Chapter 2: Flood Risk Analyses

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2. Flood Risk Analyses

Flood risks can be defined in terms of *flood hazards* (i.e., the location, magnitude, and frequency of flooding), *flood exposure* (i.e., who and what might be harmed within the region), and *vulnerabilities* (i.e., areas of exposure including communities and critical facilities which may be particularly susceptible to flood impacts). Flood risk may also be evaluated based on *existing conditions*, accounting for present-day land use and impervious cover, as well as based on *future conditions*, accounting for future land use and impervious cover trends as well as overall climate and precipitation trends.

The following chapter summarizes the existing and future condition flood risk analyses performed for the Upper Rio Grande region. Flood risks were estimated using the best available hydrologic and hydraulic modeling data within the region, including models developed specifically for the RFP.

The results of the flood risk analyses are intended for use by the RFPG to establish priorities in subsequent planning tasks and to identify areas requiring flood management evaluations (FMEs), flood management strategies (FMSs), and flood mitigation projects (FMPs). The flood risk maps presented in this RFP do not reflect the effective regulatory floodplains and do not supersede or change federal flood insurance requirements.

Similarly, the flood risk analyses in this chapter establish baseline flood risk levels as currently recognized by FEMA and other best available modeling. As a result, and in accordance with State RFP requirements, any existing levees in the region that do not meet FEMA accreditation are excluded from the baseline flood risk analysis. This consideration is especially applicable to El Paso County, where unaccredited levees are present along the Upper Rio Grande. Chapter 4 discusses potential solutions and improvements that would be needed to achieve certification of these levees.

2.1 Available Hydrologic and Hydraulic Models

In reviewing the flood studies described in *Chapter 1 (Introduction and Description of the Upper Rio Grande Flood Planning Region),* relevant flood-related models were identified and obtained. These models, and their associated flood risk data, were evaluated to identify flood hazards and data gaps for the regionwide flood risk analysis as well as to evaluate flood reduction impacts from potential FMSs and FMPs as discussed in *Chapter 4 (Flood Mitigation Solutions)*.

Table 2.1 provides a summary of flood-related models most relevant to the Upper Rio Grande RFP. In addition, descriptions of the associated planning documents are included in Chapter 1, and an overview of model coverage boundaries across the region are shown in **Map Exhibit 22** ("Model Coverage").

Two of the primary flood risk data sources used in the baseline flood risk analysis include the 2019 Preliminary FEMA El Paso County Mapping Study (Model IDs 1 and 11) and the 2021 Statewide Fathom 2D Study (Model ID 20). These studies are described in greater detail in Section 2.2.1 along with the methodology used for the identification of flood risks.

Several of the models listed in **Table 2.1** were not incorporated into the baseline flood risk analyses but are still relevant to flood planning in the region. For example, the models developed for the El Paso County Interior Drainage Study (Model IDs 3-10) were excluded since they represent flood risks based on the flood protection of unaccredited levees through most of El Paso. The remaining models were excluded from the flood risk mapping since they are primarily associated with evaluating proposed Flood Mitigation Projects (FMPs), Flood Management Evaluations (FMEs), and/or Flood Management Strategies (FMSs), which are addressed in Chapter 4.

Other relevant floodplain layers were identified for the region, although models for these floodplains were not located or obtained, since the models are either out of date, superseded by other models, or not publicly available. These floodplain layers include the First American Flood Data Services (FAFDS) dataset (containing digitized flood hazard information from previously published FIRMs and FISs), Base Level Engineering (BLE) data for El Paso County, FEMA Approximate layers for Val Verde and Ector Counties, and a floodplain study for Fort Bliss in El Paso County.

Table 2.1 Relevant Flood-Related Models

Model ID	Study ID	Location	Modeling Software	Source
3-10	24	El Paso County, within the Rio Grande Natural Valley Floodplain	FLO-2D, HEC-HMS, and HEC-RAS 2D	El Paso County Interior Drainage Study (El Paso Water and El Paso County, 2021)
1, 11	21, 22	El Paso County	HEC-HMS and HEC-RAS 2D	Preliminary FEMA El Paso County Mapping Study (FEMA, 2019) (Note: as of November 2021, preliminary models are being adjusted to address appeals submitted during the appeal process – no current timeline is available for completion)
39, 40	N/A	El Paso County	HEC-HMS and HEC-RAS 2D	El Paso County Future Conditions Analysis for Regional Flood Plan (AECOM, 2022)
15-22	26	El Paso County	HEC-HMS, HEC-RAS 1D, and CulvertMaster	El Paso County Stormwater Master Plans (El Paso County, 2010 and 2021)
38	N/A	Texas, statewide	Fathom 2D models	TWDB/Fathom (October 2021)
28, 29	N/A	Americas Ten Dam in El Paso	HEC-HMS and HEC-RAS 2D	Ongoing Planning and Design to Decommission Americas Ten Dam (El Paso Water)
2, 12	59	SH 20 (Mesa Street) From Doniphan Drive to Texas Avenue	HEC-HMS, EPA SWMM	Drainage Study for SH 20 (Mesa Street) From Doniphan Drive to Texas Avenue (TXDOT, 2019)
13, 14	57	FM 170 (Mesa Street) From Candelaria to US-67	HEC-HMS, HEC-RAS 1D	Drainage Study for FM 170 From Candelaria to US-67 (TXDOT, 2020)
27	88	City of Presidio	HEC-HMS, HY-8	Final Hydraulic Report/Drainage Study for the City of Presidio, Texas (S&B Infrastructure, 2008)
30, 31	89	Northeast El Paso	HEC-HMS, FLO-2D	Northeast Sump Improvements – Hydrologic and Hydraulic Analysis (MCi, 2017)
34	38	West El Paso	HEC-HMS	Montoya Drain H&H Analysis (AECOM)
35	90	West El Paso	HEC-HMS	Doniphan Storm Water Pump Stations PS-1 and PS-2 System Evaluation & Potential Improvements (URS, 2014)
32, 33	N/A	West El Paso	HEC-HMS, HEC-RAS 2D	NW16 from modified version of El Paso County Preliminary FEMA Hydraulic Model (WA2) and modified version of SH20 (Mesa Street) Hydrologic Model

Model ID	Study ID	Location	Modeling Software	Source
1, 11	49	San Elizario	HEC-HMS, HEC-RAS 2D	San Elizario Alt 3 from Preliminary FEMA El Paso County Mapping Study (FEMA, 2019)
41-47	24	El Paso County, within the Rio Grande Natural Valley Floodplain	HEC-HMS	El Paso County Interior Drainage Study (El Paso Water and El Paso County, 2021)
48	24	El Paso County, within the Rio Grande Natural Valley Floodplain	StormCAD	El Paso County Interior Drainage Study (El Paso Water and El Paso County, 2021)

2.2 Existing Conditions Analysis

Existing condition flood hazard analyses were performed at the region-wide level using best available data to determine the location and magnitude of both 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events. To evaluate the level of service of low water crossings, flood risks for the 10% annual chance (10-year) event were also evaluated.

2.2.1 Existing Flood Hazard Identification

Several flood hazard datasets were evaluated for the 1% and 0.2% annual chance events to develop the existing conditions flood hazard area layers for the RFP. These datasets were prioritized and consolidated into a single overall "flood quilt" for the entire region. **Table 2.2** summarizes the flood hazard datasets evaluated in this study as well as their priority order in the final existing conditions flood quilt. These datasets are also described in further detail later in this section. Existing condition flood hazard areas identified as part of this analysis are shown in **Map Exhibit 4** ("Existing Condition Flood Hazard").

The final consolidated existing conditions flood hazard spatial files are included in a GIS geodatabase format along with the RFP. Existing condition flood hazard areas are contained in a single feature class ("ExFldHazard") which includes flood hazard areas for both 1% and 0.2% annual chance events. In cases of overlapping floodplain sources during consolidation, the flood frequency attribute field ("FLOOD_FREQ") was populated using the highest intensity storm event of the overlapping layers.

Any existing levees or dams in the region that do not meet FEMA accreditation, such as unaccredited levees in El Paso County, were excluded from the baseline flood hazard analysis and addressed separately in *Chapter 4 (Flood Mitigation Solutions)*.

Table 2.2 Existing Conditions Flood Hazard Datasets and Priorities

Flood Hazard Data Source	Description	Priority Order (1 – Highest)	
		El Paso County	Outside El Paso County
National Flood Hazard Layer Preliminary Data	Detailed mapping of flood hazards for 1% and 0.2% annual chance events subject to public review and finalization. Available in El Paso County only.	1	n/a
Base Level Engineering (BLE) Floodplain	Watershed-scale modeling and mapping using automated methods. Available in El Paso County only (but mostly superseded by NFHL Preliminary Data).	n/a	n/a
National Flood Hazard Layer Approximate Effective Data	Approximate studies (Flood Zone A) on the effective FIRM map. Available in Ector and Val Verde Counties only.	n/a	1
First American Flood Data Services (FAFDS)	Digitized flood hazard information from previously published FIRMs and FISs.	n/a	2
Cursory Floodplain (Fathom)	Regionwide flood hazard dataset developed using 3-meter resolution fluvial and pluvial models by Fathom	2 (Fort Bliss only)	3

To supplement the available flood hazard datasets, community feedback was requested to identify any other potential flood prone areas that may not be captured by existing mapping. These flood prone areas were collected throughout the planning process during in-person public meetings and through an online form and map survey. Additional information pertaining to the data collection and public input process is provided in *Chapter 9 (Public Participation and Plan Adoption)*.

National Flood Hazard Layer (NFHL) Preliminary Data

The NFHL is used by FEMA to represent the regulatory floodplains for the National Flood Insurance Program (NFIP). This layer includes flood hazard maps for the 1% and 0.2% annual chance storm events, as well as other lower intensity storm events. When the NFHL is updated, preliminary NFHL datasets are issued for public review and awareness of the proposed change. Preliminary datasets include both detailed and approximate flood study data and typically represent the best available information for their study area.

The FEMA El Paso County Mapping Study was issued as preliminary on July 8, 2020, and is intended to revise the existing FIS for El Paso County. The latest available floodplains from the Preliminary study were used as the top priority floodplain layer for El Paso County in the RFP existing conditions flood quilt.

The Preliminary study was divided into 11 watershed areas, shown in **Figure 2.1**, with a selection of streams to received detailed studies. All portions of the study, with the exception of the Horizon Arroyo (Stream 2), were developed using 2D hydraulic modeling and detailed terrain data to better represent the physical characteristics of the county. As of June 2022, the preliminary models are being adjusted to address public comments submitted during the appeal process, and revised preliminary draft floodplains are anticipated to be issued for public review in late fall of 2022. No current timeline is available for the new floodplain maps to become effective.

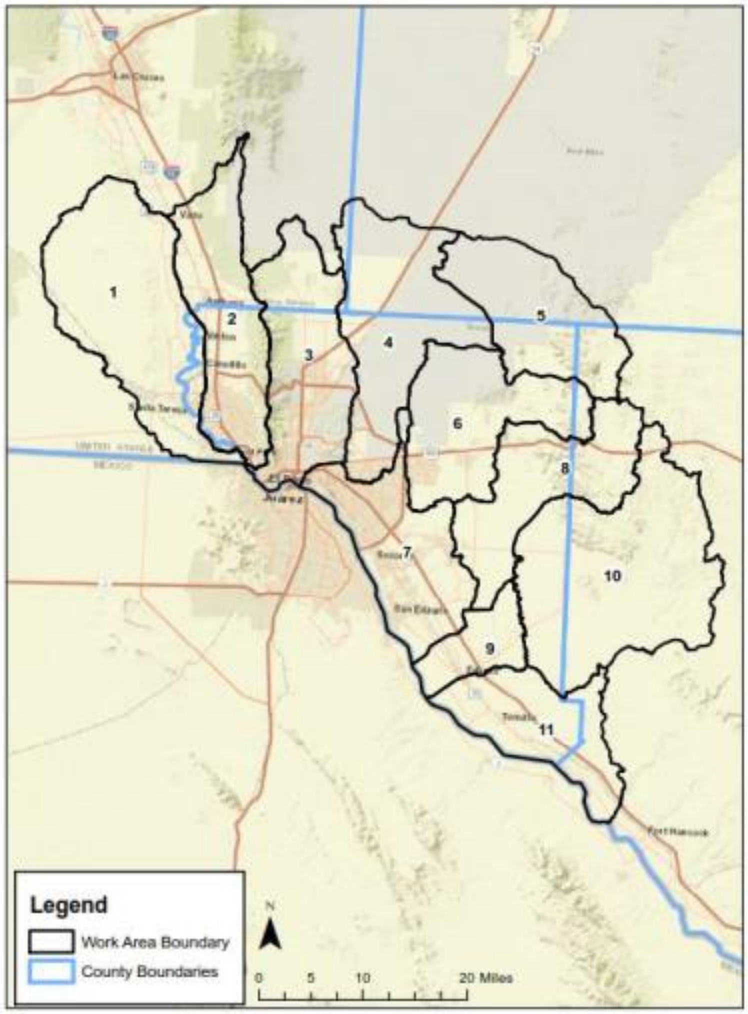


Figure 2.1 FEMA El Paso County Mapping Study Watershed Area Boundaries

Base Level Engineering (BLE) Floodplain

BLE floodplains are developed using automated methods for watershed-scale modeling and mapping. BLE floodplains were developed for El Paso County in 2016 for the FEMA Region IV RiskMAP Program and have since largely been superseded by the recent 2019 Preliminary FEMA El Paso County Mapping Study.

Fort Bliss in El Paso County is one exception to this, as the area is not covered in the 2019 Preliminary Mapping dataset, even though it is covered in the earlier BLE floodplains dataset. However, in this area, the Cursory Floodplain (Fathom) dataset was used to fill data gaps in the RFP existing conditions flood quilt and was selected over the BLE data because it is more conservative than the BLE data overall and overlaps with more than 95% of the buildings shown to be at-risk of flooding in the BLE layer. For this reason, and since the BLE floodplain is superseded by the Preliminary datasets for the rest of El Paso County, the BLE floodplain dataset was not used in developing the RFP existing conditions flood quilt.

National Flood Hazard Layer (NFHL) Approximate Effective Data

The effective NFHL contains current regulatory floodplains and includes both detailed and approximate flood study data. Two locations in the Upper Rio Grande Region have available NFHL Approximate floodplain data, including Val Verde County (with an effective floodplain date of July 22, 2010) and Ector County (with an effective floodplain date of March 15, 2012). These floodplains were used as the top priority floodplains in the RFP existing conditions flood quilt for both counties, replacing the lesser priority First American Flood Data Services (FAFDS) floodplain layer.

First American Flood Data Services (FAFDS) Floodplain

The FAFDS floodplain layer contains digitized flood hazard information from previously published FIRMs and FISs and is not available for viewing in the NFHL. While FAFDS floodplains are typically old and potentially outdated, they make up a large component of the available floodplain data in the Upper Rio Grande Region.

Due to the limited availability of more recent floodplain data across the region, FAFDS floodplains were utilized as the top priority floodplains in the RFP existing conditions flood quilt for 11 counties, including the Counties of Brewster, Crockett, Culberson, Edwards, Hudspeth, Jeff Davis, Midland, Presidio, Sutton, Terrell, and Ward. Effective map dates of these FAFDS floodplains are listed in **Table 2.3** by county.

Table 2.3 FAFDS Effective Map Dates by County

County	FAFDS Effective Map Date
Brewster	10/15/1985
Crockett	4/1/2004
Culberson	11/1/1985
Edwards	2/19/1982
Hudspeth	11/1/1985
Jeff Davis	7/18/1985
Midland	12/6/1999
Presidio	7/3/1985
Sutton	9/1/1987
Terrell	9/1/1987
Ward	10/23/1977-10/25/1977

FAFDS floodplains were not utilized for El Paso, Val Verde, or Ector Counties, where more recent floodplain data are available, or for the other nine counties where FAFDS floodplains are unavailable, including the Counties of Andrews, Schleicher, Pecos, Reagan, Upton, Crane, Loving, Reeves, and Winkler. Floodplains for these latter counties were populated in the RFP existing conditions flood quilt using the Cursory Floodplain (Fathom) dataset only.

Cursory Floodplain (Fathom)

The Cursory Floodplain dataset was developed for the TWDB by Fathom, consisting of both pluvial and fluvial floodplains. Both pluvial and fluvial floodplains were produced using 30-meter resolution models and mapped to a 3-meter resolution for the entire state of Texas. The dataset incorporates NOAA Atlas 14 rainfall data in all areas of the state and includes an estimation of flood hazards for the 20%, 10%, 1%, and 0.2% annual chance events.

At the request of the TWDB, the datasets were post-processed by Fathom to remove fluvial and pluvial cells with depths less than 0.5 feet. The Fathom datasets were provided by TWDB to each region in raster format. The datasets associated with the Upper Rio Grande Region were then processed for the RFP in accordance with additional TWDB post-processing specifications. The final post-processed Fathom floodplain layer was used in union with other available data to fill data gaps for the entire Upper Rio Grande Region outside of El Paso County and for Fort Bliss inside El Paso County.

While the Fathom dataset is useful at filling flood hazard data gaps, it also has several limitations as indicated in the TWDB Fathom dataset documentation (TWDB 2021)[1]:

- Cursory flood data may not appropriately depict flood risk associated with:
  - Constructed features that may alter flow patterns (roadways, railroads, urban areas, storm drainage systems, dams, levees, embankments, etc.)
  - Natural features that may not be fully represented in the 30-meter model (alluvial fans, sinkholes, small tributaries, waterbodies, areas of immediate topographic change, etc.)
  - Border areas along the Texas state boundary
- Limitations exist above bodies of water where underwater bathymetry might alter flood depths.
- Cursory flood depths were developed using a high-level statewide assessment and should be used as approximations of flood risk.

As a result of these limitations, the Fathom dataset was used as the lowest priority floodplain in the RFP existing conditions flood quilt for all parts of the region. However, in the case of nine counties where FAFDS floodplains were unavailable (including the Counties of Andrews, Schleicher, Pecos, Reagan, Upton, Crane, Loving, Reeves, and Winkler), the Fathom dataset was used as the primary floodplain dataset.

For additional insight, Aqua Strategies performed an evaluation for the Upper Rio Grande Region comparing a draft version of the Fathom dataset (developed using a 30-meter mapping resolution) with 1D-derived floodplain maps in the region. The comparison found reasonable similarities between the two sets of floodplains. This memorandum is provided for reference in Appendix 2C.

[1] Texas Water Development Board. Cursory Floodplain Data 3m Technical Documentation, October 2021. Accessed at https://twdb.maps.arcgis.com/sharing/rest/content/items/a59cbeae4a754cee9f38b17459521629/data

2.2.2 Existing Flood Hazard Data Gaps

While recent flood hazard mapping information is available for El Paso County, Ector County, and Val Verde County, the availability of recent flood hazard data across the rest of the region is much more limited. For the other areas outside of these three counties, as described in the previous section, the existing conditions flood hazard layer utilized a combination of digitized flood hazard areas from the FAFDS dataset (dating between 1977 and 2004) and the Cursory Floodplain Fathom dataset (with its previously-stated limitations).

As a result, two types of existing condition flood hazard data gaps were identified across the region based on data availability and reliability. The first type of data gap includes counties which do not have a broad coverage of available FAFDS information or any other available flood hazard data apart from the Fathom dataset. It also includes counties with limited FAFDS coverage (e.g., for small areas within selected municipalities) that do not have broad countywide coverage of flood hazard data. This first group is made up of five counties with no FAFDS coverage (including the Counties of Andrews, Crane, Loving, Reagan, and Schleicher) and four counties with limited FAFDS coverage (including the Counties of Pecos, Reeves, Upton, and Winkler).

The second type of data gap includes counties which do have broad coverage of FAFDS information in addition to the Fathom dataset but are in need of updated flood hazard information due to the age of the FAFDS floodplains. This second group is made up of 11 counties, including the Counties of Brewster, Crockett, Culberson, Edwards, Hudspeth, Jeff Davis, Midland, Presidio, Sutton, Terrell, and Ward.

Existing flood hazard data gaps, along with the public-provided flood prone areas, are shown in **Map Exhibit 5** ("Existing Condition Flood Hazard – Gaps in Inundation Boundary Mapping and Identify Known Flood-Prone Areas").

2.2.3 Existing Flood Exposure

Based on the identified existing conditions flood hazard areas, a high-level existing flood exposure analysis was performed to identify who or what might be harmed within the region for the 1% and 0.2% annual chance flood events. The exposure analysis evaluated potential flood impacts to population, property, critical facilities, public infrastructure, roadways, and agricultural resources.

This section describes the exposure analysis methodologies for each flood risk type. Existing conditions flood exposure results are summarized at the regionwide level in **Table 2.4**, by county in **Figure 2.2**, and by flood risk type in **Figure 2.3**. In addition, detailed results are provided in **Appendix Table 2A** and illustrated at the regionwide level in **Map Exhibit 6** ("Existing Condition Flood Exposure")**.**

Table 2.4 Existing Flood Exposure Summary

Exposure Type	Number of features		
	1% AC	0.2% AC*	Possible Flood Prone Areas
Floodplain Area (sq. mi.)	9,285	1,755	99
Structures (#)	40,121	14,290	8,426
Population (#)	115,530	47,985	35,740
Critical Facilities (#)	95	41	23
Roadway Segments (mi.)	3,047	746	178
Roadway Stream Crossings (#)	3,943	189	31
Agricultural Areas (sq. mi.)	615	135	21

*0.2% AC flood exposure results are reported separately from the 1% AC results and do not include cumulative flood hazard areas or property impacts from 1% AC flood hazard areas.

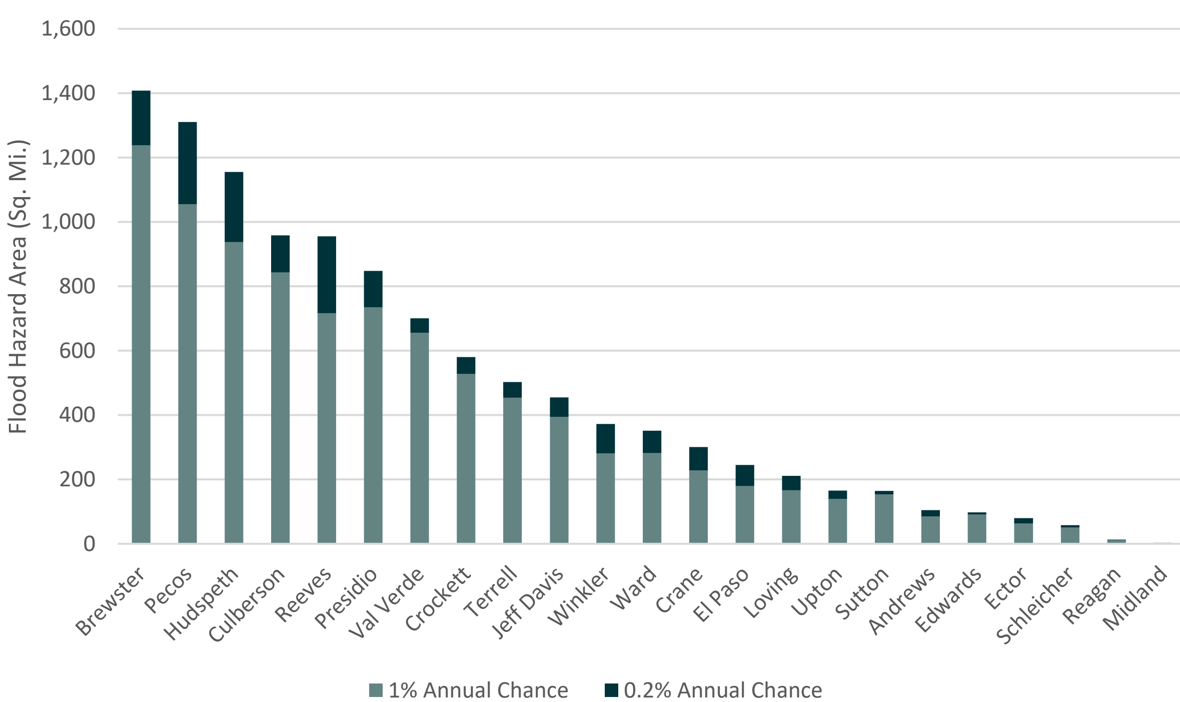


Figure 2.2 Total Existing Condition Flood Hazard Area by County

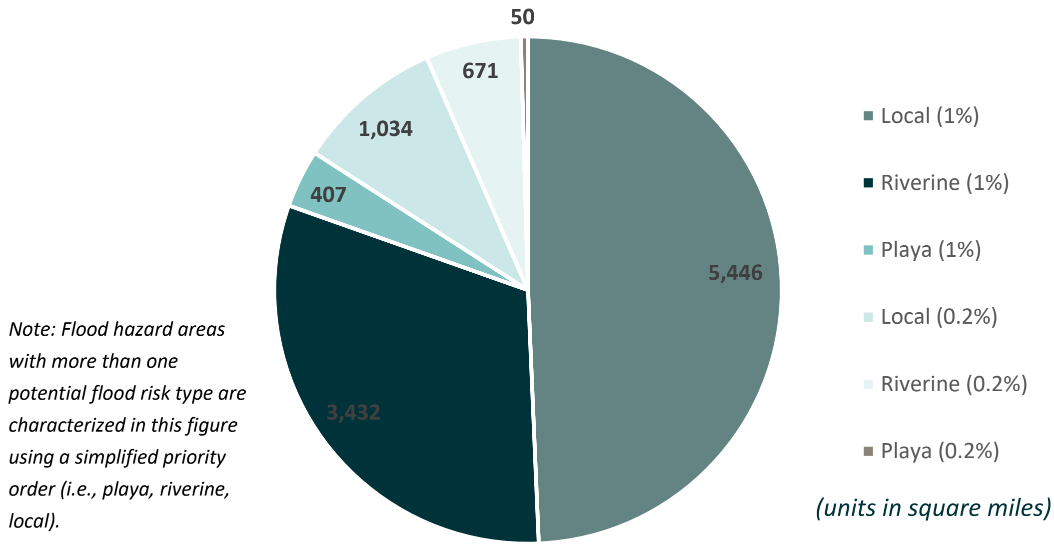


Figure 2.3 Total Existing Condition Flood Hazard Area by Flood Risk Type

2.2.3.1 Population and Property

To estimate potential flood impacts to population and property, the "Texas Buildings with SVI and Estimated Population" dataset was used as developed by the TWDB and the Texas Natural Resources Information System (TNRIS).[2] This dataset contains building footprints across the region from multiple sources including Microsoft Buildings and Stratmap LiDAR as well as various building attributes for use in the exposure analysis including land use types (residential, non-residential, vacant, etc.), daytime and nighttime population estimates, and social vulnerability index (SVI) data.

Flood impacts to building property were estimated by intersecting the building footprints with the existing conditions 1% and 0.2% annual chance event flood hazard areas. Building impacts were summarized separately for residential and non-residential building types based on the land use types populated in the source buildings dataset.

Flood impacts to population were estimated based on the building population estimates. Building populations in the source buildings dataset were derived from the ORNL LandScan dataset, which uses available data and satellite imagery to capture ambient daytime and nighttime activity and estimate associated populations. Due to the typical movement of population during the day, an area's nighttime population estimates will typically match more closely to the total census-derived population compared to its daytime population estimates.

[2] Texas Water Development Board. Texas Buildings with SVI and Estimated Population (November 2021). Accessed from https://twdb-flood-planning-resources-twdb.hub.arcgis.com/pages/buildings-nov2021

In comparing the LandScan nighttime population estimates to the TWDB 2021 Regional Water Plan and 2020 Decennial Census population estimates, the LandScan nighttime population estimates were found to be significantly lower. In addition, due to limitations in the LandScan data from the TWDB buildings dataset, several buildings across the region were noted as having a zero population values for both daytime and nighttime populations. To correct for this (and to better match the LandScan population estimates with the population estimates from the TWDB 2021 Regional Water Plan and 2020 Decennial Census), a nighttime population of three people was added to all zero-population buildings. At a regionwide level, this method resulted in a close population match between the building populations and the previous population estimates, with the total building populations matching within 1% of the TWDB 2021 Regional Water Plan populations and within 6% of the 2020 Census data.

Once the building populations were adjusted, estimated population impacts were summarized by county for buildings in the existing condition flood hazard areas. Population impacts were initially summarized separately for daytime and nighttime populations, and the maximum of the two values was used as the total estimated population for the county.

2.2.3.2 Critical Facilities and Public Infrastructure

To identify potential flood risks to critical facilities and public infrastructure across the region, the following datasets were reviewed and obtained for the region:

- *Homeland Infrastructure Foundation-Level Data (HIFLD)* – an open-source dataset distributed by the U.S. Department of Homeland Security to support nationwide community preparedness, resiliency, and research. Layers are sourced from the Oak Ridge National Laboratory (ORNL), the United States Geological Survey (USGS), the National Geospatial-Intelligence Agency (NGA) Homeland Security Infrastructure Program (HSIP) Team, and the United States Environmental Protection Agency (EPA), among other sources. Several critical facilities layers were reviewed from the HIFLD dataset including:
  - EPA Facility Registry Service (FRS) Power Plants
  - Ferrous and Nonferrous Metal Processing Plants
  - Fire Stations
  - Hospitals
  - Police Departments/Local Law Enforcement Locations (Law Enf)
  - National Shelter System Facilities (including libraries, schools, civic centers, churches, and other large public facilities)
  - Natural Gas Processing Plants (NGPP)
  - Nursing Homes
  - Power Plants and Power Stations
- *National Pollutant Discharge Elimination System (NPDES) Database* – a dataset developed by the U.S. Environmental Protection Agency (EPA) with the locations of Wastewater Treatment Facilities/Plants (WWTF/WWTP) and Water Treatment

Facilities/Plants (WTF/WTP). Original points in the source database are typically located at discharge locations along creeks rather than at the facilities. To correct for this issue in the flood exposure analysis, the wastewater and water treatment plant points were manually reviewed and updated across the region using aerial imagery. Other facility locations were identified by EPWater and by manual review using Google Maps. Wastewater treatment plant points were also compared with EPA FRS Wastewater Treatment Plants data from the HIFLD dataset.

- *Texas Schools Database (2019-2020)* – developed by the Texas Education Agency (TEA) with the locations of public schools including Elementary Schools (EL), Middle Schools (MIDDLE), and High Schools (H S). Original points in the source database are located by street address rather than by physical building location. To correct for this issue in the flood exposure analysis, school locations were manually reviewed and verified across the region. In cases where there were multiple buildings on a school property partially inundated by the floodplain, the school point was moved to correspond to one or more of the buildings located in the floodplain.
- National Transportation Atlas Database (NTAD) – a public dataset distributed by the U.S. Department of Transportation (USDOT). The following layers were reviewed from this dataset:
    - Intermodal Freight Facility
    - Intermodal Transit Facility (including passenger transportation terminals such as intercity bus stations, rail transit stations, and other terminals)

Critical facilities and infrastructure features are populated in the accompanying RFP GIS geodatabase in the feature class (“ExFldExpPol”) including at-risk features for both 1% and 0.2% annual chance flood events. Critical facilities are discussed in additional detail in the following Section 2.2.4 (Existing Vulnerability).

2.2.3.3 Roadway Crossings and Segments

Potential roadway flood impacts were estimated using existing conditions flood hazard areas as well as detailed hydraulic analyses from previous studies. Both roadway crossings and roadway segments (i.e., roadways not crossing the stream centerline) were included in the flood exposure analysis. Additional details related to the stream crossings datasets used in this analysis are provided in Chapter 1 Section 1.7.1 (Stream Crossings).

Where possible, stream crossing flood exposure information was first identified using detailed hydraulic analyses from previous studies. Different studies define roadway flood risk in different ways. In the TxDOT Bridges Dataset, the Bridge Waterway Adequacy Classifications attribute defines flood risk in terms of overtopping potential, while the FM170 dataset defines risk in terms of level of service (the point at which the roadway is not overtopped). While the two classifications are similar, the variations in nomenclature have subtle implications for flood exposure analyses. For instance, a bridge that has an overtopping potential between 3-10 years may be flooded by a 10% annual chance event, while another bridge that has a 10-year level of service may not be flooded by the 10% annual chance event.

Based on this approach, the relationships shown in **Table 2.5** were developed to match flood frequency values to overtopping potential values (from the TxDOT Bridges Dataset) and level of service values (from the FM170 dataset). According to the TWDB "Exhibit D: Data Submittal Guidelines for Regional Flood Planning" document, valid entries for flood frequencies include the 10%, 4%, 1%, and 0.2% annual chance events.

Table 2.5 Roadway Crossing Flood Frequency Relationships

TxDOT Bridges Dataset	
Overtopping Potential (recurrence interval in years)	Flood Frequency (% Annual Chance)
<3	10
3-10	10
11-100	1
>100	0.2

FM170 Roadway Crossings	
Level of Service (recurrence interval in years)	Flood Frequency (% Annual Chance)
<5-yr	10
5-yr	10
10-yr	4
25-yr	1
50-yr	1
100-yr	0.2

Once the flood frequency relationships were developed, flood frequencies were populated for crossings that were included in these hydraulic studies based on their defined overtopping potential or level of service.

Next, roadway crossings that originated from the TNRIS Statewide Low Water Crossing Inventory were assumed to be overtopped by flood events of lower intensity than the 10% annual chance event (such as the 5-year or 20% annual chance event) based on information provided in the dataset's supporting documentation.

Lastly, for roadway crossings that were not populated with flood frequency values by either of the previous methods, flood frequencies were estimated using flood depths from the Fathom Cursory Floodplain dataset. Using this method, flood frequencies were identified for each roadway crossing based on the lowest intensity (highest frequency) overtopping flood event.

Additionally, exposed roadway segments were identified by intersecting roadway segments from the TxDOT Roadway Inventory dataset with the existing conditions flood hazard areas. For this regionwide analysis, roadway segmentation rules were preserved from the source TxDOT dataset, so that a single roadway segment flooded in multiple locations would count as a single flooded segment.

2.2.3.4 Agricultural Area and Value of Crops

Potential flood risks to agricultural areas were estimated by comparing existing conditions flood hazard areas with different crop areas as identified by USDA Cropscape data. Estimated crop impacts were summarized in terms of impacted crop acreage by county as well as by the estimated crop yield and crop production value. Esri ArcMap was used to intersect the spatial Cropscape data layer with both the 1% annual chance and the 0.2% annual chance floodplains to estimate the number of agricultural acres that could potentially be impacted as a result of the two storm events. This information was summarized by county and is provided in **Table 2.6**.

Additional details regarding the assumptions and datasets used in this analysis are provided in the regionwide summary located in *Chapter 1 Section 1.4 (Agricultural Resources)*.

Table 2.6 Study Area Crop Acreage by County

County	Crop Acreage in the 1% Annual Chance Floodplain	Crop Acreage in the 0.2% Annual Chance Floodplain
Andrews	11,637	14,757
Brewster	27,234	31,244
Crane	1,680	2,281
Crockett	4,205	4,608
Culberson	20,544	22,980
Ector	266	339
Edwards	210	220
El Paso	38,830	48,552
Hudspeth	157,199	195,945
Jeff Davis	33,773	39,480
Loving	2,710	3,586
Midland	3	3
Pecos	30,393	37,174
Presidio	28,584	34,076
Reagan	9	10
Reeves	11,524	17,005
Schleicher	2,426	3,082
Sutton	1,120	1,187
Terrell	1,688	1,900
Upton	937	1,027
Val Verde	14,342	14,902
Ward	2,503	3,263
Winkler	1,627	2,091
Total	**393,444**	**479,710**

Esri ArcMap was also used to estimate the acres, by crop, potentially impacted in the 1% and 0.2% annual chance floodplains. This information is provided in **Table 2.7** (sorted by acreage in the 1% annual chance floodplain). The major crops (by acreage) within the 1% annual chance floodplain in the Rio Grande region are grassland/pasture, cotton, alfalfa, and pecans.

Table 2.7 Summary of Crops in Study Area

Crop	Crop Acreage in the 1% Annual Chance Floodplain	Crop Acreage in the 0.2% Annual Chance Floodplain
Grassland/Pasture	288,639	359,938
Cotton	27,229	30,679

Crop	Crop Acreage in the 1% Annual Chance Floodplain	Crop Acreage in the 0.2% Annual Chance Floodplain
Fallow/Idle	20,646	23,299
Alfalfa	18,826	21,306
Pecans	14,132	15,282
Winter Wheat	9,110	11,640
Oats	4,765	5,322
Sorghum	2,760	3,464
Rye	1,577	2,156
Dbl Crop WinWht/Cotton	1,041	1,241
Other Hay/Non Alfalfa	894	1,140
Grapes	726	730
Peppers	667	668
Corn	626	707
Triticale	375	427
Dbl Crop WinWht/Sorghum	360	448
Watermelons	338	424
Peanuts	239	287
Barley	199	208
Onions	136	154
Pumpkins	85	99
Dbl Crop WinWht/Corn	29	36
Peas	17	20
Sod/Grass Seed	10	10
Dbl Crop Triticale/Corn	8	12
Rice	2	2
Soybeans	2	3
Millet	2	6
Herbs	1	1
Other Tree Crops	1	1
Dbl Crop WinWht/Soybeans	0	0
Durum Wheat	0	0
Sunflower	0	0
Sugarcane	0	0
Total	**393,444**	**479,710**
Total (excluding Fallow/Idle)	**372,798**	**456,411**

The four crops (excluding grasslands and fallow/idle land) with the highest acreage within the 1% annual chance floodplain for each of the study area counties are shown in **Table 2.8**. In addition, because of the prevalence of grasslands in the study area, the table includes grasslands as a separate column. **Table 2.9** presents the same information for crops located in the 0.2% annual chance floodplain.

Table 2.8 Acres of Cropland for Major Crops in the 1% AC Floodplain by County

County	Top Crop Impacts (with Impacted Acres), 1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Andrews	Cotton (153)	Winter Wheat (34)	Winter Wheat/Cotton (17)	Barley (3)	(11,390)
Brewster	Cotton (202)	Winter Wheat (85)	Alfalfa (57)	Sorghum (34)	(26,577)
Crane	Winter Wheat (77)	Cotton (35)	Pecans (18)	Sorghum (16)	(1,496)
Crockett	Winter Wheat (116)	Cotton (56)	Sorghum (17)	Triticale (11)	(3,960)
Culberson	Cotton (2,449)	Pecans (1,266)	Alfalfa (332)	Winter Wheat (254)	(8,843)
Ector	Cotton (8)	Winter Wheat (7)	Peanuts (2)	Alfalfa (1)	(246)
Edwards	Winter Wheat (63)	Sorghum (14)	Oats (12)	Corn (12)	(58)
El Paso	Cotton (13,565)	Pecans (11,390)	Alfalfa (847)	Corn (227)	(11,712)
Hudspeth	Alfalfa (13,464)	Cotton (5,957)	Oats (2,901)	Grapes (724)	(122,031)
Jeff Davis	Cotton (23)	Alfalfa (22)	Sorghum (6)	Corn (5)	(33,689)
Loving	Cotton (67)	Winter Wheat (63)	Other Hay/Non Alfalfa (2)	Winter Wheat/Sorghum (1)	(2,569)
Midland	Cotton (2)	Winter Wheat/Cotton (1)	(--)	(--)	(--)
Pecos	Winter Wheat (4,823)	Alfalfa (2,573)	Cotton (1,978)	Oats (1,312)	(14,817)
Presidio	Cotton (248)	Winter Wheat (189)	Sorghum (104)	Alfalfa (92)	(27,741)
Reagan	Cotton (3)	Sorghum (1)	(--)	(--)	(4)
Reeves	Winter Wheat (1,553)	Alfalfa (1,285)	Winter Wheat/Cotton (605)	Cotton (585)	(4,710)
Schleicher	Cotton (1,122)	Sorghum (457)	Winter Wheat (380)	Oats (97)	(14)
Sutton	Winter Wheat (648)	Cotton (70)	Sorghum (59)	Other Hay/Non Alfalfa (26)	(31)
Terrell	Cotton (53)	Winter Wheat (43)	Triticale (8)	Sorghum (7)	(1,530)
Upton	Winter Wheat (142)	Cotton (54)	Winter Wheat/Cotton (31)	Sorghum (23)	(245)
Val Verde	Oats (132)	Cotton (95)	Winter Wheat (57)	Sorghum (48)	(13,870)
Ward	Winter Wheat (93)	Sorghum (55)	Cotton (54)	Alfalfa (34)	(2,144)

County	Top Crop Impacts (with Impacted Acres), 1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Winkler	Cotton (444)	Alfalfa (73)	Winter Wheat (46)	Peanuts (42)	(961)

Table 2.9 Acres of Cropland for Major Crops in the 0.2% AC Floodplain by County

County	Top Crop Impacts (with Impacted Acres), 0.2% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Andrews	Cotton (192)	Winter Wheat (44)	Winter Wheat/Cotton (21)	Barley (5)	(14,441)
Brewster	Cotton (214)	Winter Wheat (90)	Alfalfa (60)	Sorghum (35)	(30,547)
Crane	Winter Wheat (81)	Cotton (47)	Pecans (21)	Sorghum (20)	(2,067)
Crockett	Winter Wheat (131)	Cotton (63)	Sorghum (18)	Triticale (12)	(4,333)
Culberson	Cotton (2,720)	Pecans (1,292)	Alfalfa (346)	Winter Wheat (266)	(10,760)
Ector	Cotton (9)	Winter Wheat (7)	Peanuts (2)	Alfalfa (1)	(316)
Edwards	Winter Wheat (66)	Sorghum (14)	Oats (13)	Corn (12)	(61)
El Paso	Cotton (14,633)	Pecans (12,145)	Alfalfa (886)	Corn (230)	(19,501)
Hudspeth	Alfalfa (13,717)	Cotton (6,693)	Oats (2,938)	Grapes (727)	(158,217)
Jeff Davis	Cotton (25)	Alfalfa (22)	Sorghum (6)	Corn (6)	(39,389)
Loving	Cotton (78)	Winter Wheat (78)	Other Hay/Non Alfalfa (3)	Winter Wheat/Sorghum (2)	(3,415)
Midland	Cotton (2)	Winter Wheat/Cotton (1)	(--)	(--)	(--)
Pecos	Winter Wheat (6,302)	Alfalfa (3,585)	Cotton (2,454)	Oats (1,730)	(16,831)
Presidio	Cotton (253)	Winter Wheat (207)	Sorghum (105)	Alfalfa (92)	(33,206)
Reagan	Cotton (3)	Sorghum (1)	(--)	(--)	(5)
Reeves	Winter Wheat (2,266)	Alfalfa (2,352)	Winter Wheat/Cotton (765)	Cotton (914)	(6,561)
Schleicher	Cotton (1,484)	Sorghum (541)	Winter Wheat (466)	Oats (128)	(18)
Sutton	Winter Wheat (675)	Cotton (75)	Sorghum (62)	Other Hay/Non Alfalfa (29)	(34)

County	Top Crop Impacts (with Impacted Acres), 0.2% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Terrell	Cotton (58)	Winter Wheat (44)	Triticale (8)	Sorghum (7)	(1,728)
Upton	Winter Wheat (157)	Cotton (60)	Winter Wheat/Cotton (34)	Sorghum (24)	(259)
Val Verde	Oats (133)	Cotton (100)	Winter Wheat (59)	Sorghum (50)	(14,407)
Ward	Winter Wheat (175)	Sorghum (156)	Cotton (62)	Alfalfa (52)	(2,610)
Winkler	Cotton (537)	Alfalfa (140)	Winter Wheat (61)	Peanuts (45)	(1,232)

To estimate the potential value of the agricultural resources within the 1% annual chance floodplain, the total acreage of each crop in the floodplain was multiplied by the average yield and by the normalized price per unit (as presented in Chapter 1). The estimated value for the major crops within the study area's 1% annual chance floodplain is approximately $148 million as shown in **Table 2.10**.

Table 2.10 Estimated Value of Top Agricultural Impacts

Crop	Number of Acres (1% AC)	Value of Major Crops (1% AC)*
Alfalfa	18,826	$21,247,000
Cotton	27,229	$16,691,000
Grassland	288,639	$84,860,000
Oats	4,765	$944,000
Pecans	14,132	$18,513,000
Sorghum	2,760	$3,682,000
Winter Wheat	9,110	$2,191,000
TOTAL		**$148,128,000**

* Values rounded to nearest thousand dollars

The estimated value for each of the four crops with the largest acreage (excluding grasslands and fallow/idle land) in the 1% annual chance floodplain for each county is shown in **Table 2.11**. In addition, the table includes grasslands as a separate column. **Table 2.12** presents the same information for crops located in the 0.2% annual chance floodplain.

Table 2.13 summarizes the damages by county for the major crop types for the 1% and 0.2% annual chance floodplains. Due to uncertainties related to flood damages to grasslands (as discussed in Chapter 1), this table includes estimated damages with and without grassland damages.

Table 2.11 Estimated Value of Crop Production for Major Crops in the 1% Annual Chance Floodplain by County

County	Top Crop Impacts by Acreage (with Estimated Damages), 0.1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Andrews	Cotton ($94,000)	Winter Wheat ($8,000)	Winter Wheat/Cotton ($4,000/$10,000)	Barley ($1,000)	($3,349,000)
Brewster	Cotton ($124,000)	Winter Wheat ($20,000)	Alfalfa ($65,000)	Sorghum ($20,000)	($7,814,000)
Crane	Winter Wheat ($19,000)	Cotton ($22,000)	Pecans ($24,000)	Sorghum ($10,000)	($440,000)
Crockett	Winter Wheat ($28,000)	Cotton ($34,000)	Sorghum ($10,000)	Triticale* ($2,000)	($1,164,000)
Culberson	Cotton ($1,501,000)	Pecans ($1,659,000)	Alfalfa ($374,000)	Winter Wheat ($61,000)	($2,600,000)
Ector	Cotton ($5,000)	Winter Wheat ($2,000)	Peanuts ($1,000)	Alfalfa ($2,000)	($72,000)
Edwards	Winter Wheat ($15,000)	Sorghum ($18,000)	Oats ($2,000)	Corn ($9,000)	($17,000)
El Paso	Cotton ($8,315,000)	Pecans ($14,921,000)	Alfalfa ($956,000)	Corn ($174,000)	($3,443,000)
Hudspeth	Alfalfa ($15,195,000)	Cotton ($3,652,000)	Oats ($574,000)	Grapes ($4,425,000)	($35,877,000)
Jeff Davis	Cotton ($14,000)	Alfalfa ($24,000)	Sorghum ($3,000)	Corn ($4,000)	($9,904,000)
Loving	Cotton ($41,000)	Winter Wheat ($15,000)	Other Hay/Non Alfalfas ($1,000)	Winter Wheat/Sorghum (--)/($1,000)	($755,000)
Midland	Cotton ($1,000)	(--)	(--)	(--)	(--)
Pecos	Winter Wheat ($1,160,000)	Alfalfa ($2,904,000)	Cotton ($1,213,000)	Oats ($260,000)	($4,356,000)
Presidio	Cotton ($152,000)	Winter Wheat ($46,000)	Sorghum ($63,000)	Alfalfa ($104,000)	($8,156,000)
Reagan	Cotton ($2,000)	Sorghum ($1,000)	(--)	(--)	($1,000)
Reeves	Winter Wheat ($374,000)	Alfalfa ($1,450,000)	Winter Wheat/Cotton ($145,000/$371,000)	Cotton ($358,000)	($1,385,000)
Schleicher	Cotton ($688,000)	Sorghum ($610,000)	Winter Wheat ($91,000)	Oats ($19,000)	($4,000)
Sutton	Winter Wheat ($156,000)	Cotton ($43,000)	Sorghum ($79,000)	Other Hay/Non Alfalfas ($8,000)	($9,000)
Terrell	Cotton ($33,000)	Winter Wheat ($10,000)	Triticale* ($2,000)	Sorghum ($4,000)	($450,000)
Upton	Winter Wheat ($34,000)	Cotton ($33,000)	Winter Wheat/Cotton ($8,000/$19,000)	Sorghum ($14,000)	($72,000)
Val Verde	Oats ($26,000)	Cotton ($58,000)	Winter Wheat ($14,000)	Sorghum ($29,000)	($4,078,000)

County	Top Crop Impacts by Acreage (with Estimated Damages), 0.1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Ward	Winter Wheat ($22,000)	Sorghum ($73,000)	Cotton ($33,000)	Alfalfa ($38,000)	($630,000)
Winkler	Cotton ($272,000)	Alfalfa ($82,000)	Winter Wheat ($11,000)	Peanuts ($48,000)	($283,000)

*Note: Triticale was calculated using Rye yield/price figures from USDA, as they did not exist for Triticale

Table 2.12 Estimated Value of Crop Production for Major Crops in the 0.2% Annual Chance Floodplain by County

County	Top Crop Impacts by Acreage (with Estimated Damages), 0.1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Andrews	Cotton ($117,000)	Winter Wheat ($11,000)	Winter Wheat/Cotton ($5,000/$13,000)	Barley ($2,000)	($4,246,000)
Brewster	Cotton ($131,000)	Winter Wheat ($22,000)	Alfalfa ($68,000)	Sorghum ($21,000)	($8,981,000)
Crane	Winter Wheat ($20,000)	Cotton ($29,000)	Pecans ($27,000)	Sorghum ($12,000)	($608,000)
Crockett	Winter Wheat ($32,000)	Cotton ($38,000)	Sorghum ($11,000)	Triticale* ($3,000)	($1,274,000)
Culberson	Cotton ($1,667,000)	Pecans ($1,692,000)	Alfalfa ($391,000)	Winter Wheat ($64,000)	($3,163,000)
Ector	Cotton ($6,000)	Winter Wheat ($2,000)	Peanuts ($2,000)	Alfalfa ($2,000)	($93,000)
Edwards	Winter Wheat ($16,000)	Sorghum ($9,000)	Oats ($2,000)	Corn ($10,000)	($18,000)
El Paso	Cotton ($8,970,000)	Pecans ($15,910,000)	Alfalfa ($1,000,000)	Corn ($177,000)	($5,733,000)
Hudspeth	Alfalfa ($15,481,000)	Cotton ($4,103,000)	Oats ($582,000)	Grapes ($4,446,000)	($46,516,000)
Jeff Davis	Cotton ($15,000)	Alfalfa ($25,000)	Sorghum ($4,000)	Corn ($4,000)	($11,580,000)
Loving	Cotton ($48,000)	Winter Wheat ($19,000)	Other Hay/Non Alfalfa ($1,000)	Winter Wheat/ Sorghum (--)/($1,000)	($1,004,000)
Midland	Cotton ($1,000)	(--)	(--)	(--)	(--)
Pecos	Winter Wheat ($1,516,000)	Alfalfa ($4,047,000)	Cotton ($1,504,000)	Oats ($343,000)	($4,948,000)
Presidio	Cotton ($155,000)	Winter Wheat ($50,000)	Sorghum ($63,000)	Alfalfa ($104,000)	($9,763,000)
Reagan	Cotton ($2,000)	Sorghum ($1,000)	(--)	(--)	($1,000)
Reeves	Winter Wheat ($545,000)	Alfalfa ($2,655,000)	Winter Wheat/Cotton ($184,000/$469,000)	Cotton ($560,000)	($1,929,000)
Schleicher	Cotton ($910,000)	Sorghum ($325,000)	Winter Wheat ($112,000)	Oats ($25,000)	($5,000)

County	Top Crop Impacts by Acreage (with Estimated Damages), 0.1% Annual Chance Floodplain				
	Primary Crop	Secondary Crop	Tertiary Crop	Quaternary Crop	Grasslands/Pasture
Sutton	Winter Wheat ($162,000)	Cotton ($46,000)	Sorghum ($37,000)	Other Hay/Non Alfalfa ($8,000)	($10,000)
Terrell	Cotton ($36,000)	Winter Wheat ($11,000)	Triticale* ($2,000)	Sorghum ($4,000)	($508,000)
Upton	Winter Wheat ($38,000)	Cotton ($36,000)	Winter Wheat/Cotton ($8,000/$21,000)	Sorghum ($15,000)	($76,000)
Val Verde	Oats ($26,000)	Cotton ($62,000)	Winter Wheat ($14,000)	Sorghum ($30,000)	($4,236,000)
Ward	Winter Wheat ($42,000)	Sorghum ($94,000)	Cotton ($38,000)	Alfalfa ($59,000)	($767,000)
Winkler	Cotton ($329,000)	Alfalfa ($158,000)	Winter Wheat ($15,000)	Peanuts ($52,000)	($362,000)

Table 2.13 Summary of Crop Production for the 1% and 0.2% AC Floodplain by County

County	1% Annual Chance Crop Damages		0.2% Annual Chance Crop Damages	
	With Grasslands	Without Grasslands	With Grasslands	Without Grasslands
Andrews	$3,459,000	$110,000	$4,385,000	$139,000
Brewster	$8,043,000	$229,000	$9,223,000	$242,000
Crane	$515,000	$75,000	$696,000	$88,000
Crockett	$1,238,000	$74,000	$1,358,000	$84,000
Culberson	$6,195,000	$3,595,000	$6,977,000	$3,814,000
Ector	$82,000	$10,000	$105,000	$12,000
Edwards	$61,000	$44,000	$55,000	$37,000
El Paso	$27,809,000	$24,366,000	$31,790,000	$26,057,000
Hudspeth	$59,723,000	$23,846,000	$71,128,000	$24,612,000
Jeff Davis	$9,949,000	$45,000	$11,628,000	$48,000
Loving	$813,000	$58,000	$1,073,000	$69,000
Midland	$1,000	$1,000	$1,000	$1,000
Pecos	$9,893,000	$5,537,000	$12,358,000	$7,410,000
Presidio	$8,521,000	$365,000	$10,135,000	$372,000
Reagan	$4,000	$3,000	$4,000	$3,000
Reeves	$3,825,000	$2,440,000	$6,015,500	$4,086,500
Schleicher	$1,412,000	$1,408,000	$1,377,000	$1,372,000

County	1% Annual Chance Crop Damages		0.2% Annual Chance Crop Damages	
	With Grasslands	Without Grasslands	With Grasslands	Without Grasslands
Sutton	$295,000	$286,000	$263,000	$253,000
Terrell	$499,000	$49,000	$561,000	$53,000
Upton	$166,500	$94,500	$179,500	$103,500
Val Verde	$4,205,000	$127,000	$4,368,000	$132,000
Ward	$796,000	$166,000	$1,000,000	$233,000
Winkler	$696,000	$413,000	$916,000	$554,000

2.2.4 Existing Vulnerability

Based on the results of the existing conditions flood risk identification and exposure analyses, an existing condition vulnerability analysis was performed to identify the level of resilience or vulnerabilities related to communities, critical facilities, and critical transportation routes.

The social vulnerability index (SVI) is developed by the Centers for Disease Control and Prevention (CDC) to indicate the relative vulnerability of every U.S. Census tract. The SVI ranks tracts on 15 social factors based on survey data collected by the U.S. Census, including poverty, income, employment, minority status, disability, housing status, and other variables. SVI values are calculated as a percentage, scaled as a decimal fraction between 0-1, with higher values indicating higher levels of vulnerability.

While building footprints from TNRIS Buildings Dataset had previously been assigned SVI values, these values were verified using the complete 2018 SVI dataset obtained from the CDC website.

Another indicator of community vulnerabilities is the colonia, a substandard housing development where residents may lack basic services such as drinking water, sewage treatment, and paved roads. Colonias are found in relatively high concentration along the Texas-Mexico border, and the Office of the Attorney General of Texas maintains a database of colonias locations used to help identify and assist vulnerable populations. Within the Upper Rio Grande Region, 338 colonias were identified with a majority located in the Counties of El Paso, Pecos, Presidio, Hudspeth, and Val Verde.

Table 2.14 shows the relative vulnerability of communities across the region, including incorporated and unincorporated communities, based on the number of structures in the 1% and 0.2% annual chance floodplains (unincorporated communities are also referred to as Census Designated Places or CDPs). In addition, the table provides two specific indicators of vulnerability, including the number of buildings in each community that are within colonias as well as the average SVI value of buildings in the floodplain. The top five communities by number of structures within colonias in the 1% annual chance floodplain were found to be the City of Socorro, the City of San Elizario, Canutillo, Sanderson, and the Town of Clint. The top five communities by average SVI of buildings in the floodplain were found to be Fabens, Redford, the City of Presidio, the City of San Elizario, and the Town of Van Horn. Five counties (Culberson, El Paso, Hudspeth, Presidio, and Reeves) contain areas with high SVI values (greater than 0.75).

In addition to summarizing SVI values by community, average building SVI values were summarized by county and reported as part of the existing conditions flood exposure results in **Appendix Table 2A**. An overview of regionwide existing condition vulnerability results is provided in **Map Exhibit 7** ("Existing Condition Flood Vulnerability including Critical Infrastructure"). Detailed maps of communities with more than 100 buildings in the floodplain are also provided as part of **Map Exhibit 15** ("Greatest Flood Risk") included with *Chapter 4.1 (Flood Mitigation Needs Analysis).*

Apart from direct flood risks to communities, flood risks to critical facilities and infrastructure also increase overall community vulnerabilities based on the potential for cascading negative impacts from loss of function during a flood. **Table 2.15** summarizes the potential vulnerabilities of critical facilities for the existing conditions 1% and 0.2% annual chance flood events by county. In addition, Section 2.4 provides qualitative descriptions of the expected loss of function for various critical facility types in the region.

Furthermore, flood risks along critical transportation routes lead to increased community vulnerabilities due to the potential for a community to become isolated during a flood from emergency services, such as police and fire departments or hospital, ambulance, and rescue services. Since the rate and urgency of emergency incidents is likely to increase during a flood event, reduced roadway access may be especially detrimental to community emergency response efforts. To identify critical routes across the region, roadways were categorized according to their TxDOT roadway classification, and the top 10% of roadways by annual average daily traffic (AADT) from each category were selected as critical routes. In addition to this analysis, major roadways appearing on commonly-used region-wide base maps were also considered to be critical routes. Critical routes with potential flood exposure were then identified as potential vulnerabilities. **Table 2.16** summarizes the potential vulnerabilities of critical routes for the existing conditions 1% and 0.2% annual chance flood events by county.

Table 2.14 Summary of Existing Conditions Vulnerability – Community Property Impacts

	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		
Place Name	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Average SVI of Structures in Floodplain*
Acala CDP	**3**	**3**	**5**	**3**	**0.932**
Agua Dulce CDP	**7**	**7**	**7**	**7**	**0.915**
Alpine city	1,643	0	1,837	0	0.574
Amistad CDP	11	11	11	11	0.549
Anthony town	**86**	**0**	**125**	**0**	**0.923**

Place Name	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		Average SVI of Structures in Floodplain*
	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	
Balmorhea city	361	0	361	0	0.357
Barstow city	149	0	249	0	0.520
Box Canyon CDP	27	21	27	21	0.549
Butterfield CDP	**12**	**7**	**23**	**15**	**0.784**
Canutillo CDP	**676**	**298**	**683**	**302**	**0.759**
Clint town	**249**	**249**	**268**	**268**	**0.753**
Crane city	143	0	181	0	0.560
Dell City city	**293**	**0**	**293**	**0**	**0.932**
El Paso city	12,324	39	18,480	39	0.678
Fabens CDP	**200**	**12**	**528**	**12**	**0.980**
Fort Bliss CDP	1,145	0	1,836	0	0.344
Fort Davis CDP	131	0	163	0	0.408
Fort Hancock CDP	**54**	**29**	**92**	**39**	**0.932**
Fort Stockton city	168	0	316	1	0.586
Grandfalls town	71	0	227	0	0.520
Homestead Meadows North CDP	359	246	562	377	0.747
Homestead Meadows South CDP	8	0	14	0	0.519
Horizon City city	11	0	11	0	0.518
Imperial CDP	272	246	276	246	0.329
Iraan city	83	82	101	100	0.329
Kermit city	1,126	0	1,979	0	0.594
Lake View CDP	9	9	12	12	0.549
Lindsay CDP	**189**	**189**	**194**	**194**	**0.825**
Marathon CDP	89	85	117	109	0.512
Marfa city	**212**	**0**	**350**	**0**	**0.913**
McCamey city	172	0	437	0	0.658
Mentone CDP	2	0	11	0	0.502
Monahans city	440	0	802	0	0.683
Morning Glory CDP	**1**	**0**	**1**	**0**	**0.930**
Ozona CDP	944	0	1,046	0	0.608
Pecos city	1,944	7	2,798	7	0.587
Prado Verde CDP	112	57	112	57	0.095

Place Name	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		Average SVI of Structures in Floodplain*
	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	
Presidio city	**655**	**0**	**674**	**0**	**0.951**
Pyote town	15	0	24	0	0.520
Rankin city	74	0	82	0	0.426
Redford CDP	**15**	**6**	**19**	**9**	**0.951**
San Elizario city	**544**	**421**	**544**	**421**	**0.938**
Sanderson CDP	258	258	313	313	0.453
Sheffield CDP	2	0	4	0	0.329
Sierra Blanca CDP	**36**	**36**	**38**	**38**	**0.932**
Socorro city	**2,578**	**1,228**	**3,106**	**1,630**	**0.919**
Sonora city	690	0	827	0	0.651
Southwest Sandhill CDP	794	0	1,005	0	0.520
Sparks CDP	7	4	21	17	0.695
Study Butte CDP	23	19	26	22	0.512
Terlingua CDP	4	3	4	3	0.512
Thorntonville town	195	0	333	0	0.520
Tornillo CDP	**49**	**43**	**214**	**199**	**0.930**
Toyah town	**101**	**101**	**101**	**101**	**0.825**
Valentine town	16	16	18	18	0.408
Van Horn town	**170**	**159**	**227**	**215**	**0.935**
Vinton village	**73**	**0**	**119**	**1**	**0.870**
Westway CDP	**36**	**34**	**63**	**60**	**0.785**
Wickett town	23	0	31	0	0.520
Wink city	23	0	41	0	0.544
All Other Colonias (outside boundaries of incorporated place or CDP)	-	1,818	-	2,026	-

*0.2% AC flood vulnerability results include cumulative property impacts from 1% AC flood hazard areas.

Communities in **bold have a high SVI (over 0.75)

Table 2.15 Summary of Existing Conditions Vulnerability – Critical Facilities

County	Potential Existing Conditions Critical Facilities Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Andrews	• None identified	• None identified
Brewster	• EPA NPDES: CITY OF ALPINE MUNICIPAL WWTF • HIFLD Law Enf: ALPINE POLICE DEPARTMENT • HIFLD Law Enf: BREWSTER COUNTY SHERIFFS OFFICE • Hospital: BIG BEND REGIONAL MEDICAL CENTER • School: ALPINE EL • School: ALPINE H S • School: ALPINE MIDDLE	• Same as 1% Annual Chance
Crane	• National Shelter System Facility: Crane County Library	• HIFLD Law Enf: CRANE COUNTY SHERIFFS OFFICE / CRANE COUNTY JAIL • HIFLD NGPP: CORDONA LAKE GAS PLANT
Crockett	• EPA NPDES: MAIN WWTF • HIFLD NGPP: NELEH GAS SYSTEM • HIFLD NGPP: SOUTHWEST OZONA GAS PLANT • HIFLD NGPP: TIPPETT GAS PLANT • Intermodal Transit Facility: Caprock Diesel • National Shelter System Facility: Ozona Convention Center • School: OZONA EL • School: OZONA MIDDLE	• Same as 1% Annual Chance
Culberson	• None identified	• None identified
Ector	• None identified	• None identified
Edwards	• None identified	• None identified
El Paso	• EPA NPDES: CANUTILLO ISD WWTP • EPA NPDES: TORNILLO WWTF • Fire Station: El Paso Fire Department Station 9 • Fire Station: West Valley Fire Department Canutillo Station • Google: Bonnie Moorhouse Reverse Osmosis Water Treatment Facility • HIFLD Nursing Homes: ADAM MC CARE LLC • HIFLD Nursing Homes: VILLAS DEL SOL ASSISTED LIVING LLC • HIFLD: FORT BLISS (DEA EPIC) • Hospital: UNIVERSITY MEDICAL CENTER OF EL PASO • Intermodal Freight Facility, RAIL & TRUCK: EL PASO TERMINAL WAREHOUSES, INC.-EL PASO-TX • Intermodal Freight Facility, RAIL & TRUCK: SWIG COTTON-EL PASO-TX • National Shelter System Facility: DAACG • National Shelter System Facility: Nations Tobin Recreation Center • National Shelter System Facility: WELLINGTON CHEW SENIOR CENTER • School: CANUTILLO MIDDLE • School: CHAPIN H S • School: CLINT H S	• EPA NPDES: HORIZON REGIONAL MUD - HORIZON CITY WWTP • Fire Station: El Paso Fire Department Station 26 • Fire Station: El Paso Fire Department Station 31 • Fire Station: Montana Vista Fire Rescue Station 2 • Fire Station: West Valley Fire Department Anthony Station • HIFLD Nursing Homes: GOOD SAMARITAN SOCIETY--WHITE ACRES • HIFLD Nursing Homes: LA FAMILIA ASSISTING LIVING • HIFLD Nursing Homes: THE FOREST ASSISTED LIVING • HIFLD: HOOVER COMPANY • National Shelter System Facility: DON HASKINS REC CENTER • School: ANDRESS H S • School: CONSTANCE HULBERT EL • School: CROSBY EL • School: DAVINCI SCHOOL FOR SCIENCE AND THE ARTS • School: DOWELL EL

County	Potential Existing Conditions Critical Facilities Vulnerabilities	
	1% Annual Chance	0.2% Annual Chance
	• School: CLINT ISD EARLY COLLEGE ACADEMY • School: COOLEY EL • School: EL PASO ACADEMY WEST • School: EL PASO LEADERSHIP ACADEMY • School: HAWKINS EL • School: HENDERSON MIDDLE • School: JOSE H DAMIAN EL • School: LEE EL/National Shelter System Facility • School: MILAM EL • School: NEWMAN EL • School: RED SANDS EL • School: ROBBIN E L WASHINGTON EL • School: SAN ELIZARIO H S/National Shelter System Facility • School: STANTON EL • School: TEJAS SCHOOL OF CHOICE • School: THE LINGUISTIC ACAD OF EL PASO-CULTURAL DEMO SITE • School: WESTERN HILLS EL • School: WM DAVID SURRATT EL • School: YSLETA PK CENTER • School: ZACH WHITE EL	• School: H D HILLEY EL • School: H R MOYE EL • School: HORNEDO MIDDLE • School: LE BARRON PARK EL • School: MAGOFFIN MIDDLE/National Shelter System Facility • School: MARIAN MANOR EL • School: NORTH LOOP EL • School: RAMONA EL • School: TORNILLO EL
Hudspeth	• Fire Station: Hueco Volunteer Fire Department • School: DELL CITY SCHOOL	• Same as 1% Annual Chance
Jeff Davis	• EPA NPDES: FORT DAVIS WWTF	• Same as 1% Annual Chance
Loving	• HIFLD NGPP: PECOS RIVER PLANT	• Same as 1% Annual Chance
Midland	• None identified	• None identified
Pecos	• EPA FRS: CENTURY GAS PLANT • Fire Station: Imperial Fire Department • HIFLD NGPP: WAHA GAS PLANT • HIFLD: EAST PECOS SOLAR • Hospital: PECOS COUNTY MEMORIAL HOSPITAL • School: BUENA VISTA SCHOOL • School: FORT STOCKTON ALAMO EL • School: IRAAN J H • School: LYNAUGH UNIT	• EPA FRS: WAHA GAS PLANT • HIFLD NGPP: MITCHELL PLANT • HIFLD: ALAMO 6 • School: FORT STOCKTON HIGH
Presidio	• None identified	• School: PRESIDIO H S
Reagan	• None identified	• None identified
Reeves	• EPA NPDES: ORLA WWTP • Fire Station: Balmorhea Volunteer Fire Department • Fire Station: Toyah Volunteer Fire Department • HIFLD Law Enf: PECOS POLICE DEPARTMENT • HIFLD NGPP: EAST TOYAH GAS PLANT • National Shelter System Facility: Civic Center in Balmorhea • National Shelter System Facility: Community Center in Pecos City	• School: CROCKETT MIDDLE • School: PECOS H S

County	Potential Existing Conditions Critical Facilities Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
	• National Shelter System Facility: First Baptist Church - Balmorhea • School: AUSTIN EL • School: BALMORHEA SCHOOL/National Shelter System Facility	
Schleicher	• None identified	• None identified
Sutton	• EPA FRS: CITY OF SONORA • Fire Station: Border Line Volunteer Fire Department • HIFLD NGPP: SONORA GAS PLANT • Intermodal Transit Facility: Picos Food Mart • National Shelter System Facility: SUTTON COUNTY CIVIC CENTER	• HIFLD Law Enf: SONORA POLICE DEPARTMENT
Terrell	• Fire Station: Terrell County Volunteer Fire Department • Intermodal Transit Facility: Amtrak Station	• Same as 1% Annual Chance
Upton	• Fire Station: McCamey Volunteer Fire Department • HIFLD: CASTLE GAP SOLAR • HIFLD: UPTON COUNTY SOLAR	• Hospital: MCCAMEY HOSPITAL • School: MCCAMEY PRI
Val Verde	• None identified	• None identified
Ward	• Fire Station: Grandfalls Volunteer Fire Department • HIFLD NGPP: BONE SPRINGS GAS PROCESSING PLANT • HIFLD NGPP: MIVIDA JV PROCESSING PLANT • School: MONAHANS H S	• HIFLD Nursing Homes: MONAHANS MANAGED CARE CENTER • School: GRANDFALLS-ROYALTY SCHOOL • School: SUDDERTH EL
Winkler	• EPA FRS: EL PASO NATURAL GAS - KEYSTONE COMPRESSOR STATION • HIFLD Law Enf: WINKLER COUNTY SHERIFFS OFFICE / WINKLER COUNTY JAIL • HIFLD NGPP: HALLEY PLANT • Hospital: WINKLER COUNTY MEMORIAL HOSPITAL	• School: KERMIT EL • School: WINK EL

Table 2.16 Summary of Existing Conditions Vulnerability – Critical Routes

pe	Existing Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Andrews	• SW 900 Rd, resulting in access issues to South FM 181. • West Hwy 128 resulting in access issues.	• Includes existing condition 1% vulnerabilities. • SW 900 Rd, resulting in significant access issues to South FM 181. • West Hwy 128 resulting in significant access issues.
Brewster	• US67, Connection between Marfa and Alpine resulting in access issue to Alpine city, therefore access issues to the nearest hospital Big Bend Regional Medical Center. • N 5TH St. access issue to the Big Bend Regional Medical Center • SH-118, connection between Fort Davis and Alpine resulting in access issue. • Segments of US90 and intersection with US 385, resulting in access issues. • North US385, resulting in access issues, connection with Pecos County. • Roadway US67, connection from Alpine to Chancellor, resulting in access issues.	• Includes existing condition 1% vulnerabilities. • US67, Connection between Marfa and Alpine resulting in significant access issue to Alpine city, therefore access issues to the nearest hospital Big Bend Regional Medical Center. • Roadway US67, connection from Alpine to Chancellor, resulting in significant access issues. • Segments of US90 and intersection with US 385, resulting in significant access issues. • US385, connection between Marathon and Fort Stockton, resulting in significant access issue.
Crane	• Golf Course Rd, at intersection with US Highway 385 N resulting in access issues. • E 20 ST at intersection with US Highway 385 resulting in access issues. • US Highway 67, connection between Girvin Town and McCamey Town resulting in access issues.	• Includes existing condition 1% vulnerabilities. • US Highway 67, connection between Girvin Town and McCamey Town resulting in significant access issues. • Golf Course Rd, at intersection with US Highway 385 N resulting in significant access issues.
Crockett	• State Highway 163 S. Intersection with FM 1973. Resulting in access issues. The connection between Ozona city and Juno town. • Segments of IH10 resulting in access problems all along Crocket County. Main connector Route. • Segments of W US Highway 190, resulting in access problems. Connection between Iraan city and Crocket County. Possible problems accessing the nearest hospital: Iraan General Hospital.	• Includes existing condition 1% vulnerabilities. • State Highway 163 S. Intersection with FM 1973. Resulting in significant access issues. The connection between Ozona city and Juno town. • Segments of W US Highway 190, resulting in significant access problems. Connection between Iraan city and Crocket County. Possible problems accessing the nearest hospital: Iraan General Hospital. • Segments of IH10 resulting in significant access problems all along Crocket County. Main connector Route.
Culberson	• US90 Resulting in potential access issue, Connection Lobo to Van Horn. Access issue to Culberson Hospital located at Van Horn. • IH10 Resulting in Potential access issue. Connection between Hudspeth and Culberson Counties and possible access issue for Town of Van Horn. • Segments of East IH10 resulting in potential access issues. The connection between Van Horn and Kent may also be at risk leading to possible access issues for the nearest hospital, Culberson Hospital.	• Includes existing condition 1% vulnerabilities. • US180, Resulting in potential access issue between Pine Springs and Nickel Creek Station.

pe	Existing Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Ector	• County Rd 307, near White Horse Tank area, possible access issues. • IH20, Judkins area with possible access issues. • Penwell Town, Avenue A, Avenue B and Avenue J with possible access issues. • In Pleasant Farms town, Roads: W Ivory St., Thomas Blvd. and segments of US 385. Resulting in possible access issues.	• Includes existing condition 1% vulnerabilities. • Segments of County Rd 307, resulting in possible access issues. • Blockline Rd. Intersection with County Rd 307. Resulting in access issues. • IH20, Judkins area with significant access issues.
Edwards	• S US Highway 277, Connection between Sonora city and Loma Alta town resulting in access issues. • Segments of S IS Highway 377 along the county, resulting in possible access issues. Significant issues at Connection between Carta Valley town and N US Highway 277.	• Includes existing condition 1% vulnerabilities. • S US Highway 277, Connection between Sonora city and Loma Alta town resulting in significant access issues. • Segments of S IS Highway 377 along the county, resulting in significant access issues
El Paso	• Fabens Rd., intersection with IH10, resulting in potential access issue to the IH10. • West Spur 601, resulting in a potential access issue to the US 54. • East Spur 601, resulting in a potential access issue to Loop 375. • Pierce Ave, and Louisiana Ave. resulting in potential access issues to the El Paso VA Health Care System. • IH10 and US54 intersection, Durazno Ave, potential access issue to Hospitals, EP Children's Hospital, EP Psychiatric Center, and University Medical Center of El Paso.	• All Existing 1% data. • West Spur 601, and US 54 intersection, resulting in potential access issue to the nearest Hospital, El Paso VA Health Care System, critical. • Montana Ave. SH180 connection of El Paso County to Hudspeth County, Butterfield area resulting in potential access issue. • Fabens neighborhood, resulting in access issue to the nearest Police department, El Paso County Sheriff's Office, Access issue to the roads: Fassett St. Davis St. NW 3RD ST. Avenue H. Eubanks St. NW 3RD St. and CC Camp Rd.
Hudspeth	• Segments of roadway US62-180 may result in potential access issues between El Paso and Hudspeth County and Culberson County. • Segments of IH10 may result in potential access issues between El Paso/Hudspeth and Culberson/Hudspeth.	• This includes the Existing 1% • Hueco Ranch Rd. may result in potential access issues to the US62-180. • Segments of roadway US62-180 may result in potential access issues between El Paso and Hudspeth County and Culberson County. • Segments of IH10 may result in potential access issues between El Paso/Hudspeth and Culberson/Hudspeth.
Jeff Davis	• SH-118, the connection between Kent and Jeff Davis, resulting in access issues. • SH-118, the connection between Jeff Davis and Fort Davis, resulting in access issues. • SH-17, the connection between Fort Davis and Reeves County, resulting in access issues. • SH-118, the connection between Fort Davis and Alpine (Brewster County). • Roadway US90, the connection between Valentine and Culberson County, resulting in access issues.	• Includes existing condition 1% vulnerabilities. • SH-118, the connection between Kent and Jeff Davis, resulting in significant access issues. • SH-118, the connection between Jeff Davis and Fort Davis, resulting in significant access issues. • SH-17, the connection between Fort Davis and Reeves County, resulting in significant access issues. • SH-118, the connection between Fort Davis and Alpine (Brewster County), resulting in significant access issues. • SH-17, the connection between Marfa and Fort Davis, resulting in access issues.

pe	Existing Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Loving	• County Road 2 Intersection with RM 652, resulting in access issues. • West portion of RM 652, resulting in access issues to Orla in Reeves County. • South County Road 22 intersection with County Road 2, resulting in access issues to Loving County Sheriff's office. • Roadway 302 in intersection with County Rd. 200 (Metor Rd) resulting in access issues to Mentone.	• Includes existing condition 1% vulnerabilities. • South Portion of Road 302, resulting in access issues to US Hwy 285. • North County Road 2 resulting in significant access issues to RM652. • West portion of RM 652, resulting in significant access issues to Orla in Reeves County • South County Road 22 intersection with County Road 2, resulting in significant access issues to Loving County Sheriff's office.
Midland	• None identified	• None identified
Pecos	• Segments of US Highway 385 N, resulting in access issues. Connection between Fort Stockton and McCamey. • Segments of the IH10, resulting in access issues along Pecos County. IH10 segments near Fort Stockton may cause problems accessing the Pecos County Memorial Hospital. • Segments of US Highway 385 S, resulting in access issues. Connection between Marathon and Fort Stockton. • Segments of US Highway 285 S, resulting in access issues. Connection between Fort Stockton and Sanderson.	• Includes existing condition 1% vulnerabilities. • Segments of US Highway 385 S, resulting in significant access issues. Connection between Marathon and Fort Stockton. • Segments of US Highway 285 S, resulting in significant access issues. Connection between Fort Stockton and Sanderson. • Segments of the IH10, resulting in significant access issues along Pecos County. IH10 segments near Fort Stockton may cause problems accessing the Pecos County Memorial Hospital • Segments of US Highway 385 N, resulting in significant access issues. Connection between Fort Stockton and McCamey. • Segments of N US Highway 285, resulting in significant access issues. Connection between Mann Town and Fort Stockton. Possible problems accessing Pecos County Memorial Hospital.
Presidio	• US67, Connection between Presidio and Marfa, resulting in access issues. • US90, Connection between Marfa and Alpine, resulting in access issues. • US67, Intersection with roadway 170, resulting in access issues to presidio city.	• Includes existing condition 1% vulnerabilities. • US67, Connection between Presidio and Marfa, resulting in significant access issues. • US90, Connection between Marfa and Alpine, resulting in significant access issues.
Reagan	• None identified	• None identified
Reeves	• North County Road 118 may result in access issues to Pecos area. Therefore, possible access issues to the Reeves County Hospital. • Segments of the IH10 in possible access issues. • Roads: County Road 2, S Pigman St., W Schmidt Dr., S Texas St., W Stafford BL, S Cactus St., and W County RD with possible access issues to the Reeves County Hospital. • Roads: W F St, and W E St. with possible access issues to Pecos.	• Includes existing condition 1% vulnerabilities. • North County Road 118 may result in significant access issues to Pecos area. Therefore, possible access issues to the Reeves County Hospital. • South Central US 285 with possible access issues at Pecos area. • Segments of the IH20 in possible access issues near Pecos. • Segments of the IH10 in significant access issues. • Segments of the State Highway 17 in possible access issues.
Schleicher	• None identified	• None identified

pe	Existing Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Sutton	• S US Highway 277, Connection between Sonora city and Loma Alta town resulting in access issues. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital. • Segments of IH10, resulting in access issues. Significant problems at Sonora city. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital. • N US Highway 277, Segments near Sonora city resulting in access issues. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital.	• Includes existing condition 1% vulnerabilities. • Segments of IH10, resulting in access issues. Significant problems at Sonora city. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital • S US Highway 277, Connection between Sonora city and Loma Alta town resulting in access issues. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital.
Terrell	• US Highway 90 W, resulting in access issues. Connection between Dryden and Emerson. • US 285, resulting in access issue. Connection between Sanderson and Fort Stockton. • SH-349, resulting in access issues. Connection between Dryden and Sheffield.	• Includes existing condition 1% vulnerabilities. • US Highway 90 W, resulting in significant access issues along the county. Connection between Emerson and Val Verde County. • US 285, resulting in significant access issue. Connection between Sanderson and Fort Stockton. • SH-349, resulting in significant access issues. Connection between Dryden and Sheffield.
Upton	• US Highway 67, resulting in access issues at Rankin Town. Therefore, possible problems accessing the Hospitals: Rankin County Hospital District and Rankin County Hospital District. • Rankin Town, Roads: Francis St., 3rd Ave., Main St., Upon St, and 4th St. resulting in access issues. Therefore, possible problems accessing the Hospitals: Rankin County Hospital District and Rankin County Hospital District. • County Road 410 at intersection with Highway 385 S resulting in access issues. • McCamey Town, Roads: 7th St., Houston Ave., 11TH St., 6th St. Bowie Ave., 8th St., 4th St., Emerson Ave. and Ellis Ave. resulting in access issues. Possible problems accessing the McCamey Hospital.	• Includes existing condition 1% vulnerabilities. • County Road 410 at intersection with Highway 385 S resulting in significant access issue. • McCamey Town, Roads: 9th St, 10th St, 2ND St, 6Th St, Eisenhower St., Emerson Ave. Patton St. 1st.ST. resulting in access issues. Possible problems accessing the McCamey Hospital. • US Highway 67, resulting in significant access issues at Rankin Town. Therefore, possible problems accessing the Hospitals: Rankin County Hospital District and Rankin County Hospital District.
Val Verde	• Roadway FM 163 resulting in access issues along the county. Connection between Comstock and Ozona. • N US Highway 277, resulting in access issues along the county. Connection between Val Verde County and Edwards County.	• Includes existing condition 1% vulnerabilities. • W US Highway 90, resulting in access issues along the county. • Roadway FM 163 resulting in significant access issues along the county. Connection between Comstock and Ozona. • N US Highway 277, resulting in significant access issues along the county. Connection between Val Verde County and Edwards County.
Ward	• IH20 Connection between Ward and Reeves County, with possible access issues. • Business Loop 20, connection between Ward and Reeves County, with possible access issues. • S County Road 170, with possible access issues to Business Loop 20.	• Includes existing condition 1% vulnerabilities. • RM-2355 and County Road 146 with significant access issues. • S County Road 170, with significant access issues to Business Loop 20. • IH20, Monahans city area with significant access issues.

pe	Existing Conditions Critical Route Vulnerabilities	
	1% Annual Chance	0.2% Annual Chance
	• RM-2355 and County Road 146 with possible access issues. • IH20, Monahans city area with possible access issues. • Roads: Colorado St., 15th, 36th, and 45th St. located at Monahans city, with possible access issues.	• County Road 427 with possible access issues. • N State Highway 18 with possible access issues to Monahans.
Winkler	• County Road 101 with possible access issues. Connection between Winkler and Bennett County. • S Roadway 115, with possible access issues. Connection between Wink and Pyote town. • S State Highway 18, with possible access issues. Connection between Kermit and Monahans town. • W TX-302 at intersection with State Highway 18, possible access issues at Kermit town. Therefore, possible access issues to Winkler County Memorial Hospital.	• Includes existing condition 1% vulnerabilities. • S State Highway 18, with significant access issues. Connection between Kermit and Monahans town. • County Road 404, resulting in access issues. Connection between Ector County and Winkler. • W TX-302, resulting in significant access issues to Kermit town. Therefore, possible access issues to Winkler County Memorial Hospital.

2.3 Future Conditions Analysis

Future condition flood hazard analyses were performed to determine the location and magnitude of both 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events under future conditions, accounting for future projections in land use and precipitation over the next 30 years.

Due to overall differences future trends as well as in data availability, different future conditions analysis methods were utilized for El Paso County and for the remainder of the Upper Rio Grande region outside of El Paso County. In El Paso County, future condition flood risk was estimated by developing new future condition 2D models with considerations for future land use and precipitation. Outside El Paso County, future condition flood risk was identified by estimating areas of future development and using the existing condition floodplains as a proxy for future condition floodplains within those areas. The following section describes the methodology and findings of these analyses.

2.3.1 Future Land Use and Development

According to population projections from the 2021 Regional Water Plan, the Upper Rio Grande Region is projected to grow in population between 2020-2050 by approximately 400,000, which is equivalent to a 38% increase over 30 years with an average annual growth rate of 1.08%. Three counties have major population centers located outside the region watershed boundaries and are excluded from this estimate, including Ector County (City of Odessa), Midland County (City of Midland), and Val Verde County (City of Del Rio). However, even when these population centers are included in the estimate, the projected region population growth rate remains generally unchanged over the same period. El Paso County is projected to see the highest future population growth compared to other counties in the region with an increase of approximately 370,000 by 2050 or 93% of the region's total growth.

El Paso County

To perform the future land use analysis for El Paso County, future population projection data were obtained from the El Paso Metropolitan Planning Organization (MPO) Regional Mobility Strategy (RMS) 2050 Metropolitan Transportation Plan (MTP). The RMS MTP provides existing (2017) and future (2050) population and employment estimates using more than 800 Traffic Analysis Zones (TAZs) throughout El Paso County, each ranging in size from 1 acre (for dense urban areas) to 158 square miles (for dispersed rural areas).

In order to develop future condition hydrologic models based on these future population projections, a statistical analysis was performed to correlate existing TAZ population densities with land use intensity classes from the National Land Cover Database (NLCD) land cover raster layer. The NLCD land cover layer was selected for this analysis, since the layer was previously used in the 2019 Preliminary FEMA study to estimate runoff curve numbers for the hydrologic model. The future condition analysis utilized a similar modified approach by estimating a future condition land cover layer with NLCD classes developed based on future population.

To perform the statistical correlation analysis, the 2016 NLCD Land Cover dataset was used to provide a reasonably close match compared to the existing 2017 population and employment estimates from the RMS MTP dataset. Referencing the 2016 NLCD Land Cover raster, polygons were delineated in GIS to identify representative NLCD class boundaries for “open space”, “low intensity”, “medium intensity”, and “high intensity” categories. Upon delineating these representative zones for the four NLCD class types, the 2017 TAZ population and employment densities were converted to rasters, and zonal histograms were created for each zone based on the gridded TAZ densities. Using this process, correlations were developed between the NLCD intensity class zones and the TAZ densities. Correlations were defined separately for population and employment, identifying lower and upper bounds for each. The results of the correlation analysis are presented in **Table 2.17**.

These existing condition correlations were then used to estimate future condition NLCD classes based on the future condition TAZ densities. Future condition NLCD classes were estimated for population and employment separately, and the higher of the two resulting NLCD classes was assigned to the future condition NLCD class layer. The future condition NLCD class layer was then converted to a raster, and the portion of the raster within the Franklin Mountains State Park was removed from the analysis to avoid counting population growth in that area.

Table 2.17 NLCD and TAZ Correlation Ranges for Population and Employment

NLCD Class	Population		Employment	
	Lower Bound TAZ Density, population per sq. mi.	Upper Bound TAZ Density, population per sq. mi.	Lower Bound TAZ Density, population per sq. mi.	Upper Bound TAZ Density, population per sq. mi.
Open Space	100	1000	10	100
Low Intensity	1,000	3,500	100	300
Medium Intensity	3,500	12,000	300	3,500
High Intensity	12,000	-	3,500	-

Lastly, the future condition NLCD class layer was converted to runoff curve numbers using the same methodology discussed in the 2019 Preliminary FEMA Hydrology Report. In some instances, the estimated future condition curve number values were found to be lower than existing condition curve numbers from the 2019 Preliminary FEMA study (indicating a lower amount of runoff in future conditions). Therefore, as a conservative measure, a mosaic dataset was developed combining the maximum values from the existing condition and future condition curve number raster datasets to create the final future condition curve number raster.

A weighted area analysis was performed using the future condition curve number raster to estimate future curve number values for each of the 11 previously defined watersheds (or “work areas”) from the 2019 Preliminary FEMA study. **Table 2.18** summarizes the final curve number values used for the future condition analysis (column #4), compared to curve numbers developed using the 2019 NLCD land cover dataset (column #1), the 2019 Preliminary FEMA study (column #2), and future condition NLCD class dataset without modifications (column #3).

Upon calculating the final future condition curve numbers for each work area, the 2019 Preliminary FEMA study hydrologic model parameters were updated with the new curve numbers for calculating the future condition flows.

Table 2.18 Future Runoff Curve Numbers (CN) for El Paso County

Work Area	Curve Number			
	#1 Existing Condition, NLCD (2019)	#2 Existing Condition, FEMA Preliminary Mapping (2019)	#3 Estimated Future Condition (2050)	#4 Estimated Future Condition (2050) Mosaic with FEMA CN*
WA 1	62	62	62	64
WA 2	77	77	79	80
WA 3	77	78	77	79
WA 4	64	65	64	66
WA 5	76	77	76	77
WA 6	69	69	73	73
WA 7	74	73	81	82
WA 8	74	75	75	76
WA 9	66	66	66	68
WA 10	76	79	76	79
WA 11	65	67	63	68

* The final future condition CN mosaic (#4) was developed by combining maximum raster cell values from the Existing Condition FEMA Preliminary Mapping (2019) CN raster (#2) and the Estimated Future Condition (2050) CN raster (#3).

Outside El Paso County

For the rest of the Upper Rio Grande Region outside of El Paso County, a simpler method was used to account for future land use changes. This method included identifying the potential limits of future development based on future county level population projections and then using the existing condition floodplains as a proxy for future condition floodplains within those areas.

To develop boundaries for the potential limits of future development, existing (2020) and future (2050) population estimates were obtained for each county in the region from the 2021 Regional Water Plan and the 2018 Texas Demographic Center population projection datasets. Using these two datasets, future population increases were calculated in terms of the percentage increase by 2050 for each county and for each population dataset as shown in **Table 2.19**. The maximum percent increase value from each dataset was used as the basis for creating a spatial buffer around existing developed areas to represent the limits of future development.

Spatial buffers were applied to existing development boundaries (incorporated and unincorporated area limits) by calculating the effective radius of each developed area (assuming a circular boundary) and scaling the effective radius by the percent future population growth rate of the area's applicable county. This process produced a buffer distance for the projected area of future development over the next 30 years.

Table 2.19 Future Population Projections (2020-2050) by County

County	Population Estimates						
	TWDB Regional Water Plan (2021)			Texas Demographic Center (2018)			Max % Increase by 2050
	2020	2050	% Increase by 2050	2020	2050	% Increase by 2050	
Andrews	19,089	30,111	58%	22,269	100,655	352%	352%
Brewster	9,727	10,334	6%	9,133	7,816	-14%	6%
Crane	5,056	6,737	33%	6,209	18,425	197%	197%
Crockett	4,111	4,486	9%	4,040	4,224	5%	9%
Culberson	2,695	3,173	18%	2,245	1,594	-29%	18%
Ector	164,289	233,048	42%	184,841	494,892	168%	168%
Edwards	2,123	2,123	0%	1,991	1,641	-18%	0%
El Paso	925,565	1,296,927	40%	876,120	1,046,847	19%	40%
Hudspeth	3,913	4,511	15%	3,400	2,399	-29%	15%
Jeff Davis	2,398	2,398	0%	2,113	1,458	-31%	0%
Loving	82	82	0%	92	77	-16%	0%
Midland	169,062	232,357	37%	187,364	573,981	206%	206%
Pecos	17,718	22,021	24%	16,533	17,112	4%	24%
Presidio	8,692	10,972	26%	5,906	2,662	-55%	26%
Reagan	3,853	4,812	25%	4,226	8,150	93%	93%
Reeves	15,125	17,650	17%	15,707	22,013	40%	40%
Schleicher	3,811	4,350	14%	3,312	3,858	16%	16%
Sutton	3,817	4,279	12%	4,381	4,229	-3%	12%
Terrell	1,045	1,069	2%	1,054	1,017	-4%	2%
Upton	3,690	4,272	16%	3,983	6,559	65%	65%
Val Verde	54,694	71,566	31%	48,253	41,593	-14%	31%
Ward	11,454	13,029	14%	13,592	33,350	145%	145%
Winkler	8,033	10,147	26%	9,295	23,364	151%	151%

Once the areas of potential future development were identified, existing condition floodplains from the Fathom dataset were used as a proxy for future condition floodplains within those areas. This process is described in further detail in Section 2.3.3.

2.3.2 Future Precipitation

Future precipitation trends are influenced by changes in climate. Future climate projections for the Southwest and Southern Great Plains have primarily projected decreases to total annual precipitation and increased drought risk.[3] On the other hand, future increases to atmospheric

[3] Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner, 2018: Our Changing Climate. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R.

temperatures have also been projected to increase the magnitude of extreme precipitation events throughout the U.S, as a result of increased atmospheric moisture carrying capacity.[4]

In addition to these projections, the Office of the Texas State Climatologist issued recommendations in April 2021 on accounting for future precipitation in Regional Flood Planning.[5] The analysis showed moderate trends of increasing rainfall near El Paso County based on trends in 100-year return values of 1-day precipitation amounts in NOAA Atlas 14 data. However, for the majority of the Upper Rio Grande region, results were inconclusive regarding future precipitation trends.

Furthermore, while increased rainfall is likely to result in increased runoff in urban areas where land cover is impervious, the Rio Grande and other rivers (which are primarily controlled by upstream dams) are less likely to see significantly increased flows during extreme precipitation events due to the influence of upstream controlling reservoirs.

Based on the recommendations from the Texas State Climatologist report, the future condition analysis for El Paso County was modified to include a 20% increase in precipitation. This amount corresponds to the report's high change scenario for urban watersheds in the 2050-2060 time horizon, whereas no changes were made along the Rio Grande due to the larger uncertainty of impacts for riverine watersheds.

For the rest of the Upper Rio Grande Region outside of El Paso County, no modifications were made to the future condition analysis to account for future precipitation. This is consistent with the inconclusive precipitation trends shown for a majority of the region east of El Paso County in the Texas State Climatologist report.

2.3.3 Future Flood Hazard Identification

The future conditions flood quilt was developed to include the future 1% and 0.2% annual chance events as described in the following section. Future condition flood hazard areas identified as part of this analysis are shown in **Map Exhibit 8** ("Future Condition Flood Hazard"). In addition, a comparison between the existing and future condition flood hazard areas is provided in Section 2.3.4.

El Paso County

Future conditions flood hazards were estimated for El Paso County by modifying the input parameters for the 2019 Preliminary FEMA models to account for future trends in land use and precipitation. Hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models for each of the 2019 Preliminary FEMA study work areas were obtained and updated based on the findings presented previously in Sections 2.3.1 and 2.3.2.

Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144. doi: 10.7930/NCA4.2018.CH2. Accessed at https://nca2018.globalchange.gov/chapter/2/

[4] Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017: Precipitation change in the United States. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 207-230, doi: 10.7930/J0H993CC. Accessed at https://science2017.globalchange.gov/chapter/7/

[5] Nielsen-Gammon, J., S. Jorgensen, 2021: Climate Change Recommendations for Regional Flood Planning. Department of Atmospheric Sciences, Texas A&M University. Accessed at https://climatexas.tamu.edu/files/CliChFlood.pdf

Updates to the hydrologic models included replacing the existing condition curve number inputs with future condition curve number inputs (to estimate future land use) and scaling the input rainfall by 20% (to estimate future precipitation increases).

After running the future condition hydrologic models for all work areas, the updated excess precipitation results were applied as inputs in the 2D hydraulic models. To account for interdependent work areas that share outflow and inflow boundary conditions, initial 2D simulations were performed to identify outflows greater than 1,000 cfs. In cases where flows from an upstream work area were found to have a significant impact on flows in a downstream work area, model inflows were updated for the downstream work area based on the outflows from the upstream work area.

Based on the results of the future condition 2D hydraulic analyses, future condition floodplains were mapped for all 11 work areas, covering El Paso County and the west part of Hudspeth County (corresponding to the HUC-8 watersheds 13040100 and 13030102). Whereas the 2019 Preliminary FEMA study did not include the area inside Fort Bliss, the area was included along with the rest of El Paso County in the future conditions results.

Future floodplain polygons for El Paso County were post-processed using 2D BLE Tools from a proprietary AECOM Hydraulics tool set. The tool delineates 1% and 0.2% flood hazard areas using stream centerlines and HEC-RAS outputs including water surface elevation and depth rasters. Floodplain polygons were delineated based on areas which have a depth of at least 1 foot and intersect the streamlines. Areas of isolated flooding disconnected from the stream centerline were removed during this process.

Finally, the future condition flood hazard areas were merged with the existing condition flood hazard areas ensuring that the future conditions flood hazard area is equal to or greater than the existing condition flood hazard area. This process also ensured that all flood hazard areas from the 2019 Preliminary FEMA study were included in the future conditions floodplain, since portions of the study were not delineated based on the 2D work area models but were instead delineated based on the results of other studies such as the Rio Grande Natural Valley Study.

Outside El Paso County

After estimating the limits of future development areas outside El Paso County (discussed in Section 2.3.1), proxy floodplains for these future development areas were selected by using the higher intensity *pluvial* floodplain from the existing conditions dataset as a proxy for future conditions. For example, within these areas, the 0.2% existing 3m Fathom pluvial floodplain was used as a proxy for the 1% future pluvial floodplain, while the 0.1% existing 30m Fathom floodplain [from an earlier July 2021 Draft Cursory version of the Fathom release] was used as a proxy for the 0.2% future pluvial floodplain. No changes were made to the fluvial floodplains during this process since, at the regionwide level, future development is estimated to impact localized runoff to a greater degree than watershed-scale riverine runoff.

For areas outside the limits of future development, future condition flood hazards were estimated to be equivalent to existing condition flood hazards without the need for a proxy floodplain. Due to the Upper Rio Grande region's size and remote nature, it was assumed there would be no significant changes in land use outside the limits of future development.

2.3.4 Extent of Increase of Future Flood Hazard Compared to Existing Condition

A comparison showing the extent of increase between the existing condition and future condition flood hazard areas is summarized in **Table 2.20** and illustrated in **Map Exhibit 10** (“Extent of Increase of Flood Hazard Compared to Existing Condition”).

As a result of the future conditions flood hazard analysis, future flood hazard areas in El Paso County were increased by a significantly greater degree than the future flood hazard areas outside of El Paso County. Whereas the future condition adjustments in El Paso County resulted in a total future condition flood hazard area between 1.5-2 times the size of the total existing condition flood hazard area, adjustments outside of El Paso County resulted in only a 1% increase in the flood hazard area change. Several reasons were noted to explain this difference:

- In El Paso County[6], future condition flood hazards included an additional rainfall adjustment of 20% to account for future precipitation projections; whereas, outside of El Paso County, a similar adjustment was not applied (discussed in Section 2.3.2);
- In El Paso County, future condition flood hazards were estimated by adjusting hydrologic model parameters based on detailed future population projections from the El Paso MPO; whereas, outside of El Paso County, future condition flood hazards were estimated by using higher intensity existing condition floodplains as a proxy for future condition floodplains (discussed in Section 2.3.3); and
- In El Paso County, future condition flood hazards were estimated for the entire area of the county; whereas, outside of El Paso County, future condition flood hazards were only estimated for areas of projected future development, which were approximated by applying a spatial buffer to the current development area equal to the county-level future population growth rates (discussed in Section 2.3.3).

Table 2.20 Extent of Increase of Future Flood Hazard Compared to Existing Condition

Flood Hazard	Extent	Total Existing Area (Sq. Mi.)	Total Future Area (Sq. Mi.)	Area Change (sq. mi.)	Area Change (%)
1% AC	El Paso County	179	356	175	99%
1% AC	Outside El Paso County	9,106	9,187	67	1%
0.2% AC*	El Paso County	66	105	105	59%
0.2% AC*	Outside El Paso County	1,689	1,702	76	1%

*0.2% AC flood hazard area results are reported separately from the 1% AC results and do not include cumulative 1% AC flood hazard areas.

[6] For the purpose of this comparison, “El Paso County” represents El Paso County watersheds which also include a small portion of west Hudspeth County.

2.3.5 Future Flood Hazard Data Gaps

Due to the limited availability of future condition flood hazard information across the region (such as detailed future land use data or future conditions flood studies), future flood hazard data gaps were identified for the entire region with one exception. As part of the RFP future flood hazard analysis described in the previous section, the watersheds of El Paso County and western Hudspeth County were evaluated under a potential 2050 future condition scenario (accounting for future population growth and future increases in precipitation), which fills the future flood hazard data gaps for these areas.

Future flood hazard data gaps, along with the public-provided flood prone areas, are shown in **Map Exhibit 9** ("Future Condition Flood Hazard – Gaps in Inundation Boundary Mapping and Identify Known Flood-Prone Areas").

2.3.6 Future Flood Exposure

Based on the identified future conditions flood hazard areas, a high-level future flood exposure analysis was performed to identify who or what might be harmed within the region for the future condition 1% and 0.2% annual chance flood events. The exposure analysis evaluated potential flood impacts to population, property, critical facilities, public infrastructure, roadways, and agricultural resources.

The methodology of the future condition exposure analyses was based on the methodology previously discussed for the existing condition exposure analyses in Section 2.2.3.

Future conditions flood exposure results are summarized at the regionwide level in **Table 2.21**, by county in **Figure 2.4**, and by flood risk type in **Figure 2.5**. In addition, detailed results are provided in **Appendix Table 2B** and illustrated at the regionwide level in **Map Exhibit 11** ("Future Condition Flood Exposure")**.**

Table 2.21 Future Flood Exposure Summary

Exposure Type	Number of features		
	1% AC	0.2% AC*	Possible Flood Prone Areas
Floodplain Area (sq. mi.)	9,543	1,807	161
Structures (#)	67,134	35,167	12,393
Population (#)	253,678	110,302	71,036
Critical Facilities (#)	178	56	19
Roadway Segments (mi.)	3,846	1,035	353
Roadway Stream Crossings (#)	1,467	585	147
Agricultural Areas (sq. mi.)	678	149	39

*0.2% AC flood exposure results are reported separately from the 1% AC results and do not include cumulative flood hazard areas or property impacts from 1% AC flood hazard areas.

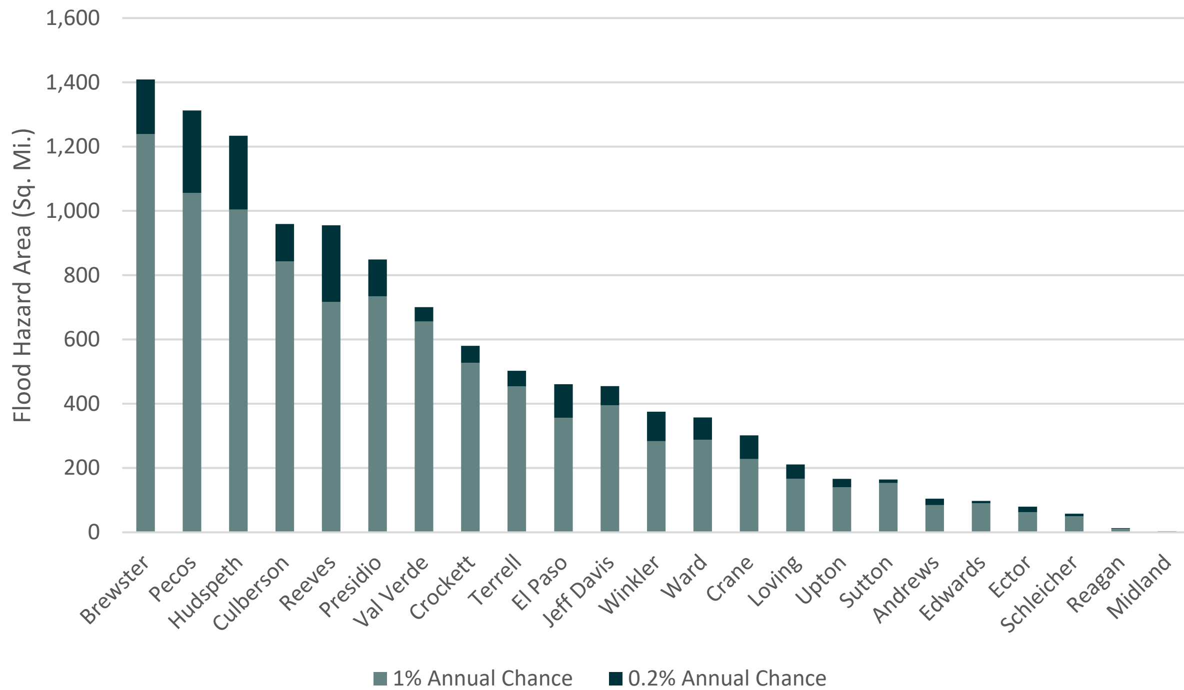
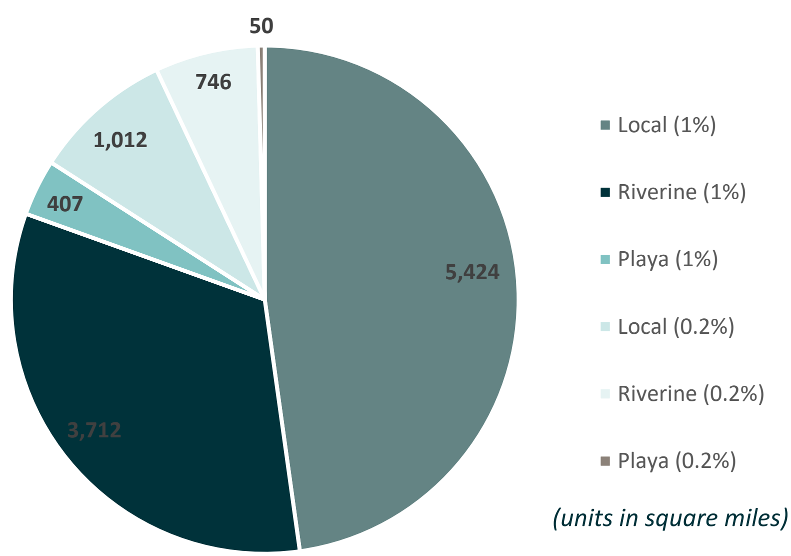


Figure 2.4 Total Future Condition Flood Hazard Area by County



Note: Flood hazard areas with more than one potential flood risk type are characterized in this figure using a simplified priority order (i.e., playa, riverine, local).

Figure 2.5 Total Future Condition Flood Hazard Area by Flood Risk Type

2.3.7 Future Vulnerability

Based on the results of the future conditions flood risk identification and exposure analyses, a future condition vulnerability analysis was performed to identify the level of resilience or vulnerabilities related to communities, critical facilities, and critical transportation routes.

The methodology of the future condition vulnerability analyses was based on the methodology previously discussed for the existing condition vulnerability analyses in Section 2.2.4.

Table 2.22 shows the relative vulnerability of communities across the region, including incorporated and unincorporated communities, based on the number of structures in the 1% and 0.2% future condition annual chance floodplains. The top five communities by number of structures within colonias in the 1% future condition annual chance floodplain were found to be the City of Socorro, Homestead Meadows North, Homestead Meadows South, the City of San Elizario, and the Town of Clint. The top five communities by average SVI of buildings in the floodplain were found to be Fabens, Redford, the City of Presidio, the Town of Van Horn, and the City of San Elizario.

In addition to summarizing SVI values by community, average building SVI values were summarized by county and reported as part of the future conditions flood exposure results in **Appendix Table 2B**. An overview of regionwide future condition vulnerability results is provided in **Map Exhibit 12** ("Future Condition Flood Vulnerability including Critical Infrastructure").

Table 2.23 summarizes the potential vulnerabilities of critical facilities for the future conditions 1% and 0.2% annual chance flood events by county, while **Table 2.24** summarizes potential vulnerabilities oof critical routes for the same events. In addition, Section 2.4 provides qualitative descriptions of the expected loss of function for various critical facility types in the region.

Table 2.22 Summary of Future Conditions Vulnerability – Community Property Impacts

	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		
Place Name	**Number of Structures in Floodplain**	**Number of Structures in Floodplain within Colonias**	**Number of Structures in Floodplain**	**Number of Structures in Floodplain within Colonias**	**Average SVI of Structures in Floodplain****
Acala CDP	**3**	**3**	**5**	**3**	**0.932**
Agua Dulce CDP	**357**	**346**	**468**	**451**	**0.902**
Alpine city	1,784	0	1,980	0	0.570
Amistad CDP	11	11	11	11	0.549
Anthony town	**258**	**3**	**264**	**3**	**0.925**
Balmorhea city	361	0	363	0	0.357
Barstow city	166	0	249	0	0.520
Box Canyon CDP	27	21	27	21	0.549

Place Name	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		Average SVI of Structures in Floodplain**
	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	
Butterfield CDP	**26**	**18**	**26**	**18**	**0.784**
Canutillo CDP	**710**	**325**	**749**	**340**	**0.768**
Clint town	**406**	**406**	**493**	**493**	**0.753**
Crane city	182	0	242	0	0.560
Dell City city	**293**	**0**	**293**	**0**	**0.932**
El Paso city	29,043	72	50,174	128	0.711
Fabens CDP	**580**	**12**	**888**	**12**	**0.974**
Fort Bliss CDP	1,156	0	1,844	0	0.344
Fort Davis CDP	155	0	226	0	0.408
Fort Hancock CDP	**92**	**39**	**117**	**43**	**0.932**
Fort Stockton city	296	1	322	1	0.589
Grandfalls town	192	0	253	0	0.520
Homestead Meadows North CDP	1,222	881	1,612	1,179	0.754
Homestead Meadows South CDP	783	587	1,619	1,299	0.641
Horizon City city	926	5	1,898	7	0.540
Imperial CDP	272	246	276	246	0.329
Iraan city	101	100	120	119	0.329
Kermit city	1,293	0	2,075	0	0.593
Lake View CDP	12	12	12	12	0.549
Lindsay CDP	**189**	**189**	**194**	**194**	**0.825**
Marathon CDP	91	87	118	109	0.512
Marfa city	**285**	**0**	**488**	**0**	**0.913**
McCamey city	196	0	577	0	0.658
Mentone CDP	11	0	15	0	0.502
Monahans city	789	0	891	0	0.687
Morning Glory CDP	**96**	**67**	**134**	**94**	**0.930**
Ozona CDP	1,047	0	1,056	0	0.608
Pecos city	1,958	7	2,835	7	0.588
Prado Verde CDP	112	57	112	57	0.095
Presidio city	**666**	**0**	**754**	**0**	**0.951**
Pyote town	18	0	30	0	0.520

Place Name	1% Annual Chance Flood Risk		0.2% Annual Chance Flood Risk*		Average SVI of Structures in Floodplain**
	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	Number of Structures in Floodplain	Number of Structures in Floodplain within Colonias	
Rankin city	82	0	82	0	0.426
Redford CDP	**16**	**7**	**30**	**14**	**0.951**
San Elizario city	**816**	**502**	**1,050**	**678**	**0.934**
Sanderson CDP	291	291	323	323	0.453
Sheffield CDP	4	0	12	7	0.329
Sierra Blanca CDP	**38**	**38**	**50**	**50**	**0.932**
Socorro city	**4,382**	**2,222**	**6,066**	**3,245**	**0.903**
Sonora city	827	0	876	0	0.651
Southwest Sandhill CDP	828	0	1,046	0	0.520
Sparks CDP	115	111	212	206	0.695
Study Butte CDP	24	20	31	26	0.512
Terlingua CDP	4	3	6	5	0.512
Thorntonville town	217	0	333	0	0.520
Tornillo CDP	**186**	**179**	**228**	**210**	**0.930**
Toyah town	**101**	**101**	**101**	**101**	**0.825**
Valentine town	18	18	49	48	0.408
Van Horn town	**229**	**217**	**638**	**623**	**0.935**
Vinton village	**147**	**1**	**397**	**2**	**0.866**
Westway CDP	**93**	**90**	**164**	**160**	**0.785**
Wickett town	31	0	39	0	0.520
Wink city	41	0	70	0	0.544
All other colonias (outside boundaries of incorporated place or CDP)	-	2,410	-	3,193	-

*0.2% AC flood vulnerability results include cumulative property impacts from 1% AC flood hazard areas.

Communities in **bold have a high SVI (over 0.75)

Table 2.23 Summary of Future Conditions Vulnerability – Critical Facilities

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	**0.2% Annual Chance**
Andrews	• None identified	• None identified
Brewster	• EPA NPDES: CITY OF ALPINE MUNICIPAL WWTF • HIFLD Law Enf: ALPINE POLICE DEPARTMENT • HIFLD Law Enf: BREWSTER COUNTY SHERIFFS OFFICE • Hospital: BIG BEND REGIONAL MEDICAL CENTER • School: ALPINE EL • School: ALPINE H S • School: ALPINE MIDDLE	• Same as 1% Annual Chance
Crane	• HIFLD Law Enf: CRANE COUNTY SHERIFFS OFFICE / CRANE COUNTY JAIL • National Shelter System Facility: Crane County Library • **School: CRANE EL**	• HIFLD NGPP: CORDONA LAKE GAS PLANT • **National Shelter System Facility: Mountain View Community Center**
Crockett	• EPA NPDES: MAIN WWTF • HIFLD NGPP: NELEH GAS SYSTEM • HIFLD NGPP: SOUTHWEST OZONA GAS PLANT • HIFLD NGPP: TIPPETT GAS PLANT • Intermodal Transit Facility: Caprock Diesel • National Shelter System Facility: Ozona Convention Center • School: OZONA EL • School: OZONA MIDDLE	• Same as 1% Annual Chance
Culberson	• None identified	• **Intermodal Transit Facility: Pilot Travel Center** • **School: VAN HORN SCHOOL**
Ector	• None identified	• None identified
Edwards	• None identified	• None identified
El Paso	• **EPA NPDES: CANAL WTP** • EPA NPDES: CANUTILLO ISD WWTP • EPA NPDES: HORIZON REGIONAL MUD - HORIZON CITY WWTP • EPA NPDES: TORNILLO WWTF • **Fire Station: El Paso Fire Department Station 25** • Fire Station: El Paso Fire Department Station 26 • Fire Station: El Paso Fire Department Station 9 • **Fire Station: Montana Vista Fire Rescue Station 1** • Fire Station: Montana Vista Fire Rescue Station 2 • Fire Station: West Valley Fire Department Anthony Station • Fire Station: West Valley Fire Department Canutillo Station • Google: Bonnie Moorhouse Reverse Osmosis Water Treatment Facility	• **Fire Station: El Paso Fire Department Station 18** • Fire Station: El Paso Fire Department Station 31 • **HIFLD Nursing Homes: OASIS NURSING & REHABILITATION CENTER** • **Hospital: DEL SOL MEDICAL CENTER A CAMPUS OF LPDS HEALTHCARE** • **Intermodal Freight Facility, RAIL & TRUCK: UP-EL PASO-TX-201 DODGE** • **National Shelter System Facility: GARY DEL PALACIOS REC CENTER** • **National Shelter System Facility: Marty Robbins Recreation Center** • **National Shelter System Facility: Socorro Community Center**

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	**0.2% Annual Chance**
	• **HIFLD Law Enf: CLINT POLICE DEPARTMENT** • **HIFLD Law Enf: EL PASO COUNTY SHERIFFS OFFICE - HEADQUARTERS** • HIFLD Nursing Homes: ADAM MC CARE LLC • HIFLD Nursing Homes: GOOD SAMARITAN SOCIETY--WHITE ACRES • HIFLD Nursing Homes: LA FAMILIA ASSISTING LIVING • **HIFLD Nursing Homes: ROSEMARY WILLIAMS MELENDEZ CASA FELICITAS** • **HIFLD Nursing Homes: SUNRIDGE AT CAMBRIA** • **HIFLD Nursing Homes: THE ETERNAL YOUTH HOME** • HIFLD Nursing Homes: THE FOREST ASSISTED LIVING • HIFLD Nursing Homes: VILLAS DEL SOL ASSISTED LIVING LLC • HIFLD: FORT BLISS (DEA EPIC) • HIFLD: HOOVER COMPANY • **HIFLD: MONTANA POWER STATION** • **Hospital: EL PASO CHILDREN'S HOSPITAL** • **Hospital: PREMIER SPECIALTY HOSPITAL OF EL PASO** • **Hospital: THE HOSPITALS OF PROVIDENCE TRANSMOUNTAIN CAMPUS** • Hospital: UNIVERSITY MEDICAL CENTER OF EL PASO • Intermodal Freight Facility, RAIL & TRUCK: EL PASO TERMINAL WAREHOUSES, INC.-EL PASO-TX • Intermodal Freight Facility, RAIL & TRUCK: SWIG COTTON-EL PASO-TX • **Intermodal Freight Facility, TRUCK - PORT - RAIL: YELLOW-EL PASO-TX TERMINAL** • **Intermodal Transit Facility: Greyhound Station** • National Shelter System Facility: DAACG • National Shelter System Facility: DON HASKINS REC CENTER • **National Shelter System Facility: EPCC Administrative Building** • **National Shelter System Facility: Houchen Center** • **National Shelter System Facility: MULTIPURPOSE CENTER** • National Shelter System Facility: Nations Tobin Recreation Center • **National Shelter System Facility: San Pablo Lutheran Church** • **National Shelter System Facility: Socorro Entertainment Ctr** • **National Shelter System Facility: St. Ignatius Church**	• **School: ALICIA R CHACON** • School: ANDRESS H S • **School: CACTUS TRAILS** • **School: CARROLL T WELCH EL** • **School: CEDAR GROVE EL** • **School: COL JOHN O ENSOR MIDDLE** • School: DAVINCI SCHOOL FOR SCIENCE AND THE ARTS • **School: DEL VALLE H S/National Shelter System Facility** • **School: DELTA ACADEMY** • **School: DESERTAIRE EL** • **School: DOLPHIN TERRACE EL** • **School: EASTWOOD KNOLLS** • **School: EL DORADO H S/National Shelter System Facility** • **School: ESCONTRIAS EARLY CHILD CTR** • **School: FANNIN EL** • **School: FRANKLIN H S** • **School: GUILLEN MIDDLE** • **School: HARMONY SCIENCE ACAD (EL PASO)** • **School: HORIZON HEIGHTS EL** • School: HORNEDO MIDDLE • **School: HOWARD BURNHAM EL** • **School: HUECO EL** • **School: IDEA EDGEMERE ACADEMY** • **School: JANE A HAMBRIC SCHOOL** • **School: JEFFERSON H S** • **School: PASO DEL NORTE SCHOOL** • **School: PEBBLE HILLS H S** • **School: PRESA EL** • **School: RIVERSIDE H S** • **School: RIVERSIDE MIDDLE** • **School: SANCHEZ STATE JAIL** • **School: SCOTSDALE EL** • **School: SUN RIDGE MIDDLE; LUJAN-CHAVEZ EL/National Shelter System Facility** • **School: TIPPIN EL** • **School: YSLETA H S**

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	**0.2% Annual Chance**
	• National Shelter System Facility: WELLINGTON CHEW SENIOR CENTER • **School: AMERICAS H S/National Shelter System Facility** • **School: ANTHONY EL** • **School: ASCARATE EL** • **School: BONHAM EL** • School: CANUTILLO MIDDLE • School: CHAPIN H S • School: CLINT H S • School: CLINT ISD EARLY COLLEGE ACADEMY • **School: CLINT J H SCHOOL** • School: CONSTANCE HULBERT EL • School: COOLEY EL • School: CROSBY EL • **School: DESERT VIEW MIDDLE** • **School: DESERT WIND EL** • School: DOWELL EL • **School: EAST POINT EL** • **School: EASTWOOD H S/National Shelter System Facility** • **School: EASTWOOD MIDDLE** • School: EL PASO ACADEMY WEST • School: EL PASO LEADERSHIP ACADEMY • **School: GLEN COVE EL** • School: H D HILLEY EL • School: H R MOYE EL • School: HAWKINS EL • School: HENDERSON MIDDLE • **School: HORIZON H S** • **School: HORIZON MIDDLE** • **School: IRVIN H S** • **School: J M HANKS H S** • **School: JOHN DRUGAN SCHOOL** • **School: JOHNSON EL** • School: JOSE H DAMIAN EL • **School: JOSEFA L SAMBRANO EL** • **School: LA FE PREPARATORY SCHOOL** • School: LE BARRON PARK EL • School: LEE EL/National Shelter System Facility • **School: LORENZO LOYA PRI** • **School: MACARTHUR EL-INT** • School: MAGOFFIN MIDDLE/National Shelter System Facility • School: MARIAN MANOR EL • **School: MESITA EL** • School: MILAM EL • **School: MONTWOOD MIDDLE; ELFIDA CHAVEZ EL**	

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	0.2% Annual Chance
	• School: NEWMAN EL • School: NORTH LOOP EL • **School: PARKLAND H S/National Shelter System Facility** • **School: PARKLAND PRE K CENTER** • **School: PASODALE EL** • **School: POLK EL** • **School: PREMIER H S OF EL PASO** • School: RAMONA EL • School: RED SANDS EL • **School: RIO BRAVO MIDDLE** • School: ROBBIN E L WASHINGTON EL • School: SAN ELIZARIO H S/National Shelter System Facility • **School: SILVA HEALTH MAGNET** • **School: SOUTH LOOP EL** • School: STANTON EL • School: TEJAS SCHOOL OF CHOICE • **School: TELLES ACADEMY** • School: THE LINGUISTIC ACAD OF EL PASO-CULTURAL DEMO SITE • **School: TIERRA DEL SOL EL** • School: TORNILLO EL • School: WESTERN HILLS EL • **School: WILLIAM D SLIDER MIDDLE** • School: WM DAVID SURRATT EL • School: YSLETA PK CENTER • School: ZACH WHITE EL • **School: ZAVALA EL**	
Hudspeth	• Fire Station: Hueco Volunteer Fire Department • School: DELL CITY SCHOOL	• Same as 1% Annual Chance
Jeff Davis	• EPA NPDES: FORT DAVIS WWTF	• **School: VALENTINE SCHOOL**
Loving	• HIFLD NGPP: PECOS RIVER PLANT	• Same as 1% Annual Chance
Midland	• None identified	• None identified
Pecos	• EPA FRS: CENTURY GAS PLANT • Fire Station: Imperial Fire Department • HIFLD NGPP: WAHA GAS PLANT • HIFLD: EAST PECOS SOLAR • Hospital: PECOS COUNTY MEMORIAL HOSPITAL • School: BUENA VISTA SCHOOL • School: FORT STOCKTON ALAMO EL • School: FORT STOCKTON HIGH • School: IRAAN J H • School: LYNAUGH UNIT	• EPA FRS: WAHA GAS PLANT • HIFLD NGPP: MITCHELL PLANT • HIFLD: ALAMO 6
Presidio	• None identified	• School: PRESIDIO H S

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	0.2% Annual Chance
Reagan	• None identified	• None identified
Reeves	• EPA NPDES: ORLA WWTP • Fire Station: Balmorhea Volunteer Fire Department • Fire Station: Toyah Volunteer Fire Department • HIFLD Law Enf: PECOS POLICE DEPARTMENT • HIFLD NGPP: EAST TOYAH GAS PLANT • National Shelter System Facility: Civic Center in Balmorhea • National Shelter System Facility: Community Center in Pecos City • National Shelter System Facility: First Baptist Church - Balmorhea • School: AUSTIN EL • School: BALMORHEA SCHOOL/National Shelter System Facility	• School: CROCKETT MIDDLE • School: PECOS H S
Schleicher	• None identified	• None identified
Sutton	• EPA FRS: CITY OF SONORA • Fire Station: Border Line Volunteer Fire Department • HIFLD Law Enf: SONORA POLICE DEPARTMENT • HIFLD NGPP: SONORA GAS PLANT • Intermodal Transit Facility: Picos Food Mart • National Shelter System Facility: SUTTON COUNTY CIVIC CENTER	• Same as 1% Annual Chance
Terrell	• Fire Station: Terrell County Volunteer Fire Department • Intermodal Transit Facility: Amtrak Station	• Same as 1% Annual Chance
Upton	• Fire Station: McCamey Volunteer Fire Department • HIFLD: CASTLE GAP SOLAR • HIFLD: UPTON COUNTY SOLAR • Hospital: MCCAMEY HOSPITAL	• School: MCCAMEY PRI
Val Verde	• None identified	• None identified
Ward	• Fire Station: Grandfalls Volunteer Fire Department • HIFLD NGPP: BONE SPRINGS GAS PROCESSING PLANT • HIFLD NGPP: MIVIDA JV PROCESSING PLANT • HIFLD Nursing Homes: MONAHANS MANAGED CARE CENTER • School: GRANDFALLS-ROYALTY SCHOOL • School: MONAHANS H S • School: SUDDERTH EL	• Same as 1% Annual Chance
Winkler	• EPA FRS: EL PASO NATURAL GAS - KEYSTONE COMPRESSOR STATION • HIFLD Law Enf: WINKLER COUNTY SHERIFFS OFFICE / WINKLER COUNTY JAIL	• KERMIT EL

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

County	Future Conditions Critical Facilities Vulnerabilities*	
	1% Annual Chance	**0.2% Annual Chance**
	• HIFLD NGPP: HALLEY PLANT • Hospital: WINKLER COUNTY MEMORIAL HOSPITAL • School: WINK EL	

*Critical Facilities in **bold** were identified as potential vulnerabilities in future conditions flood events (1% or 0.2% annual chance) but were not previously identified as potential vulnerabilities in the existing conditions flood events (1% or 0.2% annual chance) listed in **Table 2.15.**

Table 2.24 Summary of Future Conditions Vulnerability – Critical Routes

County	Future Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Andrews	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities.
Brewster	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • Roadway 118, resulting in access issues to the hospital Big Bend Regional Medical Center.
Crane	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • US Highway 385 S, resulting in access issues. Problem accessing the Crane Memorial Hospital.
Crockett	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • Segments of IH10 near Ozona town, resulting in significant access issues.
Culberson	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • IH10 intersection with US90, may result in access issues to the nearest hospital, Culberson Hospital.
Ector	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities.
Edwards	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities.
El Paso	• Includes existing condition 1% vulnerabilities. • N Boone, Reynolds St. and N Concepcion St. resulting in potential access issues to Hospitals: EP Children's Hospital, EP Psychiatric Center, and University Medical Center of El Paso. • South US 54, Above intersection with IH10, potential access issue to main Highway. • Butterfield area, O Leary Dr. resulting in potential access issue to Montana Ave.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • N Mesa St. resulting in potential access issue to hospital: Las Palmas Rehabilitation Hospital. • Tierra Arroyo Dr. and Tierra Este Dr. resulting in potential Access issues to Hospital: The Hospitals of Providence east campus. • Homestead Meadows South area, roadway: N Ascension St. resulting in potential access to Agua Dulce.
Hudspeth	• Includes existing condition 1% vulnerabilities. • Segments of roadway US62-180 may result in potential access issues between El Paso and Hudspeth County and Culberson County. • Segments of IH10 may result in potential access issues between El Paso/Hudspeth and Culberson/Hudspeth.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • Hueco Ranch Rd. may result in potential access issues to the US62-180. • Segments of IH10 may result in potential access issues between El Paso/Hudspeth and Culberson/Hudspeth. • IH10 at the Sierra Blanca area may result in potential access issues.
Jeff Davis	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • SH-17, the connection between Marfa and Fort Davis, resulting in access issues near the intersection with SH-17.

County	Future Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Loving	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • South County Road 22 intersection with County Road 2, resulting in significant access issues. • Roadway 302 at the intersection with County Rd. 20 (Metor Rd) resulting in access issues to Mentone city.
Midland	• None identified	• None identified
Pecos	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • IH10 near Fort Stockton may cause problems accessing the Pecos County Memorial Hospital • N US Highway 285, near Fort Stockton may cause problems accessing the Pecos County Memorial Hospital.
Presidio	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • US67, Intersection with roadway 170, resulting in access issues to presidio city. • US90 Intersection with US67, resulting in access issues to Marfa city.
Reagan	• None identified	• None identified
Reeves	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • North Central US285 with possible access issues near Pecos area. • IH20 near Toyah town with possible access issues.
Schleicher	• None identified	• None identified
Sutton	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • Segments of IH10 at Sonora city resulting in access issues. Therefore, possible problems accessing Lilian M. Hudspeth Memorial Hospital • E 2ND St. resulting in access issues. Possible problems accessing Lilian M. Hudspeth Memorial Hospital.
Terrell	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities.
Upton	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • McCamey Town, Roads: 21St St. Medical Dr. resulting in access issues. Possible problems accessing the McCamey Hospital. • McCamey Town, Segments of US Highway 385-FM 305, resulting in access issues. Possible problems accessing the McCamey Hospital. • US Highway 67, resulting in significant access issues at Rankin Town. Therefore, possible problems accessing the Hospitals: Rankin County Hospital District and Rankin County Hospital District.

County	Future Conditions Critical Route Vulnerabilities	
	1% Annual Chance	**0.2% Annual Chance**
Val Verde	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities.
Ward	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • IH20, Monahans city area with significant access issues. • S State Highway 18 with significant access issues to Grandfalls Town.
Winkler	• Includes existing condition 1% vulnerabilities.	• Includes existing condition 0.2% and future condition 1% vulnerabilities. • S Roadway 115, with significant access issues. Connection between Wink and Pyote town. • S State Highway 18, with significant access issues. Connection between Kermit and Monahans

2.4 Expected Loss of Function

When key community assets are impacted by floods, the associated flood damages may result in reduced or total loss of function of the affected assets. These disruptions can also lead to cascading risks of harm to life, property, and transportation throughout the community. This summary discusses the potential impacts of flood events on the operations and expected functions for the following community assets:

- Fire Stations
- Hospitals
- National Shelter System Facility
- Schools
- Intermodal Freight Facility
- Intermodal Transit Facility
- Water treatment plants
- Wastewater treatment plants
- Police departments
- Assisted living facilities
- Natural gas processing plants
- Power plants
- Solar farms

Fire Stations

The public relies heavily on first responders and fire fighters during emergencies such as flood events, and the more substantial the incident, the greater the need for assistance delivered by the fire department and others with public safety missions. During flood events, fire departments coordinate with other agencies and respond to:

- Incidents caused by structural damage from moving water, disruptions to utility services and damage from debris being moved by the water.
- Evacuation of low-lying areas.
- Increased rescue problems or situations such as people trapped in structures by rising waters, and people trapped in motor vehicles by rising waters.
- Damage to infrastructure such as roads and bridges, limiting response. During flood events, the fire department usually works closely with law enforcement and the agencies that maintain the roads and highways.
- Some communities that are prone to severe flood pre-deploy specialized rescue teams when heavy rains are forecast or when ground saturation levels reach predetermined

points. These teams include rescue swimmers, small boat handlers, rope riggers, and team leadership.[7]

If fire service facilities are compromised due to being inundated, there may be cascading impacts on the communities they serve. Service personnel will have limited access to the equipment they need for their operations and this will impede their service delivery. Communication and coordination may be impacted or delayed if communication hubs situated within fire service centers are disabled due to water inundation. If fire service vehicles are parked in low lying areas, flooding of these vehicles will disable them and limit resources during rescue operations. It is therefore imperative that these facilities are prepared for flood events.

Hospitals

Hospitals provide critical services during flood events for vulnerable population groups. Severe flood events can impact medical services, ancillary services such as the functioning of pharmacies, laboratories, blood banks, mechanical systems such as ventilation and lift systems, water and sewer systems.

Severe flood events can both damage hospital facilities directly and disrupt access to them. Damage to the hospital facilities can result in loss of life at worst but also delays in providing routine medical services and emergency services to highly vulnerable populations. Flooding may also lead to direct costs due to damage to infrastructure, or expensive medical equipment. There may also be indirect costs of such as increased risk of outbreaks due to loss of laboratory and diagnostic support, and the loss income normally generated by health care services.[8]

The emergency power supply system is the most critical service in continued operation of a hospital during a power outage. Together with fuel supply and storage facilities, this system enables all the other hospital installations and equipment that have not sustained direct physical damage to function normally in any disaster. However, uninterrupted operation of a hospital during a power outage is possible only if adequate electrical wiring is installed in all the areas that require uninterrupted power supply. Since extra wiring and additional circuits for emergency power increase the initial construction costs of the building, the decision on the emergency power coverage requires a thorough evaluation of the relative vulnerability of various functions to power outage. As patients become more critically ill and the nature of diagnosis and treatment becomes more dependent on computers, monitors, and other electrical equipment, the need for emergency power is pertinent. In some healthcare facilities, to make critical services more accessible for maintenance and monitoring, they are placed on the ground floor or basement. This increases the risks from flooding to these services. Storm water can fill the basements and first floor and cause the backup generators to be inoperable. During flood events, sewers can overflow, back up, or breakdown. Waste disposal is essential for

[7] FEMA, 2008. *Special Report: Fire Department Preparedness for Extreme Weather Emergencies and Natural Disasters*. [online] Available at: <https://www.usfa.fema.gov/downloads/pdf/publications/tr_162.pdf> [Accessed 24 March 2022].

[8] Yusoff, N., Shafii, H., & Omar, R. (2017). The impact of floods in hospital and mitigation measures: A literature review. *IOP Conference Series: Materials Science And Engineering*, *271*, 012026. doi: 10.1088/1757-899x/271/1/012026

any hospital, because when the toilets back up, or sterilizers, dishwashers, and other automated cleaning equipment cannot be discharged, patient care is immediately affected.[9]

Elevator service is vulnerable not only to power outages, but also to direct damage to elevator installations. The flooding of elevator pits was a common problem during Hurricane Katrina, and responsible for the loss of elevator service.

In anticipation of severe flooding, timely evacuation of some or all of the hospital patients to facilities out of the disaster area may be a prudent choice for patient welfare. Severe floods can cause blockage of access roads, cutting off a hospital from normal evacuation routes. Surface escape routes can be under water and unusable, and air evacuation can be impaired if many ground level helicopter landing pads are under water. Elevated helipads located on roof tops or elevated parking structures are invaluable features in this type of an emergency. The spatial relationship of helipads to hospital building is another aspect that greatly influences the evacuation and reduced the risk of aggravating patients' condition. Helipads physically connected to the hospital are most useful, because patients could be transported directly and very rapidly from the upper levels of the hospital to the helipad without interference from other hospital functions.[9]

When an existing facility is exposed to flooding, or if a new facility is proposed to be in a flood hazard area, steps need to be taken to minimize the risks. A well-planned, designed, constructed, and maintained hospital should be able to withstand damage and remain functional after and during a flooding event.

National Shelter System Facilities

The National Shelter System is a network of facilities that can house individuals in the event of an issued evacuation for the facilities service area. The facilities included in this network are those have been designated as a Shelter by either the Federal Emergency Management Agency (FEMA) or the American Red Cross (ARC).[10] In addition to general population shelters, the system includes:

- Medical shelters, shelter-in-place locations (SIP)
- Household pet shelters, kitchens
- Points of Distribution (POD's), warehouses
- Warming, cooling, and respite centers
- Embarkation, Debarkation, and Reception processing sites
- Any type of shelter or facility related to the management of the people affected by the operation[11].

[9] FEMA. (2007). Risk Management Series Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds. *Risk Management Series*. Retrieved from https://www.wbdg.org/FFC/DHS/fema577.pdf

[10] National Shelter System Facilities. (2022). Retrieved 3 April 2022, from https://hifld-geoplatform.opendata.arcgis.com/datasets/geoplatform::national-shelter-system-facilities/about

[11] FEMA. (Not Dated). NATIONAL SHELTER SYSTEM – FACT SHEET. Retrieved from https://www.fema.gov/pdf/media/factsheets/2011/fema_national_shelter_system.pdf

Sheltering facilities are primarily for planned as survival places for the victims displaced after a flood event when rehabilitation is underway immediately afterwards. These will be used only for a short period of time during a flood.

Ideally, shelters should also be located outside areas known to be flood prone, including areas within the 100-year floodplain. Shelters in flood-prone areas will be susceptible to damage from hydrostatic and hydrodynamic forces associated with rising flood waters. Damage may also be caused by debris floating in the water. Most importantly, flooding of occupied shelters may well result in injuries or deaths. Furthermore, shelters located in flood-prone areas, but properly elevated above the 100-year flood elevation, could become isolated if access routes were flooded. As a result, shelter occupants could be injured, and no emergency services would be available.[12]

Schools

Existing schools that are in flood hazard areas are exposed to flood risk. The nature and severity of damage are functions of site-specific characteristics. Damages may impact the property, buildings, , service equipment, and also pose health and safety threats due to contaminated floodwater.

Regardless of the nature and severity of damage, schools impacted by floods are typically not functional while cleanup and repairs are undertaken. The length of closure impacts the ability of the school district to provide instruction and may setback students from achieving their education milestones. The duration of the closure depends on the severity of the damage and lingering health hazards. It may also depend on whether the building was fully insured or whether disaster assistance is made available quickly to allow speedy repairs and reconstruction. Sometimes, repairs are put on hold pending a determination of whether a school should be rebuilt on the same site. When damage is substantial, rehabilitation or reconstruction is allowed by FEMA only if full compliance with flood-resistant design requirements is achieved.[13]

Potential damage identified by FEMA include:[14]

- Health threats - Mold growth and contaminants in flooded schools can pose significant health threats to students and staff.
- Playing field surfaces - In addition to damage by erosion and scour, graded grass fields and applied track surfaces can be damaged by standing water and deposited sediments.
- Vehicles and buses - If left in flood prone areas, vehicles may not be functional and available for service immediately after a flood and must be replaced or cleaned to be serviceable.

[12] FEMA. (2006). Risk Management Series Design Guidance for Shelters and Safe Rooms. *Risk Management Series*. Retrieved from https://www.fema.gov/pdf/plan/prevent/rms/453/fema453.pdf

[13] National Clearinghouse for Educational Facilities. (2011). Flooding and Schools. *National Clearinghouse For Educational Facilities*. Retrieved from https://files.eric.ed.gov/fulltext/ED539485.pdf

[14] FEMA. (2010). Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds, *FEMA P-424*. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_p-424-design-guide-improving-school-safety.pdf

- Site damage - School grounds may be subject to erosion and scour, with the possible loss of soil and damage to paved areas, including access roads. Large amounts of debris and sediment can accumulate on the site, especially against fences.
- Structural damage - Foundations can be eroded, destabilizing or collapsing walls and heaving floors.
- Saturation damage - Saturated walls and floors can lead to plaster, drywall, insulation, and tile damage, mold and moisture problems, wood decay, and metal corrosion.
- Utility system damage - Electrical wiring and equipment can be shorted, and their metal components corrode. Ductwork can be fouled and expensive heating and cooling equipment ruined. Oil storage tanks can be displaced and leak, polluting the areas around them. Sewers can back up and contaminate the water supply and building components.
- Content damage - School furniture, computers, files, books, lab materials and equipment, and kitchen goods and equipment can be damaged or contaminated.

Intermodal Freight Facility

Flooding events can disrupt the operations of freight transportation facilities and infrastructure. This may result in significant economic impacts due to delivery delays associated with rerouting in affected areas . The inability to deliver to locations that have been cut off from the freight network will also have economic impact. Overall, the cost rates of moving goods, increase as roads become impassable. The need to take alternate routes is likely to increase fuel consumption and lengthen driver on-duty time, both of which increases costs for companies and ultimately consumers. After a severe flood event, there is often increased competition for limited transportation resources and equipment such as shipping containers, trucks and trains. This limited capacity will naturally push costs up, but even if there is affordability, the capacity might be impossible to find. This overall disruption in the supply chain and increase in overall costs will impact community members access to necessary resources.

Water stagnation or other structural damage caused by the floods to freight facilities will limit its operations. It may reduce storage capacity and further stress the supply-chain.[15]

Intermodal Transit Facility

Transportation networks underpin socio-economic development by enabling the movement of goods and people. Disruptions due to flooding of roadway and rail tracks can cause operating services to reroute or suspend service to hard hit areas. Power outages can also disable transit service. Highways and arterials need electrical power to operate traffic lights and signs. Railroads require electricity to operate signal systems and crossing gates. Under this situation, it is likely that headway time will increase as transit is re-routed, travel speed is reduced and hence travel time increases. This leads to substantial economic costs to local commuters. Overall, accessibility to jobs decreases under flooded conditions. As most transit users are from

[15] Grenzeback, L. R., Lukman, A. T., & Systematics, C. (2008). *Case study of the transportation sector's response to and recovery from Hurricane's Katrina and Rita*. Transportation Research Board.

lower income communities, this raises an equity concern. The closure of transit facilities due to water stagnation will cut-off access for all its users.[16]

Water Treatment Facilities/Plants

Floods can impact the operations of water treatment plants. For example, reductions in the ability to feed raw water to the process tanks or damage to the Automatic Transfer Switch (which detects power failures, initiate generator startup, transfer load, and perform other functions without human intervention would render the facility inoperable. Additionally, the inability to provide high air pressure will limit the operation of pneumatic valves on the treatment process systems. This can also render the facility inoperable.[17]

Flood events may lead to water contamination or reduced water supply, which impacts consumers who rely on these systems for safe drinking water, cooking or cleaning. Depending on the severity of the flood, it could take up to several months to have a water professional monitor and certify it as safe for drinking. Without access to clean drinking water, consumers ultimately become reliant on bottled water which is likely to increase drastically in price during such a time. In poor and impoverished communities, this reality is even more detrimental because they may not have the economic means to “stock up” on bottled water in comparison to more affluent communities. Moreover, during a severe flood event, retail locations are often inaccessible and/or low on water supply as well.[18]

Wastewater Treatment Facilities/Plants

A wastewater treatment plant is most at risk for flooding when it’s in a low-lying area near a water body from which it discharges its final effluent and enables gravity-fed collection systems. Pump stations, where differential head is insufficient for flow, are included in some systems and increases the likelihood of flooding. Pumps develop differential head, or differential pressure. This means the pump takes suction pressure, adds more pressure (the design pressure), and generates discharge pressure . In cases where the differential head is not adequate, the pump station will be located closer to the discharge location. If components are in areas vulnerable to flooding, designing them to be submersible is preferred.[19]

In older water systems, sanitary sewer overflow is an issue. Unexpected heavy rainfalls introduce too much water into the system and can cause pump stations and treatment plants to break down, as well as untreated sewage to overflow from manhole covers and pour into water

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[16] He, Y., Thies, S., Avner, P., & Rentschler, J. (2021). Flood impacts on urban transit and accessibility—A case study of Kinshasa. *Transportation Research Part D: Transport And Environment*, *96*, 102889. doi: 10.1016/j.trd.2021.102889

[17] FLOOD RESILIENCE A Basic Guide for Water and Wastewater Utilities. (EPA, 2014). Retrieved from: https://www.epa.gov/sites/default/files/2015-08/documents/flood_resilience_guide.pdf

[18] Flooding's Impact on Public Water Supplies, Sanitation. (Water Utility Management, 2021). Retrieved from: https://www.waterworld.com/water-utility-management/article/14211783/floodings-impact-on-public-water-supplies

[19] Tips for Flood-Proofing Wastewater Treatment Plants. (Nielson, 2018). Retrieved from: https://atsinnovawatertreatment.com/blog/flood-proof-wastewater-treatment-plant/

bodies. The outflow of raw sewage can endanger the local aquatic ecosystem and impact water quality.20

Excess floodwater can contaminate private drinking water sources, such as wells and springs, when rainfall makes contact with the ground and comes into contact with contaminants such as animal waste. This increases the amount of bacteria, sewage, and other industrial waste or chemicals that seep into the water source or leaky pipes. Additionally, excess water makes it more difficult for water treatment devices to treat the water efficiently and effectively. If there is any contamination at any step of the water flow process, this puts consumers at risk of exposure to dangerous toxins that could result in serious harm such as wound infections, skin rashes, gastrointestinal illnesses, and tetanus.[21]

Police Departments

The police co-ordinate with emergency services during a major flood and assist with the evacuation of people from their homes when necessary. If police facilities are compromised due to being inundated, there may be cascading impacts on the communities they serve. Service personnel will have limited access to the equipment they need for their operations and this will impede their service delivery. Communication and coordination may be impacted or delayed if communication hubs that are situated within police stations are disabled due to water inundation. If police vehicles are parked in low lying areas, flooding of these vehicles will disable them and limit resources during rescue operations. It is therefore imperative that these facilities are prepared for flood events.

Assisted Living Facilities

Assisted living facilities tend to house vulnerable, medically frail elderly and disabled residents. The residents, in the case of severe floods, tend to have lesser resources and higher health risks during evacuation. If inundated during flood events, assisted living facilities will have limited capacity to provide the necessary care needed for its residents in the form of power, food and water, medications, and supplies.

Assisted living facilities ideally require an emergency stockpile of medications and medical supplies adequate to cover all residents in the facility for at least 72 hours and ideally, up to a week. In the case of both food and medications/supplies, facility leaders may face supply chain issues after severe flood events. Even if they have secured purchasing agreements with more than one vendor, if roadways are flooded, delivery may be difficult or impossible, and supplies may be scarce.[22]

[20] Sewage Floods Likely to Rise. (Scientific America, 2016). Retrieved from: https://www.scientificamerican.com/article/sewage-floods-likely-to-rise/

[21] Flooding's Impact on Public Water Supplies, Sanitation. (Water Utility Management, 2021). Retrieved from: https://www.waterworld.com/water-utility-management/article/14211783/floodings-impact-on-public-water-supplies

[22] Emergency Preparedness Planning for Nursing Homes and Residential Care Settings in Vermont. (JSI, 2010). Retrieved from: https://www.michigan.gov/documents/mdch/Emergency_Preparedness_Planning.-_Vermont_428874_7.pdf

Natural Gas Processing Plants

Impacts from flooding of natural gas processing plants can include damage to infrastructure assets and disruption to service. Severe flooding at the regional scale can lead to supply chain disruptions and delays in in transporting Liquified Natural Gas (LNG) products to the market. Natural gas processing plants in the study area include plants which produce petroleum products such as natural gas, propane, butane, and condensate from raw natural gas or carbon dioxide. Petroleum products such as propane and butane serve as fuel for other industrial processes.

In the case of carbon capture plants, flood damages could disrupt or reduce carbon sequestration and could cause an interruption in the production of methane gas, which is the byproduct of the carbon capture process. As methane is also used to retrieve oil and natural gas from underground deposits, interruptions to carbon capture facilities due to flooding could have cascading impacts on other parts of the oil and natural gas supply chain.

Severe flooding of facilities can impact labor productivity and safety. In some cases, it can lead to environmental contamination that will require separate remediation efforts. If damage to the facilities cannot be restored quickly after a flood event, the limitation in production will have economic consequences. This may be in the form of an increase in product price that could then cascade to other products in the supply-chain. For instance, liquid propane gas is a necessary ingredient in the production of propylene, the building block of the plastic polypropylene. That particular plastic is used in the making of automotive interiors and packaging.

Power Plants

Severe flooding can disrupt the electricity supply chain, including electricity generation, transmission and distribution. Flood risks to electricity generation are a consequence of the need for most power plants to be close to sources of cooling water for their operations. In most cases, these are located next to natural water bodies such as lakes. As a result, they tend to be located in low lying areas and are prone to flooding. Floods can impact power plants in several ways including damage to equipment, which can knock out the plant's electrical systems and disable its cooling mechanisms. This in turn, may limit or halt electricity generation. Power plants that require fossil fuels for operation can be impacted by limited fuel supply if there are delays in the supply chain or flood damage to transportation infrastructure such as roadways and ports.

After severe flood events, key community assets such as police and fire stations, and hospitals, will rely on backup generators until power is restored. Damage to the network would need to be fixed as soon as possible. In cases where the power plants are limited in generating electricity, even after transmission and distribution infrastructure is restored, the shortage in supply may lead to a rise in price, which will have a disproportionate impact on lower income communities. Shortages of electricity will impact every household and business is likely to have wide reaching economic and quality of life repercussions. [23]

[23] Climate change, disasters and electricity generation. Urban, F., & Mitchell, T. (2011). Retrieved from: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.825.4966&rep=rep1&type=pdf

Solar Farms

When solar farms are located in low lying areas, they are prone to inundation which may impact their operations. Solar panels can be damaged by floods but selecting high quality components such as module junction boxes, backsheets and cables can dramatically increase the resilience of panels and a solar powered farm to floods.

The continuous immersion in water has the potential to adversely affect the bottom of solar panels, which consists of a module junction box and a backsheet. Cables that go from solar panels to inverters can potentially be damaged by flood water as these parts are exposed to the outside to a large extent. Design interventions and material selection can minimize damage.[24]

Solar farms play important role in community resilience. After severe flood events, key community assets such as police and fire stations and hospitals, rely on backup generators until power is restored. More frequent storms and flood events increases the importance of the electricity system to become less centralized so that when one component of the distribution or generation system stops working, others can remain online. A less centralized system would be less vulnerable to mass outages when a power line breaks or when a substation floods. A more decentralized system is well-suited to renewable energy, and solar energy in specific, which is spread out across the grid.[25]

[24] Can Solar Panels be Damaged by Floods? - Solar Mango – #1 guide for solar. (2022). Retrieved 6 May 2022, from https://www.solarmango.com/2016/08/07/can-solar-panels-damaged-floods/

[25] Solar Energy Largely Unscathed by Hurricane Florence's Wind and Rain - Inside Climate News. (2022). Retrieved 6 May 2022, from https://insideclimatenews.org/news/20092018/hurricane-florence-solar-panel-energy-resilience-extreme-weather-damage-wind-flooding/