studies b. Engineering Project Planning i. Feasibility Assessments c. Preliminary Engineering (alternative analysis and up to 30% design) d. Studies on Flood Preparedness
FMP	**Structural** a. LWCs or Bridge Improvements b. Infrastructure (channels, ditches, ponds, stormwater pipes, etc.) c. Regional Detention d. Regional Channel Improvements e. Storm Drain Improvements f. Reservoirs g. Dam Improvements, Maintenance, and Repair h. Flood Walls/Levees i. Coastal Protections j. Nature Based Projects – living levees, increasing storage, increasing channel roughness, increasing losses, de-synchronizing peak flows, dune management, river restoration, riparian restoration, run-off pathway management, wetland restoration, low impact development, green infrastructure k. Comprehensive Regional Project – includes a combination of projects intended to work together.
	Non-Structural a. Property or Easement Acquisition b. Elevation of Individual Structures c. Flood Readiness and Resilience d. Flood Early Warning Systems, including stream gauges and monitoring stations e. Floodproofing f. Regulatory Requirements for Reduction of Flood Risk
FMS	None specified; RFPGs were instructed to include at a minimum any proposed action that the group wanted to consider for inclusion in the RFP that did not qualify as either an FME or FMP.

Source: TWDB Technical Guidance

Generally, an action was considered an FME if it required a study to quantify flood risk in an area, define potential FMPs and FMSs to address the risk, or assess downstream impacts. Potential actions that could be considered FMPs and FMSs were screened to determine if they have been developed in enough detail and include sufficient data to meet the technical requirements for these action types. Actions that were initially considered for FMSs and FMPs that did not meet these requirements were adapted and repurposed as FMEs. Additionally, project planning FMEs that already had calculated construction costs were recorded in the appropriate field that captures the full expense of implementing those projects once the FME is complete and the project is ready to move to construction. The specific requirements for each action type are described in subsequent sections.

FMSs were also identified for other strategies the RFPG wishes to pursue. One example of a potential FMS is assisting communities to apply to join the NFIP or adopt equivalent standards. Another example would be a program to enhance public education and awareness about flooding throughout the region, which does not include a construction cost.

Across the region, there were 265 potential flood mitigation actions identified across the three main categories as shown in **Table 4-13**. The following sections expand on the actions identified in each category. Additionally, one page project summaries have been developed for identified actions and are included in **Appendix D-2.**

Table 4-13: Identified Potential FMEs and Potentially Feasible FMPs and FMSs

Flood Mitigation Action Type	Count
FME	185
FMP	18
FMS	62
Total	**265**

4B.2.1 Determination of Emergency Need

For the purposes of this evaluation, an action was considered to meet an emergency need if it addresses an issue related to infrastructure in immediate need for repair or construction, particularly following a natural disaster or other destructive event. No actions were classified as demonstrating an emergency need in this first planning cycle.

4B.3 Evaluation of Potential FMEs

Several actions were identified as potential FMEs to address gaps in available flood risk data associated with the first planning cycle. The following sources of data were used to identify FMEs across the region:

- HMAPs
- Drainage master plans
- Previous flood studies
- Direct input from the RFPG

The evaluation of FMEs relied on the compilation of planning level data to gauge alignment with regional goals and flood planning guidance, the potential flood risk in the area, and the funding need and availability. This data included:

- Type of study and location
- Availability of existing flood modeling and mapping data
- Regional flood mitigation and floodplain management goals addressed by the FME
- Flood risk information, including flood risk type, number and location of structures, population, roadways, and agricultural areas at risk
- Sponsor entity and other entities with oversight
- Cost information, including study cost and potential funding sources

4B.3.1 FME Types

The definition of an FME allows for a variety of study types to help assess flood risk and potentially define future FMPs and FMSs. A general list of study types was previously summarized in **Table 4-12**. The following section describes these project types in more detail and provides a summary of the different potential FMEs identified in Region 1.

Watershed Planning

FMEs classified as Watershed Planning typically involve efforts associated with H&H modeling to help define flood risk or identify flood prone areas at a regional and/or watershed scale. The goal of Watershed Planning is to distribute resources equitably throughout the watershed to implement plans, programs, and projects that maintain watershed function and prevent adverse flood effects. A wide variety of project types fit under the umbrella of Watershed Planning, and the subcategories defined in Region 1 include:

- Drainage master plans
- FIS
- Watershed Studies
- Other H&H modeling

Engineering Project Planning

FMEs classified as Engineering Project Planning include studies to evaluate potential structural mitigation projects. These evaluations include feasibility assessments, preliminary alternatives analysis, and preliminary engineering design. The scope of the flood planning process allows for an FME to include project effort up to a 30% design level. Beyond this point, additional design and implementation effort for the project must be associated with an FMP.

Flood Preparedness Studies

FMEs classified as Flood Preparedness Studies include proactive evaluations of a community's readiness to respond to a flood event. The identified FMEs under this category consider non-structural mitigation actions such as evaluating stormwater pump stations in areas of interest to stakeholders.

FME Classification Summary

An overall summary of the identified FMEs is provided in **Table 4-14.** All potential FMEs that were identified are listed with their supporting technical information in TWDB-required **Table 12 (Appendix D-3)**. In total, 185 potential FMEs were identified and evaluated. The geographical distribution of the identified FMEs, which include counties, cities, project watersheds, and other boundaries, is shown in **Map 16 (Appendix D-4)**. Color gradations in **Map 16** reflect the number of FMEs that overlap for the same area; the darker the color, the greater the number of FMEs.

Table 4-14: FME Types and General Description

FME Type	Description	Number of Studies
Watershed Planning	FEMA mapping, drainage master plans, watershed evaluations, river modeling	120
Project Planning	Project design development	49
Preparedness	Pump station rehabilitation	1
Other	GIS development, dam evaluations, data collection systems	15

4B.3.2 Planning Level Cost Estimates

A planning level cost estimate was developed for each FME in accordance with the *Technical Guidelines*. The process to produce these cost estimates for each FME project type is outlined in the following sections. Cost estimates presented in this section are for planning purposes only and are not supported by detailed scopes of work or manhour estimates. It is anticipated that scopes of work and cost estimates will be refined prior to any future funding application through TWDB or other sources.

Watershed Planning – H&H Modeling and Regional Watershed Studies

Planning level cost estimates were developed for these types of FMEs assuming a typical scope of work that includes management, data collection, topographic survey, hydrologic analysis, hydraulic analysis, alternatives evaluation, and final deliverables. A range of unit costs was developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. Experience from previous studies was used to scale the study effort and estimate the LOD associated with the H&H analyses that are required for these studies. Unit costs were applied to reflect these different LODs, which reflect differences in the physical characteristics of the regions and their levels of urban development.

Each cost estimate also includes standard budget items based on the total project cost. These include a markup of 2% to account for quality assurance and quality control and 15% for project management, survey data capture, and technical reporting. Finally, a 30% contingency was applied to account for uncertainties associated with planning level estimates.

For studies of watersheds draining to playas within Amarillo, the standard numbers were not applicable since playas have different requirements than riverine analyses. Based on prior projects, an average of $500,000 was assumed for each study, and then the total value of all the watershed studies was distributed to each project based on the area of the watershed, with a maximum of $1,000,000. Two watersheds, Tributary to West Amarillo Creek and Lawrence Lake, have the maximum cost. The cost for other watersheds ranges from $195,442 to $922,535.

Watershed Planning – Flood Risk Mapping Updates

Flood risk mapping data helps communities quantify and manage their flood risk. It also provides communities a pathway to access flood insurance administered through the NFIP. Flood Risk Mapping FMEs were identified for all counties within Region 1 except Archer County, which had a FIS completed in 2021. The FMEs included both projects to develop regulatory maps where none exist and to update existing maps to account for revised rainfall data, recent development or topographic changes, and advances in floodplain modeling and mapping methodologies.

A spreadsheet was generated to produce planning level cost estimates for FIS utilizing relevant line items from the FEMA guidance document *Estimating the Value of Partner Contributions to Flood Mapping Projects* ("Blue Book"), *version 4.1*. Costs pertaining to management, discovery data capture, hydrologic data capture, hydraulic data capture, floodplain mapping data capture, and final deliverables were included as part of the overall cost. The number of FIRM panels that were contained within each project boundary was also accounted for in the cost estimates.

The FME study area was defined as the total area of the county, regardless of the size of the county within the region. A range of unit costs were developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. It was estimated that the stream miles to be included would be 10% of the total stream miles classified as FEMA Zone A or unmapped within a given study area. This estimate was based on an estimate of how much of the county is urban, as the stream miles in and around municipalities would require higher detail to refine the flood risk.

Experience with previous mapping projects was used to estimate the LOD associated with the H&H analyses that are required for these studies. The LOD needed to perform a regulatory study reflects differences in the physical characteristics of the regions and their levels of urban development. In terms of hydrologic analysis, it was estimated that 80% of the total project area could be analyzed using low-detail methods, while 20% would require more detailed rainfall-runoff analyses. For the hydraulic analysis, it was estimated that 70% of the included streams could be properly modeled with a low-detail

hydraulic model, 20% with a medium-detail model, and the remaining 10% would require highly detailed models. Unit costs were applied to reflect these different levels of detail.

Each cost estimate also includes standard budget items based on the total project cost. These include a markup of 2% to account for quality assurance and quality control and 15% for project management, survey data capture, and technical reporting. Finally, a 30% contingency was applied to account for uncertainties associated with planning level estimates.

Engineering Project Planning

Engineering project planning considers two important components: (1) the evaluation of a proposed project to determine whether implementation would be feasible, and (2) an initial engineering assessment including conceptual design, alternative analysis, impacts analysis, benefit-cost analysis (BCA), and up to 30% engineering design. The goal of these evaluations is to define alternatives in a sufficient LOD so they can be assessed as FMPs in future cycles. Each evaluation area is project-specific and varies greatly due to the wide range of improvements in channels, LWCs, roads and bridges, storm drain systems, and levee systems. CIPs were used for the respective entity in determining planning level cost estimates. It was assumed that each evaluation would be 5% of the total construction cost reported in the CIP escalated to 2020 dollars or a minimum of $250,000.

Flood Preparedness

Flood preparedness encourages preemptive evaluations and strategies to better prepare an area in the event of a flood. The identified FME in this category is to evaluate pump stations and identify improvements in order to prepare for future events. The cost for this project was determined based on professional engineering experience and the costs of similar projects.

Other

There are three types of FMEs classified as “Other”. The first is to develop GIS inventory and basic condition assessments for various entities that reported having existing drainage infrastructure, but did not provide GIS documentation. The cost for this type of project was determined to be $50,000 based on professional engineering experience with similar projects.

The second type of project classified as “Other” is dam evaluations. This includes both a specific evaluation for Farmers Creek Watershed Authority, which reported deficient or non-functioning dams in its location, and a region-wide project to coordinate an investigation into current dam safety status. Unit prices were established for data capture, a screening assessment, and a detailed dam breach analysis. For the Farmers Creek Watershed Authority evaluation, all 34 dams within the entity were listed in the screening assessment, and it was assumed that 10 of those dams would have a detailed dam breach analysis conducted. For the Region Wide Dam Safety evaluation, all 624 dams within the region were listed under the screening assessment, but no detailed dam breach analysis were planned.

The third project classified as "Other" is a centralized data collection project for drainage service requests for the City of Canyon. Pricing for this project was based on professional engineering experience and the costs of similar projects and was determined to be $50,000.

4B.3.3 Process to Determine Flood Risk Indicators

Flood risk indicators were quantified to define the existing flood hazard, flood risk, and flood vulnerability within each FME project area. Calculations were performed in GIS to combine and summarize this information by examining the flood risk information generated for the region as part of **Task 2A** in the individual project boundaries associated with each FME. The resulting flood risk indicator information was used to populate the associated fields in the FME feature class. These values are summarized in **Table 12** in **Appendix D-3**.

4B.4 Evaluation of Potentially Feasible FMPs and FMSs

Potentially feasible FMPs were identified based on responses to survey, reviews of previous studies, and direct coordination with stakeholders. FMSs and FMPs are required to be developed in a sufficient LOD to be included in the RFP and recommended for state funding. In most cases, this includes having recent H&H modeling data in order to assess the impacts of the project and an associated project cost to develop the project's benefit-cost ratio (BCR). The development and use of the technical information to evaluate potentially feasible actions is described in the subsections that follow.

Additionally, evaluation of FMPs and FMSs considered potential impacts and benefits from the FMS or FMP to the environment, agriculture, recreational resources, navigation, water quality, erosion, sedimentation, and other resources deemed relevant to the RFPG. These types of impacts vary project to project, but included in some cases: loss of agricultural land; green space allocation; enhanced use of recreational facilities such as parks, trails, and golf courses; and promotion of water quality. **Chapter 5** describes these specific impacts of each recommended FMP in more detail.

Finally, evaluation of FMPs and FMSs considered implementation issues including those related to rights-of-way, permitting, acquisitions, relocations, utilities and transportation. It is not uncommon for construction projects to face implementation contstraints. They are often resolved through engagement with stakeholders and in some cases, design modifications. Identifying such constraints early can lead to proactive planning and considerate design. Each FMP and FMS was evaluated for implementation issues, and identified issues for recommended actions are outlined in **Chapter 5**.

4B.4.1 Potentially Feasible FMPs

Three drainage studies identified conceptual projects that were considered as potentially feasible FMPs within Region 1: the 2014 *T-Anchor Lake Drainage Master Plan*, the 2011 *Wichita Falls Drainage Master Plan*, and the 2011 *USACE Flood Mitigation Study* in Canyon. These studies include a total of 18 potential FMPs that are primarily focused on stormwater infrastructure and storm drain improvements. None have been classified as meeting an emergency need. No FMPs were classified as being infeasible, but further information on FMPs that were not recommended is available in **Chapter 5.**

A summary listing of FMPs by source data is provided in **Table 4-15**. Detailed project descriptions are provided for the recommended FMPs in **Chapter 5**. The geographical distribution of each identified FMP is shown in **Map 17 (Appendix D-4)** with technical information for each FMP summarized in TWDB-required **Table 13 (Appendix D-3)**. Color gradations in **Map 17** reflect overlap of FMPs for the same area.

With additional funding provided by TWDB, additional potentially feasible FMPs may be identified through continued outreach with regional stakeholders and through the execution of identified FMEs, either as FMEs are approved by the RFPG to be performed with additional funding provided by TWDB, or as other funding sources are acquired by sponsors. These additional FMPs will be included in the Amended RFP due in July 2023 and subsequent RFPs.

Table 4-15: FMP Summary by Source

FMP Source	Number of FMPs Identified
2014 T-Anchor Lake Drainage Master Plan	1
2011 Wichita Falls Drainage Master Plan	9
2011 USACE Flood Mitigation Study in Canyon	8

4B.4.2 Potentially Feasible FMSs

The RFPG identified 62 potentially feasible FMSs for Region 1. No FMSs were identified and classified as unfeasible, but information on FMSs that were not recommended can be found in **Chapter 5.** The geographic distribution, which include counties, cities, and other boundaries, of each FMS is shown in **Map 18 (Appendix D-4)** with technical information for each FMS summarized in TWDB-required **Table 14 (Appendix D-3)**. Color gradations in **Map 18** reflect the number of FMSs that overlap for the same area, the darker the color, the greater the number of FMSs.

A variety of FMS types were identified. None have been classified as meeting an emergency need. A summary listing of FMS types is provided in **Table 4-16**.

Some strategies encourage and support communities and municipalities to actively participate within the NFIP. Other FMSs recommend the establishment and implementation of public awareness and educational programs to better inform communities of the risks associated with flood waters as well as the ecological and societal benefits of flooding. Additional FMSs promote preventive maintenance programs to optimize the efficiency of existing stormwater management infrastructure, recommend the development of a stormwater criteria to encourage best management practices, or promote the establishment of flood warning systems.

In some cases, flood mitigation actions that were not defined in sufficient enough detail to qualify as an FMP were classified as FMSs. These are FMSs that will eventually result in FMPs with capital costs, including gates at LWCs, flood warning systems and gauges, and property acquisition and structural elevation.

Table 4-16: FMS Type and General Description

FMS Type	Description	Number of Strategies
Property Acquisition and Structural Elevation	Acquiring properties and creating regulation to raise future structures	1
Infrastructure Projects	Gates at LWCs	1
Education and Outreach	Public education programs	2
Flood Measurement and Warning	Warning systems and gauges	3
Regulatory and Guidance	NFIP participation, CRS, stormwater utility fee development	54
Other	Maintenance	1

4B.4.3 Effects on Neighboring Areas of FMS or FMP

Each potentially feasible FMP and FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation. No negative impact means that a project will not increase flood risk to surrounding properties. The analysis must be based on best available data and be sufficiently robust to demonstrate that the post-project flood hazard is no more than the existing flood hazard.

Some communities in the Canadian–Upper Red Region have established no negative flood impact policies for proposed development, but communities have different thresholds for defining what level of impact is considered adverse and require the analysis to be performed for different flood event scenarios. The *Technical Guidelines* governing regional flood planning require the impacts analysis to be performed for the 1% ACE and provide specific criteria to be met in order to establish no negative impact.

If negative impacts are identified, mitigation measures may be utilized to alleviate such impacts. Projects with design level mitigation measures already identified may be included in the RFP and could be finalized at a later stage to conform to the no negative impact requirements prior to funding or execution of a project.

A comparative assessment of pre- and post-project conditions for the 1% ACE was performed for each potentially feasible FMP based on their associated H&H models. The floodplain boundary extents, resulting water surface elevations, and peak discharge values were compared at pertinent locations to determine if the FMP conforms to the no negative impacts requirements. This comparative assessment was performed for the entire zone of influence of the FMP. Further details pertaining to the no negative impact determination for each potentially feasible FMP are provided in **Chapter 5**.

4B.4.4 Estimated Benefits of FMS or FMP

To be recommended, each FMP or FMS must align with a regional floodplain management or flood mitigation goal established under **Task 3** and demonstrate a flood risk reduction benefit, where

applicable. To quantify the flood risk reduction benefit of each FMP or FMS, the anticipated impact after project implementation was evaluated with the following criteria:

- Reduction in habitable, equivalent living units flood risk
- Reduction in residential population flood risk
- Reduction in critical facilities flood risk
- Reduction in road closure occurrences
- Reduction in acres of active farmland and ranchland flood risk
- Estimated reduction in fatalities, when available
- Estimated reduction in injuries, when available
- Reduction in expected annual damages from residential, commercial, and public property

These estimated benefits were produced from geospatial data by analyzing the existing 1% and 0.2% annual chance floodplain boundaries with the proposed post-project floodplain boundaries. These proposed flood risk conditions were compared to the existing conditions flood risk indicators for a given area to quantify the reduction of flood risk achieved by implementation of an FMP or FMS. The results of the analysis are shown for each FMP or FMS in **Table 13** and **Table 14**, respectively, in **Appendix D-3**.

4B.4.5 Potential Impacts and Benefits from the FMS or FMP to Other Resources

Action specific impacts for FMSs or FMPs to the environment, agriculture, recreational resources, navigation, water quality, erosion, or sedimentation are documented in **Chapter 5** and **Chapter 6**, as applicable. The majority of actions have no anticipated major impacts or benefits.

4B.4.6 Estimated Capital Cost of FMPs and FMSs

Cost estimates for each FMP were acquired from the engineering report that was used to generate the FMP. Cost estimates were adjusted as needed to account for inflation and other changes in the price of labor and commodities that had taken place since the publication date of the original reports. The cost estimates listed in **Table 13** and **Table 14** in **Appendix D-3** are expressed in 2020 dollars as required by the *Technical Guidance*.

Cost estimates for each FMS were developed by determining a general project scope and estimating costs to perform the work based on engineering experience and other similar projects. The basic rationale for each FMS type is outlined in **Table 4-17** with all costs presented in in 2020 dollars.

Table 4-17: FMS Cost Development Rationale

FMS Type	Cost Estimate Range	Scope and Rationale
Public Awareness and Educational Programs	$100,000	**Region-Wide Public Education on Flooding:** Estimated $100,000 based on other similar educational programs.
Flood Warning Systems	$250,000	**Early Alert System/Gauge Notification:** Estimated $250,000 based on similar projects that have received TWDB flood grants.
Property Acquisition and/or Flood Proofing Programs	$6,000,000	**Property Acquisition and Structural Elevation:** Estimated a baseline $250,000 per structure removed from the floodplain, and set a program limit of $6,000,000, though the overall need is greater.
Regulatory and Guidance	$100,000 to $250,000	**NFIP Participation:** Estimated $100,000 to cover engineering consultant fees. **Criteria and Ordinance Development:** Estimated $100,000 to cover engineering consultant fees. **Stormwater Fee Development:** Estimated $200,000 to cover engineering consultant fees.
Preventive Maintenance Programs	$100,000	**Stream and Culvert Debris Maintenance Program:** Assume $100,000 based on similar projects.
Infrastructure Projects	$1,000,000	**LWC Gate Installation:** FMS is based on installing 5 gates at $200,000 per gate to be installed

4B.4.7 Benefit-Cost Ratio for FMPs

BCA is the method by which the annualized future benefits of a hazard mitigation project are determined and compared to its annualized costs. The end result is a BCR, which is 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 to be 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, 2022). However, a BCR equal or greater than 1.0 is not a requirement for inclusion in the RFP. The RFPG can decide to recommend a project with a lower BCR with appropriate justification.

When a BCR had been previously calculated in an engineering report or study that was used to create an FMP, the previously calculated BCR value was utilized for the FMP analysis. BCR calculations from the T-Anchor Lake Drainage Master were used for the T-Anchor Lake Watershed Drainage Improvements Project, after escalating project costs and benefits to 2020 dollars. For all other FMPs, which 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 BCR value for each FMP is listed in **Table 13** in **Appendix D-3**.

4B.4.8 Residual, Post-Project, and Future-Flood Risks of FMPs

It is expected that the implementation of recommended FMPs will reduce current and future levels of flood risk in the region. However, it is not possible to protect against all potential flood risks and there is potential for future increases in flood risk due to lack of maintenance or even a catastrophic failure. In general, residual and future risks for FMPs could be characterized as follows:

1. Flood events may exceed the level of service for which infrastructure is designed. As the period of record for flood data increases, our understanding of what constitutes a 1% ACE flood may change, particularly with the impacts from climate variability.
2. Potential failure or overtopping of dams and levees.
3. Communities depend on future funding and program priorities to maintain, repair, and replace flood protection assets. Routine maintenance of infrastructure is required to maintain its design capacity. Maintenance is sometimes overlooked due to budget, staff, and time constraints.
4. In our representative government, policy changes that adversely impact budgets, prior plans, assets, and standards are always a possibility.
5. Human behavior is unpredictable, people may choose to ignore flood warning systems or cross over flooded roadways for a variety of reasons.

4B.4.9 Implementation Issues of FMPs

Implementation issues that could be identified include conflicts pertaining to rights-of-way, permitting, property acquisitions, utility or transportation relocations, among other issues that might be encountered before an FMP is able to be fully implemented.

One unique issue to this region is how to classify playas in accordance with waters of the United States. The federal government regulates construction activities that take place within a region designated as a water of the United States. As stated in 33 CFR 3.28.3(a)(3), playas are considered waters of the United States, as are wetlands adjacent to waters of the United States. However, communication with USACE on previous projects indicates that this may not apply to all playas. Therefore, close coordination with USACE on any playa projects is a necessity. Additionally, playas were favored by prehistoric groups because they provided a more consistent source of water, wild game, and other resources. Therefore, coordination with the State Historic Preservation Officer and the Texas Historical Commission per the

National Historic Preservation Act and Antiquities Code of Texas regulations could be required for some projects.

4B.5 Potential Funding Sources

A wide variety of funding opportunities could be utilized to fund the identified actions. Traditionally, stormwater and FMP funding sources have either been locally-sourced user fees or general taxes, or externally by state and federal grants. While low-interest loan programs do provide for additional funding, few local entities choose this path due to the lack of a dedicated funding source sufficient to cover debt service. Therefore, many communities adopted a "pay-as-you-go" method of funding stormwater projects or, in the event of a disaster, applying for state and federal disaster recovery grants.

Today, communities have a broader range of funding sources and programs that include the above sources plus recently created mitigation grant and loan programs such as Building Resilient Infrastructure Communities (BRIC) and the TWDB FIF. The potential funding sources for the identified FME, FMP and FMS are listed in **Tables 12**, **13** and **14**, respectively in **Appendix D-3**. Further details on funding opportunities and the anticipated funding sources for the recommended actions are included in **Chapter 9**.

Chapter 5. Evaluation and Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects

The objective of Task 5 was for RFPGs to use the information developed under **Task 4** to recommend flood mitigation actions (FMEs, FMSs, and FMPs) for inclusion in the RFP. While **Chapter 4B** discusses the technical evaluations of the potential FMEs and potentially feasible FMSs and FMPs identified by the RFPG, **Chapter 5** focuses on how the RFPG used this data to make a recommendation for a given flood mitigation action. Generally, this chapter summarizes and documents:

1. The process undertaken by the RFPG to make final recommendations on each flood mitigation action type
2. The potential FMEs and potentially feasible FMSs and FMPs identified and evaluated under **Task 4B** and whether these actions are recommended by the RFPG.

5.1 RFPG Evaluation and Recommendation Process

Even though there are significant needs within the region, not every conceivable flood mitigation action can be recommended in the RFP or included in the SFP. The RFPG evaluated the identified potential flood mitigation actions and recommended those that met TWDB requirements and had no objections from stakeholders or the RFPG, with the understanding that not all recommendations may be performed in the same planning cycle as they are identified. Finally, all recommendations were evaluated for alignment with RFPG-adopted flood mitigation and floodplain management goals.

The RFPG considered recommendations on flood mitigation actions through a multi-step process. The general methodology included a screening of all potential flood mitigation actions considering TWDB requirements for inclusion in the RFP. The reasons for not recommending a particular flood mitigation action were clearly documented as part of the evaluation and recommendation process.

TWDB left some evaluation criteria to the discretion of the RFPG to implement during the screening process. The main discretionary evaluation criteria are the LOS to be provided by an FMP and the BCR for the project. TWDB recommends that, at a minimum, FMPs should mitigate flood events associated with the 1% annual chance flood (100-year LOS). However, if a 100-year LOS is not feasible, the RFPG can document the reasons for its infeasibility and still recommend an FMP with a lower LOS. Similarly, 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. Actions were recommended in accordance with the following strategies:

1. The RFPG will not require confirmation from potential sponsors to support a flood mitigation action as a prerequisite for recommendation (see **Section 5.2**).
2. All potential actions should be considered for inclusion in the RFP unless an entity specifically declines to be listed as a sponsor and no other appropriate potential sponsor is identified.
3. If a potential flood mitigation action falls within multiple FPRs, the RFPG will still consider recommending that action.
4. The RFPG is willing to accept flood mitigation actions with a LOS that is lower than the 100-year flood event. Information regarding the estimated LOS for each FMP will be provided, and the RFPG will make the final determination for its recommendation.
5. The RFPG is willing to accept an FMP with a BCR less than one. The estimated BCR for each FMP will be provided, and the RFPG will make the final determination regarding each FMP recommendation.

The potential list of actions was screened based on the technical data. Draft recommendations along with supporting technical information for each flood mitigation action were presented to the RFPG on April 14, 2022. A final list of recommendations was prepared afterwards, capturing all the input gathered during the meeting and any further information obtained from stakeholders or analysis. On May 11, 2022, the RFPG voted to recommend FMEs, FMPs, and FMSs. The RFPG approved these actions with the understanding that they could revisit them at a future meeting if new information warranted additional discussion and possible action. On June 22, 2022, the RFPG voted to recommend additional FMPs after the required technical data was developed and considered.

Figure 5-1: FME Screening Process

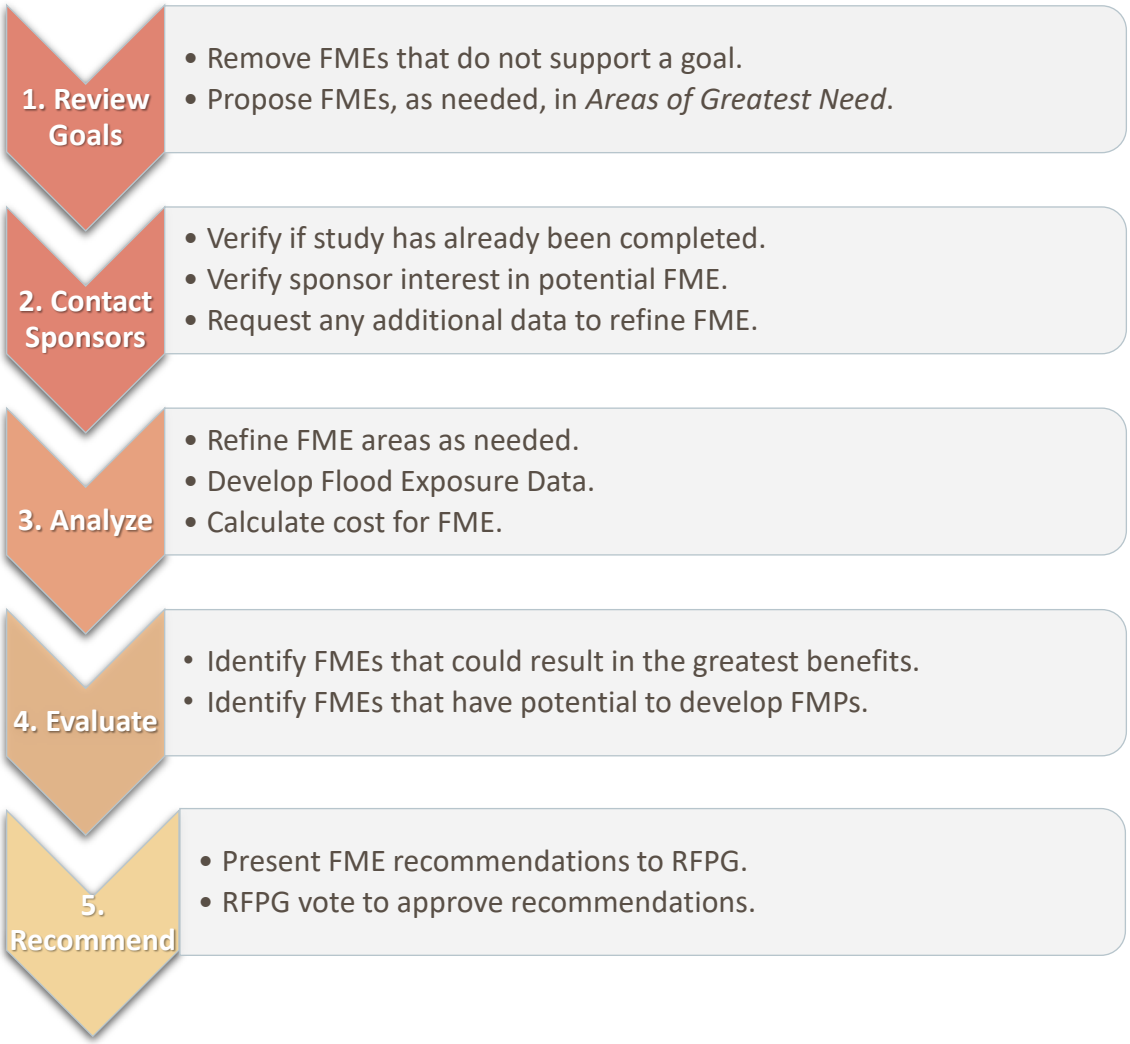


Figure 5-2: FMP and FMS Screening Process

5.2 Sponsor Outreach

A supplemental effort to contact potential sponsors was conducted to obtain clarification on flood mitigation actions. Feedback from potential sponsors was requested via email. These outreach e-mails included a one-page summary of the potential flood mitigation action with a map showing its approximate location, allowing the potential sponsors to view the potential actions for their entity. In addition, potential sponsors were encouraged to provide any other flood mitigation action of their interest for the RFPG to consider for inclusion in the RFP. Several conference call meetings were held following this outreach effort, which resulted in multiple positive outcomes for the flood planning process. Potential sponsors were able to fill in data gaps, identify actions that were already completed or had allocated funding, add new actions for consideration, and confirm interest in including the identified potential actions in the RFP.

Flood mitigation actions must be included in the RFP to be eligible for future state funding from the TWDB-administered FIF. Given this constraint, along with the limited timeline for this first planning cycle, the RFPG decided that an affirmative willingness to sponsor a given action would not be a prerequisite for inclusion in the RFP. As a result, all potential actions were considered for inclusion 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 needs in the region.
2. It does not obligate an entity to sponsorship; it simply allows an entity to be eligible for funding if interest in and capacity to sponsor an action becomes evident before the next RFP is adopted.

It is important to note that all sponsors associated with recommended actions subsequently received a survey to communicate that they were identified as a sponsor and were asked to provide information for potential funding sources for the actions listed in the RFP. This effort is detailed in **Chapter 9**.

5.3 Flood Management Evaluations

5.3.1 Summary and Approach in Recommending FMEs

The RFPG evaluated the identified potential FMEs and, based on the significant needs in the region, recommended all FMEs that met TWDB requirements, with the understanding that not all FMEs may be performed during the same planning cycle as they are identified. Recommended FMEs were also required to demonstrate alignment with at least one regional floodplain management and flood mitigation goal developed in **Chapter 3**.

It is the intent that all FMEs with an H&H modeling component will evaluate multiple storm events, including the 1% ACE. The exact solutions identified through performing these FMEs cannot be defined at this time. However, it is anticipated that an impact analysis will be performed for all alternatives and project benefits will be tabulated for the 1% ACE to inform any recommended alternatives and to define potentially feasible FMPs under this planning framework. Based on these TWDB requirements, the RFPG identified and recommended three main types of FMEs:

1. Recommended FMEs include those that would result in increased flood risk modeling and mapping coverage across the region as they are implemented. Across the region, there is an absence of flood risk modeling and effective mapping data which precludes participation in the NFIP and hinders effective floodplain management. While it is anticipated that BLE data will become available for the entire region by 2023, FEMA mapping and FISs were included in the recommendations with the understanding that the exact project scope could be tailored to leverage BLE data.
2. Recommended FMEs classified as project planning types were also included. These FMEs are generally studies or preliminary designs to address a specific, known flood need. However, these flood mitigation actions currently lack some or all of 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 impacts analysis. Completing these components as part of an FME will result in a potentially feasible FMP for consideration during future flood planning efforts.

3. Recommended FMEs that result in increased knowledge about current infrastructure conditions and safety are the last type of FME included. These projects include GIS development and dam evaluations and allow municipalities and other entities to better monitor and plan for maintenance and construction needs, including potential FMPs in future cycles.

The primary reason for not recommending an FME was based on sponsor input. An FME was not recommended if a sponsor indicated that the proposed study is currently in progress, has been completed already, or was no longer a priority they intended to pursue. This was the case for the one FME that was not recommended, Borger City Drainage Master Plan, as it has already begun.

5.3.2 Description and Summary of Recommended FMEs

A total of 185 potential FMEs were identified and evaluated by the RFPG. Of these evaluations, 184 were recommended, representing a combined total of approximately $84.4 million dollars of FME needs across the region. The only FME that was not recommended was the Borger City Drainage Master Plan, as the sponsor indicated that the proposed study is currently in progress. From 45 of the project planning FMPs with construction costs, an additional $70.9 million of need was identified, making the total cost of implementation of the FMEs and their anticipated FMPs $155.3 million.

The number and types of projects recommended by the RFPG are summarized in **Table 5-1**. The full list of recommended FMEs and supporting technical data is included as **Table 15** in **Appendix E-1**. A map of recommended FMEs is presented in **Appendix E-2** as **Map 19**. A one-page report summary for each recommended FME is included in **Appendix D-2**.

Table 5-1: Summary of Recommended FMEs

FME Type	Description	Number of Potential FMEs Identified	Number of FMEs Recommended	Total Cost of Recommended FMEs
Watershed Planning	FEMA mapping, drainage master plans, watershed evaluations, river modeling	120	119	$68,737,000
Project Planning	Project design development	49	49	$12,691,000
Preparedness	Pump station rehabilitation	1	1	$125,000
Other	GIS development, dam evaluations, data collection systems	15	15	$2,885,000
	Total:	**185**	**184**	**$84,438,000**

5.4 Flood Mitigation Projects

5.4.1 Summary and Approach in Recommending FMPs

For consideration as an FMP, a project must be defined in a sufficient LOD to meet the technical requirements of the regional flood planning project *Scope of Work* and the associated *Technical Guidelines* developed by TWDB. In summary, the RFPG must be able to demonstrate that each recommended FMP meets the following TWDB requirements:

1. Supports at least one regional floodplain management and flood mitigation goal.
2. The primary purpose is flood mitigation.
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 to an entity's water supply

d. No overallocation of a water source based on the water availability allocations in the most recently adopted SWP. Water supply and water availability impacts of recommended FMPs are discussed in **Chapter 6B**.

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

Updated construction cost estimates and estimates of project benefits must also be available to define a BCR for each recommended FMP. 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 that had the necessary data and detailed H&H modeling results available to populate these technical requirements were considered for recommendation by the RFPG. Pertinent details about the FMP evaluation are provided in **Section 5.4.2**.

5.4.2 FMP Evaluation

5.4.2.1 Initial Evaluation

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**. Based on a review of the supporting studies and H&H models, the region determined that the primary purpose for each FMP is flood mitigation, the FMP is a discrete project, and the FMP does not have any anticipated impacts to water supply or water availability allocations as established in the most recently adopted SWP. An overall summary of water supply impacts, overall flood risk benefits, and other impacts of recommended FMPs is included in **Chapter 6**.

5.4.2.2 No Negative Impacts Determination

Each identified FMP must demonstrate that no negative impacts on a neighboring area would result from its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. Using best available data, the increase in flood risk is measured by the 1% ACE water surface elevation and peak discharge. According to the *Technical Guidelines* it is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be sufficient to prove proposed project conditions are equal to or less than the existing conditions.

The following requirements, per the *Technical Guidelines*, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.
5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (subbasins, 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. Projects with design level mitigation measures already identified may be included in the RFP and could be finalized at a later stage to conform to the "no negative impact" requirements prior to funding or execution of a project.

Furthermore, the RFPG has flexibility to consider and accept additional "negative impact" for requirements 1 through 5 based on engineer's professional judgment and analysis given any affected stakeholders 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.

A comparative assessment of pre- and post-project conditions for the 1% ACE was performed for each potentially feasible FMP based on their associated H&H models. The floodplain boundary extents, resulting water surface elevations, and peak discharge values were compared at pertinent locations to determine if the FMP conforms to the no negative impact requirements. A summary of the determinations and the source data is shown in **Table 5-2**.

Table 5-2: Summary of No Negative Impact Determinations

FMP ID	FMP Name	FMP Meets All No Negative Impacts Requirements*	Sources for Determining No Negative Impact	
			Study Report	Hydraulic Model ID and Name
013000001	T-Anchor Lake Watershed Drainage Improvements	Yes	2014 T-Anchor Lake Drainage Master Plan	010000000004: Amarillo T-Anchor Lake Study
013000002	Rhea Road Drainage Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Rhea Hydraulic Model
13000003	Brenda Hursh Enhancement Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Brenda Hursh Hydraulic Model

FMP ID	FMP Name	FMP Meets All No Negative Impacts Requirements*	Sources for Determining No Negative Impact	
			Study Report	Hydraulic Model ID and Name
013000012	City of Canyon Flood Mitigation Project	Yes	2011 USACE Flood Mitigation Study in Canyon	010000000002: USACE City of Canyon Flood Study
013000013	Wichita Gardens Drainage Improvements	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Wichita Gardens Hydraulic Model
013000015	Echo/Neta Lane Drainage Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Echo Neta Hydraulic Model
013000016	Hirschi - Huskie Drainage Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Hirschi-Huskie Hydraulic Model
013000017	Landon, Duty and Sunset St Drainage Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Landon, Duty, Sunset Hydraulic Model
013000018	Spanish Trace Drainage Project	Yes	2011 Wichita Falls Drainage Master Plan	010000000006: Wichita Falls Drainage Master Plan Models, Spanish Trace Hydraulic Model

5.4.2.3 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 BCR, which is 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 to be 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 a requirement for inclusion in the RFP. The RFPG can decide to recommend a project with a lower BCR with appropriate justification.

TWDB funded and guided development of a BCA input spreadsheet that is used in conjunction with the FEMA BCA Toolkit 6.0 for use in any project without an existing BCR. The process makes several assumptions, including (AECOM, 2022):

- 7% discount rate
- Annual inflation is ~2%
- Each residence houses 3 people (including 2 workers)
- The per diem for displaced residents is $240/day per household (this includes 1 hotel room and meals for 3 people)
- Residential square footage based on house size:
    - Small = 1,000
    - Average = 2,500
    - Large = 5,000
- Each commercial building employs 10 people
- Commercial property value is $100/square foot

For projects using the TWDB BCA method, construction cost estimates were escalated to 2020 dollars using the Consumer Cost Index. Benefits to structures, roadways, and other infrastructure were taken directly from model results or reports and applied to the BCA spreadsheet as directed. Existing BCAs were used where possible with some modifications to meet the flood planning guidelines. BCR calculations are available as part of the supporting technical memoranda for each project included in **Appendix E-3**.

5.4.3 Description and Summary of Recommended FMPs

5.4.3.1 Descriptions of Recommended FMPs

A general description of the scope of work and a summary of the expected impacts of the proposed improvements for each recommended FMP is provided below. Based on the evaluation performed by the RFPG, it was determined that all recommended FMPs conform to the no negative impact requirements. Projects are explained in the descriptions below.

T-Anchor Lake Watershed Drainage Improvements (FMP 013000001) – City of Amarillo

Halff Associates prepared the *T-Anchor Lake Drainage Master Plan* for the City of Amarillo in August 2014. T-Anchor Lake is a series of five interconnected playas located in central Amarillo. The lake is

bordered to the south by Interstate Highway 40, to the west by Ross Street, and to the north and east by Southeast 10th Avenue/T-Anchor Boulevard.

The master plan evaluated the T-Anchor Lake watershed and recommended Capital Improvement Project alternatives to alleviate flood hazards. The recommended improvements for this watershed included a four-phase series of playa excavations entailing 1.6 million cubic yards of excavation and the relocation of one pump station to provide 100-year flood protection to surrounding homes and businesses. The master plan also recommended improvements to two closed storm systems along Ross-Osage Street and the SE 10th Avenue corridor that outfall into the lake to improve drainage in these two areas, which experience repeated and severe flooding. The T-Anchor projects have been rolled into one FMP for the purpose of inclusion in the list of potential projects in Region 1. It was determined that combining the various phases into a single project allowed T-Anchor to be represented at an appropriate scale for the RFP while still meeting the requirement of being a discrete project.

The existing conditions analysis identified 407 structures in the 1% ACE floodplain in the project area. After implementation of the playa excavation components, only 10 structures remained in the 100-year floodplain, and estimated damages were reduced by 94%. Impacts to flooded roadways by the storm drain projects were not directly assessed, but flood depths were significantly reduced or eliminated at several locations. The areas addressed by the storm drain projects include places that have historically been locations of high-water rescues and at least one instance of loss of life. Despite the roadways benefits not being evaluated, the BCR was found to be 1.7 with a total project cost of $31.3 million dollars. Potential implementation issues are potential for archaeological sites, which will require coordination with state entities, and environmental permitting. Additional benefits of the project are development of wetland habitat and opportunities for recreation due to the new playa shape.

This project meets all no negative impact requirements. However, it is anticipated that impacts will be periodically evaluated, and any negative impacts will be addressed as part of the design process.

Rhea Road Drainage Project (FMP 013000002) – City of Wichita Falls

The Rhea Road drainage area is located in Wichita Falls, Wichita County, TX. It was designed to convey runoff primarily by street flow to McGrath Creek. Due to the lack of drainage infrastructure in the area, many structures along Rhea Road are subject to flooding. To alleviate flood risk, it is proposed to increase the size of the storm drain system to increase capacity.

The initial evaluation and conceptual design for this project was conducted in 2011 by Freese and Nichols Inc. (FNI) as a part of the Wichita Falls Drainage Master Plan. An EPA Storm Water Management Model (SWMM) 5.0 model was developed by FNI to evaluate flooding extents and conceptual project design. The original study identified 27 residential and commercial structures that are potentially inundated by the 1% ACE. In post-project conditions, all 27 properties were removed from the 1% ACE, corresponding to a population of 81. This results in a decrease in estimated loss and damages from $2.7 million to $0. The total project cost is $3.0 million, with a resulting BCR of 1.1.

This project meets all no negative impact requirements. However, it is anticipated that impacts will be periodically evaluated, and any negative impacts will be addressed as part of the design process.

Brenda Hursh Enhancement Project (FMP 013000003) – City of Wichita Falls

Brenda Hursh Channel and Brenda Hursh Creek are concrete lined channels located in Wichita Falls, Texas. Multiple residential properties along Brenda Hursh Creek are currently located within the 1% annual chance floodplain. To alleviate flood risk, it is proposed to divert flow from Brenda Hursh Creek and Brenda Hursh Channel at the Weeks Street crossings and convey runoff through a proposed pipe system that will outfall into a grass-lined channel. The proposed channel will run through The Champions Course at Weeks Park Golf Course to the west until meeting Holliday Creek.

The initial evaluation and conceptual design for this project was conducted in 2011 by FNI as a part of the Wichita Falls Drainage Master Plan. The original study identified 100 structures that are potentially inundated by the 1% ACE. In post-project conditions, 64 properties were removed from the 1% ACE, corresponding to a population of 192, and flood damages were reduced at seven additional properties. The total project cost is $4.2 million, with a BCR of 1.1. Potential implementation issues are local permits and standard reviews by the state, and an additional benefit of the project is the addition of riverine habitat with the construction of the natural channel.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Flood Mitigation Project (FMP 013000012) – City of Canyon

This project mitigates repetitive flooding from Palo Duro Creek in a residential area between FM 2590 and Highway 87 in the City of Canyon, TX. In May 2011, USACE performed a flood mitigation study to propose various alternatives to mitigate flooding problems in the study area. The study recommended a combination of two upstream flood detention structures coupled with enlargement of a flood diversion channel located in an adjacent golf course. At the city's request, the enlargement of three LWCs was added to the FMP.

A HEC-HMS model and a HEC-RAS model were developed by USACE to evaluate flooding extents and conceptual project designs. From results of the original study, HDR identified 106 residential structures that are potentially inundated by the 1% ACE. In post-project conditions, 27 properties were removed from the 1% ACE, corresponding to a population of 81, and flood damages were reduced for 79 additional structures. This results in a decrease in estimated damages from $9.0 million to $6.3 million, and a decrease in estimated loss of function from $5.9 million to $4.2 million. The total project cost is $37.2 million, with a resulting BCR of 0.51.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Wichita Gardens Drainage Improvements (FMP 013000013) – City of Wichita Falls

The Wichita Gardens Neighborhood is in Wichita Falls, Wichita County, TX. The area was initially developed with limited ability to positively convey runoff to an adequate outfall. The slope of the area is

flat, and even with the presence of roadside drainage ditches, the lack of grade throughout the area prevents runoff from adequately draining from the area. Most homes are single-family units built at or below the grade of the street, subject to flooding when the roadside ditches overflow. The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by FNI.

The proposed improvements are an upgraded storm drain system combined with the installation of concrete curbs and gutters throughout the entire development. The system has curb inlets and a trunk line that runs from north to south underneath the road to an outfall at the Wichita River. The proposed pipe system was designed to eliminate structure flooding from a 25-year storm event.

In existing conditions, 100 structures lie within the 1% ACE floodplain. After the proposed improvements, 84 will be removed. There will also be benefits in reduced road flooding, although that benefit has not been calculated. The total project cost is $10.0 million dollars, with a resulting BCR of 3.1. Potential implementation issues include local permits and standard reviews by the state. The project has no additional benefits.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Echo/Neta Lane Drainage Project (FMP 013000015) – City of Wichita Falls

The project area is in the vicinity of Echo Lane and Neta Lane along Old Jacksboro Highway in Wichita Falls, Wichita County, TX. There have been multiple reports near the Echo/Neta project area about standing water. The standing water is connected with an existing pipe system, which conveys runoff from the east side of Jacksboro Highway to the west under buildings and across Neta Lane before discharging into an open channel north of the Edgemere Church of Christ parking lot. To alleviate flood risk, it is proposed to upgrade the storm drain system with curb and gutter along Jacksboro Highway beginning south of Echo Lane and reaching north to Norman Street. The system would then turn to the west and run along Norman Street parallel to an existing storm drain system.

The initial evaluation and conceptual design for this project was conducted in 2011 by FNI as a part of the Wichita Falls Drainage Master Plan. An EPA SWMM 5.0 model was developed by FNI to evaluate flooding extents and conceptual project design. The original study identified 18 residential and commercial structures that are potentially inundated by the 1% ACE. In post-project conditions, 14 properties were removed from the 1% ACE, corresponding to a population of 42, and flood damages were reduced at four additional structures. This resulted in a decrease in estimated loss and damages from $2.2 million to $166,000 for the 1% ACE. The total project cost is $2.9 million, with a resulting BCR of 3.7.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Hirschi – Huskie Drainage Project (FMP 013000016) – City of Wichita Falls

The project area is in the vicinity of Hirschi Lane and Huskie Drive in Wichita Falls, Wichita County, TX. The area is within a FEMA Zone AE floodplain and partially within the floodway. Box culverts containing East Plum Creek from Iowa Park Road to Ridgeway Drive have partially collapsed. To alleviate flood risk, it is proposed to extend the existing storm drain system located on Huskie Drive to reach further west along Hirschi Lane and acquire the three properties that are negatively impacted by the East Plum Creek culvert.

The initial evaluation and conceptual design for this project was conducted in 2011 by FNI as a part of the Wichita Falls Drainage Master Plan. An EPA SWMM 5.0 model was developed by FNI to evaluate flooding extents and conceptual project design. The original study identified 35 residential structures that are potentially inundated by the 1% ACE. Since the post-project conditions were not modeled in the original study, maximum benefits were assumed with all structures removed from flooding. In the estimated post-project conditions, all 35 properties were removed from the 1% ACE, corresponding to a population of 105. This resulted in a decrease in estimated loss and damages from $1.9 million to $0 for the 1% ACE. The total project cost is $633,000, with a resulting BCR of 0.8.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Landon, Duty, and Sunset Street Drainage Project (FMP 013000017) – City of Wichita Falls

The project area is in the vicinity of Duty Lane, Sunset Lane and Landon Road, north of Iowa Lane in Wichita Falls, Wichita County, TX. The area is flat, with slopes as low as 0.4% in some locations. Runoff is conveyed along Duty Lane, Landon Road and Sunset Lane through inconsistent, shallow bar ditches. Many of the houses in the area are susceptible to flooding with finished floor elevations at or below the street elevation. To alleviate flood risk, it is proposed to upgrade the storm drain system and construct curb and gutter improvements along Landon Road, Duty Lane and Sunset Lane.

The initial evaluation and conceptual design for this project was conducted in 2011 by FNI as a part of the Wichita Falls Drainage Master Plan. An EPA SWMM 5.0 model was developed by FNI to evaluate flooding extents and conceptual project design. The original study identified 43 residential structures that are potentially inundated by the 1% ACE. In post-project conditions, 41 properties were removed from the 1% ACE, corresponding to a population of 123, and flood damages were reduced at two additional structures. This resulted in a decrease in estimated loss and damages from $4.2 million to $105,000 for the 1% ACE. The total project cost is $2.1 million, with a resulting BCR of 10.6.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

Spanish Trace Drainage Project (FMP 013000018) – City of Wichita Falls

Spanish Trace is located on the eastern side of Sierra Madre Drive in Wichita Falls, Wichita County, TX. Homes impacted by flooding are adjacent to an abandoned irrigation canal with finished floor elevations lower than top of bank of the canal; therefore, any overtopping of the canal results in flooding. At the southern end of the irrigation canal there is a headwall that intercepts flow and conveys it through a pipe system that continues east. Analysis indicates that this pipe system has insufficient capacity to convey flows from the canal, causing the canal to overtop and flood eight adjacent properties. To alleviate flood risk, it is proposed to re-grade the irrigation canal to convey additional flow north towards Johnson Road in the opposite direction from current flow, connecting to the existing storm drain system. In addition, installation of a new storm drain parallel to the existing 48-inch reinforced concrete pipe is proposed to convey flow south.

The initial evaluation and conceptual design for this project was conducted in 2011 by FNI as a part of the Wichita Falls Drainage Master Plan. An EPA SWMM 5.0 model was developed by FNI to evaluate flooding extents and conceptual project design. The original study identified eight residential structures that are potentially inundated by the 1% ACE. In post-project conditions, all eight properties were removed from the 1% ACE, corresponding to a population of 24. This resulted in a decrease in estimated loss and damages from $555,000 to $0 for the 1% ACE. The total project cost is $1.0 million, with a resulting BCR of 1.2.

At this preliminary stage, the project meets all no negative impact requirements. Hydraulic impacts will be confirmed, and any anticipated negative impacts will be mitigated, through final design and construction.

5.4.3.2 Summary of Recommendations

Of the 18 FMPs identified under **Task 4B**, nine have been recommended for inclusion in the RFP. Two FMPs for the City of Wichita Falls were not recommended based on a sponsor request to not include them in the RFP (Adrian Avenue Drainage Project and Briargate Drainage Reconstruction Project). The other seven FMPs that were not recommended were alternatives for the City of Canyon Flood Mitigation Project (Diversion Channel through Golf Course, Flood Walls Through the Gold Course Area for Isolated Groups of Structures, Dredging of the Palo Duro Creek and Tierra Blanca Creek, Modify Golf Course Pond Dam, Spillway, and Channel, Upstream Detention Pond, Bivins Lake Modifications for Flood Control, and Bivins Dam Rehabilitation with Diversion Channel). These were not recommended because they did not have the necessary technical data for evaluation as an FMP and because the sponsor preferred the combined detention and channel improvement alternative which was ultimately recommended for inclusion. Additionally, a recommended FME to study Bivins Lake will provide more information related to the two Bivins Dam related identified FMPs.

Some FMPs do not provide a 100-year LOS and/or their BCR is less than one. However, the RFPG recommendations considered the LOS and BCR of each FMP as discretionary evaluation criteria and recommended all projects that demonstrated a flood reduction benefit and met the no adverse impacts requirements, namely because:

- Physical, environmental, or other constraints may restrict the LOS that a given project is able to provide. However, the overarching goal of the RFP, which is "*to protect against the loss of life and property*", even if that protection can only be provided against smaller magnitude storm events. Therefore, projects that do not provide a 100-year LOS were not outright excluded from recommendation. Additionally, expanded consideration for projects that demonstrate flood reduction benefits for smaller storm events is an administrative recommendation that is further discussed in **Chapter 8**.
- The costs and benefits of the FMPs are developed at a high level or regional scale, and the demonstrated BCR is likely to change as projects are refined during design and construction. TWDB does not require a project to demonstrate a BCR greater than 1 to be included in the RFP. As a result, the RFPG considered projects for recommendation regardless of BCR if the project had sponsor and/or RFPG interest.

A summary of the recommended FMPs for inclusion in the RFP is presented in **Table 5-3**. These projects are located in the cities of Amarillo, Canyon, and Wichita Falls, and they represent a combined total construction cost of $92.3 million dollars. Supporting technical data for each FMP, including their flood risk reduction benefits, is included as **Table 16** in **Appendix E-1**. A map of project areas for the recommended FMPs is provided in **Appendix E-2** as **Map 20**. A one-page report summary for each recommended FMP is included in **Appendix D-2**. Additionally, the required *Project Details Spreadsheet,* which will be used for evaluation and project ranking by the state, is included as **Appendix E-4**.

Table 5-3: Summary of Recommended FMPs

FMP Name	Description	Sponsor	Total Cost of Recommended FMPs
T-Anchor Lake Watershed Drainage Improvements	Four-phase playa excavation and storm drain improvements	Amarillo	$31,300,000
Rhea Road Drainage Project	Install storm drain system along north on Rhea Road	Wichita Falls	$2,995,000
Brenda Hursh Enhancement Project	Construct storm system diversion to channel through golf course	Wichita Falls	$4,151,000
City of Canyon Flood Mitigation Project	Construct offline detention facilities along Palo Duro Creek, construct diversion channel through golf course to alleviate flooding, and upgrade LWCs	Canyon	$37,238,000
Wichita Gardens Drainage Improvements	Install curb and gutter and storm drain system to alleviate flooding in neighborhood	Wichita Falls	$10,008,000
Echo/Neta Lane Drainage Project	Install storm drain system with curb and gutter to alleviate flooding	Wichita Falls	$2,853,000

FMP Name	Description	Sponsor	Total Cost of Recommended FMPs
Hirschi – Huskie Drainage Project	Extend existing storm drain system and acquire properties to eliminate structural flooding	Wichita Falls	$632,000
Landon, Duty, and Sunset Street Drainage Project	Install curb and gutter street improvements and a pipe system that outfall to a drainage channel	Wichita Falls	$2,120,000
Spanish Trace Drainage Project	Regrade irrigation canal to convey flow north towards Johnson Road	Wichita Falls	$1,043,000
	Total:		**$92,343,000**

5.5 Flood Management Strategies

5.5.1 Summary of Approach in Recommending FMSs

The approach for recommending FMSs adheres to similar requirements as the FMP process. However, due to the flexibility and varying nature of RFPG's potential utilization of FMSs, some of these requirements may not be applicable 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. Supports at least one regional floodplain management and flood mitigation goal
2. The primary purpose is flood mitigation
3. Implementation of the FMS results in:
    a. Flood risk reduction benefits
    b. No negative impacts to adjacent or downstream properties
    c. No negative impacts to an entities 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, TWDB recommends that, at a minimum, FMSs with quantifiable flood risk reduction benefits should mitigate flood events associated with the 1% annual chance flood (100-year LOS). However, if a 100-year LOS is not feasible, the RFPG may document the reasons for its infeasibility and still recommend an FMS with a lower LOS.

An overall summary of water supply impacts, overall flood risk benefits, and other impacts of recommended FMSs is included in **Chapter 6**. Although each potentially feasible FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation, there were no structural FMSs identified for this region, and therefore no adverse impacts from flooding or to water supply are anticipated.

5.5.2 Description and Summary of Recommended FMSs

A wide variety of FMS types were identified and evaluated for Region 1. A total of 62 potentially feasible FMSs were considered by the RFPG and 60 were recommended for inclusion in the RFP. Generally, these FMSs recommend city-wide and county-wide strategies and initiatives that represent a combined total cost of $13.6 million dollars. These FMSs support several of the regional floodplain management and flood mitigation goals established in **Chapter 3**. The two FMSs that were not recommended were Follett NFIP Involvement, because the community decided they were not interested in participation, and the City of Canyon Create Floodplain Ordinances action, which was determined to be redundant as Canyon already has an ordinance as well as another FMS related to CRS development.

The number and types of projects recommended by the RFPG are summarized in **Table 5-4**. The full list of FMSs and supporting technical data, including their flood risk reduction benefits as applicable, is included in **Table 17** in **Appendix E-1**. A map of recommended FMSs is presented as **Map 21** in **Appendix E-2**. A one-page report summary for each recommended FMS is included in **Appendix D-2**.

Table 5-4: Summary of Recommended FMSs

FMS Type	Description	Number of Potential FMSs Identified	Number of FMSs Recommended	Total Cost of Recommended FMSs
Property Acquisition and Structural Elevation	Acquiring properties and creating regulation to raise future structures	1	1	$6,000,000
Infrastructure Projects	Gates at low LWCs	1	1	$1,000,000
Education and Outreach	Public education programs	2	2	$200,000
Flood Measurement and Warning	Warning systems and gauges	3	3	$750,000
Regulatory and Guidance	NFIP and CRS participation, stormwater utility fee development	54	52	$5,300,000
Other	Maintenance	1	1	$100,000
	Total:	**62**	**60**	**$13,350,000**

Chapter 6. Impact and Contribution of the Regional Flood Plan

The focus of the RFP is to reduce the risk to life and property caused by flooding in the region. However, flood mitigation projects have several impacts on an area beyond flood risk reduction, which are presented in this chapter. Task 6A focuses on the overall reduction in flood risk and other subsidiary benefits of the RFP. Additionally, under the broader umbrella of water resource management, FMPs and FMSs in the RFP have the potential to impact water planning efforts across the state. Task 6B focuses on quantifying impacts of the RFP specifically on water supply development, water availability, or projects in the SWP.

6A. Impacts of Regional Flood Plan

The goal of Task 6A was to summarize the overall impacts of the RFP. This summarization includes potential impacts to areas at risk of flooding, structures and populations in the floodplain, number of LWCs impacted, impacts to future flood risk, impact on water supply (details provided in **Chapter 6B**), and overall impact on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation. This chapter describes the processes undertaken by the RFPG to determine these impacts and summarizes the results of the evaluation.

The impacts will generally be determined based on before-and-after (RFP implementation) comparisons of flood risk indicators from **Chapter 2**. These comparisons illustrate how much the region's existing flood risk will be reduced through implementation of the RFP. Additionally, this section will provide a qualitative description of how much additional, future flood risk (that might otherwise arise if no changes were made to floodplain policies) will be avoided through implementation of the RFP. This evaluation will take into account recommended changes to the region's floodplain management policies.

The following sections provide:

- A region-wide summary of the relative reduction in flood risk that implementation of the RFP would achieve within the region including with regard to life, injuries, and property
- A statement that the FMPs in the RFP, when implemented, will not negatively affect neighboring areas located within or outside of the FPR
- A general description of the types of potential positive and negative socioeconomic or recreational impacts of the recommended FMSs and FMPs within the FPR
- A general description of the overall impacts of the recommended FMPs and FMSs in the RFP on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

6A.1 FMP Impacts

Nine FMPs were identified and recommended, as discussed in **Chapters 4** and **5**. Projects were evaluated for flood risk reduction benefits and to determine if the project would create any adverse flood impacts. **As proposed, the RFP and its recommended FMPs, when implemented, will not negatively affect neighboring areas located within or outside of the FPR.** The local sponsors and their engineers will be ultimately responsible for confirming that final designs and any modifications made during construction do not result in any anticipated adverse flood impacts.

The quantification of impacts for FMPs was limited to evaluation for the 1% ACE, as the H&H modeling data was not available for the 0.2% ACE in most cases. Since the FMPs are designed for a 100-year (1% ACE) level of service or less frequent event, the 0.2% impacts are expected to be minimal. As detailed in **Table 13** (**Appendix D-3**) and summarized in **Table 6-1** below, the nine FMPs would reduce the number of structures in the 1% ACE floodplain by 713 within their project areas, providing protection to an estimated 2,091 residents. Additionally, three LWCs are removed from the 1% ACE floodplain by the Canyon Flood Mitigation Project.

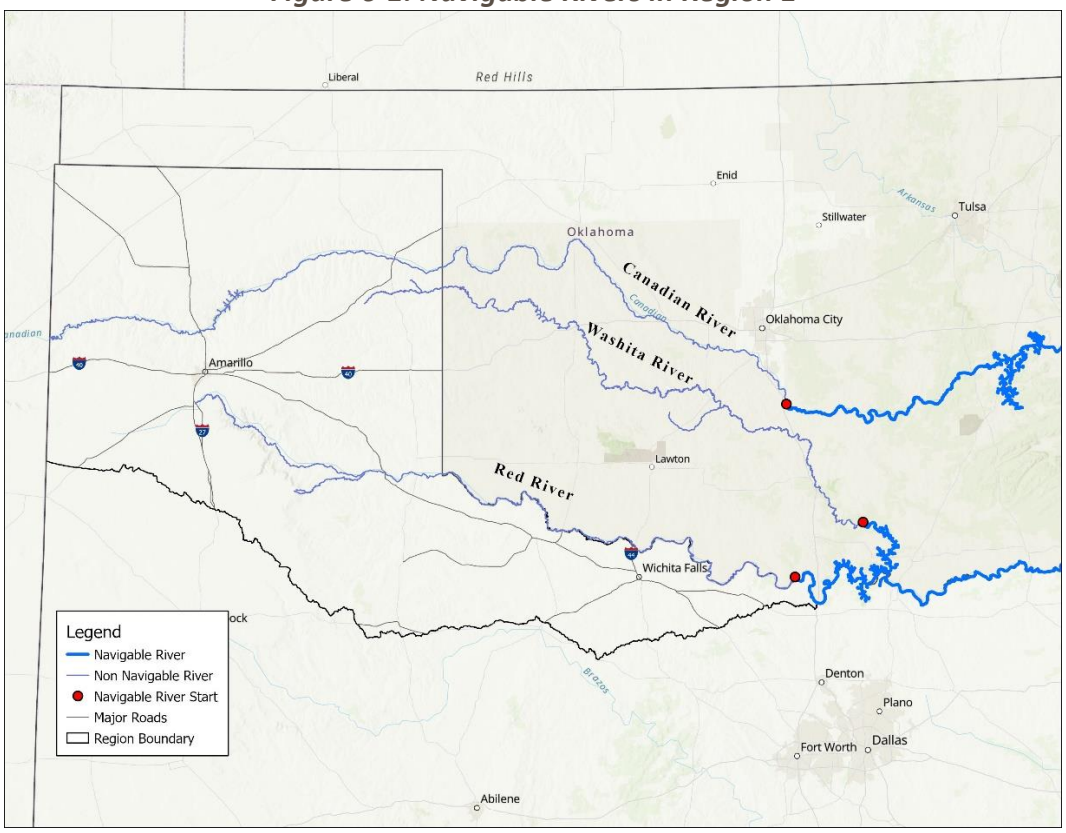
Table 6-1: Summary of Impacts of Recommended FMPs in Project Areas in 1% ACE

	Existing Conditions in FMP Project Areas	After FMP Implementation	Exposure Reduction from FMPs
Exposed Structures	858	145	713
Exposed Population	2,574	483	2,091
Exposed LWC	9	6	3

Located in the mostly urban areas of Amarillo, Wichita Falls, and Canyon, these projects are not expected to benefit any agricultural lands. Some moderate benefits to recreation may be realized through implementation of the Brenda Hursh, Canyon, and T Anchor FMPs which will reduce flooding in golf courses and open park spaces.The socioeconomic impacts were not readily quantifiable, though several FMPs are located in areas with a high SVI. Reducing flood risk in these areas will provide increased protection to vulnerable communities who would have more difficulty recovering from a flood event.

Impacts to the environment, water quality, erosion and sedimentation are expected to be minimal since all of these projects will be subject to protective drainage and floodplain development criteria of the respective jurisdictions, in addition to standard environmental permitting regulations. Impacts on navigation were also assessed by identifying navigable waterways within Region 1. Navigable waters of the United States are defined by the USACE under 33 CFR 329. All navigable rivers that pass through Region 1 are shown in **Figure 6-1**; however, in most cases, the navigable portion of these rivers begin downstream of the region boundary. The streams impacted by the recommended FMPs are not currently navigable, and this will not change when the projects are implemented.

Figure 6-1: Navigable Rivers in Region 1



Source: USACE Tulsa District

6A.2 FMS Impacts

A total of 60 FMSs have been recommended by the RFPG, in five broad categories, which are listed below, along with their general impacts.

Actions listed as **Regulatory and Guidance** include NFIP participation, stormwater management criteria development, and stormwater utility fee development. Implementation of these FMSs will improve regulation of development to decrease current and future flood risks and will provide a source of dedicated funding for construction of flood mitigation projects and operation and maintenance (O&M) of drainage infrastructure. Anticipated positive impacts include reducing the number of structures and roadways built in the floodplain, minimizing expansion of future floodplains, and protecting riparian areas from development, which protects the environment, water quality, erosion, and sedimentation. Greater NFIP involvement and higher stormwater management standards limit the potential negative impacts of development and provide more regulatory certainty and consistency across the region. While there are many positive benefits of these FMSs, enforcing these standards and regulations may require additional time, staff, and training resources for communities and may come at an increased cost to citizens.

Property Acquisition and Structural Elevation FMSs include flood-proofing, acquiring, or buying out flood prone structures protect against flooding. Anticipated positive impacts are a reduced number of

structures in the floodplain and increased protection of citizens by providing inhabitants of a floodplain a mechanism to move away from the area of hazard without losing their real estate investments. Increase in open space also has the potential to provide recreation, environmental, and water quality benefits. However, such programs have the potential to be politically objectionable and may cause "blight" in certain neighborhoods if not handled appropriately.

Actions considered **Education and Outreach** increase awareness of flooding issues, risks, and regulation to citizens and other stakeholders. The Turn Around, Don't Drown campaign and the Public Awareness campaign are both examples of this type of strategy. Anticipated positive impacts include reduced violations of floodplain regulations which can decrease flood risks, increased awareness of flood hazard areas, increased awareness of imminent flood events which can help with early evacuations and mitigation measures to prevent damages and save lives, and minimized risky behavior during floods which can reduce deaths, especially while driving. However, these programs require additional time, staff, and financial resources to be effective.

Flood Measurement and Warning actions involve the installation and operation of flood gauges and flood warning systems, as well as the installation of protective barricades and warnings. The most obvious positive impact would be providing advanced warning for people at risk of flooding to prepare, mitigate damages, and evacuate the area. Additionally, implementation of these FMSs would prevent cars from driving on flooded roads, one of the most common causes for loss of life due to flooding. Potential negative impacts include the need for additional time, staff, and financial resources to operate and maintain these systems and the potential for false alarms or failed warnings if system is not properly maintained and calibrated.

If all of these FMSs are implemented, impacts from flooding are likely to be less severe, and anticipated increases in future flood exposure is likely to be reduced. These strategies tend to reduce future development in the floodplain and encourage better floodplain management policies which prevent increases in flooding due to development. These programs and policies also reduce the impact of development to downstream flows and help protect the floodplain from over-development, which in turn help to protect the environment and reduce erosion, channel incision, and sedimentation.

Under the future conditions, no action scenario, increased risk to people and property are expected to increase as shown in **Table 6-2**. While implementing all FMSs may not prevent all anticipated increases in flood exposure, it can be expected to mitigate damages. By increasing regulation, awareness, and removing structures from the floodplain, many of these impacts can be reduced.

Table 6-2: Increases in Flood Risk Under "No Action" Scenario

	1% ACE Event	0.2% ACE Event
Floodplain Area (sq. mi.)	930	700
Exposed Structures	12,180	5,310
Exposed Population	36,931	522

The recommended FMSs are expected to reduce the number of injuries and deaths due to flooding by educating people about the risks of flooding, providing warnings of current and potential flooding, and reducing the frequency and severity of flooding of roads and structures. While the number of injuries and deaths prevented by these FMSs could not be readily quantified, they have the potential to be significant. However, these positive impacts will only be realized if communities are able to enact these strategies and enforce these policies.

The primary downside of these FMSs is the additional burden it places on the communities that will have to adopt and enforce the measures. In addition, some of the regulations and guidance will impose restrictions on building within the floodplain. While this helps protect citizens from putting themselves and others at risk, it does have some political risks for those seeking to adopt them. Considering the abundance of land in the region, there is ample room for development while preventing people from building in high-risk floodplain locations.

6A.3 FME Impacts

A total of 184 FMEs were recommended by the RFPG in four broad categories. These categories, examples, and their positive and negative impacts are described in this section.

Preparedness actions perform evaluations pertaining to preparing for flood events. The recommended preparedness FME is a pump station rehabilitation evaluation and design. This can provide a positive impact by assisting in draining playas at a faster rate during and after storm events, thereby decreasing flooding. However, this does not address the root cause of playa flooding.

Actions marked as **Project Planning** conduct up to 30% design for specific projects and flood mitigation measures that were previously identified by sponsors. Typical projects include storm sewer upgrades, culvert upsizing, and channel modifications. Expected positive impacts include reducing flooding and exposure to flooding, reducing impact of flooding on existing facilities, and reducing roadway overtopping. Potential negative impacts should be evaluated and assessed during alternatives analysis, design, and implementation. In some cases, mitigation measures will need to be considered during project development.

Actions conducting watershed studies to establish accurate floodplain modeling and mapping and evaluation potential flood mitigation measures are marked as **Watershed Planning**. This includes FIS, watershed studies, and drainage master plans. Accurate flood maps allow for risk avoidance, better regulations, and better planning. Understanding the needs for flood reduction in a watershed allows for better allocation of resources to design and implement projects to reduce flooding and exposure to flooding. However, more projects than funding are usually identified, and in most cases, not all of the needs of a watershed can be adequately addressed.

Actions outside of these categories, marked **Other**, include GIS data development, dam evaluations, and stormwater drainage and control systems. These actions allow for increased awareness of the condition of stormwater infrastructure, leading to better prioritization for maintenance. However, these projects

do not directly address flooding issues. Additionally, these systems require local government participation in maintaining data, using resources such as budget and staff time.

Most of Region 1 has no floodplain mapping, and the areas that do have mapping are generally based on outdated or approximate data. As a result, some degree of floodplain modeling or mapping is needed across the entire region, over 34,600 square miles of total area, in which there is an estimated 4,300 square miles of 1% ACE floodplain and 930 square miles of additional floodplain for the 0.2% ACE event. Improved mapping and models will allow citizens, developers, planners, and community officials to consider their flood risks when choosing where and how to develop. Increased model availability will help communities evaluate potential FMPs to reduce flood risks and impacts in the area. These models, along with flood gauges and warning systems, will also help save lives by warning people of flooding in advance and allow for more rapid and accurate road closures. Detailed modeling and mapping will also help protect recreation resources and agriculture by providing a means for evaluation of impacts of future development.

Until the FMEs are completed, their specific benefits cannot be quantified; however, there are an estimated 11,550 structures located in the 1% ACE floodplain, with 12,170 in the 0.2% ACE floodplain. These structures represent a population of nearly 41,800 and 54,020 people, respectively. Tens of thousands more are exposed to risk as they travel across flooded roadways and LWCs. These FMEs will help reduce the risks to these people and help prevent additional flood exposure by providing more accurate information on the flood risks, empowering communities to keep citizens and their property out of harm's way.

Approximately 49 of the FMEs will specifically evaluate proposed FMPs as "project planning" type FMEs. **Table 6-3** tabulates flood exposure within these study areas, with the exception of a county-wide culvert evaluation, which was excluded as to not over represent potential impacts. While it is unlikely that implementing FMPs in these areas will fully resolve flood exposure, these numbers reflect the maximum potential impact of implementing FMPs identified by the project planning studies.

Table 6-3: Total Project Planning Flood Mitigation FME Existing 1% ACE Exposures

Flood Mitigation FME Exposures	
Structures	1,168
Population	6,398
Ag Land (ac)	2,075
Critical Facilities	5
Road Length (mi)	82

6A.4 Impacts of Recommended FMPs, FMEs, and FMSs Compared to Regional Goals

The RFPG established the flood mitigation and floodplain management goals for the region as presented in **Chapter 3**. Progress toward these goals is intentionally measurable, such as reducing the number of habitable structures within the 1% ACE flood hazard layer by 20 percent in 10 years (short term) and 50 percent in 30 years (long term). Accordingly, each FMS, FME, and FMP that is recommended in the RFP addresses at least one of the goals established by the RFPG.

The primary goals addressed by the various FMSs, FMEs, and FMPs recommended in the RFP are presented in **Table 6-4**.

Table 6-4: Comparison of Recommended FMSs, FMEs, and FMPs to Regional Goals

Recommended FMS, FME, or FMP	Sponsors/Impacted Communities	Primary Goal Addressed
Recommended FMSs		
Join NFIP or adopt similar standards	47 communities/counties	Increase NFIP participation or adopt similar standards
Various drainage capital projects	Amarillo and Canyon	• Consider and incorporate nature-based practices • Reduce number of habitable structures at flood risk • Improve safety at LWCs
Update subdivision ordinance to enhance flood consideration	Wichita County	Increase NFIP participation or adopt similar standards
Educate public on flood safety	Region-wide	Improve safety at LWCs
Provide resources/assistance to communities for funding	Region-wide	• Increase percentage of communities with dedicated funding sources • Reduce number of habitable structures at flood risk
Recommended FMEs		
Dam safety evaluations	Region-wide plus Bivins Lake and Farmers Creek	Develop baseline understanding of risks from high-hazard dams
Detailed H&H study of Wichita River, Drainage Master Plans, Perform/Update FIS Studies, GIS inventories	• 64 drainage master plans • 41 FIS studies • 11 GIS inventories	Evaluate watersheds to confirm and/or refine flood risk

Recommended FMS, FME, or FMP	Sponsors/Impacted Communities	Primary Goal Addressed
Multiple (37) planning projects	Amarillo	• Reduce number of habitable structures at flood risk • Improve safety at LWCs
Recommended FMPs		
Various FMPs recommended	Amarillo, Canyon, and Wichita Falls	• Reduce number of habitable structures at flood risk • Improve safety at LWCs

6A.5 Summary of the Impacts of the RFP

If fully implemented, the RFP will have profound and lasting impacts on flooding in Region 1. In addition to tangible reductions in flood risks through the implementation of FMPs, the recommended FMSs and FMEs will significantly reduce the expansion of flood risks in the future by providing communities with the data and resources needed to control floodplain development and prevent the expansion of the floodplain. While in some cases not readily quantifiable, these measures will protect the health and safety of the region, as well as its economic wellbeing.

Development in general, and especially in the floodplain, has the potential to increase flood flows that can cause downcutting and erosion of streams that can lead to environmental issues and sedimentation downstream. The FMEs and FMSs in this RFP will help restore past damages and prevent future damage, which will help preserve usable land in the region, protect agricultural and recreation lands, reduce erosion, and prevent downstream sedimentation. Additionally, the FMPs that are recommended in the plan are not anticipated to have negative environmental or water quality impacts.

Flood mitigation measures have the potential to adversely impact neighboring areas, especially when conveyance is increased. The FMPs recommended in this plan were determined to have no adverse flood impacts at this stage in project development. Any impacts identified in future design and construction efforts will be mitigated as required by the flood planning process and the development criteria of the respective jurisdictions.

The recommended FMSs largely require more active and proactive floodplain management by communities in the region. These initiatives will require additional training, education, and staff to effectively enforce regulations and may meet some resistance from citizens wishing to engage in risky floodplain construction. However, through increased public education and outreach and the coherent set of recommendations provided by this RFP, citizens will become more informed and more likely willing to accept the limitations as a trade-off for personal and public safety. Overall, the

implementation of this RFP and subsequent planning efforts will lead to stronger, more resilient communities across the region.

None of the FMSs, FMEs, or FMPs are expected to have an impact on the water supply. This evaluation is further discussed in Task 6B.

6B. Contributions to and Impacts on Water Supply Development and the State Water Plan

The goal of Task 6B was to evaluate potential impacts of the RFP on water supply development and the SWP. This chapter describes the processes undertaken by the RFPG to perform this evaluation and summarizes the outcomes of this effort.

The following sections provide:

- A region-wide summary and description of the contribution that the RFP would have on water supply development, including a list of specific FMSs and FMPs that would measurably impact water supply
- A description of any anticipated impacts that the RFP FMSs and FMPs may have on water supply, water availability, or projects in the SWP.

6B.1. Contribution of the Regional Flood Plan on Water Supply Development

The RFP must identify recommended FMSs or FMPs that, if implemented, would measurably contribute to water supply. This categorization would include any FMS and FMP that:

- Directly increases water supply volume available during drought of record, which requires both availability increase and directly connecting supply to specific WUG(s) with an identified water supply need
- Directly or indirectly benefits water availability

Examples of FMSs and FMPs that could measurably contribute to water supply include projects that directly or indirectly recharging aquifers. Within Region 1, this is an especially important consideration, since playas in the Texas High Plains play an important role in groundwater recharge of the Ogallala Aquifer.

Additionally, large detention structures could potentially be modified to include a water supply component for irrigation or other needs. Another example could be the implementation of stormwater management ordinances that manage flooding but could also include a water supply aspect of beneficial reuse for irrigation purposes. Finally, while not generating a measurable water supply, green infrastructure, natural channel design, stormwater detention, low impact development, and other measures can help mitigate flood flows and at the same time protect water quality. This can help manage downstream water treatment costs and benefit rate payers.

Additionally, RFPGs must also list recommended FMSs or FMPs that, if implemented, would negatively impact and/or measurably reduce:

- Water availability volumes that are the basis for the most recently adopted SWP
- Water supply volumes if implemented

An example of an FMS or FMP that could measurably reduce water availability involves reallocating a portion of reservoir storage that is currently designated for water supply purposes to be used for flood storage instead. Additionally, land use changes over time could potentially reduce groundwater availability due to less naturally occurring aquifer recharge and an FMS that preserves open space or limits additional impervious cover could help maintain aquifer recharge.

As noted in **Table 13** and **Table 14** (**Appendix D-3**), it was determined that there **are no recommended FMSs or FMPs that would measurably contribute or have a negative impact and/or measurably reduce water supply if implemented.**

6B.2 Anticipated Impacts to the State Water Plan

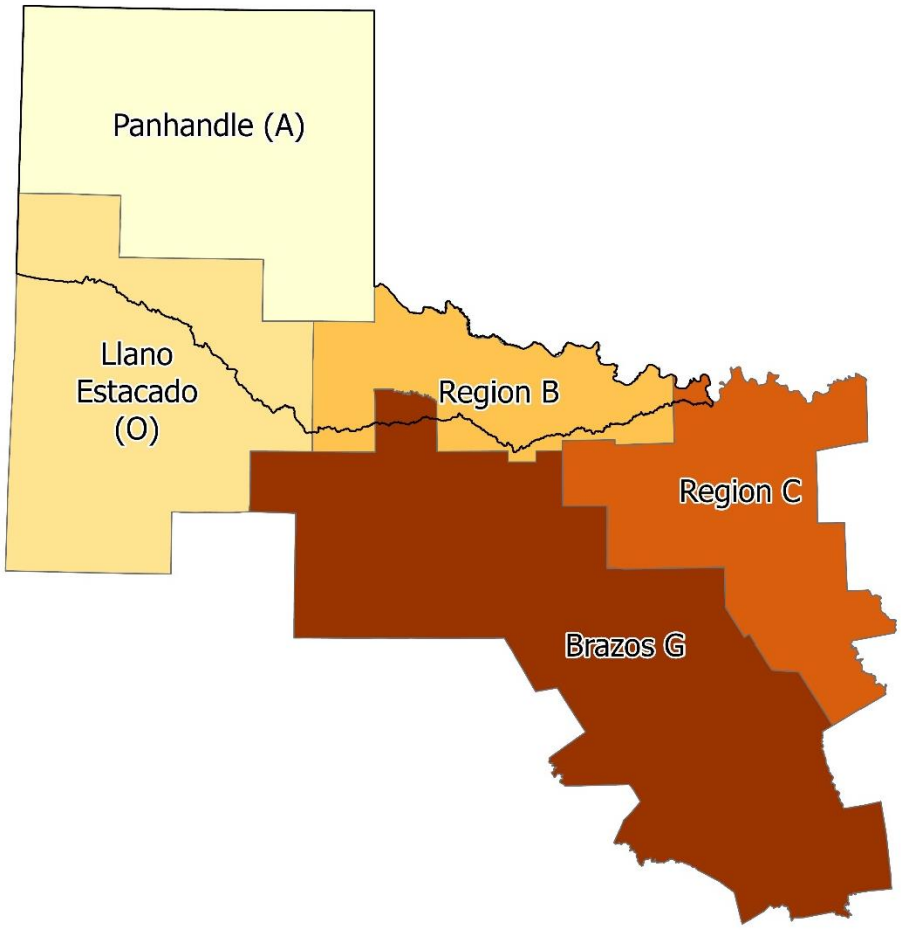
In response to the 1950's drought, TWDB was established in 1957 to prepare a comprehensive long-term plan for the development, conservation, and management of the state's water resources. The current SWP, *2022 State Water Plan – Water for Texas*, was produced by TWDB and based on approved RWPs in accordance with SB 1, enacted in 1997 by the 75th Texas Legislature. As stated in SB 1 Section 16.053.a, the purpose of the regional water planning effort is to:

"…provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of that particular region."

TWDB established 16 Regional Water Planning Areas (RWPAs) and appointed members who represent key public interests to the Regional Water Planning Groups (RWPGs). This grassroots approach allows planning groups to evaluate region-specific risks, uncertainties, and potential water management strategies. Region 1 encompasses all of the Region A (Panhandle), along with portions of Region B and O (Llano Estacado) and small portions of Regions C and Brazos G.

The following sections describe the portions of the RWPAs that are contained in Region 1 and identifies the major reservoirs that are contained within Region 1. **Overall, there are no FMSs or FMPs recommended in this RFP that would negatively impact or measurably reduce water available to water management strategies recommended in any 2020 RWP or the 2022 SWP.**

Figure 6-2: Region 1 Overlap with Water Planning Regions



Source: Water Planning Areas (TWDB Data Hub)

6B.2.1 Region A (Panhandle)

Region 1 contains all of Region A, which includes 21 counties and the major cities of Amarillo, Pampa, Borger, and Dumas. The primary aquifer in this region is the Ogallala Aquifer, and there is one other major aquifer and three minor aquifers. Most of the region relies on groundwater supplies, as surface water is limited.

According to the 2021 Region A Water Plan, there are three major reservoirs and nine minor reservoirs in the region. These existing reservoirs in Region A by river basin are listed in **Table 6-5**. Five existing reservoirs, Lake Meredith, Lake McClellan, Buffalo Lake, Lake Marvin, and Lake Fryer, list flood control as one of multiple uses, with the other reservoirs being used for water supply, recreation, soil conservation, or groundwater recharge. There are no recommended FMSs or FMPs that impact the proposed operation of these existing reservoirs.

Table 6-5: Existing Major Lakes and Reservoirs in Region A

Lake/Reservoir	River Basin	County
Baylor Lake	Baylor Creek	Childress
Bivins Lake	Palo Duro Creek	Randall
Buffalo Lake*	Tierra Blanca Creek	Randall
Greenbelt Reservoir	Salt Fork of the Red River	Donley
Lake Childress	Unnamed tributary to Baylor Creek	Childress
Lake Fryer*	Wolf Creek	Ochiltree
Lake Marvin*	Boggy Creek	Hemphill
Lake McClellan*	McClellan Creek	Gray
Lake Meredith*	Canadian River	Hutchinson/Moore/Potter
Lake Tanglewood	Palo Duro Creek	Randall
Palo Duro Reservoir	Palo Duro Creek	Hansford
Rita Blanca Lake	Rita Blanca Creek	Hartley

Source: 2021 Region A Water Plan
**known flood control function*

6B.2.2 Region B

Region 1 contains the majority of Region B, which includes primary cities of Burkburnett, Vernon, and Wichita Falls, and parts or all of 11 counties. There are two major and two minor aquifers in this area of Region B. Groundwater provides the majority of total water use in eight counties, while surface water provides the majority in three counties.

According to the 2021 Region B Water Plan, there are 14 major reservoirs in this portion of Region B, listed in **Table 6-6**. Lake Kemp has an operational goal of flood control, and all other reservoirs provide flood control benefits, while being primarily used for water supply and recreation. There are no recommended FMSs or FMPs that impact the proposed operation of these existing reservoirs.

Table 6-6: Major Existing Reservoirs in Region B Associated with Region 1

Lake/Reservoir	River Basin	County
Bowie Lake	Middle Belknap Creek	Montague
Lake Arrowhead	Little Wichita River	Archer/Clay
Lake Cooper	Mesquite Creek	Archer
Lake Diversion	Wichita River	Archer/Baylor
Lake Electra	Camp Creek	Wilbarger
Lake Iowa Park	Stevens Creek	Wichita
Lake Kemp*	Wichita River	Baylor
Lake Kickapoo	Little Wichita River	Archer
Lake Nocona	Farmer's Creek	Montague
Lake Olney	Mesquite Creek	Archer
Lake Pauline	Wanderer's Creek	Hardeman
Lake Wichita	Holliday Creek	Archer/Wichita
North Fork Buffalo Creek Reservoir	N. Fork Buffalo Creek	Wichita
Santa Rosa Lake	Beaver Creek	Wilbarger

Source: 2021 Region B Water Plan
**operational goal of flood control*

6B.2.3 Region O (Llano Estacado)

Region 1 contains portions of Region O, including the City of Hereford and parts or all of nine counties. Region O shares its primary aquifer, the Ogallala Aquifer, with Region A. There are two major and three minor aquifers in this area of Region O. Groundwater provides the majority of total water use in all nine counties.

According to the 2021 Region O Water Plan, Mackenzie Reservoir is the only major reservoir in this area of Region O. Mackenzie Reservoir has an operational goal of water supply, but also provides some flood control benefits. There are no recommended FMSs or FMPs that impact the proposed operation of this reservoir.

6B.2.4 Regions C and G

Only one county in Region G is partially included in Region 1, Knox County. There are one major and one minor aquifer in the area of Region G shared by Region 1. Groundwater provides the majority of total water use in area of Region 1 that covers Region G.

According to the 2021 Region G Water Plan, Truscott Brine Lake, operated by the USACE for the removal of chlorides and not water supply, is the only reservoir in the area of Region G shared by Region 1. There are no recommended FMSs or FMPs that impact the proposed operation of these existing reservoirs.

Only a small portion of Region C, part of Cooke County, is located in Region 1. Hubert M Moss Lake is the only major reservoir in this area and is used for water supply and recreation.

Chapter 7. Flood Response Information and Activities

This chapter provides an overview of flood emergency management and focuses on the preparedness, response, and recovery phases of flood emergencies specific to the Canadian–Upper Red Region. In addition, a brief summary of recommendations to improve the region's flood emergency management is included. The summarized information in this chapter relies upon survey responses, oral testimony of entities and citizens from the region, and local knowledge of the technical consultants with the idea that the presented flood response information and activities are specific to this region.

7.1 Flood Management Overview

FEMA defines the four phases of emergency management as follows: Mitigation, Preparedness, Response, and Recovery. Error! Reference source not found. presents these four phases with definitions and example specifically related to flooding emergencies.

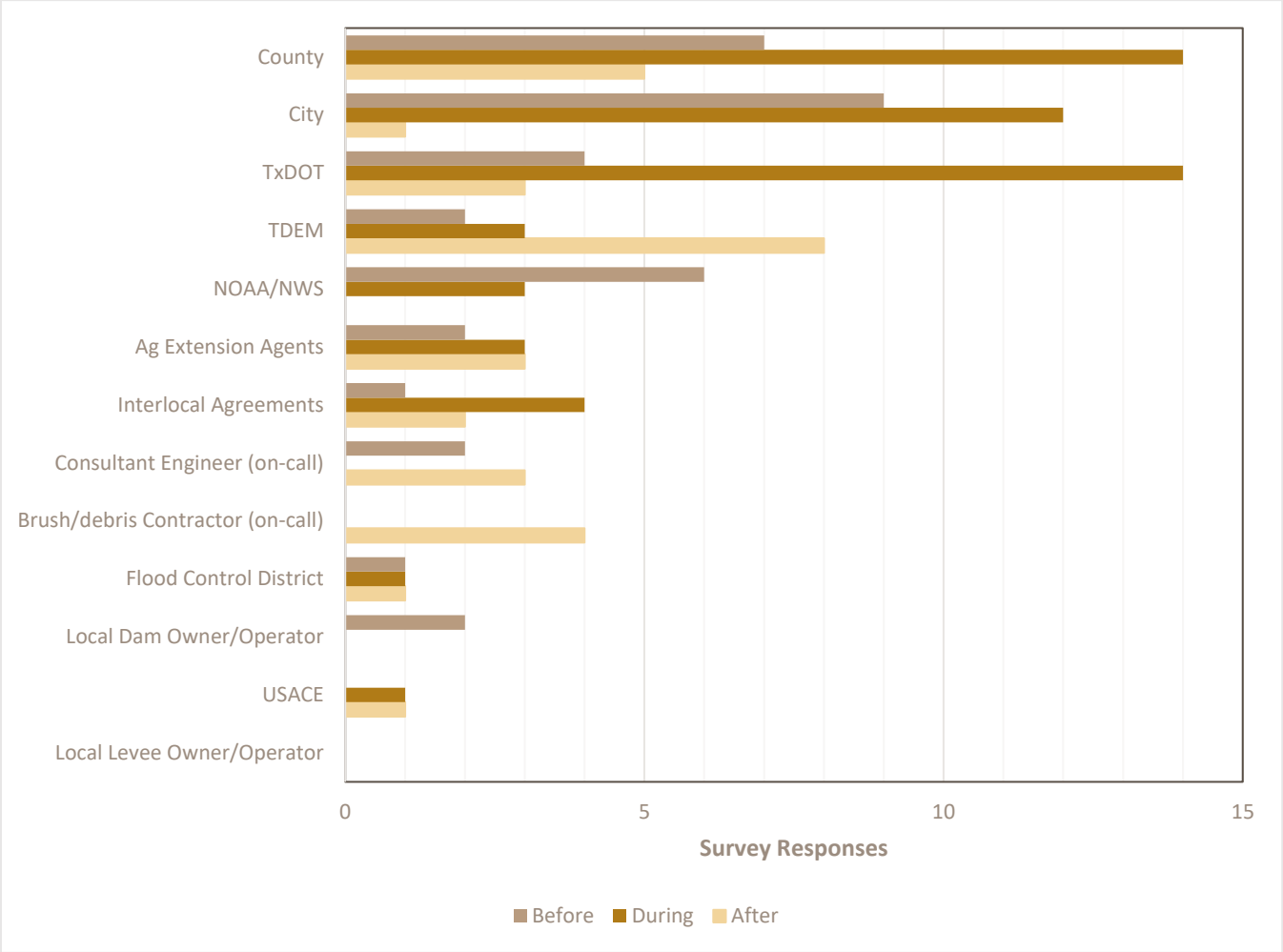
Since much of the RFP focuses on flood mitigation, the remainder of this chapter highlights the regional status of the last three phases of flood emergencies: preparedness, response, and recovery. However, analysis and other activities related to planning for disaster response or recover activities is not a focus of the regional flood planning effort. **Figure 7-1** shows survey responders' reliance upon various entities during flood emergencies. These responses are divided into before, during, and after a flood emergency, which would correspond to preparedness, response, and recovery. A more detailed look at the flood emergency management measures provided by the key entities is provided in the corresponding section highlighting preparedness, response, and recovery.

Table 7-1: Four Phases of Flood Management

Phase	General Definition	Example Activities (not an exhaustive list)
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." (Title 31 TAC, 361.10(k))	Improving LWCs or bridges; constructing storm drainage infrastructure; acquiring, elevating, and/or floodproofing structures in the floodplain; and developing regulatory requirements for reduction of flood risk.
Flood Preparedness	Actions, aside from mitigation, that are taken before flood emergencies to prepare for flood response activities.	Developing emergency management and evacuation plans, preparing staging areas, and building flood early warning systems.
Flood Response	Actions taken during and in the immediate aftermath of a flood emergency to save lives and prevent property damage.	Conducting evacuations, performing rescue operations, providing shelters, closing flooded roads, operating flood warning systems.
Flood Recovery	Actions taken after a flood emergency to return to normal or safer conditions following the event.	Repairs to damaged infrastructure, storm event debris removal, seeking financial assistance.

Source: TWDB Technical Guidance (adapted from Table 18)

Figure 7-1: Entities and Mechanisms Involved with Flood Emergency Management According to Survey Responses



Source: Region 1 Stakeholder Survey Responses

7.2 Flood Preparedness Activities

Aside from preparedness activities related to flood mitigation, the region largely lacks dedicated flood preparedness such as emergency planning documents, staff, equipment, and systems for flooding emergencies. When surveyed, approximately 40% responding entities have staff dedicated to flood emergency situations with 75% of those staff embedded within emergency operations. These dedicated staff generally include elected officials, emergency management coordinators, law enforcement, and administration from a local city or county.

Most governmental entities and citizens within the region primarily rely upon the NOAA for forecasting of riverine flooding and flash flooding events through the National Weather Service (NWS). The NWS issues watches, advisories, and warnings for both flooding and flash flooding, as well as hydrologic, hazardous weather, and excessive rainfall outlooks.

The Arkansas-Red Basin River Forecast Center, a division of the NWS, provides river flood forecasting for the region, which is normally given as river stage forecasts within the flood warning statement. Unfortunately, this type of flood forecasting is only available for limited parts of the region threatened by riverine flooding. The river stages are measured at specific locations on major streams including:

- Beaver Creek
- Canadian River
- Palo Duro Creek
- Pease River
- North Fork (Red River)
- Salt Fork (Red River)
- Prairie Dog Town Fork (Red River)
- Red River
- Sweetwater Creek
- Wichita River
- Wolf Creek

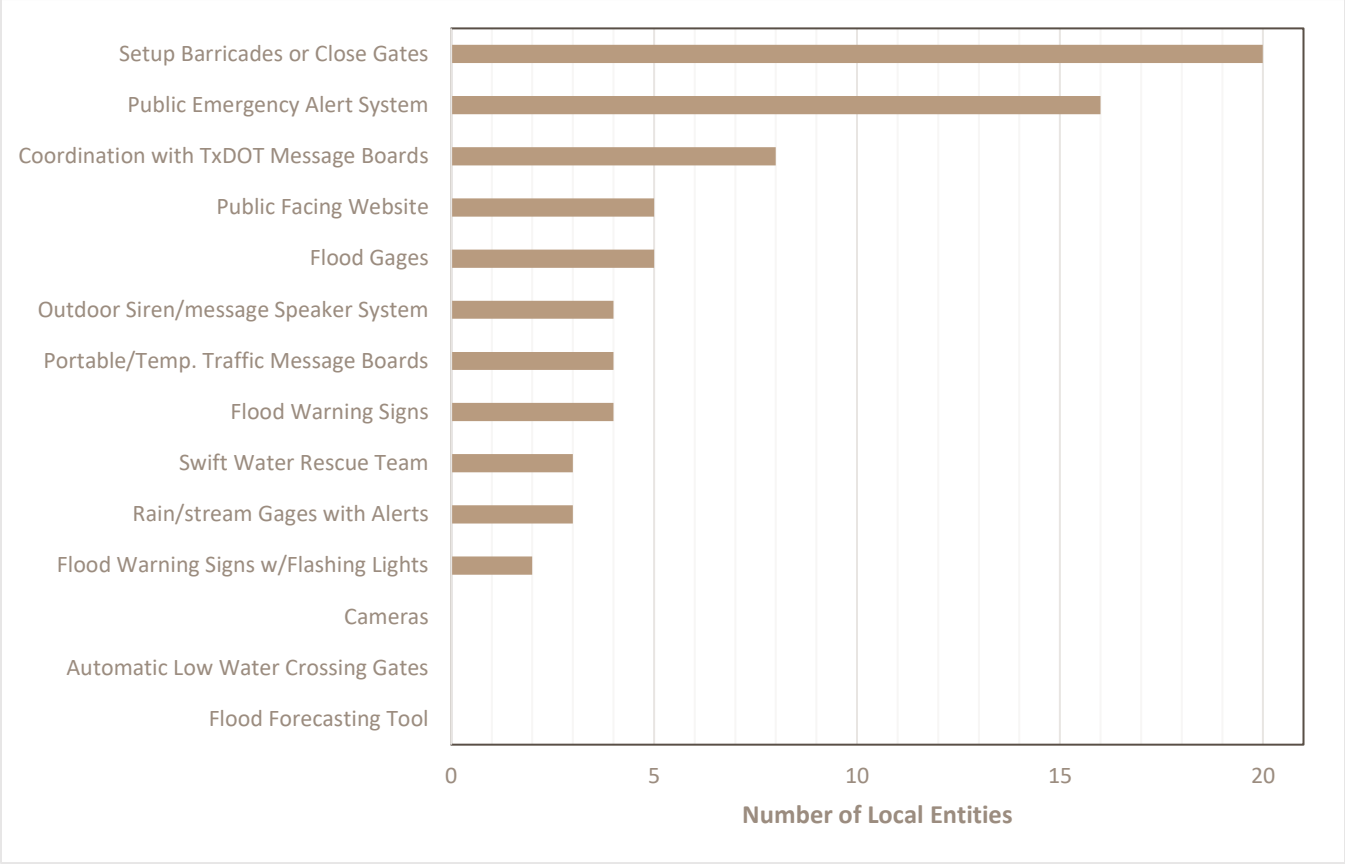
Since there is limited flood warning infrastructure in the region, local emergency managers are forced to rely on less sophisticated flood forecasting mechanisms to keep their communities safe. It was reported that in some cases, rudimentary staff gauges along streams, such as carvings on trees from historical floods, are used to forecast the severity of downstream flooding. More often, even less sophisticated flood forecasting is used by estimating the rainfall intensity as indicated by the runoff depths in streets, curbs, and ditches. Otherwise, local knowledge of historical flooding and flood prone areas is the primary source of information available to city and county officials to prepare for a flood.

7.3 Flood Response Activities

Flooding events within the region are usually short-lived, so the flood response is typically provided by the local entities such as counties, cities, and TxDOT in order of significance, as indicated in **Source:** TWDB Technical Guidance (adapted from Table 18)

. The region's most common flood response measures are using the public emergency alert system, such as reverse 911, and the barricading or closing of roads. **Figure 7-2** shows the number of entities that provide various flood response measures, according to survey responses.

Figure 7-2: Flood Response Measures Used by Entities



Source: Region 1 Stakeholder Survey Responses

TxDOT has a major role in flood emergency response within the region that is primarily closure of flooded roads and using digital message boards. By far, TxDOT maintains the most roads within the region, and road closures is the most common flood emergency response mechanism within the region. Also, TxDOT's website for current road conditions, drivetexas.org, is useful during flood emergencies of extended duration.

Cities and counties are the other entities that provide significant flood emergency response within the region and their emergency responses are similar. Again, the primary response is the closure of flooded roads, with the use of the public emergency alert system the second most common response for cities and counties, as shown in **Figure 7-2**. Responses by cities and counties in the more populous areas of the region, such as Amarillo and Wichita Falls, are often more sophisticated with dedicated emergency management coordinators and first responders, which include swift water rescue teams. Wichita Falls monitors flood levels via gauges which they partnered with the USGS to install and maintain. They utilize this information along with predetermined inundation maps tied to gauge heights to manage evacuations along the Wichita River. Amarillo city staff manually check playa levels during and after flood events. Ponding areas along I-40 in Amarillo are critical locations that require road closures during flood events.

Rarely, evacuations are necessary and are ordered by cities and/or counties within the region. However, evacuations of residents along the Wichita River, Pond Creek, and Gilbert Creek in Wichita County in response to flooding were conducted in 2007 and/or 2015 by the City of Wichita Falls, City of Burkburnett, and Wichita County.

7.4 Flood Recovery Activities

The most common flood recovery activity within the region is debris removal at culvert entrances and bridges, which, if not remedied, compounds the next flood emergency. This activity is primarily conducted by cities, counties, and TxDOT. A lack of coordination between the responsible entities for debris removal at these facilities is a commonly reported problem by cities and counties.

FEMA is the primary agency that provides funding and support for recovery efforts after severe flooding emergencies within the region. Cities, counties, and individuals coordinate rebuilding efforts through FEMA, which are aided by relief funds and low-interest loans.

The Texas Division of Emergency Management (TDEM), a division of the Texas Department of Public Safety, coordinates recovery efforts through support of local governments and direct operations. TDEM assesses damages, identifies community needs, and advises local officials regarding state assistance and resources. Region 5 of TDEM is responsible for most of the Canadian–Upper Red Region, with Region 1 covering Cooke County.

Occasionally, recovery activities include the demolition and/or repair of flooded structures. After the 2007 flooding of the Wichita River in Wichita Falls, several structures were purchased and demolished by the City of Wichita Falls. Also, the City of Wichita Falls initiated a program that removed underbrush and trees in the immediate floodplain of the Wichita River within and downstream of Wichita Falls. In Wichita County along Pond Creek, several homes were repaired after a flash flooding event in 2015 (Forester, 2016). These recovery activities are generally funded through FEMA, TDEM, and individual citizens.

7.5 Recommendations

According to survey responses, 24% of responding entities want the implementation of flood warning and response mechanisms to be a priority of the RFP. Flood warning and response can be improved through several strategies and initiatives, including:

- Increasing public education of flooding issues
- Developing a flood hazard map for LWCs
- Enhancing infrastructure at LWCs (flashing signs, gates, gauges)
- Increasing training opportunities and funding for local flood managers
- Expanding the coverage and density of real-time stream gauges
- Promoting coordination between TxDOT and local governments after flooding events

Chapter 8. Administrative, Regulatory, and Legislative Recommendations

As guided by the TWDB rules for regional flood planning, the RFPGs may adopt recommendations on policy issues related to floodplain management and flood mitigation planning and implementation. Specifically, the RFPGs may adopt:

1. *legislative recommendations that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation;*
2. *other regulatory or administrative recommendations that they consider 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; and*
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."*

These recommendations may address items that benefit and/or can be implemented at the local, regional, or state levels and may include suggested changes to the flood planning process for the TWDB to consider in the next regional and state flood planning cycle.

The Canadian–Upper Red RFPG discussed the following recommendations during the April 14, 2022, May 11, 2022, and June 22, 2022 meetings. Any modifications made subsequent to the June 22, 2022 meeting are of strictly an editorial and organizational nature. Where helpful, additional explanation is given for specific recommendations.

8.1 Administrative Recommendations

The Canadian–Upper Red RFPG encourages TWDB to pursue the following administrative recommendations, as presented in **Table 8-1**.

Table 8-1: Administrative Recommendations

ID	Recommendation	Explanation
8.1.1	Develop model standards and ordinances for general law cities (e.g., building codes, subdivision regulations, etc.).	Over time, as communities utilize these model ordinances when adopting new ordinances or updating existing ordinances, there will tend to be a more consistent and robust level of practice statewide.
8.1.2	Develop model floodplain management standards for varied levels of floodplain management practices (low, medium, high) to encourage increased levels.	Over time, as communities utilize these model ordinances when adopting new ordinances or updating existing ordinances, there will tend to be a more consistent and robust level of practice statewide.
8.1.3	Compile research and develop standards for flood management inside and adjacent to playas. This would include best practices for dealing with the unique hydrology of playas.	Playa hydrology is a subject area unique to the High Plains region and deserves the support of additional technical resources to develop science-based playa management practices and promote effective floodplain management moving forward.
8.1.4	Provide ongoing training targeted to non-technical floodplain administrators to promote a higher level of floodplain management in communities across the State that may not have the necessary resources or technical expertise to perform these functions themselves.	An example of non-technical Floodplain Administrators would be county judges who serve as floodplain administrators. This effort would include the development of online resources including training modules, webinars, and print resources. This would also include guidance regarding their expected roles and regulatory authority. It could be accomplished under a partnership with the Texas Floodplain Managers Association (TFMA).
8.1.5	Provide funding and/or technical assistance to smaller jurisdictions to assist them in dealing with flood planning and management and encourage interjurisdicational cooperation.	Most of the 90 communities in Region 1 have less than 2,500 residents. Often these communities do not have the technical, administrative, or financial resources to effectively pursue flood evaluations, FMPs or even apply for funding. Assistance from TWDB could include the following: a. Assistance in preparing funding applications. b. Training for Councils of Government to assist cities with funding processes. c. Use of the project list in the SFP to help connect local communities to federal grant programs that are administered by state agencies (TWDB/TDEM) and provide a “one stop” application process. d. Expanded consideration and priority for FMEs that establish initial FEMA effective floodplains in smaller communities. Establishing BFEs is a key first step for many communities to consider floodplain

ID	Recommendation	Explanation
		management practices and identify FMPs. This recommendation would be for TWDB to provide the technical services or funding for a FME that would provide the technical information necessary for FEMA to establish BFEs for a community. e. Development of state incentives for local governments to participate in the FEMA NFIP and CRS program. Develop a model process for participation in each program. Many communities don't know how to start the process, or even if they want to start in the first place, because many communities have a distrust of federal programs. If TWDB were to provide incentives, part of the "package" should be a clear explanation of the benefits and limitations that such participation brings. f. Provision of a funding mechanism for smaller communities to acquire funds for studies to identify FMSs, FMEs and FMPs.
8.1.6	Develop alternatives to a traditional BCR when ranking projects within the SFP that benefit agricultural and energy activities.	Projects that benefit primarily agricultural and energy activities typically will not score well from the perspective of a traditional BCR analysis. TWDB is encouraged to develop an alternative methodology to account for the benefits to agricultural and energy when ranking projects.
8.1.7	Expand consideration for projects that do not provide 1% ACE (100-year) flood LOS but can demonstrate substantial benefit during higher frequency (smaller) events.	The “100-year” flood from riverine sources has traditionally been the focus for much flood mitigation activity. However, for many communities in Region 1, localized flooding from more frequent, non-riverine events is the primary cause of repetitive flood losses. It can also be challenging to identify flood mitigation solutions for 100-year flood events that demonstrate an acceptable BCR. Regional and State planning processes should acknowledge this fact and provide greater emphasis on a wider range of flood events that contribute to flood damages including these smaller, localized events.

ID	Recommendation	Explanation
8.1.8	Develop a publicly available statewide database and tracking system to document flood-related fatalities. This could be an addition to the Flood Plan Data Hub to capture existing data from TxDOT, NOAA, or others.	This would help educate the public about flood-related issues and establish metrics to show progress towards reducing flood-related fatalities.
8.1.9	Partner with TFMA to promote public education and outreach about flood awareness and flood safety and provide outreach materials to communities.	This would help educate the public about flood-related issues.
8.1.10	Maintain a flood hazard area map on a public web map platform database, potentially integrated with the existing Water Data interactive site.	This would help educate the public about flood-related issues.
8.1.11	Provide outreach information that varies geographically and is tailored to a wide variety of flood situations.	The way that floods cause harm is different in wetter and dryer areas, areas which are more urban versus rural, coastal versus inland, and localized depressions such as playas versus riverine. People will be more receptive to acknowledging flood risk if the message provided to them is tailored towards the type of place that they live. For example, outreach focused on urban flooding provided to a small, rural town may seem irrelevant to that audience.
8.1.12	Develop a model-based future conditions flood hazard data layer using BLE data and provide it for use by RFPGs and the technical consulting teams during the next flood planning cycle.	This will greatly improve the information regarding future flood risk presented in the RFPs and provide more uniformity in data and mapping quality across the regions.
8.1.13	Incentivize voluntary buyout programs, turning previously flooded properties and neighborhoods into green space and parkland as an alternative to large-scale construction projects.	This will encourage use of alternatives to hard projects for flood mitigation. When buyouts occur and the structures are demolished, the now vacant lots should be converted to green space in a manner consistent with the climate and topography of the area to reduce demands on increasingly stressed water supplies.

ID	Recommendation	Explanation
8.1.14	Provide training to state agencies, local governments, engineers, and planners in the use of natural floodplain preservation/ conservation techniques.	This will encourage the use of alternatives to hard projects for flood mitigation.
8.1.15	Identify and eliminate barriers that prevent jurisdictions from working together to provide regional flood mitigation solutions and identify process that would encourage greater regional cooperation.	For example, if a primary sponsor meets all administrative requirements but additional participating jurisdictions do not, allow the regional solution to remain in contention for state funding.
8.1.16	Provide funding to support multi-jurisdictional cooperation on FMEs, FMSs and FMPs.	Often, no single jurisdiction has the funding available to "get the ball rolling" on a project or evaluation that would span or include adjacent flood management jurisdictions. Such funding would encourage regional solutions to flood problems.

8.2 Regulatory and/or Legislative Recommendations

Floodplain management and flood mitigation can be improved through encouragement of consistent statewide or nationwide standards, enhanced availability of funding and adoption of specific legislation, as presented in **Table 8-2**. Regulatory and legislative recommendations have been grouped together because there is potential for overlap between regulatory requirements and the need for legislative action from the State. Many of these recommendations also identify new revenue raising opportunities or mechanisms for floodplain management and flood mitigation activities.

Table 8-2: Regulatory and/or Legislative Recommendations

ID	Recommendation	Explanation
8.2.1	TWDB and TFMA should encourage communities to adopt 2015 or 2018 versions of International Building Code and International Residential Code as State Building Standards. Additionally, TWDB and TFMA should recommend to FEMA updating BRIC scoring criteria to better capture the disparate needs of Texans across the State.	If a building standard is adopted statewide, this would improve Texas' eligibility for funding under the BRIC program. A key measure of the 2015 International Building Code is the requirement of one foot of freeboard for new buildings. Given the physical size of the State of Texas and the wide range of conditions where infrastructure is built, it is unlikely and potentially inappropriate that a standard building code would be adopted statewide. Instead, TWDB should begin discussions with the BRIC program to provide additional credits when building codes are adopted on a county-wide basis. The rationale for considering a Texas county equivalent to a state for scoring purposes is that many Texas counties are as large geographically or as populous as some eastern states.
8.2.2	TWDB and TFMA should recommend (not adopt or require) a statewide building standard of a minimum floor elevation equal to the BFE plus freeboard.	This will account for potential changes in future rainfall depths and flood elevations but may not be appropriate as a statewide minimum standard given the physical size of the State and the wide range of conditions where infrastructure is built.
8.2.3	TxDOT should review and update its design criteria to identify opportunities to improve consideration for flood safety to better align with the goals and objectives of the regional flood planning criteria.	This will allow for more consistency across a FPR and encourage TxDOT to consider regional flood planning goals as it plans future projects.
8.2.4	TxDOT should review and update its design criteria to require no adverse impacts for proposed road projects.	This will reduce the likelihood of a TxDOT project negatively impacting existing development.
8.2.5	TxDOT should review and update its design criteria to require design for future conditions.	This will help ensure that TxDOT projects are designed holistically with regard to expected development.
8.2.6	TWDB and TFMA should encourage FEMA to streamline the CRS application process.	This will make it easier for communities to obtain certification and implement at the local level.

ID	Recommendation	Explanation
8.2.7	The Texas Legislature should allocate funding for recurring biennial appropriations to the FIF for study, strategy, and project implementation.	This will provide a consistent, statewide source of funding for local communities to utilize to mitigate flood risk.
8.2.8	The Texas Legislature should allocate funding for a dedicated funding mechanism for TxDOT to improve the flood safety of transportation facilities.	This will help TxDOT prioritize flood safety considerations in its biennial budgeting.
8.2.9	The Texas Legislature should allocate funding for a state levee safety program similar to the TCEQ dam safety program.	Levee failures can be similarly catastrophic as dam failures and levees should be provided a similar level of priority.
8.2.10	The Texas Legislature should allocate funding for a program to assist private dam owners and agencies owning former NRCS dams with the costs associated with evaluation, repair and maintenance of those structures.	Many of these owners lack the resources necessary to evaluate their structures and enact the necessary repairs and maintenance on their own.
8.2.11	The Texas Legislature should allocate funding for incentives for establishment of dedicated drainage funding.	Local jurisdictions often lack the resources to fix drainage problems, and a statewide program incentivizing this investment would lessen this problem.
8.2.12	The Texas Legislature should provide guidance for use of public funds to improve private properties for flood risk reduction.	No direct guidance exists for how to utilize public funds to address flood risks to private properties.
8.2.13	The Texas Legislature should provide counties with legislative authority to establish drainage utilities and assess drainage fees under similar to those authorized for municipalities under Local Government Code, Title 13, Subtitle A, Chapter 552.	The voters within an individual county should have to ability to establish a county-wide drainage utility if it makes sense for that particular county. Given the wide variation across Texas, this recommendation would not necessarily be advantageous to all counties. However, it should be an allowable method for counties which may benefit from developing a dedicated revenue source to fund drainage projects.

ID	Recommendation	Explanation
8.2.14	The Texas Legislature should provide counties with expanded regulatory authority to manage new development to reduce future flood risk and benefit water supplies.	Counties currently lack this authority and are unable to control the impacts of rapid growth on existing communities. Additionally, while State legislation provide counties the authority to regulate floodplains, interpretation of these regulations varies widely from county to county. Additional implementation guidance in the form of administrative rules would help regulate development in unincorporated areas to reduce future flood risk.
8.2.15	The Texas Legislature should provide clarity on roles and responsibilities within ETJ areas related to floodplain management activities.	Current statutes are unclear regarding some of the roles and responsibilities with a City's ETJ with regard to floodplain management.
8.2.16	The Texas Legislature should increase cooperative funding with the USGS to expand the stream gauging network in Texas to provide better information for flood planning and response and improve information available for regional water supply planning.	The utility of this information extends across jurisdictional boundaries. Developing additional hydrological data will improve both planning and response efforts.

8.3 Other Recommendations

Alongside the administrative, regulatory, and administrative recommendations, other recommendations are identified based on regional flood mitigation and floodplain management goals. These include developing flood hazard maps for LWCs and enhancing infrastructure at LWCs (such as flashing signs, gates, and gauges) to improve safety at LWCs. To further preparedness prior to, during, and after flooding events, the expansion of real-time stream gauges is recommended, alongside the promotion of coordination between TxDOT and local governments.

Chapter 9. Flood Infrastructure Financing Analysis

The Region 1 RFPG has recommended a total of 253 flood mitigation actions to address flood risk across the planning region. Combined, these flood mitigation actions are anticipated to cost $261 million to implement.

Table 9-1: Total Cost of Recommended Flood Mitigation Actions

Flood Mitigation Action Type	Number of Recommended Actions	Anticipated Total Cost of Implementation
FME	184	$155.3 M
FMP	9	$92.3 M
FMS	60	$13.4 M
Total	**253**	**$261 M**

Stormwater infrastructure and floodplain management activities are historically underfunded programs compared to other infrastructure types, and this is a continued challenge that local entities documented through their initial survey responses. Lack of funding was indicated as a primary cause of inadequate or deficient drainage infrastructure in nearly all of the surveys received.

This chapter documents the results of Task 9, specifically, how potential sponsors propose to finance recommended FMEs, FMSs, and FMPs. It also presents an overview of common sources of funding for flood mitigation planning, projects, and other flood management efforts. The primary objective of this task is to demonstrate the funding needs of local sponsors and propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs.

9.1 Sources of Funding for Flood Management Activities

Communities across the state utilize a variety of funding sources for their flood management efforts, including local, state, and federal sources. This section discusses some of the most common avenues of generating local funding and discusses various state and federal financial assistance programs available to communities. **Table 9-2** summarizes the local, state, and federal sources discussed in this chapter, and characterizes each by the following three key parameters: first, which state and federal agencies are involved, if applicable; second, whether they are classified as regularly occurring opportunities or are only available after a disaster; and third, whether they offer grants, loans, or both.

Table 9-2: Common Sources of Flood Funding in Texas

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

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
		TWDB	Texas Water Development Fund (DFund)	G	L	
		TSSWCB	O&M Grant Program	G		
		TSSWCB	Flood Control Dam Infrastructure Projects - Supplemental Funding	G		
Local	Not Applicable		General Fund	Not Applicable		
			Stormwater or Drainage Utility Fee			
			Special-Purpose District Taxes and Fees			
			Tax Applications			
			Bonds			

Source: Various Sources
**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, which is similar to grant funding.*

9.1.1 Local Funding

Many communities do not have any dedicated or regular funding sources for stormwater infrastructure or flood management activities, with these communities tending to be smaller, resource-limited, and/or more rural. This describes most of the communities in Region 1. Region 1 only includes 10 municipalities with populations over 10,000 and only three counties with populations over 100,000. Additionally, 32 out of 44 counties, and the region overall, have a median household income below the state level. These communities face an uphill battle to fund community initiatives and capital projects.

Communities that do have local funding generally rely on the following primary sources: general fund; dedicated fees, such as stormwater or drainage utility fees; special districts; tax applications; and bonds. However, each avenue presents its own unique challenges and considerations, to be described in the following sections. Even with these various revenue-raising options, the availability of local funding for stormwater programs is generally much lower than the total need, leading local communities to seek out state and federal financial assistance programs.

9.1.1.1 General Fund

A community's general fund revenue stems from sales, property, and other taxes and is typically the primary fund used by a government entity to support most departments and services such as police, fire, parks, trash collection, and local government administration. Due to the high demands on this fund for

many local needs, there is often not a significant amount available for funding flood projects out of the general fund (Comptroller of Texas).

9.1.1.2 Stormwater or Drainage Utility Fees and Impact Fees

Dedicated fees such as stormwater or drainage fees are an increasingly popular tool for local flood-related funding. Municipalities can establish a stormwater utility (sometimes called a drainage utility), which is a legal mechanism used to generate revenue to finance a city's cost to provide and manage stormwater services. To provide these services, municipalities assess fees to users of the stormwater utility system (Texas Government).

Of the 90 municipalities in Region 1, only five have been identified as having a dedicated stormwater utility fee: the cities of Amarillo, Burkburnett, Iowa Park, Gainesville, and Wichita Falls (Campbell and Bradshaw). It is important to note that while Texas municipalities have the authority to implement utility fees for stormwater and drainage, the State Legislature has not granted that same authority to counties. It is a specific recommendation under **Chapter 8** that the State Legislature consider allowing county providers of drainage services to levee drainage fees, as this represents a currently inaccessible potential revenue source.

Impact fees, which are collected from development to cover a portion of the expense to expand storm water systems necessitated by the new development, can also be used as a source of local funding for flood-related efforts (Texas Government). None of the entities in Region 1 have indicated that they use impact fees to fund drainage projects. State law requires the entity to determine a development's proportional share of use of the proposed drainage infrastructure in order to assess an impact fee, a calculation that can be challenging and time-consuming to produce.

9.1.1.3 Special Districts

Another source for local funding to support flood management efforts includes special districts. A special district is a political subdivision established to provide a single public service (such as water supply, drainage, or sanitation) within a specific geographic area. Examples of these special districts include Water Control and Improvement Districts, MUD, Drainage Districts, and Flood Control Districts. Each of the different types of districts are governed by different state laws, which specify the authorities and process for creation of a district. Districts can be created by various entities, from the Texas Legislature or the TCEQ to county commissioners' courts or city councils. Depending on the type of district, the districts may have the ability to raise revenue through taxes, fees, or issuing bonds to fund flood and drainage-related improvements within a district's area (Comptroller of Texas).

9.1.1.4 Tax Applications

Tax applications include sales/property taxes, sales tax reallocations, and special tax districts, including Tax Increment Financing. Taxes are not a dedicated source of funding for stormwater, and increasing taxes or diverting revenue away from other programs is generally not politically popular. Special tax districts are a useful financing method which allows local governments to invest in public infrastructure improvements in areas that are expected to develop by diverting future tax revenue from these areas to

pay for the cost of these improvements. This mechanism localizes cost to fund projects to an area receiving the benefit; however, it relies on the development in the district to occur as expected in order to finance the project and also diverts future tax revenue away from other programs or needs that may arise.

9.1.1.5 Bonds

Municipalities and counties also have the option to issue debt through bonds which are typically paid back using any of the previously mentioned local revenue raising mechanisms (Texas Association of Counties). There are many types of bonds, including general obligation (GO) bonds, revenue bonds, or certificates of obligation (CO) (Comptroller of Texas). Revenue bonds typically are not used to finance drainage infrastructure, since they are used to finance municipal projects that generate revenue that is then used to make payments to bond holders, which is not typical of drainage infrastructure.

Of the remaining two bond types, GO bonds are more common. While these bonds typically have a high bond rating and low interest rates, there are a handful of constraints. First, different city programs are typically competing with each other for funding through a given bond program. Second, debt obligations contribute to a lack of flexibility in future financing applications. Last but not least, GO bonds require voter approval.

CO bonds typically do not require voter approval and are available to provide flexibility when projects need to be funded quickly. However, they are somewhat controversial and unpopular when not used in emergency applications. Like GO bonds, they contribute to debt obligations which impact future funding decisions.

9.1.2 State Funding

Today, communities have a broader range of state funding sources and programs available due to new grant and loan programs that did not exist even five years ago. There are two primary state agencies currently involved in providing state funding for flood projects: TWDB and the TSSWCB. State and federal financial assistance programs discussed herein are not directly available to homeowners nor the general public. Local governments apply on behalf of their communities to receive and implement funding for flood projects in their jurisdiction.

9.1.2.1 Texas Water Development Board

TWDB's **Flood Infrastructure Fund (FIF)** is a new funding program passed by the Texas Legislature and approved by Texas voters through a constitutional amendment in 2019. The program provides financial assistance in the form of low or no interest loans and 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, including structural and nonstructural projects, planning studies, and preparedness efforts such as flood early warning systems. After the first SFP is adopted, only projects included in the most recently adopted state plan will be eligible for funding from the FIF. FMEs, FMSs, and FMPs recommended in this RFP will be included in the overall SFP and will thus be eligible for this funding source.

TWDB also manages the **Texas Water Development Fund (Dfund) program**, which is a state-funded streamlined loan program that provides financing for several types of infrastructure projects to eligible political subdivisions. This program enables 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 nonstructural projects, planning efforts, and flood warning systems.

9.1.2.2 Texas State Soil & Water Conservation Board

The TSSWCB has three state-funded programs specifically for flood control dams: the 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 a grant program for local soil and water conservation districts (SWCD) and certain co-sponsors of flood control dams. This program reimburses SWCDs 90% of the cost of an eligible O&M activity as defined by the program rules; the remaining 10% 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% of the cost of allowable repair activities on dams constructed by the USDA-NRCS, including match funding for federal projects through the **Dam Rehabilitation Program** and the **Emergency Watershed Protection (EWP) Program** of the Texas NRCS.

9.1.3 Federal Funding

Federal funding currently accounts for a large share of total available funding for flood projects throughout the state, with federal funding programs having greater access and availability to large funding amounts from the federal government appropriated by Congress. There are 12 federal funding programs discussed in this section, administered by several federal agencies and organizations. The funding for these programs originates from the federal government, but for ten of the 12 funding programs, a state agency partner plays a key role in the management of the program. Each funding program has its own unique eligible applicants, eligible project types, requirements, and application and award timelines.

9.1.3.1 Federal Emergency Managment Agency

Common FEMA-administered federal flood-related funding programs include Flood Mitigation Assistance, Building Resilient Infrastructure and Communities, Safeguarding Tomorrow through Ongoing Risk Mitigation, Rehabilitation of High Hazard Potential Dam Grant Program, Hazard Mitigation Grant Program, the Public Assistance program, and the Cooperating Technical Partners Program.

The **Flood Mitigation Assistance Grant Program (FMA)** is a nationally competitive grant program that provides funding to states, local communities, federally recognized tribes, and territories. FMA is administered in Texas by TWDB. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the NFIP. Funding is typically a 75% federal grant with a 25% local match. Projects mitigating Repetitive Loss and Severe Repetitive Loss properties may be funded through a 90% federal grant and 100% federal grant, respectively.

The **Building Resilient Infrastructure and Communities (BRIC)** is a new program implemented in 2020 which replaced the previous Pre-Disaster Mitigation Grant Program. 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 TDEM. Funding is typically a 75% federal grant with a 25% local match. Small, impoverished communities and U.S. island territories may be funded through a 90% federal grant and 100% 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 RFP, 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 TCEQ, provides technical, planning, design, and construction assistance in the form of grants for rehabilitation of eligible high hazard potential dams. The cost share requirement is typically no less than 35% state or local share.

Under the **Hazard Mitigation Grant Program (HMGP)**, FEMA provides funding to state, local, tribal, and territorial governments so they can rebuild from a recent disaster in a way that reduces, or mitigates, future disaster losses in their communities. The program is administered in Texas by TDEM. Funding is typically a 75% federal grant with a 25% 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.

The FEMA **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% federal grant (25% local match) and typically not more than 90% federal grant (10% local match). In Texas, FEMA PA is administered by TDEM.

The **Cooperating Technical Partners (CTP) Program** is an effort launched by FEMA in 1999 to increase local involvement in developing and updating FIRMs, FIS 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 nonprofits 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) 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% 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. 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 which will lessen the impact of future disasters.

The **Community Development Block Grant (CDBG)** program provides annual grants on a formula basis to small, rural cities and to 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).

9.1.3.2 U.S. Army Corps of Engineers

The USACE works with non-Federal partners (states, tribes, counties, or local governments) throughout the country to investigate water resources and related land problems and opportunities and, if warranted, develop 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 **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 via another legislative vehicle. Congress will not provide project authority until a completed study results in a recommendation to Congress of a water resources project, conveyed 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 has technical assistance opportunities, including **Floodplain Management Services** and the **Planning Assistance to States Program**, available to local communities.

9.1.3.3 U.S. Environmental Protection Agency

The **Clean Water State Revolving Fund (CWSRF)** provides financial assistance in the form of loans with subsidized interest rates and opportunities for partial principal forgiveness for planning, acquisition, design, and construction of wastewater, reuse, and stormwater mitigation infrastructure projects. Projects can be structural or non-structural. Low Impact Development (LID) projects are also eligible. The CWSRF is administered in Texas by TWDB.

9.1.3.4 U.S. Department of Agriculture

The USDA's 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 governments protect and restore watersheds; to prevent erosion, floodwater, and sediment damage; to further the conservation development, use and disposal of water; and to further the conservation and proper use of land in authorized watersheds.

The focus of **Watershed Surveys and Planning Program** is funding watershed plans, river basin surveys and studies, flood hazard analyses, and floodplain management assistance aimed at identifying solutions that use land treatment and nonstructural 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 also offers various water and environmental grant and loan funding programs, which can be used for water and waste facilities, including stormwater facilities, in rural communities.

9.1.3.5 Special Appropriations

On occasion and when the need is large enough, Congress may appropriate funds for special circumstances such as natural disasters or pandemics. A few examples of 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 for 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 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 called the **Bipartisan Infrastructure Law**, authorizes over $1 trillion for infrastructure spending across the U.S. 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.

9.1.4 Barriers to Funding

Local communities in Region 1 identified several barriers to accessing or seeking funding sources for flood management activities, including lack of knowledge of funding sources, lack of expertise or resources to apply for funding, and no local funds available for local match requirements. As opposed to some other types of infrastructure, flood projects do not typically generate revenue, and many communities do not have steady revenue streams to fund flood projects, as discussed previously. Consequently, communities struggle to generate funds for local match requirements or loan repayment.

Complex or burdensome application or program requirements as well as prolonged timelines also act as barriers to accessing state and local financial assistance programs. Of those communities able to overcome these barriers, apply for funding, and generate local resources for match requirements, the high demand for state and federal funding, particularly for grant opportunities, means that need outstrips supply, leaving many local communities without the resources they need to address flood risks. Several recommendations under **Task 8** are meant to enhance the availability of state and federal funding for FMPs and to simplify the process for communities to apply for and receive this funding.

9.2 Flood Infrastructure Financing Survey

The Canadian–Upper Red RFPG is committed to assisting local communities with acquiring funding for the flood mitigation actions identified in the RFP. As a first step, the RFPG developed a flood infrastructure financing survey for potential sponsors to gain an understanding of the funding needs in the region and to characterize what role the the RFPG proposes for the state in financing the recommended FMEs, FMSs, and FMPs.

9.2.1 Survey Methodology

The financing survey was a simple survey with a table listing each flood mitigation action for which an entity was identified as a sponsor or co-sponsor in the RFP and instructing them to indicate which

funding sources, if any, had been identified. The survey also included a link to a OneDrive folder that contained project summary sheets for each flood mitigation action listed in the RFP as a resource for sponsors.

The survey was sent via email to 98 community officials on May 23, 2022 requesting responses by June 6, 2022. The contact list was compiled from various sources, including the initial contact list that was used to distribute the survey under **Chapter 1**, contact information collected through the initial flood planning survey for community officials, and available online data.

Where no response was received by the deadline, it was assumed that the action would need 100% funding from the state. Additionally, there were eight communities listed as potential sponsors in the RFP for 11 flood mitigation actions for which no contact information was available. These communities all have populations less than 1,000. Therefore, it was anticipated that they would not have funding available to contribute financially to the projects in the RFP, and it was assumed these actions would require 100% funding from the state.

Table 9-3: Communities with No Contact Information for Financing Survey

Municipality	Number of Flood Mitigation Actions Listed in RFP	Total Cost of Flood Mitigation Actions Listed in RFP
Cashion Community	2	$350,000
Dean	1	$100,000
Jolly	2	$350,000
Lake Tanglewood	1	$250,000
Megargel	1	$250,000
Mobeetie	1	$100,000
Nazareth	1	$100,000
Windthorst	2	$350,000

9.2.2 Survey Results

Table 19 in **Appendix F-1** presents the results of the survey for each FME, FMS, and FMP. Of the 98 communities contacted, 12 responded to the survey, a response rate of 12%. With additional time provided in the second cycle of regional flood planning, and a greater awareness by Texas communities of flood planning initiatives, it is anticipated that a greater response rate may be obtained.

While the overall response rate was low, there is significant interest and continued participation demonstrated by major regional stakeholders. The communities that responded to the survey are listed as sponsors for a combined 98 flood mitigation actions (38%) accounting for $198 million (75%) of total implementation cost. As a result, even with a low response rate, the information received provides a representative picture of total funding needs across the region.

9.3 Proposed Role of State in Financing

Overall, there is an estimated $203 million of funding need to implement the recommended FMEs, FMSs, and FMPs in this RFP beyond what is anticipated to be funded by local sponsors. This figure represents 78% of the total cost of the flood mitigation actions identified in this RFP. There may be other sources of funding through the federal programs outlined in previous sections, or future revenue sources, but these have not been acquired to date for the actions listed in the RFP.

Table 9-4: Anticipated Funding Availability for Flood Mitigation Actions

Flood Mitigation Action Type	Anticipated Total Cost of Implementation	Estimated Funding Available	Estimated Funding Need
FME	$155.3 M	$24.4 M	$130.9 M
FMP	$92.3 M	$33.2 M	$59.1 M
FMS	$13.4 M	$0.4 M	$13.1 M
Total	**$261 M**	**$58.0 M**	**$203.1 M**

This number does not represent the amount of funding needed to mitigate all risks in the region nor to 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 Canadian–Upper Red Region.

For planning purposes, the RFPG recommends using this figure to estimate the need for funding from the state. While certain communities may choose to adjust their expenditure priorities or find ways to generate additional revenue for drainage projects, the RFPG anticipates that a large gap will remain between the cost to implement the RFP and the funding that can be generated by local jurisdictions. The RFPG also recognizes that it is unlikely, if not impossible, for enough money to be appropriated to the FIF to be able to fill the funding gap across the region and the state overall.

The RFPG recommends that TWDB utilize the information generated by these RFPs to assist communities with identifying and leveraging existing funding sources that are available for FMPs, such as by providing assistance to small and underserved communities with funding applications and simplifying and streamlining program and application requirements. The RFP also provides recommendations to help identify other potential revenue-raising opportunities for flood mitigation in the state. These recommendations are discussed in more detail in **Chapter 8**.

Chapter 10. Public Participation and Plan Adoption

This chapter describes the various public participation, information, outreach, and education activities conducted by the Canadian–Upper Red RFPG. All activities and events discussed in this section were performed in direct support of the regional flood planning effort and demonstrate the RFPG's commitment to ensuring that the public is provided with timely, accurate information regarding the flood planning process and that opportunities to provide input are available as often as possible.

The chapter also details the plan adoption process followed by the RFPG. The process explains the required hearing, receipt of comment, comment response, and final adoption of the RFP.

10.1 Public Information and Participation Initiatives

The Region 1 RFPG made a distinct effort to facilitate public participation in the flood planning process. Planning group activities were open and accessible to all interested parties, and numerous opportunities were provided for interested parties to participate in planning group activities and to receive timely information regarding the planning process. Local entities and the public were engaged throughout the process. Public participation opportunities were afforded to the region through the following broad categories. **The RFPG met all requirements of the Texas Open Meetings Act and Public Information Act in development and adoption of the RFP.**

10.1.1 Media

Media concerning the flood planning process was provided through the Texas Water Newsroom and Press Releases from TWDB. Additionally, media outlets across the state provided information about the flood planning process. In Region 1, several local newspapers, radio stations, and universities provided region-specific information about the flood planning process and opportunities for public input.

10.1.2 Electronic Communication Web Access to Planning Information

The Region 1 RFPG runs an updated and detailed project website (www.canadianupperredrfpg.org) where the public is able to access information concerning the RFPG and planning process, including background and context; meeting notices, agendas, and minutes; a GIS dashboard displaying spatial project information; and relevant planning documents. The website also provides several mechanisms for the public to get involved and stay informed about RFPG activities, including a public survey and RFPG member contact information. Additional information concerning the state flood planning process is also available at TWDB's flood planning website (www.twdb.texas.gov/flood/planning/index.asp).

10.1.3 Public Meetings

The RFPG held all meetings in accordance with the Texas Open Meetings Act and encouraged public attendance at the meetings. Initially, public meetings were held fully online via GoToWebinar, a publicly accessible video conferencing platform, due to the COVID-19 pandemic. Once it was deemed safe to begin holding meetings in-person, meetings were conducted in-person at the TxDOT Childress District

Office with a virtual option for the convenience and safety of the attendees and an enhanced opportunity for public participation across the region.

10.1.3.1 Regional Flood Planning Group Meetings

The Region 1 RPFG held several meetings over the course of the planning cycle to perform RFPG functions and to receive updates from the technical consultant. Each meeting had time allotted to public comments and questions. A full list of RFPG meetings for the first planning cycle is included in **Table 10-1**.

Table 10-1: First Cycle RFPG Meeting Dates

Meeting Type	Meeting Date
Regular RFPG Meeting	October 26, 2020
Regular RFPG Meeting	November 18, 2020
Executive Committee Meeting	January 13, 2021
Regular RFPG Meeting	January 14, 2021
Executive Committee Meeting	February 22, 2021
Regular RFPG Meeting	March 11, 2021
Regular RFPG Meeting	April 28, 2021
Regular RFPG Meeting	June 10, 2021
Regular RFPG Meeting	July 22, 2021
Regular RFPG Meeting	August 18, 2021
Regular RFPG Meeting	September 13, 2021
Regular RFPG Meeting	October 14, 2021
Regular RFPG Meeting	November 10, 2021
Regular RFPG Meeting	December 9, 2021
Regular RFPG Meeting	February 23, 2022
Regular RFPG Meeting	April 14, 2022
Regular RFPG Meeting	May 11, 2022
Regular RFPG Meeting	June 22, 2022
Regular RFPG Meeting – Draft RFP Approval	July 18, 2022
Draft RFP Public Hearing	September 8, 2022
Regular RFPG Meeting – Final RFP Adoption	December 7, 2022

10.1.3.2 Required Public Meetings

While all regular RFPG meetings were open to the public, at least one meeting was specifically required to be designated as a public meeting to gather general suggestions and recommendations from the public as to the issues, provisions, and types of FMSs, FMPs, and FMEs that should be considered or addressed or provisions that should be considered and potentially included during that regional flood planning cycle. This meeting was held on January 14, 2021, and additional input on this task was continuously solicited throughout the planning process.

A second meeting was required specifically to identify flood risk in the region. This meeting was held on June 10, 2021. A flood risk map was developed and shared at that public meeting to allow members of the public to identify any flood risks that were not captured by the available data. Additionally, an online web map was developed and made accessible via the RFPG webpage, where the general public could mark areas subject to flooding and provide information about flooding type, cause, and frequency. Nearly 200 comments were received through this web map, making it a highly useful tool for receiving this type of public input.

10.1.4 Surveys

The Region 1 RFPG created a public survey to solicit knowledge about the flood planning area and input on regional strategies and initiatives. The survey was made available on the RFPG webpage and also emailed directly to community officials and other key stakeholders in the region. These community officials were also contacted by the RFPG and technical consultant, either by phone or in person, and encouraged to participate in the survey.

In addition to the formal survey, the public also had access to an interactive web map to identify areas of flood risk, as well as existing FMP areas in the region. Finally, an online portal was provided for stakeholders to upload relevant data and information to contribute to the planning process.

10.1.5 Interregional Coordination

Natural watersheds do not follow jurisdictional boundaries. As such, single jurisdictions had the potential to be included in multiple FPRs, and single projects had the potential to impact entities in multiple regions. Interregional coordination is and will continue to be critical to the success of flood planning initiatives.

The Region 1 RFPG coordinated with its neighboring regions on projects that were located in multiple regions or would have effects on a neighboring region. Since the Red River Basin is split between the Upper and Lower-Red FPRs, the Region 1 RFPG liaison attended Region 2 RFPG meetings and reported relevant information back to the RFPG. Additionally, consultant teams provided status updates to one another from each region throughout the planning process. Overall, the Region 1 RFP was developed in coordination with the following FPRs:

- Region 2 – Lower Red-Sulphur-Cypress
- Region 3 – Trinty

- Region 7 – Upper Brazos
- Region 8 – Lower Brazos

10.1.6 RFP Adoption Process

In accordance with the relevant rules governing the flood planning process, the RFPG conducted a formal process for the adoption of the RFP. Four formal deliverables have been or will be prepared in accordance with the following deadlines:

1. Technical Memorandum – January 7, 2022 and March 7, 2022
2. Draft RFP – August 1, 2022
3. Final RFP – January 10, 2023
4. Amended RFP – July 14, 2023*

**Indicates future deadline*

10.1.6.1 Technical Memorandum

The first deliverable for the RFP was the Technical Memorandum, **Task 4C**, intended to demonstrate progress towards compiling the necessary technical information and analyses needed to develop the RFP and meet contract requirements. Content from the Technical Memorandum served as a basis for development of Chapters 1-4 of the RFP and for the execution of subsequent tasks. Changes to the data and information presented in the Technical Memorandum were incorporated into subsequent deliverables as the project progressed. The Final RFP and the SFP approved by the RFPG and TWDB supersede all previous deliverables.

The administrative deadline for the submission of the Technical Memorandum was January 7, 2022. On August 17, 2021 TWDB issued an extension of time to March 7, 2022 for certain portions of the Technical Memorandum deliverables, specifically items related to the flood risk analyses (**Task 2**) and assessment and identification of flood mitigation needs (**Task 4**).

The initial Technical Memorandum for Region 1 was submitted on January 4, 2021 and was determined by TWDB to be administratively complete on January 26, 2022. The subsequent Technical Memorandum was submitted on March 6, 2022 and was determined by TWDB to be administratively complete on March 22, 2022. Informal comments on the initial and subsequent Technical Memoranda were received from TWDB on April 15, 2022 and May 16, 2022, respectively. Changes were incorporated into subsequent RFP deliverables.

10.1.6.2 Draft RFP Adoption

The RFPG conducted a formal Planning Group meeting on July 18, 2022 prior to the Public Hearing. The Draft RFP was given approval for submission to the TWDB by a formal vote of the RFPG. **The development and adoption of the Draft RFP by the RFPG conformed to 31 TAC §361.21.**

10.1.6.3 Public Input Relating to Draft RFP

The Draft RFP was subject to a public review period of 60 days. The RFPG conducted a public meeting on September 8, 2022 to take public input related to the RFPG's Draft RFP. Required notifications for the meeting were posted 30 days in advance. Printed copies of the Draft RFP were located in three publicly accessible locations in the region. In Region 1, printed copies were available in the cities of Amarillo (PRPC office), Wichita Falls (Wichita Falls City Hall), and Childress (Childress City Hall) for at least 30 days before and 30 days after the meeting. The Draft RFP was also made available to the public on the RFPG website.

10.1.6.4 State and Federal Agency Review

The adopted Draft RFP was submitted to TWDB by the August 1, 2022 deadline. TWDB confirmed receipt of the Draft RFP on August 2, 2022 and determined the Draft RFP to be administratively complete on August 5, 2022. Comments were accepted from the TWDB Executive Director and other state and federal agencies in accordance with the review periods set forth by the regional flood planning guidelines.

10.1.6.5 Response to Comments

Comments on the Draft RFP were received from TWDB, TPWD, and USACE Tulsa District and were carefully considered by the RFPG. Modifications were made to the Final RFP in response to comments and were documented as **Appendix G-1**.

10.1.6.6 Final RFP Adoption

The Final 2023 RFP was approved and adopted by the RFPG on December 7, 2022. **The Final RFP was developed according to all statute and rule requirements.** The RFP and supporting materials were submitted to TWDB in accordance with the contractual requirements by the January 10, 2023 deadline.

10.1.7 Public Participation and RFP Adoption Summary

The Region 1 RFPG maintained a high level of commitment to public participation throughout the planning process. The RFPG believes that public information and participation activities are at least as important to the success of regional flood planning initiatives as the data accumulated and analyzed. A key recommendation of the RFPG is to continue to fund and encourage public information activities throughout all subsequent flood planning cycles.

10.2 Flood Planning Guidance Principles

As required by 31 TAC §361.50, **the RFP adequately provides for the preservation of life and property and the development of water supply sources, where applicable**. To meet this objective, the regional flood planning process is governed by 39 overarching guidance principles, as described in 31 TAC §362.3. **This RFP conforms with each of these guidance principles, including the requirement that the RFP will not negatively affect any neighboring areas.** Specifically, the provisions of each principle are addressed in the report sections outlined in **Table 10-2**.

Table 10-2: Alignment of RFP with Guidance Principles

Guidance Principle ("The regional and state flood plans:…")		RFP Section(s)
1	shall be a guide to state, regional, and local flood risk management policy;	Chapter 3
2	shall be based on the best available science, data, models, and flood risk mapping;	Chapter 2
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;	Chapter 2; Chapter 3; Chapter 4/5
4	shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2 percent annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historic flood events;	Chapter 2
5	shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0 percent annual chance flood event (the 100-year flood) and address, through recommended strategies and projects, the flood mitigation goals of the RFPG (per item 2 above) to address flood events associated with a 1 percent annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historic flood events;	Chapter 2
6	shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk;	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;	Chapter 1, Chapter 2
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;	Chapter 1, Chapter 2
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;	Chapter 4/5
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 RFP;	Chapter 4/5, Chapter 6

	Guidance Principle ("The regional and state flood plans:…")	RFP Section(s)
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;	Chapter 1, Chapter 4/5
12	shall include the estimate of costs and benefits at a LOD sufficient for RFPGs and sponsors of FMPs to understand project benefits and, when applicable, compare the relative benefits and costs, including environmental and social benefits and costs, between feasible options;	Chapter 4/5
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;	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;	Chapter 4/5
15	shall be supported by state agencies, including TWDB, GLO, TCEQ, TSSWCB, TPWD, and the TDA, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources;	Chapter 10
16	shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits;	Chapter 4/5
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;	Chapter 4/5
18	shall contribute to water supply development where possible;	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;	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;	Chapter 10
21	shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation;	Chapter 10
22	shall include FMSs and projects recommended by the RFPGs that are based upon identification, analysis, and comparison of all FMSs the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals;	Chapter 4/5

	Guidance Principle ("The regional and state flood plans:…")	RFP Section(s)
23	shall consider land use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals;	Chapter 3
24	shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services;	Chapter 3
25	shall be consistent with the NFIP and shall not undermine participation in nor the incentives or benefits associated with the NFIP;	Chapter 3
26	shall emphasize the fundamental importance of floodplain management policies that reduce flood risk;	Chapter 3
27	shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains;	Chapter 3, Chapter 4/5
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;	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;	Chapter 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 RFP;	Chapter 4/5
31	shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction;	Chapter 1
32	shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property;	Chapter 8
33	shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals;	Chapter 10
34	shall be in accordance with all existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties;	Chapter 6
35	shall consider protection of vulnerable populations;	Chapter 4/5
36	shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate;	Chapter 2, Chapter 4/5, Chapter 6

	Guidance Principle ("The regional and state flood plans:…")	RFP Section(s)
37	shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards;	Chapter 4/5, Chapter 6
38	shall consider how long-term maintenance and operation of flood strategies will be conducted and funded; and	Chapter 9
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.	Chapter 4/5

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