Chapter 1: Introduction and Description of the Upper Rio Grande Flood Planning Region

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1. Introduction and Description of the Upper Rio Grande Flood Planning Region

Sections 16.061 and 16.062 of the Texas Water Code direct the Executive Administrator of the Texas Water Development Board (TWDB) to prepare and maintain a comprehensive State Flood Plan. The overall goal of the State Flood Plan is to identify specific flood risks as well as flood studies, strategies, and projects to reduce those risks in coming years within Texas. This effort is aimed at better managing flood risk to reduce loss of life and property from flooding.

In April 2020, the TWDB adopted rules establishing 15 regional flood planning areas (**Figure 1.1**). Each planning area has its own regional flood planning group (RFPG) responsible for preparing a consensus-based Regional Flood Plan (RFP). The TWDB incorporates the resulting RFPs into the State Flood Plan, which is updated in 5-year cycles. It is anticipated that the current cycle of Regional Flood Plans will be finalized and adopted by January 2023. Subsequently, by September 2024, the TWDB will prepare its first State Flood Plan.

The Upper Rio Grande Flood Planning Region, designated by the TWDB as “Region 14” and led by the Upper Rio Grande Flood Planning Group (URGFPG), encompasses all or part of 23 West Texas counties as listed below and shown in **Figure 1.2** (partial counties denoted with asterisks):

- Andrews*
- Brewster
- Crane
- Crockett*
- Culberson
- Ector*
- Edwards*
- El Paso
- Hudspeth
- Jeff Davis
- Loving
- Midland*
- Pecos
- Presidio
- Reagan*
- Reeves
- Schleicher*
- Sutton*
- Terrell
- Upton*
- Val Verde*
- Ward
- Winkler

The planning area for Region 14 follows the Upper Rio Grande in West Texas along the US-Mexico border from the City of El Paso to the Amistad Reservoir in Val Verde County as well as the Pecos River from the New Mexico Border to the Rio Grande. This region is the largest of the fifteen state flood planning regions by area, covering more than 43,000 square miles across three river basins – the Upper Rio Grande, the Pecos River, and the Devils River.

The entirety of the Upper Rio Grande watershed area covers nearly 180,000 square miles, draining into the Lower Rio Grande through the Amistad Reservoir and, ultimately, into the Gulf of Mexico. A majority of the Upper Rio Grande watershed originates upstream of the Texas state line, with Texas representing only 24% of the total watershed area. The remainder of the watershed covers New Mexico (43%), Mexico (29%), and Colorado (4%).

The regional flood plan includes the following sections:

- Planning area description (Chapter 1)
- Existing and future condition flood risk analysis (Chapter 2)
- Evaluation and recommendations on floodplain management practices; Flood mitigation and floodplain management goals (Chapter 3)
- Identification of flood needs and identification and recommendation of flood solutions including flood management evaluations (FMEs), flood management strategies (FMSs), and flood mitigation projects (FMPs) (Chapter 4)
- Impacts of regional flood plan; contributions to and impacts on water supply development and the State Water Plan (Chapter 5)
- Flood response information and activities (Chapter 6)
- Administrative, regulatory, and legislative recommendations (Chapter 7)
- Flood infrastructure financing analysis (Chapter 8)
- Public participation and plan adoption (Chapter 9)

The overall goal of the State Flood Plan is “to protect against the loss of life and property,” as set forth in the Guidance Principles in 31 Texas Administrative Code (TAC) §362.3. Flood management evaluations, flood management strategies, and flood mitigation projects aim to mitigate flood events associated with a 1% annual chance flood event. During the process of developing flood management evaluations and strategies and flood mitigation projects within each region, benefits to water supplies, economic and environmental impacts, and public acceptance were considered. This includes local impacts to agriculture, recreational resources, transportation, and sustainability.

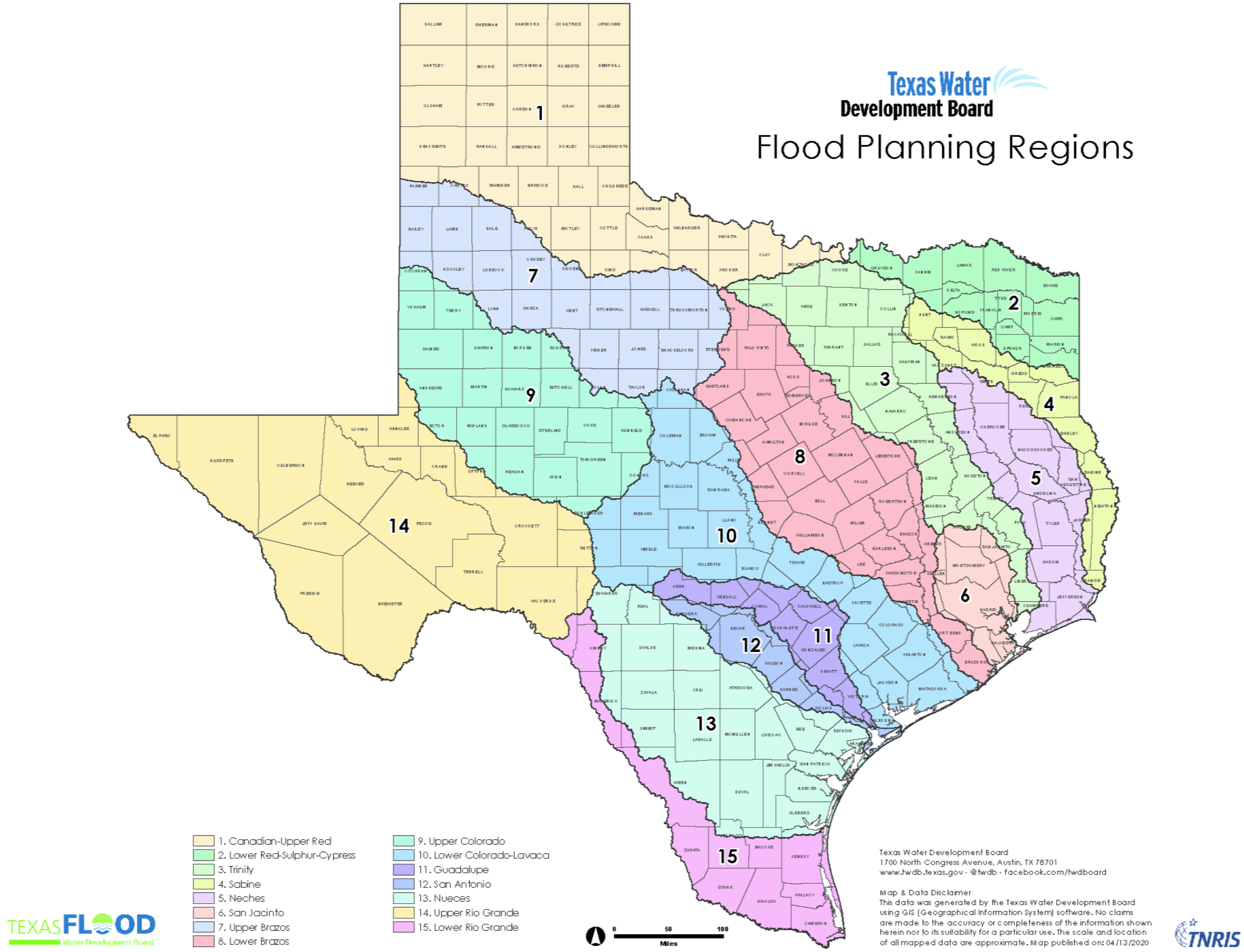


Figure 1.1 TWDB Designated Flood Planning Regions

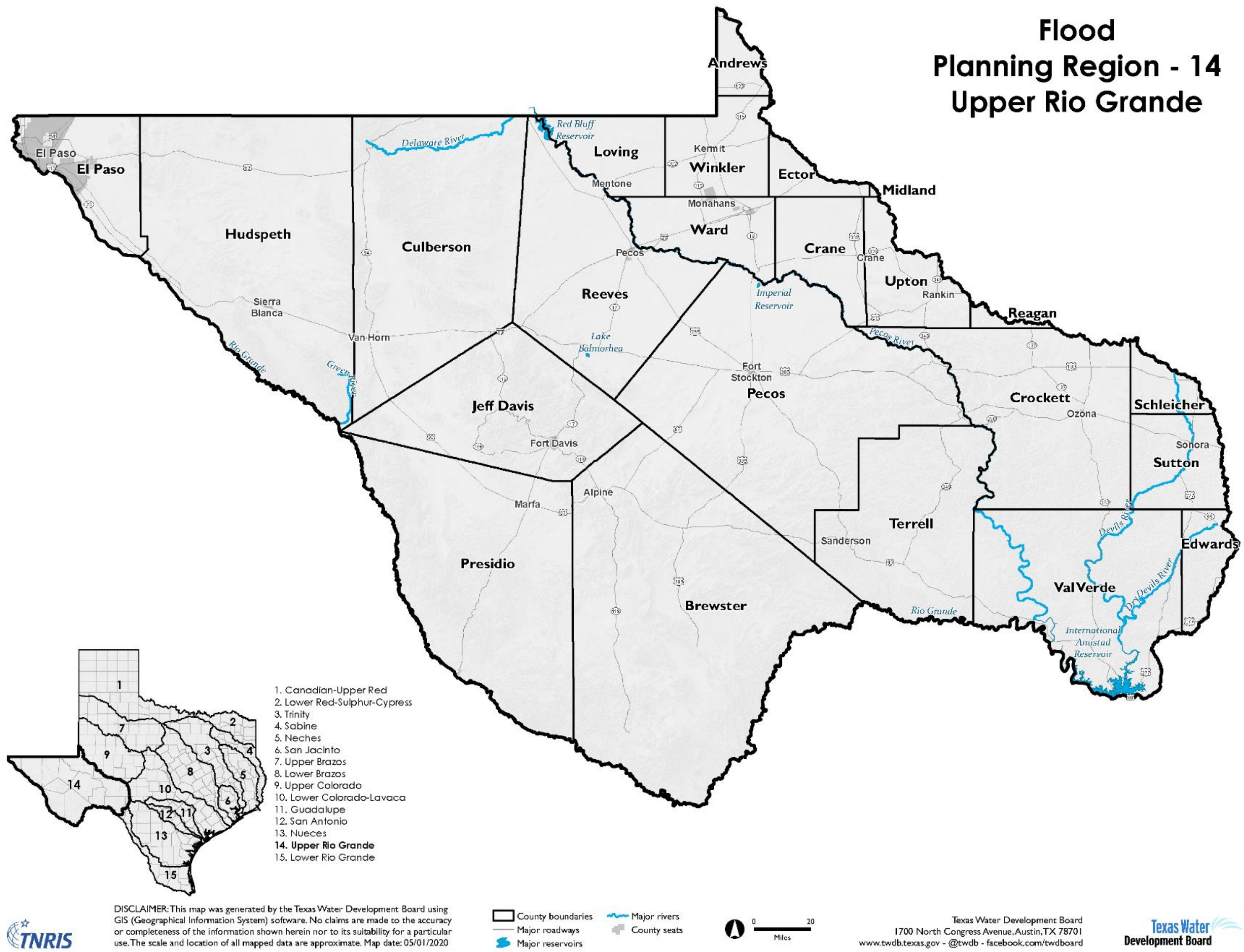


Figure 1.2 Upper Rio Grande Flood Planning Region (Region 14)

1.1 Social and Economic Characteristics

The Far West Texas region is well known for its wide-open expanses and rugged landscapes. Compared to other flood planning regions across the state, Region 14 remains primarily rural and less impacted by urban development.[1] Neverthless, flooding continues to pose a substantial risk to communities of all sizes across the region. The following section describes the social and economic characteristics of the region, including development, population, and economic activity.

1.1.1 Population & Development

Population

Regional county-level population estimates were obtained and compared from multiple sources including the TWDB Regional Water Plan (2021), the Texas Demographic Center Texas Population Projections Program (2018), the American Community Survey (ACS) 5-year Estimates (2016-2020), and the 2020 Decennial Census Redistricting Data Summary Files.

Existing (2020) populations by county in the region are summarized in **Table 1.1**. Populations were adjusted to reflect only the population estimated inside the Region 14 Flood Planning boundaries, excluding populations for urban centers outside the region such as the Cities of Midland and Odessa (represented in Region 9) as well as the City of Del Rio (represented in Region 15). In addition, populations for smaller counties such as Loving and Midland County were estimated using Landscan nighttime population estimates from the Oak Ridge National Laboratory (ORNL) datasets.

The top five counties by population in Region 14 include the Counties of El Paso (89%), Pecos (2%), Reeves (2%), Ward (1%), and Brewster (1%). Several of the region's largest cities are located in El Paso County, including the Cities of El Paso, Socorro, Horizon City, and San Elizario. Other prominent cities in the region by population include the City of Fort Stockton (Pecos County), the City of Pecos (Reeves County), the City of Alpine (Brewster County), the City of Monahans (Ward County), and the City of Presidio (Presidio County).

Population within Region 14 is projected to grow on pace with the rest of Texas between 2020 and 2050, with an estimated annual growth rate between 1.1% and 1.8%, according to the TWDB 2021 Regional Water Plan and 2018 Texas Demographic Center estimates. A more detailed analysis of future population trends is presented in *Chapter 2 (Flood Risk Analyses)*.

[1] Texas A&M Natural Resources Institute (NRI). *West Texas Landowner Report: Energy and Growth Trends.* December 2019. *https://nri.tamu.edu/media/2786/west-texas-landowner-report-final-20200115.pdf*

Table 1.1 Existing Population by County in Region

County	Estimated Population in Region, 2020	% of Population in Region
Andrews	138	<0.1%
Brewster	9,727	0.9%
Crane	5,056	0.5%
Crockett	4,111	0.4%
Culberson	2,695	0.3%
Ector	4,705	0.5%
Edwards	2,123	0.2%
El Paso	925,565	89.0%
Hudspeth	3,913	0.4%
Jeff Davis	2,398	0.2%
Loving	157	<0.1%
Midland	80	<0.1%
Pecos	17,718	1.7%
Presidio	8,692	0.8%
Reagan	3,853	0.4%
Reeves	15,125	1.5%
Schleicher	3,811	0.4%
Sutton	3,817	0.4%
Terrell	1,045	0.1%
Upton	3,690	0.4%
Val Verde	1,933	0.2%
Ward	11,454	1.1%
Winkler	8,033	0.8%
Total	1,039,839	100%

Social Vulnerability

The Social Vulnerability Index (SVI) is an index used by the Centers for Disease Control and Prevention (CDC) that measures 15 social factors from the U.S Census, including poverty, lack of vehicle access, and crowded housing, among others. The SVI can help public health officials and local planners better prepare for and respond to emergency events like flooding, hurricanes, disease outbreaks, or exposure to dangerous chemicals. The SVI ranges from zero (0) to one (1) with higher SVI values indicating a higher degree of vulnerability relative to other areas.

Figure 1.3 shows a percentile ranking of social vulnerability for each census tract in Region 14. Based on these estimates, the west portion of the region (including the Counties of El Paso, Hudspeth, Culberson, and Presidio) exhibits a high degree of vulnerability with SVI values of 0.8 or greater. SVI values are examined in further detail in *Chapter 4 (Flood Mitigation Solutions)*.

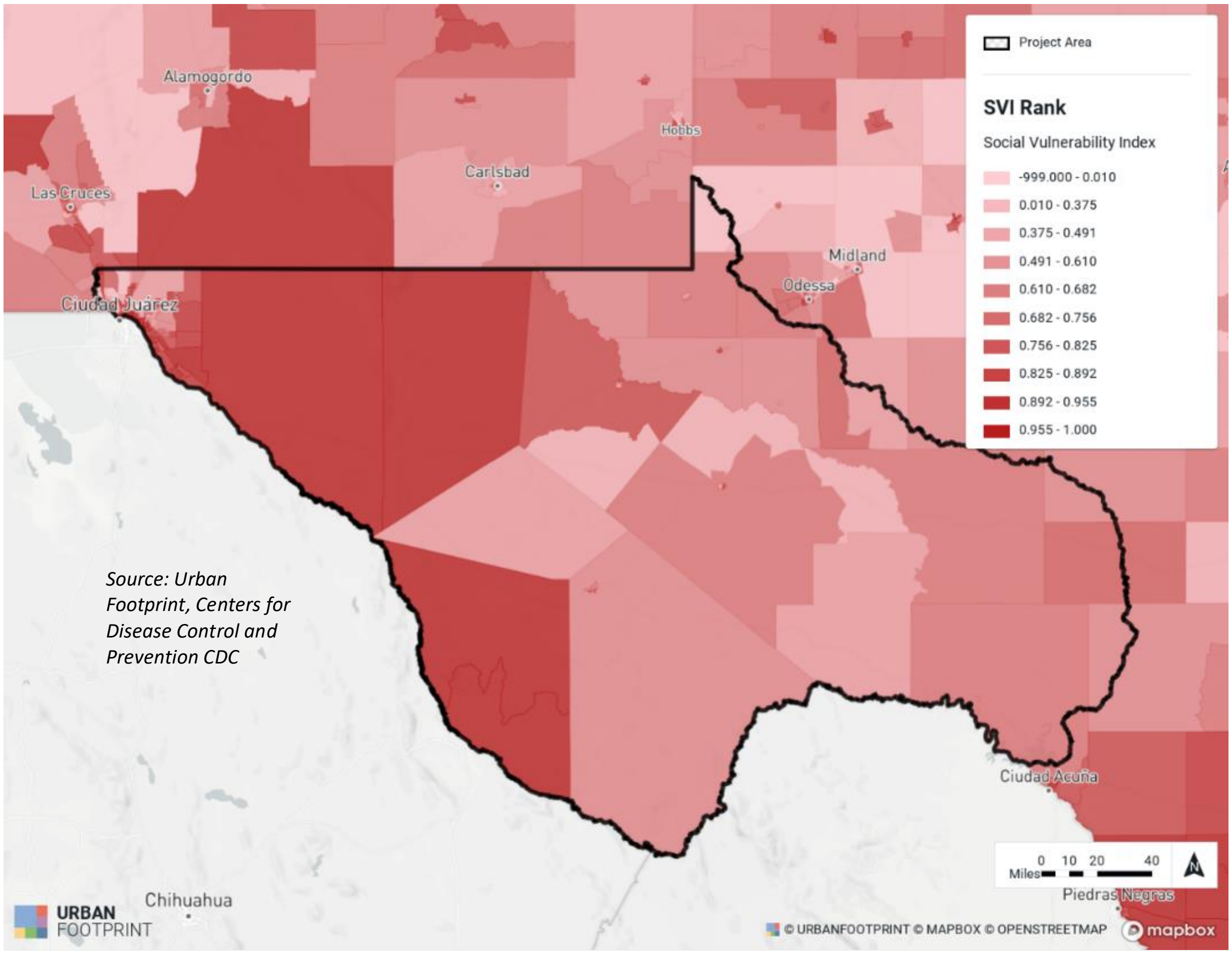


Figure 1.3 Social Vulnerability by Census Tract

Development

Regionwide land use data were obtained using Urban Footprint for a variety of Land Use types. These land use types are shown below in **Figure 1.4** and summarized in **Table 1.2**.

According to these estimates, nearly 90% of the region's area consists of natural, undeveloped land, and approximately 3% of the area is represented by parks and open space (such as Big Bend National Park and Guadalupe Mountains National Park). Of the remaining developed land use categories, the highest land use categories are residential (approximately 41% of developed areas) and agricultural cropland (approximately 39% of developed areas, excluding grassland/pasture). In total, all developed areas, which include residential, agricultural (excluding grassland/pasture areas), civic, commercial, industrial, mixed-use, and transportation/utilities land use types, make up approximately 2.0% of the total region by area.

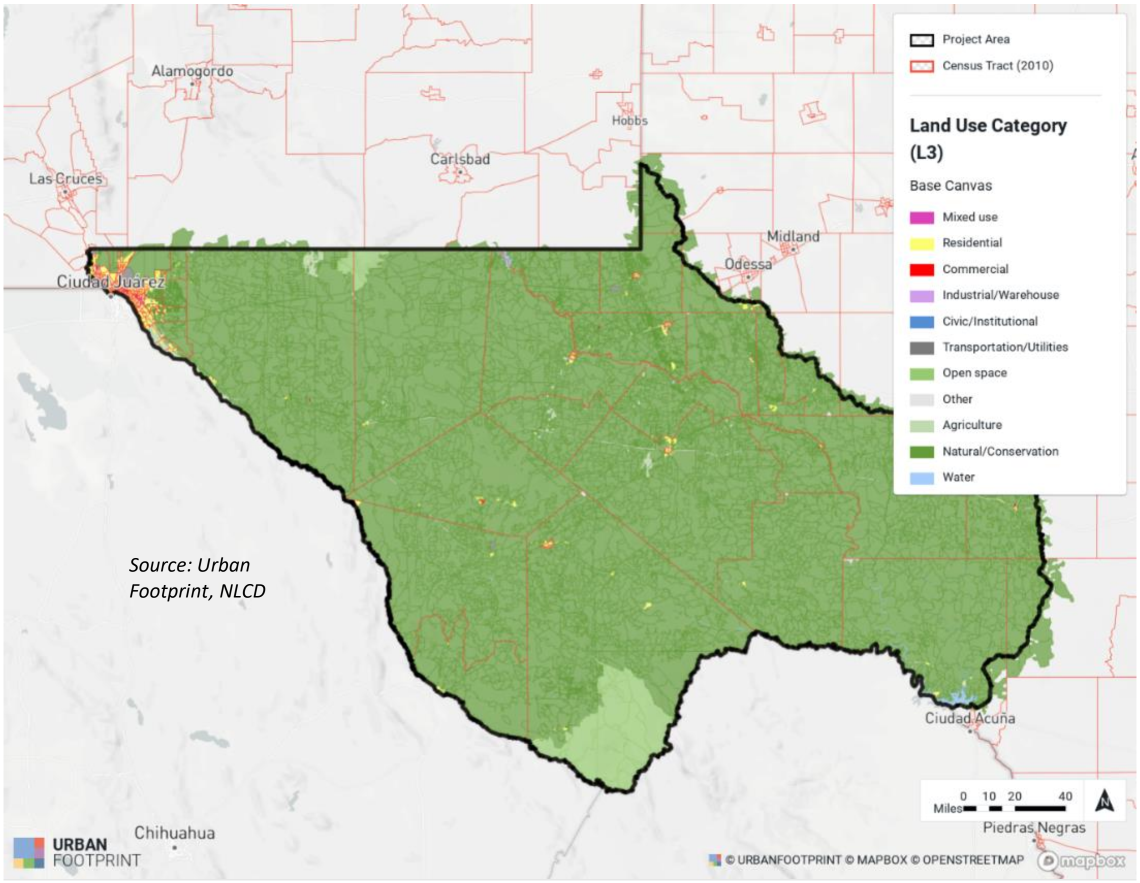


Figure 1.4 Regionwide Land Use

Table 1.2 Summary of Land Use Types

Land Use Type	Total Area (acres)	% of total
Agriculture (grassland/pasture)	1,571,000	6%
Agriculture (other crops)	206,000	<1%
Civic/Institutional	2,000	<1%
Commercial	13,000	<1%
Industrial	68	<1%
Mixed-use	27,000	<1%
Natural/Conservation	25,349,000	89%
Parks & Open Space	972,000	3%
Other	40,000	<1%
Residential	216,000	1%
Transportation/Utilities	25,000	<1%
Water	68,000	<1%

Source: USDA CropScape Data Layer used for agricultural areas (including grassland/pasture and other crops); Urban Footprint used for non-agricultural areas

1.1.2 Primary Economic Activities & At-Risk Sectors

To evaluate economic activities and trends across the region, industry and business data were obtained from Esri Business Analyst Data, Emsi Labor Market Analytics & Economic Data, and the Texas Almanac. Economic activity can be evaluated in the region both by total employment and by the concentration of industries relative to the national average.

As of 2021, the region employs an estimated 590,000 jobs across its 23 counties, with about 91,000 of these jobs added since 2010. In the past decade, jobs in the region have grown at an annual rate of 1.5%, faster than the U.S. average (0.9%) and similar to the Texas average (1.7%).

By total employment, the region's top five industries (representing approximately 45% of total jobs) include human health (healthcare, such as hospitals and pharmaceuticals), food services (restaurants and other food services), education (schools and universities, public and private), oil and gas upstream (oil extraction and related activities), and non-food retail. With the exception of the oil and gas upstream industry, the concentration of these industries in the region is similar to the average concentration of the industries across the U.S.

In terms of regional specialization (i.e., evaluating the concentration of industries relative to the national average), the region's top five industries include oil and gas upstream (oil extraction and related activities), oil and gas downstream (manufacturing from processed petroleum or support services for oil/gas), federal military, rental and leasing, and textile manufacturing. In particular, the region's oil and gas upstream industry is highly specialized, with a concentration 17 times higher than the U.S. average. Other noteworthy industries, based on Texas Almanac data, include tourism and ranching.

Table 1.3 lists the primary economic base of each county as well as the breakdown of mining and agricultural activities, according to data from the Texas Almanac.

Many economic sectors are susceptible to flood risks. In reviewing data for major businesses in the region, around 450 businesses with more than 100 employees were identified, and, among these, approximately 60 (14%) were found to be located in the existing 1% or 0.2% annual chance floodplains.

In the event of major flooding, post-disaster impacts to businesses include damages to properties, facilities and assets directly owned by the business, as well as disruptions to suppliers, customers and employees. A business' ability to recover and resume operations is typically dependent on its size since larger companies are more likely to have a continuity plan in place. For oil and gas industries, flooding can result in the disruption of oil and gas operations and damage to supply systems, such as ruptured flow lines and storage tanks.[2] For agricultural resources, extended periods of flooding may damage crops leading to reduced crop yields or total loss (the region's agricultural resources are discussed in further detail later in this chapter in Section 1.4).

[2] Cornell, Kenneth. *Environmental Exposure: Flood Risk in the Oil & Gas Industry.* April 7, 2014. https://www.insurancejournal.com/magazines/mag-features/2014/04/07/325072.htm

Table 1.3 Primary Economic Activities by County

County	Primary Economic Base	Mineral Deposits	Agriculture
Andrews*	Natural resources/mining; manufacturing; trade, construction; government/services; agribusiness.	Oil and gas.	Beef, cotton, sorghums, grains, corn, hay.
Brewster	Agriculture, tourism, government/ services, Sul Ross State University, mining.	Bentonite.	Beef cattle, meat goats, horses.
Crane	Oil and gas; agriculture; government/services.	Oil, gas production.	Beef cattle, goats.
Crockett*	Oil and gas, ranching, hunting leases.	Oil, gas production.	Sheep (first in numbers), goats; beef cattle.
Culberson	Tourism, government/services, talc mining and processing, agribusiness, sulfur mining.	Sulfur, talc, marble, oil.	Beef cattle; cotton, vegetables, melons, pecans; 6,000 acres in irrigation.
Ector*	Center for Permian Basin oil field operations, plastics, electric generation plants.	More than 3 billion barrels of oil produced since 1926; gas, cement, stone.	Beef cattle, horses are chief producers; pecans, hay, poultry; minor irrigation.
Edwards*	Hunting leases, tourism, oil, gas production, ranching.	Gas.	Second in number of goats. Mohair-wool production, Angora goats (first in numbers), sheep, cattle, some pecans. Cedar for oil.
El Paso	Government, military are major economic factors; wholesale and retail distribution center, education, tourism, maquiladora plants, varied manufacturing, oil refining, cotton, food processing.	Production of cement, stone, sand and gravel.	Dairies, cattle, cotton, pecans, onions, forage, peppers. Third in colonies of bees. 25,000 acres irrigated, mostly cotton.
Hudspeth	Agribusiness, mining, tourism, hunting leases.	Talc, stone, gypsum.	Most income from cotton, vegetables, hay, alfalfa; beef cattle raised; 18,000 acres irrigated.
Jeff Davis	Tourism, agriculture, McDonald Observatory.	Not significant.	Greenhouse tomatoes, beef cattle, horses, meat goats.
Loving	Oil and gas operations; cattle.	Oil, gas.	Cattle ranching.
Midland*	Among leading petroleum-producing counties; distribution, administrative center for oil industry; varied manufacturing; government/services.	Oil, natural gas.	Beef cattle, horses, sheep and goats; cotton, hay, pecans; some 11,000 acres irrigated.
Pecos	Oil, gas, agriculture, government/services, wind turbines.	Natural gas, oil, gravel, caliche.	Cattle, alfalfa, pecans, sheep, goats, onions, peppers, melons. Aqua-culture firm producing shrimp.
Presidio	Government/services, ranching, hunting leases, tourism.	Sand, gravel, silver, zeolite.	Cattle, tomatoes, hay, onions, melons. Some irrigation near Rio Grande.
Reagan*	Oil and gas production, hunting, ranching.	Gas, oil.	Cotton, cattle, sheep, goats.

County	Primary Economic Base	Mineral Deposits	Agriculture
Reeves	Oil and gas, agriculture, tourism, food processing, government/services, gravel.	Oil, gas, gravel.	Ranching, dairies, hay, cotton, cantaloupes, pecans, pistachios. Some 11,000 acres irrigated.
Schleicher*	Oil, ranching, and hunting.	Oil and natural gas.	Beef cattle, sheep, goats, and cotton, hay.
Sutton*	Natural gas, ranching, hunting.	Oil, natural gas.	Meat goats (first in numbers), sheep, cattle, Angora goats (second in numbers). Exotic wildlife. Wheat and oats raised for grazing, hay; minor irrigation.
Terrell	Ranching, hunting leases, oil, gas exploration, tourism.	Gas, oil, limestone.	Goats (meat, Angora); sheep (meat, wool); some beef cattle.
Upton*	Oil, wind turbines, farming, ranching.	Oil, natural gas.	Cotton, sheep, goats, cattle, watermelons, pecans. Extensive irrigation.
Val Verde*	Agribusiness, tourism, trade center, military, Border Patrol, hunting leases, fishing.	Production sand and gravel, gas, oil.	Sheep, Angora goats, meat goats (second in numbers); cattle; minor irrigation.
Ward	Oil, gas, government/services.	Oil, gas, caliche, sand, gravel.	Beef cattle, greenhouse crops, alfalfa, horses.
Winkler	Oil, natural gas, ranching, prison, some farming.	Oil, gas.	Beef cattle.

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

1. *Source: Texas State Historical Association (Texas Almanac 2018-2019). Texas Comptroller of Public Accounts, Texas Economy.*

1.2 Historical Flooding

Flooding in Texas is principally associated with hurricanes, tropical storms, and high intensity storms. Flooding is usually caused by high precipitation volumes, long precipitation duration, and high precipitation intensity. Hurricanes and tropical storms have the potential for each dangerous mode of precipitation as they are large storms fed from warm oceans and can linger over a location. A summary of historical flooding events throughout the region is presented in **Table 1.4**.

El Paso County has experienced long duration/low intensity rain events (e.g., 7.95 inches over four days in 2006) and short duration/high intensity rain events (e.g., 3.18 inches over one hour in 2021) which result in various flood hazards and require different mitigation strategies. Both of these storm events, shown in **Figure 1.5**, had an extremely low Annual Exceedance Probability (AEP) of approximately 0.4% (or the 250-year return period). Both of these storms covered the streets in debris and caused significant damage.

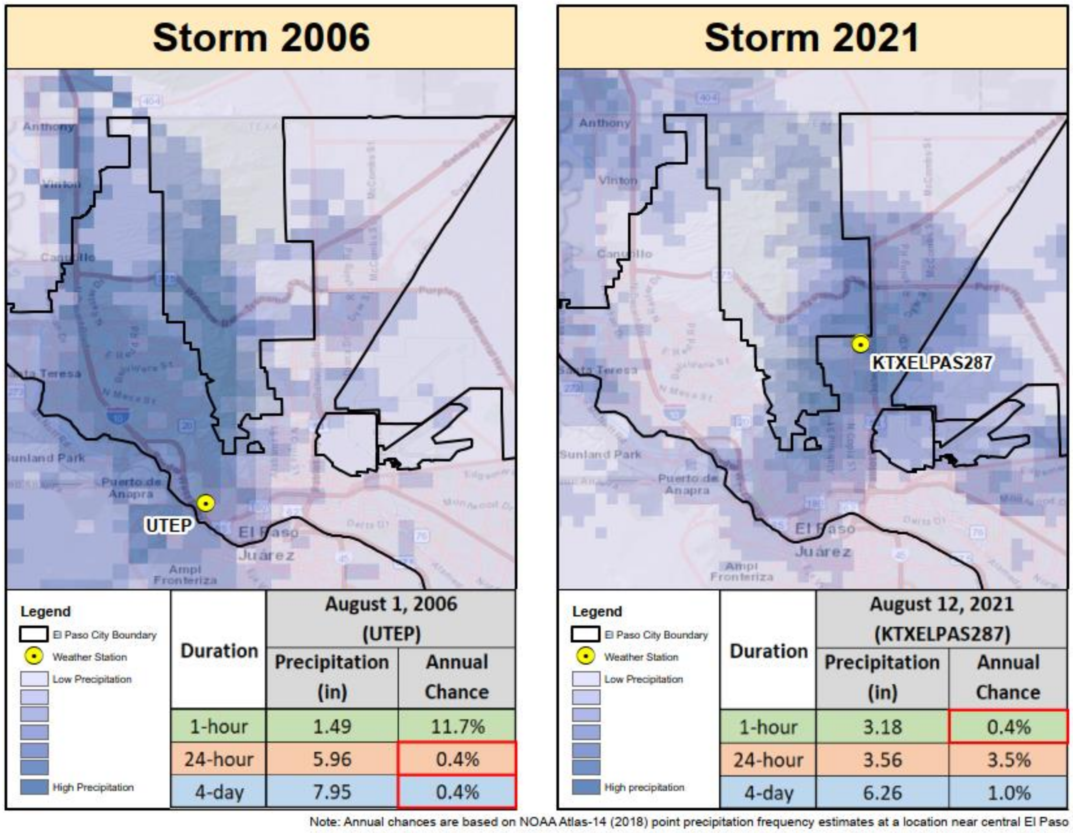
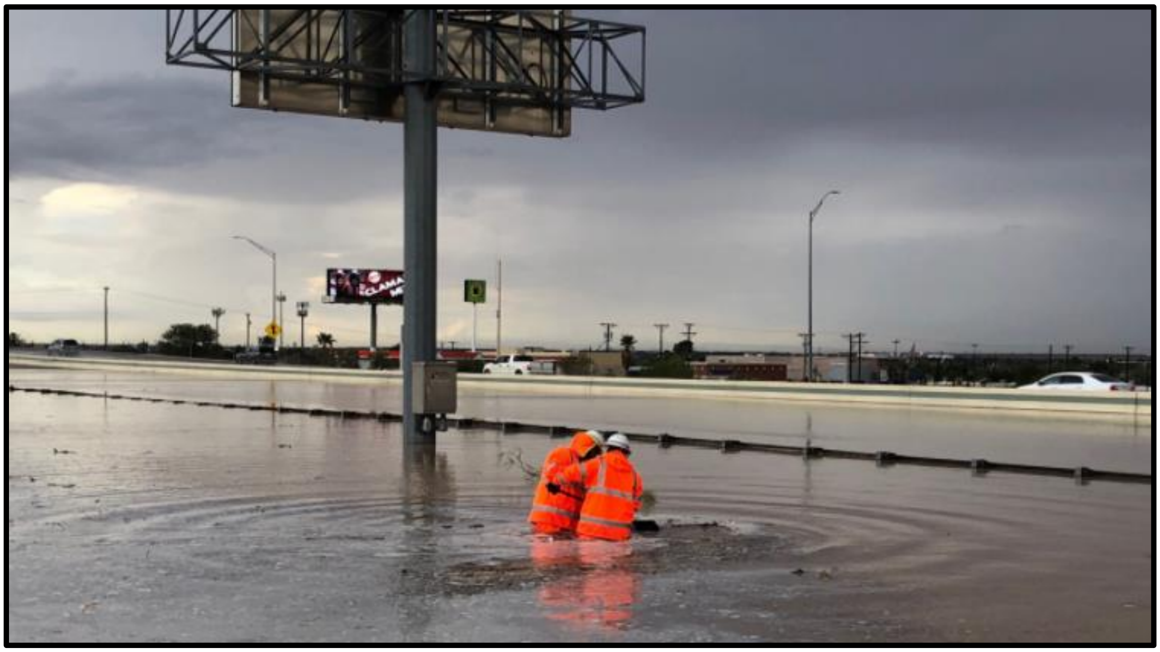


Figure 1.5 Precipitation and Annual Exceedance Probabilities of 2006 and 2021 Floods in El Paso, Texas

The August 2021 is an example of high precipitation intensity flooding (see **Figure 1.6**). This short, intense, extreme storm overwhelmed drainage infrastructure in east central El Paso. Several small flood control structures had major releases from emergency spillways, Interstate Highway (IH)-10, was overtopped, and numerous neighborhoods and streets experienced short term flooding.



U.S. 54 and Hercules Flooded from 2021 Storm. Source: KVIA News, https://kvia.com/traffic/2021/07/01/for-3rd-day-this-week-flash-floods-hamper-el-paso-commute/

Figure 1.6 Example of High-Intensity Flooding during 2021 Flood in El Paso, Texas

The August of 2006 storm in El Paso County (the most populated county in Region 14) is an example of a long duration high volume flood event in the region. The County received one year's worth of rainfall in two days, with more rain falling before and after the peak of the event. In addition to the exceptional volume, saturated conditions created more runoff than what would usually occur on dry ground, worsening the effects downstream. It led to the overtopping of Interstate IH-10, and sediment/debris flows from Franklin mountain arroyos into the city drainage infrastructure in west/ northwest El Paso and in northeast El Paso. The resulting blockage of drainage infrastructure led to extensive property damage. The storm caused $200 million in damages to businesses and homes, and an additional $115 million in damage to the city's stormwater system. The high stage in the Rio Grande coupled with limited drainage structure/ pump station capacity led to extensive flood damage in several locations within the flat riverine terrace adjacent to the Rio Grande.

A significant flooding event also affected Presidio, Texas, and Ojinaga, Mexico in September 2008, causing damaging flooding along the Rio Grande and Rio Conchos as shown in **Figure 1.7**. This storm, centered over the Rio Conchos watershed in Mexico, sent a massive flood down the Rio Conchos into the Rio Grande. Flooding occurred along the Rio Grande from the confluence with the Rio Conchos to Amistad Reservoir. This flood breached and/or overtopped both US and Mexican levees at locations along the Rio Conchos and the Rio Grande. Flooding in Presidio was primarily limited to the low-lying farmland adjacent to the levees.

Figure 1.7 Flooding along the Rio Grande and Rio Conchos in Presidio, Texas and Ojinaga, Mexico on September 19, 2008

Image: Jeff Bennett, Upper Rio Grande Regional Flood Planning Group

Western Texas has a history of damaging and dangerous floods. Despite the region's largely arid climate and low rainfall totals, extreme storms are influenced by weather systems from the Gulf of Mexico including warm fronts, tropical storms, and hurricanes. During previous hurricanes, Hurricane Paul caused 2.26" of rain in El Paso County in 1982, and Hurricane Alice caused 34" of rain in Val Verde County in 1954. Carefully analyzing and evaluating needs and improvements associated with stormwater infrastructure remains important for dealing with these severe events.

Another significant component of flooding in the region is the Upper Rio Grande watershed which has more than 76% of its area lying outside of the region in New Mexico, Mexico, and Colorado. It is estimated that only 5% of typical flow from New Mexico reaches Texas, as water supply in New Mexico is heavily managed to meet the needs of communities in New Mexico, Texas, and Mexico.

Historic Flooding occurred in April 2004 in Pecos and Reeves County, resulting in significant flooding downstream of Comanche Creek Dam in Fort Stockton and a collapsed I-20 bridge over Salt Draw between Toyah and Pecos (see **Figure 1.8**). In addition, a levee protecting Toyah was breached during the flood event.

April 2004 flood caused this I-20 bridge over Salt Draw to collapse, located between Toyah and Pecos. Source: NOAA and NWS; https://www.weather.gov/maf/2004_04_02_SevereWeather

Figure 1.8 Toyah and Pecos, Texas, 2004 Flood

Table 1.4 Historical Flood Events with the Upper Rio Grande Region

County	Date	Location	Significance	Source*
Brewster	September 9, 2008	Brewster	Indeterminate amount of rainfall caused $16.8M in flood damages. Large portions of FM-170 were inundated and suffered damage. Rio Grande Village was evacuated and facilities were closed for months.	6, 8
Brewster	October 1, 1990	Brewster	Indeterminate amount of rainfall caused $1.98M in flood damages.	6
Brewster	September 3, 1986	Brewster	Indeterminate amount of rainfall caused $1.18M in flood damages	6
Brewster	August 10, 1980	Chisos Basin, Pecos and Devils Rivers	Hurricane Allen caused 6" of rain over a 5 day period.	3
Culberson	September 24, 1978	Guadalupe National Park	Tropical Storm Paul caused 15" of rain in one day. (See Hudspeth County)	3
Edwards	June 23, 1948	Countywide	24" of rainfall caused $3.6M in damages	3
Edwards	June 10, 1935	Carta Valley	17.6" of rainfall caused $20M in damages	3
El Paso	August 12, 2021	City of El Paso, Franklin Mnt.	Some parts of El Paso received over 4 inches of rain in a short period of time creating significant flash flooding which included two deaths in the east side of the Franklin Mountains.	8
El Paso	June 28, 2021	City of El Paso	Some locations of the city received over 4 inches of rain in 36 hours. $500k in property damages occurred as water entered homes in parts of West El Paso when nearby drainage ponds overflowed. One death occurred on Thunderbird Trail after water rushed down the side of the mountain.	8
El Paso	July 31, 2006	City of El Paso, Franklin Mnt.	FEMA-1658-DR-Recorded the highest level in Rio Grande since 1912. Several storms contributed to high environmental moisture and more runoff that expected. 3.5" of rainfall was recorded for July 31st through August 1st. 19.5" of total rainfall was recorded 2006.	1, 2, 4
El Paso	August 1, 2002	City of El Paso, Franklin Mnt.	An intense storm over the mountains causes 1" of rain over a 10 minute period leading to flash floods.	1
El Paso	August 3, 1966	City of El Paso	2" of rain in under an hour caused flash flooding that damaged homes, businesses, and made several roads and railroads impassible.	1
El Paso	June 1884	City of El Paso	A storm of Indeterminate strength caused over $1M in damages to rail infrastructure.	3
El Paso	July 21, 1880	City of El Paso	3.3" of rain was recorded over two days in 1880.	2
Hudspeth	August 12, 2021	Sierra Blanca/ Allamoore	Heavy rains and flash flooding, washed out poorly maintained county roads, trapping ranchers and Sunset Ranch (20 acre) residents for 5+ days during monsoon season. Heaviest rains began 8/12. Residents and workers could not leave or access ranches until 8/18.	7

County	Date	Location	Significance	Source*
Hudspeth	September 24, 1978	Guadalupe National Park	Tropical Storm Paul caused 15" of rain in one day. (See Culberson County)	3
Hudspeth	September 14, 1974	Continental Ranch	23" of rain over 9 days.	3
Hudspeth	August 22, 1966	Dell City	12" of rain over two days caused $4.3M in damages, with 3' of flooding in 50 houses.	3
Midland	October 9, 1985	Midland	6" of rain over 2 days.	3
Pecos	April 4, 2004	Fort Stockton	A rare early morning severe weather event hit Fort Stockton area around 5am CDT. The area adjacent to Comanche Creek, which runs through James Rooney Memorial Park, was one of the worst flooded areas in Fort Stockton.	9
Presidio	June 27,2021	Marfa	5” of rainfall over two days created flash floods and high currents at low water crossings. One fatality occurred near a border control outpost where a jeep utility car was swept off a crossing.	10
Presidio	September 9, 2008	City of Presidio	Indeterminate amount of rainfall caused $1.17M in flash flood damages. During the summer of 2008, monsoon rainfall filled reservoirs across northern Mexico. On September 7, Governor Perry executed the State Emergency Plan, issued a Disaster Declaration for Presidio County, TX, and a Proclamation of State Disaster. On September 9, the levees near Redford, TX failed. This resulted in water covering the entire city of Redford. Water also topped the levees near Presidio Golf Course on the September 16th-17th, and IBWC reported cracks in the levees near the golf course.	6, 8
Presidio	April 4, 2004	Toyah	Indeterminate amount of rainfall caused $1.33M in flood damages.	6
Presidio	October 1, 1990	Presidio County	Indeterminate amount of rainfall caused $1.92M in flood damages.	6
Reeves	July 1, 1945	Kingston Farm	13.1" of rain over 3 days causing $52,000 in damages.	3
Schleicher	August 30, 1932	Eldorado	15.4" of rainfall	3
Schleicher	July 16, 1928	Eldorado	13" of rainfall in Eldorado caused 6 fatalities and $5M in damages	3
Sutton	September 22, 2018	Sonora	Flash flooding damaged or destroyed 250 houses after 16" of rain fell in a couple hours.	5
Sutton	August 26, 1932	Sonora	A long storm over 13 days caused 13.74" of rain to fall in Sonora causing 9 deaths and $1M in damages	3
Terrell	June 10, 1965	Sanderson	9" of rain fell over a period of 2 days causing flash floods. $2.7M in damages were caused, with 26 deaths and hundreds displaced.	3
Upton	October 4, 1986	McCamey	16" of rain over a day caused 1 death due to a flash flood washing a car off the road.	3
Val Verde	August 22, 1998	Del Rio	Tropical Storm Charlie caused 16" of rain over a single day with significant rapid rise in San Felipe	3

County	Date	Location	Significance	Source*
			Creek. Entire residential slabs were wiped down to the foundation. A total of 13 fatalities were recorded in relation to the storm and subsequent flooding.	
Val Verde	June 24, 1954	Langtry, Del Rio	Hurricane Alice moved inland up the Rio Grande. Several ranches in the region recorded rainfall of 35" causing significant flooding. International Bridge was destroyed when overtopped by 10' with the Rio Grande measuring 3 miles wides in Eagle Pass.	3

*Sources:
1) FEMA Study, https://elpasoready.org/history/
2) Robert Bettes 2021, KTSM, Accessed 17 December 2021, https://www.ktsm.com/weather/as-of-610-pm-today-is-the-25th-highest-rainfall-event-in-el-paso-history/
3) R. M. Slade & J. Patton 2002, USGS, Accessed 17 December 2021, https://www.floodsafety.com/texas/USGSdemo/county.htm
4) El Paso City-County Office of Emergency Management, Accessed 17 December 2021, https://elpasoready.org/history/
5) Joe Holley 2018, Houston Chronicle, Accessed 17 December 2021, https://www.houstonchronicle.com/news/columnists/native-texan/article/Flood-waters-ravage-a-little-West-Texas-town-13281371.php
6) Historical County Hazard Mitigation Plans
7) Hudspeth County Emergency Management Coordinator/County Administrator (email dated 4/26/2022).
8) NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=48%2CTEXAS
9) National Weather Service: https://www.weather.gov/maf/2004_04_02_SevereWeather.
10) Ursula Muñoz-Schaefer, *High water at Alamito Creek overtakes 2 vehicles, killing 1 Marfa resident.* Big Bend Sentinel. Accessed July 19, 2022, https://bigbendsentinel.com/2021/06/30/high-water-at-alamito-creek-overtakes-2-vehicles-killing-1-marfa-resident/

1.3 Flood-Related Authorities & Regulation

The Upper Rio Grande Region spans multiple entities, including 23 counties, 30 municipalities, and 31 unincorporated areas. To prepare for potential flood impacts, flood risk planning and regulation is essential among authorities within the region. While cities and counties can engage in flood planning activities, the flood planning role extends to all political subdivisions with flood-related districts or authorities created under Article III, Section 52, or Article XVI, Section 59, of the Texas Constitution. This includes any political subdivision of the state, any interstate compact commission, and any nonprofit water supply corporation created and operating under Chapter 67.

The region includes several entities which have influence over the region's flood mitigation planning and responses efforts. These include 2 Councils of Government (Rio Grande COG and Concho Valley COG); 46 water supply and utility districts; 5 National Parks, 1 National Historic Site, 7 State Parks, 1 State Historic Site, 3 State Natural Areas, 3 Wildlife Management Areas, and the US Army's Fort Bliss. A detailed list of entities within the region is provided in **Appendix Table 1A**.

Flood-regulating entities, such as counties and incorporated areas, have the authority to define and enforce flood regulations and ordinances for flood mitigation. For communities which participate in the National Flood Insurance Program (NFIP), the Texas Water Code § 16.315 requires NFIP participants to adopt a floodplain management ordinance and to designate a local floodplain administrator who is responsible for ensuring floodplain management regulations are followed within the community. Other entities in the region play an important role in flood planning in various ways such as communicating flood response efforts, planning and maintaining flood infrastructure, and supporting flood-related development codes. **Table 1.5** provides a summary of political subdivisions with flood-related authority and shows that all 23 counties (100%) and 24 out of 30 municipalities (80%) within the region are active in some form of floodplain management activity.

Table 1.5 Political Subdivisions with Flood-Related Authority

Type of Political Entity	# of Entities	# of Entities Active in Flood Planning	% of Entities Active in Flood Planning
Municipality	30	24	80%
County	23	23	100%
Government/Council/Commission	19	17	89%
Water Supply & Utility District	58	51	88%
National Park, State Park, Wildlife Management Area	24	5	21%

The Upper Rio Grande basin faces unique challenges. These include flash flooding, significant sediment transport during rain events, limited populace to fulfil regulatory planning roles, vast private lands, a state border and an international border to consider when coordinating flood planning and emergency response. Local regulations and development codes, floodplain ordinances, zoning and land use policies, drainage and building design standards, flood plans, and hazardous mitigation plans exist and are in development to prepare for and mitigate negative impacts of stormwater in the region. These efforts are often conducted with the cooperation of county, city, utility districts, COG, private and government bodies to mitigate shared flood risks at the watershed scale.

A summary of existing floodplain regulations adopted by entities in the region is provided in **Table 1.6**. Local regulations and development codes, as well as their prevalence in Region 14, are discussed in greater detail in Chapter 3 (*Floodplain Management Practices and Goals*).

Table 1.6 Summary of Existing Flood Plans and Regulations

Type of Regulation	Count
Comprehensive Plan / Unified Development Code (UDC)	22
Drainage Criteria Manual /Design Manual	2
Floodplain and Drainage Ordinances	9
Land Use Regulations (Zoning and Subdivision Ordinances)	10

1.4 Agricultural Resources

More than 30 types of crops are grown in the Upper Rio Grande Region, with the top seven crops most at risk to flooding including grassland/pasture, cotton, alfalfa, pecans, winter wheat, oats, and sorghum. The top five counties for agricultural production include the Counties of Hudspeth (notably Dell City), El Paso, Jeff Davis, Pecos, and Presidio. Additional agricultural activities are listed by county in Section 1.1.2.

1.4.1 Crop Production and Value Per Yield

To identify the agricultural resources most at risk to flooding and their estimated values, a cursory level analysis was performed using historical crop production datasets and information from the United States Department of Agriculture (USDA) Cropscape dataset[3] and Texas A&M University. Yield per acre and normalized price per unit values were obtained from the 2021 USDA State Agriculture Overview[4] for Texas and the USDA Quick Stats tool[5], as shown in **Table 1.7**.

Detailed flood exposure analyses for all crop types were performed based on the estimated 1% and 0.2% annual chance flood hazard areas identified in *Chapter 2 (Flood Risk Analyses).*

Table 1.7 Crop Production Value Per Yield

Crop	Yield Per Acre	Value per Yield
Alfalfa	5.4 Tons/Acre	$209/Ton
Cotton	695 LB/Acre	$0.882/LB
Grassland	2 Tons/Acre	$147/Ton
Oats	45 BU/Acre	$4.4/BU
Pecans	1,000 LB/Acre	$1.31/LB
Sorghum	61 BU/Acre	$9.85/CWT*
Winter Wheat	37 BU/Acre	$6.5/BU

*1 CWT = 2.22 BU

1.4.2 Potential Factors Impacting Flood Damage to Crops

Flooding of crops may result in a wide range of outcomes, including no crop damage, damage requiring a replant of the crop, reduced crop yields, or the total loss of a crop. Some critical factors that impact the extent of damage from flooding are the type of crop, production stage at the time of flooding, depth of flooding, velocity of floodwaters, and duration of inundation. Other damages from floods include sedimentation that covers crops or reduces soil fertility, and increased soil salinity, which can damage roots and reduce yields for multiple planting seasons.

[3] USDA National Agricultural Statistics Service Cropland Data Layer. 2020. Published crop-specific data layer [Online]. Available at http://nassgeodata.gmu.edu/CropScape/ (accessed 2/23/2022). USDA-NASS, Washington, DC.
[4] 2021 State Agriculture Overview (https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=TEXAS)
[5] USDA Quick Stats Tool. Published database [Online]. Available at https://quickstats.nass.usda.gov/ (accessed 7/27/2022). USDA-NASS, Washington, DC.

One key factor of the impact that flooding will have on agriculture is the timing of the flood. In general, production stages for any crop would include field preparation, seeding/planting, growing season, and post-harvest/dormant. The production stage of the crop when flooding occurs can have a significant impact on the extent of damage/loss for the crop and the options available to the farmer to salvage the growing season. If a flood occurs prior to the start of field preparation, it may result in a delay of seeding, which could result in reduced yields at harvest. A damaging flood that occurs near the beginning of the growing season may require that the farmer rework the land and replant the same or a substitute crop to minimize loss at harvest. Flooding during the growing season may result in a reduced yield or loss of all or a portion of the crop. Depending on the crop, flooding during the harvest season may have little impact on production or it could result in a total loss.

In general, floods occurring during the growing season have the largest potential for damages/crop loss, as the crops are susceptible to damage while maturing; and if the crops are damaged, the farmer will have fewer options and less opportunity to salvage the growing season. In addition, when planting or replanting following a flood, the variable production costs are usually higher than without a flood due to the following reasons:

- Additional fertilizer must be applied to offset loss of soil fertility;
- Herbicides are often required to combat weed infestation;
- Additional preparation of seed beds is required; and
- Severe loss of nitrogen due to denitrification in saturated soils.

Information on the usual planting and harvesting month for the major crops in the study area was obtained from the Texas Agricultural Statistics, which is provided in **Table 1.8**.

Table 1.8 Crop Planting and Harvesting Schedule

Crop		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alfalfa	Planted												
	Harvested					8%	33%	32%	23%	4%			
Cotton	Planted			15%	37%	36%	12%						
	Harvested									6%	16%	44%	36%
Oats	Planted									28%	49%	23%	
	Harvested					33%	62%	5%	6%				
Pecans	Planted												
	Harvested								6%	33%	36%	21%	4%
Sorghum	Planted			5%	40%	43%	12%						
	Harvested							8%	33%	32%	27%		

Crop		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter Wheat	Planted									34%	47%	19%	
	Harvested					9%	74%	17%					

Precipitation by month can be used as a proxy to estimate the likelihood of when flood inundation could occur. While this does not determine if a flood event would occur, the likelihood of a flood occurring during months of higher precipitation is greater. Average monthly precipitation values for Climate Division 5[6] were divided by the total average annual precipitation to calculate the percentage of precipitation that occurs each month (**Table 1.9**). As the table shows, there is a higher chance of precipitation during the summer months, which would indicate a greater likelihood of flooding.

Table 1.9 Likelihood of Flooding by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4%	4%	3%	4%	9%	13%	16%	15%	15%	9%	4%	4%

Source: NOAA National Centers for Environmental information, Climate at a Glance: County Time Series, published December 2020, retrieved on January 29, 2021 from https://www.ncdc.noaa.gov/cag/

While the season a flood occurs is important, the depth and duration that a crop is submerged is also an important factor in determining crop damages. Plants can be damaged from lack of oxygen if fully submerged and/or from root rot for long duration floods. Yield reductions could occur as a result of as little as one day of inundation for cotton, while other crops, such as grasslands, can withstand a week of inundation. **Table 1.10** provides a summary of anticipated damages from flooding by crop for the major crops found in the 1% annual chance floodplain within the study area.

Table 1.10 Anticipated Damages by Crop

Crop	Anticipated Damages Occurring During a Flood	Anticipated Damages Occurring During Reseeding/Recovery
Alfalfa/Hay/Sorghum[7]	*Dormant:* Can withstand flooding up to 10 days without significant loss *Harvest:* Can withstand submersion up to 3-4 days without significant loss	Limited reseeding of established fields may be necessary
Corn/Oats[8]	Can withstand flooding up to 48 hours with limited damage Greater yield losses likely earlier in the season	Flooding may have long term negative impact on crop yield and root damage

6 Division 5 averages were between 2000 and 2021 from National Oceanic and Atmospheric Administration's (NOAA's) National Center for Environmental Information

7 "Salvaging Crops After Flooding". North Dakota State University. Online. https://www.ndsu.edu/agriculture/ag-hub/salvaging-crops-after-flooding

8 "Flooding Effects on Corn". Updated 2018. Corn Agronomy. University of Wisconsin. Online. http://corn.agronomy.wisc.edu/Management/L038.aspx

Crop	Anticipated Damages Occurring During a Flood	Anticipated Damages Occurring During Reseeding/Recovery
Cotton[9]	*Planting:* Water-logged soils can reduce crop growth rate *Harvesting:* Potential for crop loss	Stunted growth is a potential lingering effect
Pecans[10]	*Harvesting:* Beyond 5 days of flooding will prompt a photosynthesis reduction, and reduction in harvest.	If trees remain flooded for 35 days or more, they may lose part of their root system
Winter Wheat[11]	*Harvesting:* Yield reduction impacts to flooding in as few as 48 hours	If submerged more than 5 to 7 days, plants will die

Table 1.11 and **Table 1.12** provide estimates of percent crop yield loss for one and three days of inundation, which represent an estimate of the percentage of the mature crop value that is expected to be reported as damaged (assuming the crop was planted on the beginning of the season).

Table 1.11 Crop Damages from One-Day Inundation

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corn	0%	0%	0%	4%	13%	22%	25%	27%	32%	24%	10%	0%
Oats	14%	22%	25%	27%	32%	24%	10%	0%	0%	0%	0%	4%
Winter Wheat	25%	24%	21%	11%	1%	0%	0%	0%	4%	13%	22%	25%

Source: HEC-FIA

Table 1.12 Crop Damages from Three-Day Inundation

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Corn	0%	0%	0%	12%	40%	66%	75%	82%	95%	72%	29%	0%
Oats	42%	67%	75%	81%	96%	73%	30%	0%	0%	0%	0%	13%
Winter Wheat	75%	72%	63%	34%	4%	0%	0%	0%	12%	40%	66%	75%

Source: HEC-FIA

The timing of the flood and the production stage of the crop during a flood can determine whether damage occurs and the potential extent of that damage. As shown previously in **Table 1.9**, there is a greater chance of precipitation during the summer months, which would

[9] "What should I do with a flooded cotton field? University of Georgia Cotton Team, 2013. Online. https://www.farmprogress.com/cotton/what-should-i-do-flooded-cotton-field

[10] Wells, Lenny. "Effects of Flooding on Pecan Trees." University of Georgia Cooperative Extension, 2014. Online. https://site.extension.uga.edu/pecan/2014/04/effects-of-flooding-on-pecan-trees/#:~:text=The%20pecan%20tree%E2%80%99s%20native%20environment%20is%20found%20along,in%20a%20river-bottom%3F%20The%20key%20is%20soil%20drainage.

[11] "Flooding Impacts Winter Wheat". North Dakota State University, 2009. Online. Flooding Impacts Winter Wheat — Extension and Ag Research News (ndsu.edu)

indicate a higher likelihood of flooding. In addition, as shown previously in **Table 1.8**, flooding occurring during this time would have an impact on the majority of the crops that are planted in the study area and could lead to crop damage or reduced yields. If flooding occurs in late spring or summer, the opportunity to replant a flooded field is limited given the time needed for soil dry-out and balancing. In those cases, crop production for the fall harvest would be significantly reduced.

While the timing of the flood is key, the depth and duration of submerged crops is also an important factor in determining crop damages from flooding events. Plants can be damaged from lack of oxygen if fully submerged and/or from root rot for long duration floods. Yield reductions could occur as little as one day of inundation for cotton (which has production value of over $16 million in the study area), while some crops can withstand a week of inundation, such as grassland (which has production value of nearly $85 million in the study area).

Overall, the longer the inundation, the greater the potential damages to the crops and the lower the production value for the counties. While the production values are for annual harvest, there is evidence that continued damages occur beyond the typical harvest from increased soil salinity, imbalanced soil, mold issues, and weed control.

Lastly, uncertainties related to flooding impacts to grassland/pasture areas are significant. Grasslands can often withstand multiple days of flooding without a significant negative impact, especially when the grass is dormant. At times, flooding may even increase the yield of grasslands because of the increased moisture content in the soil. Another consideration is if grasslands are being grazed at the time of the flooding, which could lead to negative impacts to the herd from increased disease and injuries. If flooding is extensive enough, the herd may need to be relocated to another pasture and/or provided with supplemental feed until the grasslands recover.

1.5 Natural Resources

Ephemeral, perennial, and intermittent watercourses are the dominant hydrologic features of arid landscapes and serve the vital functions of storing and moving water and sediment throughout their respective water catchments. Unfortunately, many of the streams in the deserts of west Texas are characterized by incised channels that quickly and efficiently collect and transport water and sediment downstream. Stream incision results from a combination of historic impacts including grazing pressure, logging and other vegetation impacts; physical impacts to streams; and ecosystem changes such as removal of beavers. Water catchments now have diminished water and sediment storage capacities.

The resulting rapid runoff and transport of flood waters, especially when land development and population growth result in increased frequency and severity of flood events, may disproportionately affect natural and agricultural resources. In addition, as streams become more deeply incised, the water table is lowered and the riparian vegetation is negatively affected.[12] Livestock and wildlife depend on intact riparian resources; In arid regions, about 60% of all vertebrate species and 70% of all threatened and endangered species depend on riparian areas.[13] and forage for livestock is often best in riparian areas. Flooding could have the following potential impacts on vegetation and wildlife species:

- Channel erosion leading to decreased floodplain connectivity and recharge of riparian aquifers.
- Loss of vegetation: forage for livestock and wildlife due to scouring.
- Loss of nesting or sheltering habitat for both livestock and wildlife due to vegetation impacts.
- For aquatic species, direct impacts to rearing and reproductive habitat due to flooding.
- Impacts to water quality in aquatic habitats.
- Impacts to streambed habitats due to increased sediment loading or sediment deposition.
- Impacts to streamflow in aquatic habitats.

A summary of federal- and state-listed threatened and endangered species in the Upper Rio Grande Region is provided in **Table 1.13**. Several protected species in the region are dependent on native riparian habitats (vegetation occurring along water bodies) and aquatic habitats. The western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) is a federally threatened bird species that occurs in riparian habitats and potentially occurs in most Region 14 counties. The U.S. Fish and Wildlife Service (USFWS) has designated critical habitat for this species along much of Rio Grande in Brewster County. The southwestern willow flycatcher (*Empidonax traillii extimus*) is a federally endangered bird species occurring in riparian habitat. Critical habitat for this species has not been designated in the Region 14 Plan Area. Since these bird species nest in riparian habitats along water bodies, they may be affected by increasing frequency and severity of flood events.

[12] USDA. 2020. Incised stream restoration in the Western U.S. USDA Northwest Climate Hub, https://www.climatehubs.usda.gov./hubs/northwest/topic/incised -stream-restoration-western-us. Accessed July 11, 2022.
[13] USDA. 2012. Threats to western United States riparian ecosystems: a bibliography. General Technical Report RMRS-GTR-269. December 2012.

Federally endangered and rare freshwater mussel species that occur in Region 14 may be affected by flood-induced impacts to water quality and streambed substrates. Protected freshwater mussels in the Region 14 Plan Area include the federally endangered Texas hornshell (*Popenaias popeii*), which occurs in the Rio Grande and Pecos Rivers, and the federal candidate species Texas fatmucket (*Lampsilis bracteata*), which occurs in the Colorado River basin.

Similar to many wildlife species, human settlements have always had a close connection to water sources. Hundreds of known archaeological sites and historic structures occur along the Rio Grande and other rivers and streams within the Region 14 Plan Area and a significant proportion of these occur within the 1% annual chance floodplain. Historic resources that may be negatively affected by flooding include:

- Cemeteries
- Historic districts
- Historic irrigation systems
- Historic structures (residences, businesses, public buildings, churches, missions, bridges, etc.)

A few examples of historic resources identified in the Region 14 Plan Area include the El Paso County Water Improvement District No. 1 (EPCWID) National Register District, the Elephant Butte Irrigation National Register District, Fort Bliss Main Post Historic District and National Cemetery, and San Elizario Historic District. Historic adobe structures may be particularly vulnerable to impacts from rising flood levels and/or flood frequency. Flood damage to foundations can also pose significant risk to the stability of historic structures.

Table 1.13 Threatened and Endangered Species Listings

Species Common Name[a]	Species Scientific Name	Federal Status*	State Status*	Federally Designated Critical Habitat in Region?	Where Found
Birds					
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	T		Yes	Breeds in riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwoods and willows.
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	E	No	Thickets of willow, cottonwood, mesquite, and other species along desert streams
Rose-throated becard	*Pachyramphus aglaiae*		T	N/A	Riparian corridors; trees, woodlands, open forest, scrub, and mangroves; breeding April to July. Included on TPWD county species list for Jeff Davis County but no other counties in the planning area.

Species Common Name[a]	Species Scientific Name	Federal Status*	State Status*	Federally Designated Critical Habitat in Region?	Where Found
Tropical parula	*Setophaga pitiayumi*		T	N/A	Dense of open woods and understory long edges of rivers and other water bodies.
Interior least tern	*Sternula antillarum athalassos*	DL: Delisted	E	N/A	Nests along sand and gravel bars within braided streams, rivers; also known to nest on man-made structures, Rio Grande and Pecos rivers.
Fish					
Mexican stoneroller	*Campostoma ornatum*		T	N/A	Rio Grande tributaries in Brewster and Presidio counties.
Proserpine shiner	*Cyprinella proserpina*		T	N/A	Limited range includes Devils and lower Pecos rivers; Las Moras, Pinto, and San Felipe creeks; and Independence Creek in the Rio Grande watershed in western Texas. Associated with spring-fed tributaries and spring-runs. May be found in flowing pools, swift runs and riffles.
Leon Springs pupfish	*Cyprinodon bovinus*	E	E	Yes	Leon Creek, a tributary of the Pecos River (Pecos County); Diamond Y Spring. Natural spring-fed marshes, pools, and slow-flowing waters; usually near edges with minimal growth of vegetation.
Comanche Springs pupfish	*Cyprinodon elegans*	E	E	No	Restricted to small series of springs and their outflows, and man-made irrigation canals in the area of Balmorhea, Texas, including Phantom Springs (Jeff Davis County), San Solomon Springs, Griffin Springs and Toyah Creek (Reeves County). Native range: Comanche, Phantom Cave, San Solomon springs (Pecos and Reeves counties). Presently restricted to San Solomon and Phantom Cave and associated springs, and downstream irrigation canals.
Conchos pupfish	*Cyprinodon eximius*		T	N/A	Devils River and Alamito Creek.
Pecos pupfish	*Cyprinodon pecosensis*		T	N/A	Presently restricted to upper basin of the Pecos River.
Devils River minnow	*Dionda diaboli*	T	T	Yes	Devils River, San Felipe and Sycamore creeks in Val Verde County.
Roundnose minnow	*Dionda episcopa*		T	N/A	Clear spring-fed waters with stable temperatures.

Species Common Name[a]	Species Scientific Name	Federal Status*	State Status*	Federally Designated Critical Habitat in Region?	Where Found
Rio Grande darter	*Etheostoma grahami*		T	N/A	Essentially restricted to the mainstream and spring-fed tributaries of the Rio Grande and the lower Pecos River downstream to the Devils River and Dolan, San Felipe and Sycamore creeks.
Big Bend gambusia	*Gambusia gaigei*	E	E	No	Presently restricted to two artificial springfed pools in Big Bend National Park close to the Rio Grande.
Spotfin gambusia	*Gambusia krumholzi*		T	N/A	Restricted to San Felipe and Sycamore creeks in Texas.
Pecos gambusia	*Gambusia nobilis*	E	E	No	Restricted to two locations in Texas (Balmorhea springs complex and Diamond Y Draw).
Rio Grande chub	*Gila pandora*		T	N/A	Isolated population found in Little Aguja Creek in the Davis Mountains of Trans-Pecos Texas.
Headwater catfish	*Ictalurus lupus*		T	N/A	Limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers.
Speckled chub	*Macrhybopsis aestivalis*		T	N/A	Found throughout the Rio Grande and lower Pecos River but occurs most frequently between the Rio Conchos confluence and the Pecos River.
Tamaulipas shiner	*Notropis braytoni*		T	N/A	Restricted to the Rio Grande basin in Texas including the lower Pecos River.
Chihuahua shiner	*Notropis chihuahua*		T	N/A	Limited to smaller tributaries of the Rio Grande in the Big Bend region.
Rio Grande shiner	*Notropis jemezanus*		T	N/A	Rio Grande drainage.
Mexican blindcat	*Prietella phreatophila*	E	E	No	Subterranean freshwater cave environments in the northern Coahuila, Mexico and Val Verde County, Texas portions of the Edwards-Trinity Aquifer.
Mammals					
White-nosed coati	*Nasua narica*		T	N/A	Woodlands, riparian corridors and canyons. Most individuals in Texas probably transients from Mexico.
Reptiles					
Chihuahuan mud turtle	*Kinosternon hirtipes murrayi*		T	N/A	Observed in permanent water along lower Alamito Creek in Presidio County.[b]

Species Common Name[a]	Species Scientific Name	Federal Status*	State Status*	Federally Designated Critical Habitat in Region?	Where Found
Crustaceans					
Diminutive amphipod	*Gammarus hyalelloides*	E	E	Yes	Known only from the Phantom Lake Spring system.
Pecos amphipod	*Gammarus pecos*	E	E	Yes	Springs.
Mollusks					
Pecos assiminea snail	*Assiminea pecos*	E	E	Yes	Semiaquatic; usually found on moist ground or beneath emergent plants within a few centimeters of flowing water; only known remaining Texas population at near Fort Stockton, Pecos County.
Crowned cavesnail	*Phreatodrobia coronae*		T	N/A	Springs.
Texas Hornshell	*Popenaias popeii*	E	E	Yes	Rio Grande and Pecos River.
Salina Mucket	*Potamilus metnecktayi*		T	N/A	Rio Grande Basin.
Diamond Y springsnail	*Pseudotryonia adamantina*	E	E	Yes	Known from a spring system and associated outflows in Pecos County.
Limpia Creek spring snail	*Pyrgulopsis davisi*		T	N/A	In and on mud and rocks among patches of watercress in spring-fed rivulets
Caroline's Springs pyrg	*Pyrgulopsis ignota*		T	N/A	Known only from Caroline Springs in Terrell County.
Presidio County spring snail	*Pyrgulopsis metcalfi*		T	N/A	Found in the outflows of springs in fine mud and dense watercress.
Phantom springsnail	*Pyrgulopsis texana*	E	E	Yes	Known only from three spring systems and associated outflows in Jeff Davis and Reeves counties.
Mexican Fawnsfoot	*Truncilla cognata*		T	N/A	Rio Grande Basin.
Phantom tryonia	*Tryonia cheatumi*	E	E	Yes	Known only from three spring systems and associated outflows in Jeff Davis and Reeves counties.
Gonzales tryonia	*Tryonia circumstriata*	E	E	Yes	Only known from a spring system and associated outflows in Pecos County.
Metcalf's tryonia	*Tryonia metcalfi*		T	N/A	Locality is a complex of small seeps that discharges into a broad arroyo. This species was found on mud, decaying vegetation, and on the undersides of rocks in water in Presidio County.
Carolinae tryonia	*Tryonia oasiensis*		T	N/A	Lower Pecos River basin in a complex of large springs, which is also known as T5 Springs.

Species Common Name[a]	Species Scientific Name	Federal Status*	State Status*	Federally Designated Critical Habitat in Region?	Where Found
Plants					
Pecos sunflower	*Helianthus paradoxus*	T	T	No	Perennially wet soils of subirrigated terraces just above the wettest sites.
Leoncita false-foxglove	*Agalinis calycina*		T	N/A	Grasslands on perennially moist, heavy, alkaline/saline, calcareous silty clays and loams in and around cienegas (desert springs) and seeps.
Little Aguja pondweed	*Potamogeton clystocarpus*	E	E	No	Submersed in still or slowly flowing water of pools in intermittent creeks and rooted in sand and gravel derived from igneous rock of surrounding mountain slopes.
Tobusch fishhook cactus	*Sclerocactus brevihamatus ssp. tobuschii*	T	E	No	Usually on level to slightly sloping hilltops; occasionally on relatively level areas on steeper slopes, and in rocky floodplains.
Texas snowbells	*Styrax platanifolius ssp. texanus*	E	E	No	Limestone bluffs, boulder slopes, cliff faces, and gravelly streambeds, usually along perennial streams or intermittent drainages in canyon bottoms.

* T = Threatened, E = Endangered, C = Candidate, DL = Delisted

[a] TPWD. 2022. Texas Parks and Wildlife Department Annotated County Lists of Rare Species. Last Update March 17, 2022.

[b] iNaturalist. 2022. Big Bend Mud Turtle (Subspecies Kinosternon hirtipes murrayi) · iNaturalist, accessed July 11, 2022.

1.6 Existing Natural Flood Mitigation Features

The arid climate and landscape associated with Region 14 provides a unique selection of natural flood mitigation features, but also requires careful consideration of groundwater recharge and discharge, geomorphology, and native ecosystems, which have a strong influence on sustainable flood benefits in a changing environment. Due to the region's arid landscape, sedimentation from arroyos is a common issue after floods, especially in El Paso where arroyos from the Franklin Mountains frequently deposit sediment impacting downstream culverts, roadways, agricultural land, and irrigation system infrastructure. Conventional flood protection infrastructure (e.g., dams, levees, channels, etc.) designed to decrease flood risk and capture sediment, can eventually have an adverse effect on natural sediment movement and downstream habitats which are sensitive to minimum seasonal flow cycles.

Therefore, it is important to consider stormwater operations and land management techniques that promote a healthy ecosystem, and design new stormwater infrastructure which mimics and utilizes surrounding natural flood mitigation features, where possible. The following natural features will be discussed in this section, along with their flood mitigation benefits and risks: floodplains; arroyos; natural depressions; wetlands; playa lakes; sinkholes; and alluvial fans. **Exhibit 1B** summarizes the existing flood infrastructure geodatabase and identifies both constructed and natural features. The locations of features described in this section are shown in **Map Exhibit 1** ("Existing Flood Infrastructure"), while non-functional or deficient flood mitigation features are shown in **Map Exhibit 3** ("Non-Functional or Deficient Flood Mitigation Features or Infrastructure").

1.6.1 Rivers and Tributaries

The watershed contributing to the Rio Grande (also known as the Río Bravo del Norte in Mexico), includes sub-basins for the Pecos River, the Devils River, and the Rio Conchos. The Rio Conchos joins from the Mexican side just upstream of the City of Presidio, Texas, while the Pecos River and the Devils River flow through Region 14. The Upper Rio Grande Basin and Bay Expert Science Team (URG BBEST) conducted an assessment of Sound Ecological Environment (SEE) for the Rio Grande Basin between the City of Presidio, Texas and Amistad Reservoir, including the Pecos and Devils River Basins. The results are documented in "Environmental Flows Recommendations Report" (URG BBEST, 2012), and the authors conclude that that the "Lower Pecos" reach of the Pecos River, the "Lower Canyons" reach of the Rio Grande (La Linda, Mexico to the headwaters of Amistad Reservoir) and the Devils River currently support a sound ecological environment. These reaches are identified with a condition of "Functional" and a deficiency description of "Non-deficient" in the RFP "Existing Flood Infrastructure" dataset. Specific flow recommendations to sustain or improve this status are provided in the report.

However, URG BBEST also concludes that the "Parks" reach of the Rio Grande (the Rio Conchos confluence to La Linda, Mexico) and the upper Pecos (between Red Bluff reservoir and Independence Creek) are not sound, and variable recommendations are made to improve or not degrade the environment in these reaches. These reaches are identified with a condition of "Non-functional" and a deficiency description of "Deficient" in the RFP "Existing Flood Infrastructure" dataset. Environmental flow recommendations provided by URG BBEST for the Pecos and the Rio Grande do not exceed the limitations of the 1944 Treaty with Mexico or the

Pecos River Compact, and include components for subsistence flows, base flows, high flow pulses, and overbank flows (URG BBEST, 2012).

Tributaries for all counties within Region 14 except for El Paso County were identified in the "Existing Flood Infrastructure" RFP dataset using the National Hydrography Dataset (NHD) spatial data provided by TWDB in the Flood Planning Data Hub.[14] In El Paso County, the stream lines developed in the El Paso County Federal Emergency Management Agency (FEMA) mapping project, completed by Compass PTS JV (Compass) in 2019, were used to identify the natural rivers and tributaries within the county.

1.6.2 Floodplains

Floodplains can provide flood mitigation benefits because these areas can absorb a great deal of water during flooding and slowly release them over time. When floodwaters can connect with a floodplain, floodwater velocity is reduced, and the water is delivered downstream over a longer period. Each of the rivers flowing through Region 14 and their vast tributary systems have their own diverse history and floodplain footprints, which have widened and narrowed over time depending on their topography, geology, flow sources, groundwater characteristics, and influences from development and complex socio-ecological systems. While the United States (U.S.) generally associates floodplains with risk, it is important to recognize the benefits of floods for ecology, water quality, and water supply purposes. "Flood policy—at least on the aspirational level—is shifting from flood 'control' to a new view that integrates ecosystem components and functionality as part of social-ecological systems." (Frontiers in Environmental Science, 2022).

The upper Rio Grande hydrology is affected by inflows from rivers and several large desert arroyos, runoff from monsoonal rains, groundwater inflows from aquifers, as well as hurricanes and tropical storms from both the Pacific Ocean and the Gulf of Mexico (URG BBEST, 2012). With segments that establish the border between two countries, the Rio Grande attracts many cultures, economies, and political interactions between the U.S. and Mexico. The political landscape controlling water rights and agricultural needs has had long term effects on the Rio Grande floodplain throughout the Region 14 boundary. Two particular reaches, which have been studied from an environmental and geomorphic perspective, and which are the focus of tourist attractions include the "Forgotten Reach" of the Rio Grande from Fort Quitman to the City of Presidio, Texas and the "Rio Grande Wild and Scenic River" which begins at the Big Bend National Park and ends at the boundary between Val Verde County and Terrell County.

1.6.3 Arroyos

Arroyos are dry washes and often steep-sided gullies that traverse steep terrain in semi-arid and arid landscapes, such as Region 14. Some are deeply incised and broken streams with significant unrealized storage capacity. If an arroyo does not enter an urban area, the defined channel tends to disappear where the terrain flattens out. Throughout El Paso County, many arroyos are named as "Flowpaths" followed by a number.

[14] U.S. Geological Survey. National Hydrography Dataset. Available at https://twdb-flood-planning-resources-twdb.hub.arcgis.com/pages/national-hydrography-dataset-nhd

Increased impervious cover associated with new development and/or unregulated off-road vehicle activity can redirect and concentrate additional stormwater runoff, which can then form new arroyos, putting downstream communities at risk of flooding and sediment deposition. This has been a reported issue in El Paso and Hudspeth counties, where rapid development is taking place. It is important to establish effective construction permitting and stormwater management procedures and enforce appropriate regulations to prevent new arroyos from forming upstream of populated areas.

1.6.4 Natural Depressions

Natural depressions in the terrain can serve as flood storage to recharge the groundwater table and reduce or eliminate downstream flooding, depending on the size of the available storage volume. In the “Montana Sector” of El Paso, County, an ArcGIS (ESRI) spatial analysis was performed as part of the El Paso County Stormwater Master Plan (EP County SWMP) (AECOM, 2021) to identify large natural depressions for consideration in the development of hydrologic and hydraulic (H&H) models. The EP County SWMP spatial analysis results were used to identify a portion of the natural depressions identified in this report.

As the flow reaches the residential areas in the Montana Sector, the natural arroyos become less defined and the flow begins to disperse, traveling along the path of least resistance, until the arroyos disappear altogether in large natural depressions. While these depressions can store floodwater and reduce risk of flooding downstream, they can be a risk themselves if development occurs inside these low-lying areas, which has occurred in this rapidly growing area of northeast El Paso County.

Additional natural depressions were identified typically outside of city limits by reviewing surface water polygons developed during Phase 2 of the El Paso County FEMA mapping project (Compass, 2019). The publicly available preliminary mapping data were used as a basis for several flood-related data sets and will be referenced as “El Paso County Preliminary FEMA” (Compass, 2019) data throughout this report. The National Parks Service also provides publicly available land subsidence features spatial data in Terrell and Val Verde counties in the form of polygons, which were included in the RFP data set as natural depressions.

1.6.5 Wetlands

Wetlands are areas where water is present either at or near the surface of the soil for varying periods of time throughout the year. The U.S. Fish and Wildlife Service’s (USFWS) National Wetlands Inventory (NWI) was used to identify different types of wetlands throughout Region 14, including: freshwater emergent wetlands, freshwater forested/shrub wetlands, as well as wetlands associated with freshwater ponds, lakes, and riverine features.

Wetlands can provide flood mitigation benefits because they act similar to natural sponges, absorbing large volumes of water, and slowly releasing them over time. They can also slow the velocity of floodwater in a floodplain during and after a storm event. Wetland-associated habitats in the Chihuahuan Desert’s Rio Grande floodplain have undergone a 93% reduction over the past century (Hink and Ohmart 1984, Scurlock 1998). Constructed wetland projects can clean stormwater, graywater, and/or wastewater, improving habitat and enhancing biodiversity. Stormwater wetlands thoughtfully designed in urban settings can clean urban runoff, reduce flooding, and create spaces for tourists and the community to enjoy nature.

The 372-acre Rio Bosque Wetlands Park in southeast El Paso is a compilation of wetlands and riverside forest which serves as habitat for over 200 species of birds. The United States Army Corps of Engineers (USACE) is proposing improvements to the Wetlands Park to address issues associated with lower quality wetland habitats and a reduction in wildlife diversity compared to the Park's potential.

Southeast of the City of Presidio, Texas, the La Junta Heritage Center is creating a master plan to restore the La Junta site, including wetland and riparian restoration. The natural systems along this neglected segment of the Rio Grande have been greatly impacted by flood-control levies and flood events over the past several decades. Restoration efforts for the B.J. Bishops wetland would also provide economic benefits to this largely low-income, agricultural region. The nearby wetlands in the "Forgotten Reach of the Rio Grande", upstream of Presidio and near Candelaria, are a popular birding destination for tourists.

1.6.6 Playas

Playas are extremely flat, dried lake beds found in interior desert basins which form when evaporation processes exceed recharge. During flood events, due to their flat terrain, playa surfaces may be inundated for many miles, leading to a residual concentration of fine-grained sediment and salts after flood waters evaporate. As with other types of flat terrain flooding, playa lakes create a unique flood risk challenge, typically requiring long, attenuated hydrographs and 2D hydraulic analysis.

The Upper Rio Grande region consists of several playas, including most notably the West Texas Salt Basin, which stretches from Dell City to Van Horn. Based on maps available in studies from the New Mexico Geological Society Guidebook and the Texas Water Development Board, playa boundaries for the West Texas Salt Basin, covering approximately 560 square miles, were digitized and overlaid with available flood hazard layers.[15,16]

In addition to the West Texas Salt Basin, playa areas were identified and delineated near the Town of Pecos City (Mosquito Lake and Toyah Lake) as well as near Imperial north of the Pecos River. These playas, covering approximately 36 square miles, were identified based on discussions with stakeholders from Reeves County and the Town of Pecos City and digitized using aerial imagery.

1.6.7 Sinkholes

A sinkhole is a geologic feature characterized by ground depression with no external surface drainage. Stormwater runoff intercepted by a sinkhole typically ponds or drains into the subsurface. The size of sinkholes can vary significantly, from a couple square feet to hundreds of acres, and depths can vary from 1 ft to greater than 100 feet. In west Texas, the most common category of sinkhole is bedded salt dissolution. While sinkholes can be beneficial to flooding during storm events by capturing and removing surface water runoff, they are

[15] Sharp, John M., Jr., James R. Mayer, and Eldon McCutcheon. Hydrogeologic Trends in the Dell City Area, Hudspeth County, Texas. New Mexico Geological Society Guidebook, 44th Field Conference, Carlsbad Region, New Mexico and West Texas, 1993, pp. 327-330. https://nmgs.nmt.edu/publications/guidebooks/downloads/44/44_p0327_p0330.pdf (accessed 2/14/2022)
[16] Angle, Edward S. Aquifers of West Texas (R356), Chapter 17: Hydrogeology of the Salt Basin. Texas Water Development Board, December 2001, page 233. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R356/Chapter17.pdf (accessed 2/14/2022)

sometimes hazardous because they can form very quickly, jeopardizing buildings or roadways with little to no warning. They can develop due to natural or man-made activities.

According to FEMA, “the number of human-induced sinkholes has doubled since 1930, insurance claims for damages as a result of sinkholes has increased 1,200 percent from 1987 to 1991, costing nearly $100 million.” Areas in Texas prone to sinkhole development are located where underlying rock layers of salt, limestone, and gypsum occur. Human activity such as oil well drilling, can potentially exacerbate the danger in these areas. The Permian Basin is a large sedimentary basin which is known for oil well drilling, and covers a large portion of Region 14, stretching from Lubbock, past Midland and Odessa, and south toward the Rio Grande. While it is difficult to correlate a relationship between oil extraction locations and sinkholes, there is anecdotal evidence suggesting a relation between the two activities. In order to verify this relationship, sinkhole location data must be acquired. However, Texas government sinkhole data are extremely sparse at this time. The National Parks Service provides publicly available spatial data in Terrell and Val Verde counties in the forms of point locations of sinkholes.

Sinkholes have also formed in Region 14 during or immediately after significant flood events. This occurred during the April 2004 flood event along a County Road located southwest of the City of Pecos, as shown in **Figure 1.9.**

Sinkholes formed along this County Road southwest of Pecos, Texas during the April 2004 storm event.
Source: NOAA and NWS; https://www.weather.gov/maf/2004_04_02_SevereWeather

Figure 1.9 Sinkholes in Pecos, Texas, April 2004 Flood

1.6.8 Alluvial Fans

An alluvial fan is a fan-shaped mass composed of loose, unconsolidated materials deposited as the flow of a river decreases in velocity, typically found at a topographic break where stream channels become less confined. The downstream boundary, or “toe,” of an alluvial fan is located at an axial stream, lake or landform that was not formed by alluvial fan flooding processes. Alluvial fans are important to societies in arid and semiarid locations where they may be the principal groundwater source for irrigation farming. While these natural features decrease flood depths as they disperse upstream concentrated flows over wide areas, the shallow flow velocities on alluvial fans typically remain high, exposing downstream areas to debris flow, erosion hazards, and flood waters bulked with sediment. Moreover, as was observed in the August 2006 flood event in El Paso, Texas, the erosion and removal of stabilizing vegetation can increase the amount of sediment and debris available for transport during future flash flood events. In addition to the debris hazards that were experienced in the 2006 event, the City of El Paso experienced significant debris flow on the east side of the Franklin mountains during the August 2021 flood event, where multiple streets at the base of the mountains were buried with sediment and/or exposed to large boulders and debris from the flash flooding that occurred.

The El Paso Water Utilities and City of El Paso Stormwater Master Plan (EP City SWMP) (URS and MCi, 2009) identifies areas at risk of potential sediment and debris flow, and documents alluvial fan investigations, providing active fan process area maps. These risk areas are mapped on the east and west sides of the Franklin Mountains to help prevent future development from occurring in and around these areas. Recommendations in Appendix C of the EP City SWMP (URS and MCi, 2009) include the strategic design of new sediment basins with consideration of the mapped hazard areas and applying increased sediment bulking factors during the sizing of the basins. Regular maintenance of existing sediment basins following flood events can also decrease the risk of debris hazards downstream of those basins during future flood events.

In addition, the 2019 El Paso County Preliminary FEMA study included an investigation and floodplain mapping report for alluvial fans in El Paso County entitled, “Alluvial Fan Landform Assessment” (JE Fuller, 2019). This report documents the detailed assessment of geology and topography applied to identify and map flood hazards associated with alluvial fans. While several active alluvial fans were identified through field observations, most were either located on military reservation lands (with unexploded ordinance risks preventing future development) or they had been altered with flood/sediment mitigation structures which reduced the flow path uncertainty; these features were eliminated from the analysis. One area located near Vinton Road and Interstate 1 was found to meet the FEMA criteria for mapping alluvial fan flood hazard zones. The report states that due to the significant uncertainty associated with flow paths on alluvial fans, the Preliminary FEMA flood zones on these features had to be delineated using geomorphic data in conjunction with two-dimensional (2D) hydraulic modeling results (JE Fuller, 2019).

1.7 Constructed Major Flood Infrastructure

Region 14 includes the following existing stormwater infrastructure, which will be discussed in this section: stream crossings; levees; flood protection dams; detention and retention ponds; storm drain systems; stormwater canals; pump stations; and weirs. While statewide and nationwide data sets for dams and levees are available throughout the region, there was generally a lack of digital data for stormwater infrastructure in all Region 14 counties other than El Paso County. This section discusses available digital infrastructure data for constructed flood mitigation features incorporated into the RFP "Existing Flood Infrastructure" dataset. **Appendix Table 1B** summarizes the existing flood infrastructure geodatabase and identifies both constructed and natural features.

1.7.1 Stream and Low Water Crossings

Stream crossing features, including crossings at roadways and railroads as well as low water crossings, were identified using the following sources:

- Texas Statewide Low Water Crossings Inventory, maintained by TNRIS and publicly available at: https://data.tnris.org/collection?c=f692bfd4-4dea-4c8b-a14d-a5a73660c074#5.09/31.32/-100.08
- TxDOT Bridges Dataset, publicly available at: https://gis-txdot.opendata.arcgis.com/datasets/TXDOT::txdot-bridges/about
- El Paso County Interior Drainage Study for the City of El Paso and El Paso Water Utilities (2021)
- Drainage Study for FM 170 from Candelaria to US-67 (TxDOT, 2020)
- Drainage Study for SH-20 (Mesa Street) from Doniphan Drive to Texas Avenue (TxDOT, 2019)
- Spatial analysis by AECOM using a combination of centerline data for roadways and streams along with aerial imagery (2022)

Where possible, stream crossing level of service information was identified using detailed hydraulic analyses from previous studies. For other stream crossings where previous detailed analyses were not available, level of service information was estimated using available flood depth data (i.e., from 2019 Preliminary FEMA El Paso County Mapping and Fathom Cursory Floodplain Data). All crossings with an estimated level of service equal to or less than the 10% annual chance flood event were identified as low water crossings, including all crossings identified from the Texas Statewide Low Water Crossings inventory.

Further information pertaining to the level of service methodology and results is discussed in *Chapter 2 (Flood Risk Analyses).*

1.7.2 Levees

The following datasets were utilized in the development of levee spatial data for the RFP:

- National Levee Database (NLD), maintained by USACE and publicly available at: https://levees.sec.usace.army.mil/#/
- 2019 El Paso County Preliminary FEMA spatial data set; publicly available through at https://msc.fema.gov/portal/home
- The FEMA Mid-Term Levee Inventory (MLI) database; publicly available through FEMA's Regional Service Centers
- U.S. International Boundary and Water Commission (USIBWC) geospatial database, provided by USIBWC for the development of the RFP

Populations at risk for levees were estimated based on populations within service areas of levees, as documented in the National Levee Database.

1.7.2.1 Levee Accreditation

There are multiple unaccredited levee segments along the Rio Grande River through El Paso County that currently provide flood protection to adjacent areas. These levees are designed and operated by the USIBWC. A certified levee indicates that the levee segment is formally recognized by FEMA as providing flood risk reduction for the 1% annual chance (AC) flood on the applicable Flood Insurance Rate Map(s) (FIRMs). While the USIBWC levee segments through El Paso are typically designed to contain the 1% AC flood level with freeboard, in order to achieve FEMA accreditation, the levee systems must meet and continue to meet the minimum design, operation, and maintenance standards per Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44 CFR Section 65.10). This regulation specifies select items that need to be submitted and reviewed by FEMA to obtain levee accreditation, including the following:

- Documentation that the levee meets design criteria (freeboard, stability, settlement, etc.);
- Certified as-built levee plans showing tie-ins at roads, bridges, and high ground;
- Officially adopted operation and maintenance (O&M);
- Emergency Preparedness Plan (including documentation of flood warning systems, emergency notification flowchart); and
- Interior drainage evaluation.

The reasons specific levees are not accredited throughout the region vary based on the geology, topography, and hydrologic conditions at each identified levee segment. For example, in El Paso County, the reasons for unaccredited levees may include not meeting minimum freeboard or geotechnical requirements, tie-in requirements, and/or lack of an interior drainage study throughout the entire levee segment. Note, some levee segments extend into Doña Ana County, New Mexico and an interior drainage study has not been performed on the Rio Grande outside of El Paso County for these segments.

Per the RFP scope of work, if a levee is not accredited by FEMA, the levee segment was assumed not to be in place when developing the 1% AC flood map boundaries. This approach is consistent with the 2019 El Paso County Preliminary FEMA mapping approach, which was incorporated in the RFP flood mapping within El Paso County. These unaccredited levee segments are identified with a condition of "Non-functional" in the RFP "Existing Flood Infrastructure" dataset. As of June 2022, there is only one FEMA accredited levee in Region 14, which stretches along the U.S. side of the Rio Grande in El Paso County from International Dam to Zaragosa Road. This FEMA- accredited levee segment is identified with a condition of "Functional" in the RFP "Existing Flood Infrastructure" dataset.

Since the 2019 El Paso County Preliminary FEMA floodplains only incorporate flood protection from one FEMA-accredited levee segment, there are large portions of the county which will be mapped in the 1% AC flood hazard zone when the Preliminary FEMA maps become effective, assuming additional levee segments do not become FEMA-accredited before that time. The 1% AC flood inundation extents preliminarily mapped by FEMA in areas adjacent to unaccredited levees are based upon mapping and H&H models documented in the "FEMA Natural Valley Analysis Pre-LAMP Report" (FEMA, 2016), which considers all levee segments to be removed. This 1% AC "no-levee" flood mapping scenario is referenced as the "natural valley floodplain" throughout this report.

1.7.2.2 Interior Drainage Studies

Additional 1% AC spatial flood mapping and H&H models are available in El Paso County which consider the levees to be in place. These studies are required to be completed before a levee can be certified for accreditation and are referenced as "interior drainage studies" throughout this report; however, it is important to note that these flood maps are non-regulatory. The "El Paso County Interior Drainage Study" (AECOM, 2021) incorporates best available interior drainage studies for levee segments along the Rio Grande, where available, and developed new interior drainage flood maps and H&H models where previous interior drainage studies along the Rio Grande were not previously available in El Paso County. In the RFP, these interior drainage models and maps were utilized, where appropriate, to evaluate existing and proposed conditions for Flood Mitigation Projects (FMPs) affected by the natural valley floodplain in areas adjacent to non-certified levees.

1.7.2.3 Presidio Levees

Additional unaccredited levees exist along Cibolo Creek and the Rio Grande in the City of Presidio. While the Cibolo Creek levees are noted in the NLD as having an "Incipient Overtopping Annual Exceedance Probability (AEP)" of 0.001 (the 1,000-year flood event), the level of service annual probability was reported as "0.2" since the 0.2% AC flood (500-year) is the lowest exceedance value considered as a valid entry in the RFP geodatabase. The left Cibolo Creek levee, which was designed to protect the City of Presidio is identified as "Deficient" in the RFP "Existing Flood Infrastructure" database based upon the description of levee performance provided in the NLD which states, "There is a moderate likelihood of embankment erosion leading to poor performance given there are areas without riprap revetment or other forms of erosion protection. However, given the short flood durations and the levee material composed of compacted granular material it is believed the levee is moderately resistant to erosion." USACE constructed the Cibolo Creek levees, which run along the northwest boundary of the City of Presidio; however, they are currently maintained and operated by Presidio County.

The Rio Grande levee which runs along the southern boundary of the City of Presidio, owned and operated by USIBWC, was designed to provide 4-ft of freeboard protection above the flood event associated with 42,000 cfs, which was documented to be less than the 5% A.C. (20-year flood) of 43,000 cfs in a report entitled, “Hydraulic Modeling Analysis for the Presidio/Ojinaga Flood Control Project” (USIBWC, 2003). However, during the September 2008 flood of the Rio Conchos and the Rio Grande, from Presidio to the Amistad Reservoir, sections of the Rio Grande levee on the U.S. side were damaged in the Presidio area (including the presence of boils), flooding low-lying agricultural areas adjacent to the levee. These levee failures required emergency responses from USIBWC, who coordinated with USACE and Texas Division of Emergency Management (TDEM) on temporary repairs including sand bags and plastic lining of the levees. While failed levee segments in the Presidio area were later repaired by USIBWC, breached Rio Grande levees protecting agricultural land adjacent to the City of Redford, located downstream of Presidio, were not repaired.

1.7.3 Flood Protection Dams

Multiple data sources were used to identify and complete “Existing Flood Infrastructure” data fields for flood protection dams in Region 14, including:

- National Inventory of Dams (NID), maintained by USACE;
- Texas Commission on Environmental Quality (TCEQ) database of dams regulated by the State of Texas, maintained by TCEQ; and
- Natural Resources Conservation Service (NRCS) database of NRCS-designed dams in Texas, maintained by the NRCS State office.

1.7.3.1 Data Sources

The NID database includes basic information for 127 dams in Region 14, including location, owner, purpose (water supply, flood control, irrigation, etc.), dimensions (height of dam, normal and maximum reservoir storage), and information on whether an Emergency Action Plan was developed and when. The TCEQ maintains an updated database of the same information for 122 state regulated Texas dams (i.e dams above the size thresholds of Texas Administrative Code Title 30, Part 1, Chapter 299). Dams of unregulated size are deemed not to provide a safety risk to lives in the event of a breach.

The TCEQ list also contains fields that provide the dam hazard class per Chapter 299, and hydraulic information about dam discharges during dam safety events (events much larger than the 1% AC event). The TCEQ dam database is provided to the USACE every two years minus the hazard class and hydraulic information. The Texas NRCS State office maintains a similar dam database of NRCS-designed dams in Texas, with dam hazard class per NRCS Technical Report 60. There are inconsistencies between TCEQ and NRCS hazard class determinations, which, because of the varying wording between the federal and state definitions, are not resolved. The TCEQ dam inventory is not readily available to the public (i.e. is not at a web link), but can be procured through a Public Information Request. The TCEQ dam inventory provided to the public will not include hazard class or the hydraulic information; thus, property owners are not readily aware of risk associated with a dam.

According to the TCEQ hazard classifications, the dam hazard classifications are as follows:

- High Hazard: In the event of failure, the hazards may include the loss of 7 or more lives, inundate 3 or more permanent habitable structures, and/or result in excessive economic loss.
- Significant Hazard: In the event of failure, the hazards may include the loss of 1-6 or more lives, inundate 1-2 permanent habitable structures, and/or result in appreciable economic loss.
- Low Hazard: In the event of failure, the hazards will not include loss of life, inundation of permanent habitable structures, or result in significant economic loss.

1.7.3.2 Data Input Assumptions

Due to the confidential nature of dam hazard classifications, the “Existing Flood Infrastructure” attribute, “Population Protected by Infrastructure” was not completed for dams as part of the RFP. However, the “Condition” attribute from the available data were compared, giving priority to the TCEQ data, to estimate whether a dam was “Deficient” or “Non-deficient” in the RFP dataset. Dams with a “Condition” of “FAIR” or “GOOD” in the TCEQ dataset were assumed to be “Non-deficient” while a condition of “POOR” was identified as “Deficient” in the RFP dataset.

Another attribute included in the TCEQ dataset is “Hydraulic Adequacy” attribute, which is identified by TCEQ as “YES,” “NO,” or “NOT DETERMINED”. There are 27 dams in Region 14 that are determined to be hydraulically inadequate by TCEQ, while 51 dams are identified by TCEQ as hydraulically adequate. The hydraulically adequate dams were assigned a “CONDITION” rating of “Functional” in the RFP dataset; since the dams are assumed to meet their intended design level of service per it’s current hazard classification. Per TCEQ, it is possible that prior “Not Determined” has been assigned in the “Hydraulically Inadequate” data field due to a myriad of factors, such as

- Not yet being studied for hydraulic adequacy based on the current hazard classification;
- Configuration issues – current dam/spillway(s) size/elevation/etc. not (or no longer) consistent with prior H&H study;
- Significant changes to drainage area (and/or upstream channel), along with the age of H&H study;
- Uncertainty if a dam (that was designed to be overtopped) can safely pass its design storm without suffering undue erosion; or
- Other issues that would ‘invalidate’ a prior H&H study

Furthermore, the Level of Service (LOS) associated with dams was assigned as either 1, indicating it can safely pass the 1% AC event or 0.2, indicating it can safely pass the 0.2% AC event based upon the hydraulic adequacy and the Probable Maximum Flood (PMF) percent passing, per the TCEQ dataset. If the dam was identified to pass 100% of the PMF per the TCEQ dataset, and the dam was determined to be hydraulically adequate, the LOS was assumed to be 0.2% AC (the 500-year flood and the largest flood considered a valid entry in the RFP dataset). Similarly, if the dam was hydraulically adequate and the percent PMF passing was less than 100%, but still equal to or greater than the PMF required per the TCEQ dataset, then the dam was assumed to have a LOS of 1% AC (i.e., it safely passes the 1% AC flood event).

1.7.4 Detention and Retention Ponds

The digital data sources for detention and retention ponds obtained for Region 14 were from the following sources, which were all located within El Paso County:

- 2019 El Paso County Preliminary FEMA (Compass, 2019) spatial data set (polygons); publicly available at https://msc.fema.gov/portal/home;
- EP City SWMP (URS and MCi, 2009) Electronic Files spatial data for ponds (points); and
- EPWater's City of El Paso stormwater infrastructure GIS dataset (EPWater, 2021) for pond (points).

Point and polygon features symbolizing ponds and basins from each spatial dataset were compared to eliminate duplicate features in the RFP dataset.

1.7.5 Storm Drains, Stormwater Canals, and Pump Stations

EPWater's City of El Paso stormwater infrastructure GIS dataset (EPWater, 2021) for Conduits, Channels, and Pump Stations was used to identify constructed infrastructure features within Region 14. These features were input as "Storm Drains", "Stormwater Canals", and "Pump Stations," respectively, for the "Infrastructure Type" attribute of the RFP geodatabase. In addition, the line features identified as "Agricultural_Drain" in the infrastructure geodatabase provided by EPWater were included as "Stormwater Canals" in the RFP dataset. In El Paso, there are multiple agricultural drains which are sometimes utilized for stormwater conveyance purposes during flood events. The EPWater dataset does not indicate the condition or level of service associated with the City infrastructure.

A report entitled, "Final Hydraulic Report/Drainage Study for the City of Presidio, Texas" (S&B Infrastructure, 2008) was obtained from the City of Presidio, which includes an "Appendix B – Structure Inventory" documenting the location and sizes of stormwater infrastructure in the City of Presidio at the time of that study. The digital data associated with the Appendix were not included in the electronic files provided with the report. S&B Infrastructure was contacted to obtain the electronic files associated with the report appendix but confirmed that digital versions of the data were no longer available. Therefore, these infrastructure data were not included in the RFP geodatabase.

1.7.6 Weirs

Only six weirs were identified in Region 14, all located in the northwest portion of El Paso County. These weir locations were obtained from the 2019 El Paso County Preliminary FEMA (Compass, 2019) spatial data set ("S_Gen_Struct.shp" polylines); which are publicly available at https://msc.fema.gov/portal/home. Five of these weirs are located on a channelized section Flowpath No. 4, and one is located immediately downstream of the Resler Channel crossing under IH-10.

1.8 Proposed or Ongoing Major Flood Infrastructure and Mitigation Projects

The table in **Appendix Table 1C** includes a summary of proposed or ongoing flood mitigation projects within Region 14, and **Map Exhibit 2** ("Proposed or Ongoing Flood Mitigation Projects") shows the location of the proposed or ongoing flood mitigation projects. These are projects within the region that already have committed funding for final design and/or construction. The status of each project in **Appendix Table 1C** states what phase each project is currently under. It should be noted that these projects are different from the Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs) identified and recommended in Chapters 4 and 5 of the RFP, respectively; since they already have committed funding and some are even currently under construction. All of the projects are located within El Paso County, and two are located within El Paso city limits. Existing funding sources include the TWDB Flood Infrastructure Fund (FIF), El Paso Water, and USACE.

1.9 Relevant Existing Planning Documents

Appendix Table 1D provides a list of relevant existing planning documents for Region 14. The list is consistent with types of planning study documents referenced under 31 TAC §361.22. The most relevant planning documents for Region 14, which are directly related to Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs) evaluated in the RFP, are described below and organized by Study ID number associated with **Appendix Table 1D**.

3- DRAFT EPCWID Incident Report, Arroyo Flow and Flooding into Mesa Spur Drain Near Mankato Road, July 22, 2017 at 4 pm

- On July 22, 2017, a short duration intense rainfall event occurred in the watershed of the un-named arroyo that drains into the Mesa Spur Drain near Mankato Road in Socorro, Texas. This document is a collection of weather data from that event. The later named, "Mankato Arroyo" was evaluated as the SOC4 Flood Mitigation Project (FMP 143000021) in the RFP. SOC4 is a proposed sediment basin in the EP County SWMP (AECOM, 2021), and the project is a high priority for the El Paso County Water Improvement District No.1.

4- Final - Evaluation of Reduced Flow Capacity of the Rio Grande and the Impacts on the Operations of the Rio Grande Project Leasburg Dam to American Dam, Phase I - Main Channel and Floodways - Anthony, NM to American Dam

- This report documents existing conveyance capacity of the Rio Grande from NM Highway 225 to the American Diversion Dam in El Paso, Texas. The report, authored by a Joint Committee on Rio Grande Project Flood Risk documents the changes to flood risk and impact on Rio Grande Project operations resulting from accumulated sediment and vegetation in the main channel. The RFP Flood Management Evaluation (FME 141000001) is based on the findings and recommendations from this report.

13- El Paso Stormwater Master Plan Update (2021)

- The main purpose of the updated EP City SWMP (AECOM, MCi, 2021) was to update the original 2009 EP City SWMP to improve the drainage infrastructure of El Paso and reduce the flood risk to the public and property. Five FMPs and one FME from this document are evaluated in the RFP.

24- El Paso County Interior Drainage Study, Methodology and Mapping Results Report

- The purpose of the El Paso County Interior Drainage Study is to identify the sources of flooding from the landward sides of the levees along the 65 miles of the Rio Grande within El Paso County, where depths exceed 1 ft based on current conditions. The modeling and mapping from this study was utilized to help analyze existing damages and proposed benefits for FMPs affected by the natural valley floodplain, including NW3 (FMP 143000111) and NW26 (FMP 143000113).

25- El Paso County Stormwater Master Plan

- The EP County SWMP addresses stormwater needs in El Paso County, outside of City of El Paso limits. As the City master plan was being completed, El Paso County recognized that a similar effort was needed to address stormwater needs throughout the rest of the County. Four FMPs and one FME from this document are evaluated in the RFP.

33- Hudspeth County, Texas. Villa Alegre, Fort Hancock East Unit 1, & Fort Hancock East Unit 2. Colonia Area Study and Plan 2019 - 2029.

- The information gathered in this study sheds light on the housing needs of the community, helps to direct the formation of housing goals, and establishes a blueprint for future actions Hudspeth County might take to provide adequate housing for those residents. This document was the basis for the evaluation of FMP 143000009 and FME 141000014 in the RFP.

38- Technical Memorandum with Project Recommendation. Montoya Drain H&H Analysis.

- This Study was performed to provide a recommendation to El Paso Water regarding the use of a parcel of land as a potential site for floodwater detention. The project concept was later modified to include a constructed wetland on the same site. Project NW26 (FMP 143000113) from the EP City SWMP (AECOM, MCi, 2021) is based upon this Memo.

44- Pecos River Basin Salinity Assessment, Santa Rosa Lake, New Mexico, to the Confluence of the Pecos River and the Rio Grande, Texas, 2015. Scientific Investigations Report 2019-5071.

- The salinity of the Pecos River increases downstream and affects the availability of useable water in the Pecos River Basin. The document explains how specific areas might be contributing to the elevated salinity in the Pecos River and how salinity of the Pecos River has changed over time. FMS 142000007 is based upon information presented in this document.

49- Drainage Feasibility Study. Socorro Rd. Intersections with San Antonio St. and Main St.

- The City of San Elizario, Texas has continuously experienced flooding of the intersections of Socorro Rd. and San Antonio St., and Socorro Rd. and Main St. This study identifies existing flood risk and related drainage infrastructure, and analyzes three alternative improvements. FMP 143000003 is based upon this document.

59- Drainage Study for SH 20 (Mesa Street) From Doniphan Drive to Texas Avenue

- The drainage analysis includes assessing cross drainage structures of multiple varieties, evaluating the current level of service (LOS) of the roadway at all cross drainage structures, identifying locations where the roadway drainage system provides less than a 1% AC LOS and providing conceptual recommendations to mitigate localized flooding and erosion. FMP 143000005 was based upon this document.

78- A Watershed Protection Plan for the Pecos River in Texas

- This WPP addresses water quality concerns for the Pecos River in Texas. The Pecos River watershed is assessed, and baseline data is established for a voluntary watershed protection plan. FMS 142000007 is based upon information presented in this document.

87- Environmental Flow Recommendations Report

- The Upper Rio Grande Basin and Bay Expert Science Team (URG BBEST) conducted an assessment of Sound Ecological Environment (SEE) for the Rio Grande Basin between the City of Presidio, Texas and Amistad Reservoir, including the Pecos and Devils River Basins. Environmental flow recommendations provided for the Pecos and the Rio Grande include components for subsistence flows, base flows, high flow pulses, and overbank flows. FMS 142000006 is based upon information presented in this document.