

CHAPTER 3

Floodplain Management Practices and Flood Protection Goals

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Task 3: Floodplain Management Practices and Flood Protection Goals

The Lower Brazos Regional Flood Planning Group (RFPG) solicited local entity and public input in the development of floodplain management practices and flood protection goals for the Lower Brazos region. The data collection effort provided feedback from 73 entities on specific topics, representing 12 percent of the region. Public comment was taken at the planning group meetings in July, August, and September 2021, and input and constructive feedback was received by the RFPG during meetings.

Task 3A: Evaluation and Recommendations on Floodplain Management Practices

The purpose of Task 3A is to evaluate existing floodplain management practices within the Lower Brazos River Flood Planning Region and recommend floodplain management standards that minimize both increasing existing flood risk and creating new flood risk. It is important to note the RFPG themselves do not have the authority to enact or enforce floodplain management, land use, or other infrastructure design standards. Any standards considered, recommended, and accepted by the Lower Brazos RFPG would be aimed at encouraging implementation by local entities in the region with flood-related authority.

Floodplain management standards fall into two main categories, *adoption*, and *recommendation*. Coordination with the RFPG resulted in a group consensus that standards produced as part of the flood planning effort should be classified as *recommendations* for general consideration by entities and communities within the region. For context, *adopted* standards are more specific minimum standards that must be implemented by entities prior to the RFPG including any flood management evaluations (FMEs), flood management strategies (FMSs), or flood mitigation projects (FMPs) into the regional flood plan on behalf of that entity. Although standards for *adoption* are not proposed for this initial flood plan, it is conceivable that future updates to the regional flood plans may incorporate standards for *adoption*.

The recommended standards for consideration are divided into two distinct categories, i.e., standards for (1) region-wide recommendation (Figure 1) and (2) standards recommended for smaller “zones” within the region delineated along Hydrologic Unit Code 8 (HUC 8) boundaries (Figure 2). These categories allow for a broad application of standards as well as a tailored formulation for capturing flood risk variability, natural hydrography, topography, climatological effects, and demographics throughout the river basin. The different categories of standards are described further in subsequent sections along with the definitions of each standard. Table 1 provides a summary of the recommended standards for each category.

Definitions

0.2% Annual Chance Floodplain. The 0.2% annual chance floodplain is defined as the area that will be inundated by a flood event having a 0.2-percent chance of being equaled or exceeded in any given year. The 0.2% annual chance floodplain is also referred to as the 500-year flood.

1% Annual Chance Floodplain. The 1% annual chance floodplain is defined as the area that will be inundated by a flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1% annual chance floodplain is also referred to as the base flood or 100-year flood.

Critical Facilities. Critical facilities are defined by TWDB as hospitals, schools (K through 12th), schools for children with special needs, fire stations, police stations, emergency shelters, water and wastewater treatment plants, power generating facilities, power transmitting facilities, assisted living facilities, and nursing homes.

Low Water Crossing. Low water crossings are roadway creek crossings that are subject to frequent inundation during storm events or subject to inundation during a 50% annual chance storm event.

Table 1. Summary of Lower Brazos River Basin Recommended Standards

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

Section 1.0 Recommended Standards

1.1 Recommended Standards Region-Wide

Region-wide standards for the full 23,500 square mile coverage of the Lower Brazos Flood Planning Region (Figure 1) are assumed to be applied region-wide and are described below.

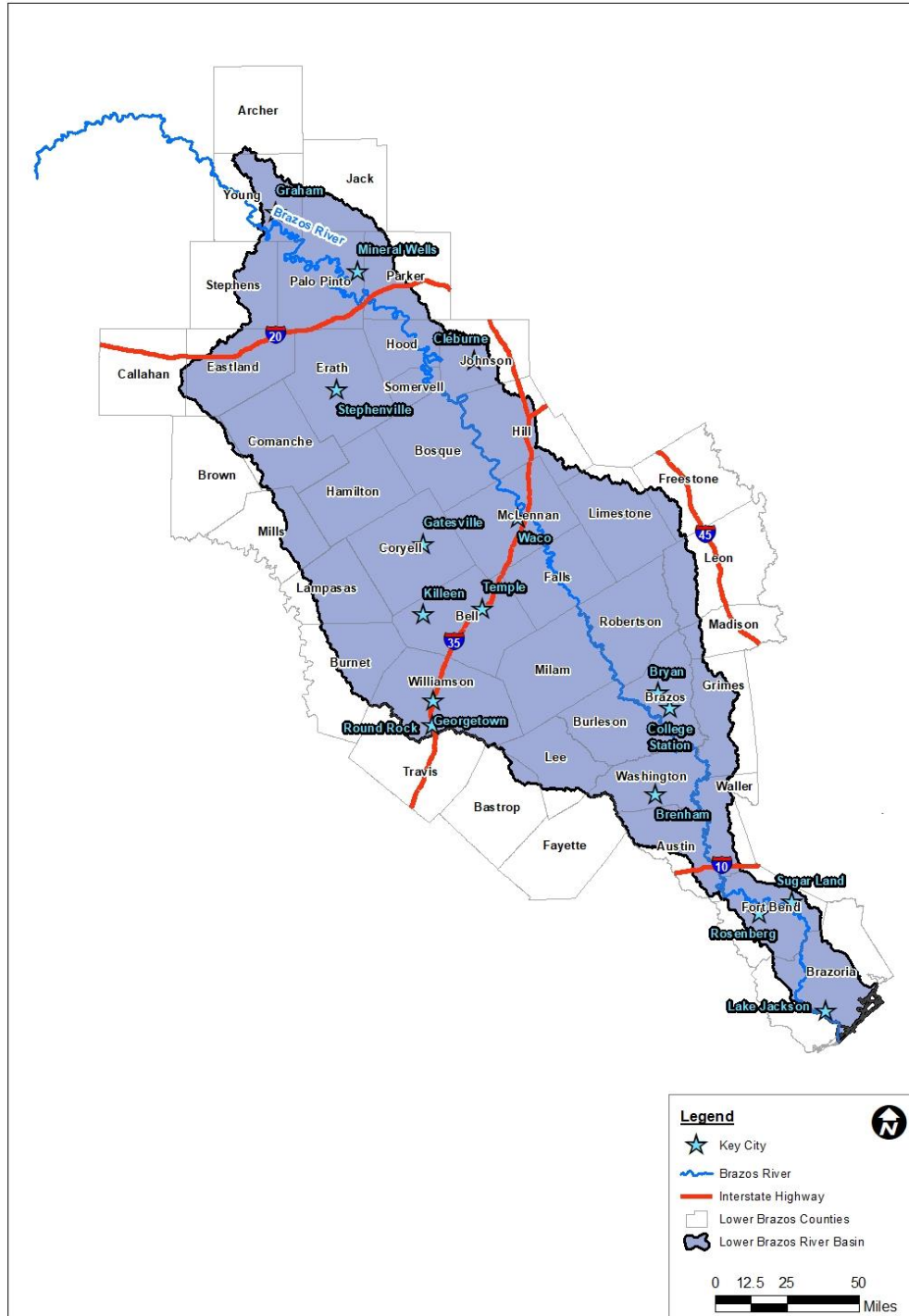


Figure 1. Lower Brazos Flood Planning Region 8

National Flood Insurance Program (NFIP) Participation. All entities should enact ordinances that meet minimum requirements for NFIP Participation and be active NFIP participants in good standing. This standard would only apply to communities that are not already NFIP participants in good standing (e.g., Hamilton County, Falls County, and a handful of municipalities). NFIP participation is voluntary, however it allows for discounted insurance premiums, eligibility for federal grants and loans, and federal disaster assistance. For communities to participate in the NFIP program, they must do the following.

- Adopt and enforce a flood damage prevention ordinance.
- Require permits for all types of development in the floodplain.
- Ensure that building sites are reasonably safe from flooding.
- Estimate flood elevations that were not determined by FEMA.
- Require new or substantially improved homes and manufactured homes to be elevated above the Base Flood Elevation (BFE).
- Require other buildings to be elevated or floodproofed.
- Conduct field inspections and cite violations.
- Require Elevation Certificates to document compliance.
- Carefully consider requests for variances.
- Resolve non-compliance and violations.
- Advise FEMA when updates to flood maps are needed.

Compensatory Storage Requirement in 1% Floodplain. Any reduction in floodplain storage or conveyance capacity within the 1% annual chance regulatory floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction. Floodplains provide critical and beneficial functions for flood storage, natural habitat, and water quality. Fill placed within the floodplain impairs the benefits provided by the floodplain and should be avoided. This standard may be exercised for planned development or fill placement located within the 1% regulatory floodplain. Such mitigation shall be within the same watershed or at an alternative site that is approved by that community's Floodplain Administrator. A full hydrological and hydraulic analysis must be submitted to support a request for mitigation outside the boundaries of the property being developed. This requirement may not apply to FEMA classified flood zones with velocity hazard (FEMA Flood Zone V and VE).

No Adverse Impacts for the 1% Storm Event. The 1% annual chance storm event is considered the primary storm for basing no adverse impacts. This applies to private development and city work. Incorporating no adverse impacts can help minimize flood damages caused by activities that could adversely impact flood damage to another property or community. This practice is cited in TFMA's Higher Standards (TFMA 2018). This standard will require a full hydrologic and hydraulic analysis be submitted to support the no adverse impact requirement. Considerations should be made by each entity on the best practice for determining no adverse impacts including the extent of impact consideration, no rise in water surface elevation versus no increase in peak flow, and regional mitigation versus local development mitigation. Example no adverse impact determinations are provided for reference.

- A rise of 0.01 feet on another property is non-permissible and is considered an adverse impact. In addition, any loss in floodplain volume on the property is also an adverse impact.
- An increase in peak flow in the receiving waterway downstream of development is non-permissible and is considered an adverse impact.

Improved Flood Response. This measure includes appropriate efforts for enhancing flood notification and communication, both with emergency response personnel and the public. Efforts to improve flood response can include development of an Emergency Action Plan for significant storm events, communication plans to contact residents of emergency situations during storm events, implementation of an emergency response system, and execution of emergency response tabletop exercises. This can improve flood risk communication and mobility (both response and evacuation) at large geographic scales.

Improved Flood Risk Awareness/Education. This standard recommends implementation of flood risk awareness and education within the zone. Flood risk awareness and education can include a website or webinars to increase the public flood risk awareness.

1.2 Recommended Standards by Zone

Zone level standards (Figure 2) better tailor recommendations with varying flood risk, natural hydrography, topography, climatological effects, and demographics throughout the river basin. Much of this variation can be attributed to variations in inherent flood risk by rainfall and population growth (urban versus rural communities). Table 1 lists how standards vary by zone. Zone level standards are described as follows.

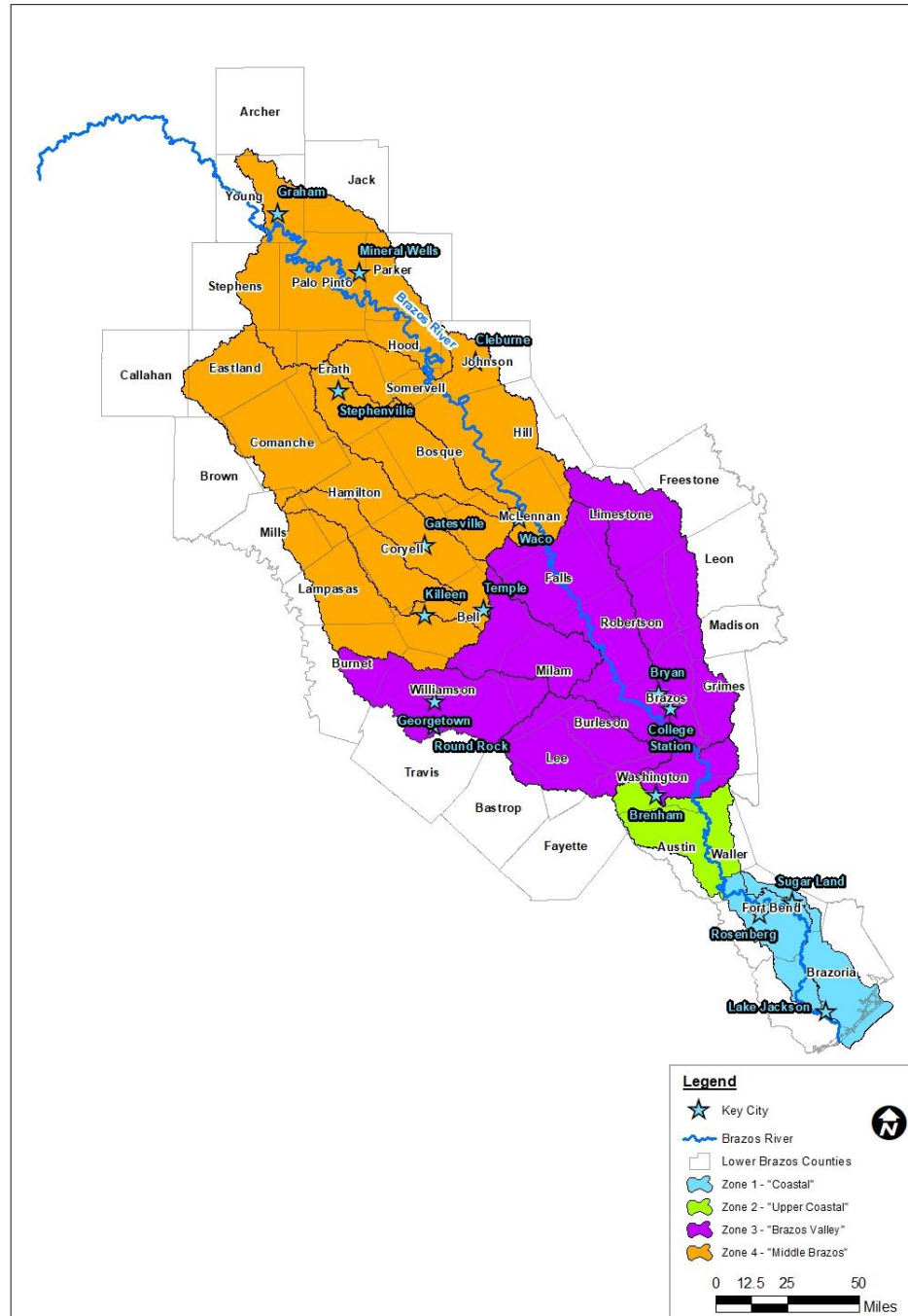


Figure 2. Lower Brazos Regional Zones

Use of Best Available Rainfall Data. Utilize the latest rainfall data as the more conservative rainfall estimates (for regions where applicable) as part of new analysis and design standards and flood prevention regulations. As of 2021, Atlas 14 (Volume 11) revised rainfall is the current best available data for rainfall estimates.

No Adverse Impacts for the 1% and 10% Storm Events. The 1% and 10% annual chance storm events are considered the primary storm for basing no adverse impacts. This applies to private development and city work. Incorporating no adverse impacts can help minimize flood damages caused by activities that could adversely impact flood damage to another property or community. This practice is cited in TFMA's Higher Standards (TFMA 2018). This standard will require a full hydrologic and hydraulic analysis be submitted to support the no adverse impact requirement. Considerations should be made by each entity on the best practice for determining no adverse impacts including the extent of impact consideration, no rise in water surface elevation versus no increase in peak flow, and regional mitigation versus local development mitigation. Example no adverse impact determinations are provided for reference.

- A rise of 0.01 feet on another property is non-permissible and is considered an adverse impact. In addition, any loss in floodplain volume on the property is also an adverse impact.
- An increase in peak flow in the receiving waterway downstream of development is non-permissible and is considered an adverse impact.

Formation of a Voluntary Buyout Program. This practice recommends the formation of a voluntary buyout program by local entities to assist in the reduction of flood damage within certain areas of the floodplain. Implementation of the program would help improve coastal resiliency and reduce repetitive flood damage.

Long-Term Operation and Maintenance Planning of Drainage Infrastructure. Development of a plan for long-term operation and maintenance of critical drainage infrastructure within each entity is recommended to improve coastal resiliency and reduce flood risk in the zone. This plan should include a defined sustainable funding mechanism to support long-term operation and maintenance. Critical drainage infrastructure can include dams, levees, floodwalls, and any other infrastructure identified as critical by the entity.

Drainage Corridor Preservation. Construction of infrastructure should avoid high risk and sensitive areas such as floodways, floodplains, coastal dunes, and areas downstream of dams, levees, and floodwalls. New buildings should be prohibited within the regulatory floodplain.

Compensatory Storage requirement in 0.2% Floodplain. Any reduction in floodplain storage or conveyance capacity within the 0.2% annual chance floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction. This standard may be exercised for planned development or fill placement located within the 0.2% annual chance regulatory floodplain. Such mitigation shall be within the same watershed or at an alternative site that is approved by that community's Floodplain Administrator. A full hydrological and hydraulic analysis must be

submitted to support a request for mitigation outside the boundaries of the property being developed. This requirement does not apply to flood zones with velocity hazard (Zone V and VE).

Requirements for Culvert and Bridge Crossings. Culverts and bridges at arterial roadways, access roads to critical facilities, emergency routes, and evacuation routes should pass the 1% annual chance storm event with a minimum of 1 foot of freeboard. This standard assists in reducing the number of new low water crossings within the zone.

Roadway requirements within the Floodplain. New arterial roadways, access roads to critical facilities, emergency routes, and evacuation routes within the regulatory floodplain should be at or above the base flood elevation to provide access for emergency vehicles during a flood.

Culvert and Bridge Hydrologic and Hydraulic Analysis requirement. New culverts or bridges constructed in the floodway should require a full hydrologic and hydraulic analysis.

Section 2.0 Data Collection and Watershed Characteristics

2.1 Data Collection

Several data sources were utilized to inform the determination of floodplain management standards. These sources include survey feedback, existing criteria, standards, programs, regulations, reports, and available Texas Water Development Board (TWDB) data sources. Survey feedback was gathered to better understand the existing floodplain management practices throughout the region and identify standards that entities within the Lower Brazos region would like to see included in the regional flood plan. Existing criteria and standards were looked at to provide information on existing floodplain management practices for entities that did not provide survey feedback. This information supplemented the data gathered from the survey and provided a better understanding of the entire region in regard to floodplain management practices. Reports like the Lower Brazos Flood Protection Planning Study (Halff 2019) provided information on existing flood hazards in the region. Spatial data provided by TWDB helped determine characteristics for areas within the river basin that assisted in refining recommended standards to be tailored to each area.

Entities within the Lower Brazos River Basin provided feedback through a basin wide survey initiated in July 2021. The survey included questions regarding existing floodplain management practices and considerations for minimum standards across the river basin. The responses provided insight into the existing standards being practiced by entities in the basin and suggested minimum standards that the communities would prefer to see implemented. Figure 3 provides the survey responses regarding minimum standards that entities within the Lower Brazos River Basin want to see recommended.

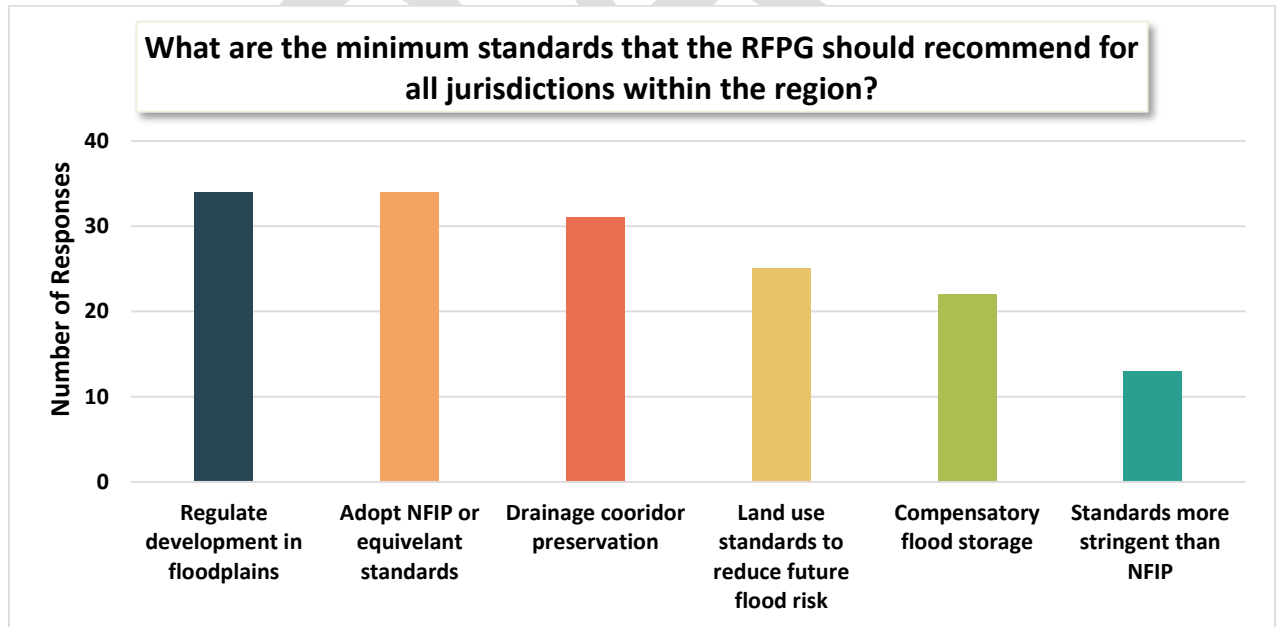


Figure 3. Responses to Question 12 from Lower Brazos Data Collection Survey

Existing criteria and standards were analyzed for many of the entities within the region. The existing criteria included drainage criteria manuals, engineering standards, master plans, stormwater management programs, subdivision regulations, and ordinances. Cities had a greater variation in existing criteria with many having drainage criteria manuals, master plans, and stormwater management programs. Counties primarily had subdivision regulations and stormwater management programs. The criteria vary over the river basin however many of the entities have more stringent floodplain management standards than the minimum standards set by the National Flood Insurance Program (NFIP). Even though there are many entities that have higher standards, only 11 entities participate in the Community Rating System (CRS). The CRS is a program within the NFIP that recognizes communities that implement standards higher than minimum floodplain management standards. NFIP participating communities and CRS communities are shown in Figure 4.

TWDB technical guidance provided an outline for developing region-specific floodplain management standards. This included example standards, resources for higher standards including reports by Texas Floodplain Managers Association (TFMA) and FEMA CRS standards, and considerations to make when developing the standards. TWDB provided a rich assortment of spatial data that included FEMA flood claims, low water crossings, critical infrastructure, flood control infrastructure, and floodplain quilt. The data was analyzed through GIS to highlight specific watershed characteristics for each HUC 8 within the region. The metrics calculated were used to help tailor standards to each HUC 8 and regional zone.

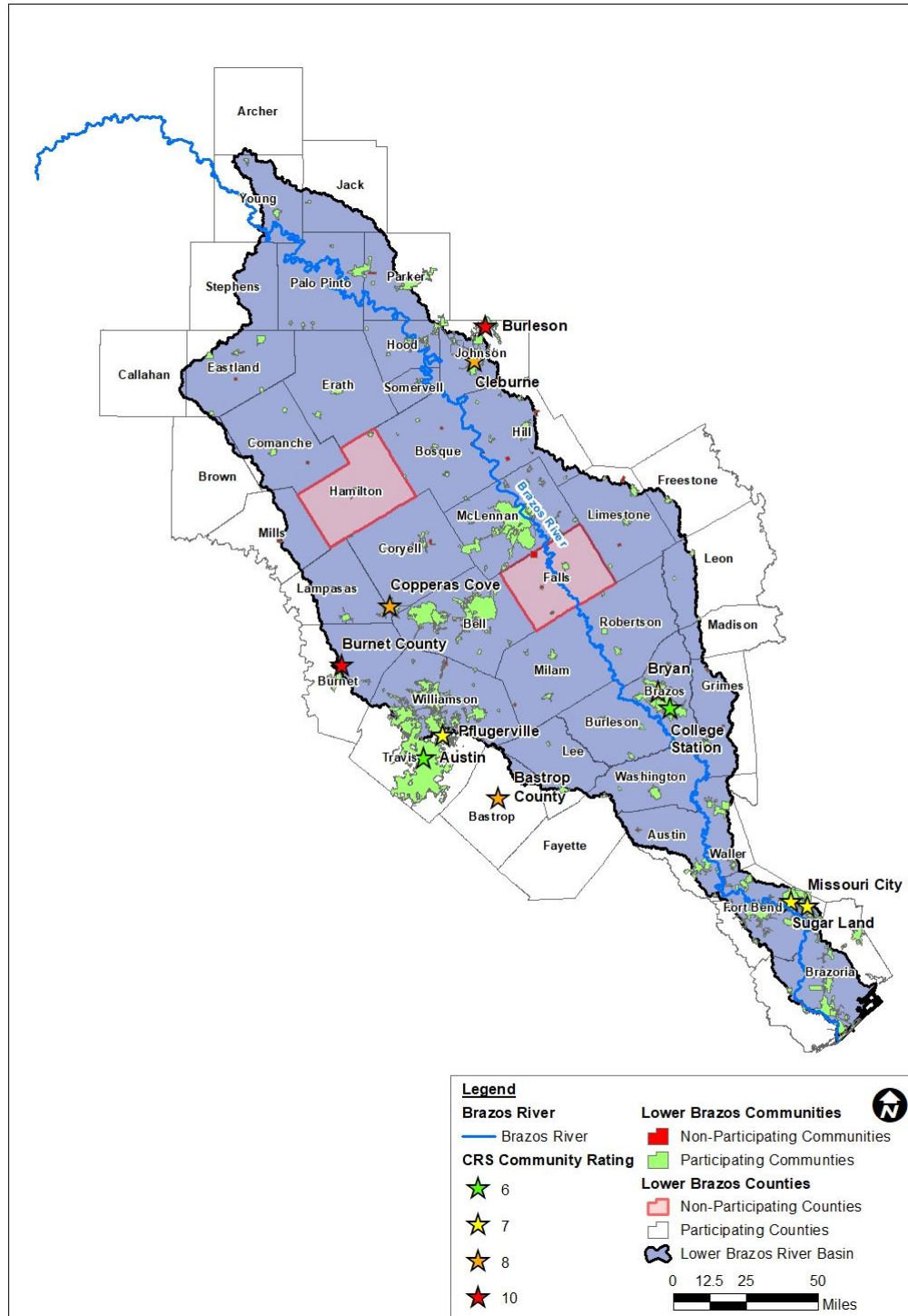


Figure 4. Lower Brazos NFIP and CRS Participation

2.2 Watershed Characteristics

Each zone has defining characteristics that were used to tailor recommended standards to help local entities establish preventative measures for reducing flood damage. Table 2 summarizes the characteristics for each zone.

Table 2. Lower Brazos “Zone” Characteristics

Zone	Flood Claims	NFIP Participation (% of Entities)	Critical Infrastructure in Floodplain	Low Water Crossings	Area of Floodplain (sq mi)
Zone 1 “Coastal”	12,321	100%	307	7	735
Zone 2 “Upper Coastal”	63	93%	21	21	258
Zone 3 “Brazos Valley”	1,884	87%	152	533	1893
Zone 4 “Middle Brazos”	1,705	86%	271	594	1466

Zone 1 is defined as the coastal region nearest the Gulf of Mexico. The zone is comprised of Brazoria County and Fort Bend County. The defining characteristics of this zone are a high number of FEMA flood claims, high NFIP participation, high number of critical infrastructure within the floodplain, and only a few low water crossings. Over half of the zone is within the 500-year floodplain. Precipitation estimates for this zone have increased with Atlas 14 revised rainfall data.

Zone 2 is the upper coastal region and is comprised of Austin, Waller, and Washington Counties. The defining characteristics of this zone are a low number of FEMA flood claims, high NFIP participation, low number of critical infrastructure within the floodplain, and only a few low water crossings. Precipitation estimates for this zone have increased with Atlas 14 revised rainfall data.

Zone 3 is defined as the Brazos Valley region and is comprised of the central HUC 8s within the river basin. The defining characteristics of this zone are a moderate amount of FEMA flood claims, medium to high NFIP participation, moderate number of critical infrastructure within the floodplain, and a significant number of low water crossings. Precipitation estimates for areas within this zone have increased with Atlas 14 revised rainfall data.

Zone 4 is the Middle Brazos region and is comprised of the northwestern HUC 8s within the Lower Brazos River Basin. The defining characteristics of this zone are a moderate amount of FEMA flood claims, medium to high NFIP participation, large number of critical infrastructure within the floodplain, and a significant number of low water crossings.

Each HUC 8 has defining characteristics that were used to tailor the zone-specific recommended

standards to help local entities establish preventative measures for reducing flood damage. HUC 8s are watersheds for medium sized rivers delineated by the United States Geologic Survey (USGS). The 14 HUC 8s within the Lower Brazos River Basin vary in size from 422 to 3200 square miles. Table 3 summarizes the characteristics for each HUC 8. Figure 5 through Figure 7 provide visuals of computed metrics for each HUC 8.

Table 3. Lower Brazos HUC 8 Characteristics

HUC 8	Flood Claims	NFIP Participation (% of Entities)	Critical Infrastructure in Floodplain	Low Water Crossings	Area of Floodplain (sq mi)
Austin-Oyster	7201	100%	130	1	380
Bosque	38	88%	8	19	57
Cowhouse	2	82%	2	8	51
Lampasas	173	78%	19	103	168
Leon	482	88%	36	237	188
Little	85	94%	10	60	225
Lower Brazos	5183	97%	198	27	613
Lower Brazos- Little Brazos	334	88%	44	98	770
Middle Brazos- Lake Whitney	488	83%	126	107	463
Middle Brazos- Palo Pinto	465	96%	66	69	411
Navasota	655	81%	54	106	486
North Bosque	57	93%	14	51	128
San Gabriel	714	92%	26	210	154
Yegua	96	100%	18	59	258

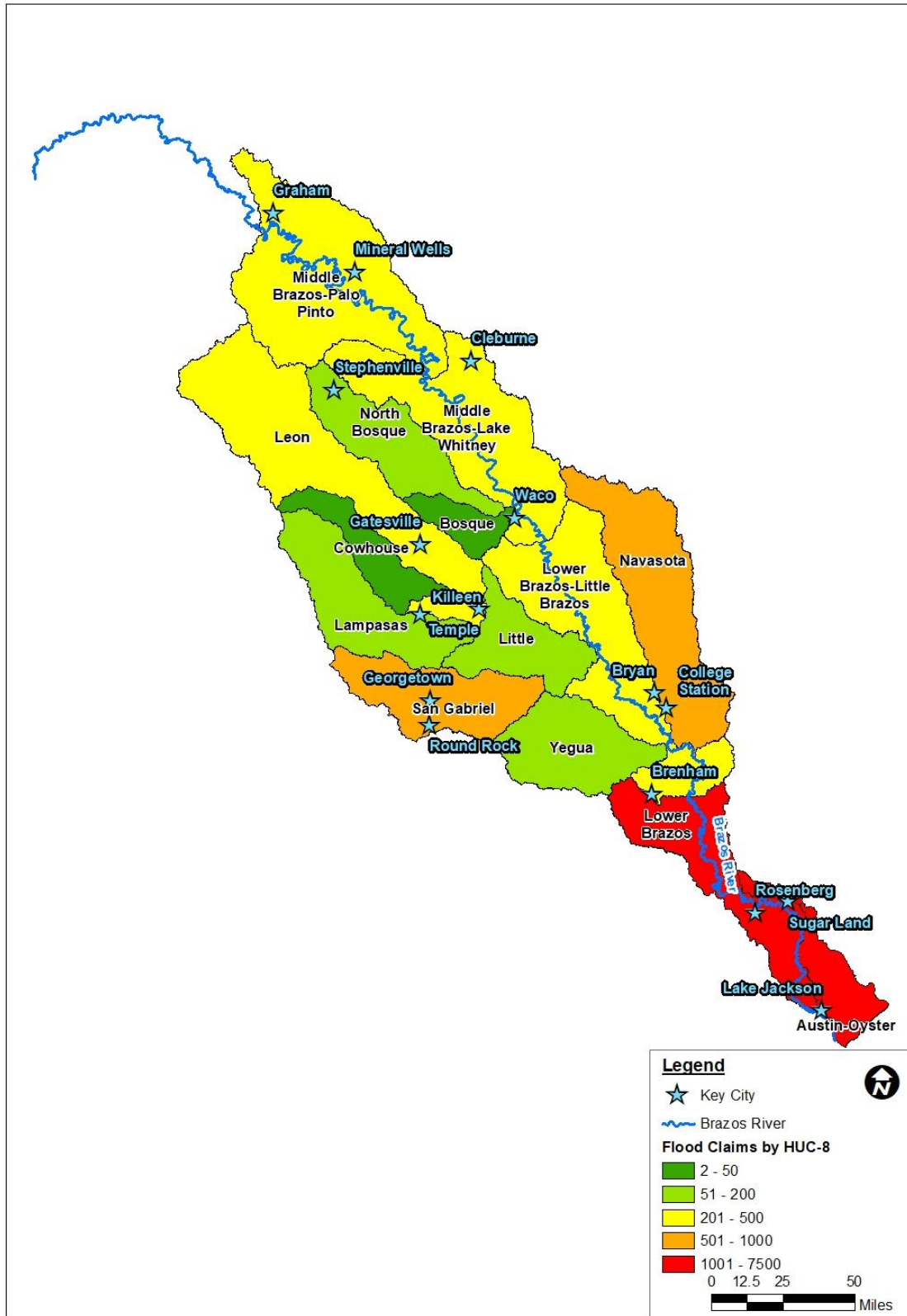


Figure 5. Lower Brazos Flood Claims by HUC-8

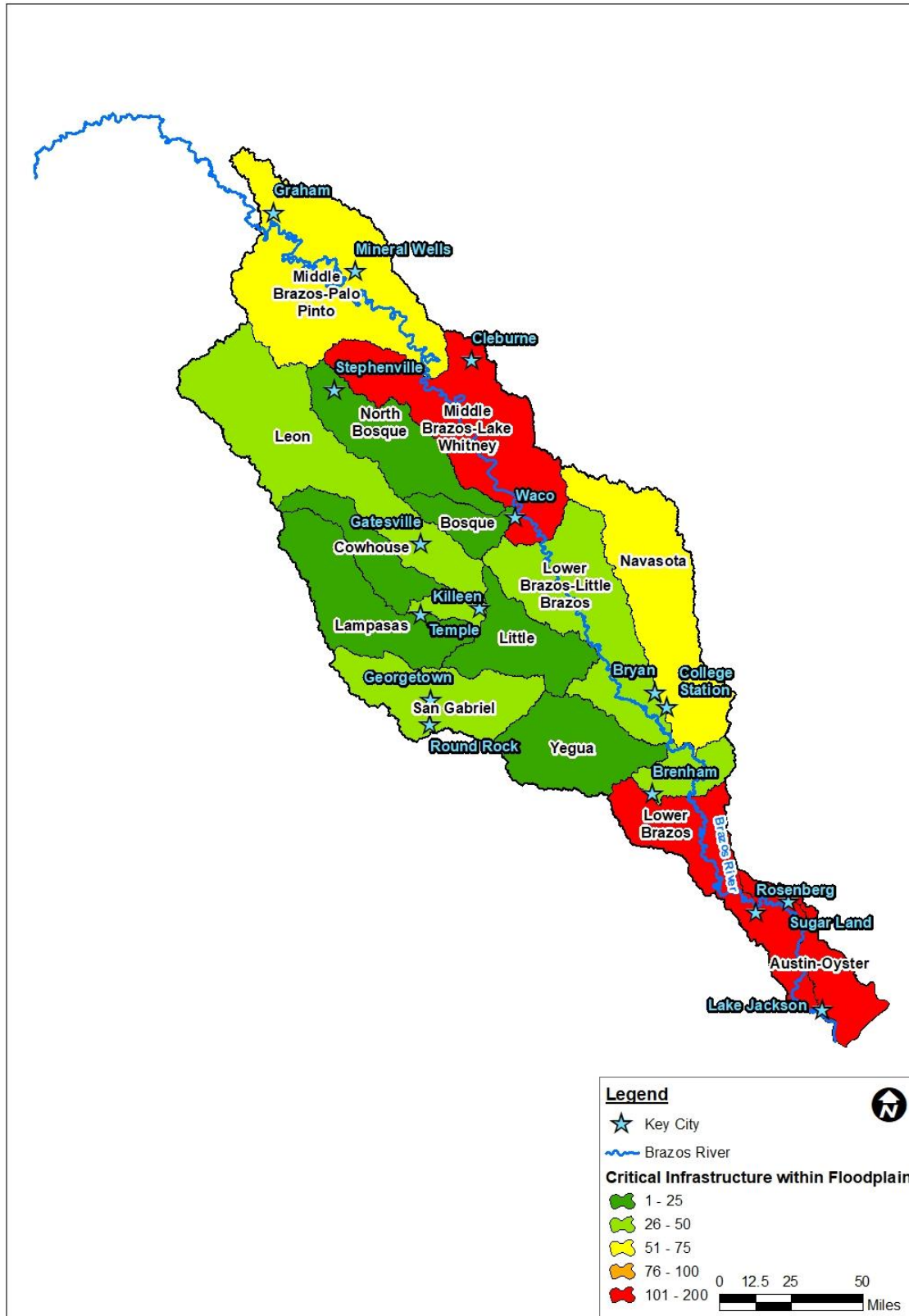


Figure 6. Critical Infrastructure within the Floodplain by HUC-8

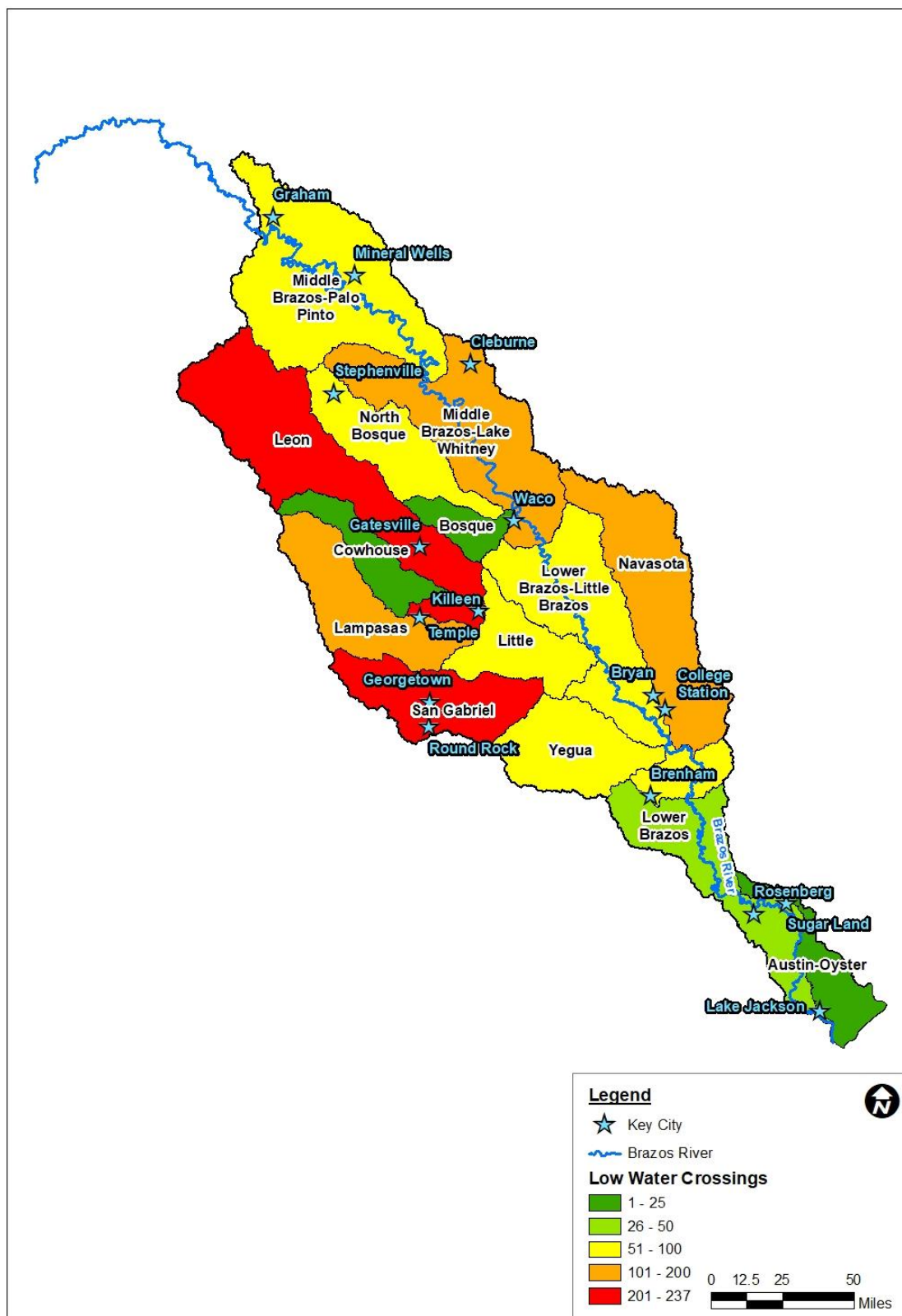


Figure 7. Low Water Crossings by HUC 8

Task 3B – Flood Mitigation and Floodplain Management Goals

Section 1.0 Purpose and Intent

The purpose of this task is to define flood mitigation and floodplain management goals for the Lower Brazos Region, as directed by the Lower Brazos Regional Flood Planning Group (RFPG). The intent of these goals is driven by the Texas Water Development Board (TWDB) in 31 TAC 362.3, “to protect against loss of life and property”. To accomplish this task, the TWDB developed six key elements to consider throughout its development:

1. Define specific and achievable goals with target years that address risks to life and property,
2. Identify any remaining risk after goals are met,
3. Organize goals to be easily understood by the public,
4. Use the goals to guide the flood mitigation needs analysis and the identification, evaluation, and recommendation of FMEs, FMSs, and FMPs,
5. Use the Hydrologic Unit Codes (HUC)-8 geographic divisions to specify which goals are intended for which region(s) (See Figure 8),
6. Select which goals should be considered short-term (10 years) and long-term (30 years).

The key elements above are intended to “guide the overall approach and recommendations in the plan and to ensure the coherence of the entire plan”.¹ Furthermore, these guidelines will influence how the Regional Flood Plan approaches creating and establishing regulatory goals.

Regulatory goals will be used to guide the development of minimum floodplain management standards as well as gauge the effectiveness and necessity of future Flood Management Strategies (FMSs), Evaluations (FMEs), and Projects (FMPs). Therefore, it is important that these goals meet the intent of the TWDB as stated above, address the needs of the stakeholders, and reflect the unique characteristics and flood risks for the Lower Brazos Region.

Floodplain management compliance and consideration of the goals will provide flood risk benefits to individuals, communities, and the overall flood planning region as a whole as well as demonstrate the overall purpose and intent of this regional flood planning study.

The intent of this document is to present the regional flood planning group with a list of goals for consideration that also includes recommendations from the Halff team. Any feedback from the RFPG will be incorporated into a revised document, which will include finalized goals along with their respective feasibility, time frame, and regions of applicability. It is expected that draft goals will need to be finalized by the **end of October 2021** to remain on schedule.

¹ Exhibit C: Technical Guidelines for Regional Flood Planning, April 2021.

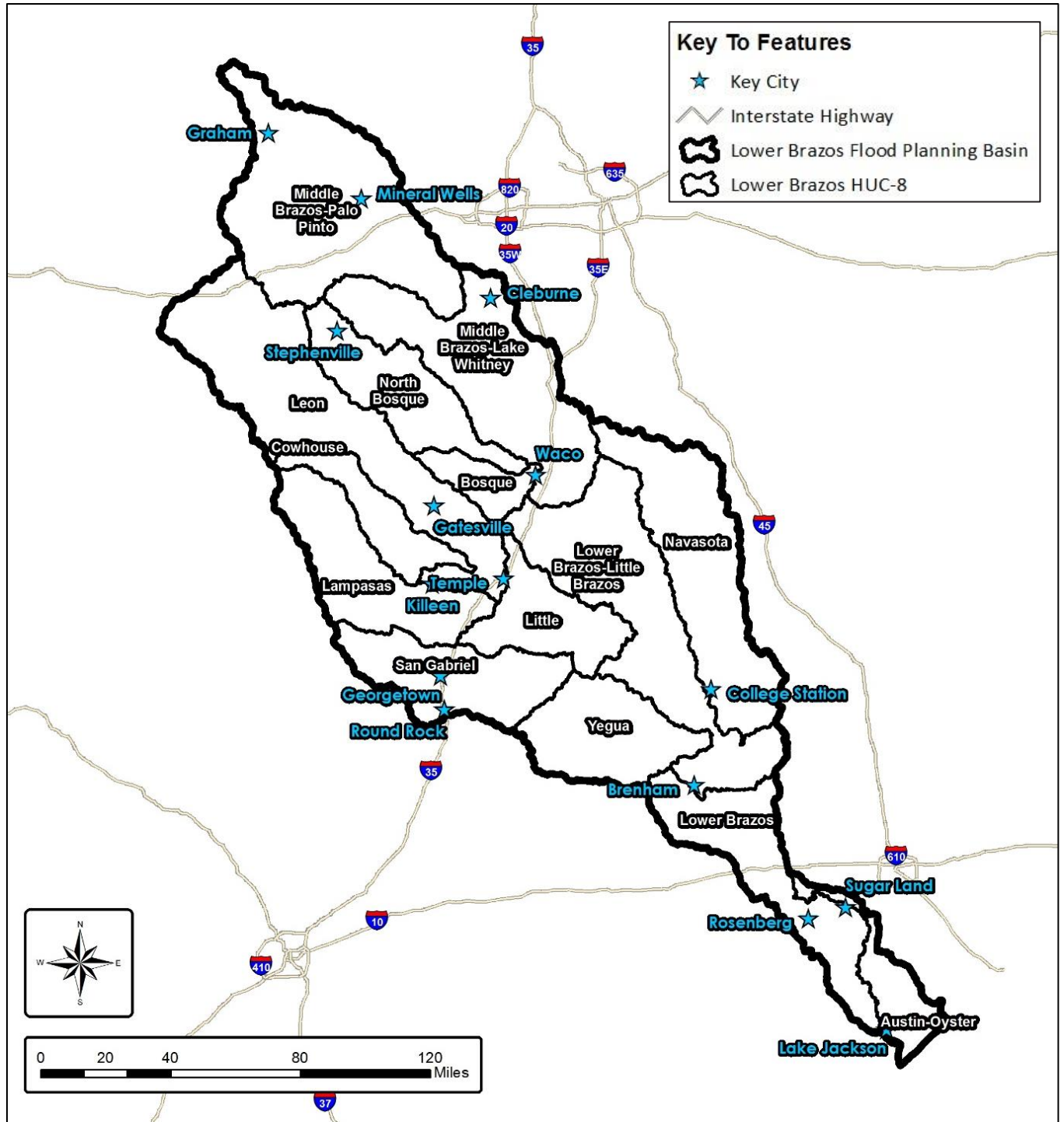


Figure 8. HUC-8 Geographic Divisions in the Lower Brazos Region

Section 2.0 Goal Categories

The Halff Team has developed goal categories in order to help provide some clarity as to the general focus and resulting benefits of each specific, measurable goal. The categories and goals were developed with consideration given to the TWDB overarching goal as well as the survey results. Additional information regarding the development of the goal categories can be found in Section 4 Goal Setting Direction and Section 5 Watershed Characteristics.

During the review of potential goals for the region, five distinct goal categories emerged. A description of each category, along with how it achieves the TWDB goals, are described below.

Category 1: Floodplain Management

- Introduce criteria, regulations, or actions that will help reduce the risk of loss of life and the risk of flood damage to properties.
- Encourage those counties or communities who have floodplain regulatory authority to take stronger action.
- Mitigate current floodplain risk by promoting responsible development practices and implementing higher standards.
- This category indirectly supports the overarching goal of protecting against the loss of life and property by reducing the increase in future flood risk.

Category 2: Flood Studies and Analysis

- Provide communities with updated flood studies and updated floodplain maps.
- Give communities a more accurate depiction of flood risks in their area through improved flood information.
- This category indirectly supports the overarching goal of protecting against the loss of life and property by providing more flood risk awareness to the public.

Category 3: Mitigation Projects

- Implement mitigation projects, property acquisition, drainage infrastructure improvements, elevation of structures, or floodproofing of structures.
- This category directly supports the overarching goal of protecting against the loss of life and property by reducing current flood risk.

Category 4: Flood Warning and Readiness

- Improve flood information systems and a community's communication capabilities before, during and after an emergency event.
- Can include the installation of rainfall, stage, and flow gages throughout the region and by developing procedures and additional means of rapid and broad communication.
- This category indirectly supports the overarching goal of protecting against the loss of life by keeping the public informed, prepared, and aware of flood risk.

Category 5: Education and Outreach

- Increase public awareness of the possibility of flood damage, the type various flood risks that exist in the region, and the level of flood risk in the Region.
- Can include educating the public about risks associated with travelling through flood waters, how to interpret flood maps, varying risks within a flood zone, and ways communities might mitigate future flood risk.
- This category indirectly supports the overarching goal of reducing loss of life and property by helping people understand and avoid flood risk.

A list of direct of potential benefits associated with each goal category is provided in Table 4 below for consideration and assistance in selecting a list of effective and well-rounded set of goals for the region.

Table 4. Goal Categories and Benefits

Category / Benefits	1. Floodplain Management	2. Flood Studies and Analysis	3. Mitigation Projects	4. Flood Warning and Readiness	5. Education and Outreach	Legend
Protect against loss of life	■	■	■	■	⊙	■ Benefit ⊙ Potential Benefit *Single project with multiple benefits, i.e., improves floodplain protection and water supply, increases recreation opportunities, habitat preservation, etc.
Protect against loss of property	■	■	■	⊙	⊙	
Protect infrastructure	■	■	■	⊙		
Protect environment	⊙	■	■		⊙	
Protect water supply	⊙	⊙	⊙	⊙	⊙	
Sustain the economy		⊙	■	⊙		
Design for co-benefits*			⊙			
Increase public awareness	⊙	⊙		■	■	
Build community support	⊙	⊙		■	■	

Based on the benefits listed with each category compared with the overarching goal of the TWDB and the feedback from the survey, we have prioritized the goals categories, as follows, to help select an adequate number of goals for a given category.

1. Floodplain Management
2. Mitigation Projects
3. Flood Studies and Analysis
4. Flood Warning and Readiness
5. Education and Outreach

The priority of the categories is reflected in the number of goals that were selected for each category. Categories that were given lower priority have fewer goals than those that were ranked higher priority based on community stakeholder results, input from the Flood Planning Group, and overarching TWDB goals.

Section 3.0 Specific Goal Statements

Combining the benefit potential of each category from theError! Reference source not found. above with the direction provided by TWDB, the stakeholders, and the characteristics of the basin, we have developed a list of 10 goals for the regional flood planning group’s consideration which are listed in Table 5 below. These are in a generic format for preliminary review only. Goals can be removed, added, or revised as seen fit by the Regional Flood Planning Group (RFPG). Also, the group can decide on additional or fewer goals, as the TWDB did not set any requirements on the number of goals. However, we recommended that the group only select less than 15 specific goals total in an effort to ensure achievability.

Goals are presented with draft time frames, levels of achievement, and geographic applicability. These proposed values reflect data inputs that are known at this point in time and what goals can be reasonably achieved during the given time frame. Values can be edited by the RFPG and updated to reflect additional information obtained but will need to be finalized and accepted by the RFPG in order to track achievement.

The goals that are recommended for adoption by the Regional Flood Planning Group (RFPG) will eventually be submitted utilizing the format of Table 11 in Exhibit C of the Texas Water Development Board’s guidance. Table 7 in Appendix A details that table, supplemented with information that can be determined at this time. Additional information can be added as the flood plan progresses.

TASK 3: FLOODPLAIN MANAGEMENT PRACTICES AND FLOOD PROTECTION GOALS

Table 5. Lower Brazos Regional Floodplain Goals

ID	Goal	Category	Baseline	Short Term Goal 2033	Long Term Goal 2053
1	Increase the number of counties and communities that are enrolled in the National Flood Insurance Program.	Floodplain Management	Participating Communities - 152 (85%) Participating Counties - 41 (95%) ²	Communities enrolled – 90% Counties enrolled – 100%	Communities enrolled – 95% Counties enrolled – 100%
2	Increase the number of counties and communities that have adopted higher than NFIP-standards including directing development away from the floodplain.	Floodplain Management	39 out of a total of 221 counties and communities have higher standards ³	Increase the number of counties and communities with higher standards by 10%	Increase the number of counties and communities with higher standards by 40%
3	Increase the number of entities that have adopted the latest rainfall data.	Floodplain Management	Number of entities that are affected by the updates of the latest rainfall data	Establish a baseline measurement	80%
4	Improve safety at low water crossings by adding warning systems/signage or improving low water crossings in high-risk areas.	Mitigation Projects	895 existing low water crossings in region	Improve 90 low water crossings	Improve 270 low water crossings

² The total number of communities in the Lower Brazos region is 178. The total number of counties is 43.

³ Obtained from TWDB higher standard survey results.

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ID	Goal	Category	Baseline	Short Term Goal 2033	Long Term Goal 2053
5	Reduce the number of structures that are at risk of repetitive flooding during the 1% annual chance flood event by both structural (flood infrastructure) and non-structural (elevation, acquisition, relocation, etc.) means.	Mitigation Projects	17,732 repetitive-loss structures in the flood quilt	Reduce risk to 5% of structures	Reduce risk to 15% of structures
6	Reduce the number of critical facilities ⁴ that are at risk of repetitive flooding during a 1% annual chance of flooding to above the 0.2% annual chance flood event by both structural (flood infrastructure) and non-structural (elevation, buy-outs, relocation, etc.) means.	Mitigation Projects	538 ⁵ critical facilities are within the flood quilt	Establish the quantity of at-risk critical facilities in the region	Reduce risk to 10% of facilities
7	Increase the accuracy of flood hazard data in the FPR by performing detailed studies using the best available terrain, land use, and precipitation data to reduce gaps in floodplain mapping.	Flood Studies and Analysis	n/a	Establish a baseline measurement	50% data gap reduction

⁴ Critical facilities include: colleges, EPA power plants, fire stations, hospitals, law offices, nursing homes, petrol storage facilities, power plants, schools (private and public), shelters, superfund sites, and wastewater treatment plant outfalls.

⁵ Preliminary information obtained from GIS – additional scrutiny of this data (including if the facilities have existing levels of flood protection) is required

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ID	Goal	Category	Baseline	Short Term Goal 2033	Long Term Goal 2053
8	Increase the number of communities with warning and emergency response programs that can detect flooding threats and provide timely warning of impending flood danger.	Flood Warning and Readiness	n/a	Establish a baseline measurement	Increase the number of communities with programs by 40%
9	Increase number of flood gauges (rainfall, stream, reservoir, etc.) in the Region.	Flood Warning and Readiness	119 USGS rainfall gages in the region	Perform an evaluation on the number of basins in the region and establish a baseline of where additional gages are needed	Add gages based on the results of the evaluation (Increase by 30%)
10	Increase the number of public outreach and education activities to improve awareness of flood hazards and benefits of flood planning in the Region.	Education and Outreach	n/a	Develop outreach and education program	Majority participation in annual events throughout the basin

Section 4.0 Goal Setting Direction

To facilitate goal setting for the Lower Brazos Region, several sources of information were pulled together to help provide direction in the goal setting process. These include TWDB guidance, survey feedback, and data-defining watershed characteristics.

4.1 TWDB Goal

The TWDB has provided direction to all the regional flood plans by requiring each region to set an overarching goal “to protect against the loss of life and property”. The specific goals for the Lower Brazos region must directly or indirectly contribute to this overarching goal and the selected goals should be weighted heavily to directly contribute to this goal.

4.2 Lower Brazos Region Data Collection Survey

Another point of direction is feedback from various Region 8 communities and agencies using the Lower Brazos Survey which was initiated in July 2021. The survey was sent out to all the pertinent jurisdictions in the region (Cities, Counties, MUDs, LIDs, etc.). It included questions that were specifically designed to discern general goals that the entities would like to set or, at least, discern the benefits that the entities would like to see as a result of this regional flood plan. Select questions were pulled from the Data Collection Survey to provide some insight into the needs of the communities.

Questions and information from the Lower Brazos Region Data Collection Survey that are referenced in this section are shown in Attachment 1: Lower Brazos Data Collection Supporting Data.

Based on the survey results, there are multiple prominent, useful conclusions that helped directed the goal setting process:

1. Entities show a general desire to have better flood risk information (flood studies and mapping) to better understand current and future flood risk.
2. Willingness to implement flood mitigation measures and reduce current flood risk is generally high across the region.
3. Stronger action could be taken by communities to promote flood resilience to reduce future flood risk than is currently being undertaken.
4. Stronger enforcement of floodplain management regulations than is currently occurring could be provided by many communities to reduce future flood risk.
5. In areas lower in the region, higher floodplain management standards could be implemented by many communities to reduce future flood risk.

4.3 Establishment of Goal Targets

Each goal was reviewed to determine the applicability of the goal to the region, and whether the goal should be applied on a region-wide basis, a zone basis⁶, or a HUC-8 basis. The region varies greatly in terms of population, topography, climate effects, and overall flood risk. Therefore, some rules are better applied on a smaller scale.

⁶ The four zones that make up the Lower Brazos region are 1 (Coastal), 2 (Upper Coastal), 3 (Brazos Valley), and 4 (Middle Brazos). For additional information, see the Chapter for Task 3A.

The selection of 10- and 30-year goals was determined based upon guidance from the Texas Water Development Board. In addition, the selection of these target dates aligns with other regions, which will help the TWDB measure achievement across the state. Based on the implementation date of 2023, the goal milestones would be achieved in 2033 and 2053, respectively.

Quantities of measurement for each goal has been recommended in this document. However, the values selected are subject to change as additional data becomes available and finalized. A brief discussion of the selection of each quantity, with limitations, is detailed below.

- **Goal 1:** Percentages were chosen on what could be reasonably achieved. As only two counties do not participate in NFIP, full participation should be able to be achieved in 10 years. It is assumed that not every community will have the capability to join the NFIP, so the value proposed is reasonably close to 100% while still being achievable.
- **Goal 2:** The selected short-term goal is to increase the number of counties with higher-than-NFIP standards by 10%, and the number of communities by 30%. For the long-term goal, the proposed values are an increase in county regulations of 50%, and communities of 70%. Additional research is needed to fine-tune the baseline value presented, including determining the number of communities that currently have higher than NFIP standards, as well as the breakdown between counties and communities.
- **Goal 3:** A baseline measurement will be established as the first goal of this task to determine the number of entities affected by updates in rainfall totals. Using that baseline, 80% of communities should adopt the higher standards by 2053.
- **Goal 4:** The implementation of safety standards at low water crossings or removal of the crossings was assumed to be at a rate of 10% per decade. Low water crossings that are in the future floodplain cannot be determined until the 'future floodplain' is defined, so this goal focuses on crossings in the existing floodplain.
- **Goal 5:** Structures that are at risk for repetitive flooding during the 1% Annual Chance Event (ACE) will be evaluated to determine where structural and non-structural measures can be implemented to reduce flood risk. Reduction of risk was assumed to be at 5% for the short-term and 30% for the long-term. This goal focused on reducing risk due to the large number of structures outside of the existing ACE.
- **Goal 6:** The reduction of critical facilities was assumed to be at a rate of 10% per decade. Consensus will need to be reached on what defines a 'critical facility'. Critical facilities that are in the future floodplain cannot be determined until the 'future floodplain' is defined, so this goal focuses on facilities in the existing floodplain.
- **Goal 7:** A baseline measurement will be established as the first goal of this task to determine the number of communities with gaps in flood hazard mapping, as well as where maps can be updated with additional information. Evaluation will be required as some areas may not have changed imperviousness or precipitation values since the latest FEMA-maps were issued and will therefore not require updates.
- **Goal 8:** A baseline measurement will be established as the first goal of this task to determine the number of communities with established flood warning systems. From there, a 40% increase in the number of communities and warning systems was determined to be a reasonable long-term goal.
- **Goal 9:** The number of stream gages presented is based on USGS information. However, there are likely additional rainfall gages in the region that are operated by municipalities and counties. The short-term goal for increasing the number of rain gages will be to

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establish a baseline measurement and identify where gaps in data should be addressed. From there, additional gages will be added based on the results of the evaluation.

- **Goal 10:** An outreach program will be established as part of this goal, and annual events will be calculated to determine participation. The nature of the program will reflect the measurement determined (for example, whether this will be calculated using number of events or number of participants).

DRAFT

Section 5.0 Watershed Characteristics

Data was gathered from various sources such as FEMA, TWDB, TXDoT, and local entities and was organized and analyzed to highlight the unique characteristics and varied flood risk across the region. Characterizing the region ensures the development of regional goals purposefully affects the reduction of loss of life and property. Some of the data analyzed included flood risk mapping, flood claims, location of structures (including critical infrastructure), and floodplain management participation levels. This data will help identify the type and level of flood risk throughout the region to specifically:

1. Manage the achievability and appropriateness of each goal.
2. To appropriately specify the regional application of each goal.

5.1 Population Density

Regional population density is a key metric in determining where most of the population resides in the region as shown in Figure 9. A larger population typically corresponds with a higher flood risk due to increased development and residence in flood hazard area and increased urbanization which can exacerbate flooding issues. Mitigation projects implemented in areas of larger population density may see larger benefits due to the number of people and properties the projects will benefit.

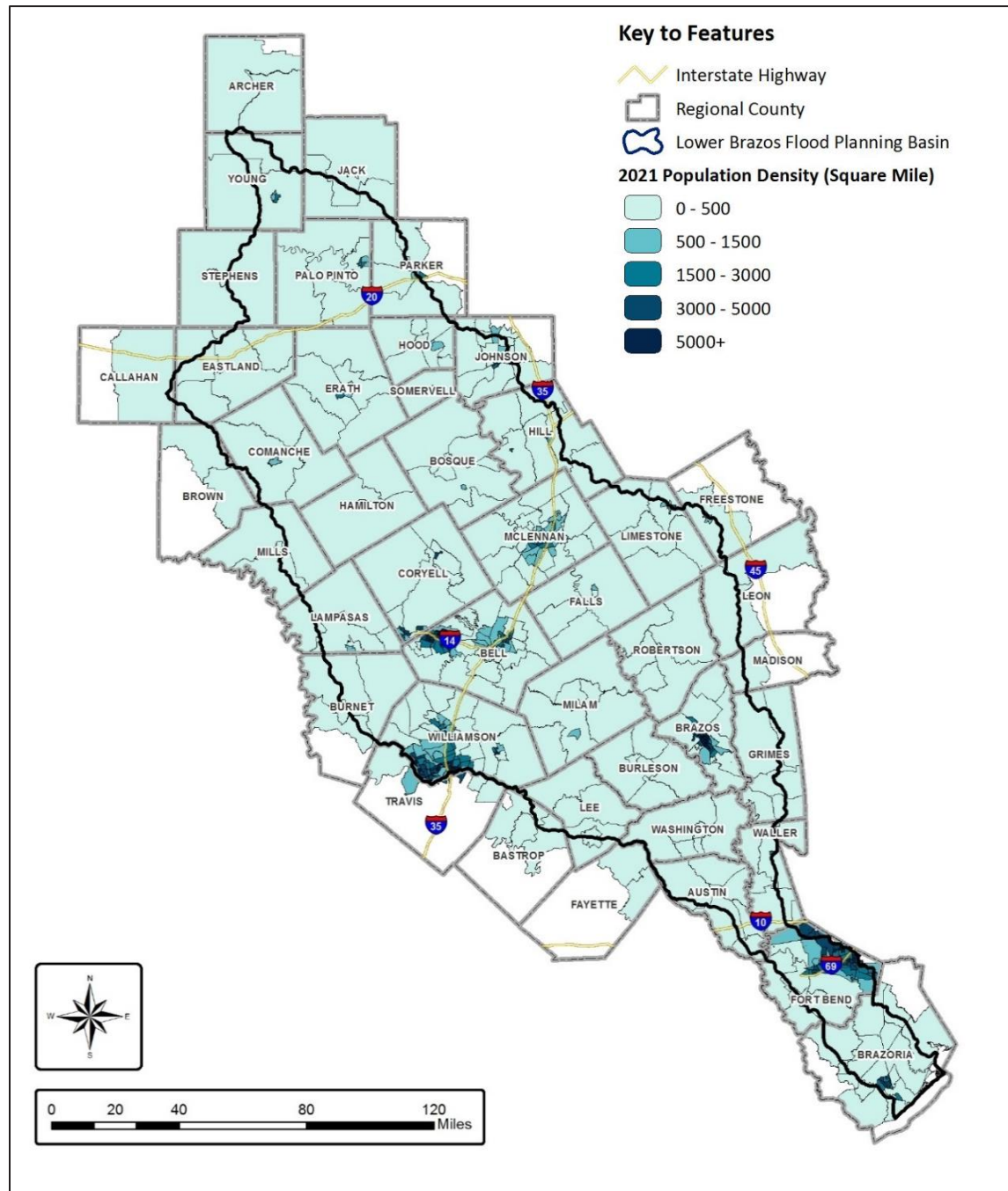


Figure 9. Lower Brazos Watershed Population Density

5.2 FEMA Flood Claims

Figure 10 is a graphical representation of the number of FEMA flood claims per year in the Lower Brazos region since 1979. The figure details the scale of the magnitude of flood risk throughout the region and can be used to help quantify level of flood reduction that is desired for the entire region.

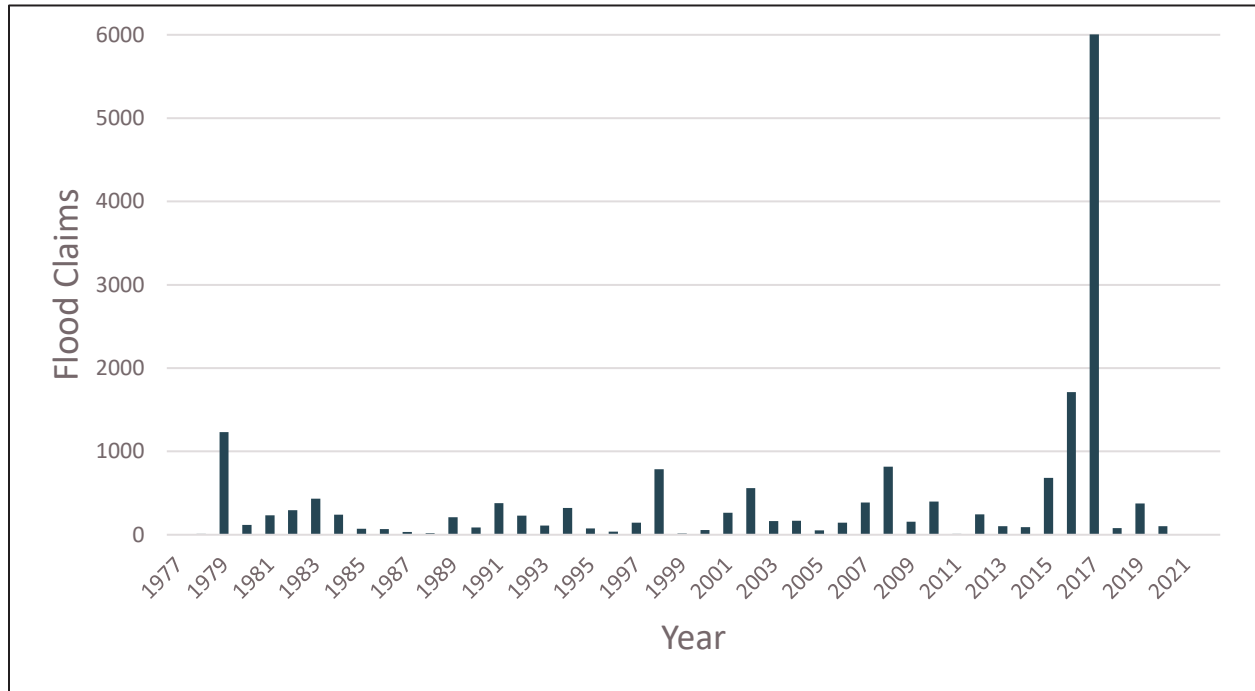


Figure 10. Lower Brazos Watershed FEMA Flood Claims by Year

The density map shown in Figure 11 breaks down the number of FEMA flood insurance claims by HUC-8 regions. These are the total claims are from 1979 to 2021. The figure shows the scale of magnitude of flood claims across the Lower Brazos region, as well as the varying density of these claims. As expected, the flood claim density is highest near heavily populated areas. This is especially true around the Houston region where the terrain is also relatively flat. However, even some of the less populated regions still have a significant number of flood claims over the same given time period.

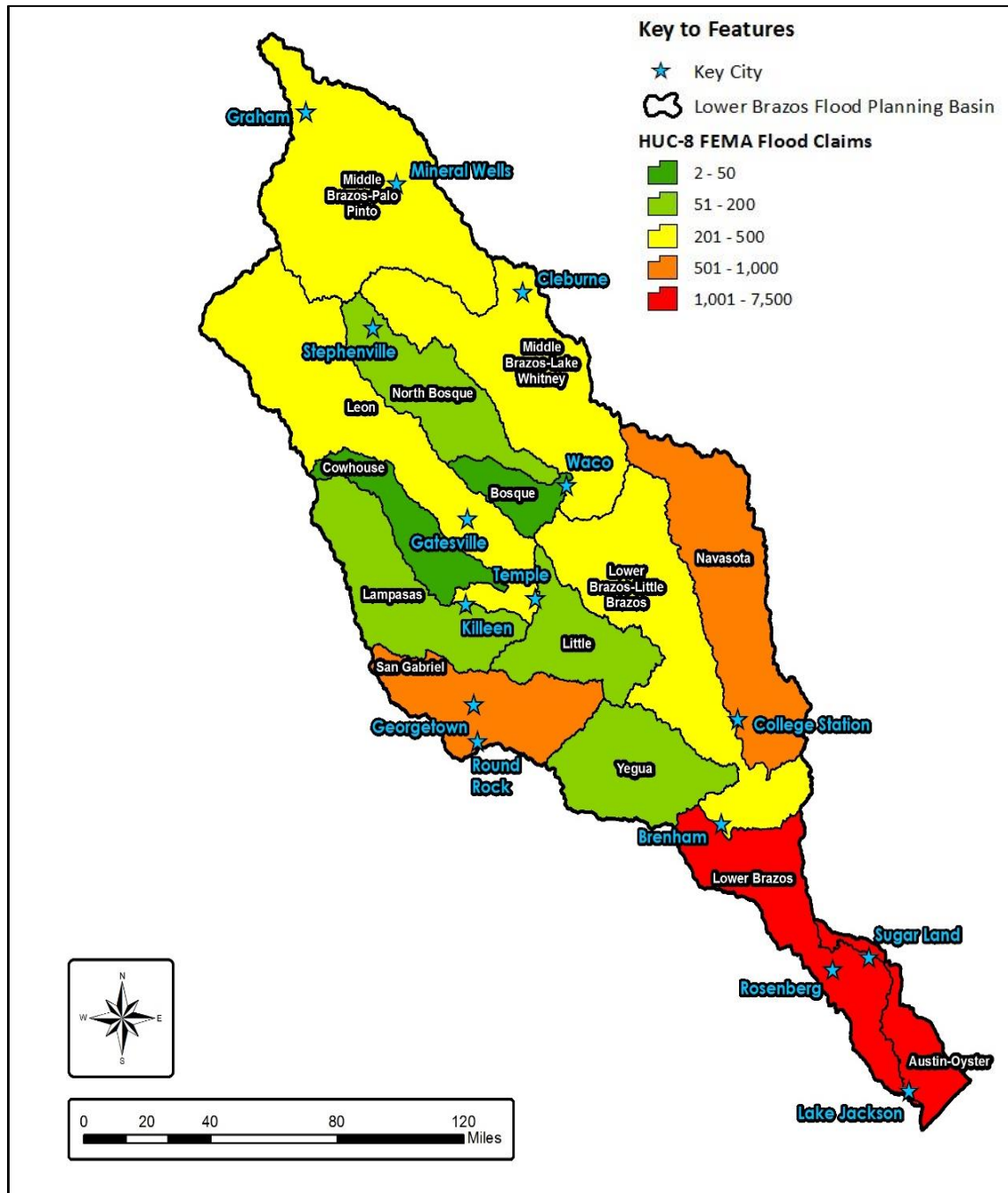


Figure 11. Lower Brazos FEMA Flood Claims by HUC-8

5.3 Flood Hazard Area Impact

Figure 12 details the number of structures in the Lower Brazos region's flood hazard zone, broken down by HUC-8. Important items to note include the fact that some structures may be elevated above the base flood elevation, but that feature not reflected in this map. Additionally, the results are based on the latest flood plain quilt data and is subject to change as more floodplain quilt data is received. However, the figure gives a good indication of the varying density across the region of structures currently located in high flood risk areas.

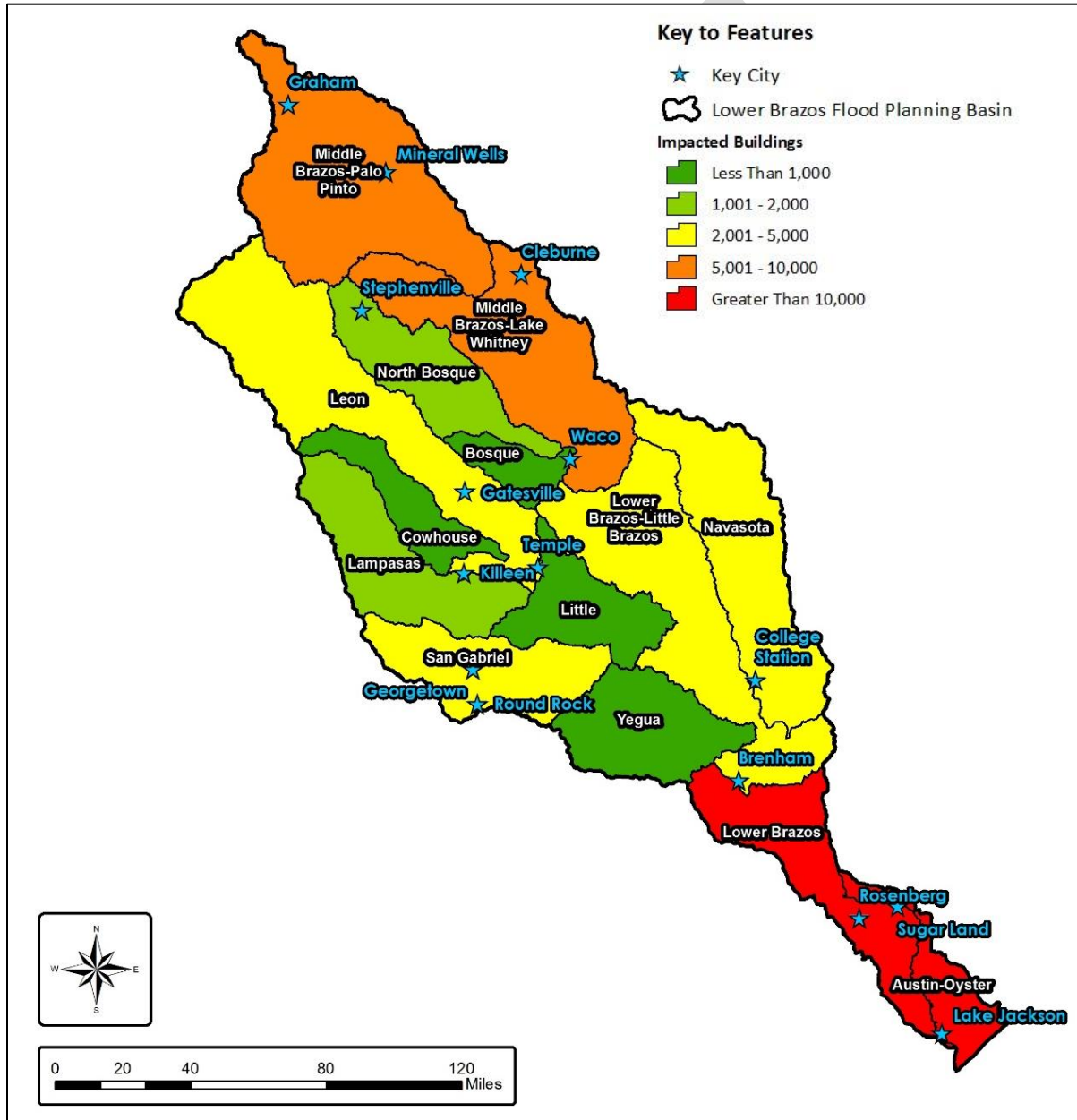


Figure 12. Structures Located within Flood Hazard Areas by HUC-8

5.4 Critical Infrastructure

Figure 13 details the number of critical structures in the Lower Brazos region's flood hazard zone, broken down by HUC-8. Critical structures include, but is not limited to, hospitals, fire and police stations, colleges, nursing homes, and schools. The notes listed above regarding elevation and the status of the floodplain quilt apply to this figure as well. The figure gives a good indication of the varying density across the region of critical infrastructure currently located in high flood risk areas.

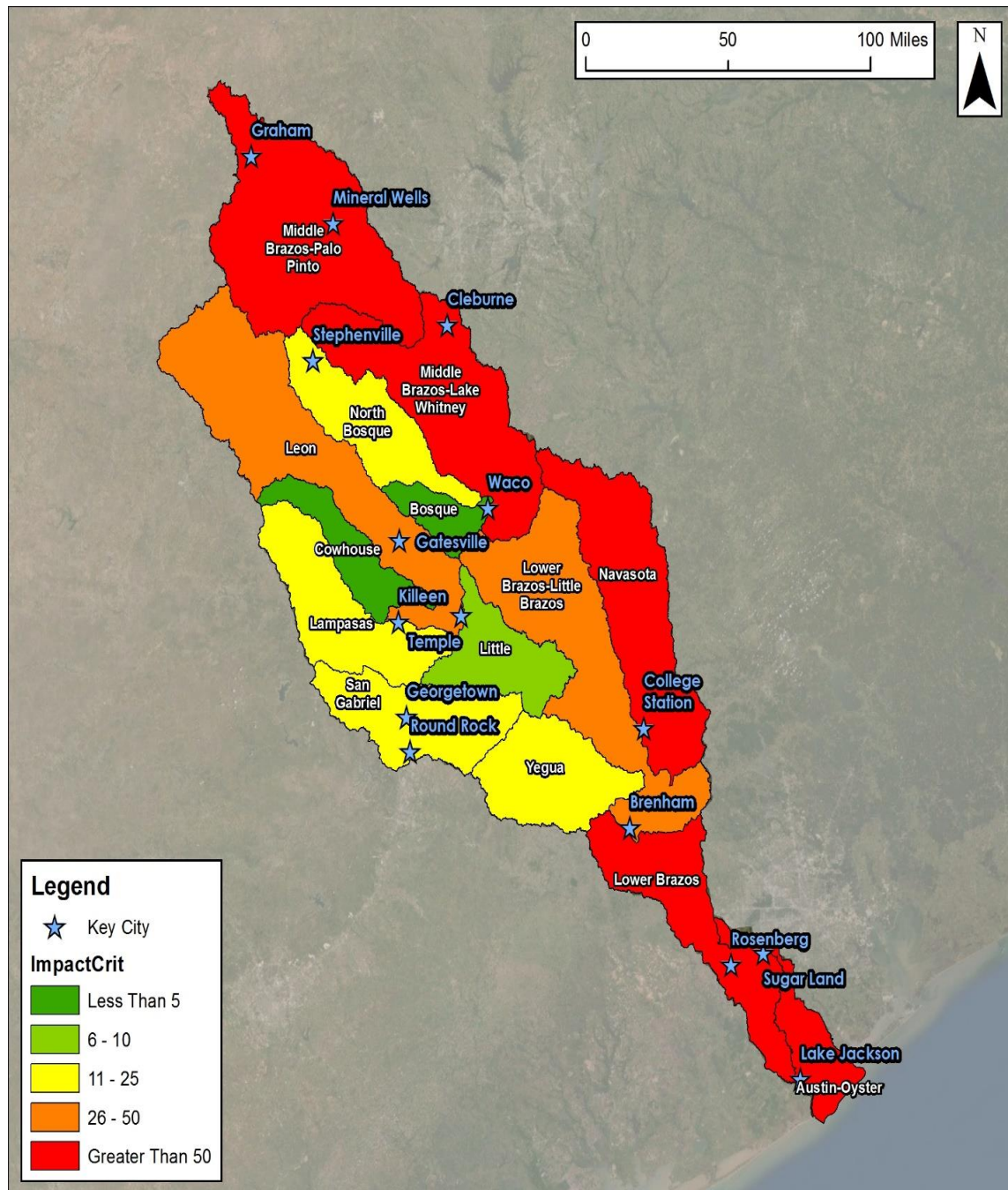


Figure 13. Critical Infrastructure Located within Flood Hazard Areas by HUC-8

5.5 NFIP Participation

Participation in the National Flood Insurance Program (NFIP) is highly encouraged by the Federal Emergency Management Agency (FEMA) and is required for property owners to be eligible for flood insurance and federal flood disaster money. Figure 14 shows the communities and counties that have and have not enrolled in the program. The map clearly shows that there are still areas where NFIP participation should be encouraged.

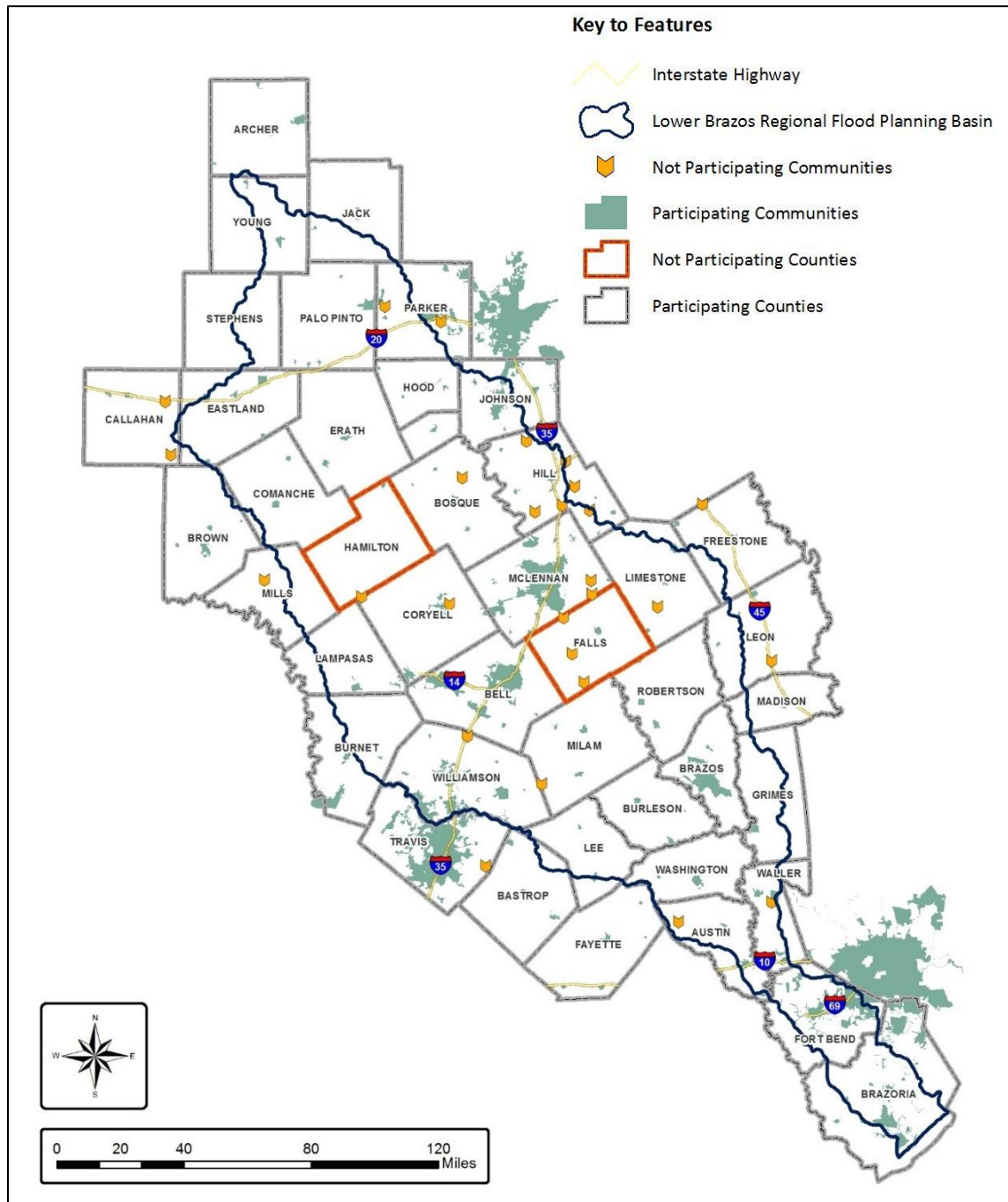


Figure 14. Lower Brazos Watershed Community NFIP Participation

5.6 Higher Community Standards

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. These communities can adopt and enforce higher standards than the FEMA NFIP minimum standards to better protect people and property from flooding, and to reflect the unique characteristics of each community or county. Enforcing higher standards is supported by FEMA.

According to the TWDB Exhibit C guidance document, the term “higher” standard is defined as freeboard, detention requirements or fill restrictions. FEMA defines freeboard as additional height above the base flood elevation that serves as a factor of safety when determining the elevation of the lowest floor. The Texas Floodplain Management Association (TFMA) performs a Higher Standards Survey every year of cities and counties to document which entities have adopted higher development standards. Table 6 below details the community response regarding what regulations are required for floodplain development.

Table 6. NFIP Higher Standards

NFIP Higher Standard Required	Count of Entities
At or above current base flood elevation (BFE)	30
BFE + 1 foot (current 1% annual chance event)	16
BFE + 2 foot (current 1% annual chance event)	20
BFE + 2 foot (current 0.2% annual chance event)	2
BFE + 2 foot (future 1% annual chance event)	1
TOTAL ENTITIES ABOVE CURRENT BFE	39

5.7 Low Water Crossings

Low Water Crossings are roadway crossings that can easily be inundated during a flood event. These areas are important to track because they pose a risk to people who try to cross them during flood events. Often, the depth and speed of the water is underestimated, and people and vehicles may be washed away, causing injury or fatalities. As shown in Figure 15 below, the low water crossings are found throughout the Lower Brazos region, but especially concentrated towards the western portion.

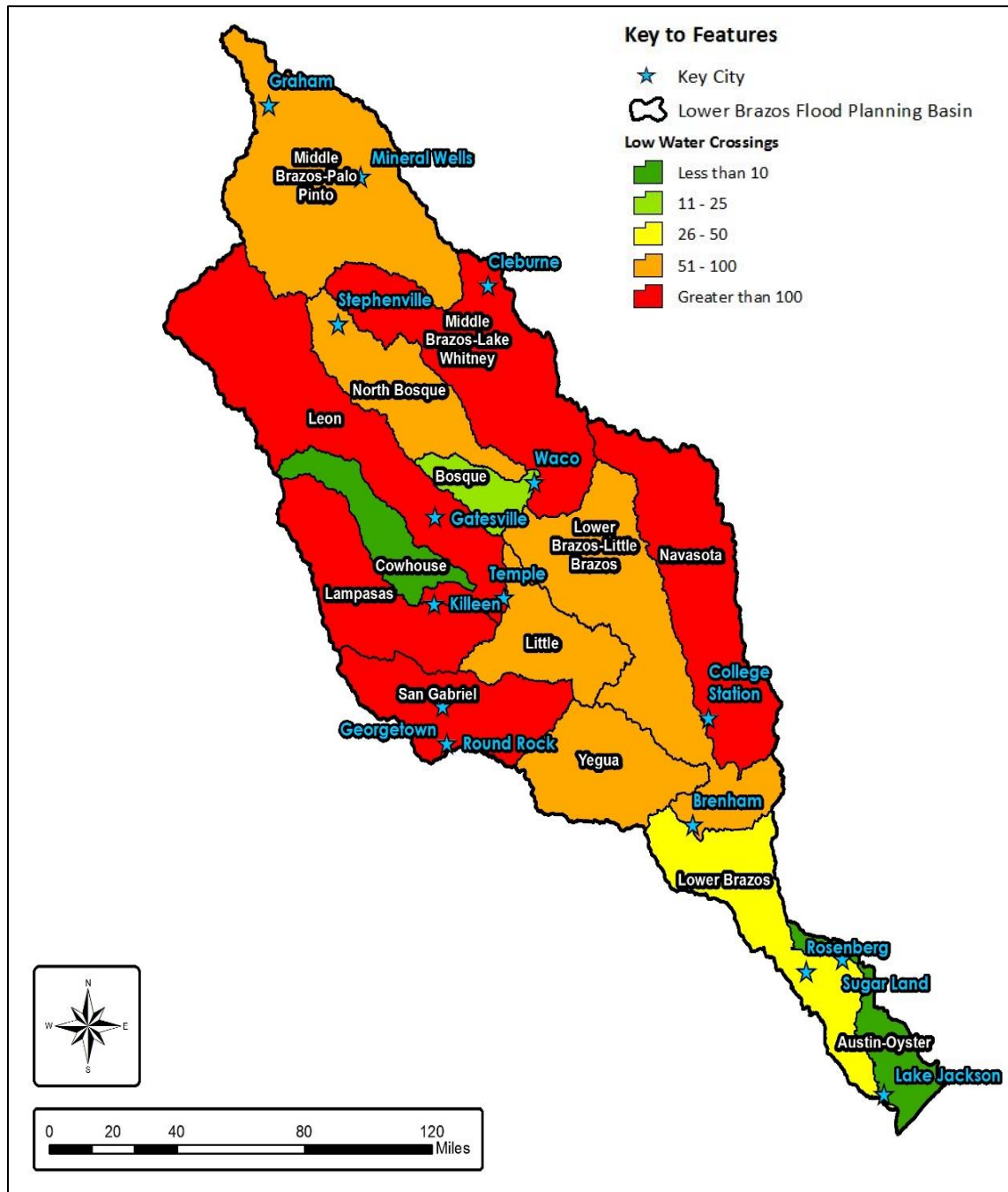


Figure 15. Low Water Crossings

Attachment 1: Lower Brazos Data Collection Supporting Data

As of September 7th, 2021, the Lower Brazos Data Collection Survey had been completed to varying extents by the following representation of entities:

- 36 Cities,
- 15 Counties,
- 9 Municipal Utility Districts,
- 8 Levee Improvement Districts,
- 3 Councils of Government,
- 1 Water Control District, and
- 1 River Authority

The following graphics show the distributions for answers to various questions. Some questions were presented in a format where multiple selections were possible, which may cause some graphics to show more responses than communities.

The response concerning the availability of floodplain management regulations coupled with the high National Flood Insurance Program (NFIP) participation rate (see Figure 16), indicates that communities are generally implementing some sort of floodplain management regulations. Based on the “No” and “I do not know” responses, these floodplain regulations may only be the default minimum NFIP regulations with little implementation of higher standards.

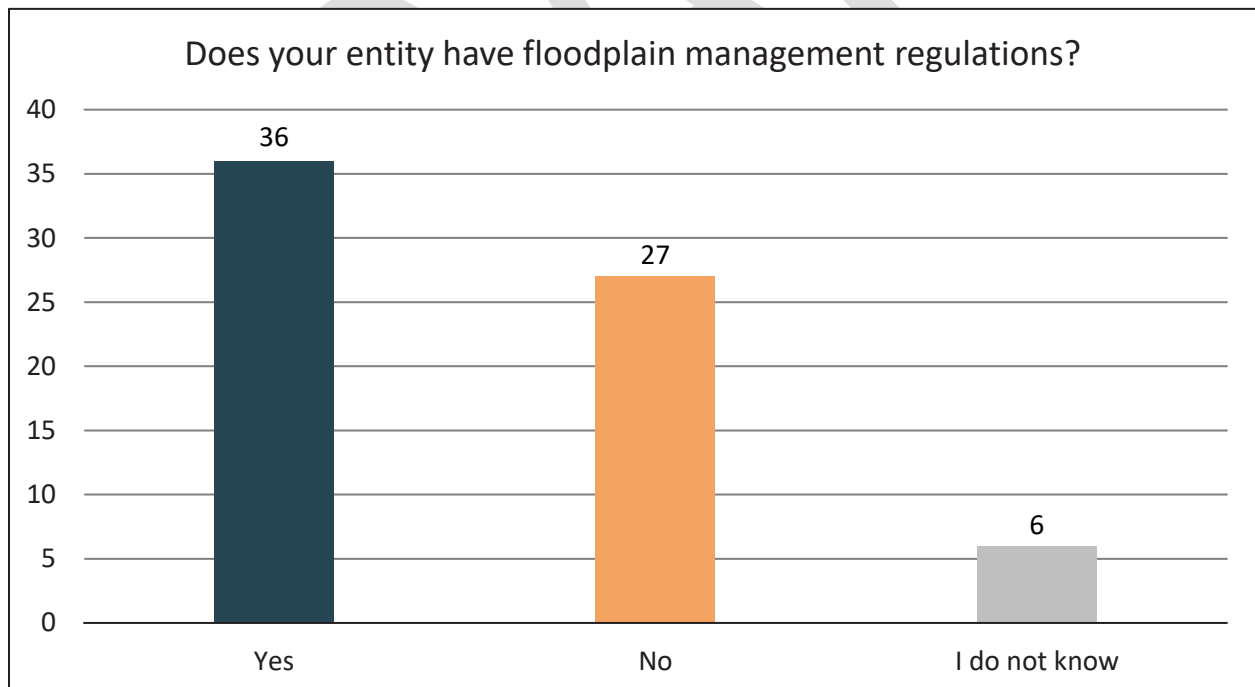


Figure 16. Responses to Question 1 from Lower Brazos Data Collection Survey

Figure 17 indicates that the general desire of the region is to implement floodplain standards that match the NFIP minimum standards. However, there appears to be some desire to implement higher standards

that may include preserving existing floodplains, implementing land use standards, and requiring compensatory floodplain storage for any fill in the floodplain.

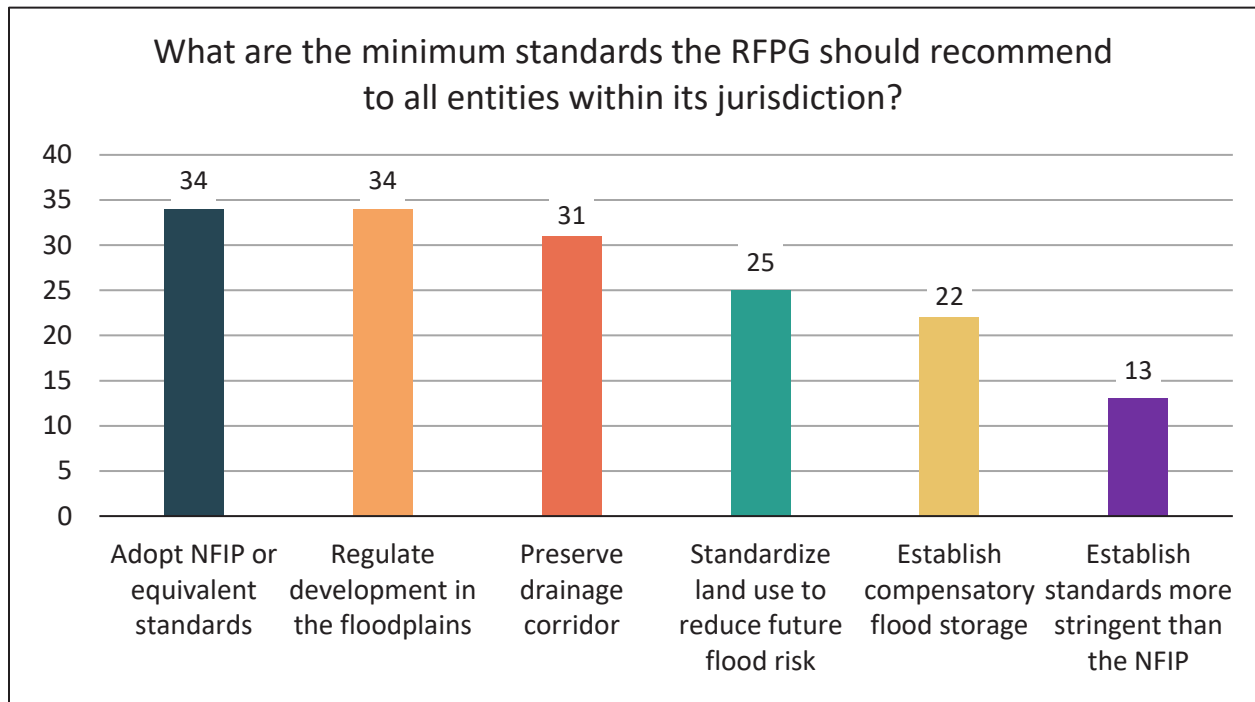


Figure 17. Responses to Question 12 from Lower Brazos Data Collection Survey

The two question response groups shown in Figure 18 and Figure 19 give some insight into the community's level of action regarding floodplain management activity and enforcement. To summarize, more action could be taken by communities to promote flood resilience and enforce minimum floodplain standards.

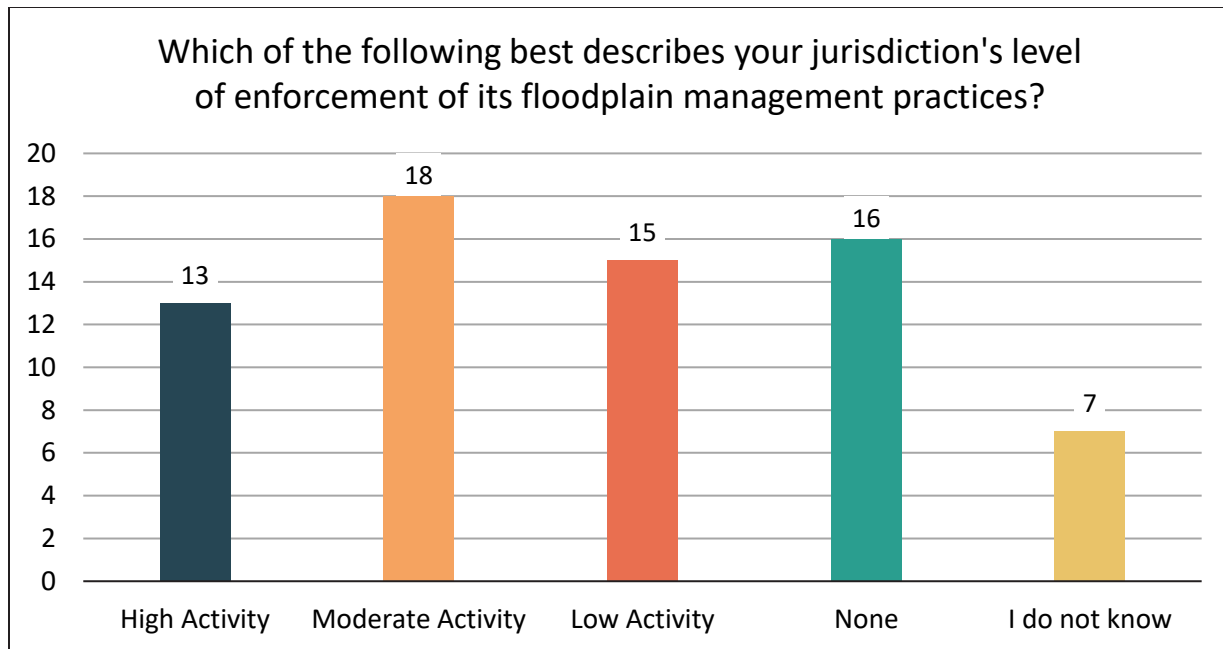


Figure 18. Responses to Question 10 from Lower Brazos Data Collection Survey

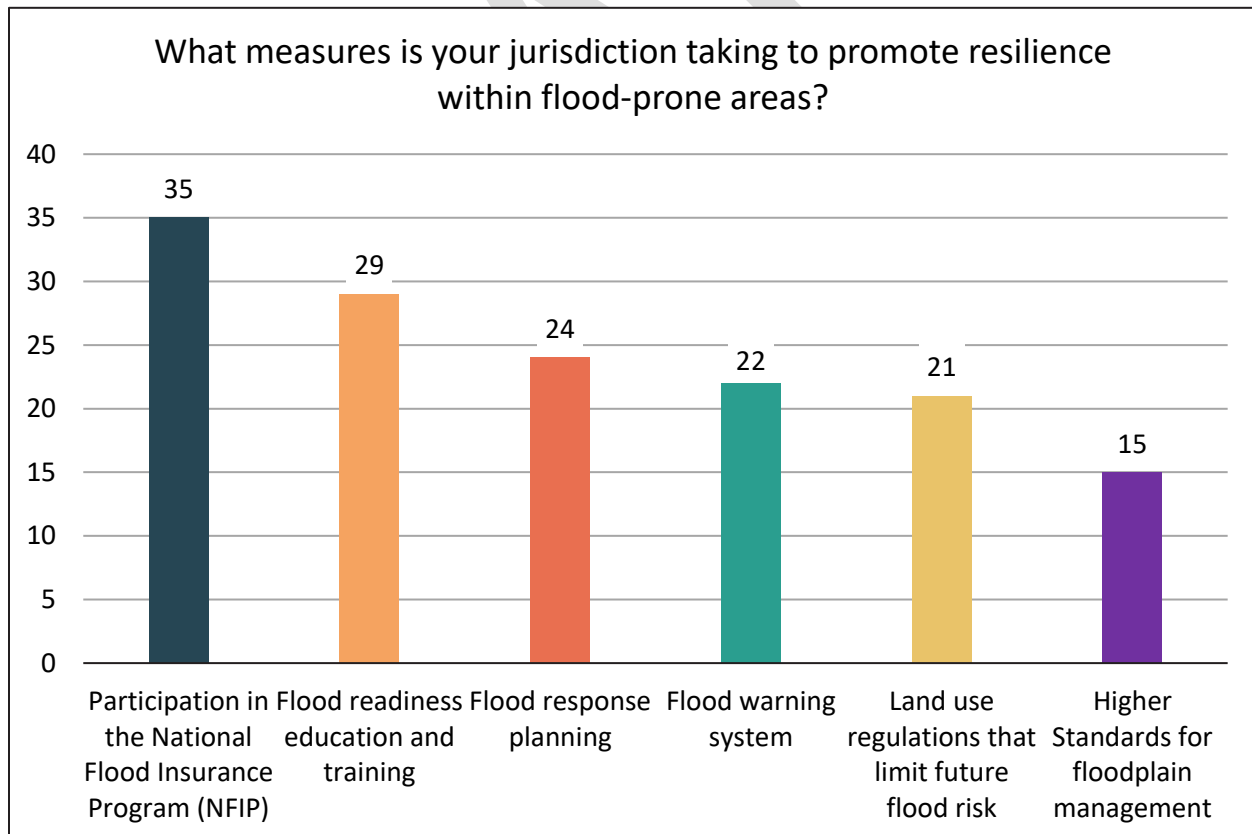


Figure 19. Responses to Question 15 from Lower Brazos Data Collection Survey

The question shown in Figure 20 gives a general idea of the level of higher standards that are being implemented. It appears that a large number of communities are applying only the minimum standards required to participate in the NFIP. Implementation of higher floodplain standards than the NFIP could help reduce future flood risk, especially when considering future flood level changes.

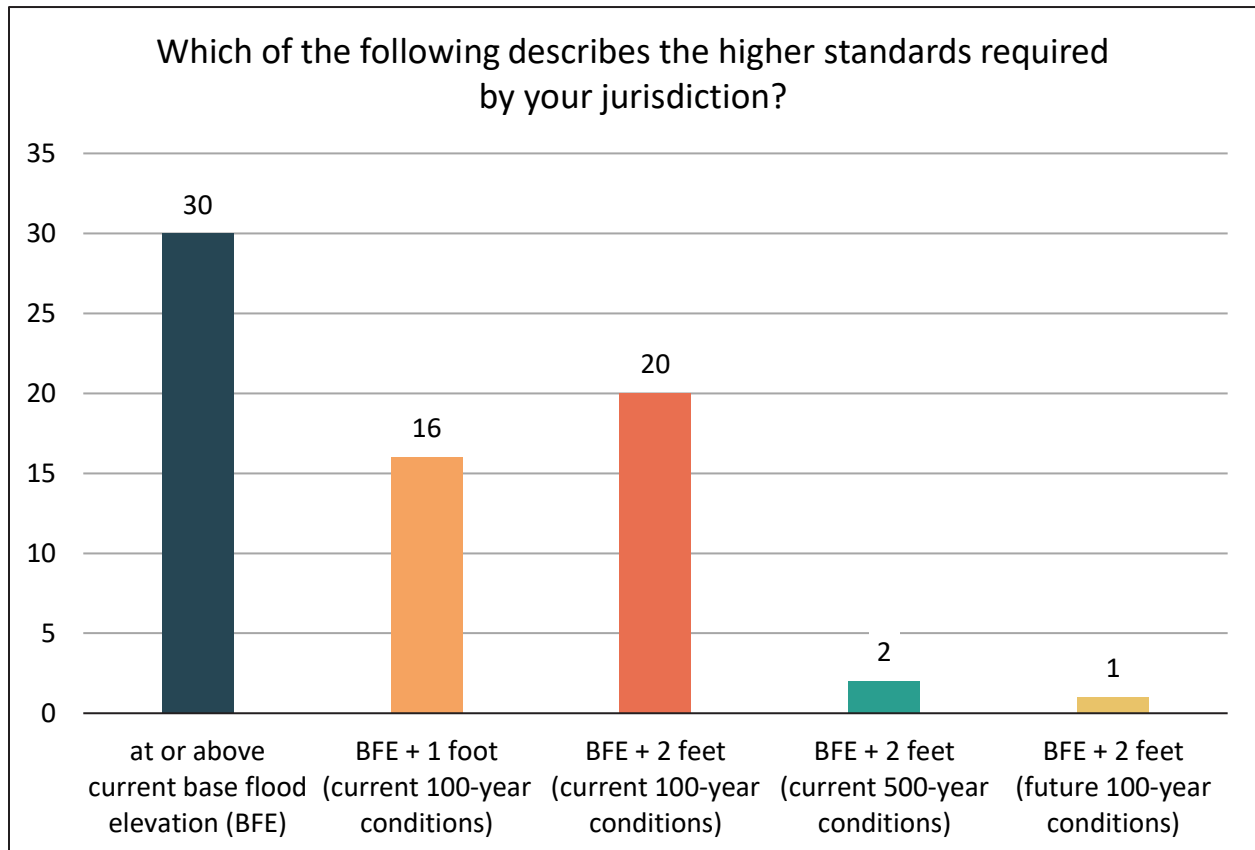


Figure 20. Responses to Question 20 from the Lower Brazos Data Collection Survey

The highest response from Question 19, pictured in Figure 21, is heavily influenced by entities located along the Brazos River in the downstream-most region of the basin, in regions such as Fort Bend County and Brazoria County. This will be important when setting specific goals to this localized area. The 2nd and 3rd highest results appear to be more indicative of the response from the rest of the region.

In summary, flood risk mitigation projects and better flood risk information are the desired results that communities want to see from the Regional Flood Plan.

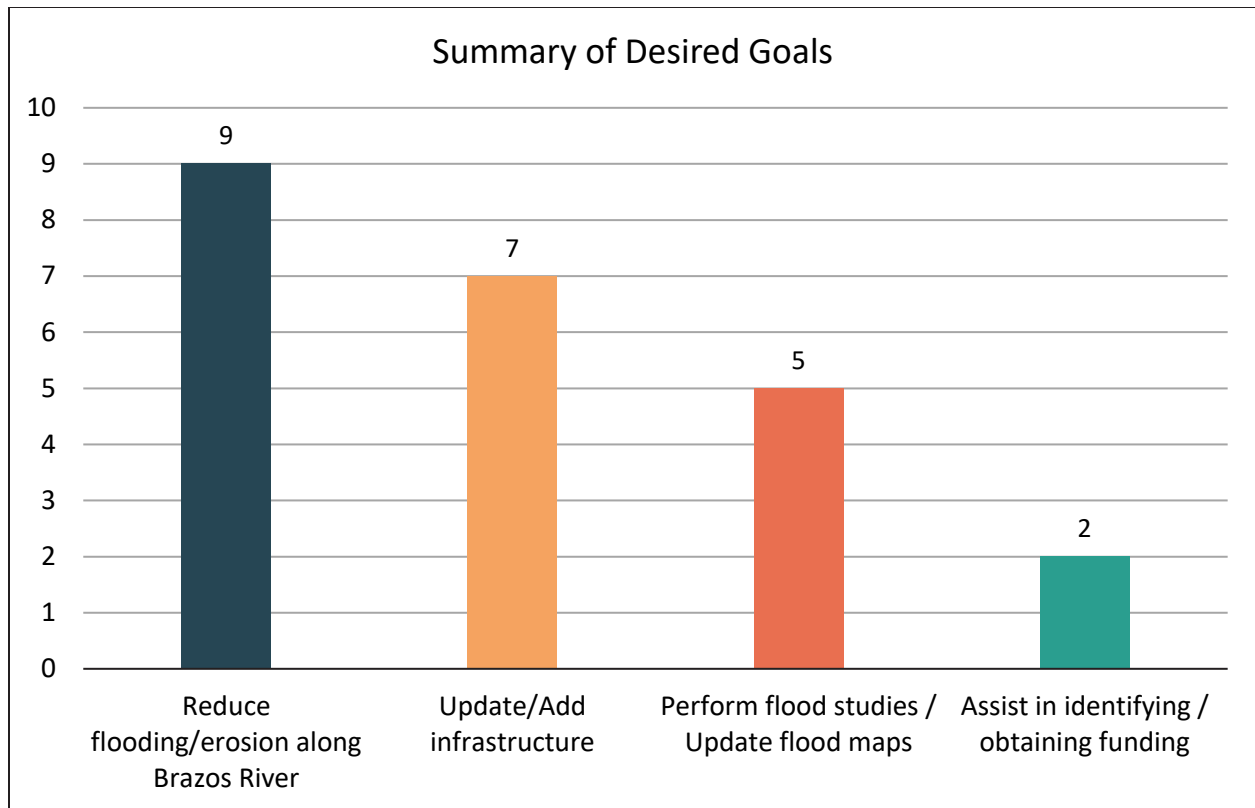


Figure 21. Summary of Responses to Question 19 from the Lower Brazos Data Collection Survey

The results of this survey were compared with the survey results from the State Flood Assessment shown in Figure 22 that was conducted by the Texas Water Development Board in 2018. Based on the question shown below, similarities between both surveys can be seen in that community's desire better flood risk information and financial assistance in implementing flood mitigation projects.

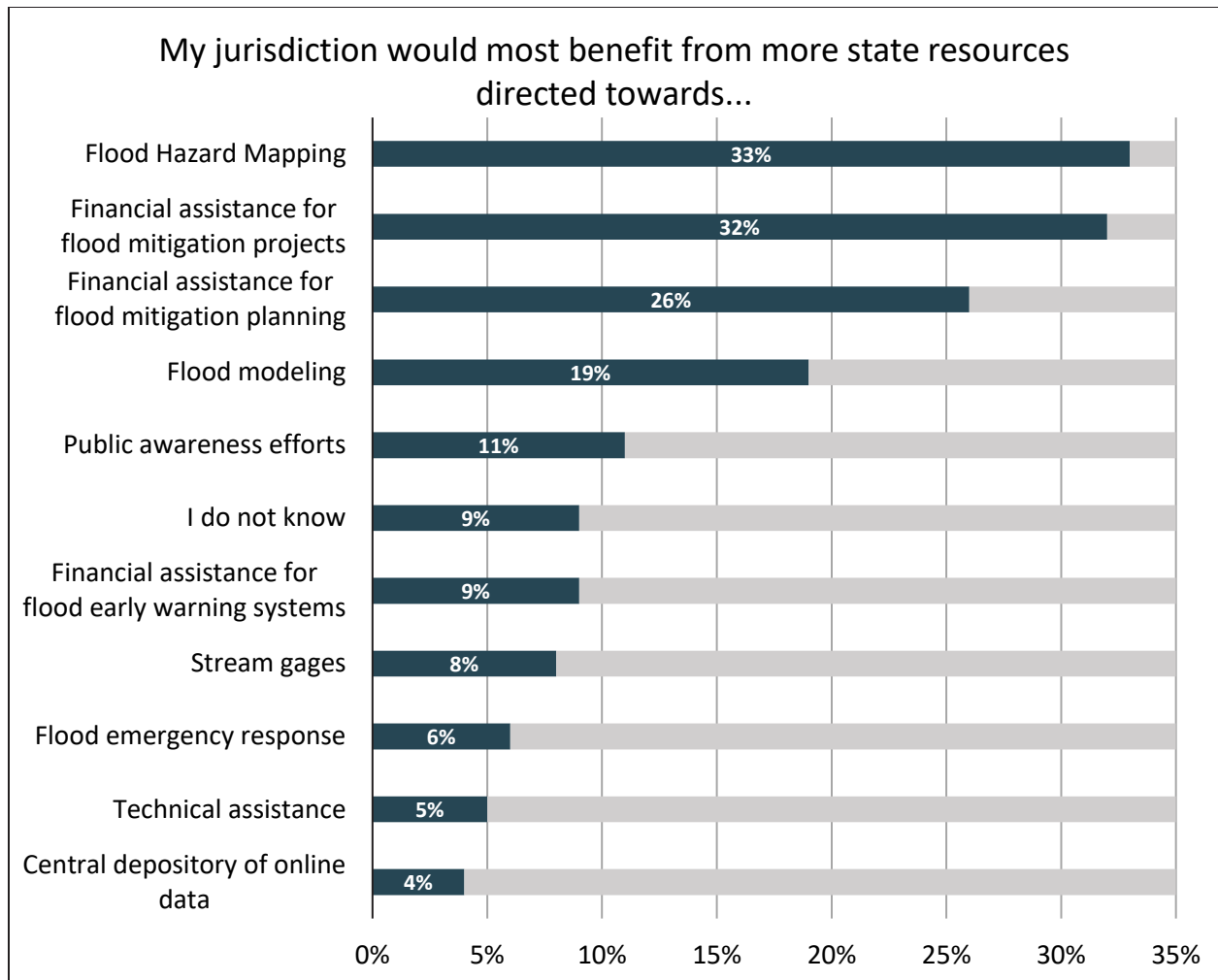


Figure 22. Responses to State Flood Assessment

Attachment 2: TWDB Table 11

Table 7. Regional Flood Plan, Flood Mitigation, and Floodplain Management Goals

Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk ⁷	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
0101	Increase the number of counties (to 100%) and communities (to 90%) that are enrolled in the National Flood Insurance Program.	Short Term (10-year)	2023	Entire RFP		Percentage of participating counties and communities	Protect against the loss of life and property	0102
0102	Maintain the number of counties (to 100%) and increase the number of communities (to 95%) that are enrolled in the National Flood Insurance Program.	Long Term (30-year)	2053	Entire RFP		Percentage of participating counties and communities	Protect against the loss of life and property	0101
0201	Increase the number of counties and communities that have adopted higher than NFIP-standards by 10%.	Short Term (10-year)	2023	Entire RFP		Percentage of participating counties and communities	Protect against the loss of life and property	0202
0202	Increase the number of counties and communities that have adopted higher than NFIP-standards by 40%.	Long Term (30-year)	2053	Entire RFP		Percentage of participating counties and communities	Protect against the loss of life and property	0201

⁷ To be determined

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Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk ⁷	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
0301	Establish a baseline of the number of entities that are affected by the latest rainfall data.	Short Term (10-year)	2023	Zone		Baseline should be established, but likely a percentage	Protect against the loss of life and property	0302
0302	Increase the number of entities that have adopted the latest rainfall data by 80%.	Long Term (30-year)	2053	Zone		80% of baseline value	Protect against the loss of life and property	0301
0401	Improve safety at 90 low water crossings by adding warning systems/signage or improving low water crossings in high-risk areas.	Short Term (10-year)	2023	Zone		Number of low water crossings improved or removed	Protect against the loss of life and property	0402
0402	Improve safety at 270 low water crossings by adding warning systems/signage or improving low water crossings in high-risk areas.	Long Term (30-year)	2053	Zone		Number of low water crossings improved or removed	Protect against the loss of life and property	0401
0501	Reduce the number of structures that are at risk of repetitive flooding during the 1% annual chance flood by both structural (flood infrastructure) and non-structural (elevation, buy-outs, relocation, etc.) means.	Short Term (10-year)	2023	Zone		Number of repetitive-loss properties with reduced risk	Protect against the loss of life and property	0502

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Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk ⁷	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
0502	Reduce the number of structures that are at risk of repetitive flooding during the 1% annual chance flood by both structural (flood infrastructure) and non-structural (elevation, buy-outs, relocation, etc.) means.	Long Term (30-year)	2053	Zone		Number of repetitive-loss properties with reduced risk	Protect against the loss of life and property	0501
0601	Establish the quantity of at-risk critical facilities that are within the 1% annual chance of flooding.	Short Term (10-year)	2023	Zone		Number of critical care facilities with reduced risk	Protect against the loss of life and property	0602
0602	Reduce the flood hazard risk of 10% of critical facilities that are below a 1% annual chance of flooding to below the 0.2% annual chance by both structural (flood infrastructure) and non-structural (elevation, buy-outs, relocation, etc.) means.	Long Term (30-year)	2053	Zone		Number of critical care facilities with reduced risk	Protect against the loss of life and property	0601
0701	Establish a baseline measurement to increase the accuracy of flood hazard data in the FPR by performing detailed studies using the best available terrain, land use, and precipitation data to reduce gaps in floodplain mapping.	Short Term (10-year)	2023	HUC-8		Baseline should be established, but likely a percentage	Protect against the loss of life and property	0702

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Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk ⁷	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
0702	Obtain a 50% gap reduction in the accuracy of flood hazard data in the FPR by performing detailed studies using the best available terrain, land use, and precipitation data to reduce gaps in floodplain mapping.	Long Term (30-year)	2053	HUC-8		Baseline should be established, but likely a percentage	Protect against the loss of life and property	0701
0801	Establish a baseline measurement to increase the number of communities with warning and emergency response programs that can detect flooding threats and provide timely warning of impending flood danger.	Short Term (10-year)	2023	Zone		Baseline should be established, but likely a percentage	Protect against the loss of life and property	0802
0802	Establish a 40% increase the number of communities with warning and emergency response programs that can detect flooding threats and provide timely warning of impending flood danger.	Long Term (30-year)	2053	Zone		Baseline should be established, but likely a percentage	Protect against the loss of life and property	0801
0901	Increase number of flood gauges (rainfall, stream, reservoir, etc.) in the Region to 143 gages.	Short Term (10-year)	2023	Entire RFP		Total number of gages throughout the region	Protect against the loss of life and property	0902

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Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk ⁷	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
0902	Increase number of flood gauges (rainfall, stream, reservoir, etc.) in the Region to 202 gauges.	Long Term (30-year)	2053	Entire RFP		Total number of gages throughout the region	Protect against the loss of life and property	0901
1001	Develop a public outreach program and education activities to improve awareness of flood hazards and benefits of flood planning.	Short Term (10-year)	2023	Entire RFP		Participation in established education and outreach program	Protect against the loss of life and property	1002
1002	Establish a majority participation in annual public outreach programs and education activities to improve awareness of flood hazards and benefits of flood planning throughout the region.	Long Term (30-year)	2053	Entire RFP		Participation in established education and outreach program	Protect against the loss of life and property	1001

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