Title Page

Brownsville to Port Isabel HUC-10 Watershed Study

Flood Infrastructure Fund Category 1
Project ID 40024

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Texas Water Development Board

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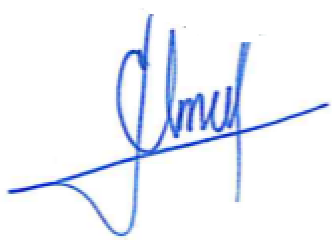

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1 Executive Summary

This Brownsville to Port Isabel HUC-10 Watershed Study, sponsored by the City of Brownsville, was funded by the Texas Water Development Board as a Flood Infrastructure Fund Category 1 study (Project ID 40025). Category 1 studies are focused on determining and describing problems related to flooding, developing solutions to flooding problems, and estimating the benefits and costs of these solutions.

The limits of this study are based on the HUC-10 area called "Brownsville Ship Channel" which encompass an approximately 366 square mile watershed located in the southern half of Cameron County, Texas. The study's northern boundary roughly follows Resaca de los Cuates, its southern boundary roughly follows the Rio Grande northern levees, and its eastern boundary is located on the Gulf. **Exhibit 1**, located in **Appendix A**, shows the study limits.

Key stakeholders for this study are:

- Cameron County
- City of Brownsville
- City of Los Fresnos
- City of Port Isabel
- Town of Rancho Viejo
- La Paloma
- Olmito
- Laguna Heights
- Cameron County Drainage District #1

The unique topography of the study area—with its flat terrain intersected with elevated Resacas (distributaries turned into amenity lakes) and irrigation canals—coupled with continual development has, over time, resulted in high flood risk for several communities and a rising number of people. Past studies have been performed to manage and reduce this flood risk. However, these studies are now outdated and do not reflect the current flood risk and flood mitigation needs of the communities. This study provides the region with an updated flood risk analysis and flood mitigation plan.

Key deliverables from this study include:

- Flood risk modeling and maps
- Identification of areas with the highest flood risk
- Conceptual flood mitigation projects with a plan to implement them

1.1 Study Results

To evaluate the flood risk throughout the entire region, the latest rain-on-mesh drainage modeling technology was used to develop a single detailed flood risk analysis for the entire study area. This model captured flood risk associated with both riverine and urban flooding, providing a wholistic understanding of flood risk throughout the region. **Appendix C** includes a map book that shows the modeled 1-percent annual chance flood depths for the entire region. These models and maps can be used by communities to help make more informed decisions to mitigate any increases in flood risk for their communities.

Based on the results of this modeling, along with input from the public and stakeholders, ten areas with high flood risk were identified and studied further. **Exhibit 9** located in **Appendix A** shows the location and ranking of these areas with highest flood risk. **Table 1.1** provides a summary of these identified areas.

Table 1.1 Summary of Selected Problem Areas

Problem Area ID	Problem Area Name	Watershed	Sponsor	Structures with Moderate to High Flood Risk
PA1	North Main Drain and Impala Ditch	North Main Drain	Brownsville	804
PA2	Cameron County Ditch 1 at Confluence	Cameron County Ditch 1	Brownsville	674
PA3	Cameron County Ditch at Cameron Park	Cameron County Ditch 1	Brownsville	400
PA4	Town Resaca at West 5th Street	Town Resaca	Brownsville	346
PA5	Cameron County Ditch 1 at Golf Center	Cameron County Ditch 1	Brownsville	196
PA6	Los Fresnos at East 10th St.	Cameron County Ditch 2	Los Fresnos	191
PA7	Cameron County Ditch 1 at Hwy 69E	Cameron County Ditch 1	Brownsville	186
PA9	North Main Drain and Hwy 69E	North Main Drain	Brownsville	135
PA11	Los Fresnos West Ocean Blvd	Cameron County Ditch 2	Los Fresnos	132
PA12	Town Resaca at Washington Park	Town Resaca	Brownsville	123

Using various improvement methodologies, flood mitigation projects were developed for each identified location to reduce the flood risk to structures (both residential and commercial). These projects are summarized in **Table 1.2**. More detailed information that includes project scope, cost breakdown, implementation constraints, etc. are provided in project fact sheets which are located in **Appendix F**.

Table 1.2 Project Cost and Benefit Summary

Project ID	Project Name	Description	# Structures Removed from 1% ACE	# Structures w/ Reduced 1% ACE	Cost ($M)	BCR
P1A	North Main Drain and Impala Ditch	Channel, Culvert, and Pump Station Improvements	131	176	46.9	0.35
P1B	North Main Drain and Four Corners	One Detention Pond and Channel and Culvert Improvements	83	417	33.3	0.05
P2	Cameron County Ditch 1 at Confluence	Five Large Detention Ponds along with one Culvert Improvement on Tributary	281	834	99.3	0.25
P3	Cameron County Ditch at Cameron Park	Five Extreme Event Storm Sewer and Overflow Routing Improvements	130	149	1.6	3.47
P4	Town Resaca at West 5th Street	Storm Sewer Improvements along with One Detention Pond	71	469	34.1	0.74
P5	Cameron County Ditch 1 at Golf Center	Conversion of Golf Course into a Detention Pond along with Channel and Crossing Improvements	399	214	45.5	0.22
P6	Los Fresnos at East 10th St.	Four Extreme Event Storm Sewer and Overflow Routing Improvements	92	100	4.4	1.10
P7	Cameron County Ditch 1 at Hwy 69E	Channel and Roadway Improvements	191	152	7.7	0.63
P9	North Main Drain and Hwy 69E	Detention Pond and Storm Sewer Improvements	84	465	32.5	0.19
P11A	Los Fresnos West Ocean Blvd	Channel and Culvert Improvements	60	53	29.3	0.09
P11B	Los Fresnos West Ocean Blvd	Detention Pond along with Channel and Culvert Improvements	17	22	17.0	0.14
P12	Town Resaca at Washington Park	Storm Sewer Improvements	48	144	8.7	0.59

In general, the implementation of each one of these projects will follow the project lifecycle shown in **Figure 1.1**. This study completed the planning portion of the project. Short term actions are those that can be implemented over the next few years and will be steppingstones to completing the projects. Phase I includes those short-term targets. Longer-term actions will likely take more than five years due to funding, construction time, and project constraints. Phase II includes the longer-term actions.

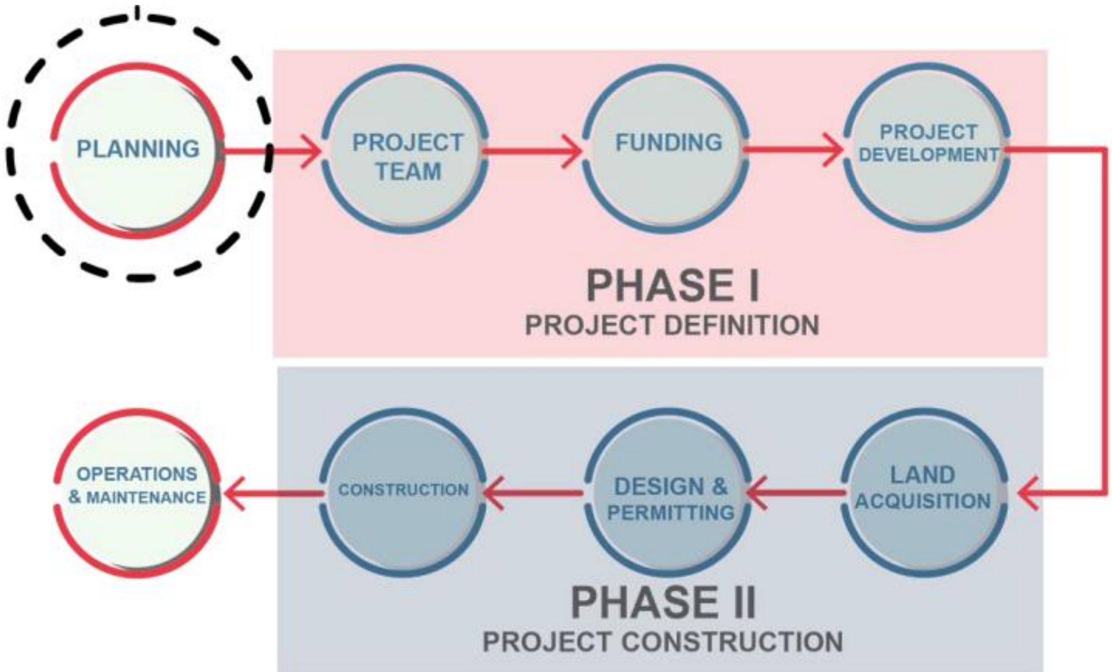

Figure 1.1 Drainage Project Lifecycle

1.1.1 Short Term Actions

The stakeholders within the study area have limited funding for drainage project implementation and therefore short-term actions, listed below, are those that can be implemented with limited funding.

- Right-of-Way dedication
- Seek funding opportunities
- Develop and implement a buyout strategy
- Continue to install flood gauges
- Continue to update drainage criteria

1.1.2 Long Term Actions

As the short-term actions are completed, funding and other strategies will become available for the recommended projects. At this point, the long-term actions will commence. These are listed below.

- Develop flood mitigation projects further to prepare for construction
- Construction of flood mitigation projects
- Maintenance of flood mitigation projects

1.1.3 Funding Sources

Funding sources are available from local, state, and federal entities, each with their own procurement, administrative, and environmental requirements, impacting the cost and schedule of the projects. The funding sources below should be considered for the projects identified in this study.

Federal Funding Sources

- Community Development Block Grant Disaster Relief (**CDBG-DR**) –
  Based on disaster declaration with LMI emphasis. The cost-share is typically 100% Federal to 0% Local.
- Community Development Block Grant Mitigation (**CDBG-MIT**) –
  Based on disaster declaration with LMI emphasis (lower scoring needed than DR). The cost-share is typically 100% Federal to 0% Local.

State Funding Sources

- TWDB Development Fund (**DFund**) - State of Texas loan program
- TWDB Flood Infrastructure Fund (**FIF**) - Loans at or below market rates for a variety of actions, including flood planning, grant application, and engineering for structural and non-structural solutions. In addition, the FIF offers grants that can be used as the local entities matching funds for other federal funding programs. The state is currently allocating additional budget for the fund and will be accepting applications in 2024.

Local Funding

- Bonds
- Fees and Ad Valorem Taxes
- Public Private Partnerships

1.1.4 Next Steps

The results of the study, including flood risk modeling and mapping, will be made available to the region's stakeholders to help make informed decisions regarding flood risk mitigation in the future. The flood mitigation projects developed in this study will also be added to the state's flood plan so that they will be eligible for future grant funding opportunities.

Stakeholders should begin addressing flood risk within their community by taking the steps outlined above and beginning the search for funding opportunities to implement the flood mitigation projects. This will require stakeholders to be engaged with the Region 15 Regional Flood Planning Group to stay apprised of funding opportunities and to inform the State of the stakeholder's flood mitigation needs. In the meantime, stakeholders can begin tackling some of the short-term actions outlined above to help reduce flood risk within their community.

2 Introduction and Background

The Brownsville to Port Isabel Hydrologic Unit Code-10 (HUC-10) Watershed Study ("Brownsville Study") is a comprehensive drainage plan for a 366 square mile watershed in the southern half of Cameron County, Texas. This study, sponsored by the City of Brownsville ("Brownsville"), was funded by the Texas Water Development Board ("TWDB") as a Flood Infrastructure Fund ("FIF") Category 1 study (Project ID 40025). Category 1 studies are focused on determining and describing problems related to flooding, developing solutions to flooding problems, and estimating the benefits and costs of these solutions.

2.1 Project need

The watershed for the Brownsville Study is situated in the Rio Grande River ("Rio Grande") delta, near the Gulf of Mexico ("Gulf"). Flood control projects, including dams, reservoirs, and levees, have hydraulically disconnected the Rio Grande from this region dramatically reducing flood risk from the river in the region. However, this has not eliminated localized flood risk in the region. Remnants of the river's past distributaries (an outflowing branch of a river, typically found in a delta), known as "resacas", are spread throughout the region. These resacas are elevated above the neighboring flat terrain leading to complex drainage patterns and significant flood ponding with limited drainage relief. This condition results in elevated flood risk to several communities, especially in the areas between the resacas.

As development has occurred in the region, additional drainage relief has been established by constructing man-made channels across the resacas that help flood waters drain to the gulf. However, these channels are often undersized, leaving numerous pockets of heavy ponding in heavily populated areas. Past studies have been performed that provided flood mitigation plans aimed at reducing flood risk in these areas. However, these plans are now outdated and do not reflect the current flood risk and flood mitigation needs of the communities.

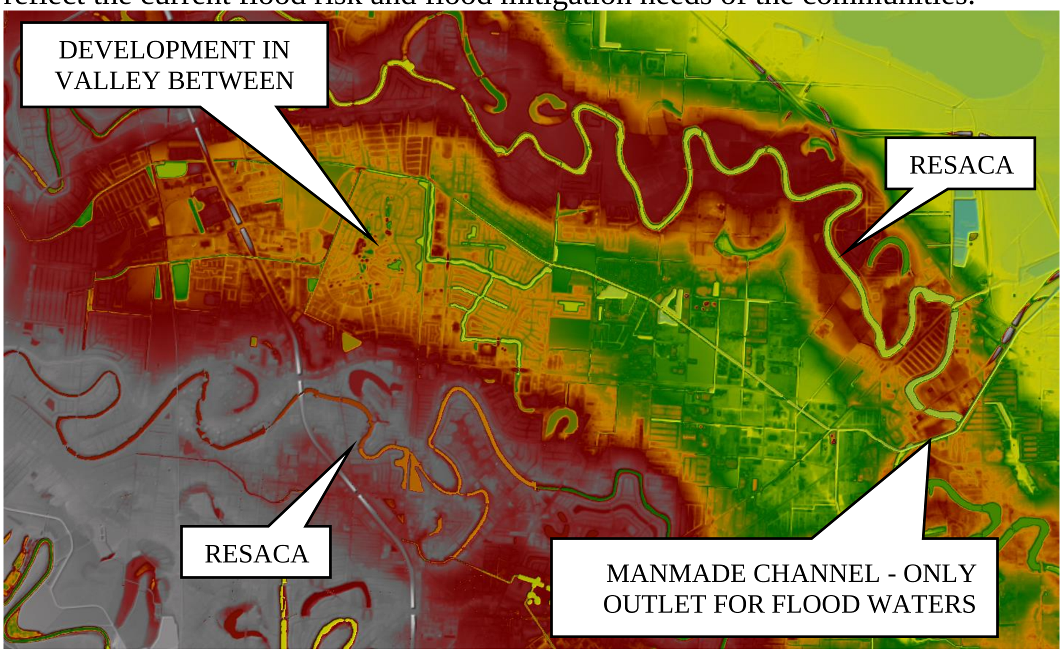

Figure 2.1 Topography Example

Additionally, the flood risk information available in the region is outdated or lacking sufficient coverage to adequately communicate the true level of flood risk. Communities need a thorough and up-to-date understanding of flood risk to inform their future infrastructure and growth management planning decisions and need a plan to strategically mitigate flood risk for vulnerable areas and provide flood mitigation solutions that reflect community needs and desires.

2.2 Project Overview

The specific goals of this study are to provide communities within the study area with a plan for a regional understanding of flood risk through the delivery of:

- Flood risk models and maps
- Identification of flood prone areas
- Potential flood mitigation projects and a plan to implement them.

The scope of work included public outreach to gather feedback and to inform stakeholders and the public of the results of the study; data collection such as in-field survey, collection of past studies, and the latest available public GIS information; and engineering services which includes drainage model development using the latest technology and data, flood risk analysis, project development, and project implementation strategy.

The results of the study, including flood risk modeling and mapping, will be made available to the region's stakeholders to help make informed decisions regarding flood risk mitigation in the future. The flood mitigation projects developed in this study will also be added to the state's flood plan so that they will be eligible for future grant funding opportunities.

2.3 Key Stakeholders

Major municipalities included in the study area, otherwise known as stakeholders, are:

- Cameron County
- City of Brownsville
- City of Los Fresnos
- City of Port Isabel
- Town of Rancho Viejo
- La Paloma
- Olmito
- Laguna Heights
- Cameron County Drainage District #1

Brownsville is the largest population center within the study area. As a result, the city was the primary facilitator of public engagement through public meetings. The city was also the study sponsor and administered the engineering services contract.

2.4 Project Area

The Brownsville Study limit is based on the HUC-10 area called "Brownsville Ship Channel" which encompasses an approximately 366 square mile area located in the southern half of Cameron County, Texas. The study's northern boundary roughly follows Resaca de los Cuates, its southern boundary roughly follows the Rio Grande northern levees, and its eastern boundary is located on the Gulf. **Exhibit 1** located in **Appendix A** shows the study limits.

Brownsville is located in the southernmost portion of the study where the highest population density for the study is located and, in turn, the most development. This is also the area with the highest level of flood risk. The northern portions of the study limit consist mostly of rural farm and ranch land. The easternmost part of the watershed consists mostly of undeveloped tidal salt flats with the exception of the ship channel located on the southeast side of study.

In general, floodwaters flow from west to east through a complicated network of storm sewer, man-made drainage channels, and resacas before emptying into the Lower Bahia Grande/Laguna Madre or the Brownsville Ship Channel and then into the Gulf of Mexico.
The study area can be subdivided into seven primary subbasins, **Figure 2.2**, that drain via manmade channel or resaca. Each of these drainage features are described in greater detail below starting on the south side of the HUC-10 area and moving northwards. The limits of these subbasins are shown in **Exhibit 2** located in **Appendix A**.

2.4.1 Town Resaca

Starting at the southern portion of the watershed, Town Resaca drains much of downtown (i.e. south) Brownsville east towards the Impala Pump Station. Flow reaching the Impala Pump Station is then either pumped over a levee into the Rio Grande during high flow conditions in Brownsville or proceeds into the North Main Drain channel and on to the Brownsville Ship Channel. As mentioned above, resacas are naturally occurring former distributaries of the Rio Grande. Today, many of the resacas are maintained as amenities with a permanent pool elevation that is set by a series of weir structures. These amenity lakes attract residential development along the banks in many of the more developed portions of the watershed and serve multiple purposes in the community including drainage conveyance, raw water supply storage, wildlife habitat, and recreational opportunities. Historically, there are several spots within the downtown area that have had flooding issues due to their low elevation and lack of overflow routes into Town Resaca.

2.4.2 North Main Drain

North Main Drain is the primary ditch draining central Brownsville from West Brownsville near Wild Rose Lane and Center Drive and running over 16 miles eastward before draining into the Brownsville Ship Channel. The surrounding watershed is highly developed with much of the area consisting of residential subdivisions interspersed with commercial developments. The downstream end of the ditch travels south of the Brownsville/South Padre Island International Airport before turning north to the Port of Brownsville. Significant drainage issues have plagued the city near a low-lying area at the intersection of Highway 48 and Boca Chica Boulevard. over the last 20 years, but limited right-of-way and undeveloped land have made addressing these issues challenging and costly.

2.4.3 Resaca de la Guerra

Resaca de la Guerra, also known as Resaca de la Palma, drains a narrow watershed area from West Alton Gloor Boulevard. to Morningside Road towards the southeast. Like Town Resaca and North Main Drain, the area is near fully developed with a mix of residential subdivisions, public parks, golf courses, small commercial developments, and local schools. While the majority of the area draining to the resaca has not historically exhibited significant drainage issues, one exception is in the Quail Hollow area near the northwest end of the resaca by Laredo Rd. Some residential structures that have been subjected to repeated flooding area were built on the low bank of the resaca and below the adjacent roadway.

2.4.4 Cameron County Drainage District No. 1 Ditch No. 1

Cameron County Drainage District No. 1 Ditch No. 1 (CCDD1 Ditch 1) drains the northern part of Brownsville extending for approximately 10.5 miles from the Resaca de la Palma Reservoir to its outfall into San Martin Lake near the ship channel. Like North Main Drain, the surrounding drainage area is largely developed with residential and light commercial developments although there remain some large agricultural and undeveloped tracts. Historic problem areas with respect to flooding are located near Brownsville County Club, Cameron Park, and a large low-lying area in the downstream section roughly centered at Central Avenue and Ruben Torres Boulevard. (FM 802). This is further compounded by a ditch that ties in from the south locally referred to as Chicago Drain. Floodwaters back up at the junction of these two ditches into the low-lying area causing flood issues for the roads and structures near this confluence.

2.4.5 Lower Resaca del Rancho Viejo

The Lower Resaca del Rancho Viejo subbasin is a narrow watershed that closely follows the resaca. On its western boundary, the subbasin receives overflows from the Upper Resaca del Rancho Viejo and conveys floodwaters west 18 miles before draining into the North Main Drain. The basin consists of higher density residential development with some light commercial areas. Flood risk along this system is minimal relative to other watershed due to it being elevated above the neighboring subbasin and its narrow shape producing lower amounts of runoff.

2.4.6 Upper Resaca del Rancho Viejo

The Upper Resaca del Rancho Viejo subbasin begins on the far western side of the study area just west of FM 509 and extends east to its primary outlets near Resaca de la Palma Reservoir. The basin is bounded by the Resaca del Rancho Viejo to the north and the Rio Grande levees to the south. The basin consists of mostly rural residential and agriculture land use. Cameron County Drainage District 3 has a complex network of ditches that drain some of the upper portions of this watershed both north through the City of San Benito to a neighboring watershed and south through a series of gated box culverts that outlet across the levees and into to the Rio Grande. However, significant floodwaters continue east through the low lying areas toward the Lower Resaca del Rancho Viejo subbasin and the Cameron County Ditch 3 subbasin. At this junction, flow continues to Cameron County Ditch 3 with overflows going across an existing drainage canal and into the Lower Resaca del Rancho Viejo.

2.4.7 Cameron County Drainage District No. 1 Ditch No. 2

The Cameron County Drainage District No. 1 Ditch No. 2 subbasin includes a majority of the northern most region of the study watershed. It is bounded to the west by Resaca del Ranch Viejo, to the north by Resaca de los Cuates, to the south by Resaca Rancho Viejo and to the east by the Gulf. The area generally drains east through a series of man-made drainage channels before converging with Cameron County Ditch No. 1 just upstream of San Martin Lake.

Cameron County Ditch No. 3 drains a significant amount of floodwaters from the Upper Resaca del Rancho Viejo and conveys it to Ditch No. 2 where it converges at Paredes Line Road just south of Los Fresnos. The subbasin consists mostly of agricultural land with sporadic concentrations of rural residential areas. The City of Los Fresnos is the major population center for this subbasin.

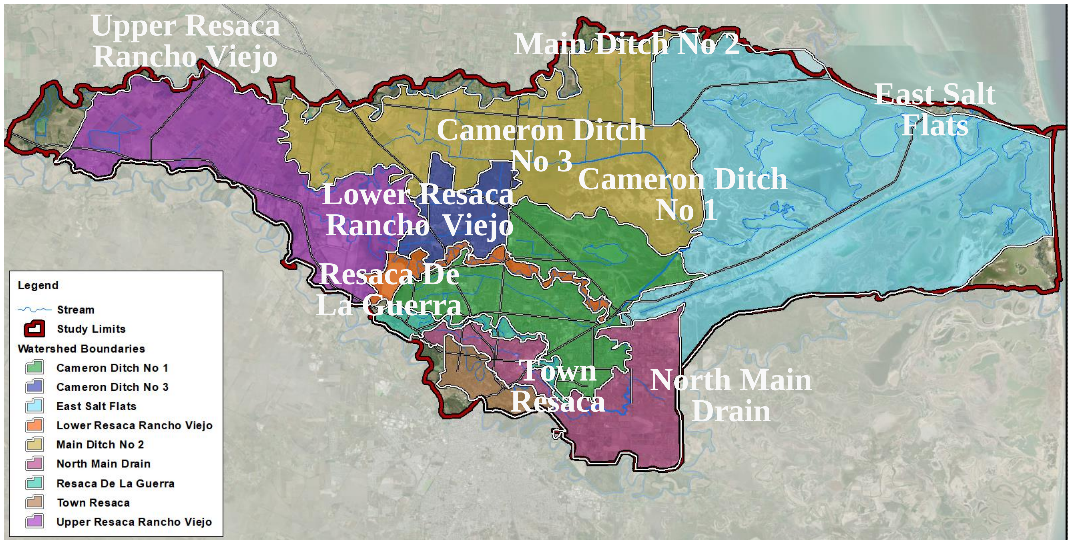

Figure 2.2 Watershed Boundaries

2.5 Project Area History

Past flood studies were obtained and reviewed to understand the history of flood planning efforts in the region and to inform the direction and recommended drainage improvements found in this study. The following studies were determined relevant to this study.

2.5.1 City of Brownsville Master Drainage Plan (1987)

In 1987 a master drainage plan was developed for the City of Brownsville (1987 MDP) by Hogan & Rasor, Inc. The focus of this study was to analyze drainage facilities and provide flood protection for the 1% annual chance event. The scope of the study included:

1. Storm Drainage System Analysis
2. Storm Drainage System Master Plan
3. Identification of Problem Areas
4. Drainage Improvements Alternatives
5. Capital Improvements and Cost Projections
6. Master Drainage Plan Implementation, and
7. Maintenance Plan

Due to the extensive amount of infrastructure information provided in this plan, it was used to estimate the size and location of storm sewer systems within Brownsville in areas where in-field data was not obtained as part of this study. The naming conventions of watersheds, regions, resacas, and other infrastructure used in this study was borrowed from the 1987 MDP.

2.5.2 1.5.2 City of Brownsville Flood Protection Plan (1996)

In January 1996, the City of Brownsville contracted with Rust Lichliter/Jameson to perform a study of Brownsville and its surrounding areas. The study included five watershed areas including, (1) North Main Drain, (2) CCDD No 1, (3) Town Resaca, (4) Resaca de la Guerra and, (5) Resaca del Rancho Viejo. However, the Resaca del Rancho Viejo watershed was later removed from the study due to the lack of readily available data and sparse development making it a lower priority for the city. The primary goal was to develop an implementable drainage plan to reduce existing flood risk and prepare for the future growth in the city.

2.5.3 City of Brownsville Flood Protection Plan Phase I (2006)

In March 2006, Ambiotec Civil Engineering Group, Inc. (Ambiotec) completed a Flood Protection Plan for the City of Brownsville. The study included four watershed areas including, (1) Town Resaca, (2) North Main Drain, (3) Resaca de la Guerra, and, (4) Cameron County Drainage District No. 1 Ditch No 1 (CCDD1). The purpose of the plan was to evaluate existing flood risk, develop potential structural and non-structural alternatives for mitigating flood risk, and to develop a Cost Implementation Plan for project implementation. Proposed mitigation projects were organized into a 20-yr CIP with an estimated capital cost of over $130 million.

2.5.4 City of Brownsville Flood Protection Plan Phase II (2011)

In August of 2011, Ambiotec completed a Phase II update of the 2006 Flood Protection Plan. The updated plan linked three of the watersheds from the 2006 study that all drain to a single outfall, provided a rough assessment of downstream storm surge conditions, added two additional watershed areas to the study that had not been evaluated in the 2006 study, and updated budgets for all of the proposed flood mitigation projects. The study also reassessed project feasibility considering new development that occurred since 2006, considering projects that had been completed from the 2006 CIP, and investigated two additional flood mitigation options.

Hydrologic and hydraulic models developed for the Flood Protection Plan Study conducted in 2006 were updated for the Phase II study in 2011. These models were utilized to obtain crossing (bridges and culvert) information where needed to compliment the in-field survey performed as part of this study.

2.5.5 City of Los Fresnos Drainage Improvements Feasibility Report (2021)

The City of Los Fresnos contracted Hanson to prepare an Engineering Feasibility Report in November of 2021 to evaluate potential projects to mitigate flooding in three identified problem areas: 1) Valle Alto Subdivision; 2) Whipple Road; and 3) Resaca Escondida. The report was prepared to meet TWDB Clean Water State Revolving Fund (CWSRF) requirements for funding eligibility. Three potential actions were evaluated for each area including a no-action alternative. Three projects, one for each site, were recommended based on an evaluation of capital and maintenance costs and coordination with City staff on the cost and perceived effectiveness of the proposed project.

3 Data collection

Data collection refers to the process of requesting, organizing, and reviewing information that is necessary to complete existing conditions flood hazard assessments as well as develop and prioritize mitigation alternatives. The data collection task includes desktop reviews of flood risk assessments complemented with field reconnaissance efforts. Collected data types include terrain, land use, structures, precipitation, existing models, previous studies, flooding complaints, field reconnaissance, and field survey. All obtained data was compiled and reviewed to extract relevant information for the study.

All data collected as part of this study is found in **Appendix I**.

3.1 Rainfall Statistics

Storm frequency data was obtained from the National and Atmospheric Administration (NOAA) Atlas 14, Volume 11 Precipitation for 24-hour storm durations. Atlas 14 was published in September 2018. This data was obtained from NOAA's Precipitation Frequency Data Server (PFDS) (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). The specific depth was determined based on the approximated centroid of the study area. **Table 3.1** contains the rainfall depth-duration-frequency data used in this study. The storm frequency is categorized by annual chance event (ACE), the likelihood the storm event will occur in a given year.

Table 3.1 NOAA Atlas 14 Rainfall

Duration	10% ACE (in)	4% ACE (in)	2% ACE(in)	1% ACE (in)	0.2% ACE (in)
15-min	1.69	2.02	2.27	2.52	3.14
30-min	2.40	2.86	3.20	3.54	4.42
60-min	3.17	3.80	4.27	4.76	6.03
2-hr	3.94	4.85	5.56	6.33	8.43
3-hr	4.41	5.50	6.39	7.38	10.1
6-hr	5.23	6.64	7.83	9.18	13.00
12-hr	6.08	7.79	9.25	10.90	15.60
24-hr	7.00	9.01	10.70	12.60	18.00

3.2 Gauges and Radar

To support model calibration, historic rainfall and water surface elevation data was obtained from the USGS website (maps.waterdata.usgs.gov). The location of the gauges used for calibration is shown in **Figure 3.1.**

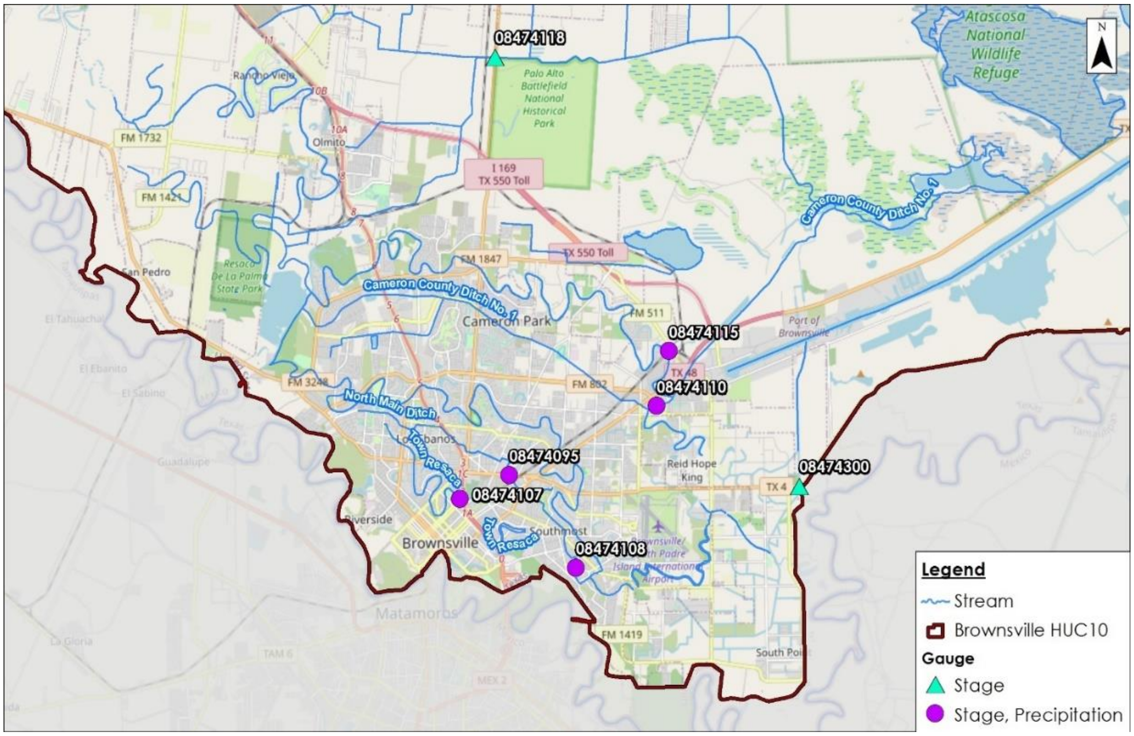

Figure 3.1 USGS Gauge Locations

To model the distribution of rainfall more accurately for the calibration event, radar data was utilized in lieu of gauge data. Radar data was obtained from Iowa State University's Iowa Environmental Mesonet website (https://mtarchive.geol.iastate.edu/2022/05/26/mrms/ncep/).

3.3 GIS Data

GIS Data was collected from various sources to support model development and evaluation of the project alternatives. Datasets collected for this study, along with their source, are presented in **Table 3.2.**

Table 3.2 GIS Data Sets

Data Set	Date	Source
Lidar (DEM)	2018	TNRIS
Land Cover	2021	NLCD
Soil Groups	2021	USDA NRCS
Building Footprints	2021	TWDB
Parcels	2021	CCAD
Storm Sewer Lines (Incomplete)	2021	Brownsville
Aerial Imagery	2022	ESRI and Nearmap
FEMA Special Flood Hazard Layers	2022	FEMA
Social Vulnerability Index	2018	CDC

3.4 As-built Data

As-built drawings for culverts, storm sewer, and detention pond infrastructure were provided by Brownsville engineering staff as requested and when available. In some instances, construction drawings were provided in lieu of as-built drawings. Since available as-built data was limited, most culvert data was collected with in-field survey as described in **Section 3.6** or obtained from previous studies and models. The location, date, and source for each as-built obtained is provided in **Table 3.3**.

Table 3.3 As-Builts

Location	Date of As-Built	Source
Palo Verde Drive	February 2006	Brownsville
Stagecoach Crossing	January 2003	Brownsville
Rustic Manor Drive	August 2008	Brownsville
Various Resaca Culvert Crossings	May 2011	Brownsville
Four Corners Detention Pond	May 2011	Brownsville
Four Corners Detention Pond (2nd Pond/Park)	July 2022	Brownsville
Southmost Trail Culvert	February 2015	Brownsville
Impala Ditch Drainage Improvements	January 2023	Brownsville
5th St. and Ramireno	March 1992	Brownsville
Garden Park Storm Sewer Improvements	March 2005	Brownsville
Towne North Subdivision Stormwater Improvements	March 2007	Brownsville

3.5 Terrain

A topographic model was developed for the entire study area by leveraging the most recent high-resolution gridded elevation data derived from Light Detection and Ranging (LiDAR) collected in 2018 and obtained from the Texas Natural Resources Information System (TNRIS) Data Hub. Further detail was added to the DEM with the incorporation of survey data, where obtained. Further detail on where and how this survey was collected and incorporated is provided in **Section 3.6**. The original raster resolution of 3-ft by 3-ft was used for model development, but all mapping results were developed with lower resolution of 9-ft by 9-ft. The extents of the LiDAR data used in this study is provided in **Exhibit 8** located in **Appendix A.**

3.6 Field survey

Field survey data was collected throughout the study area to supplement the LiDAR and as-built data. This information was collected along several of the major main-made channels and storm sewer trunk lines where high level of accuracy was needed to develop accurate flood models or areas where flood mitigation projects were developed (i.e. high flood risk areas).

For channels, bank-to-bank cross-sections were obtained with a specific focus on the portion of the channel located below the standing water level where LiDAR cannot reach.

For culverts, culvert number, size, and flow line information were obtained in addition to silt depths and road crest elevations—all necessary information for accurate model development. For storm sewer networks, select trunk lines were captured by obtaining flow line, location, and size information. Smaller lines were input into the models using existing as-built or model data provided by previous studies.

Photographs were also obtained at each survey area.
The locations of the in-field surveys are summarized in **Exhibit 3** located in **Appendix A**. All survey information is included in **Appendix I**.

3.7 Field Investigations

Multiple site visits were conducted throughout the development of the study. Site visits were primarily performed to investigate culvert infrastructure (type, size, location, etc.), confirm storm sewer outfalls, verify flow patterns, and observe potential flow restrictions. **Table 3.4** provides a summary of the significant site visits. Photos obtained from the site visits can be found in **Appendix I**.

Table 3.4 Field Measurement Summary

Location	Description
Town Resaca and 6th St.	Inspection and verification of weir infrastructure and USGS gage
Impala Pump Station	Inspection of pump outfall location and size
Impala Ditch near Town Resaca and North Main Drain	Inspection of bridge crossings and bank conditions
North Main Drain near Paredes Line Rd. and Rockwell Drive	Inspection of channel conditions
North Main Drain near Southmost Rd.	Inspection of channel conditions and culvert verification
Nopalitos Drain	New culvert verification
Hudson Canal/Cameron Country Drainage District No. 1 Ditch No. 1	Examination of structures and flow paths
Los Fresnos near E. 10th St.	Examination of problem area

4 Hydrologic analysis

The study area is characterized by flat topography, elevated resacas, and a complex network of undersized man-made drainage conveyance systems. The area's clay-rich soils and continued increase in impervious cover due to area's rapid growth inhibit water from infiltrating into the soil and results in high runoff. These characteristics, combined, make this region prone to flooding. Due to the study area characteristics and the complexity of the existing drainage network, a HEC-RAS rain-on-mesh approach was deemed the most appropriate modeling methodology for this study. As such, the hydrologic methodology for the entire HUC-10 area is limited to the development of rainfall hyetographs and estimating hydrologic losses so that the resulting rainfall excesses can be applied directly to the terrain within the HEC-RAS hydraulic models, HUC-10 area was split into two models to manage run times. The extents of the hydraulic and hydrologic analysis is shown on **Exhibit 6** and **Exhibit 7** located in **Appendix A**.

4.1 Rainfall Hyetograph

The frequency storm events considered for the study were 10-year, 25-year, 50-year, 100-year, and 500-year, described by their average chance of occurring in any given year (10%, 4%, 2%, 1% and 0.2% Annual Chance Event (ACE)). The hyetographs for each of the storm events were developed in HEC-HMS 4.9 and imported directly into HEC-RAS as a precipitation boundary condition (note: hydrologic losses were calculated directly in HEC-RAS instead of HEC-HMS). Precipitation data was acquired from the National Oceanic and Atmospheric Administration (NOAA) recently released Atlas 14, Volume 11 (https://hdsc.nws.noaa.gov/pfds/). The center of the HUC-10 watershed was chosen as the centroid for the Atlas 14 point rainfall data. **Table 4.1** shows the total rainfall depths used in this analysis for the 24-hour duration for the Atlas 14 rainfall.

Table 4.1 24-hour Precipitation Data

Annual Chance Event	Rainfall Depth (in)
10%	7.00
4%	9.01
2%	10.70
1%	12.60
0.2%	18.00

4.2 Hydrologic Losses

Hydrologic losses—or runoff—was calculated using the Natural Resources Conservation Service (NRCS) Curve Number Loss Method. This method was chosen to stay consistent with local engineering practice. This method utilizes initial abstraction (IA) to reflect the immediate infiltration of rainfall into the soil which produces in no runoff, the curve number (CN) to reflect the constant rate of precipitation losses due to infiltration into the soil after initial abstraction, and impervious percentage (IP) to reflect any surfaces that prohibit infiltration into the soil.
The IA is a parameter derived directly from the CN parameter, and the CN parameter is primarily based on soil and land cover types. The latest research suggests that the appropriate initial abstraction ratio (a parameter that relates the IA to the CN) should be assumed to be 0.05 (Hawkins, Jiang, Woodward, Hjelmfelt, & Mullem, 2003). However, the CN tables developed by the NRCS which provide CN values based on land cover and soil, were developed with an

assumed initial abstraction ratio of 0.2. Adjusting the abstraction ratio requires the adjustment of the CN to maintain the same total volume of infiltration. Therefore, the CN values provided by the NRCS were used as an initial assumption for this study but adjusted to account for a smaller initial abstraction ratio (see conversion formula shown in **Figure 4.1** provided in the referenced paper noted above). Some minor modifications were made to these values during calibration.

$$CN_{0.05} = \frac{100}{1.879[100/CN_{0.20} - 1]^{1.15} + 1}$$

Figure 4.1 CN Conversion Formula

A given CN is based on the type of soil and land cover, but it can also be modified to account for the impervious percentage of a given land cover type (e.g., residential, commercial, etc.). For this study, however, the CN and the IP were accounted for separately. This approach more accurately accounts for the immediate runoff produced by precipitation on fully impervious land cover types, such as roof tops, as opposed to the weighted CN method where this precipitation would be absorbed by the initial abstraction parameter. This was necessary, especially in the urban areas of the model, to capture the rising limb of the flood hydrographs during the calibration process.

The antecedent runoff condition (ARC) is the hydrologic condition of the soil and land cover prior to a storm event that affects the rate of infiltration. It is commonly associated with antecedent soil moisture, but it can include any antecedent condition that may affect the infiltration potential of the land cover. The NRCS has developed CN values for three different ARCs—I, II, and III—with I being associated with high infiltration potential and III being associated with low infiltration potential. It is standard practice to assume an ARC of II which is an average infiltration potential. However, during calibration, CN values that represented an ARC of I were required to obtain good model calibration. Further research was conducted and there is support for the use of an ARC of I in this region (Estimating Runoff for Conservation Practices, 1990). As shown in **Figure 4.2** below, the recommended ARC provided in the referenced technical paper appears to correlate closely with the annual mean precipitation across the state of Texas. This suggests that the ARC is somewhat dependent on the expected annual rainfall of the study area, which is to be expected. To further note, the ARC for this study area is I according to the figure. Since the calibrated CN values are supported by research conducted by the NRCS, the calibrated CN values were used for the synthetic event simulations as well.

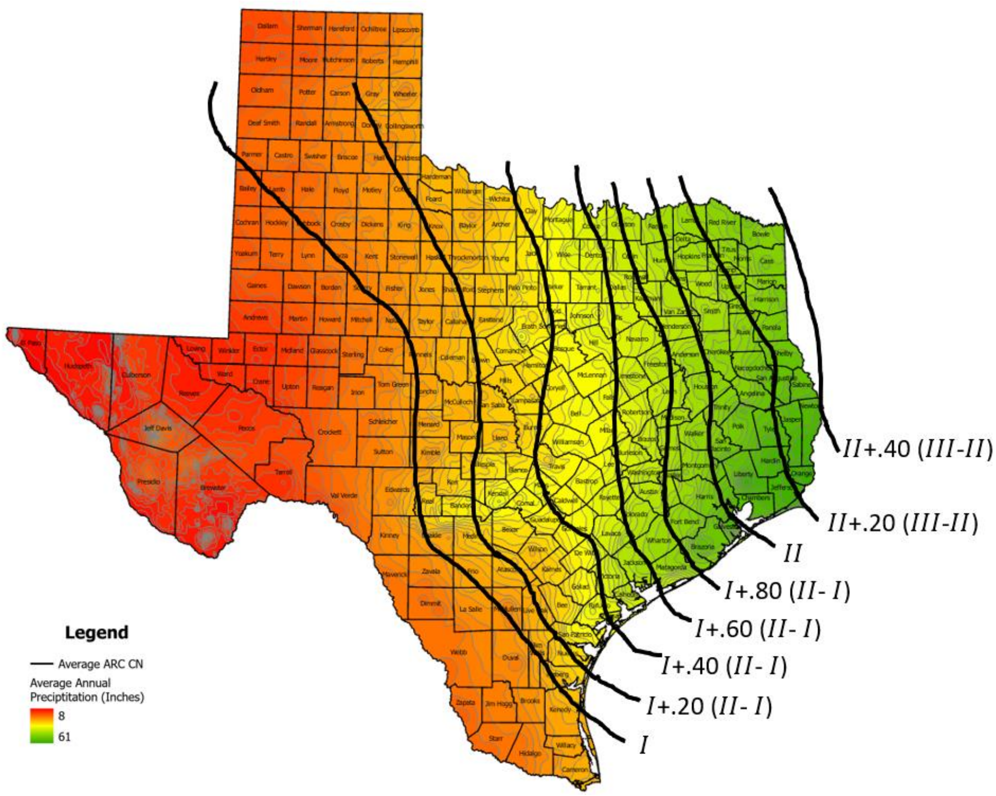

Figure 4.2 Texas Antecedent Runoff Conditions VS. Average Annual Precipitation

The land use and soil group to CN relationship used in this analysis, after being adjusted during calibration, is summarized in **Table 4.2**. Note, since the impervious percentage is calculated separately, developed low, medium, and high intensity land cover types have the same CN values as that of the Developed Open Space land cover type.

Table 4.2 CN to Land Cover and Hydrologic Soil Group Relationship

Land Cover Description	HSG A CN	HSG B CN	HSG C CN	HSG D CN
Barren Land	45	61	72	80
Cultivated Crops	28	42	56	65
Developed High Intensity	10	26	40	50
Developed Low Intensity	10	26	40	50
Developed Medium Intensity	10	26	40	50
Developed Open Space	10	26	40	50
Forest	9	25	39	48
Grassland	37	37	51	67
Open Water	98	98	98	98
Roadways	98	98	98	98
Shrubland	9	22	36	45
Wetlands	37	37	51	67

To apply these losses to the HEC-RAS model, a curve number layer was developed directly in HEC-RAS using an imported land cover layer and an imported soil layer.

The land use layer is a raster obtained from the National Land Cover Database (NLCD) that is managed by the U.S. Geological Survey (USGS). Roads were then imposed onto this layer to add definition to the layer. Each, roughly, 90’x90’ pixel indicates the estimated land use type for the entire pixel area. While this resolution is low, it is appropriate for the 2D cell resolution of roughly 200’x200’ since each cell can only use a single infiltration value making the effective resolution 200’x200’.

The soil layer is a shapefile, and it was obtained from the NRCS Web Soil Survey (WSS) website. The shapefile polygons indicate the hydrologic soil groups (A-D) of the soil in a particular region. Highly permeable sandy soils are given a classification of “A” and moderately permeable clay soils are given a classification of “D”.

An example of the CN layer that used the combined land use and soil layers is shown below in **Figure 4.3** where the different colors represent different CN values based on the land cover and soil combination. The layer for the entire study area is shown in **Exhibit 4** located in **Appendix A**.

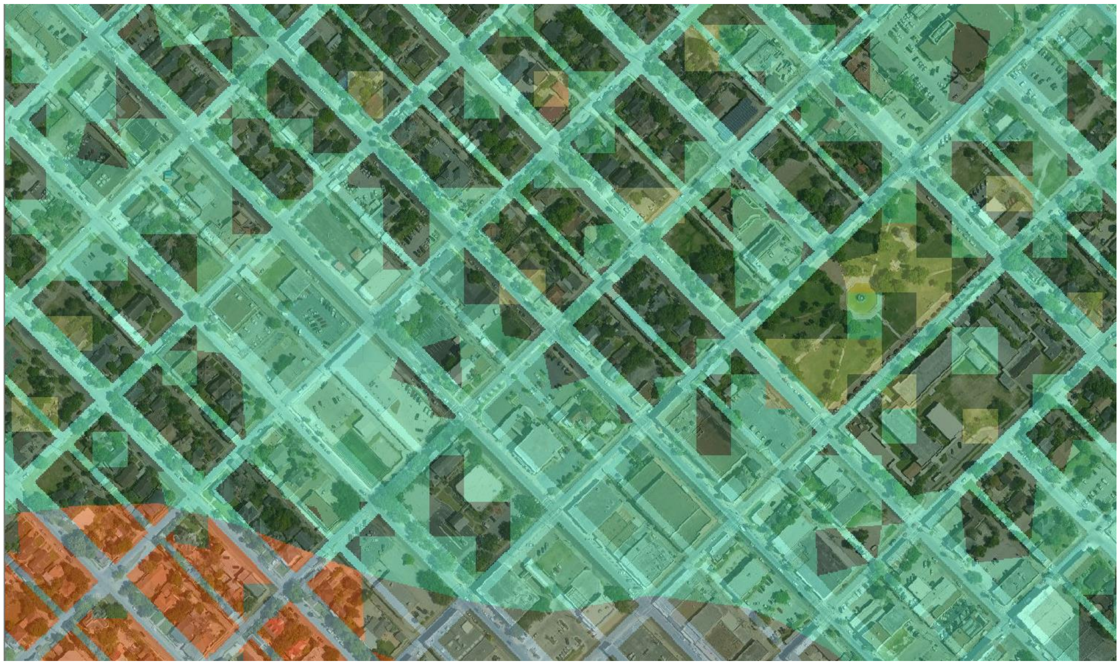

Figure 4.3 CN Layer Example

In HEC-RAS, the impervious percentage is attached to the Manning’s n layer. This layer was developed for the study using the latest aerial imagery for the specific purpose of obtaining a much higher resolution land cover to develop the Manning’s n raster. This was to facilitate more accurate hydraulic model development. **Figure 4.4** below is an example of the higher resolution land cover raster for the same area shown in CN layer figure above.

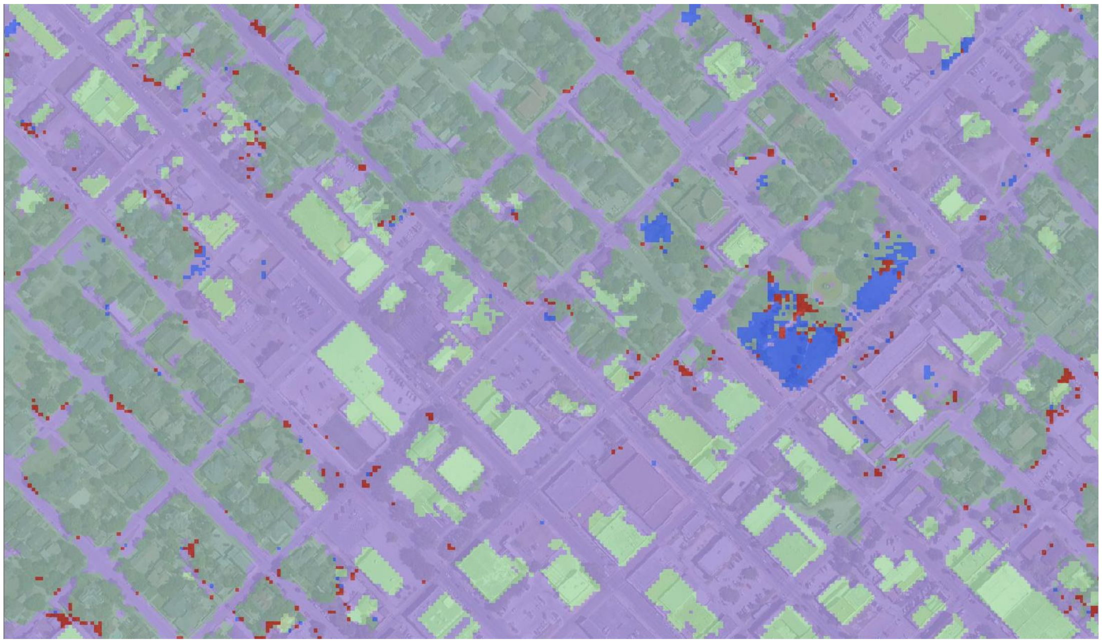

Figure 4.4 Land Cover (Impervious Percentage) Layer Example

Exhibit 5 in **Appendix A** shows the land cover developed for impervious percentage for the entire study area.

Initially, the impervious percentage value associated with each land cover type were based on average percentages calculated for the different land use types. However, a limitation of HEC-RAS 6.3.1 is that the infiltration rate for an entire 2D cell is based on the intersect of the center point of the cell with the underlying raster. So, the resolution of the 2D cell mesh does not capture the high resolution of the underlying raster. This resulted in some cells calculating high runoff if it intersected with a roof top and low runoff if it intersected with a patch of grass, regardless of the composite nature of the land cover enclosed within the cell. To account for this, the impervious percentages were heavily adjusted during calibration. The calibrated values are more a function of the resolution of the of the 2D cells than the actual expected impervious percentage of the land cover type. **Figure 4.5** is an example of how the 2D cells develop different runoff amounts for the same land cover type due to the resolution of the 2D cell center points.

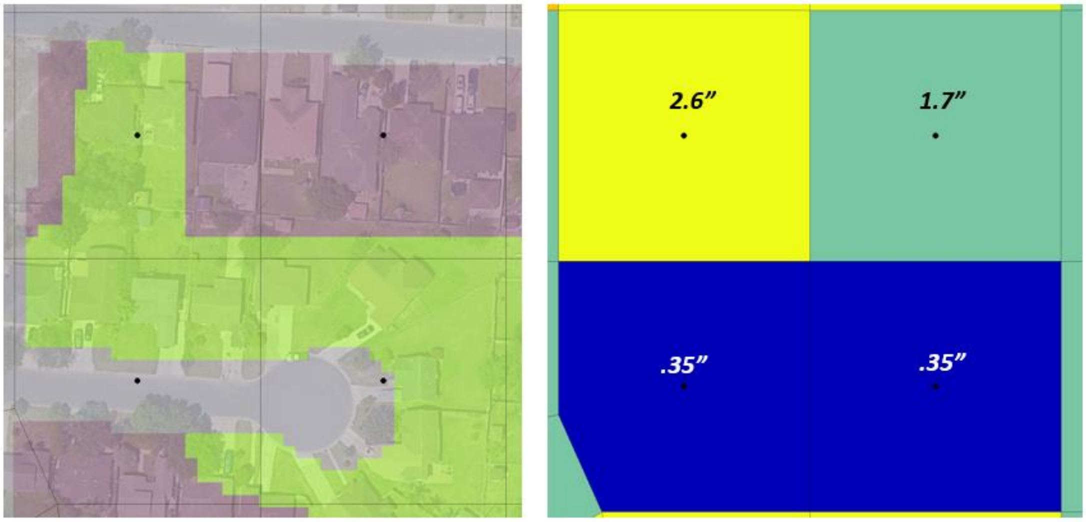

Figure 4.5 HEC-RAS Infiltration Example

Table 4.3 shows the final calibrated impervious percentages for the developed land cover types.

Table 4.3 Impervious Percentage to Land Cover Relationship

Land Cover Description	Impervious Percentage
Residential Lots	35
Developed Low Intensity	45
Developed Medium Intensity	55
Buildings	60
Open Water	60
Impervious	60
All Others	0

5 Hydraulic Analysis

As mentioned before, floodwaters flow from west to east through a complicated network of storm sewer, man-made drainage channels, and resacas before emptying into the Lower Bahia Grande/Laguna Madre or the Brownsville Ship Channel and then into the Gulf of Mexico. The complex network of man-made drainage conveyance systems, along with flat topography and elevated resacas create low-lying areas of heavy flooding throughout the entire study area. These low areas fill up with water during large storm events and the lack of conveyance on existing systems makes it exceedingly difficult for water to drain, causing significant flooding. A HEC-RAS 2D unsteady rain-on-mesh hydraulic model was developed for the entire study area to capture the complex flow patterns characteristic for this region and simultaneously capture both pluvial and fluvial flood risk. This model was used to determine and map existing flood risk for the entire study area and to evaluate the impacts and benefits of the proposed flood mitigation projects.

5.1 Model Development

HEC-RAS 6.3.1 was used to perform the hydraulic analysis. In addition to the basic features of 2D hydraulic flood modeling, this version of HEC-RAS also includes spatially varied infiltration (allows for hydrologic loss computations to be performed directly in the hydraulic model), spatially varied Manning’s n at cells faces (an upgrade from previous HEC-RAS versions), a historic rainfall boundary condition to allow for model calibration, and terrain modification tools to facilitate the development and troubleshooting of flood mitigation projects.

The study area was split into two separate hydraulic models (north and south) to manage model run times. **Exhibit 6** and **Exhibit 7** located in **Appendix A** show the limits and major components of each HEC-RAS model.

Because HEC-RAS does not explicitly model underground conveyances like storm sewers, a 1D/2D ICM model was developed for the downtown urban area between Town Resaca and the Rio Grande levees where runoff is primarily routed through a complex storm sewer network. This model was used as a check against the modeling results produced by RAS, especially during the development of the mitigation projects proposed in this area.

5.1.1 HEC-RAS 2-Dimensional Domain

The key features of a HEC-RAS 2D domain are the 2D mesh and breaklines.

5.1.1.1 2D Mesh

A 2D mesh consists of 2D cells that can model the flow of water in two dimensions. Each cell develops a stage-volume curve based on the underlying terrain and each cell face develops a stage-discharge curve based on the cell wall cross-section cut over the underlying terrain and the underlying Manning’s n layer. Combining these features, the model can simulate flow entering the cell from adjacent cells, calculate head loss across the cell, calculate the storage in the cell based on the amount of incremental inflow, and simulate flow leaving the cell into neighboring cells (see **Figure 5.1** as an example). This, in turn, results in a seamless 2D flow pattern.

The 2D mesh density varies in size for each watershed based on the size of the watershed in order to maintain manageable model run times. In general, a mesh size of 200'x200' was used for each 2D model.

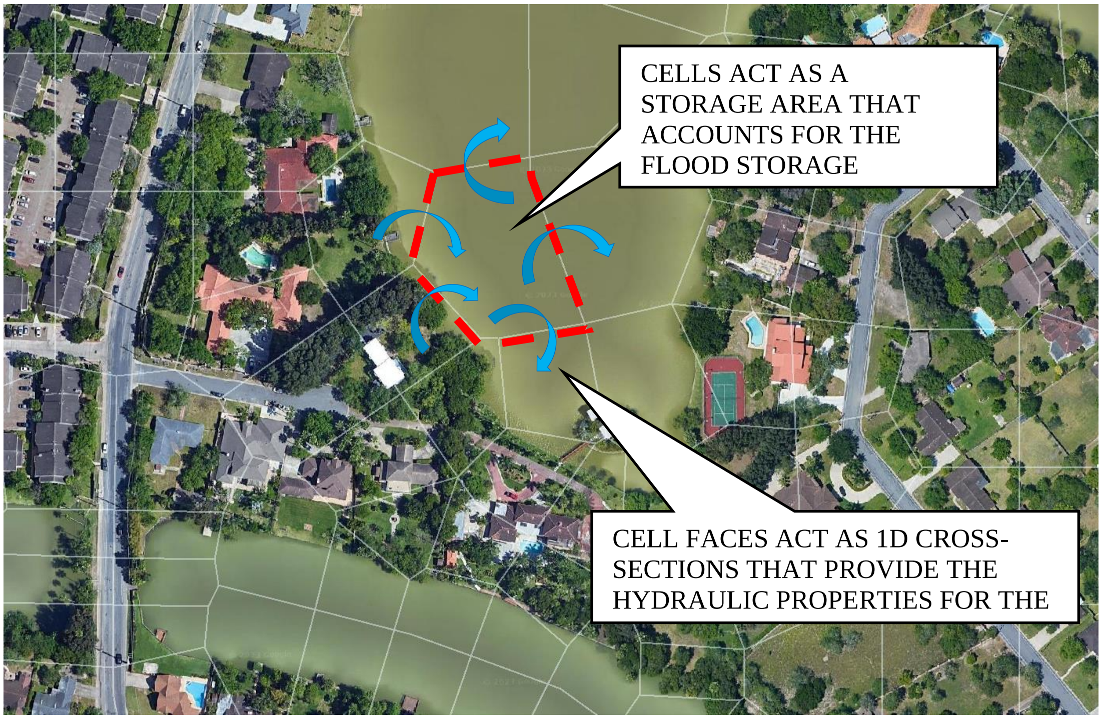

Figure 5.1 2D Mesh Example

5.1.1.2 Breaklines

Breaklines force the 2D cells within a mesh to align along the breakline. This gives the modeler flexibility in forcing cell faces to align in a particular direction, such as perpendicular to the channel flow line or parallel to a topographic ridge so that larger cell sizes can be used without losing the detail of the underlying terrain. Breaklines were added directly into RAS where a finer cell size was needed for a local region of the model and along berms and levees (roadways, dams, etc.) to properly account for these prominent topographic features. They were also placed along the bank of creeks to force the cell faces to be perpendicular to the direction of flow in high flow rate areas. See an example of typical breakline placement in **Figure 5.2.**

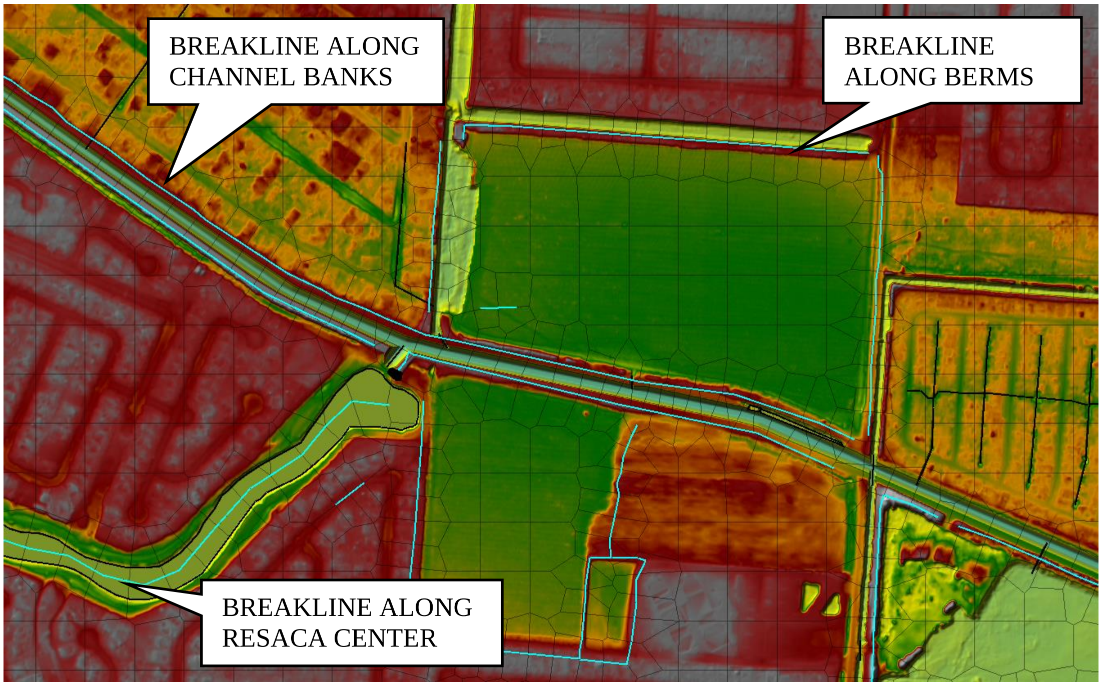

Figure 5.2 Breakline Example

5.1.2 HEC-RAS Boundary Conditions

As with any hydraulic model, boundary conditions are required for the simulation to properly account for flows entering and leaving the model. These typically include external points of inflow (flow hydrograph, precipitation, etc.) or outflow (normal depth slope, stage hydrograph, etc.). For this analysis, precipitation is the primary inflow boundary condition, and a stage hydrograph is the primary outflow boundary condition to model a static water surface elevation at the coast. However, other types of boundary conditions were used to connect the north and south models directly.

5.1.2.1 Precipitation

The hyetograph data produced by the hydrologic analysis is uniformly applied to the entire model. This is applied to each cell incrementally and the rate of application is based on the hyetograph intensity and the time step of the simulation.

For the calibration simulation, radar was used as the precipitation boundary condition (see **Section 1.1**)

5.1.2.2 Normal Depth

Normal depth boundary conditions were used along the edge of the models where there are potential overflows from one model to the neighboring model (i.e. from one watershed to another). This type of connection pulls flow from the upstream model based on normal depth slope conditions and sends this flow to the neighboring model as a flow hydrograph. As shown in **Figure 5.3**, the boundary conditions are placed on the downward slope instead of at the ridge, where the watershed boundary is located, so that the assumed normal depth condition could be better simulated. This method was only used in areas where flow from one model to the other is characterized as sheet flow.

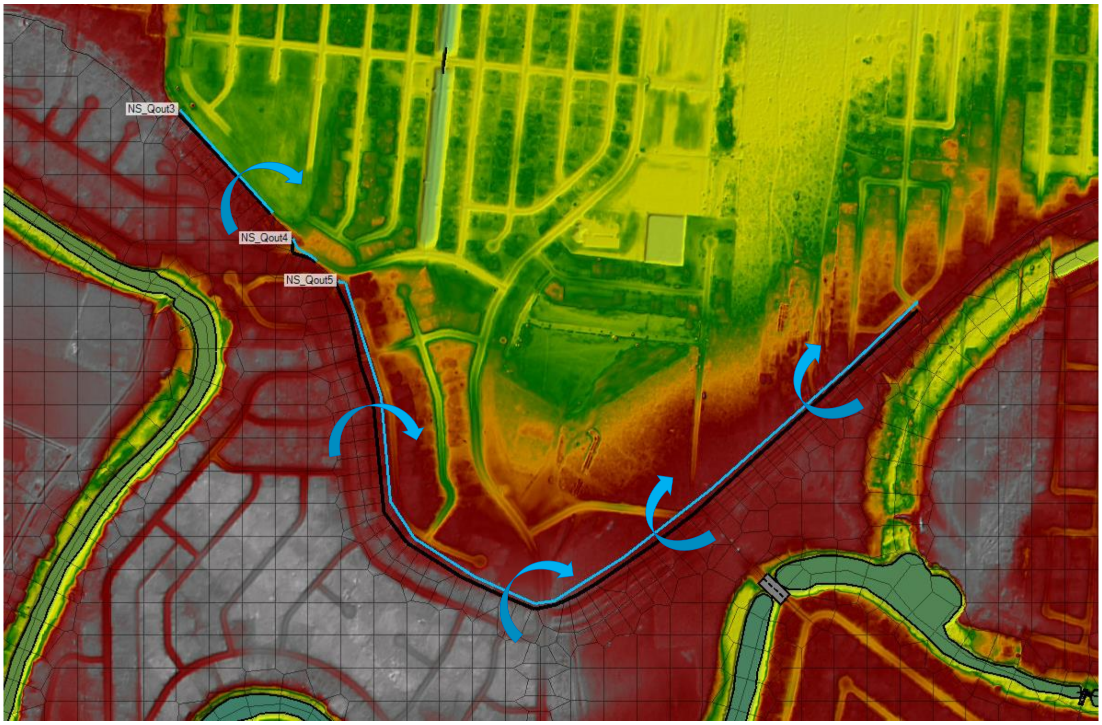

Figure 5.3 Normal Depth Slope Boundary Condition Example

5.1.2.3 Flow Hydrograph

Flow hydrographs are applied internally to the model to account for the sharing of flows between the two models. Flows being exported from a model using the normal depth boundary condition described above are imported into the neighboring model as flow hydrographs.

5.1.2.4 Stage Hydrograph

Stage hydrographs are applied as downstream boundary conditions along the Gulf where flow is ultimately leaving the study area. A static elevation of 0.85-ft was used based on the average tide elevation at the "Brazos Santiago Pass at South Padre Island, TX" gage. This was also the starting WSE for the gauges near the coast for the calibration event.

5.1.2.5 High Flow Model Coupling

The north and south models are connected on Cameron County Ditch 1 upstream of its confluence with Cameron County Ditch 2. At this interconnect, there are high flow rates within Cameron County Ditch 1 with substantial tailwater influences from the confluence downstream of the connection in the north model. To adequately account for the tailwater influences on the flow passing from south model to the north model, stage hydrographs were pulled from the north model and applied to the south model. Flow hydrographs were then pulled from the south model and applied to the north model to account for the flow transfer. Since the flow across the connection can influence both the headwater and tailwater in both models, this process of applying the hydrographs was iterated until the stage hydrograph substantially converged. **Figure 5.4** shows how this connection is configured in the model.

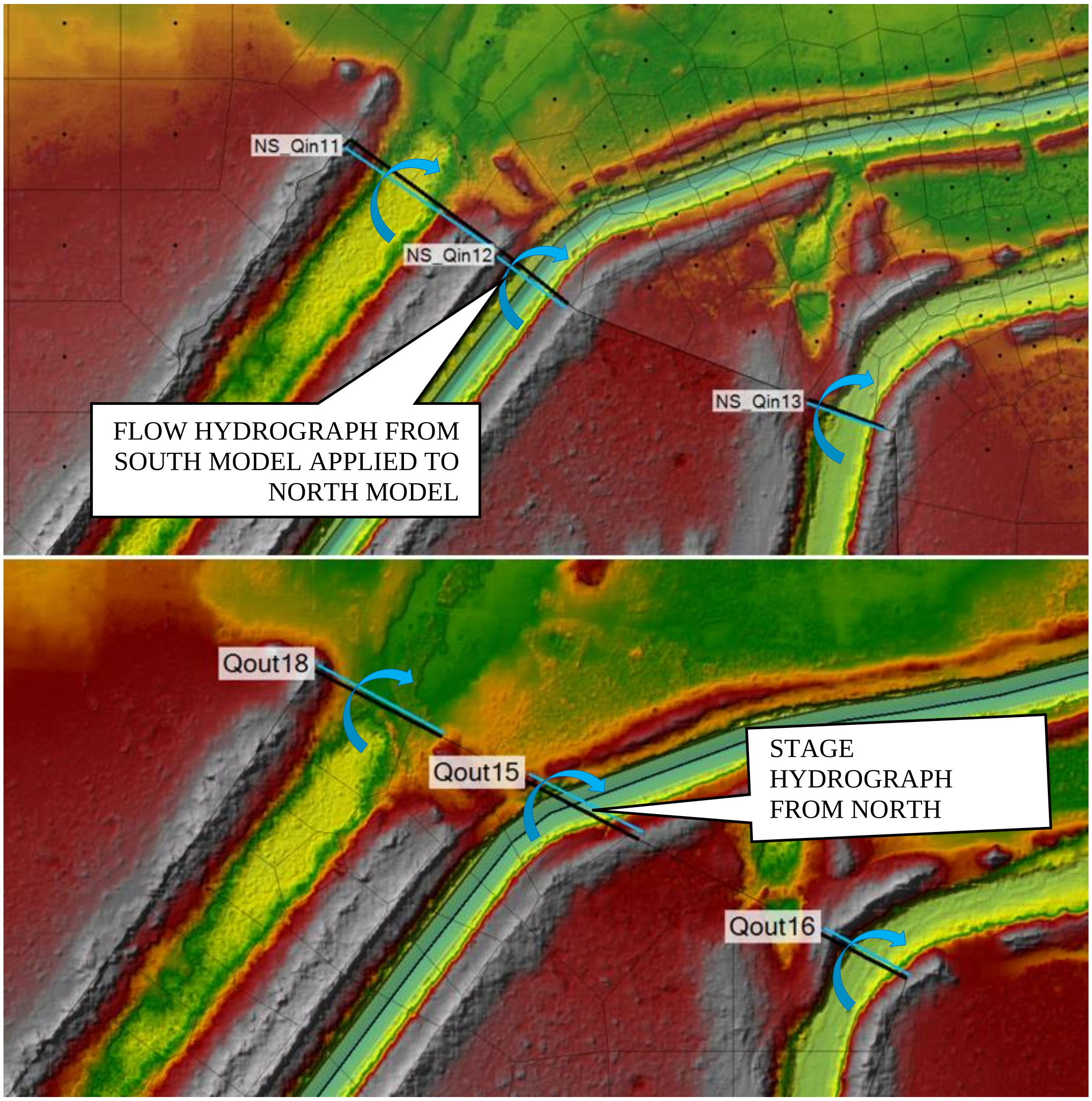

Figure 5.4 High Flow 2D Model Coupling Example

5.1.3 HEC-RAS Initial Conditions

Initial conditions were used primarily to establish standing water elevations at the beginning of the simulation. This was particularly necessary within the resacas, where the amenity levels are maintained by an outlet structure, to ensure the resacas are filled to the amenity water surface at the beginning of the simulation (see example in **Figure 5.5**). Initial conditions were also used to ensure that the water surface for the portion of the model near the coast starts at the assumed tidal elevation at the beginning of the simulation.

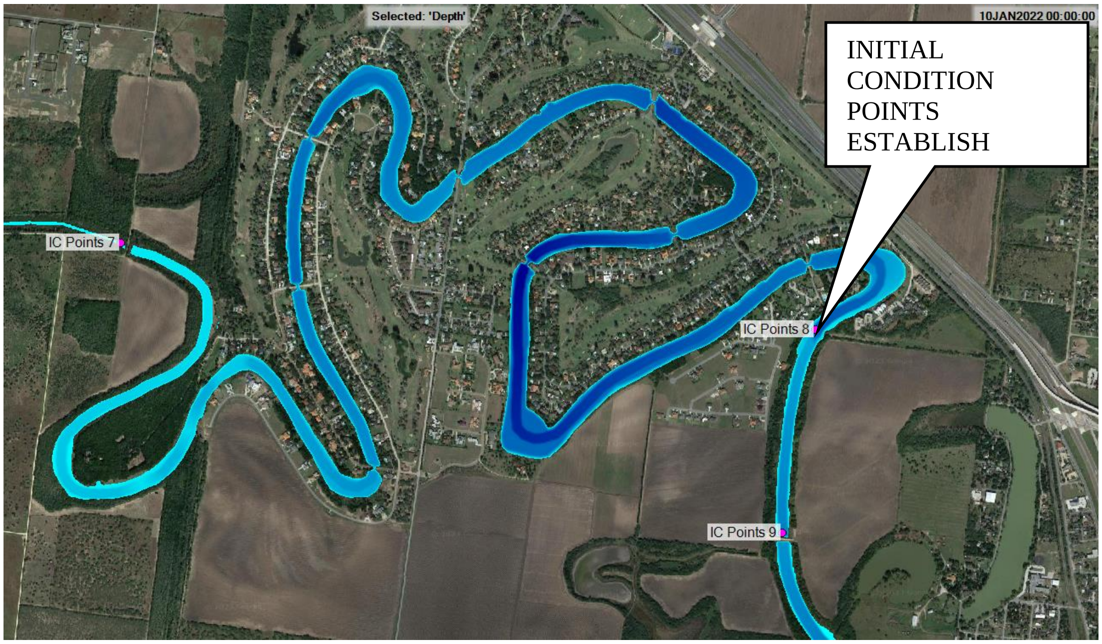

Figure 5.5 Initial Conditions Example

5.1.4 HEC-RAS Terrain

The terrain data in the hydraulic model was developed using light detection and ranging (LiDAR) topographic data acquired from the United States Geological Survey (USGS).

5.1.4.1 2018 LiDAR

For this analysis, the primary topographic source to develop the terrain is the South Texas LiDAR dataset from 2018 which covers all of Cameron County. The dataset is at a resolution of 3-ft x 3-ft and provides a single elevation at each pixel. The RAS model uses this data to develop elevation-volume curves for each cell as well as cross-sectional profiles for each cell face based on the resolution of the terrain grid.

LiDAR technologies have limitations such as diminished accuracy in areas with dense vegetation, inability to gather bathymetric topography (such as in ditches with standing water), and inability to capture the culvert openings underneath roadways. To compensate for these limitations, in-field topographic survey was obtained and incorporated into the base terrain.

5.1.4.2 Terrain Conditioning – Culverts

Since culverts are not picked up in the base terrain model, most culverts within the study area were incorporated into the model as 2D connections. However, in low population areas where it was not critical to obtain survey but still important to incorporate into the model, the terrain was modified (i.e., “burned away”) in these locations to estimate the opening size of the culvert. For instance, as shown in **Figure 5.6**, a vertical section is stripped from a roadway to account for the culvert across the road. The size of the burn strips were chosen to be a smaller width than the culvert to reflect the true open area and thereby approximate the hydraulic losses across the culvert.

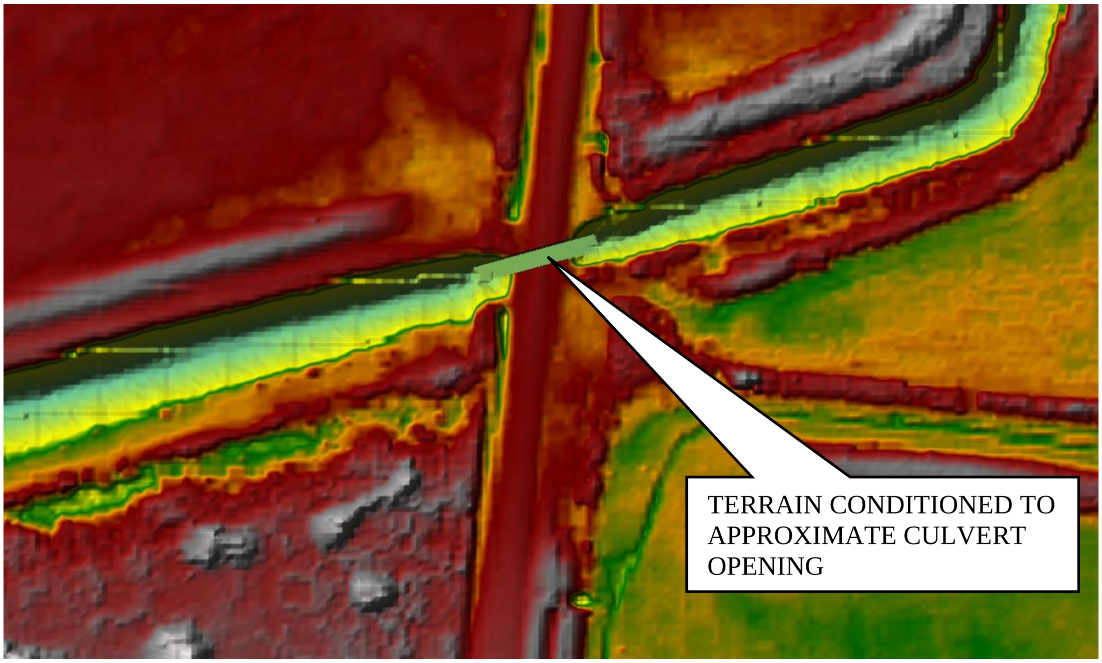

Figure 5.6 Terrain Culvert Conditioning Example

5.1.4.3 Terrain Conditioning – Storm Sewer

Like culverts, storm sewer pipes are also not captured by the LiDAR. In most instances, storm sewer networks were included in the model by incorporating them as 2D connectors, or more commonly, by modifying the terrain to "burn away" the terrain to approximate the positive conveyance that is being provided for the storm sewer (see Figure 5.7). Without any type of approximation of storm sewer, the rain-on-mesh modeling approach overestimates the amount of storage and attenuation of flood waters in developed areas due to lack of routing of urban flow where storm sewer networks are providing a substantial amount of routing of runoff to the major creeks and channels. After review of the initial modeling results, areas of potentially high flood risk due to conveyance restriction in the storm sewer network were modeled as 2D connectors. For one area, downtown Brownsville between Town Resaca and the Rio Grande, a full 1D/2D model was developed in ICM to ensure the storm sewer was being modeled and approximated sufficiently.

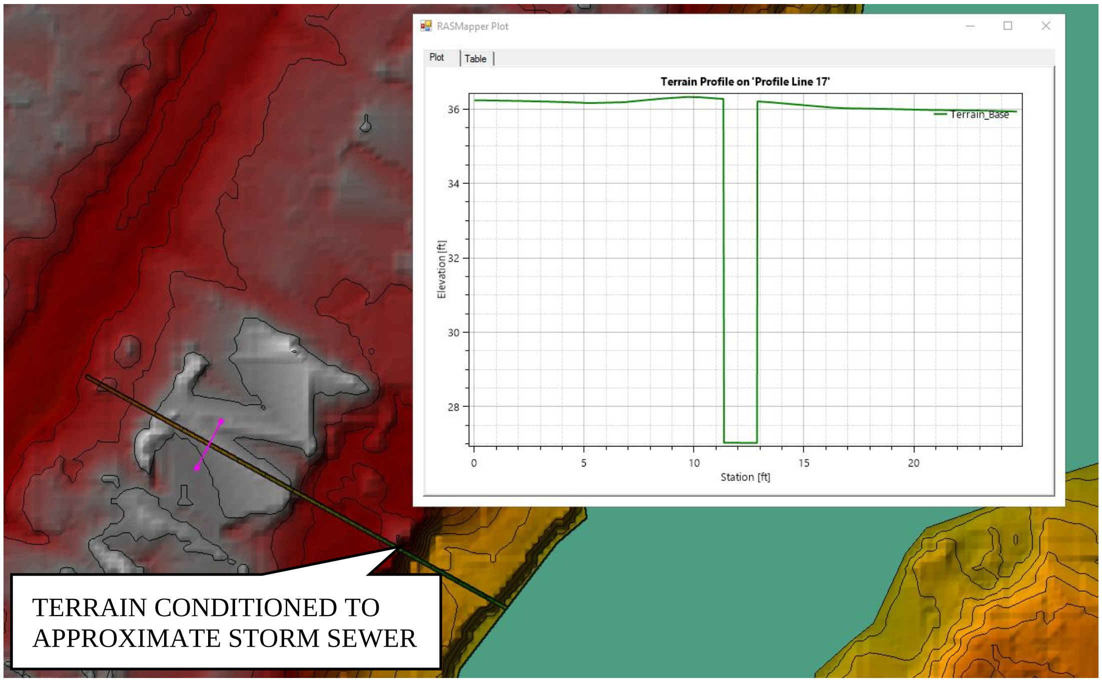

Figure 5.7 Terrain Storm Sewer Conditioning Example

5.1.4.4 Terrain Conditioning – Channels

Due to their proximity to the coast and flat topography in the region, many of the channels have permanent standing water on the bottom of the channel (as much as a few feet in places). Since channels are the backbone of the conveyance system in this region, it is critical to have an accurate representation of the full channel geometry incorporated into the model. In-field survey was obtained for most major channels.

Where survey was not obtained, channel flow lines were either interpolated between survey points, or modified based on the flow lines provided in previous study models.
Figure 5.8 shows an example of a channel that was surveyed and incorporated into the base terrain model.

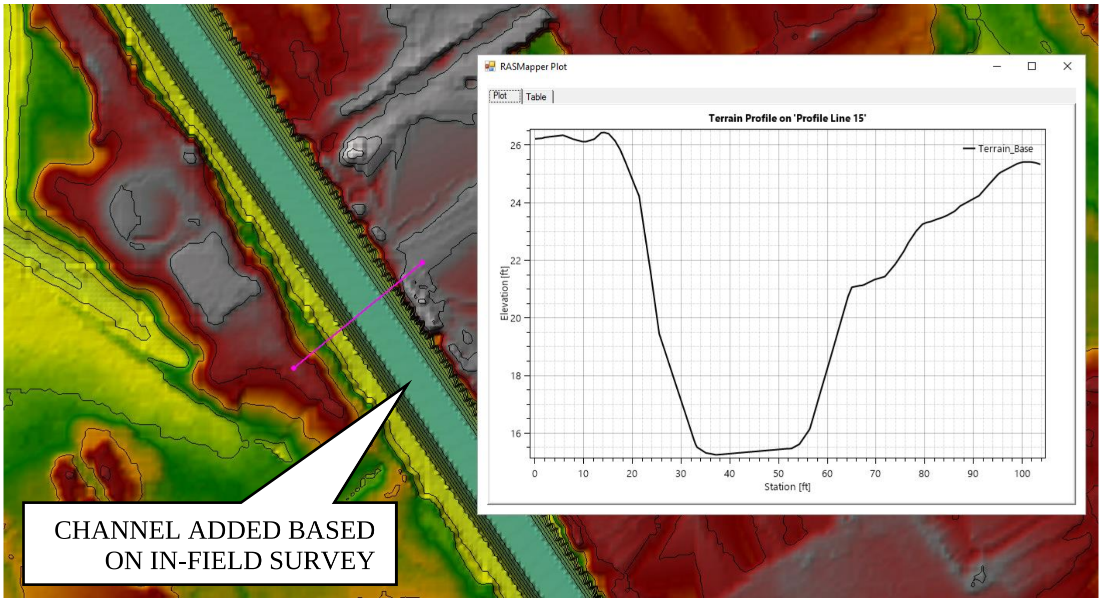

Figure 5.8 Terrain Channel Conditioning Example

5.1.4.5 Terrain Conditioning – Resaca

Most of the resacas are maintained as amenity ponds or lakes but also provide some amount of drainage conveyance. To account for the full cross-sectional area of each resaca in the conveyance calculations, the resacas were "burned away". Based on previous studies, it was assumed that most resacas are at least 5-feet deep. The footprint of the amenity level of each resaca was, in turn, burned down by 5-feet as shown in **Figure 5.9**.

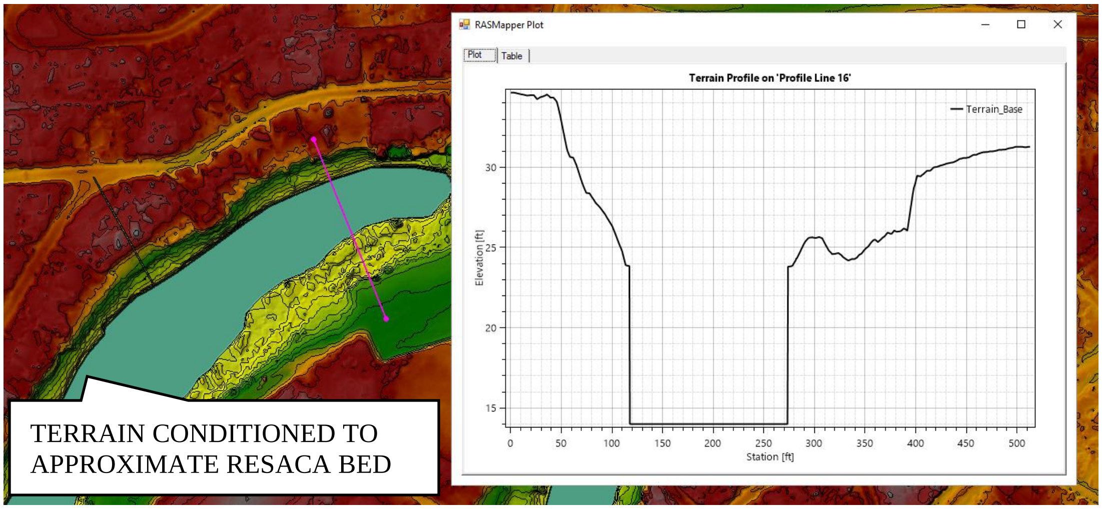

Figure 5.9 Terrain Resaca Conditioning Example

5.1.5 HEC-RAS Infiltration

Further discussed in Section 4.2, infiltration layers were developed based on the NRCS CN method to calculate rainfall infiltration and, in turn, runoff. Two layers were developed, one for

CN to calculate infiltration into the soil and the other for impervious percentage. These two layers are brought into RAS as a map layer and each 2D cell calculates runoff for the entire cell area based on the information provided by the underlying land cover layers. These two layers are shown in **Exhibit 4** and **Exhibit 5** which are located in **Appendix A**.

5.1.6 HEC-RAS Manning's 'n'

A Manning's n roughness map layer was developed for the 2D mesh based on a land cover raster developed using the latest aerial imagery available for the region. This layer is shown in **Exhibit 5** located in **Appendix A**.

With version 6.3, HEC-RAS can capture a high level of detail in the 2D cell face from the underlying manning's n layer using the "Spatially Varied Manning's n on Faces" feature. Previous versions of HEC-RAS can only pull in a single manning's n value for an entire cell face based on the intersect of the mid-point of the 2D cell with the underlying land cover map layer. This new feature now captures the high level of detail by developing a manning's n verse flow depth curve where the manning' n value at a particular depth is the weighted average of the manning's n at that depth. With this higher level of accuracy, it was appropriate to develop a map layer that captures a higher level of detail in the land cover than is provided by the NLCD.

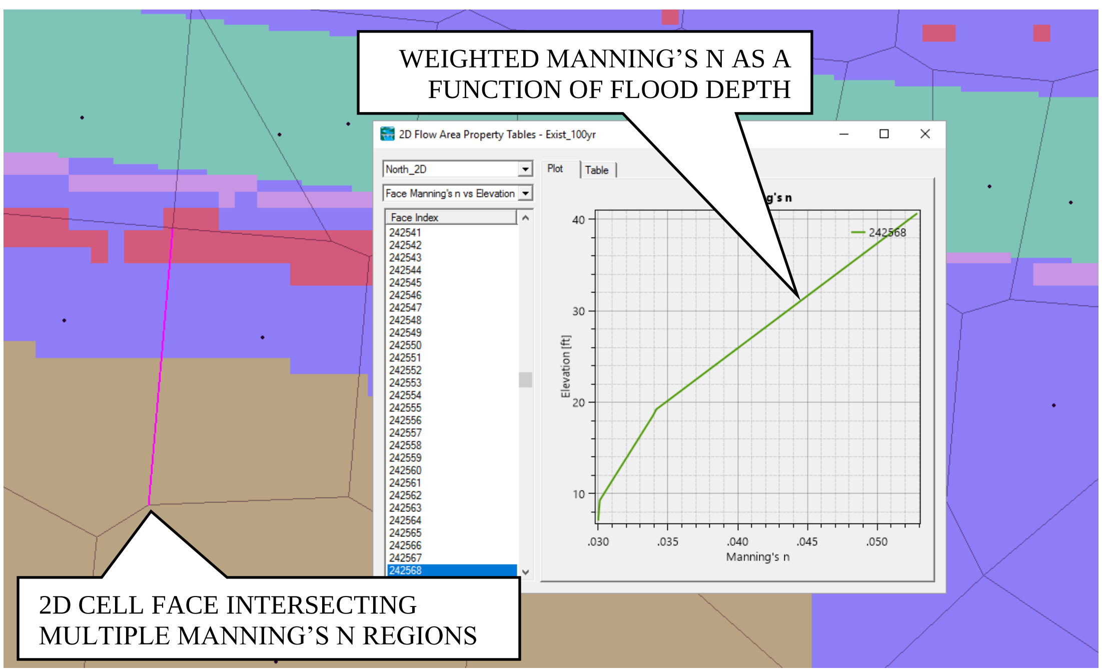

Figure 5.10 Weighted Manning's N On Cell Face Example

In urban areas, buildings often inhibit the flow of water but still provide floodplain storage if inundated. To account for this, the Manning's n layer for areas such as residential developments typically have a higher value. For this study, it was decided that additional detail needed to be provided for commercial areas where there are often large open parking areas that may have a low Manning's n but are inaccurately weighted high due to the large buildings on the site. Therefore, commercial developments were given a lower Manning's n to reflect the parking lots and any buildings were given a much higher value. The high value for buildings allows for the precipitation to be applied to the building area and be allowed to drain out of the cell while still providing enough friction to mimic the inhibitive effects of the building during high flood conditions. **Figure 5.11** shows this application to the manning's n layer.

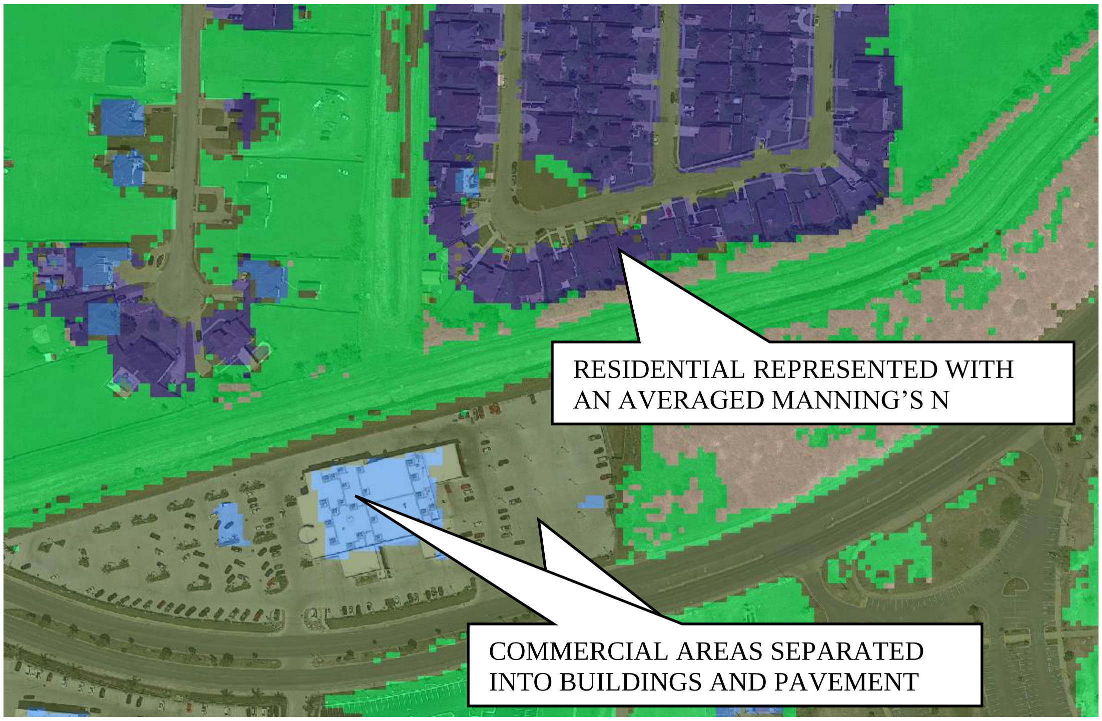

Figure 5.11 Commercial Versus Residential Manning's 'n' Layer Example

Since Manning's n is typically lower for higher flow depths, it is standard practice in 1D modeling to use a lower Manning's n values for the channel and a higher Manning's n for the shallower overbanks for the same land cover type. This same approach was used when developing the 2D model. The map layer was manually adjusted, using classification polygons, to classify the channels so that a lower Manning's n value could be applied to the channels (see **Figure 5.12** for an example of the application of the channel classification).

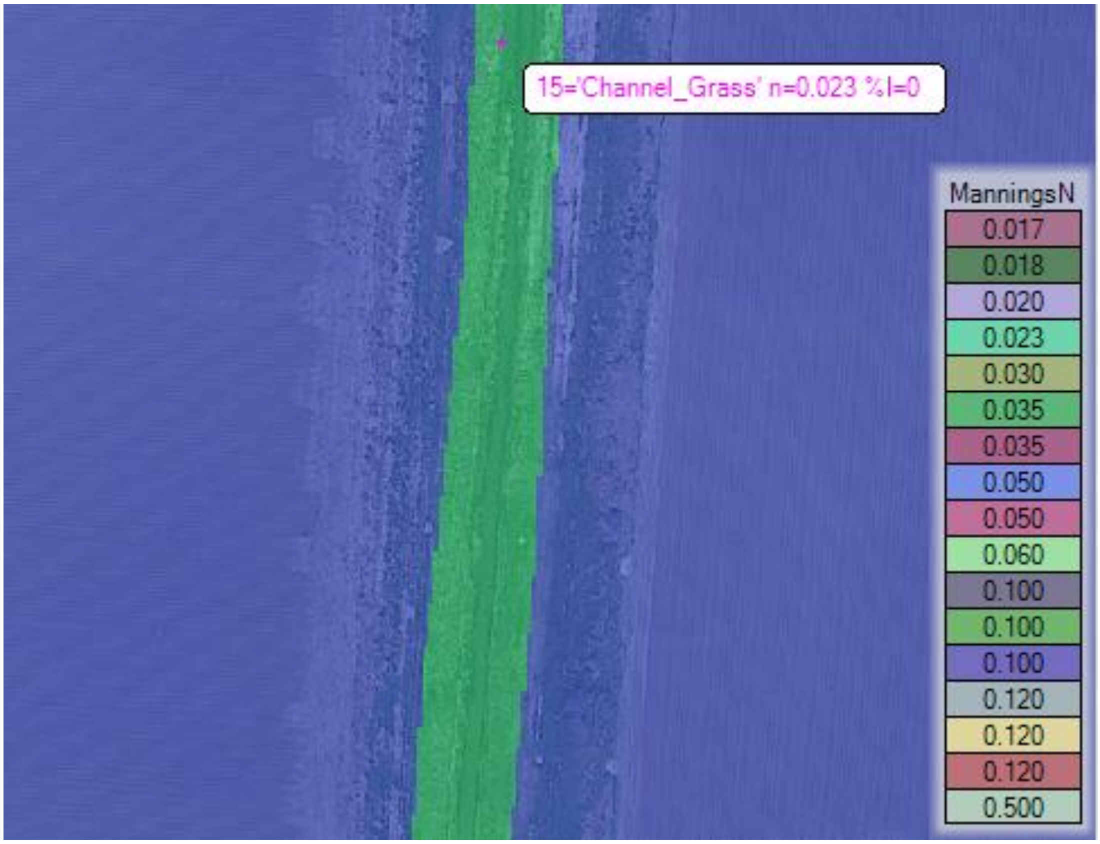

Figure 5.12 Channel Manning's 'n' Classification

After classification was complete, Manning's n values were applied to the land cover classification. Traditional and established values for riverine analyses found in engineering textbooks were used for both the channel and the overbank values. Typically, a separate classification is used for the areas of the watershed where flow is very shallow (less than 2-inches) to account for the hydrologic routing of shallow runoff in the upper parts of the watershed. However, a sensitivity analysis was done during the calibration process, and it was determined that the conditions of this region were such that the calibration was not sensitive to a higher Manning's n value in these shallow regions. For sake of simplicity, a shallow Manning's n classification was disregarded.

These values were adjusted during calibration, with an emphasis on the channel values where flow is highest and water surface elevation is most sensitive to variation in Manning's n values. **Table 5.1** shows the final calibrated manning's "n" values used in the hydraulic modeling.

Table 5.1 Final Manning's "n" Values

Land Cover Classification	Manning's "n" Value
Concrete Channel	0.017
Concrete / Grass Channel	0.018
Grass Channel	0.023
Shrub Channel	0.035
Buildings	0.50
Cultivated Crops	0.05
Dense Trees-Vegetation	0.12
Developed Grass Areas	0.06
Developed Low Intensity	0.10
Developed Medium Intensity	0.12
Forest	0.10
Impervious Areas	0.02
Open Water	0.03
Residential Lots	0.12
Shrubland	0.06
Wetlands	0.10

5.1.7 HEC-RAS 2D Connections

HEC-RAS uses 2D connections to model structures such as bridges and culverts within the 2D mesh. Most bridges and culverts were modeled using 2D connections based on field survey data. Where survey was not available, information obtained from previous studies or field visits were used to input these structures into the model. The 2D connections only span the channel portion of the crossing (see example shown in **Figure 5.13**) since the 2D equations are sufficient to model the crossing's overbanks (typically roadways).

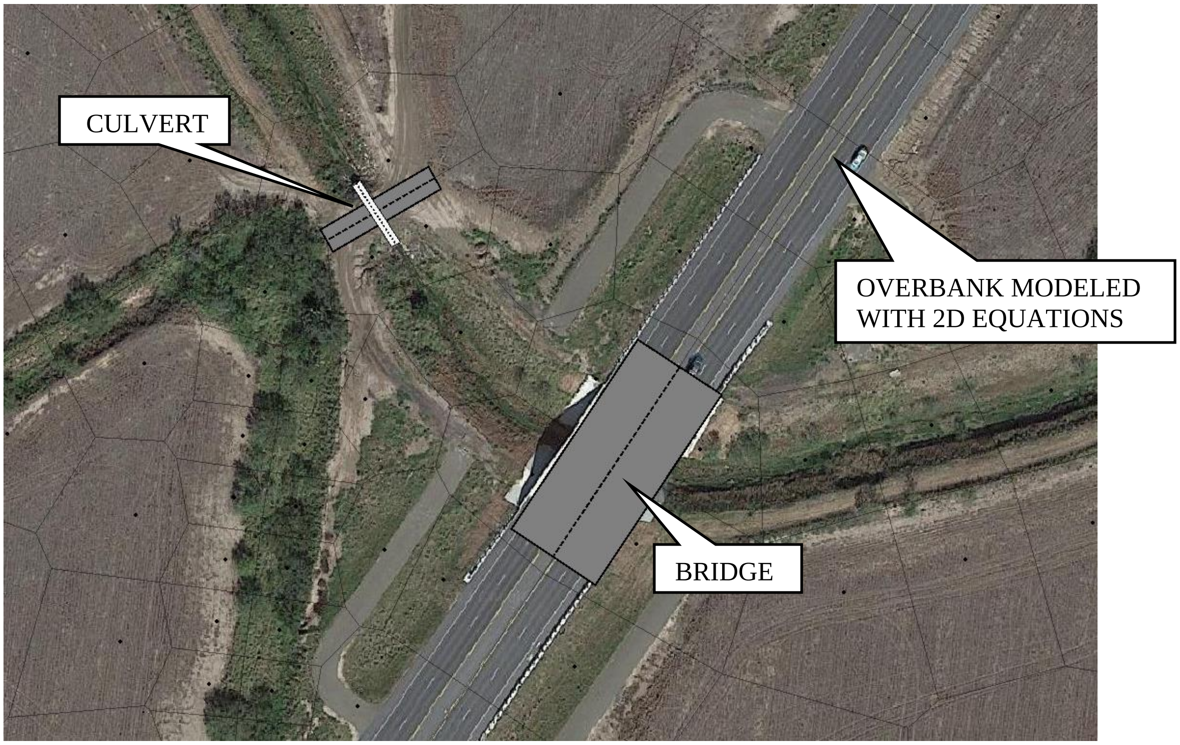

Figure 5.13 Bridge and Culvert 2D Connection Example

HEC-RAS does not have the capability to model storm sewer networks including inlet conveyance capacity. In order to approximate flow in some of the highly urban areas, many of the storm sewer trunklines were modeled with 2D connections using culvert equations to approximate friction losses while neglecting minor losses (see **Figure 5.14**). The primary intent of this approach was to ensure proper hydrologic routing through the urban areas and secondarily to ensure that pluvial flooding was not overestimated due to lack of a modeled storm sewer network.

As discussed above, an ICM model was developed for the critical urban area located between Town Resaca and the Rio Grande to ensure that the hydraulic results and the projects developed for this area are appropriate.

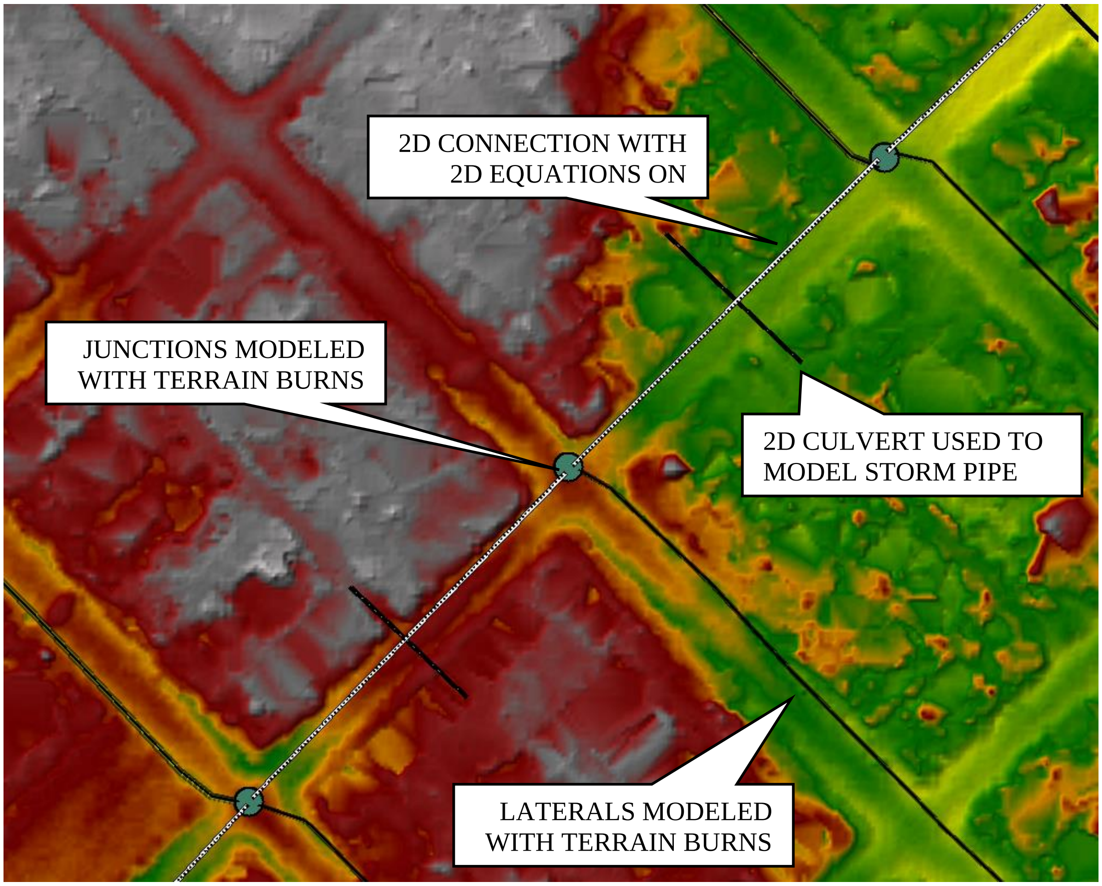

Figure 5.14 Storm Sewer Trunk Line 2D Connection Example

6 Model Calibration and Results

Calibration is a necessary part of model development to ensure that the assumptions and model development methodologies result in a model that can adequately approximate real-world flood conditions. Calibration also gives confidence to the accuracy of the flood results produced by the model and ensures the flood mitigation projects evaluated with the model will perform as intended and provide the desired flood risk reduction after construction.

The calibration process consists of gathering and analyzing historic gauge data (where available), comparing the results of the model against the historic gauge data, and adjusting model parameters until the results of the model approximate the data provided by the gauges.

The calibration is only as good as the gauge data that is available. In this case, several gauges are located on several channels located in the southern portion of the watershed where the most densely populated areas are located. However, most of these gauges are only a few years old limiting the data available for calibration.

The calibrated models were then used to simulate synthetic rain events for the 10%, 4%, 2%, 1% and 0.2% annual chance events. These synthetic storm event simulations were then used to develop high-level flood risk mapping and to support flood mitigation project development.

6.1 Calibration

A storm that occurred in May of 2022 was used to calibrate the model. The gauges recorded approximately 4.6 inches of rain during a 24-hour period. The most intense period of this storm roughly matched the intensity of a 20% annual chance event. This storm was selected for calibration since it is the highest intensity storm during the short period of record.

6.1.1 USGS Gauges

Seven gauges, managed by the USGS, provide precipitation data and stage information for main streams throughout the study area but are primarily concentrated around the most populous region of Brownsville. Six of the seven USGS gages in the HUC-10 were used for calibration. The seventh gauge was not used due to lack of available data. **Figure 6.1** and **Table 6.1** summarizes the location of the gauges used in the calibration effort.

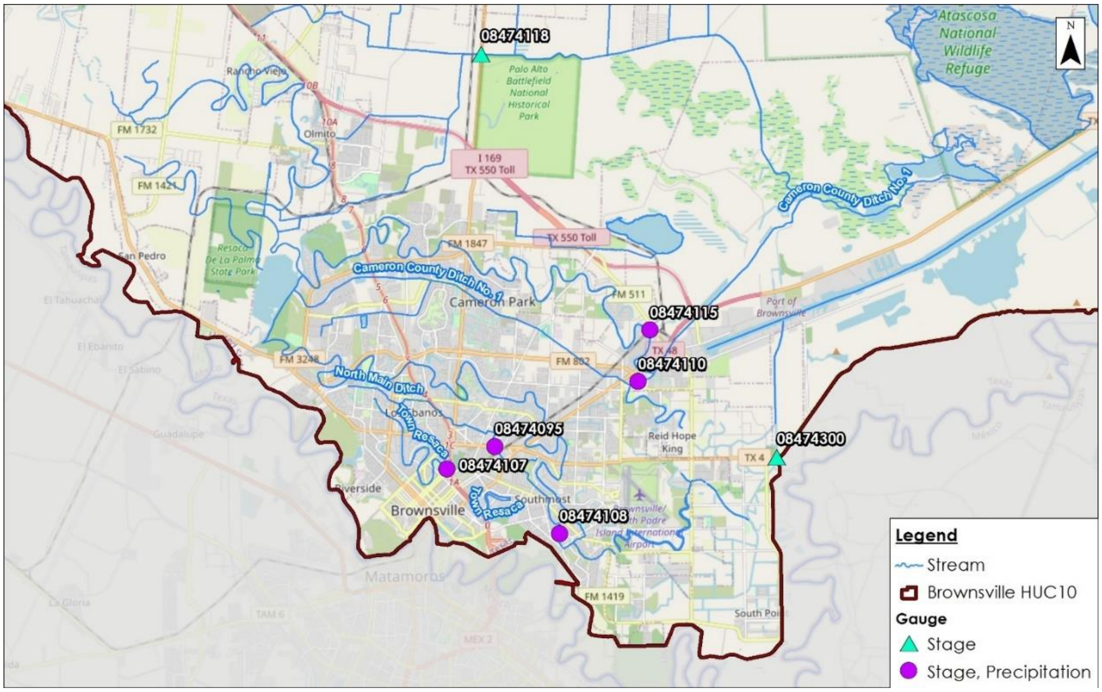

Figure 6.1 USGS Gauge Locations

Table 6.1 Summary of USGS Gauges Used for Calibration

Gauge Number	Gauge Name	Stream Name	Installation Date	Type
08474118	Cameron Co Ditch 2 at FM 1847	Cameron County Ditch No. 2	8/10/2021	Stage
08474110	Cameron Co Ditch 1 at FM 802	Cameron County Ditch No. 1	6/10/2021	Precipitation / Stage
08474107	Town Resaca at E 6th St	Town Resaca	4/27/2022	Precipitation / Stage
08474095	N Main Drain at Boca Chica Hwy	North Main Drain	2/11/2022	Precipitation / Stage
08474108	N Main Drain at Manzano St	North Main Drain	2/10/2022	Precipitation / Stage
08474300	Old Main Drain No 2 at SH 4	Old Main Drain No. 2	10/06/2021	Stage

6.1.2 Calibration Process

The May 2022 storm event rainfall data was incorporated into the hydraulic model using gridded rainfall. Since the rain-on-mesh model methodology was used for this study, the high spatial resolution provided by the gridded radar data (when compared to the point rainfall data provided by the USGS gauges) could be translated to high spatial resolution in runoff computed by the model resulting in more accurate calibration.

Figure 6.2 shows the maximum accumulated rainfall produced by this storm event.

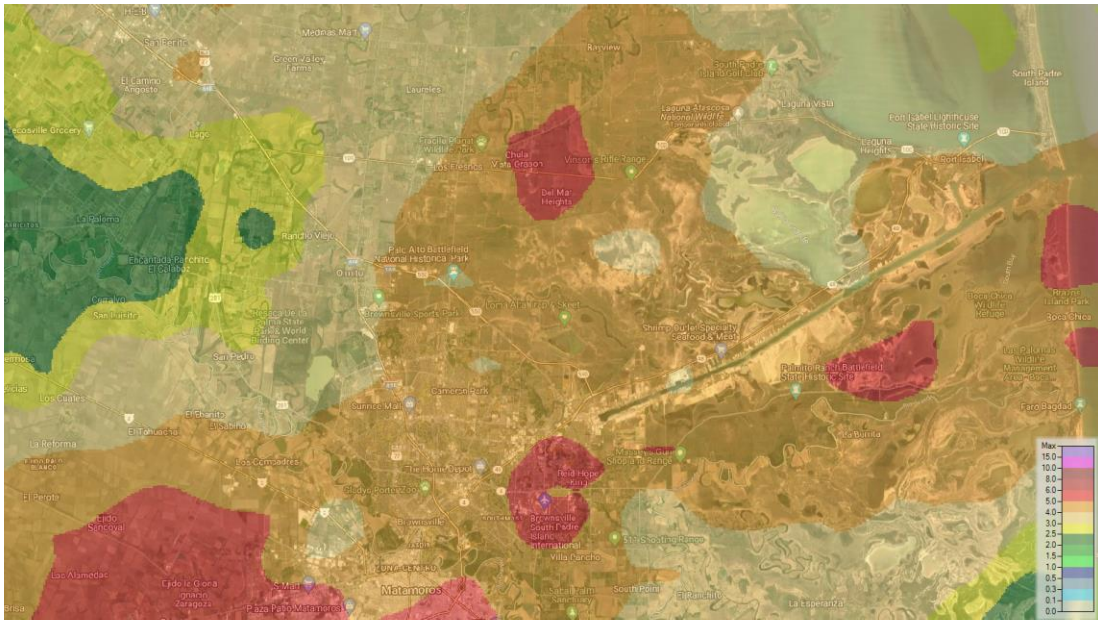

Figure 6.2 Max Rain Accumulation of the May 2022 Event

To ensure the accuracy of the radar data, the rainfall applied to the model at the location of each gauge was compared to the rainfall that the gauges recorded. As shown in **Figure 6.3**, the recorded gauge rainfall closely matches the rainfall applied to the model.

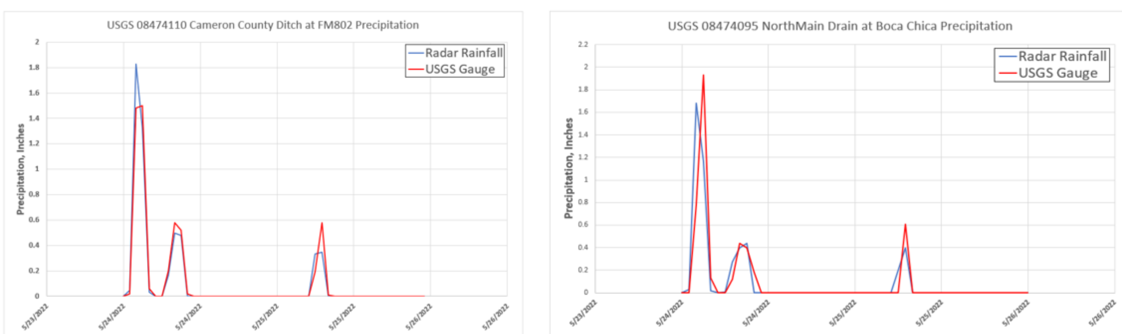

Figure 6.3 Radar Grid Data Compared to USGS Data

As previously mentioned, the USGS gauges provide stage hydrographs depicting water levels during storm events, typically near road crossings. These readings were compared against the stage hydrographs from the hydraulic model. Model parameters were iteratively adjusted until the stage hydrographs within the model approximated the gauge stage data. The stage in the model was most sensitive to infiltration rates (CN coupled with impervious percentage) and the Manning's n values for the channel. Therefore, model adjustments were primarily focused on these two parameters.

It was also noted that the accuracy of the rising limb of the stage hydrographs was highly dependent on the ability of the urban areas to route flows to the channels. The more detail added to the storm sewer networks in the urban areas, the more closely the rising limb of the hydrograph and the timing of the crest of each “hump” in the hydrograph matched the gauge data.

6.1.3 Calibration Results

The calibration goal was to have a model that produces stages that are within 0.5 feet of the observed stage for all six gauges using model parameters that fell within standard acceptable ranges.

Figure 6.4 shows examples of the calibration results for two of the gauges. **Table 6.2** provides a summary of the calibration results for all the gauges. The full calibration results can be found in **Appendix B**.

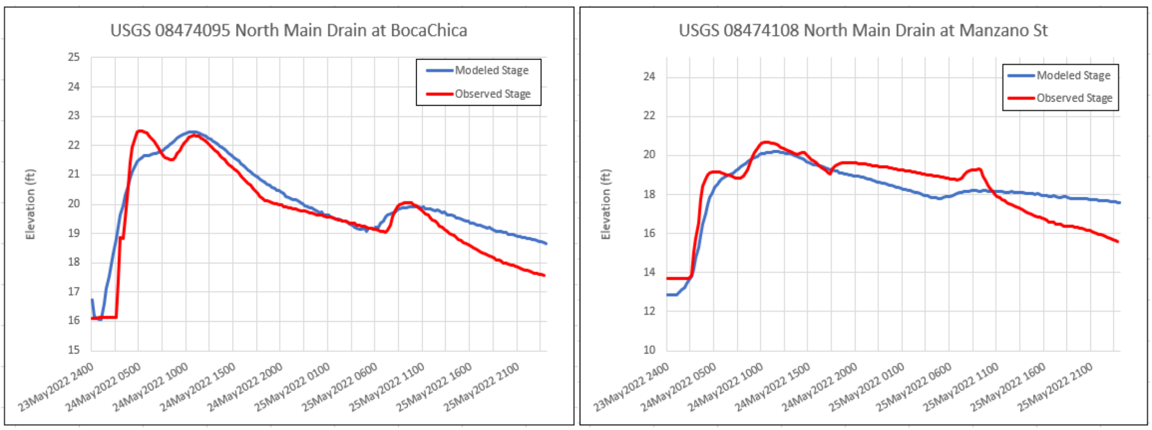

Figure 6.4 Stage Hydrographs: Calibrated Model VS USGS Gauges

Table 6.2 May 2022 Storm Observed VS Modeled WSE Summary

Gauge Number	Gauge Name	Modeled Stage (ft)	Gauge Stage (ft)	Difference (ft)
08474118	Cameron Co Ditch 2 at FM 1847	8.18	8.04	0.14
08474110	Cameron Co Ditch 1 at FM 802	9.74	9.25	0.49
08474107	Town Resaca at E 6th St	23.85	24.26	-0.41
08474095	N Main Drain at Boca Chica Hwy	22.64	22.51	0.13
08474108	N Main Drain at Manzano St	20.5	20.67	-0.17
08474300	Old Main Drain No 2 at SH 4	5.95	5.49	0.46

6.2 Synthetic Storm Simulation

The calibrated parameters were then used to simulate synthetic flood events. Synthetic rainfall for the 10%, 4%, 2%, 1% and 0.2% annual chance events (see Section 4.1) was uniformly applied to the unsteady 2D rain-on-mesh hydraulic model. This computed runoff from this rainfall is routed hydraulically through the model to produce synthetic fluvial and pluvial flood depths at each time interval of the simulation for the entire study area and for each storm event. These simulations act provide a base existing condition from which to model and compare project alternatives and estimate project benefits and impacts. The results of the simulation are summarized with the 1% annual chance event flood depth maps provided in **Appendix C**.

7 Alternatives Analysis

Potential flood mitigation projects were developed for ten areas with high flood risk. These projects were evaluated to determine project capital cost, flood risk benefit, and to ensure no adverse impact to neighboring properties. These projects have been submitted to the regional state flood planning group for consideration in the State Flood Plan.

These projects are conceptual in nature and will likely change in scope, cost, benefit, etc. as they progress through design and construction. However, this conceptual analysis is a first step to identifying projects and will give planners and decisionmakers a better understanding of the resources needed to mitigate these high flood risk areas so that action can be taken to plan for these projects. Finally, it gives stakeholders important information that will make them competitive for grant funding to help pay for these projects.

7.1 Problem Area Identification

Before developing flood mitigation projects, a flood risk evaluation was performed for the entire study area to identify the areas with highest flood risk (i.e., “problem areas”) where there is the strongest need for flood mitigation projects.

Ten problem areas were identified and ranked based on 3 categories: 2D modeling results, stakeholder identification, and historical data such as flood insurance claims and drainage complaints.

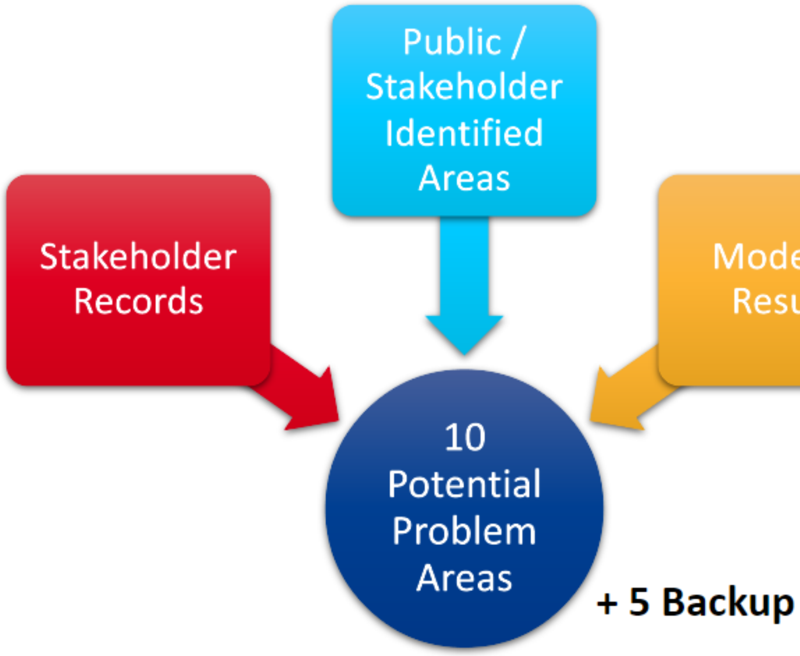

Figure 7.1 Problem Area Identification

Residential and commercial structures were classified as having low, medium, or high flood risk based on the depth of flooding at each structure as shown in **Figure 7.2**. Slab on grade structures were assumed to have a finished floor elevations (FFE) that is 6-inches above natural grade and modular homes were assumed to have a FFE that is 1.5-feet above natural grade, with natural grade based on the 2018 LiDAR topographic data.

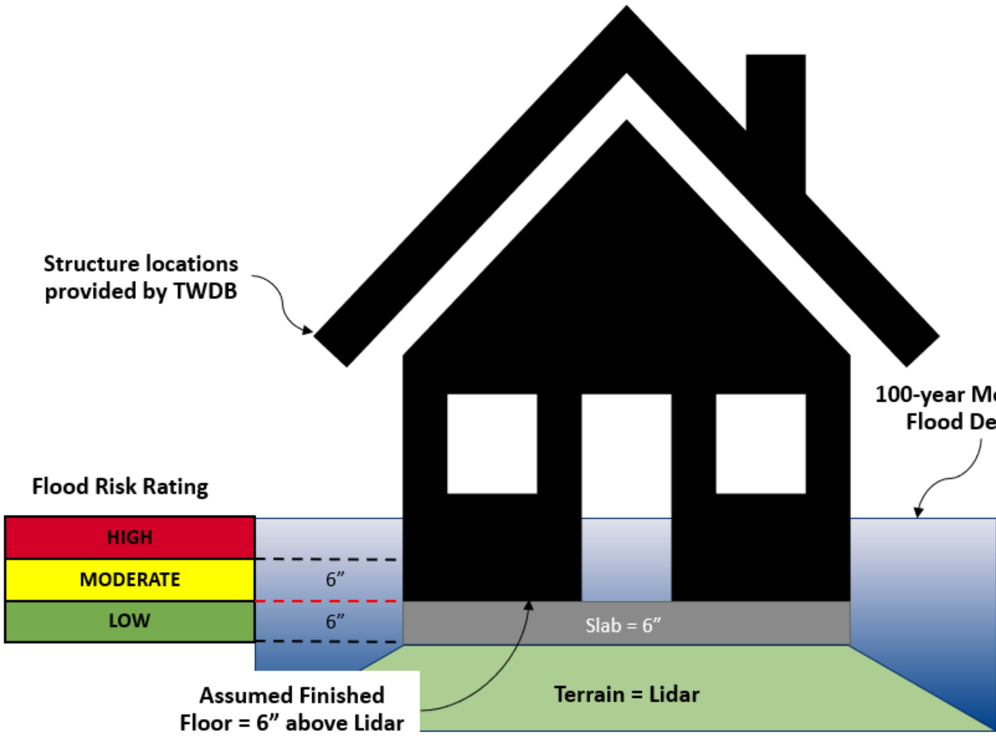

Figure 7.2 Building Flood Risk Classification

A heat map was then created which indicates the areas with the highest density of structures that were classified as having either moderate or high flood risk. Based on the location of these hot spots, fifteen problem areas were delineated. These problem areas were then checked against existing flood risk data, presented to stakeholders, and to the public to confirm that these areas have a legitimate flooding problem and that a flood mitigation project would be beneficial.

An overview of the identified problem areas is shown in **Table 7.1**. **Exhibit 9** in **Appendix A** shows the flood risk heat map along with the location of the top ten identified problem areas.

Table 7.1 Summary of Selected Problem Areas

Problem Area ID	Problem Area Name	Watershed	Sponsor	Structures with Moderate and High Flood Risk
PA1	North Main Drain and Impala Ditch	North Main Drain	Brownsville	804
PA2	Cameron County Ditch 1 at Confluence	Cameron County Ditch 1	Brownsville	674
PA3	Cameron County Ditch at Cameron Park	Cameron County Ditch 1	Brownsville	400
PA4	Town Resaca at West 5th Street	Town Resaca	Brownsville	346
PA5	Cameron County Ditch 1 at Golf Center	Cameron County Ditch 1	Brownsville	196
PA6	Los Fresnos at East 10th St.	Cameron County Ditch 2	Los Fresnos	191
PA7	Cameron County Ditch 1 at Hwy 69E	Cameron County Ditch 1	Brownsville	186
PA9	North Main Drain and Hwy 69E	North Main Drain	Brownsville	135
PA11	Los Fresnos West Ocean Blvd	Cameron County Ditch 2	Los Fresnos	132
PA12	Town Resaca at Washington Park	Town Resaca	Brownsville	123

7.2 Mitigation Goals

Due to the scale of flooding and amount of flood water volume trapped between the resacas, attempting to achieve a 1% ACE level-of-service (the 1% ACE flood event contained within the channel banks) at each problem area was deemed unfeasible since the projects would be so large and likely require the need to obtain significant numbers of homes and structures that implementation would be unrealistic. Instead, the goal was to develop projects that are implementable and cost effective, while achieving a high level of benefit.

Additionally, while some projects provide only a few inches of flood reduction benefit, the large size of the benefit areas ultimately provides justification for the project.

7.3 General Considerations

In addition to cost and flood reduction benefit, many other factors were considered when developing each recommended project including:

- Constructability – can the projects be feasibly constructed
- Maintenance – will maintenance of the project be feasible and cost effective
- Negative Flood Impacts – will the project cause any adverse impacts to flood levels either upstream or downstream of the project area

- Environmental Permitting – will the project have the potential to impact wetlands and require environmental mitigation
- Right-of-Way Acquisition – how much land will need to be acquired to implement the project
- Structural Buyouts – will the project require significant structural buyouts which has negative social
- Utility Conflicts – are there major utility conflicts that should be considered
- Permitting – will permitting with another government agency be necessary due to work within a levee, road, or railroad right-of-way
- Future Development – will growth inhibit the inability of the project to be implemented due to development of open space that was assumed available for the project to utilize

7.4 Conceptual Flood Mitigation Alternatives

In total, twelve projects were developed and evaluated for the ten problem areas listed above. Problem Area 1 was separated into two projects 1A and 1B since both are geographically disconnected from each other and can be constructed separately yet still have the same benefit area. Implementation of the projects will be easier since they are broken into more manageable pieces. Problem Area 11 was split in to two projects, 11A and 11B, for similar reasons.

Table 7.2 provides a summary of each project's estimated capital cost, estimated flood reduction benefits, and resulting benefit-to-cost-ratio (BCR).

Table 7.2 Project Cost and Benefit Summary

Project ID	Project Name	# Structures Removed from 1% ACE	# Structures w/ Reduced 1% ACE	Cost ($M)	BCR
P1A	North Main Drain and Impala Ditch	131	176	46.9	0.35
P1B	North Main Drain and Four Corners	83	417	33.3	0.05
P2	Cameron County Ditch 1 at Confluence	281	834	99.3	0.25
P3	Cameron County Ditch at Cameron Park	130	149	1.6	3.47
P4	Town Resaca at West 5th Street	71	469	34.1	0.74
P5	Cameron County Ditch 1 at Golf Center	399	214	45.5	0.22
P6	Los Fresnos at East 10th St.	92	100	4.4	1.10
P7	Cameron County Ditch 1 at Hwy 69E	191	152	7.7	0.63
P9	North Main Drain and Hwy 69E	84	465	32.5	0.19
P11A	Los Fresnos West Ocean Blvd	60	53	29.3	0.09
P11B	Los Fresnos West Ocean Blvd	17	22	17.0	0.14
P12	Town Resaca at Washington Park	48	144	8.7	0.59

Exhibits providing more detail into the specific components of each project along with exhibits showing the 1% ACE flood reduction benefits resulting from the project are provided in **Appendix E**. Additionally, project fact sheets are provided in **Appendix F** which consist of a one-page, quick overview of each project.

Each problem area has its own unique set of characteristics, and as a result, each project has its own unique set of mitigation solutions (structural measures that either convey or store flood waters) to achieve favorable flood reduction benefits. **Table 7.3** provides a summary of the different type of mitigation solutions utilized with each project.

Each project is described in further detail in the following sections.

Table 7.3 Project Mitigation Solution Summary

Project ID	Project Name	Improve Channel	Widen Channel	Upsize Culvert / Bridge	Upsize Storm Sewer	Add / Improve Pump Station	Add Det. Pond
P1A	North Main Drain and Impala Ditch	✓	✓	✓		✓	
P1B	North Main Drain and Four Corners	✓	✓	✓			✓
P2	Cameron County Ditch 1 at Confluence			✓			✓
P3	Cameron County Ditch 1 at Cameron Park				✓		
P4	Town Resaca at West 5th Street				✓		✓
P5	Cameron County Ditch 1 at Golf Center	✓	✓				✓
P6	Los Fresnos at East 10th St.				✓		✓
P7	Cameron County Ditch 1 at Hwy 69E	✓	✓	✓			
P9	North Main Drain and Hwy 69E				✓		✓
P11A	Los Fresnos West Ocean Blvd		✓	✓			✓
P11B	Los Fresnos West Ocean Blvd		✓	✓			✓
P12	Town Resaca at Washington Park				✓		

7.4.1 P1A – North Main Drain and Impala Ditch

Project P1A is located within the North Main Drain watershed located on the main stem of North Main Drain between International Blvd. and its confluence with the Impala Ditch, and along the Impala Ditch to the Impala Pump Station

This area is a valley sandwiched between the Town Resaca and Resaca De La Guerra with a manmade channel, North Main Drain, providing the primary conveyance of flood waters east toward its ultimate outlet at the ship channel. Flow is restricted where the channel crosses a high point just south of Resaca De La Guerra near the Southmost Road (see **Figure 7.3**). This restriction causes flood waters to back up and pond within the Four Corners areas. In the past, a secondary outlet was created with a man-made channel, Impala Ditch, and a pump station, Impala Pump Station, that pumps flow over the levee and into the Rio Grande River.

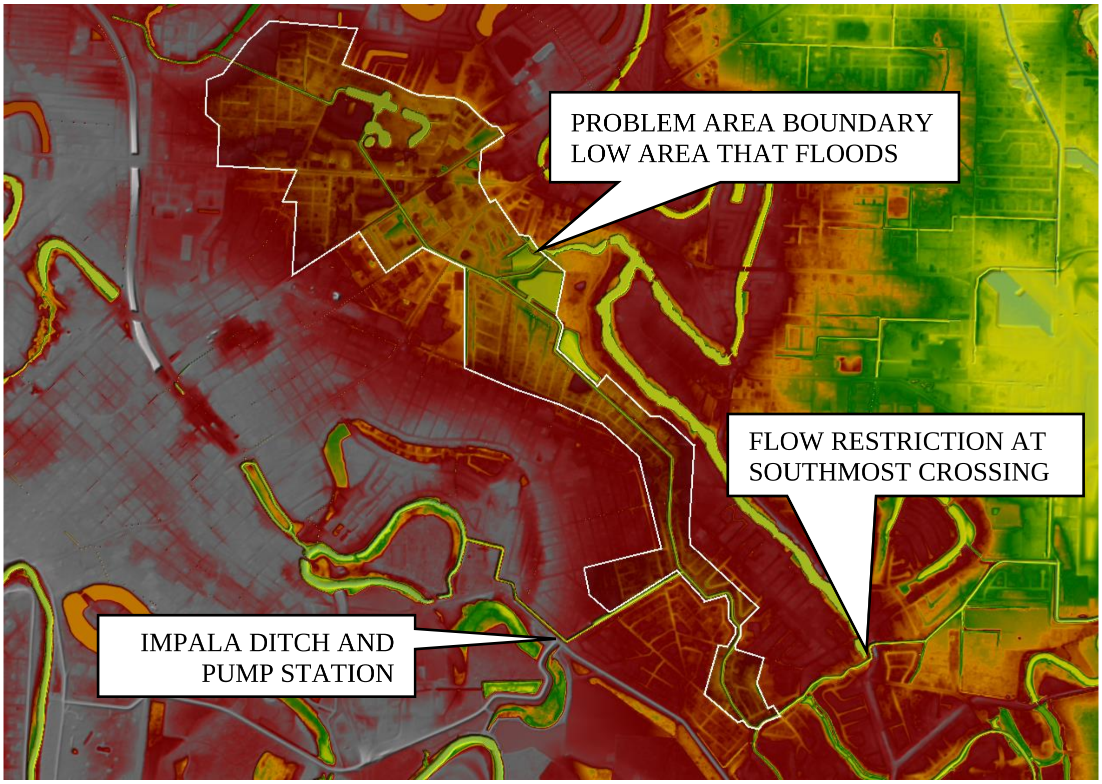

Figure 7.3 Project 1A and 1B Area Overview

Multiple preliminary alternatives were explored along this stretch of the North Main Drain and Impala Ditch to reduce flooding. The most feasible option is to construct offline detention withing the large undeveloped parcels near the Walmart located next to North Main Drain (Project 1B) and improve the secondary outlet at the Impala Pump Station.

This conceptual project includes increasing the pumping capacity of the Impala Pump station by 240,000 gpm, increasing the capacity of the Impala Ditch by expanding and concrete lining the ditch, and increasing the capacity of North Main Drain between Impala Ditch and International Boulevard, by widening the channel and concrete lining the channel. Ultimately, these improvements will allow water to convey from the problem area to the Rio Grande at a greater rate and thus reduce the level of flooding within the problem area. Since flows are being pumped to the other side of the levee and into the Rio Grande, flood mitigation will not be necessary. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 307 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
The channel widening portion of the project requires the acquisition of additional right-of-way along the rear of several lots that will require significant coordination with property owners. Additionally, some of the channel widening improvements are located adjacent to existing structures, particularly on North Main Drain just upstream of the confluence with Impala Ditch.

This project also puts a higher reliance on the Impala Ditch to control flooding in this area. The additional pumps will require additional maintenance but will provide additional redundancy to the existing pump station. Finally, since channel re-grading is being proposed, wetlands permitting may be required. Further environmental investigation should be performed to get a better understanding of the necessary wetlands permitting that will be required to construct the channel improvements.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.2 P1B – North Main Drain and Four Corners

This project serves the same area as project P1A. This project was separated from Project PA1 to give the city flexibility to implement either project independently.

This conceptual project includes channel widening and road crossing improvements between Rockwell Drive and International Boulevard along with an offline detention pond. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 0.3-feet of flood reduction for the 1% ACE which results in flood reduction for approximately 500 structures. The overtopping of the crossing at Old Port Isabel Road is also reduced, reducing mobility issues during extreme flood events. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.

The offline detention pond requires the acquisition of a large amount of privately-owned property across several parcels. As a part of the project construction there is the potential for road closure as well as utility conflict and relocation. Finally, since channel re-grading is being proposed, wetlands permitting may be required. Further environmental investigation should be performed to get a better understanding of the necessary wetlands permitting that will be required to construct the channel improvements.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.3 P2 – Cameron County Ditch 1 at Confluence

Project P2 is located within the Cameron County Ditch 1 watershed located on the main stem of Ditch 1 between Old Port Isabel Road and Ruben M Torres Boulevard.

Similar to project P1, this area is a valley sandwiched between the Resaca De La Guerra and Lower Resaca Rancho Viejo with a manmade channel, Ditch 1, providing the primary conveyance of flood waters east toward its ultimate outlet in the eastern salt flats. Flow is restricted where the channel crosses a high point just south of Resaca De La Guerra near the Ruben M Torres Boulevard (see **Figure 7.4**). This restriction causes flood waters to back up and pond within the low-lying areas. There is also another ditch, called the Chicago Ditch, that routes runoff from north part of the airport. The confluence of both channels is located just upstream of the flow restriction.

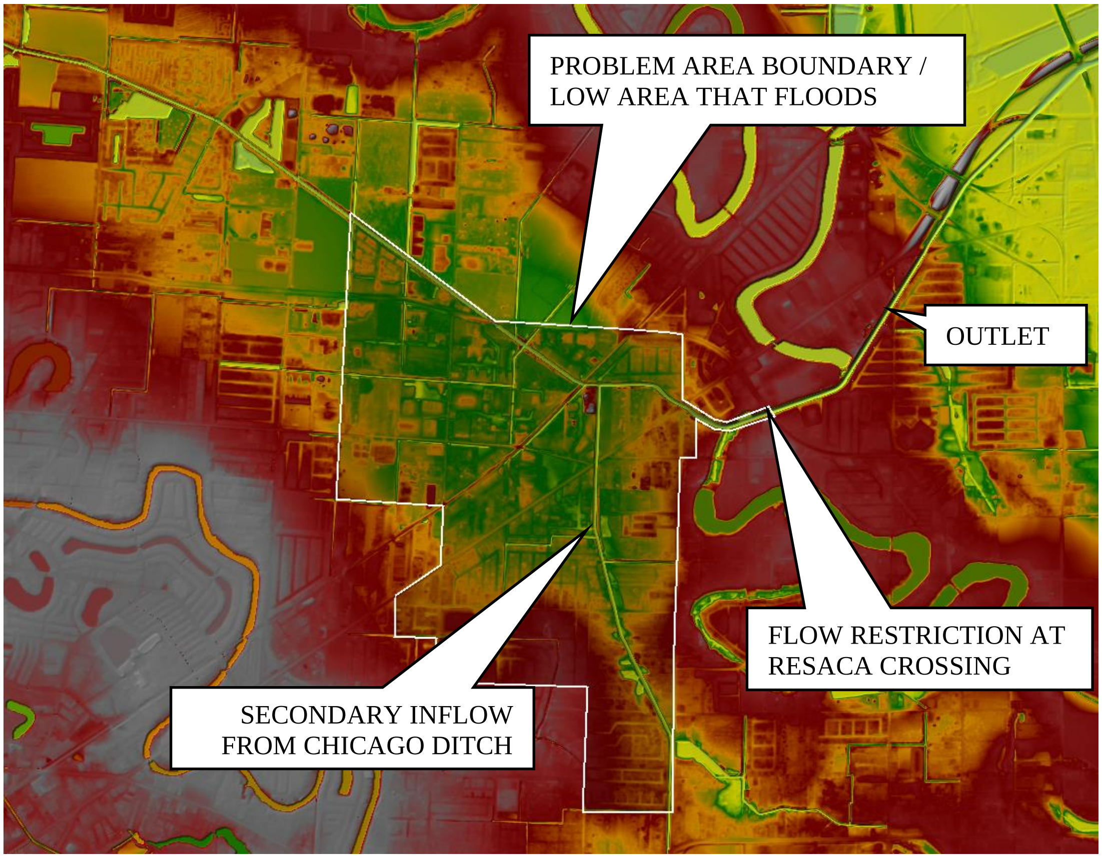

Figure 7.4 Project 2 Area Overview

Multiple preliminary alternatives were explored along this stretch of Cameron County Ditch 1. The most feasible and manageable option is to construct offline detention ponds withing the large undeveloped parcels located near the upstream side of the problem area. This conceptual project includes constructing five offline detentions ponds that provide 2,560 ac-ft of storage (approximately 1,900 ac-ft of excavation). To extend these benefits up the Chicago Ditch, the culvert on Padre Island Highway will be replaced with a clear-span bridge. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 1,115 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
The offline detention ponds will require the acquisition of a large amounts of privately-owned property across several parcels and excavation of these large areas may require environmental permitting. Finally, to construct the bridge on Padre Island Highway, significant traffic control and utility relocation may be required. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.4 P3 – Cameron County Ditch 1 at Cameron Park

Project P3 is located in the Cameron Park neighborhood and centered primarily along Avenida Florencia. Several blocks located along Avenida Florencia and Avenida Jeffery experience heavy flooding, primarily from Cameron County Ditch 1 due to problems described in **Section 7.4.3**. The improvements proposed with Project 2 will reduce the flooding caused by backwater from the ditch; however, there will still be high flood risk within the community due to inadequate internal drainage facilities conveying flows from the neighborhood to the ditch.

This conceptual project includes improving the internal drainage infrastructure by providing several extreme event overflow pipes and weirs along Avenida Florencia to adequately drain to Cameron County Ditch 1. However, since the primary source of flooding is backwater from Cameron County Ditch 1, this project does not significantly benefit the community until project P2 is implemented. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 279 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
The construction of the overflow routes will require drainage easements through several properties and may also require utility relocation. The project is also contingent on the implementation of project P2 before it will provide substantial benefit in flood risk.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.5 P4 – Town Resaca at West 5th Street

Project P4 is located near downtown Brownsville between Town Resaca and the Rio Grande levees and between Palm Blvd and W 8th Street. This area contains several low-lying urban areas that do not drain adequately due to undersized storm sewer facilities (see **Figure 7.5**).

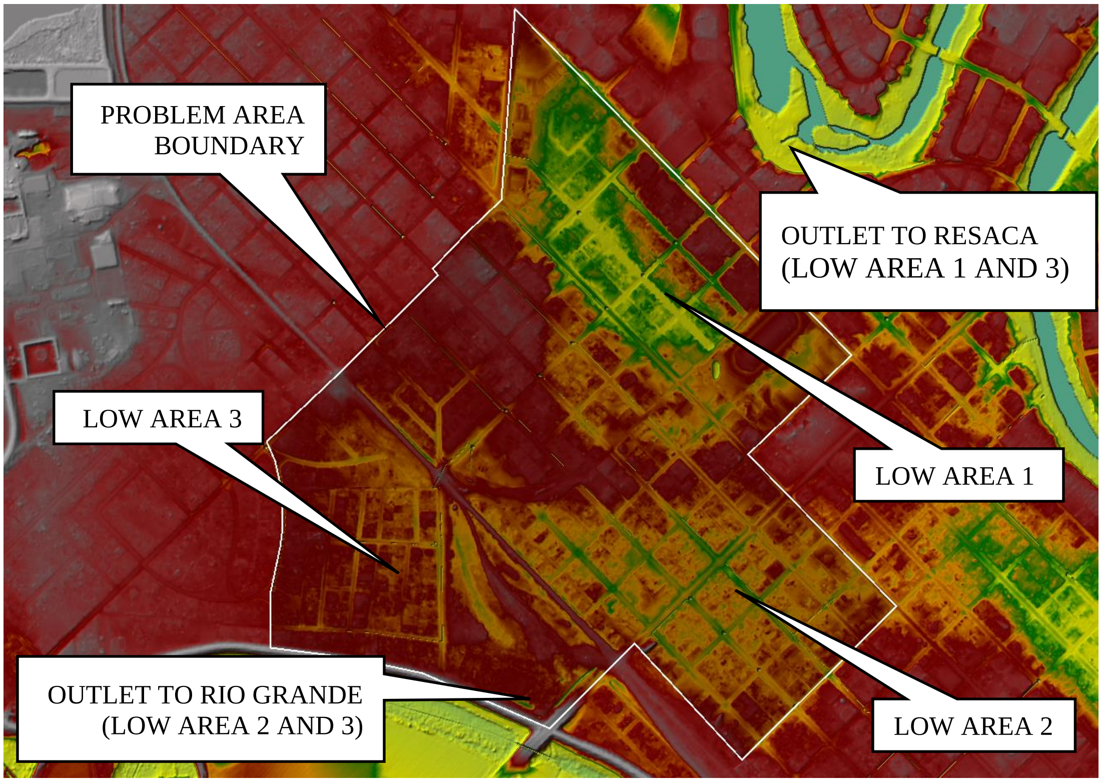

Figure 7.5 Project 4Area Overview

Several project alternatives were preliminarily explored, but due to concerns with causing impacts along Town Resaca, additional drainage capacity to this location is not feasible. This project proposes to construct a detention pond at an existing undeveloped lot located between W 5th St and Palm Boulevard and install large storm sewer infrastructure in the low-lying areas to route flows to the proposed pond. Careful sizing of the storm sewer trunk lines will also allow additional flow to drain into Town Resaca from the low-lying area located near W Adams Street and W 5th Street by balancing flows between the pond and Town Resaca. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1.5-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 540 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.

Construction of large storm sewer infrastructure will cause considerable disruption to the flow of traffic and access to properties along the drainage routes. Utility relocation is also expected to be a considerable complication with this project. Finally, to construct the detention pond, a large parcel of land will need to be acquired.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.6 P5 – Cameron County Ditch 1 at Golf Center

Project P5 is located along Cameron County Drainage Ditch No. 1 near the Brownsville Golf Center. The community around the Golf Center and the local neighborhoods experience flooding issues due to poor drainage conveyance in Cameron County Ditch No. 1. Just downstream of the Golf Center, flow in Cameron County Drainage Ditch No. 1 is routed through a series of man-made lakes. The amenity level for these lakes is controlled by a pipe and concrete weir (see **Figure 7.6**). This structure is the source of flow restriction that causes water to back up into the neighborhoods along this project.

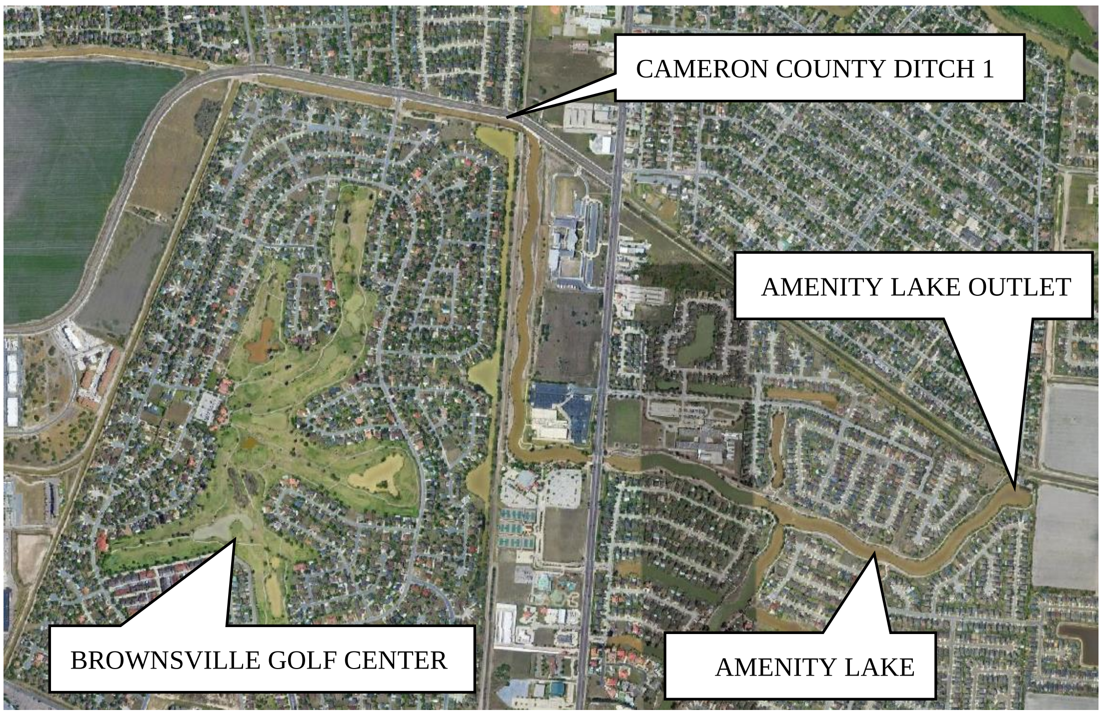

Figure 7.6 Project 5 Area Overview

To reduce flooding within the problem area, the amenity lake outlet must be increased and Cameron County Ditch 1 widened. However, this results in substantial downstream impacts to flood levels due to the loss of flood plain storage upstream of the amenity lake outlet. To compensate for this, 619 ac-ft of detention is needed to compensate for this loss of volume. The City of Brownsville engineering staff directed the study team to place the detention within the Golf Center which is owned by the city. The goal is to use this proposed pond as a multi-use facility (e.g., pond, park, playgrounds, soccer fields, etc.). In order to convey floodwaters from the ditch to the proposed pond, a large trunk storm sewer pipe will be installed within the North San Marcelo Boulevard right-of-way. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 613 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.

The road crossing improvements will require portions of East Morrison Road and Las Palomas Street to be closed for construction. Finally, since channel re-grading is being proposed, wetlands permitting may be required. Further environmental investigation should be performed to get a better understanding of the necessary wetlands permitting that will be required to construct the channel improvements.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.7 P6 – Los Fresnos at East 10th St.

Project P6 is located in a neighborhood in southeast Los Fresnos specifically at the east ends of 8th, 9th, and 10th streets. Past flooding in this area was caused by an undersized culvert located downstream of neighborhood that caused flood waters to back up into the street. A spoil berm exists along the channel that runs along the neighborhood's eastern and southern border which provides some flood protection from this backwater flooding. In 2021, however, the culvert was removed and is no longer the source of flooding in the area. However, there is still high flood risk within the community due to inadequate internal drainage facilities conveying flows from the neighborhood to the ditch in conjunction with the berm blocking any extreme event overflow routes (see **Figure 7.7**).

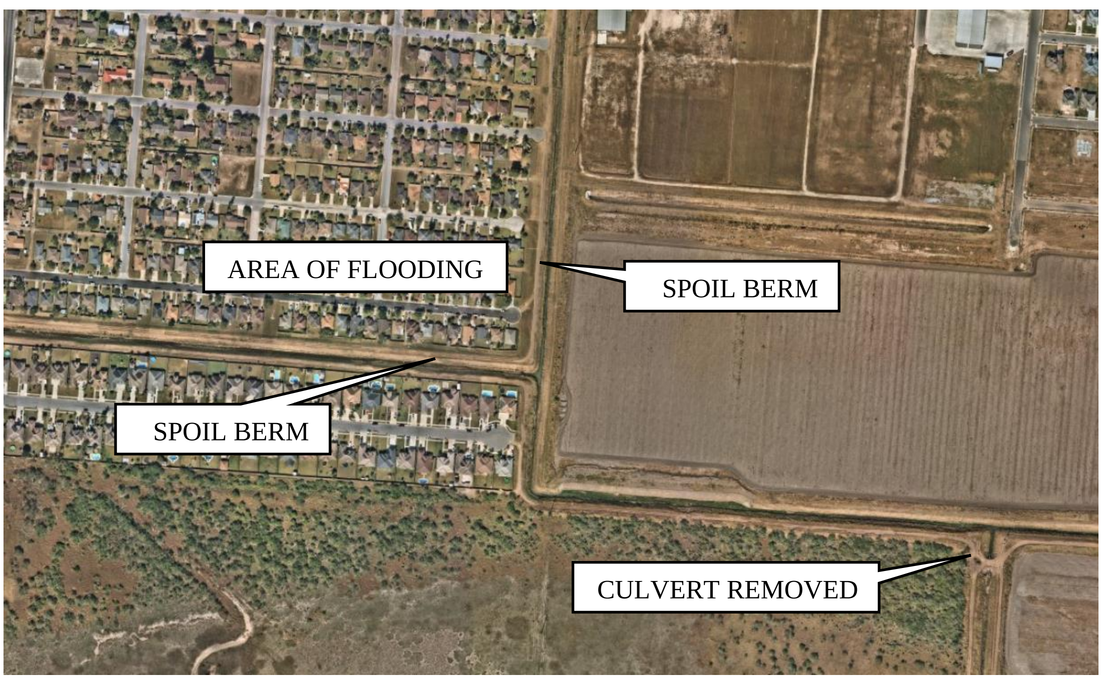

Figure 7.7 Project 6 Area Overview

This conceptual project includes improving the internal drainage infrastructure by providing several extreme event overflow pipes and weirs to help drainage on E 8th, E 9th, and E 10th streets to to the drainage channel. The increased conveyance, however, causes impacts downstream. To mitigate these impacts, a detention pond is proposed downstream of the project. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 2-feet of flood reduction for the 1% ACE which results in flood reduction for approximately 192 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
The construction of the overflow routes will require drainage easements through several properties and may also require utility relocation.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.8 P7 – Cameron County Ditch 1 at Hwy 69E

The project area is located along Cameron County Drainage Ditch No. 1 near the Walmart Supercenter and Sam's Club. The area is bounded to the West by a multiuse path and to the East by Pablo Kisel Boulevard.

The multiuse path and US Highway 69 crossings both have undersized culverts that cause flood water to back into the neighborhood that borders both sides of Cameron County Ditch 1 (**Figure 7.8**).

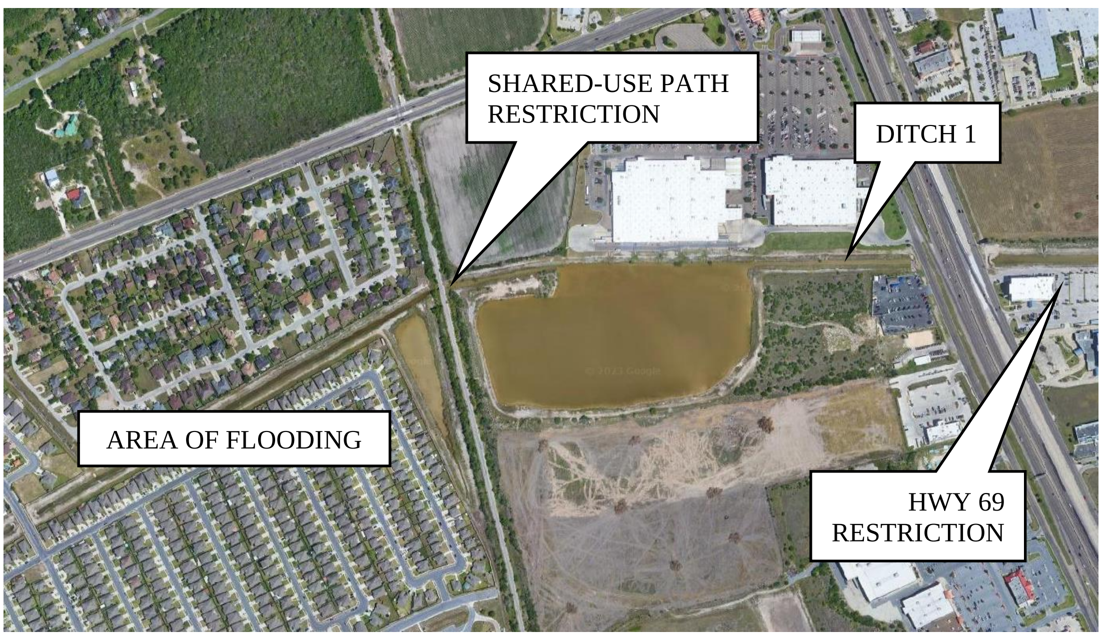

Figure 7.8 Project 7 Area Overview

To reduce flood risk in this area, this project will increase the capacity of the multi-use pathway by converting it to a pedestrian bridge and will increase the capacity of the Hwy 69E culvert by tunneling an additional 60-inch pipe. The increased conveyance causes impacts downstream. To mitigate these impacts, this additional flow needs to be conveyed downstream to the proposed detention pond (see project P6) by increasing the size of the existing channel. In lieu of expanding the existing channel, an offline detention pond could be constructed to mitigate these flow increases but this option will need to be explored further during preliminary design. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 343 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.

The construction of the pipe under Hwy 69E will require approval by TxDOT which could slow the implementation of this project. Additionally, since channel re-grading is being proposed, wetlands permitting may be required. Further environmental investigation should be performed to get a better understanding of the necessary wetlands permitting that will be required to construct the channel improvements.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.9 P9 – North Main Drain and Hwy 69E

Project P9 extends along the North Main Drain concrete channel and is bounded to the West by Central Boulevard and to the East by US Highway 69E. The area encompasses a mix of commercial and residential structures and is a high traffic area with West Price Road acting as a major thoroughfare through the City of Brownsville. North Main Drain is completely enclosed and routed beneath Wild Rose Lane via a storm sewer trunk line that is undersized. This, coupled with roadway crossing restrictions downstream of Hwy 69E causes water to pond on both sides of Hwy 69E (see **Figure 7.9**).

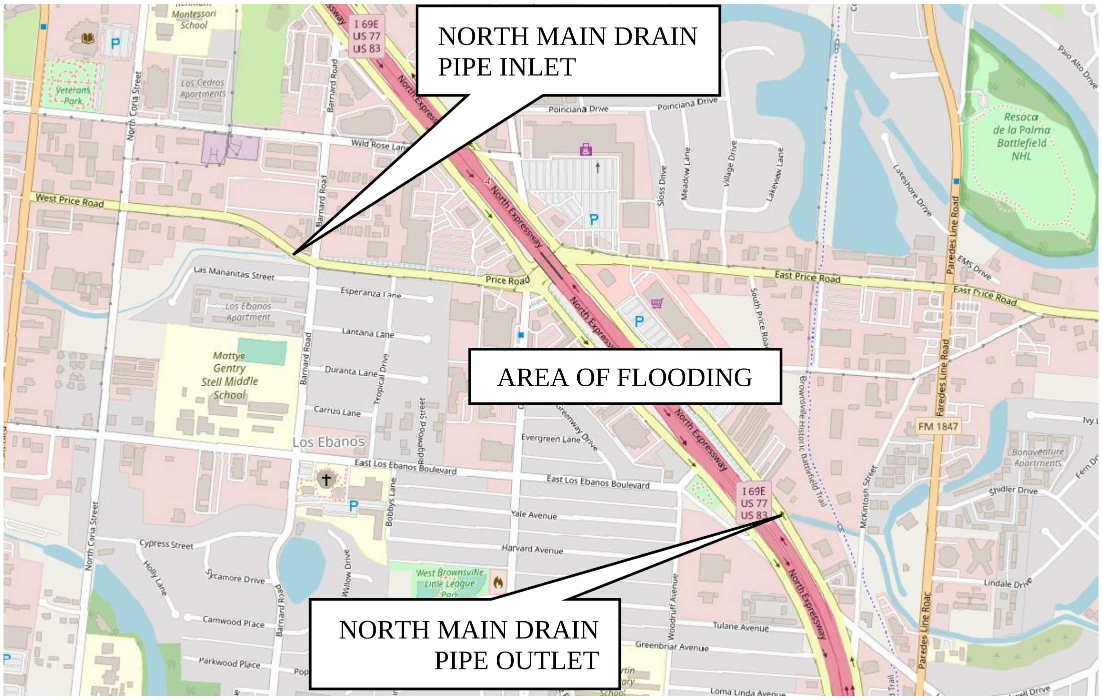

Figure 7.9 Project 9 Area Overview

Several preliminary alternatives were explored including increasing the storm piping across Highway 69E, routing excess flows north through Resaca de la Guerra, and placing detention within every undeveloped parcel of land. From a cost and implementation perspective, detention on the west side of Hwy 69E is the most feasible alternative.

This project proposes to place two detention ponds upstream of the North Main Drain storm sewer inlet. The south pond will be located off the channel in an area that is currently used as soccer fields. The north pond is located north of the channel where there is currently a golf driving range. To connect the north pond to the North Main Drain, a large storm sewer box will be placed within the N Coria Street right-of-way. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 0.5-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 549 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
Construction of large storm sewer infrastructure will cause considerable disruption to traffic and access to properties along the drainage routes. Utility relocation is also expected to be a considerable complication with this project.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.10 P11A and PA11B – Los Fresnos West Ocean Boulevard

The project area is located on the west side of Los Fresnos along Texas Highway 100 just north of the irrigation canal. The irrigation canal is elevated above the natural ground with drainage culverts allowing intersecting ditches to pass flow across the canal. However, some of these culverts are undersized and cause flood waters to inundate an area north of the canal putting many residential and commercial structures in high risk of flooding (see **Figure 7.10**).

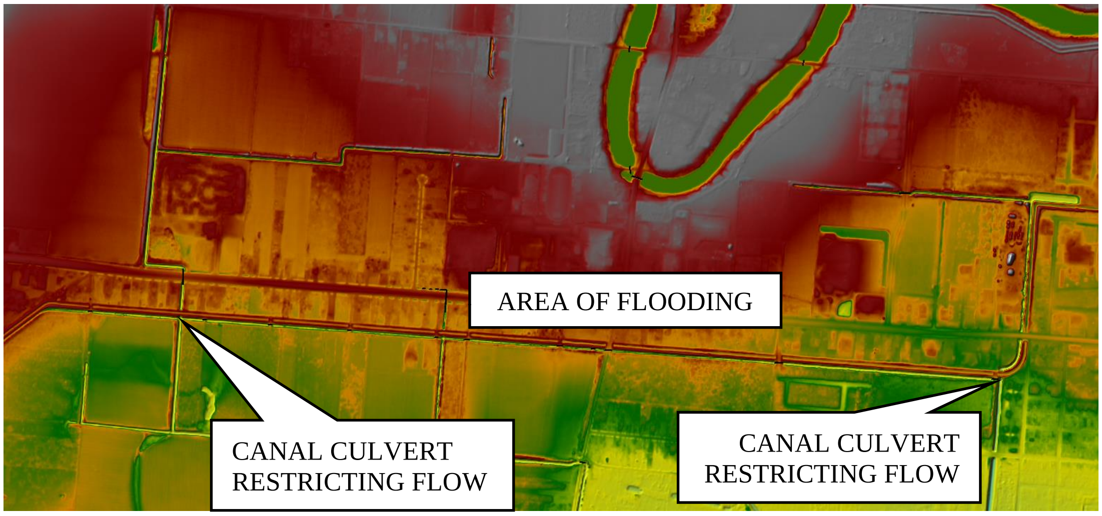

Figure 7.10 Project 11 Area Overview

Two preliminary alternatives were explored. The selected alternative included installing a larger culvert under the canal and TX-100 and placing a detention pond downstream of the canal to mitigate impacts downstream that would result from increasing conveyance across the canal. This alternative also includes improvements to the local drainage infrastructure including the construction of new channel and regrading of existing roadside ditches. This project was split into two projects, P11A and P11B, in order to give the City of Los Fresnos the flexibility to implement either project independently, if desired. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 2-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 152 structures (113 structures associated with P11A and 39 associated with P11B). Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.

To implement this project, coordination with various agencies will be required including the Cameron County Water Control and Improvement District 6, Cameron County Drainage District 1, and TxDOT which could delay implementation of these projects. Additionally, the proposed channel lies along the side and rear of private properties and will require the acquisition of drainage easements on multiple properties. The detention ponds will also require acquisition of properties.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.4.11 P12 – Town Resaca at Washington Park

Project P12 is located in downtown Brownsville between Washington Park and Town Resaca and is in a highly urbanized area low-lying area that does not drain adequately due to undersized storm sewer infrastructure (see **Figure 7.11**).

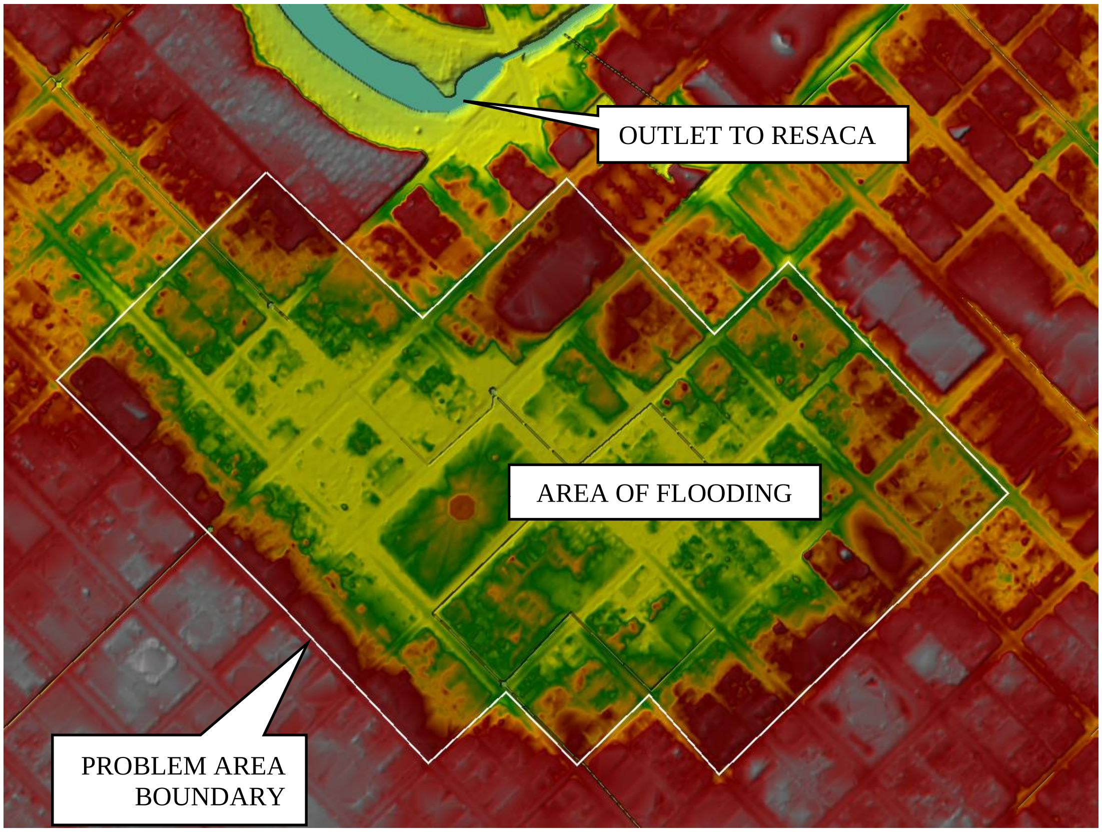

Figure 7.11 Project 12 Area Overview

Several project alternatives were preliminarily explored including different combinations of sending runoff—via large storm sewer trunk lines—to Town Resaca and across the Rio Grande levees near E St Charles Street. However, the construction of a long storm sewer trunk line will be costly, and due to the difficulty associated with permitting additional facilities under the existing Rio Grande levees, additional drainage capacity under the levees could potentially hinder the feasibility of this project. Instead, this project proposes to increase the size of the storm sewer trunk line to Town Resaca. The small size of the project's drainage area in comparison to the Town Resaca watershed and its proximity to Town Resaca means the peak flow from the project enters Town Resaca well before Town Resaca crests. More detail on the specific components of the project can be found in the Project Layout exhibit located in **Appendix E**.

This project provides up to 1.5-foot of flood reduction for the 1% ACE which results in flood reduction for approximately 192 structures. Additional details on the flood reduction provided by this project can be found in the Project Benefit exhibits located in **Appendix E**.
Construction of large storm sewer infrastructure will cause considerable disruption to traffic and access to properties along the drainage routes. Utility relocation is also expected to be a considerable complication with this project.

A project worksheet that summarizes the scope, cost, benefit, and constraints for this project can be found in **Appendix F**.

7.5 No Negative Impact Analysis

All projects conform to the TWDB criteria for no-negative impact for 2D rain-on-mesh models and will not cause a negative impact to neighboring properties when implemented. The minimum TWDB requirements are listed below.

- Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
- Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
- Maximum increase of 1D Water Surface Elevations must round to 0.0 feet (<0.05ft) measured along the hydraulic cross-section.
- Maximum increase in 2D Water Surface Elevations must round to 0.3 feet (<0.35ft) measured at each computation cell.
- Maximum increase in hydrologic peak discharge must be < 0.5 percent measured as computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

7.6 Environmental Analysis

Under Section 404 of the Clean Water Act (Section 404) the United States Army Corps of Engineers (USACE) regulates the discharge of dredge and fill material into waters of the United States (WOTUS). Evaluating Section 404 impacts and permitting requirements and estimating the cost of compensatory mitigation for adverse impacts to the aquatic environment is a key component to planning stormwater infrastructure projects because many of the projects are ultimately water-dependent and may require impacts to WOTUS. Depending on the type and extent of impacts to WOTUS, the permitting timeline and cost of compensatory mitigation can significantly affect project schedules and budgets. To evaluate the Section 404 permitting requirements and associated compensatory mitigation, Halff utilized various desktop resources (National Wetland Inventory, LIDAR terrain models, aerial photography, and topographic maps) to determine which channels are likely considered WOTUS (and those that are likely non-jurisdictional). However, during the development of the project, the Supreme Court of the United States issues a ruling that will limit the scope of the Clean Water Act as it pertains to the project. As a result, the USACE was instructed to pause jurisdictional determinations, and new guidance on the new regulations was not issued by the USACE at the time of this evaluation.

Therefore, Halff was not able to make estimates as to the level of environmental mitigation and permitting that may be required for the implementation of the channel re-grading projects.

Instead, if a project was identified as having some potential of impacting the WOTUS, environmental mitigation was included in the cost assessment as 3% of construction cost. Further environmental analysis should be performed during preliminary engineering of each of the projects for better understanding of environmental permitting requirements.

7.7 Estimate of Probable Cost

An opinion of probable cost was developed for each project to facilitate future planning and grant applications. These costs are high-level and are for planning purposes only. Additional estimates should be completed as the project progresses through funding and design and as additional information is obtained. Additionally, broad assumptions were made for several items including labor and material costs, engineering and surveying, environmental mitigation, and underground utility relocation.

Labor and material costs are based on 2020 market conditions. Updates may be required with future planning efforts for each project to adjust the costs to reflect future market conditions and effects of inflation.

The cost of excavation and fill for detention ponds, berms, and channel improvements were estimated using a rate of $20 per cubic yard. This cost is assumed to cover the labor, transport, disposal, and material costs. If a project requires both excavation and fill, the values were calculated separately to provide some contingency in the estimate.

Surveying and engineering will be required to implement each project. The cost for this effort was estimated to be approximately 18% of the construction cost.

Cost for right-of-way (ROW) acquisition was estimated for each project based on the average property value in the project area and the estimated limits of construction for each project. The average property valuation within the project area was obtained from the Cameron County Appraisal District and was used to develop a dollar-per-acre estimate. This unit amount was multiplied by the project area to estimate the total ROW acquisition cost. For an added level of contingency, a multiplier of three was then applied to this cost.

Under Section 404 of the Clean Water Act (Section 404) the United States Army Corps of Engineers (USACE) regulates the discharge of dredge and fill material into waters of the United States (WOTUS). Some of the recommended projects have been identified as possibly impacting WOTUS. As noted above, the cost for Environmental Mitigation efforts to satisfy these requirements was estimated to be 3% of construction cost.

A unit cost for utility relocation is included for each project based on information obtained from surface observations. This estimate is highly uncertain due to the lack of subsurface utility survey. A large component of the contingency described in the following paragraph is assumed to account for some of this uncertainty. It is recommended that sub-surface utilities be identified before final design is commenced to fully understand the scope and extents of the project.

Because of the high-level nature of these estimates, a 30% contingency (based on construction cost) was included for each project to cover additional costs that may result from project scope changes due to better information obtained during survey and design.

The estimate of probably cost for each project is located in **Appendix G**.

7.8 Benefit Cost Analysis

In order to perform a Benefit-Cost Analysis (BCA) for each project as required by the TWDB, the TWDB Benefit-Cost Calculator tool was used to quantity the amount of benefit provided by each project, in dollar amount. Using the flood depths for 10%, 4%, 2%, 1%, and 0.2% annual chance storm events developed by the hydraulic model, maximum water surfaces for each frequency event were calculated at each structure for both pre-project and post-project conditions. Flood depths for each structure for pre-project and post-project conditions were then input into the BCA tool. The tool calculates the total damages over the life span of the project (30 years) using all the storm events for both pre-project and post-project conditions and the difference between the two is the net benefit, in dollars, resulting from the project.

A benefit cost ratio (BCR) was then calculated by taking the total benefit and dividing it by the project's capital cost.

Excluding Project 3, none of the projects receive a benefit-to-cost ratio greater than 1. The reason for this is the high amounts of flood volume that needs to be moved in order to provide any flood reduction benefit and the resulting high costs to achieve this. Most of the problem areas are located within a low-lying area bounded by elevated Resacas. The only drainage outlet for these areas is typically a significantly undersized man-made channel. Reducing flood levels in these low-lying areas requires extensive improvements to the channels to convey these high flood volumes out of the problem areas. However, based on testing performed as part of this study, the channels and road crossings need to be expanded significantly and expansion of these channels will result in the removal of many residential structures and the complete removal of culverts to be replaced with bridges. In addition, when these outlets are widened, the flood volume moves downstream. This additional flood volume needs to be stored or routed elsewhere in order to avoid any impacts to residents downstream of the project. This requires either large amounts of detention storage (i.e., excavation) or additional large channels to convey flow to the Rio Grande or to the coast. Combined, these improvements are significant and costly. Based on our analysis, these costs are likely to only rarely be lower than the benefit provided due to the large amounts of flood volume that needs to be moved. The team, in coordination with the stakeholders, took a unique approach to each project to ensure the project scope remained manageable from a cost, logistics, environmental, and social impact perspective while achieving a benefit that was considered appropriate by the relevant stakeholder.

The supporting benefit calculations using the TWDB tool are located in **Appendix I**.

7.9 Regional Flood Plan

Additional flood risk and benefit metrics were also calculated as required by the TWDB so that these projects could be included within the State Flood Plan. These metrics are summarized in the TWDB Flood Mitigation Project (FMP) table located in Appendix H.

All 12 projects were submitted to the Region 15 Regional Flood Planning Group to be included in the amended regional flood plan and were accepted for inclusion.
The TWDB FMP Table can be found in **Appendix G**.

7.10 Implementation and Phasing

Once implemented, the identified projects will reduce flood risk within the study area. Implementation of the projects will occur over time and include both short-term and long-term actions to complete.

In general, the project lifecycle follows the flow path shown in **Figure 7.12**. This study completed the planning portion of the project. Short term actions are those that can be implemented over the next few years and will be steppingstones to completing the projects. Phase I includes those short-term targets. Longer-term actions will likely take more than five years due to funding, construction time, and project constraints. Phase II includes the longer-term actions.

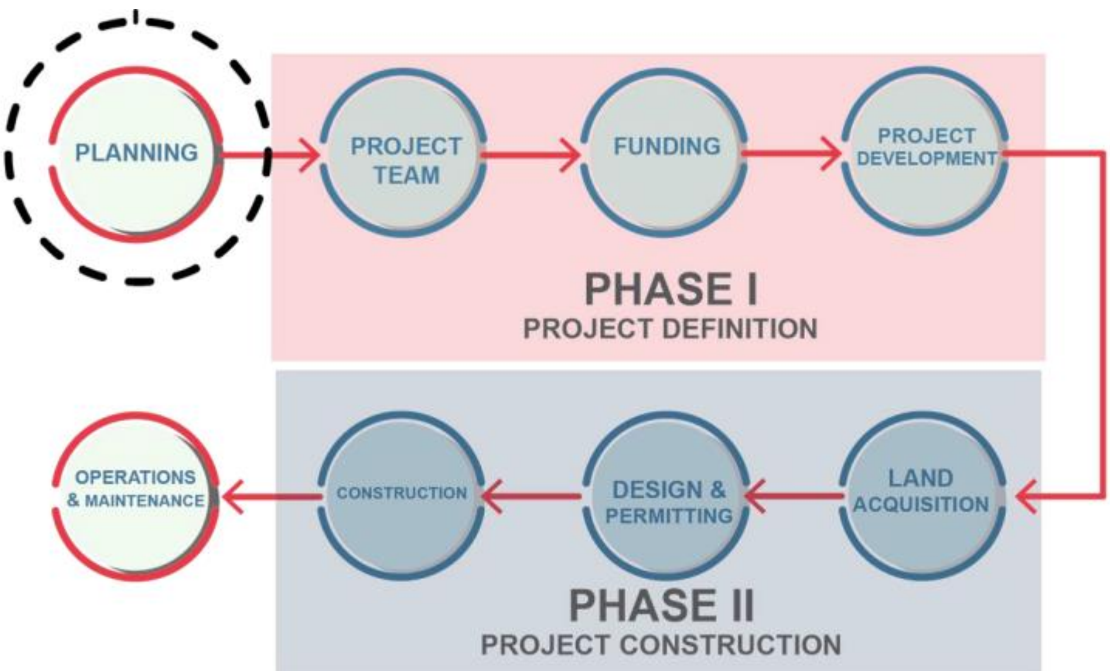

Figure 7.12 Drainage Project Lifecycle

7.10.1 Short Term Actions

The stakeholders within the study area have limited funding for drainage project implementation and therefore short-term actions are those that can be implemented with limited funding.

- **Right of Way Dedication** – Each of the projects identified requires some amount of right-of-way to implement the project. As tracts in these areas begin to develop, the relevant project stakeholder should require dedication of these areas to the stakeholder so that the right-of-way is available for future use. This could include dedication in fee to the stakeholder, dedicated to the public, or as a drainage easement. The stakeholder should work with developers and landowners as available. For the larger tracts where complete buy-out may be necessary, the city should begin to find funding and partnership opportunities to acquire these parcels before they are developed.
- **Funding Opportunities** – With the limited available budget, stakeholders should continue to investigate other funding strategies for implementation. The TWDB Flood Infrastructure Fund is a first choice since this planning study is FIF funded; however, other funding opportunities exist in both local, state, and federal sources. Some of these are included in **Section 7.10.3**.
- **Buyout Strategy** – Buyouts within the floodplain may often be the most efficient strategy to reducing flood risk within the region. Stakeholders should continue to work alongside FEMA to advocate for voluntary buyouts in these areas with identified high flood risk for the repetitive and frequently flooded structures. Stakeholders should also continue to investigate land acquisition in these areas to reduce future development within the floodplain. In many locations, structures are in areas of high flood risk as well as close to drainage infrastructure that inhibits the ability the expand the capacity of these facilities. A strategic approach to buyouts would be to focus on these structures to make room for future expansion of these drainage facilities while simultaneously removing these structures out of high flood risk areas.
- **Flood Gauges –** The region should continue its effort to install flood gauges on major channels and near highly populated areas. Using real-time remote monitoring via flood gages allows emergency managers to track the conditions of multiple locations at one time and focus response efforts on those areas that pose the most risk. Gauges also provide a historical record with which engineers can use to calibrate future flood risk models. Whether through grant funding, partnerships with other agencies and jurisdictions, or local funds, gages are a safe and relatively inexpensive way to gather information about current conditions and past flood events.
- **Drainage Criteria -** Natural drainage flow patterns are often negatively impacted as a result of new development which can cause an increase in flood risk to existing residents. During the stage of high growth that this region is experiencing, it is vital that stakeholders ensure that new development continues in a responsible manner. One method to encourage responsible development is having a strong set of enforceable regulations that are updated regularly. Regulations will mitigate the increase in future flood risks for existing residents and decrease future capital costs for the region’s stakeholder.

7.10.2 Long Term Actions

As the short-term actions are completed, funding and other strategies will become available for the recommended projects. At this point, the long-term actions will commence.

- **Project Development –** Further development and design of the project will be needed before construction. The development will include a preliminary engineering report which will include survey, geotechnical analysis, environmental study, agency coordination, utility coordination, and land acquisition. The Design will include the development of engineering drawings and permitting needed to completely implement the project.
- **Construction –** Construction of these project could take a year to several years to complete. Construction will include public notice, mobilization of the project, coordination with utilities and agencies, acquisition of construction easements, implementation of traffic control, construction of the improved infrastructure, and final inspection.
- **Maintenance –** Once constructed, the projects will require regular maintenance to remain functional for their life span. The grass channel and pond projects will require regular mowing, regular inspections, and repair throughout the project life. Storm sewer will need regular cleaning and flushing of sediment. Weirs and channel lining will need regular inspection and, at times, concrete replacement. Pumps will need ongoing inspection, testing, and pump repairs. Use of the pumps will also incur ongoing energy costs.

7.10.3 Funding Sources

The potential funding sources of the recommended projects and strategies will depend on the project type and readiness for construction. Funding sources are available from both local, state, and federal entities and each program identified may have differing procurement, administrative, and environmental requirements, impacting the cost and schedule of the projects. The funding sources below should be considered for the projects identified in this study.

Federal Funding Sources

- Community Development Block Grant Disaster Relief (CDBG-DR) - The CDBG-DR is based on response to Federally declared disaster and includes a variety of potential activities, including detention and conveyance improvements. The grant does have an LMI emphasis that may limit the applicability of this source for some projects. The cost-share is typically 100% Federal to 0% Local. More information is at https://recovery.texas.gov/local-government/resources/overview/index.html.
- Community Development Block Grant Mitigation (CDBG-MIT) - The CDBG-MIT funds are also related to disaster declarations and are a little bit more flexible in that it has a lower threshold for the LMI component than the DR funding option. Given the reduced requirement on LMI, the CDBG-MIT may be a viable funding source for several of the proposed flood mitigation projects in this study. As with the DR funds, the cost-share is 100% Federal to 0% Local. Recommended future watershed protection studies could be partially funded through this grant program. For more information, visit https://recovery.texas.gov/action-plans/mitigation-funding/index.html.

State Funding Sources

- TWDB Development Fund (DFund) - The Dfund is a State of Texas loan program, which is relatively simple and has minimal red tape. Flood control projects are eligible; however, the fund is primarily loan based.
- TWDB Flood Infrastructure Fund (FIF) - The Flood Infrastructure Fund (FIF) is administered by the TWDB. The FIF allows for loans at or below market rates for a variety of actions, including flood planning, grant application, and engineering for structural and non-structural solutions. In addition, the FIF offers grants that can be used as the local entities matching funds for other federal funding programs. The state is currently allocating additional budget for the fund and will be accepting applications in 2024.

Local Funding

- Bonds - Bond funding can be used for flood protection and management. Bonds typically provide project specific financing that requires proposed improvements to be ready for construction and meet the priorities set by the funder. Although repayment terms can offer low or no interest financing, these sources do require full repayment.
- Fees and Ad Valorem Taxes - A development impact mitigation fee is a tax that is imposed as a precondition for the privilege of developing land. Since the proposed projects address existing conditions and are not meant for mitigating the impacts associated with developing land, imposing a fee on new development to address pre-existing flooding conditions may be difficult to implement. Ad valorem taxes are based on the value of a transaction of a property. Sales taxes or property taxes are ad valorem taxes that could be considered for funding the projects.
- Public Private Partnerships - While there is not an identified stream of funding available for private investment, it may be considered as an option if the opportunity is presented. The study area includes several different industrial and commercial developments that are located within areas of high flood risk and whose owners may be looking for opportunities to reduce flood risk for their business.

7.11 Project Ranking

To further guide implementation of these projects and assist with prioritization, the projects were ranked based on the following metrics and weights provided in **Table 7.4**. These were confirmed by the City of Brownsville.

Table 7.4 Project Ranking Metrics

Metric	Score Weight
Cost	10%
Damage Reductions	15%
Structures Removed from 100-year Flood Risk	30%
BCR	15%
SVI	15%
LMI	15%
Total	100%

Based on these metrics and weight, **Table 7.5** shows the projects listed in order of ranking.

Table 7.5 Project Ranking Summary

Rank	Project ID	Project Name	Sponsor	Score
1	P11B	Los Fresnos West Ocean Blvd	Los Fresnos	3.30
2	P11A	Los Fresnos West Ocean Blvd	Los Fresnos	2.90
3	P6	Los Fresnos at East 10th St.	Los Fresnos	2.50
4	P7	Cameron County Ditch 1 at Hwy 69E	Brownsville	2.25
5	P9	North Main Drain and Hwy 69E	Brownsville	2.00
6	P12	Town Resaca at Washington Park	Brownsville	1.95
7	P1B	North Main Drain and Four Corners	Brownsville	1.90
8	P2	Cameron County Ditch 1 at Confluence	Brownsville	1.80
9	P3	Cameron County Ditch 1 at Cameron Park	Brownsville	1.75
10	P5	Cameron County Ditch 1 at Golf Center	Brownsville	1.75
11	P1A	North Main Drain and Impala Ditch	Brownsville	1.05
12	P4	Town Resaca at West 5th Street	Brownsville	1.00

8 Conclusion

The results of this study, including the updated flood risk modeling and mapping, are available to the region's stakeholders to help inform them of current flood risk within their communities and to help make informed decisions regarding mitigating flood risk in the future. Flood mitigation projects were also developed to assist communities in the region to reduce existing flood risk in those areas identified as having the most flood risk. These projects have been added to the amended State Flood Plan so that they will be eligible for future grant funding opportunities.

Stakeholders should begin addressing flood risk within their community by taking the steps outlined in **Section 7.10** and begin searching for funding opportunities to implement the flood mitigation projects. This will require stakeholders to be engaged with the Region 15 Regional Flood Planning Group to stay apprised of funding opportunities and to inform the State of the stakeholder's flood mitigation needs. In the meantime, stakeholders can begin tackling some of the short-term actions outlined in **Section 7.10.1** that are available to take immediate action to help reduce flood risk within their community.

List of References

Estimating Runoff for Conservation Practices. (1990). Soil Conservation Service.
Hawkins, R., Jiang, R., Woodward, D., Hjelmfelt, A., & Mullem, J. E. (2003). Runoff Curve Number Method: Examination of the Initial Abstraction Ratio.

Acknowledgements

City of Brownsville
Doroteo Garcia, PE, CFM, RAS
Carlos Lastra, PE
Yolanda de la Torre, EIT

City of Los Fresnos
Mark W. Millum

Valley MUD No.2
Scott Fry, PE, CFM
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Cameron County Drainage District No. 1
Albert Barreda

Cameron County
Carlos Sanchez, PE

Halff
Ryan Londeen, PE, CFM
John Clint, PE
Anne Whitko, CFM
Elmer Hinojosa, PE
Grimaldo Carrillo

Appendix A - Exhibits

1. Study Area and Location Map
2. Watershed Boundary Map
3. Survey
4. Land Cover- Curve Number
5. Land Cover- Manning's n and Impervious %
6. North Model Workmap
7. South Model Workmap
8. Terrain
9. Problem Area Heatmap

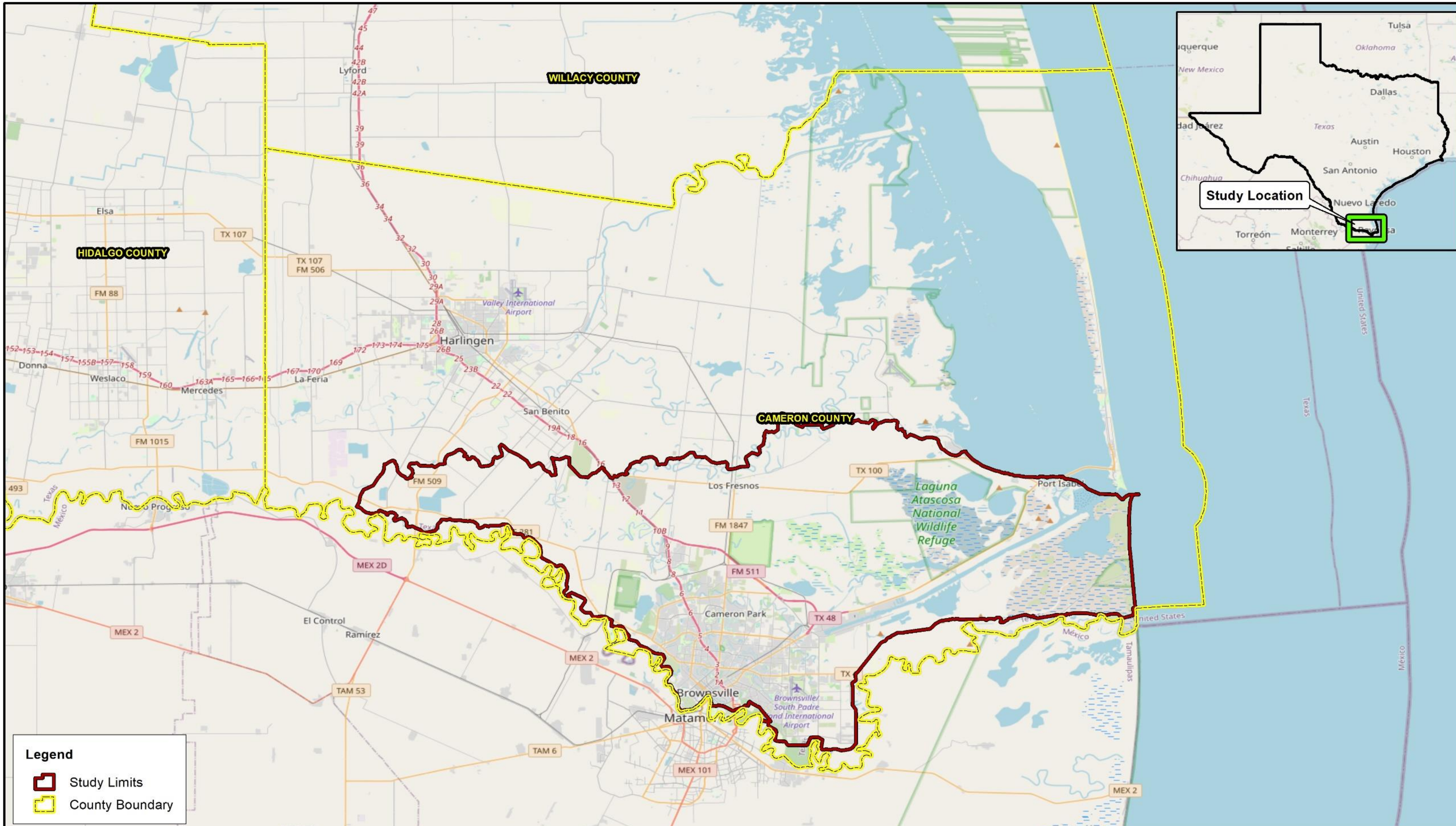
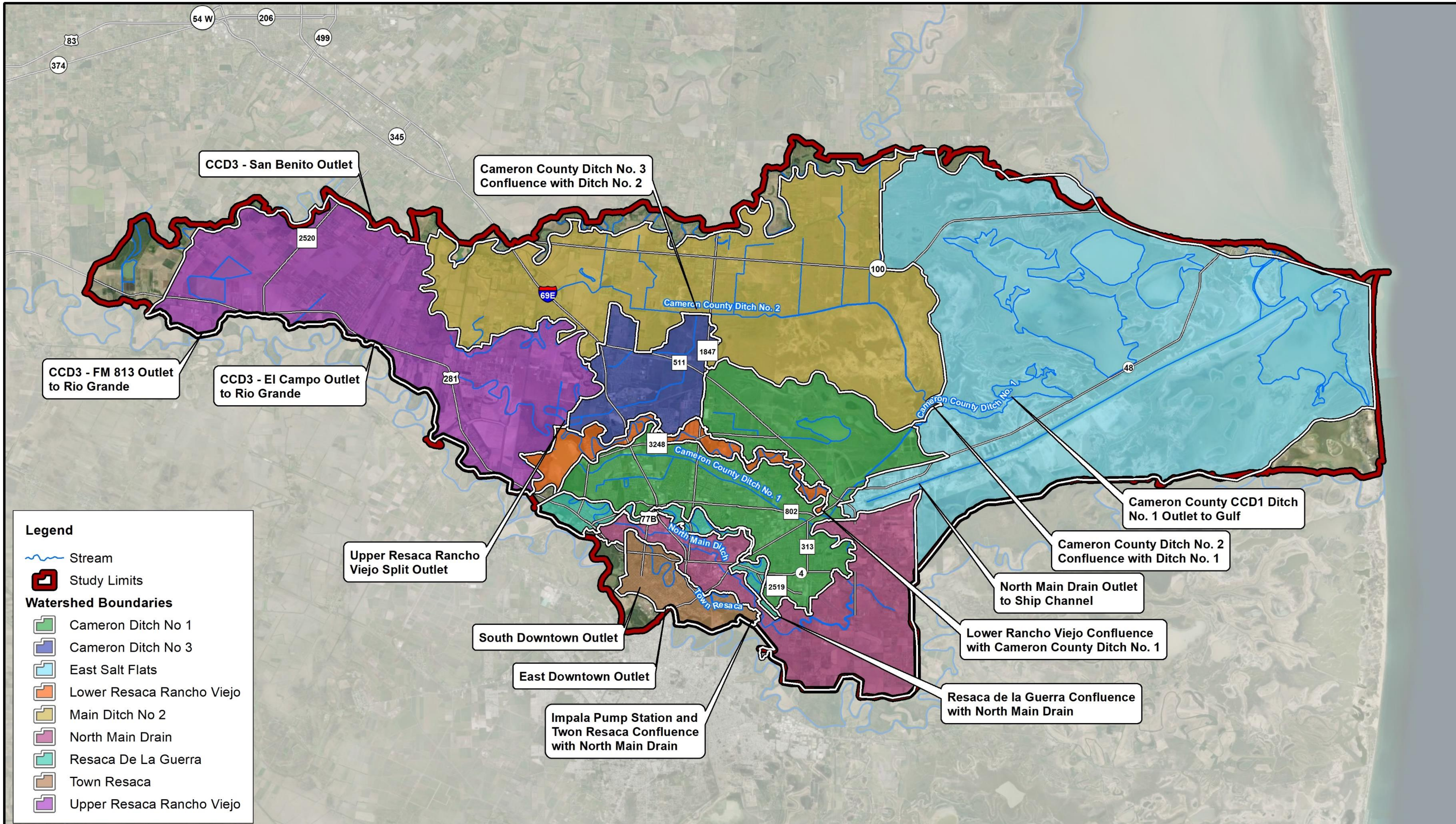


Exhibit 1: Study Area and Location Map

Brownsville to Port Isabel HUC-10 Watershed Study

0 5 10 Miles

1 in = 5 miles



Texas Water Development Board

halff

Exhibit 2: Watershed Boundary Map

Brownsville to Port Isabel HUC-10 Watershed Study

0 3 6 Miles

1 in = 3 miles

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Date: 10/13/2023

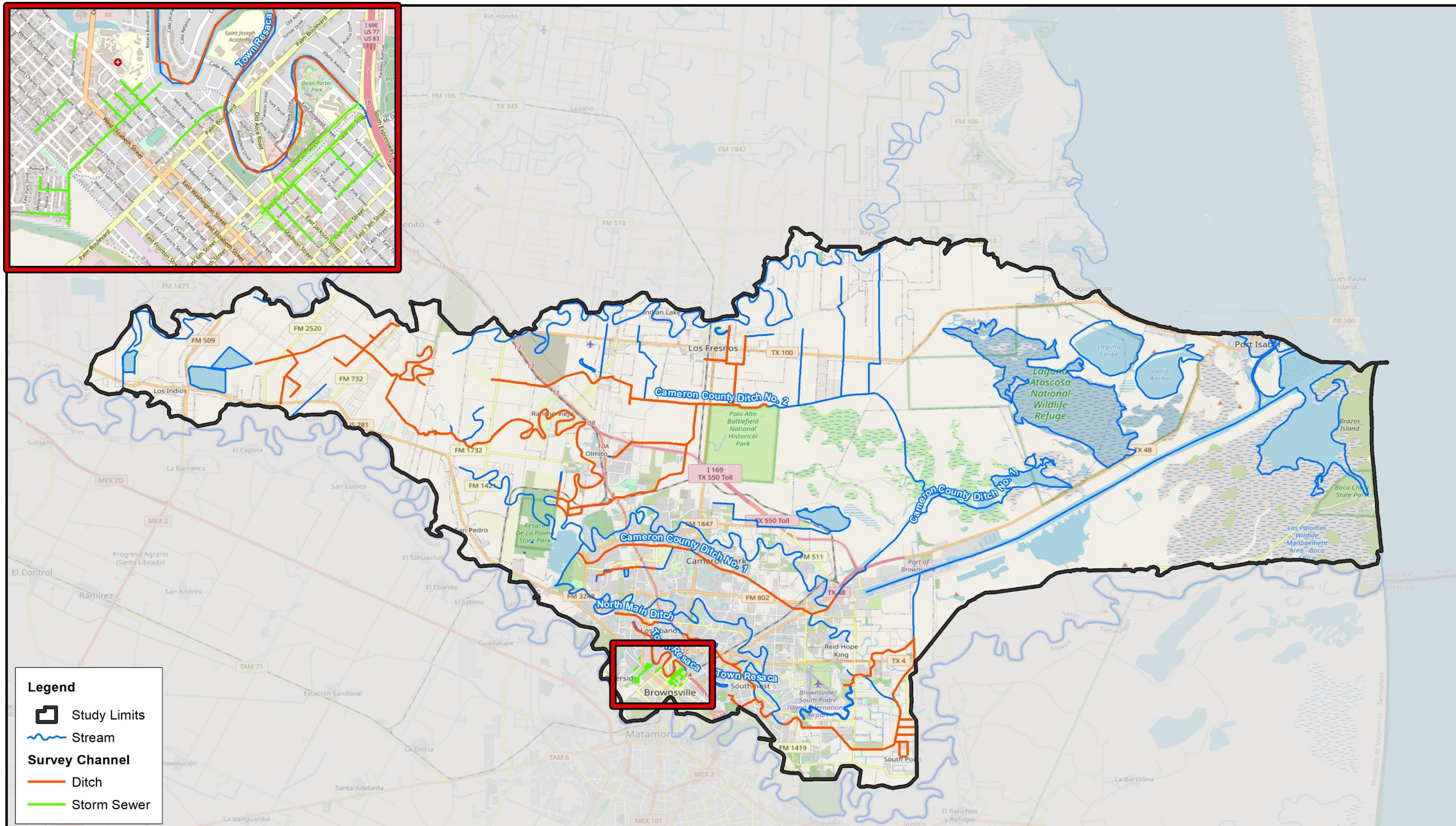

Exhibit 3: Survey

Brownsville to Port Isabel HUC-10 Watershed Study

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0 3 6 Miles

1 in = 3 miles

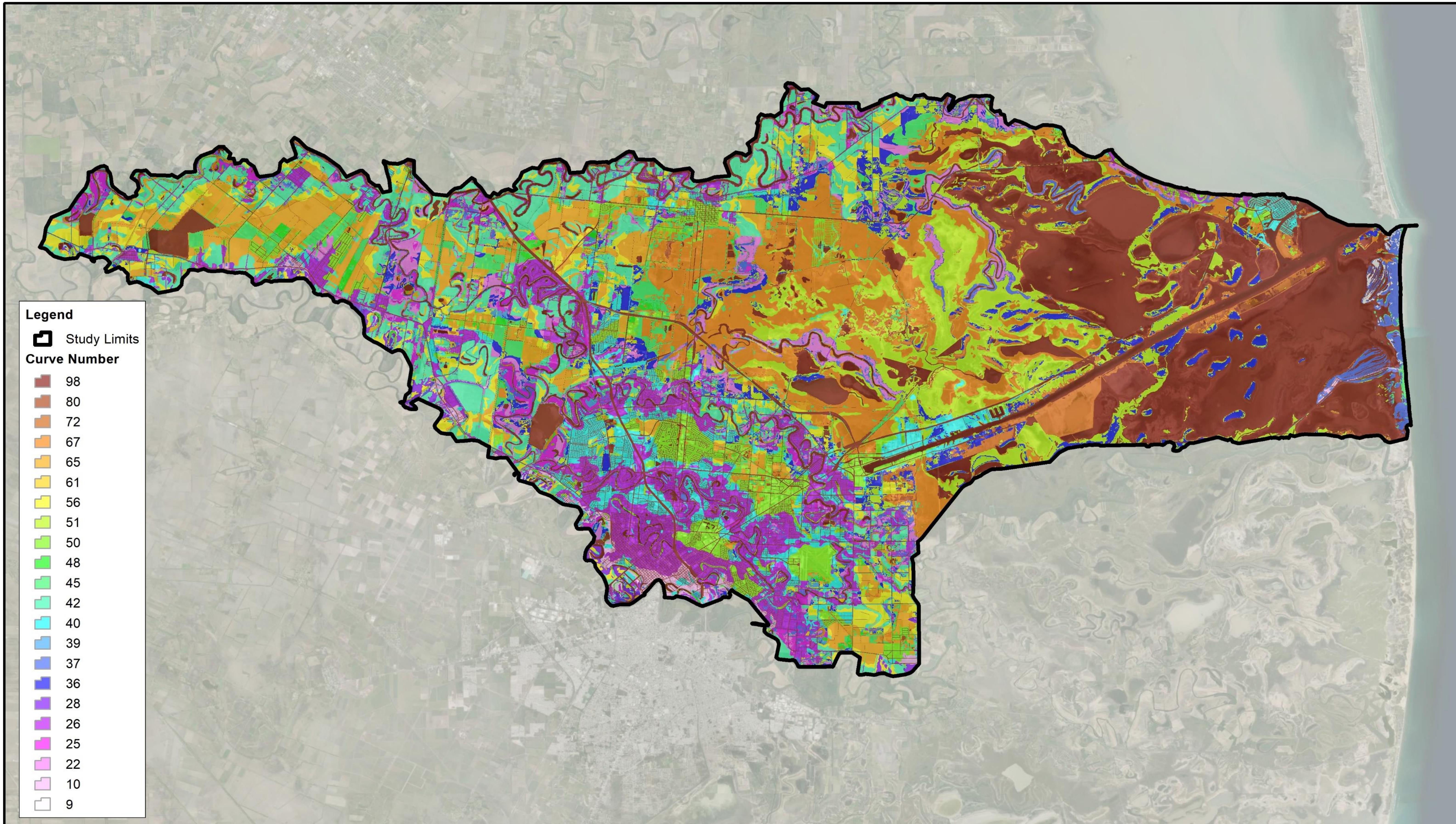

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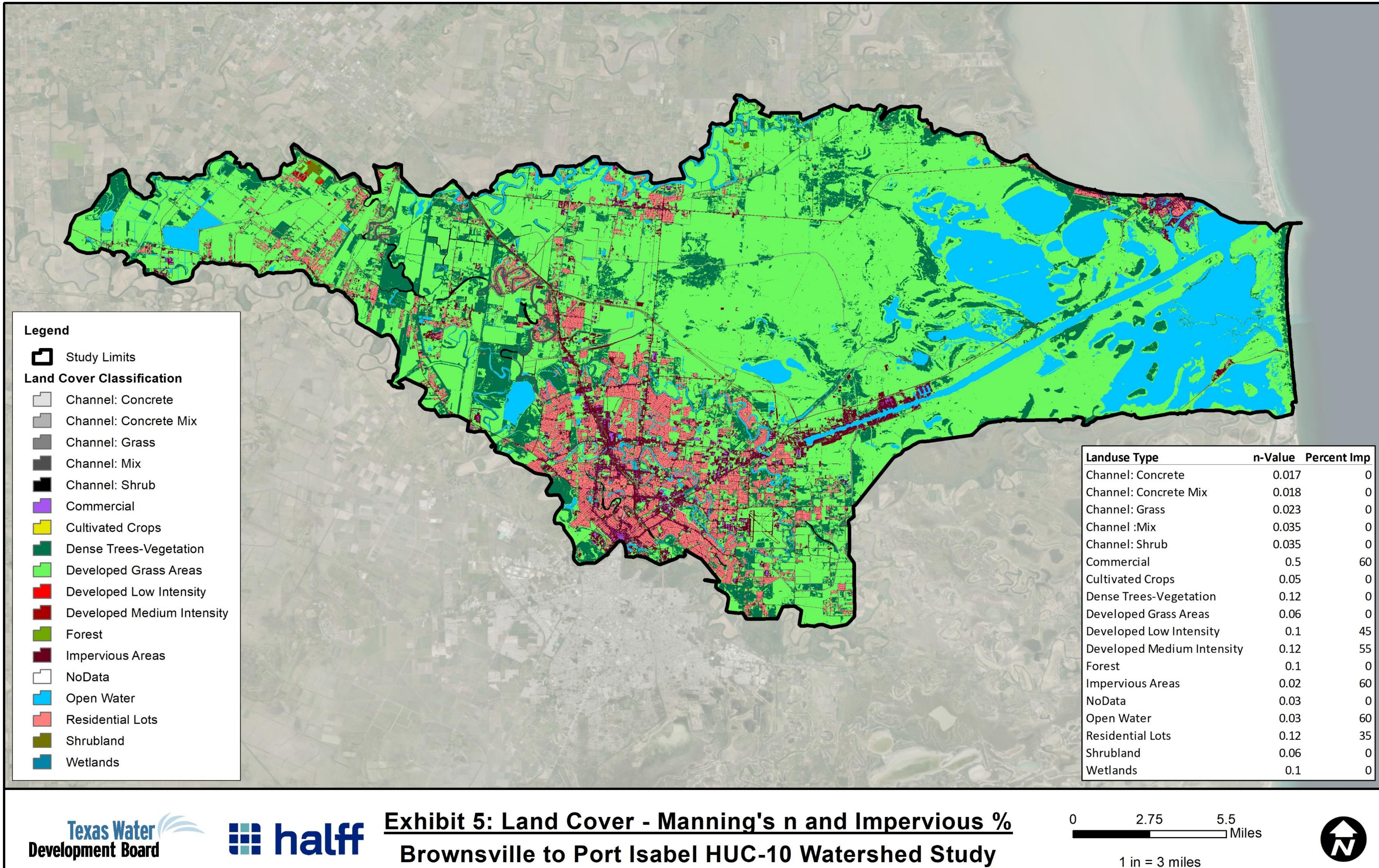
Exhibit 4: Land Cover - Curve Number

Brownsville to Port Isabel HUC-10 Watershed Study



Landuse Type	n-Value	Percent Imp
Channel: Concrete	0.017	0
Channel: Concrete Mix	0.018	0
Channel: Grass	0.023	0
Channel :Mix	0.035	0
Channel: Shrub	0.035	0
Commercial	0.5	60
Cultivated Crops	0.05	0
Dense Trees-Vegetation	0.12	0
Developed Grass Areas	0.06	0
Developed Low Intensity	0.1	45
Developed Medium Intensity	0.12	55
Forest	0.1	0
Impervious Areas	0.02	60
NoData	0.03	0
Open Water	0.03	60
Residential Lots	0.12	35
Shrubland	0.06	0
Wetlands	0.1	0

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Exhibit 5: Land Cover - Manning's n and Impervious %

Brownsville to Port Isabel HUC-10 Watershed Study

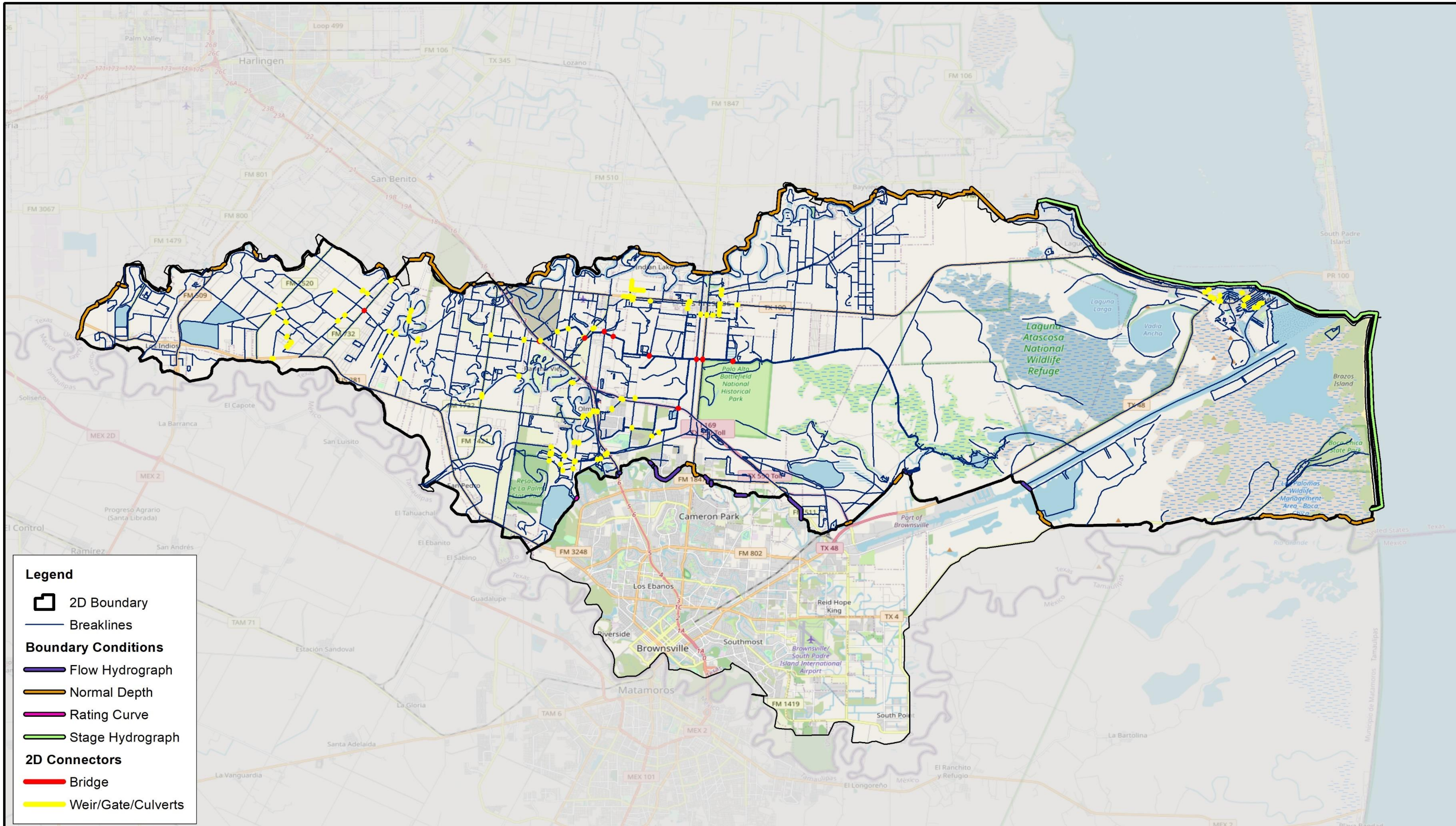

Exhibit 6: North Model Workmap

Brownsville to Port Isabel HUC-10 Watershed Study

0 3 6 Miles

1 in = 3 miles

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Date: 10/13/2023

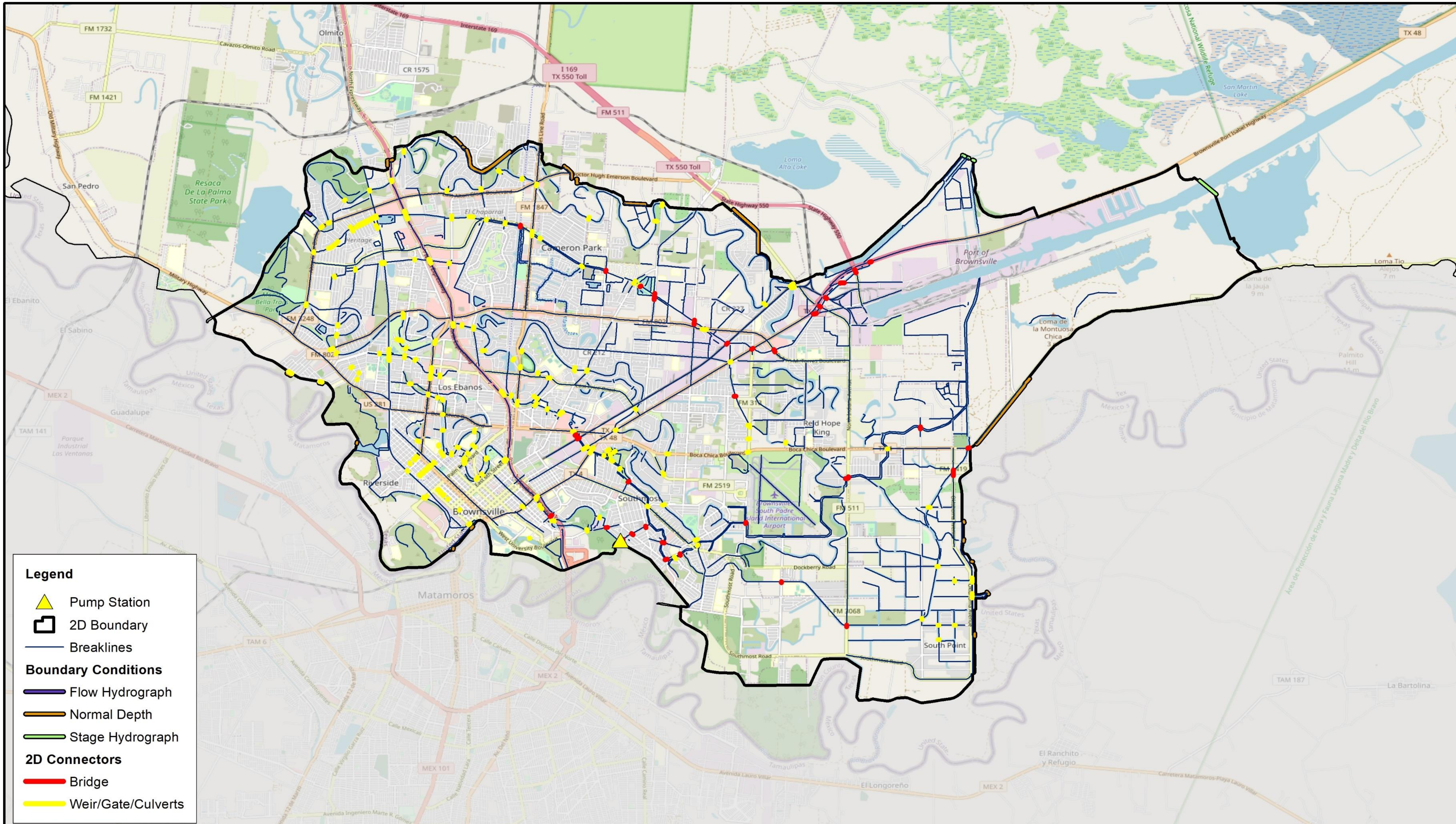

Exhibit 7: South Model Workmap

Brownsville to Port Isabel HUC-10 Watershed Study

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0 1.5 3 Miles

1 in = 1.5 miles

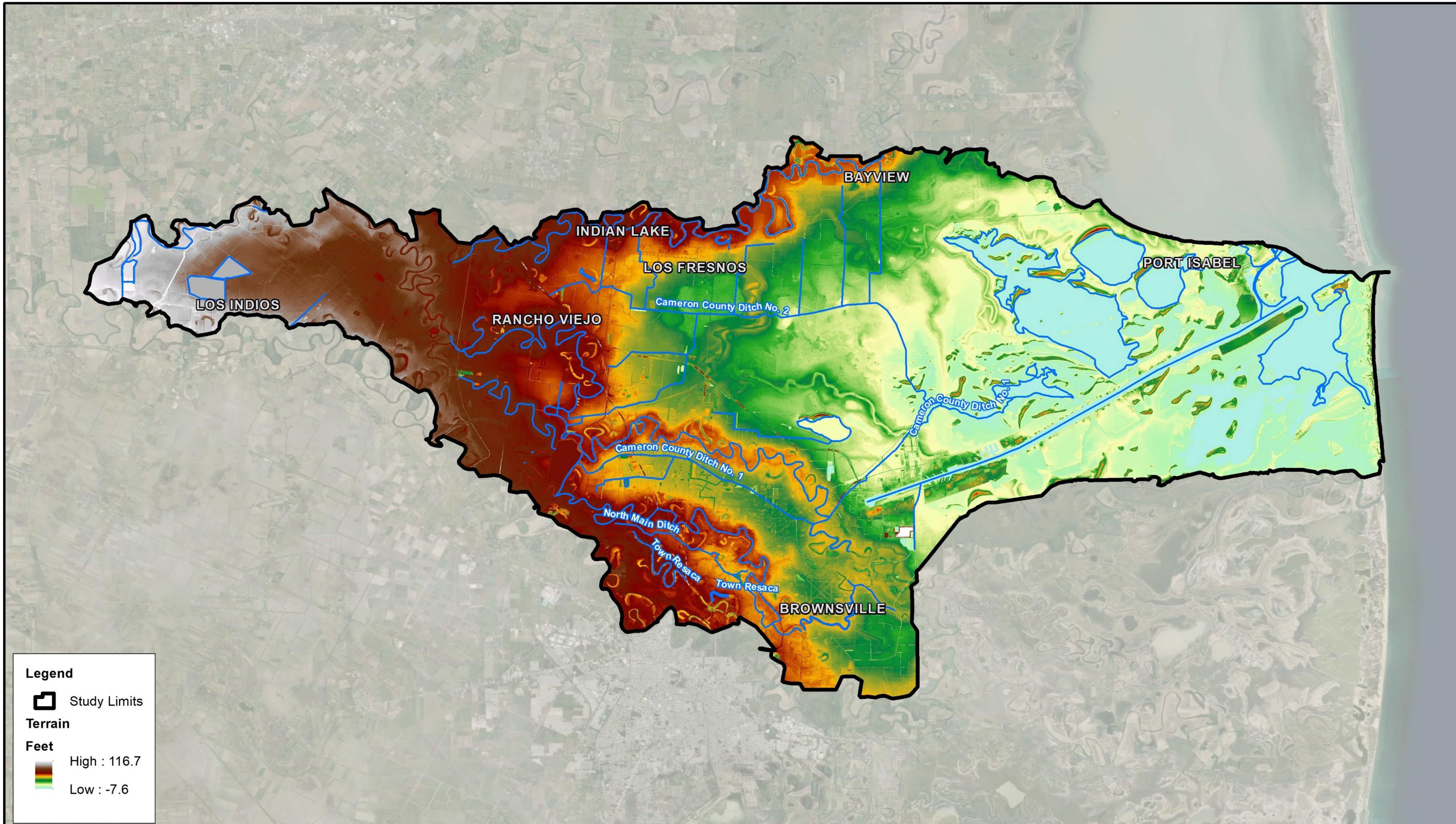

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Exhibit 8: Terrain

Brownsville to Port Isabel HUC-10 Watershed

0 3 6 Miles

1 in = 3 miles

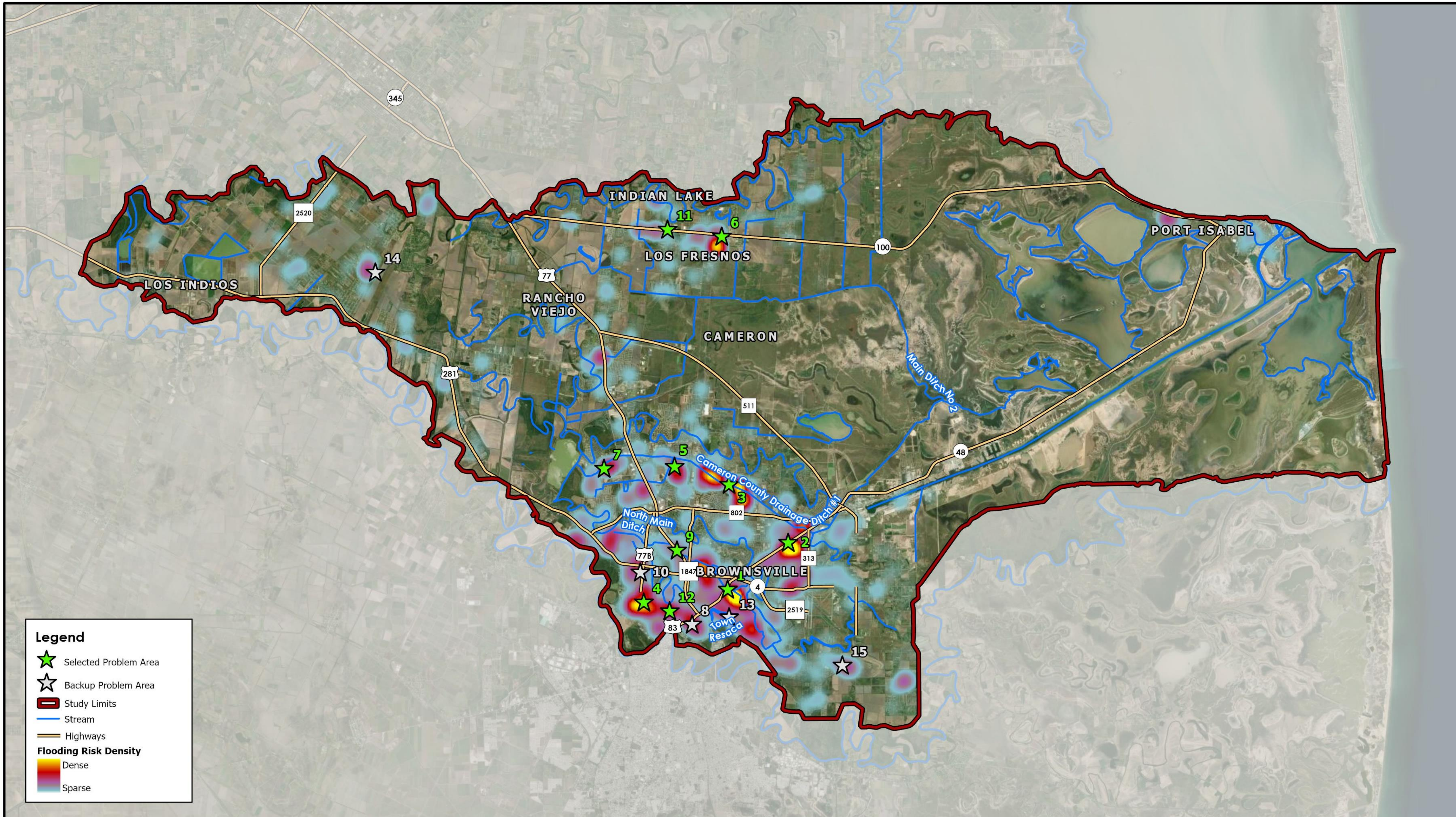

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Exhibit 9: Problem Area Heatmap

Brownsville to Port Isabel HUC-10 Watershed Study

0 3 6 Miles

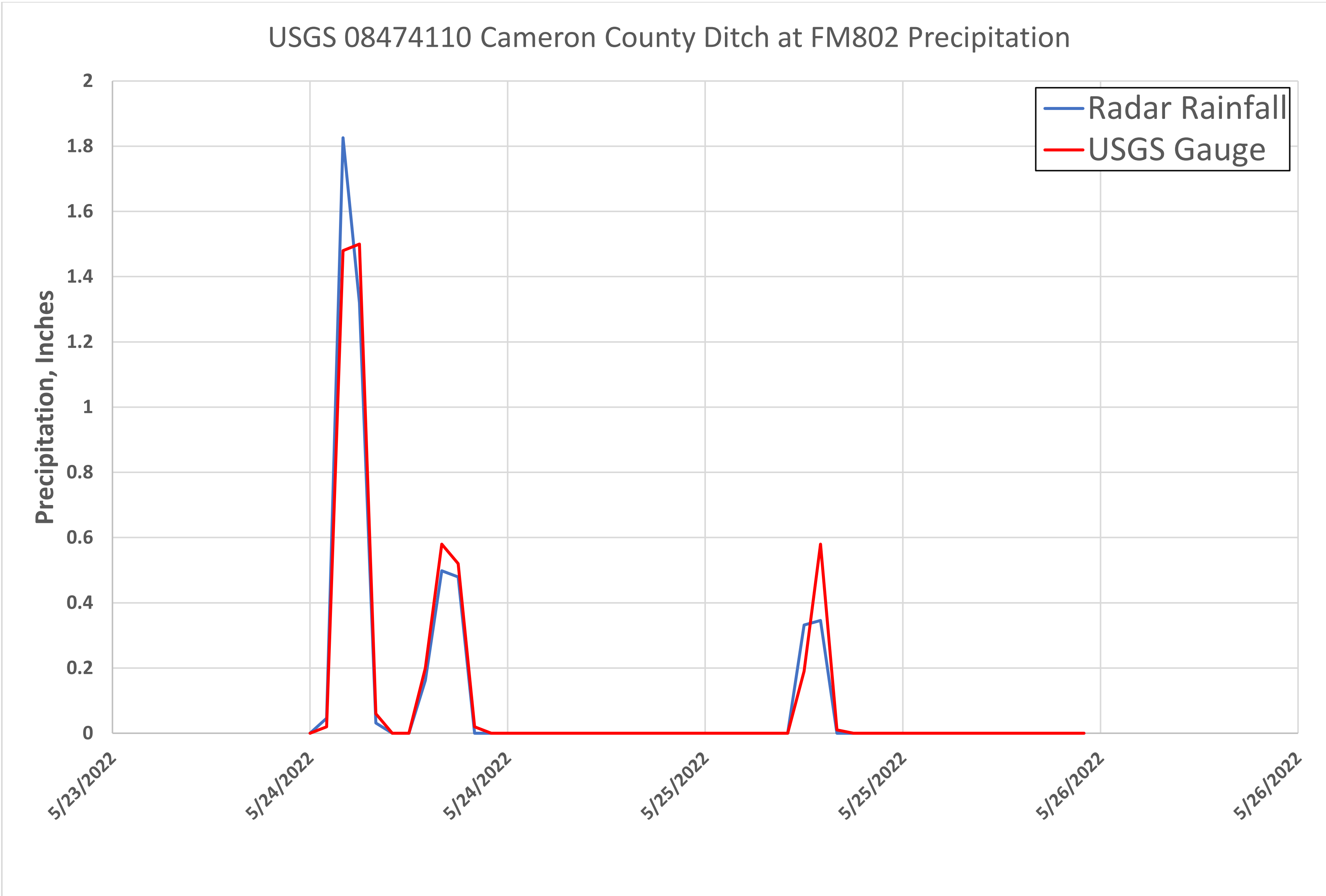
1 in = 3 Miles

N

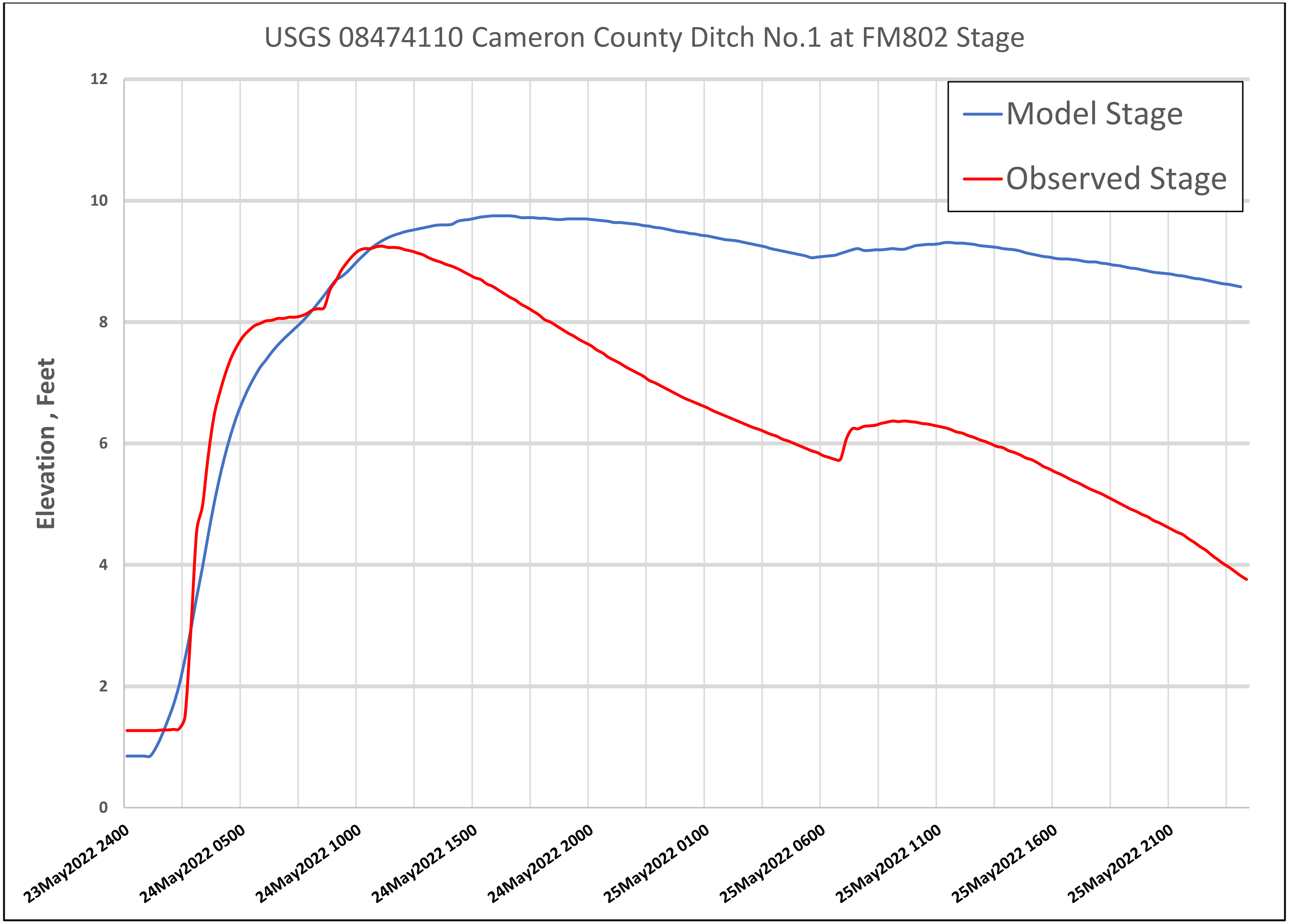
Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\Ex05_ProblemAreaHeatmap\Heatmap\HeatmapUpdate.aprx

Date: 10/13/2023

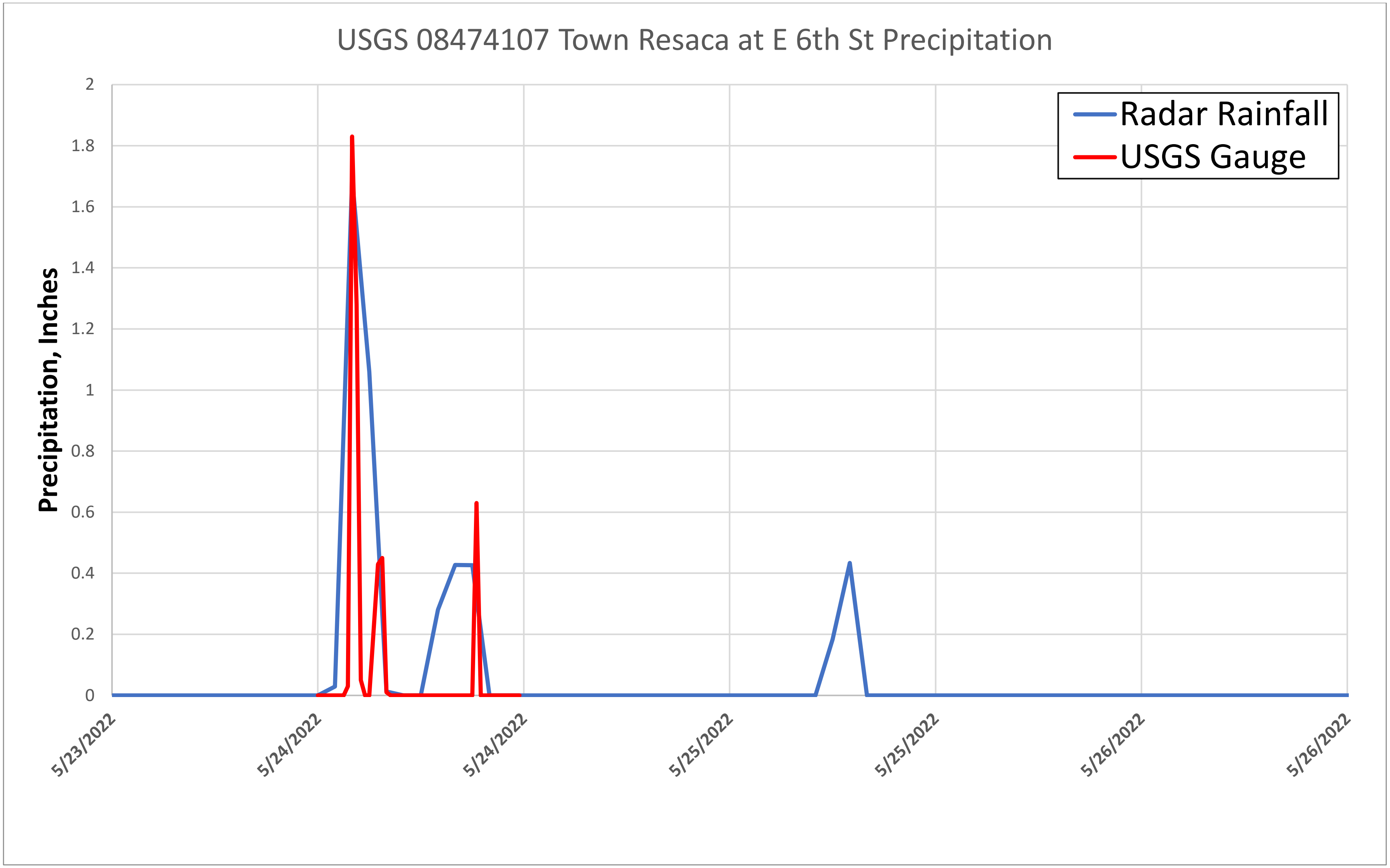
Appendix B - Calibration Results



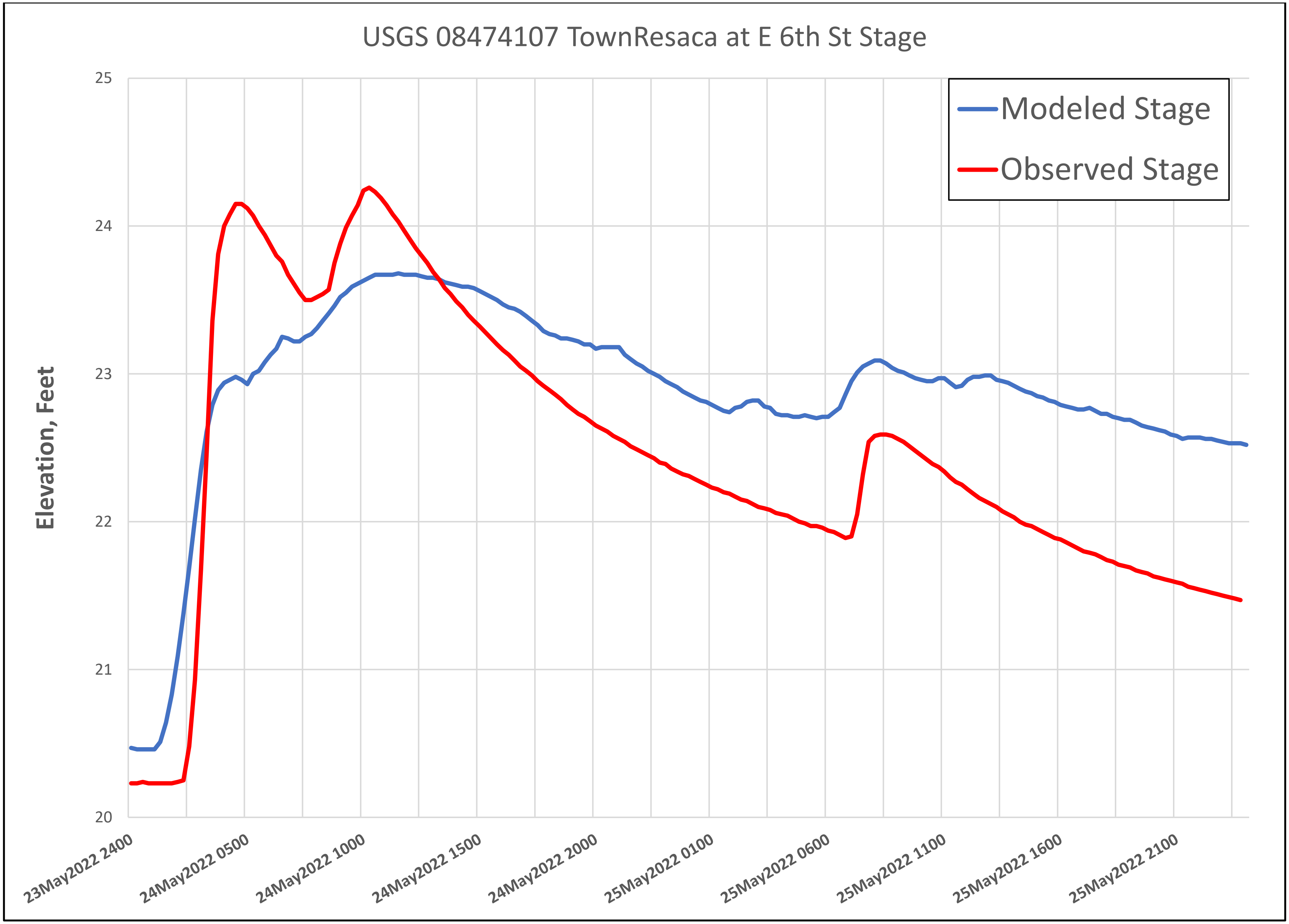
USGS 08474110 Cameron County Ditch at FM802 Precipitation
Precipitation, Inches
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/23/2022
5/24/2022
5/24/2022
5/25/2022
5/25/2022
5/26/2022
5/26/2022
Radar Rainfall
USGS Gauge



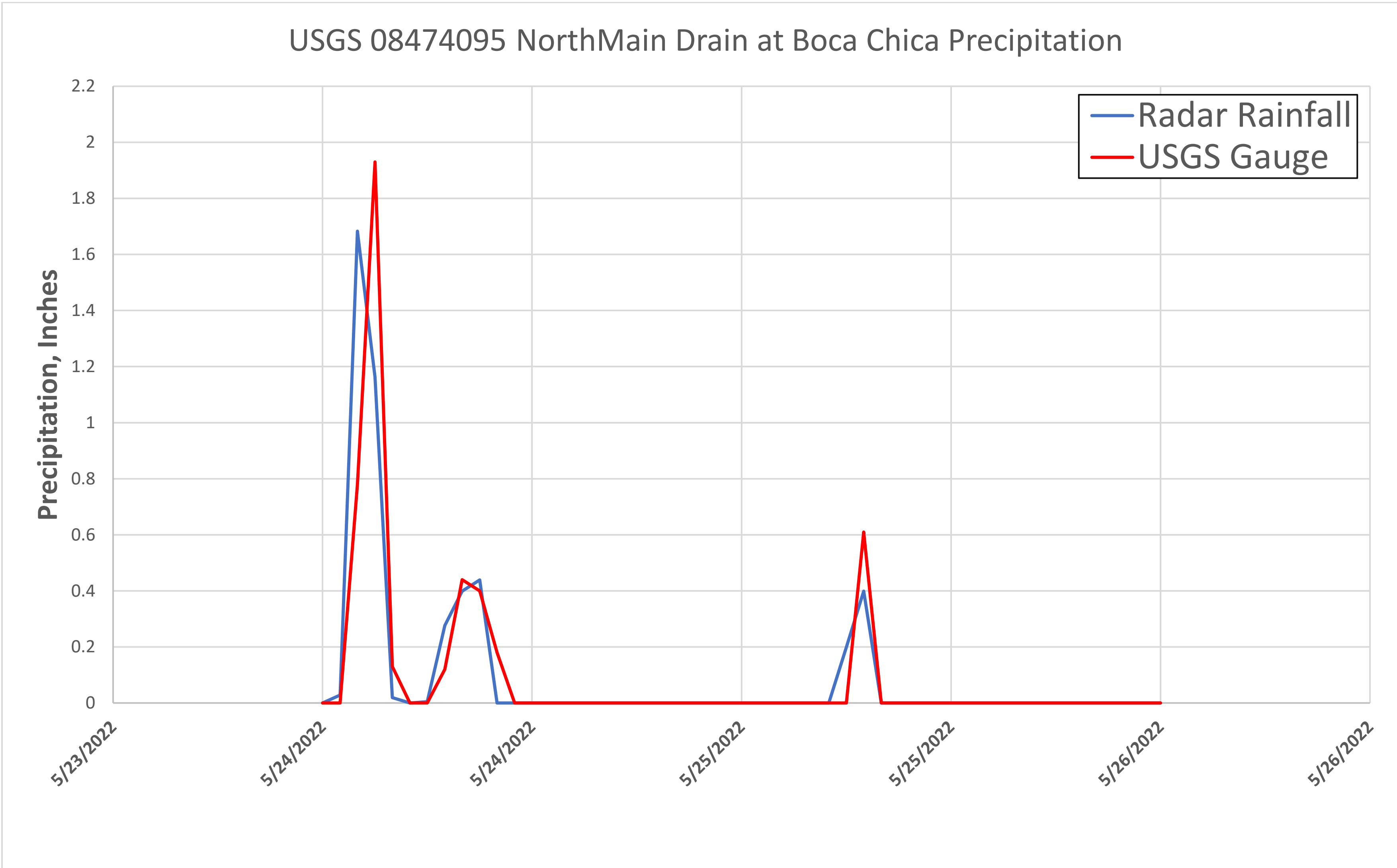
USGS 08474110 Cameron County Ditch No.1 at FM802 Stage
Model Stage
Observed Stage
Elevation , Feet
0
2
4
6
8
10
12
23May2022 2400
24May2022 0500
24May2022 1000
24May2022 1500
24May2022 2000
25May2022 0100
25May2022 0600
25May2022 1100
25May2022 1600
25May2022 2100



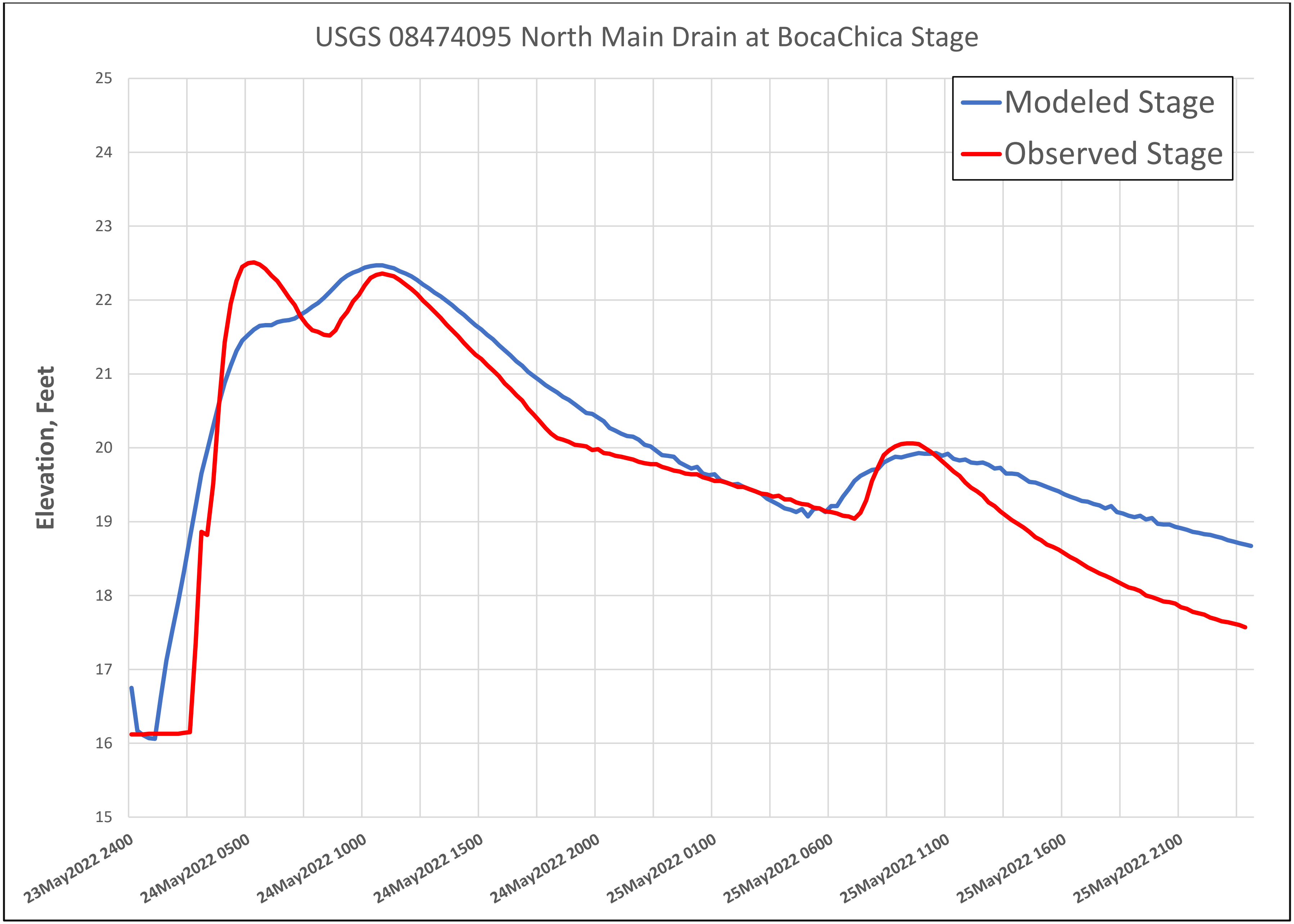
USGS 08474107 Town Resaca at E 6th St Precipitation
Precipitation, Inches
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/23/2022
5/24/2022
5/24/2022
5/25/2022
5/25/2022
5/26/2022
5/26/2022
Radar Rainfall
USGS Gauge

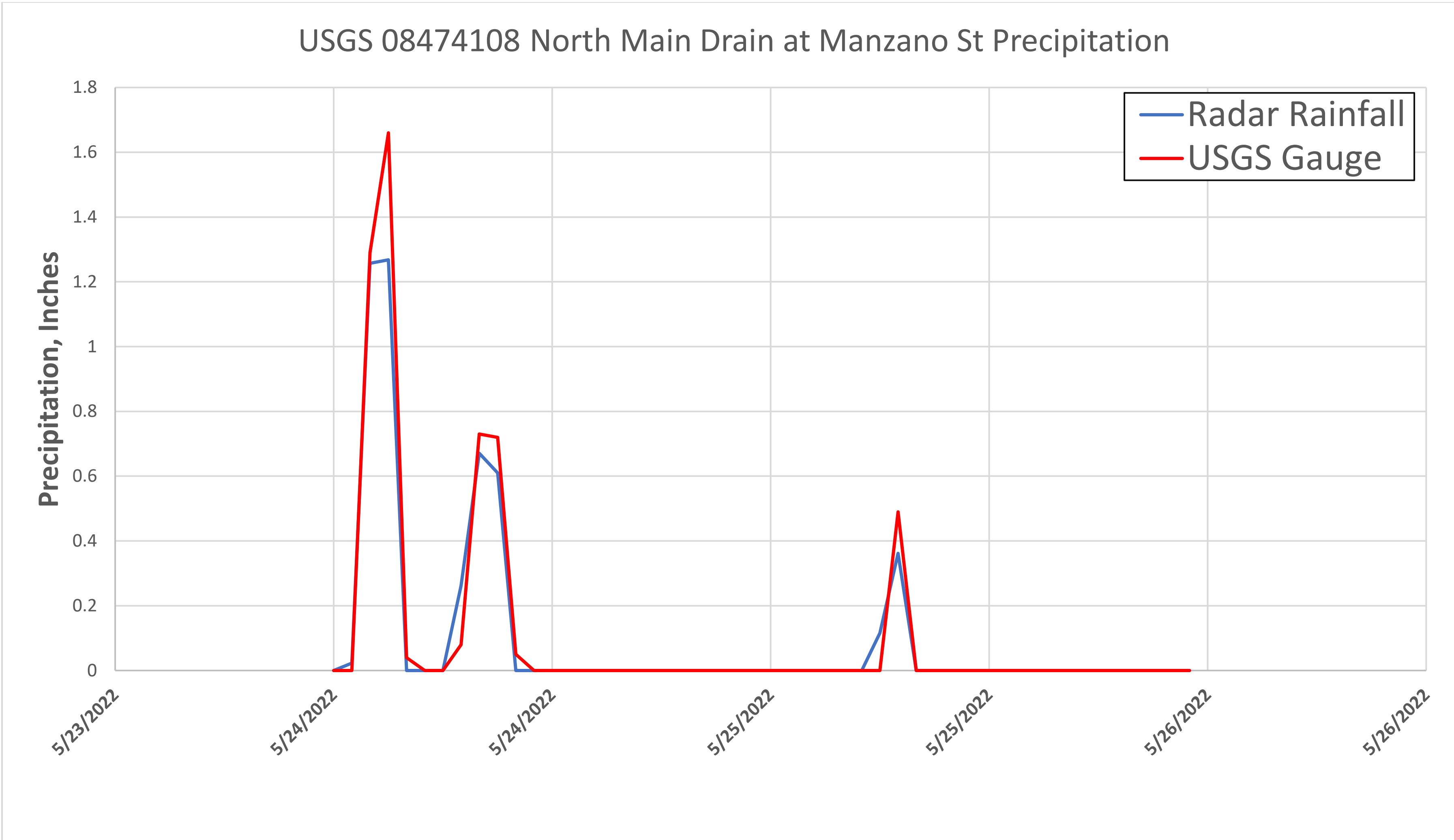


USGS 08474107 TownResaca at E 6th St Stage
Modeled Stage
Observed Stage
Elevation, Feet
25
24
23
22
21
20
23May2022 2400
24May2022 0500
24May2022 1000
24May2022 1500
24May2022 2000
25May2022 0100
25May2022 0600
25May2022 1100
25May2022 1600
25May2022 2100

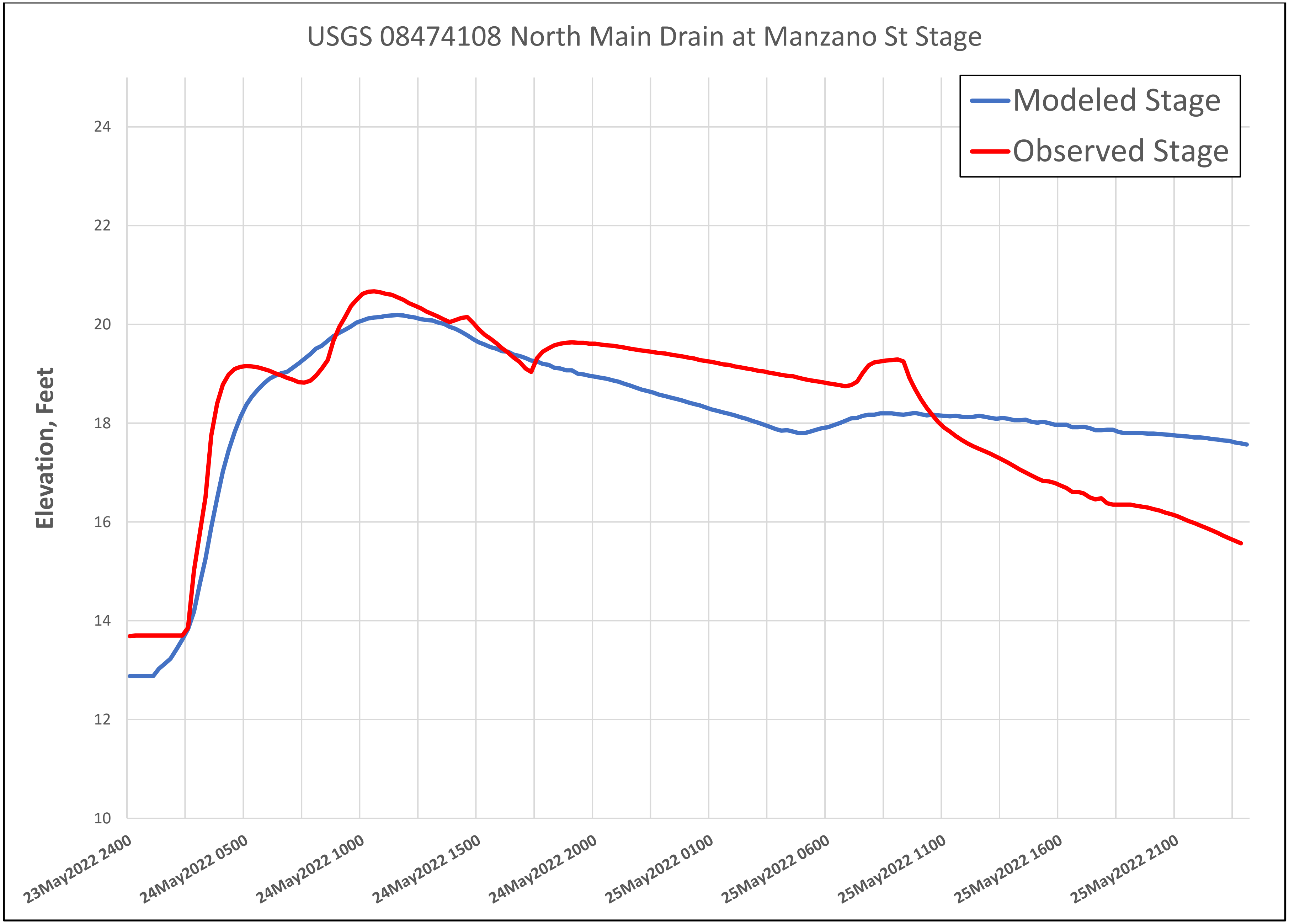


USGS 08474095 NorthMain Drain at Boca Chica Precipitation
Precipitation, Inches
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/23/2022
5/24/2022
5/24/2022
5/25/2022
5/25/2022
5/26/2022
5/26/2022
Radar Rainfall
USGS Gauge

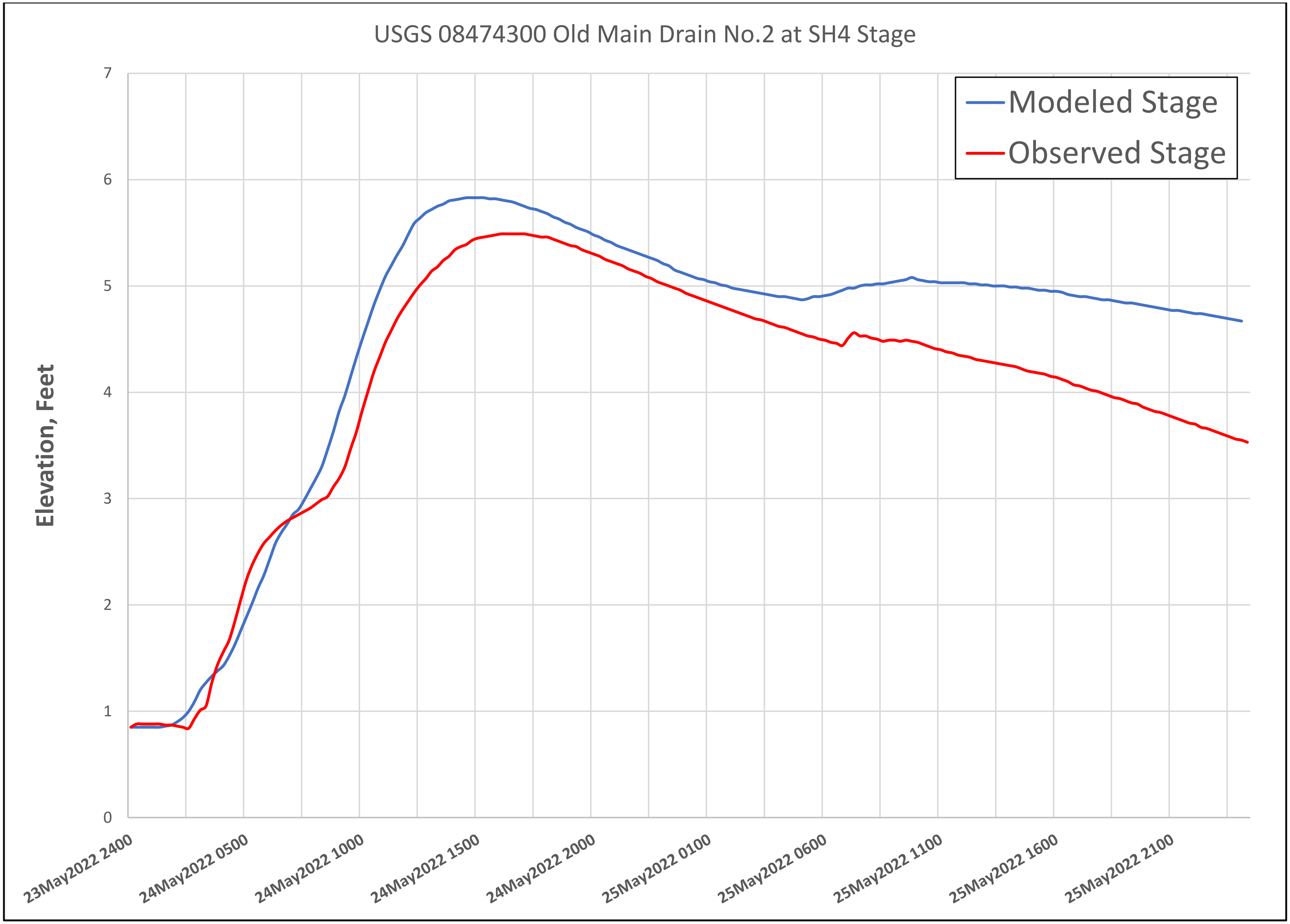

USGS 08474095 North Main Drain at BocaChica Stage
Modeled Stage
Observed Stage
Elevation, Feet
25
24
23
22
21
20
19
18
17
16
15
23May2022 2400
24May2022 0500
24May2022 1000
24May2022 1500
24May2022 2000
25May2022 0100
25May2022 0600
25May2022 1100
25May2022 1600
25May2022 2100



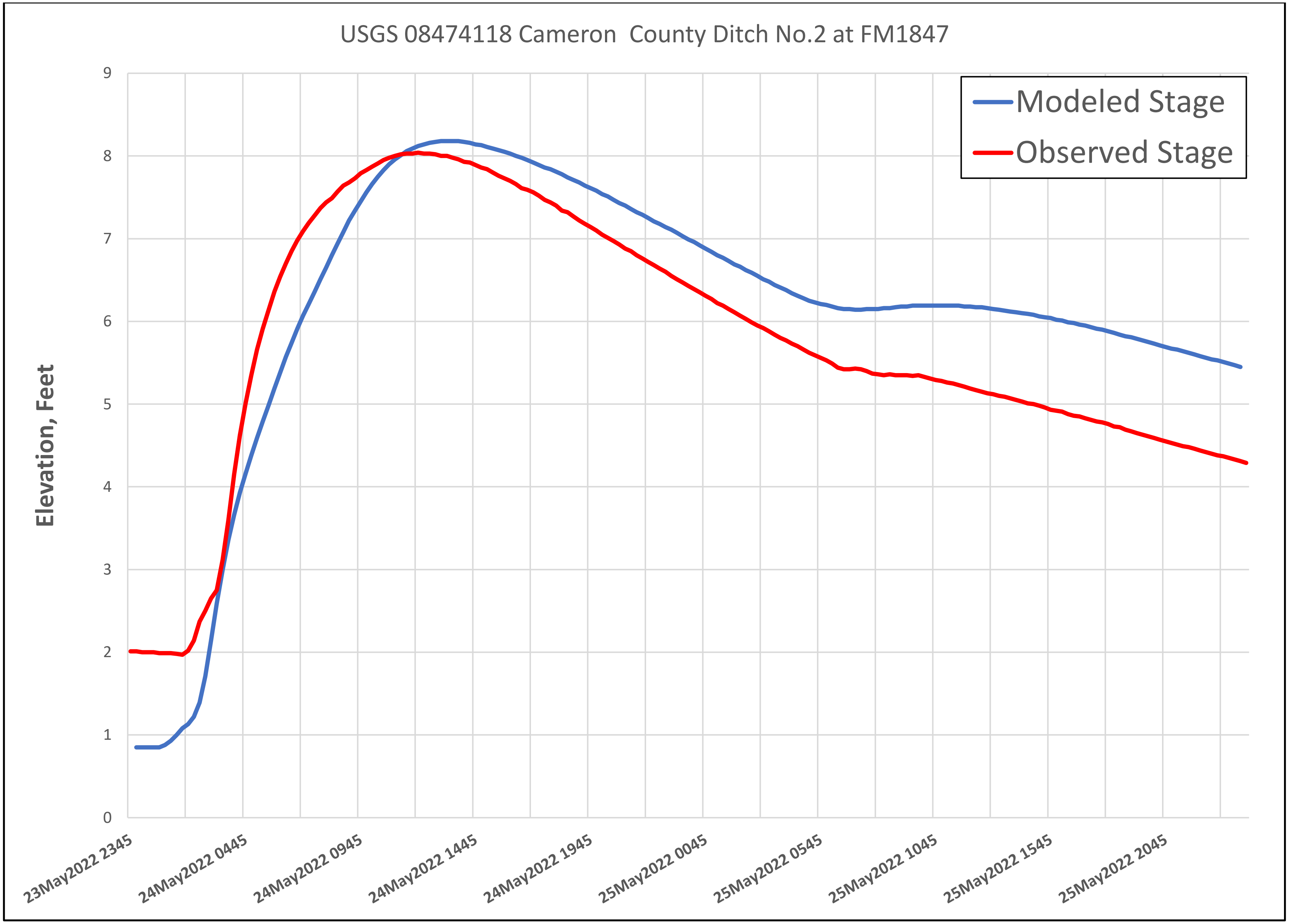
USGS 08474108 North Main Drain at Manzano St Precipitation
Precipitation, Inches
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/23/2022
5/24/2022
5/24/2022
5/25/2022
5/25/2022
5/26/2022
5/26/2022
Radar Rainfall
USGS Gauge



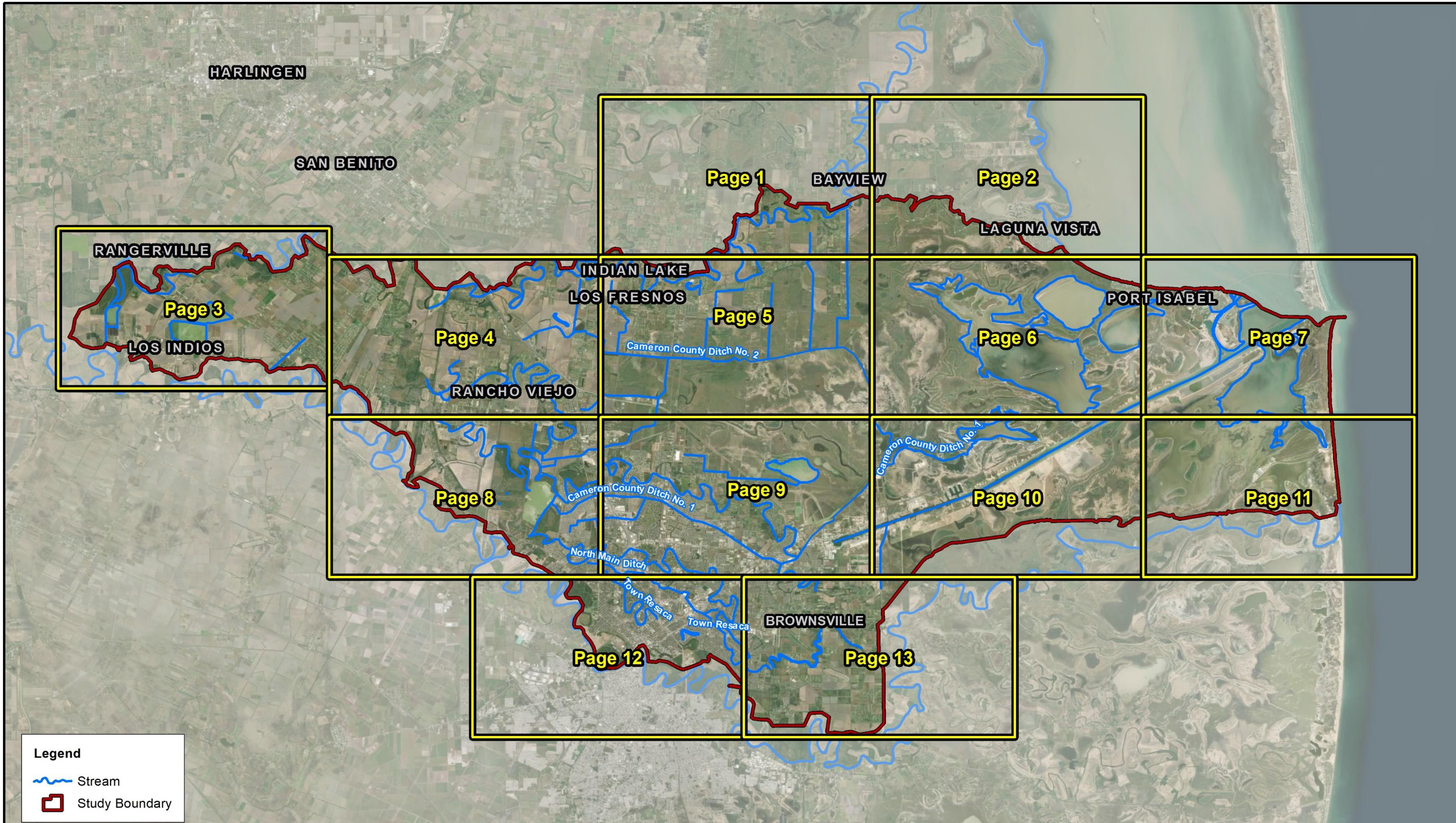
USGS 08474108 North Main Drain at Manzano St Stage
Modeled Stage
Observed Stage
Elevation, Feet
24
22
20
18
16
14
12
10
23May2022 2400
24May2022 0500
24May2022 1000
24May2022 1500
24May2022 2000
25May2022 0100
25May2022 0600
25May2022 1100
25May2022 1600
25May2022 2100



USGS 08474300 Old Main Drain No.2 at SH4 Stage
Modeled Stage
Observed Stage
Elevation, Feet
0
1
2
3
4
5
6
7
23May2022 2400
24May2022 0500
24May2022 1000
24May2022 1500
24May2022 2000
25May2022 0100
25May2022 0600
25May2022 1100
25May2022 1600
25May2022 2100


USGS 08474118 Cameron County Ditch No.2 at FM1847
Modeled Stage
Observed Stage
Elevation, Feet
0
1
2
3
4
5
6
7
8
9
23May2022 2345
24May2022 0445
24May2022 0945
24May2022 1445
24May2022 1945
25May2022 0045
25May2022 0545
25May2022 1045
25May2022 1545
25May2022 2045

Appendix C - 100-Year Flood Depth Maps



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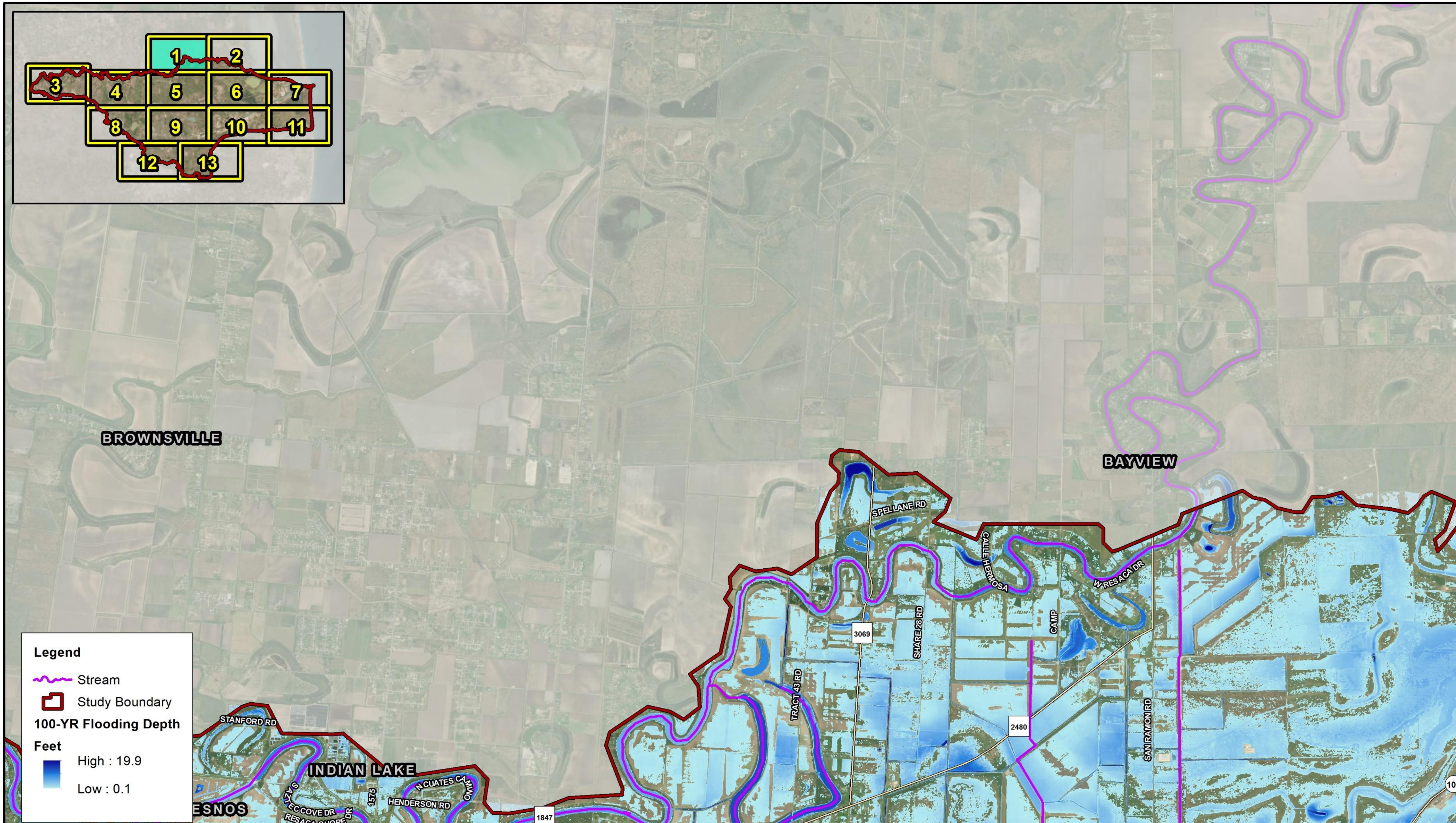
Exising 100-YR Flood Depth Map

INDEX

Port Isabel HUC-10 Watershed Study

0 16,000 32,000 Feet

1 in = 16,000 feet



Existing 100-YR Flood Depth Map

Page 1

Port Isabel HUC-10 Watershed Study

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0 4,000 8,000 Feet

1 in = 4,000 feet

N

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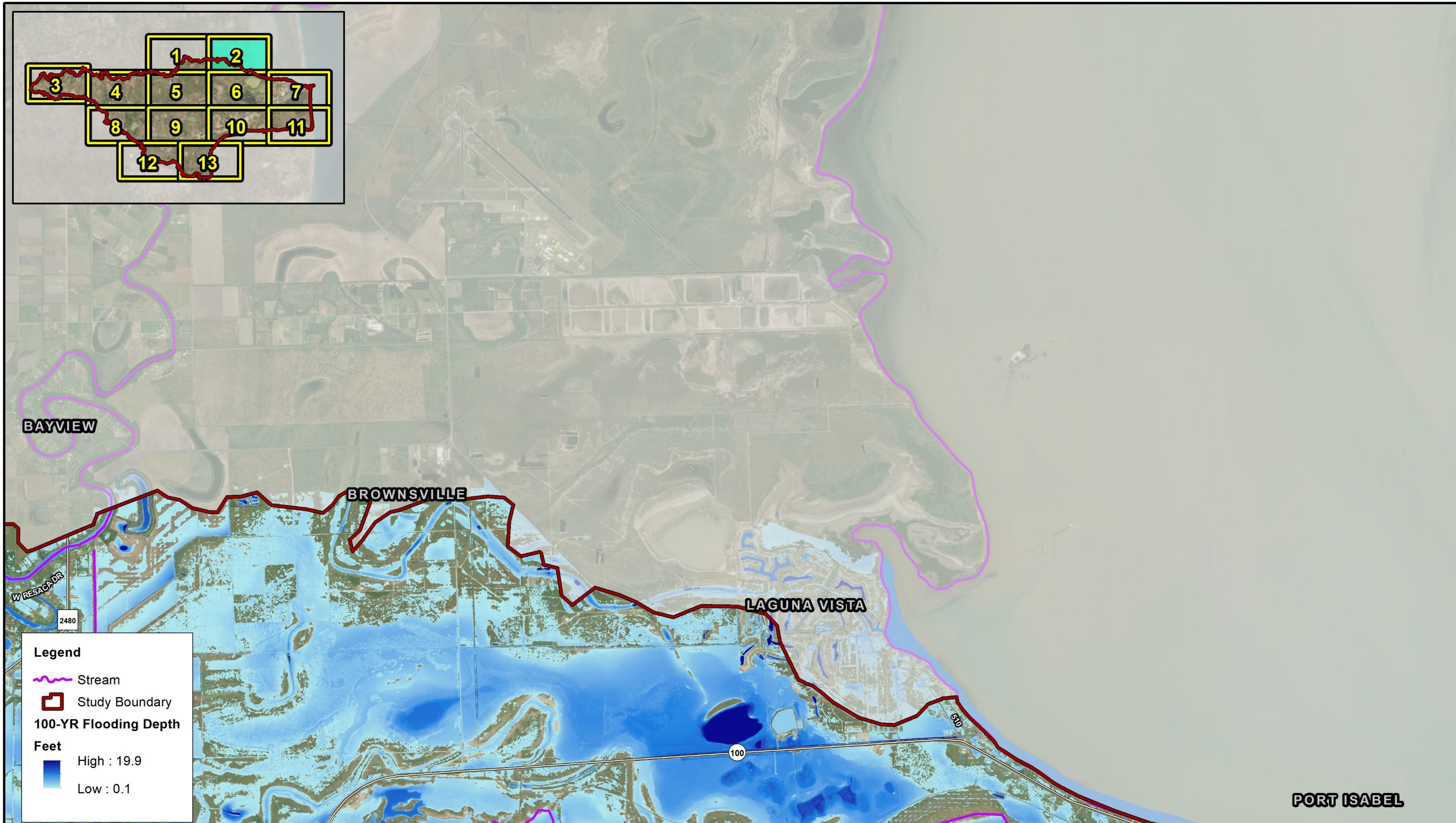

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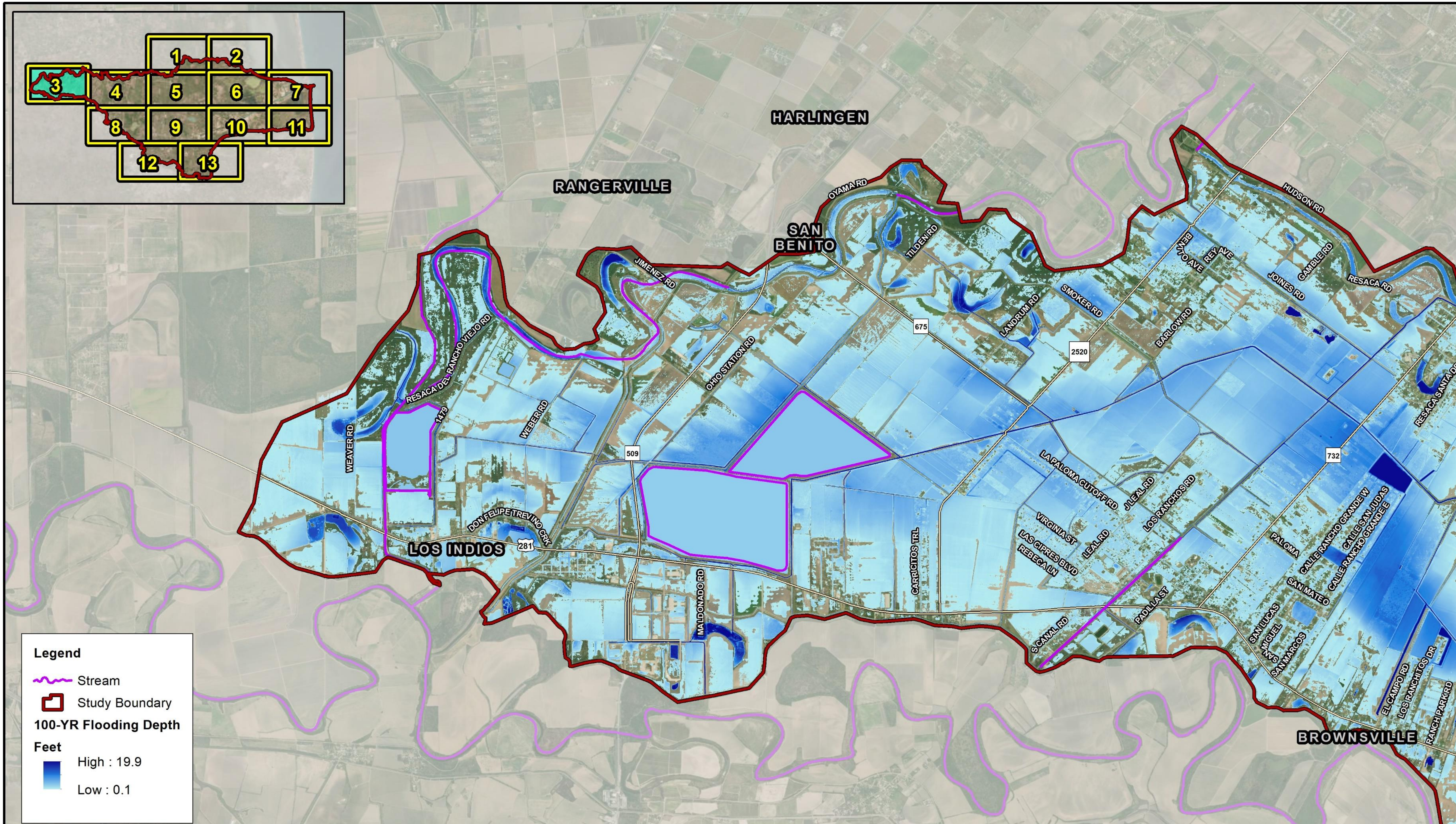
Existing 100-YR Flood Depth Map

Page 2

Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet



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Existing 100-YR Flood Depth Map

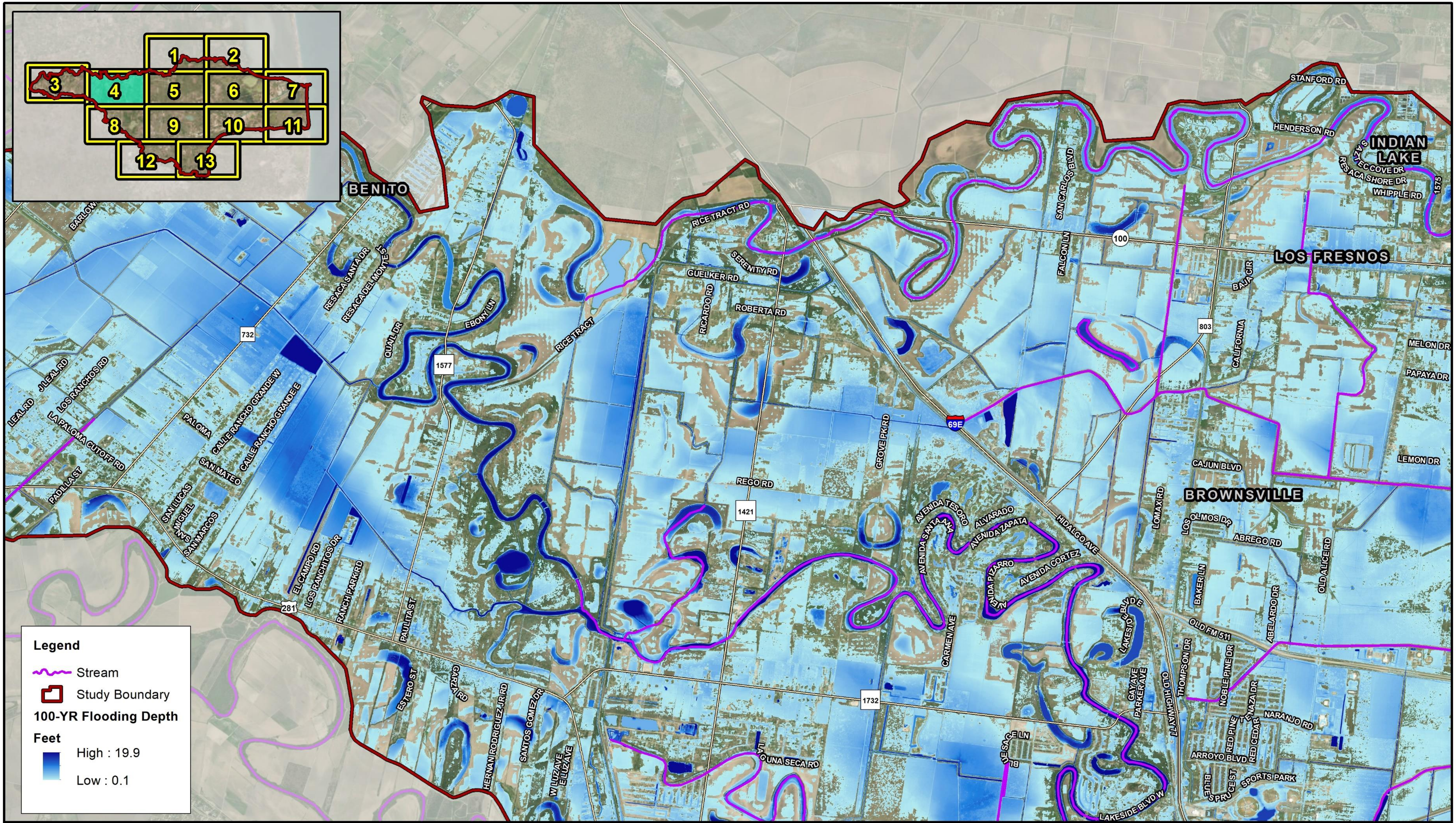
Page 3

Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

N



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Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

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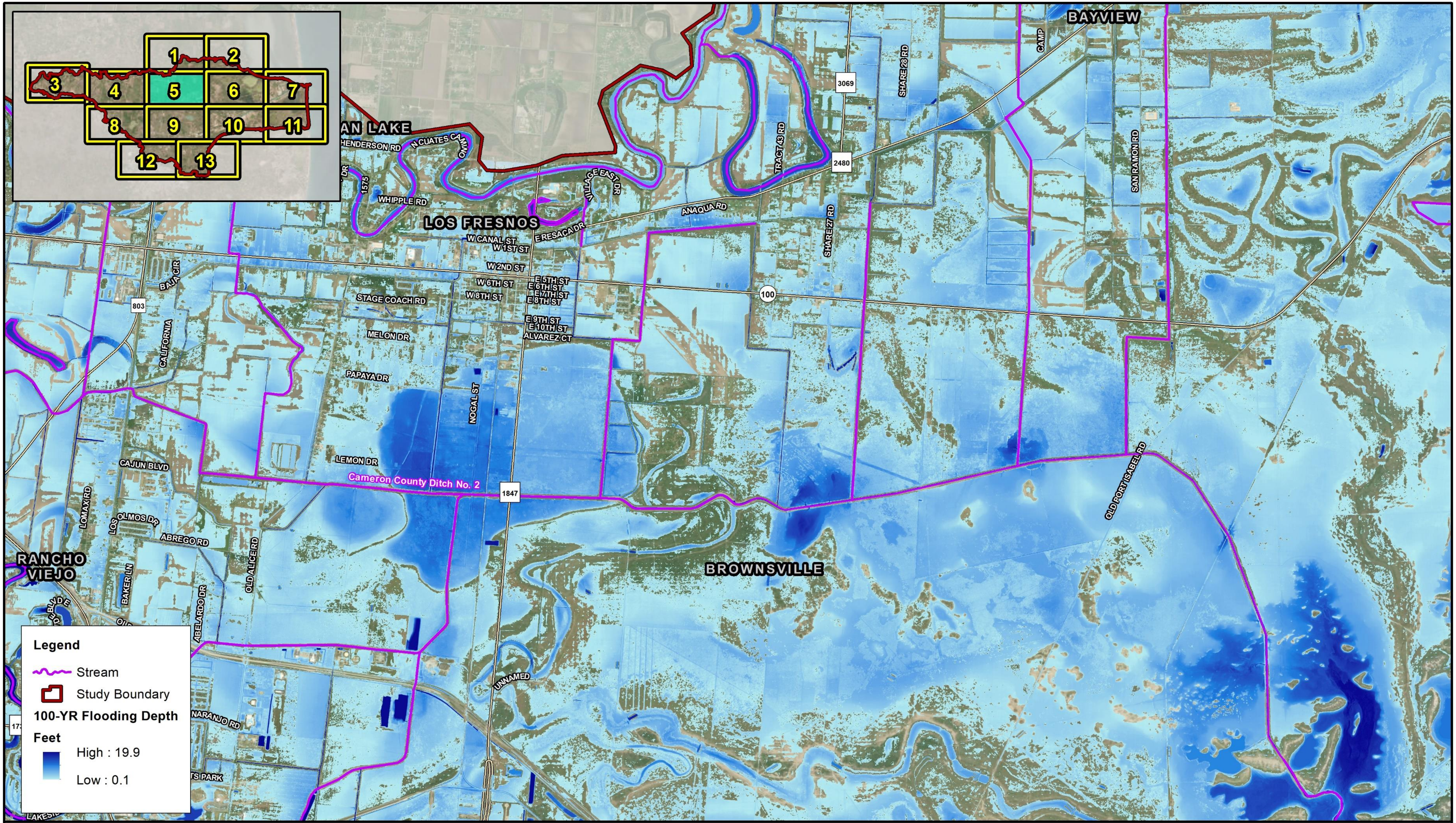
Date: 10/13/2023



Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

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0 4,000 8,000 Feet

1 in = 4,000 feet

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\Ex00_Depth_Zoom_11x17.mxd

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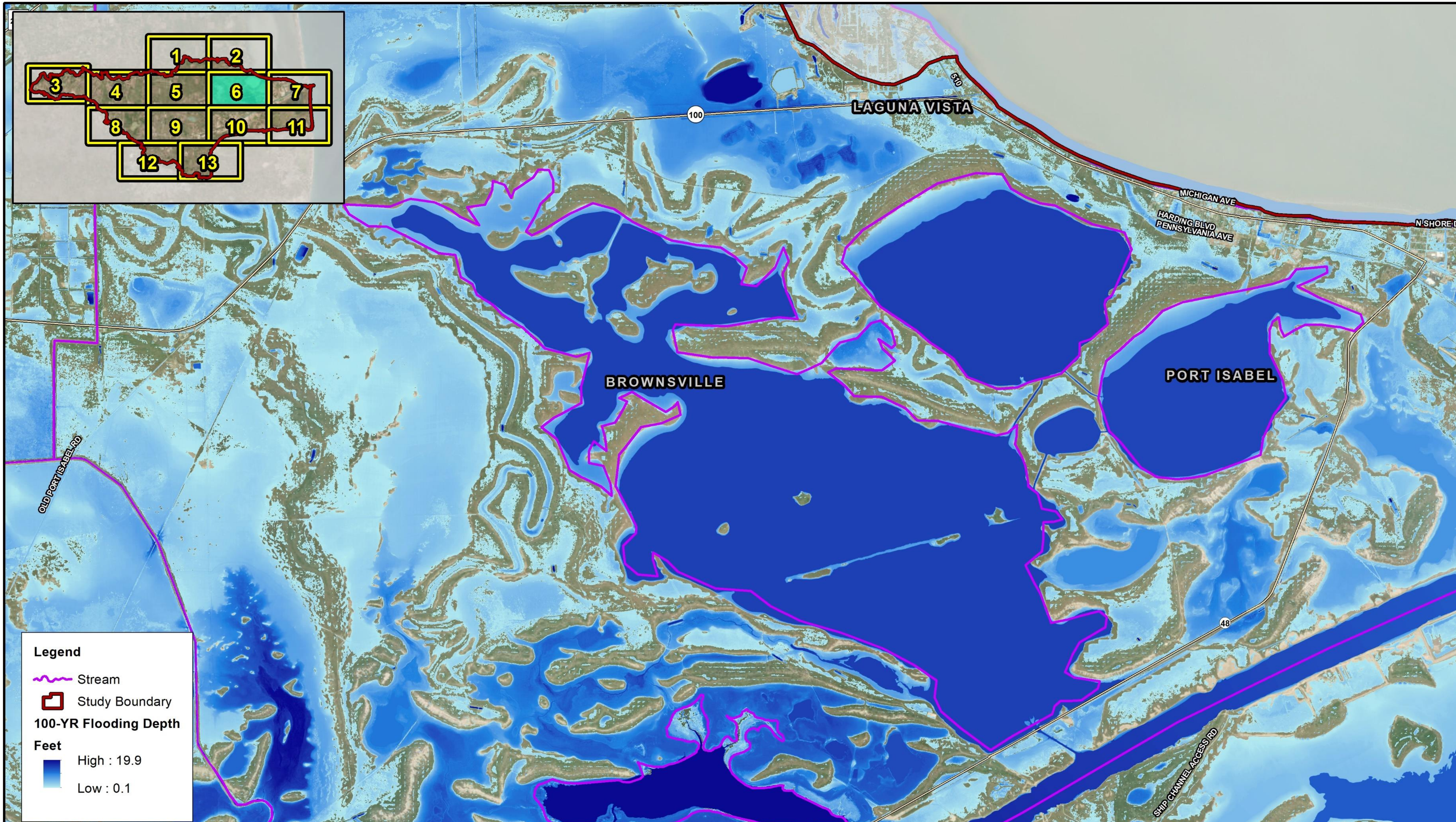

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Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\Ex00_Depth_Zoom_11x17.mxd

Date: 10/13/2023

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Existing 100-YR Flood Depth Map

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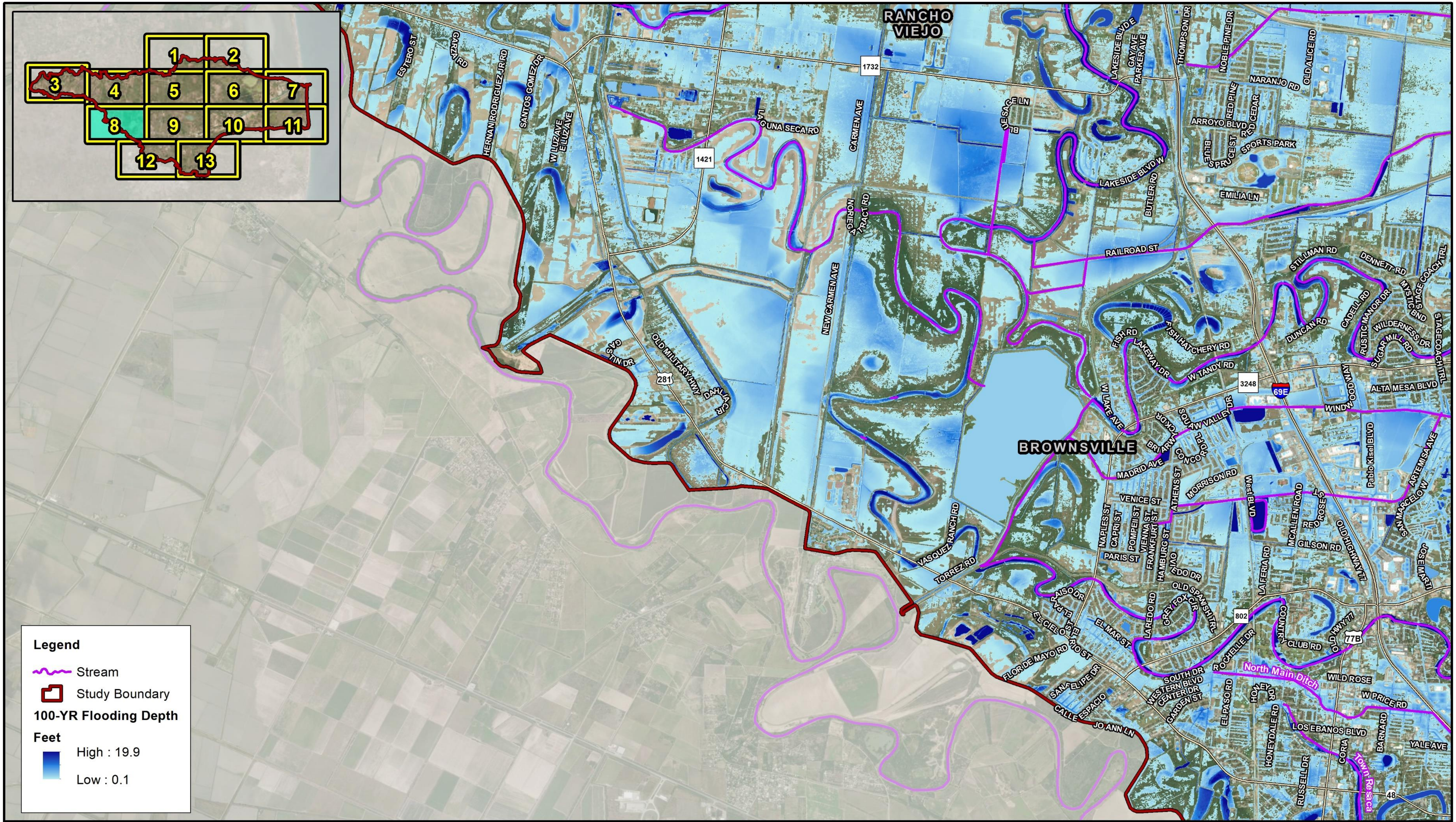
Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet



Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

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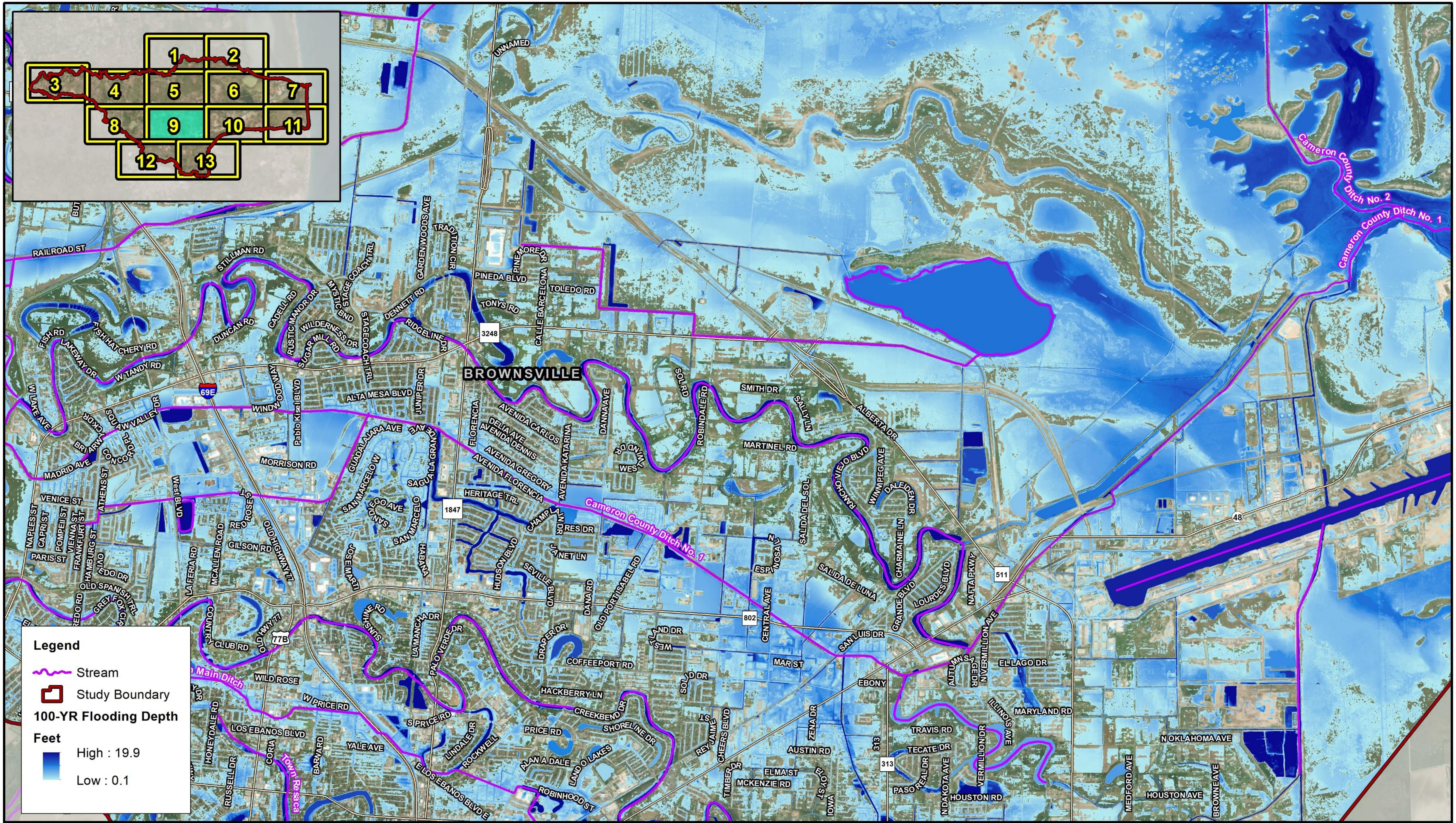
0 4,000 8,000 Feet

1 in = 4,000 feet



Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

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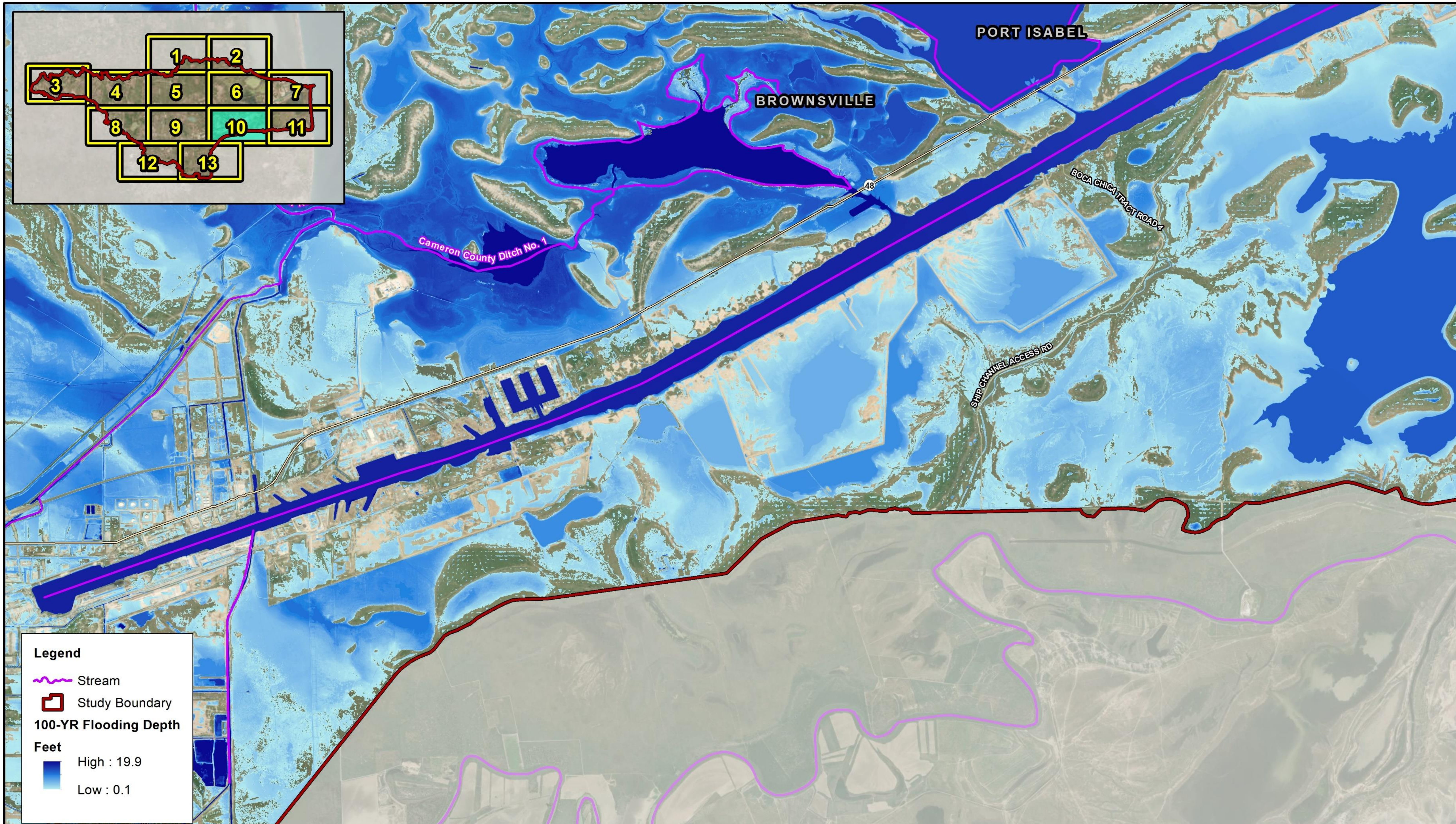
0 4,000 8,000 Feet

1 in = 4,000 feet



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Existing 100-YR Flood Depth Map

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Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

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Existing 100-YR Flood Depth Map

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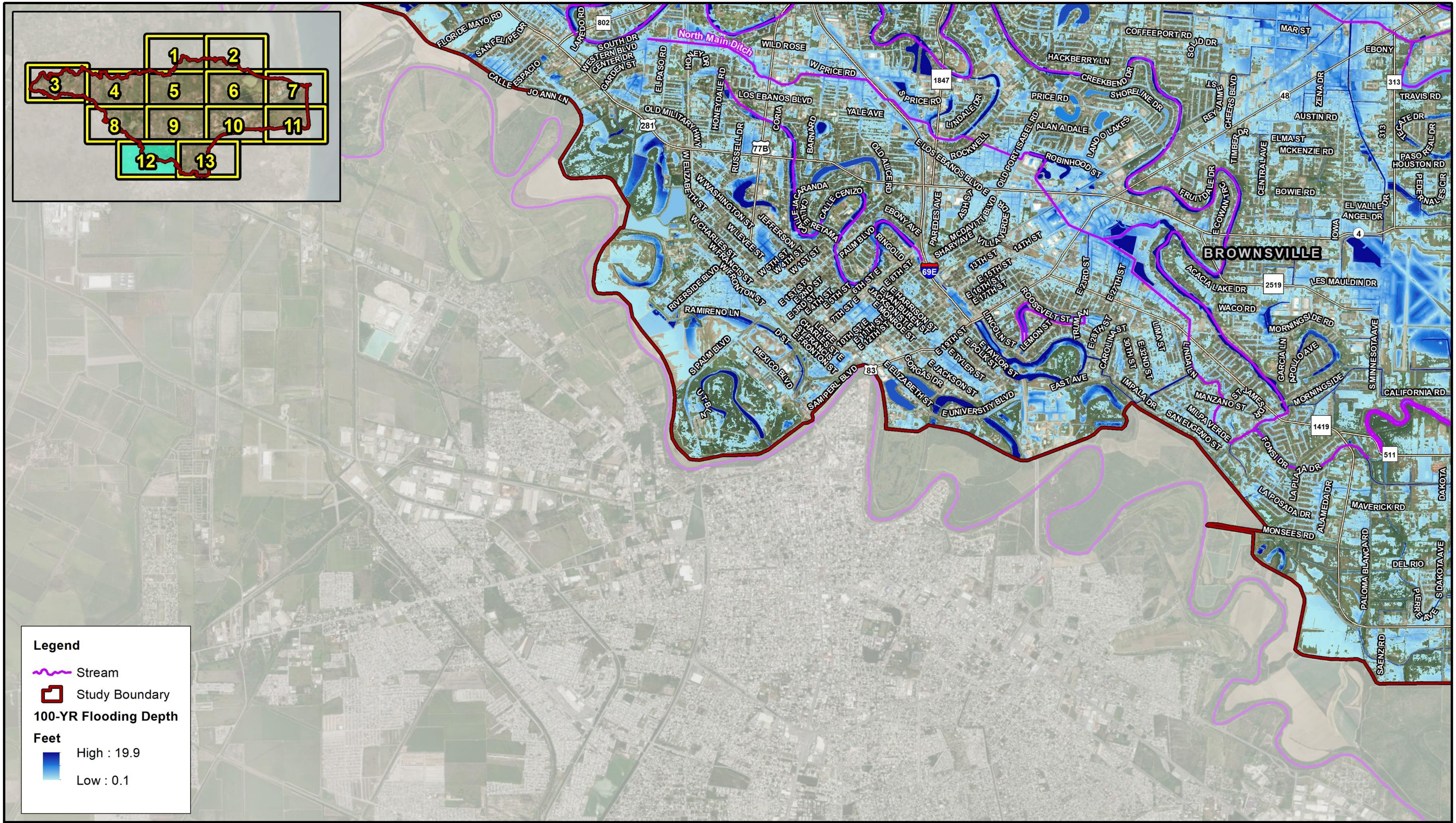
Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

N



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Existing 100-YR Flood Depth Map

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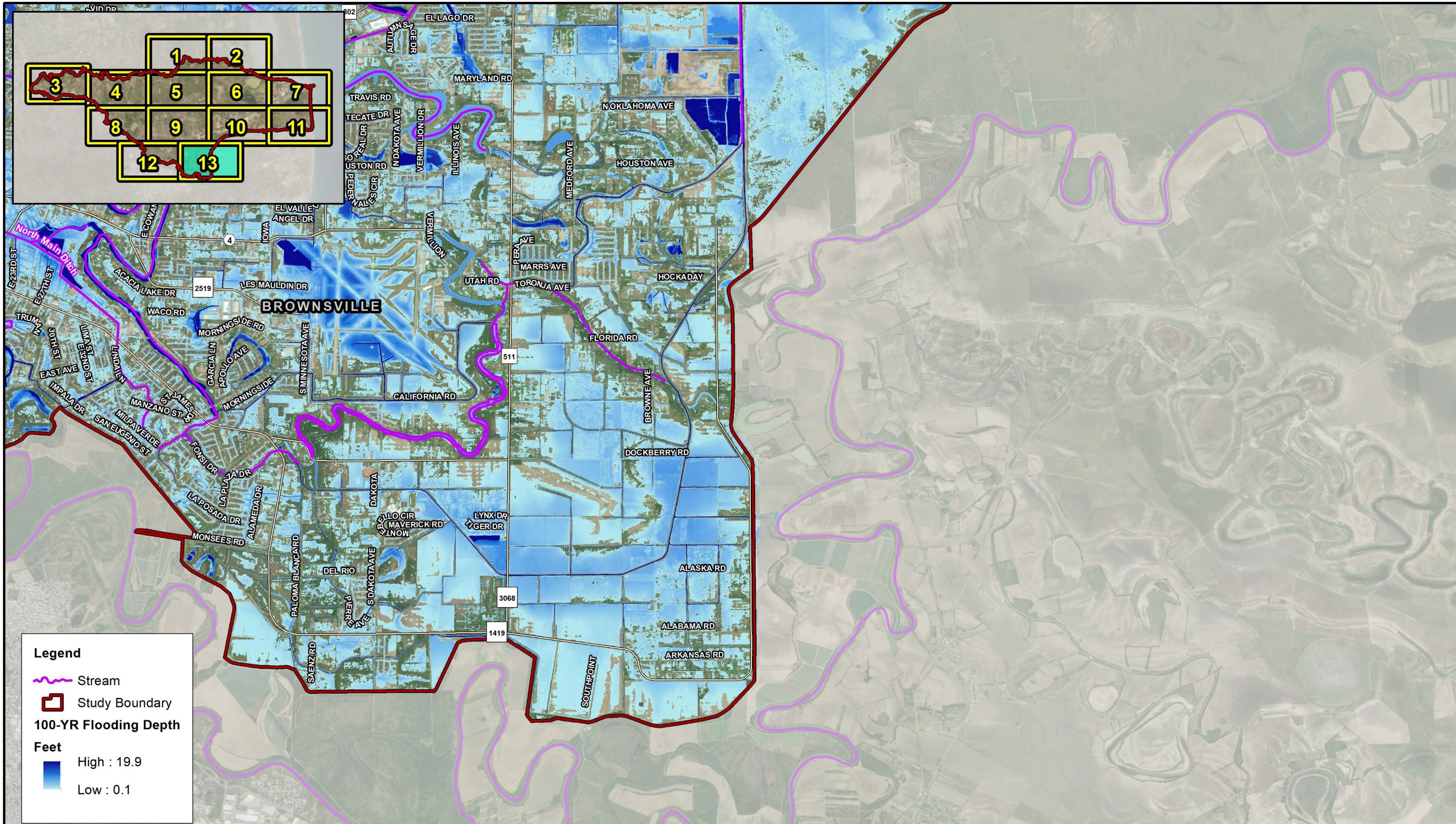
Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet



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Existing 100-YR Flood Depth Map

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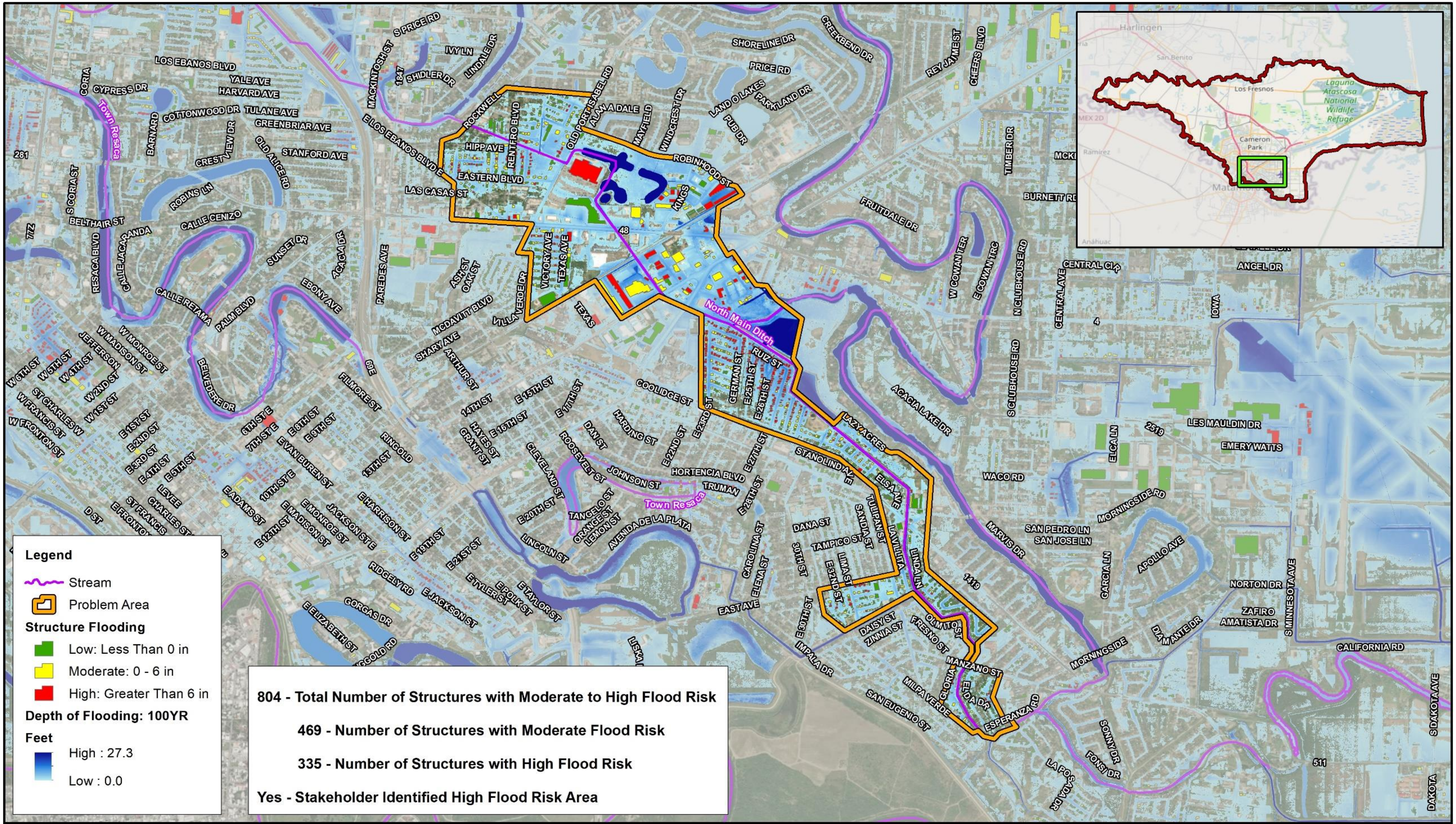
Port Isabel HUC-10 Watershed Study

0 4,000 8,000 Feet

1 in = 4,000 feet

Appendix D - Problem Area Maps



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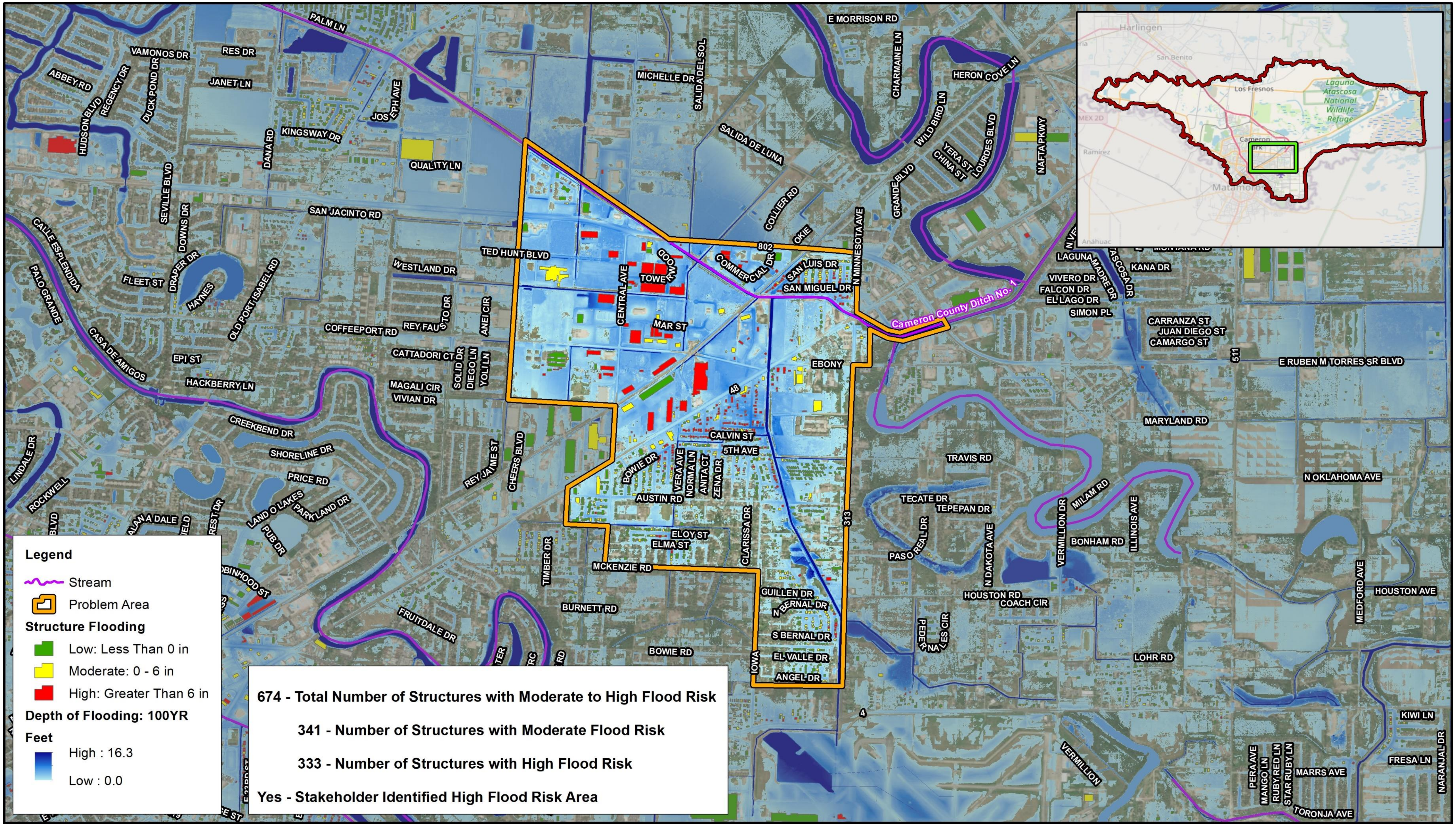
Problem Area Number 1

Brownsville to Port Isabel HUC-10 Watershed Study

0 2,000 4,000 Feet

1 in = 2,000 feet



Problem Area Number 2

Brownsville to Port Isabel HUC-10 Watershed Study

0 2,000 4,000 Feet

1 in = 2,000 feet

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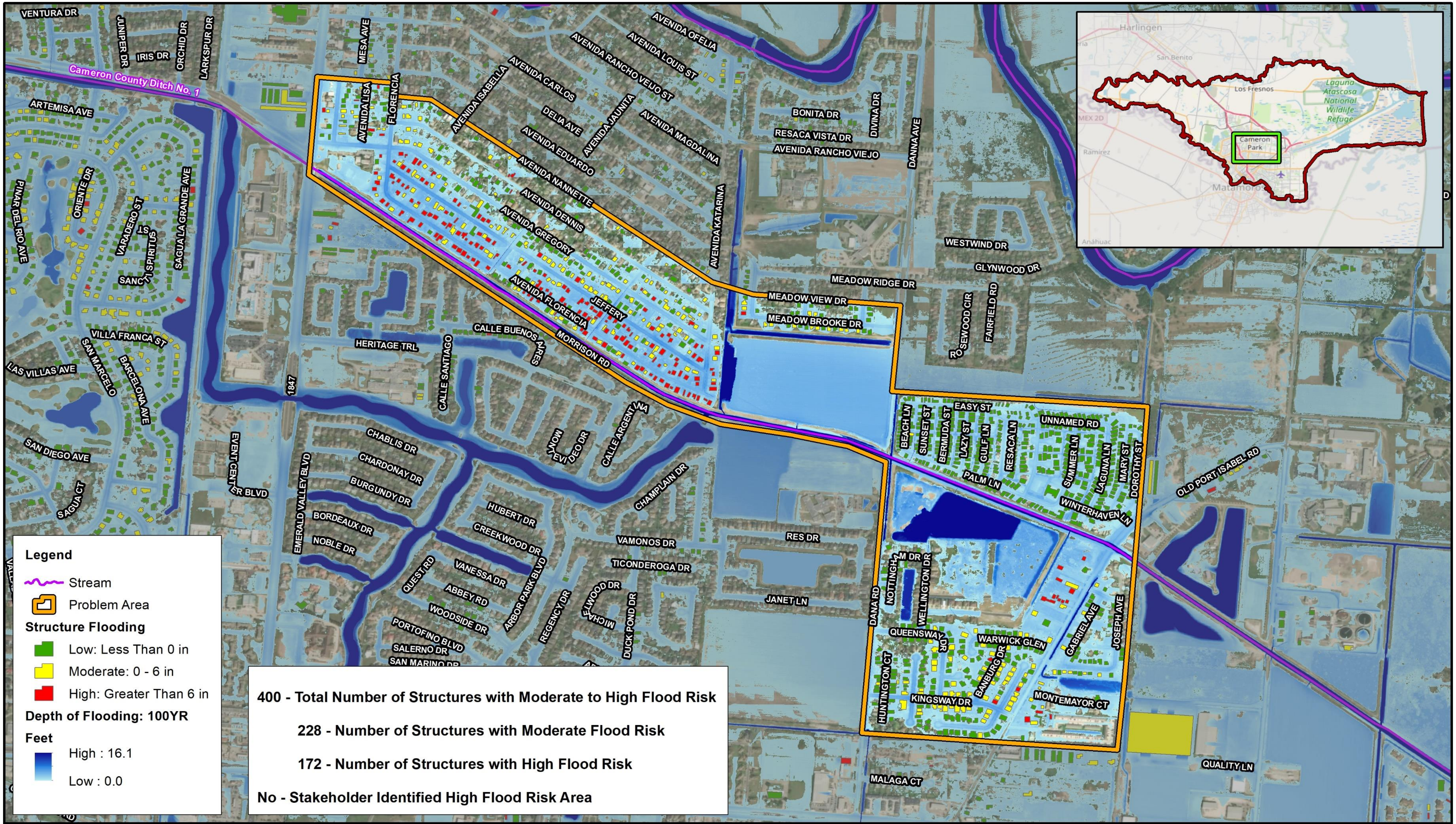

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Problem Area Number 3

Brownsville to Port Isabel HUC-10 Watershed Study

0 1,000 2,000 Feet

1 in = 1,000 feet

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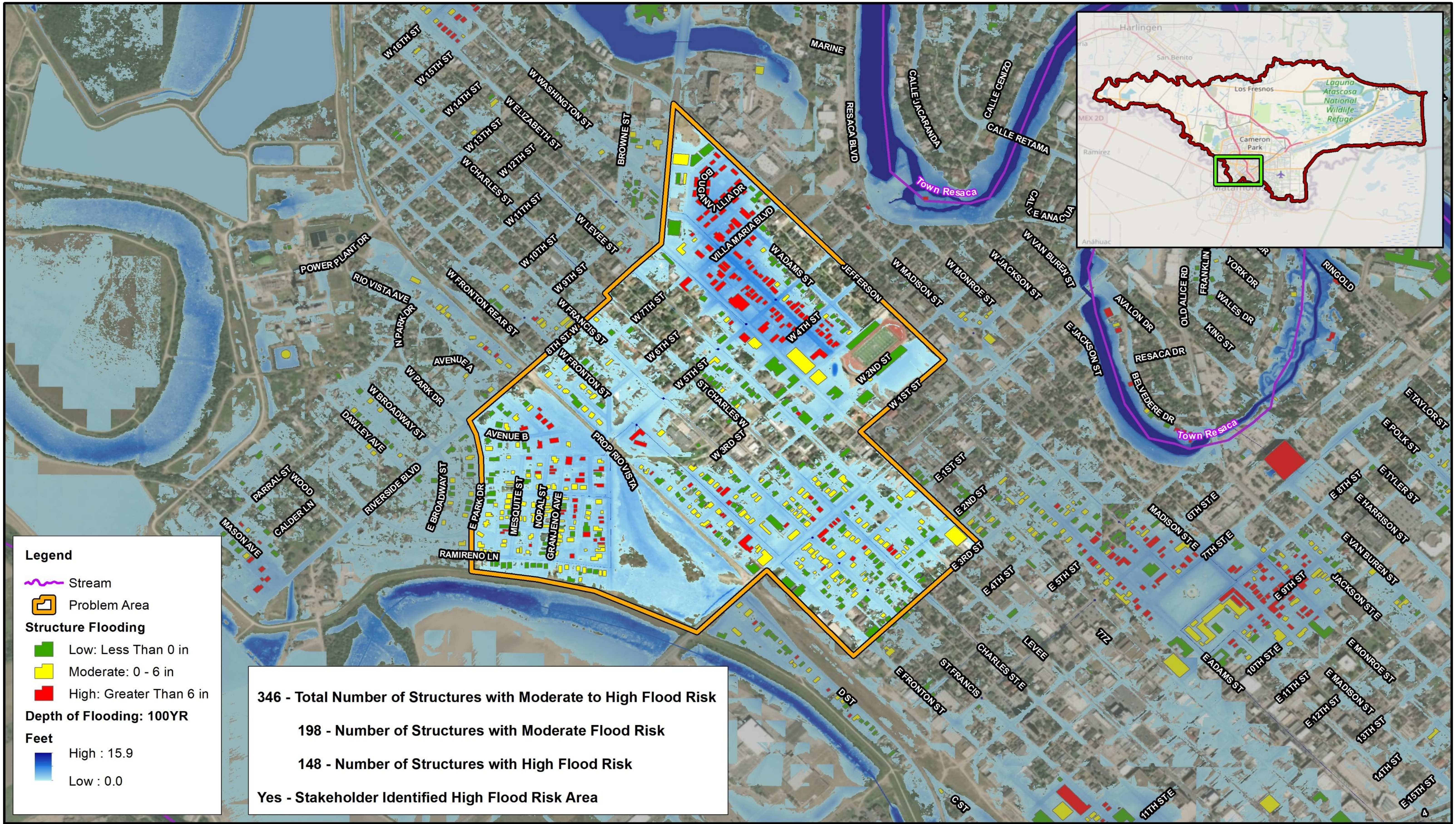

Problem Area Number 4

Brownsville to Port Isabel HUC-10 Watershed Study

0 800 1,600 Feet

1 in = 800 feet

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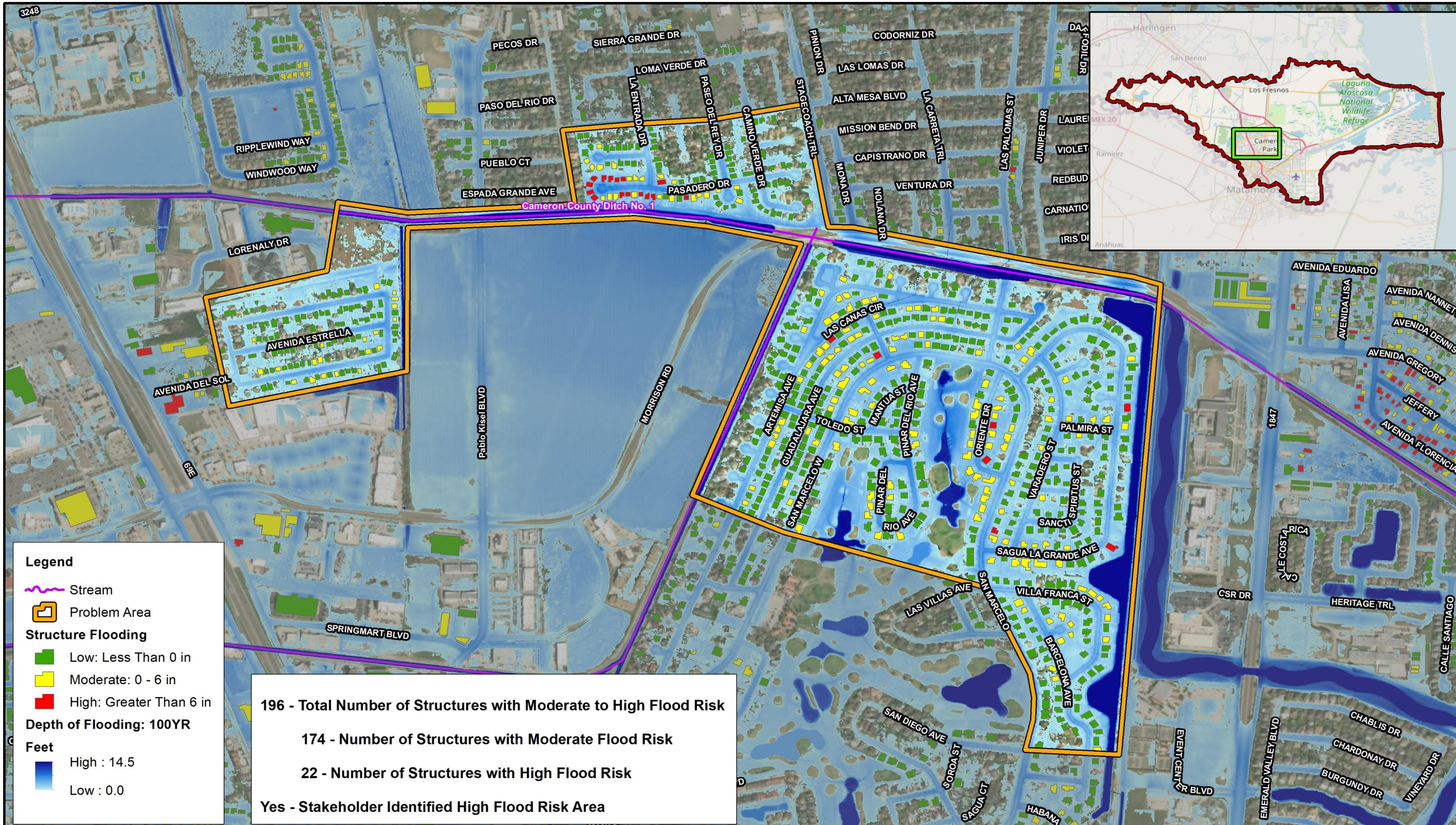

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Problem Area Number 5

Brownsville to Port Isabel HUC-10 Watershed Study

0 800 1,600 Feet

1 in = 800 feet

191 - Total Number of Structures with Moderate to High Flood Risk

136 - Number of Structures with Moderate Flood Risk

55 - Number of Structures with High Flood Risk

Yes - Stakeholder Identified High Flood Risk Area

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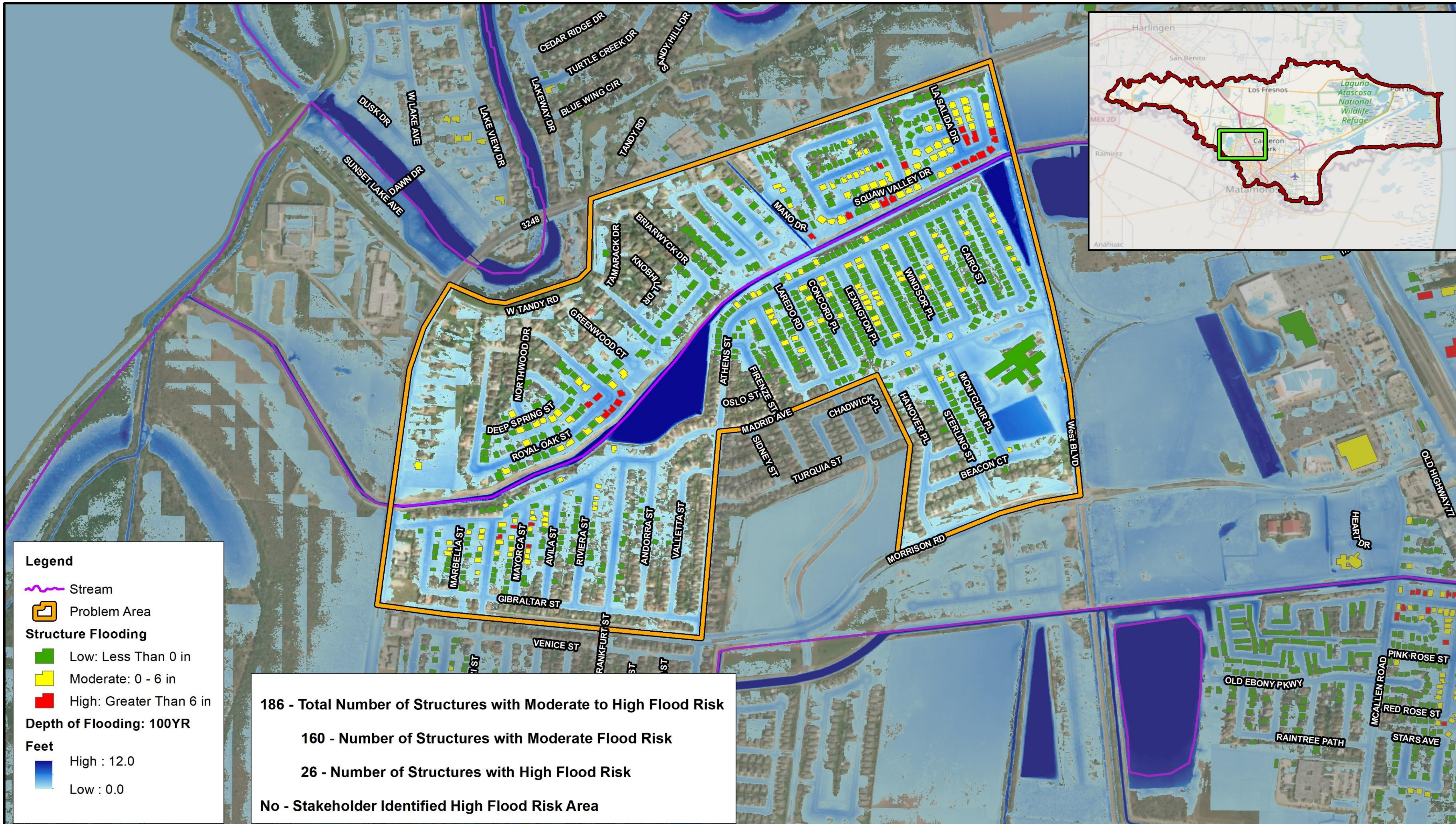
Problem Area Number 6

Brownsville to Port Isabel HUC-10 Watershed Study

0 800 1,600 Feet

1 in = 800 feet

N



186 - Total Number of Structures with Moderate to High Flood Risk

160 - Number of Structures with Moderate Flood Risk

26 - Number of Structures with High Flood Risk

No - Stakeholder Identified High Flood Risk Area

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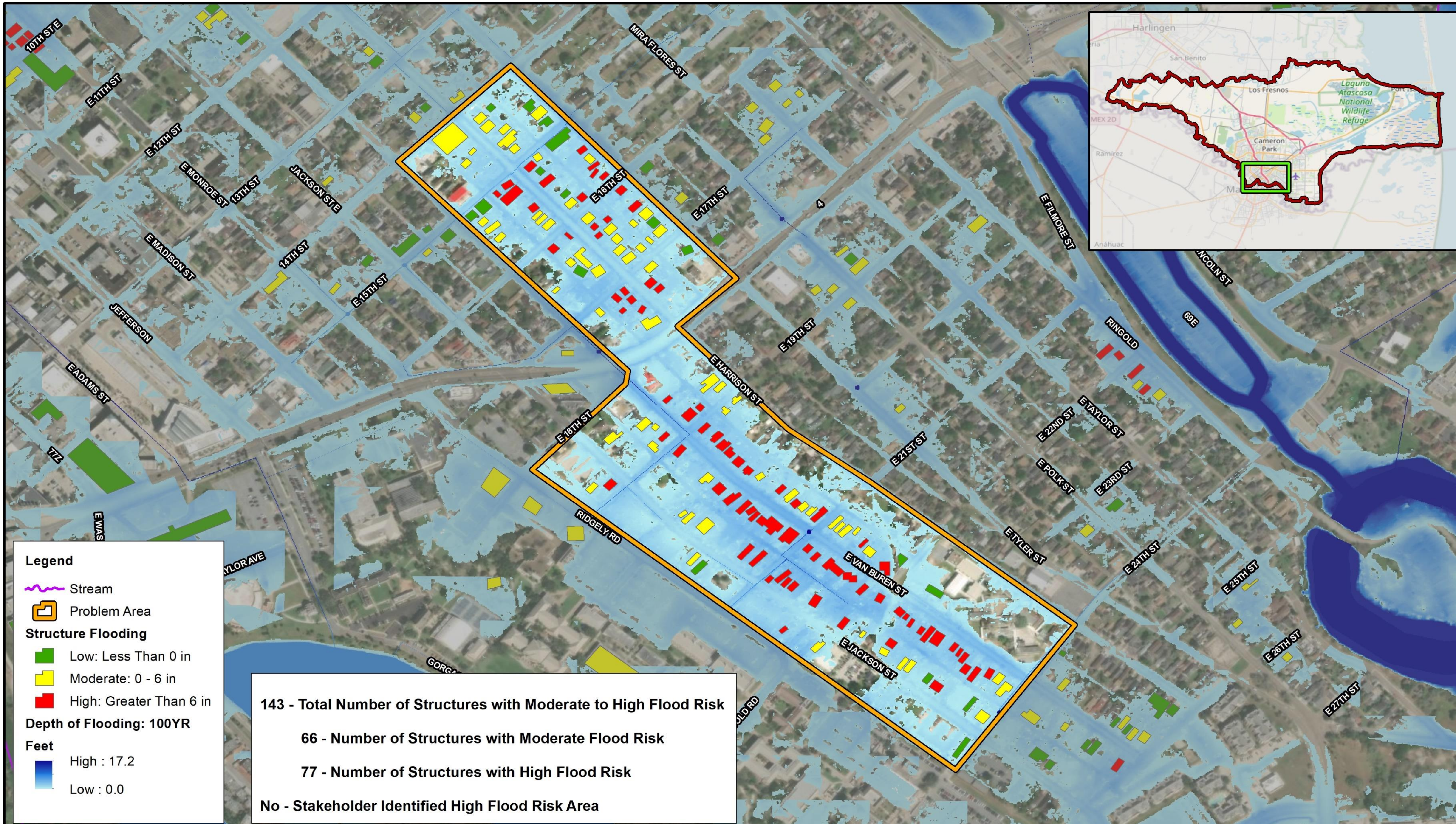
Problem Area Number 7

Brownsville to Port Isabel HUC-10 Watershed Study

0 800 1,600 Feet

1 in = 800 feet



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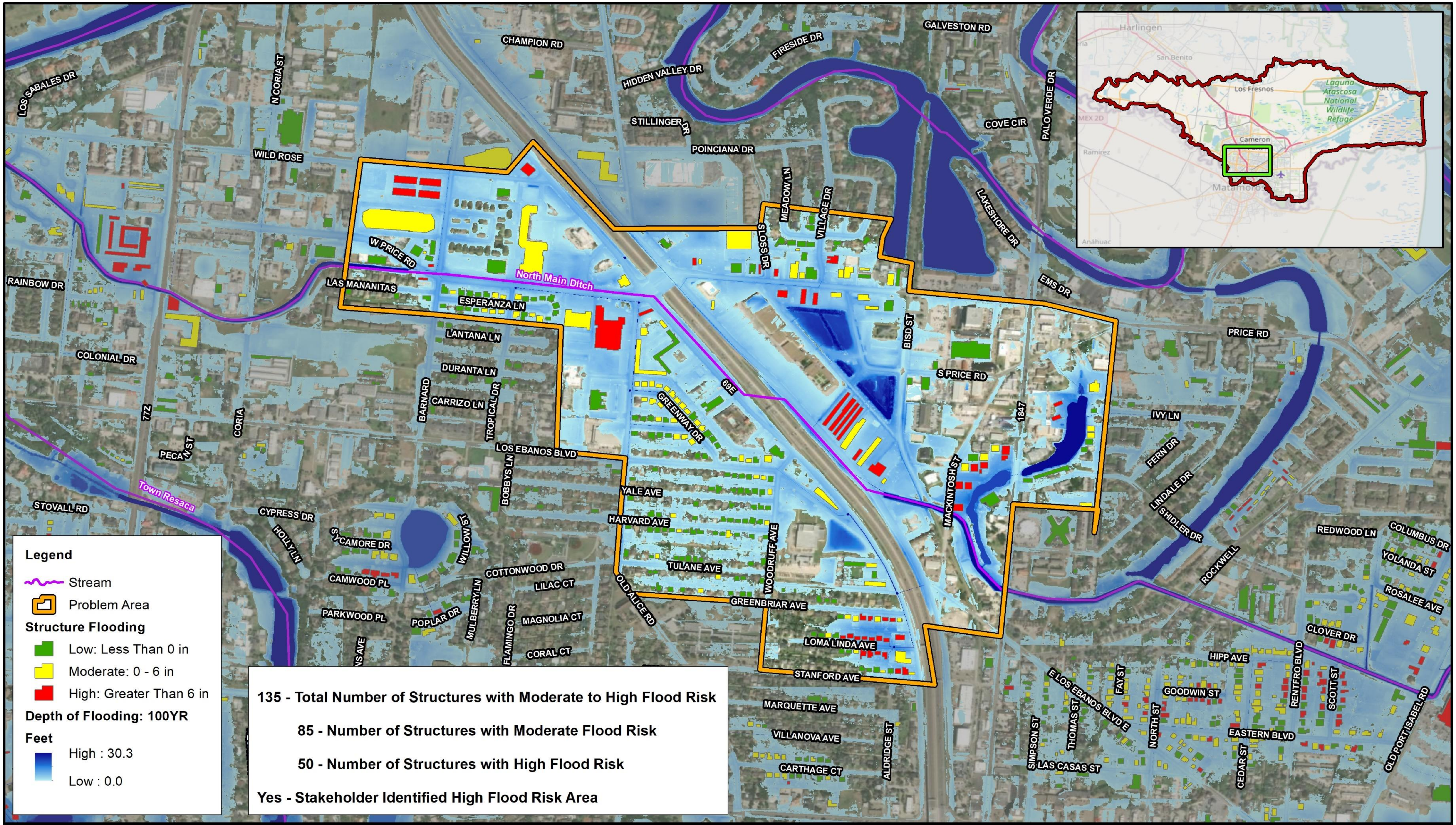
Problem Area Number 8

Brownsville to Port Isabel HUC-10 Watershed Study



Problem Area Number 9

Brownsville to Port Isabel HUC-10 Watershed Study

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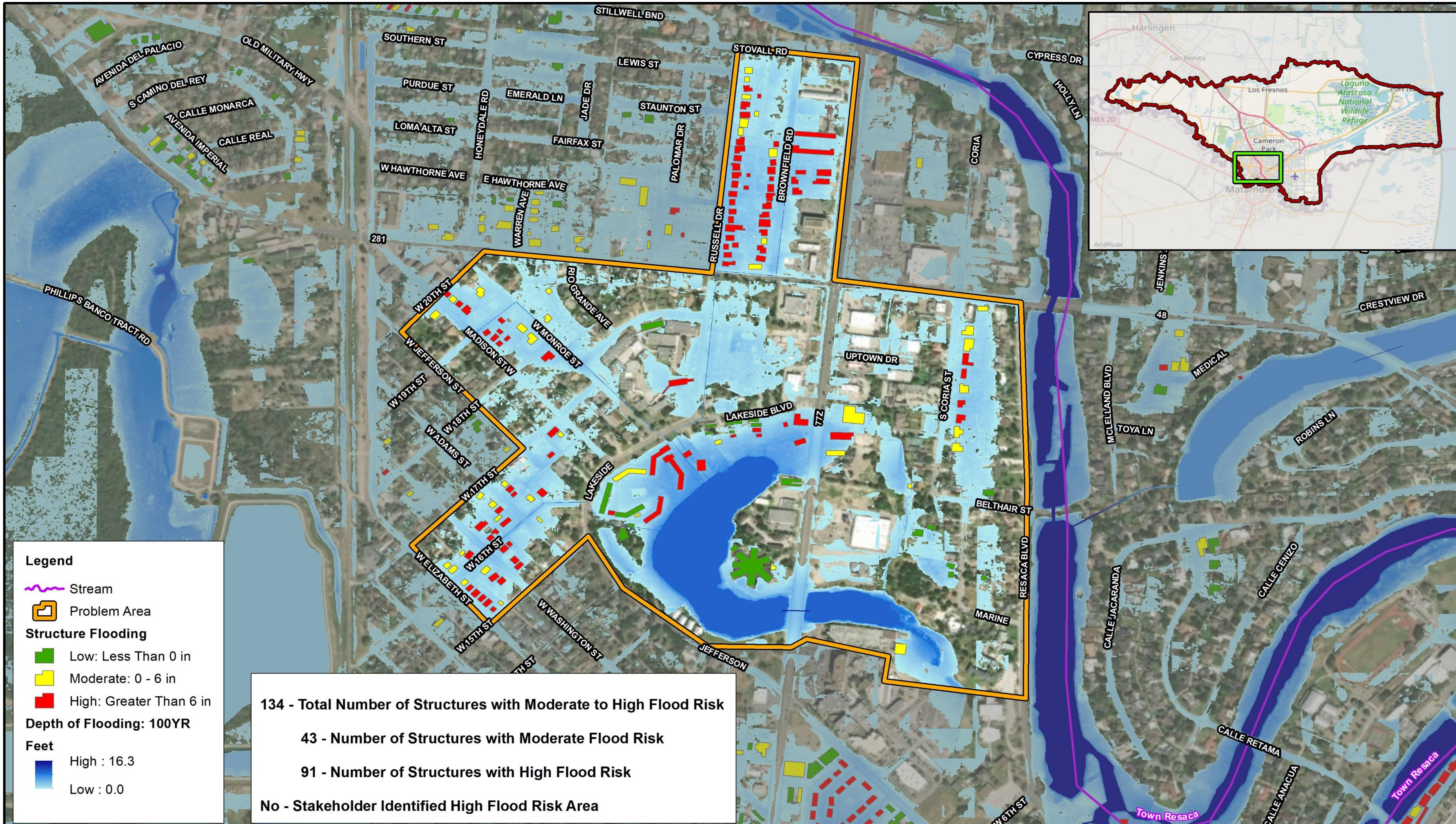
0 800 1,600 Feet

1 in = 800 feet



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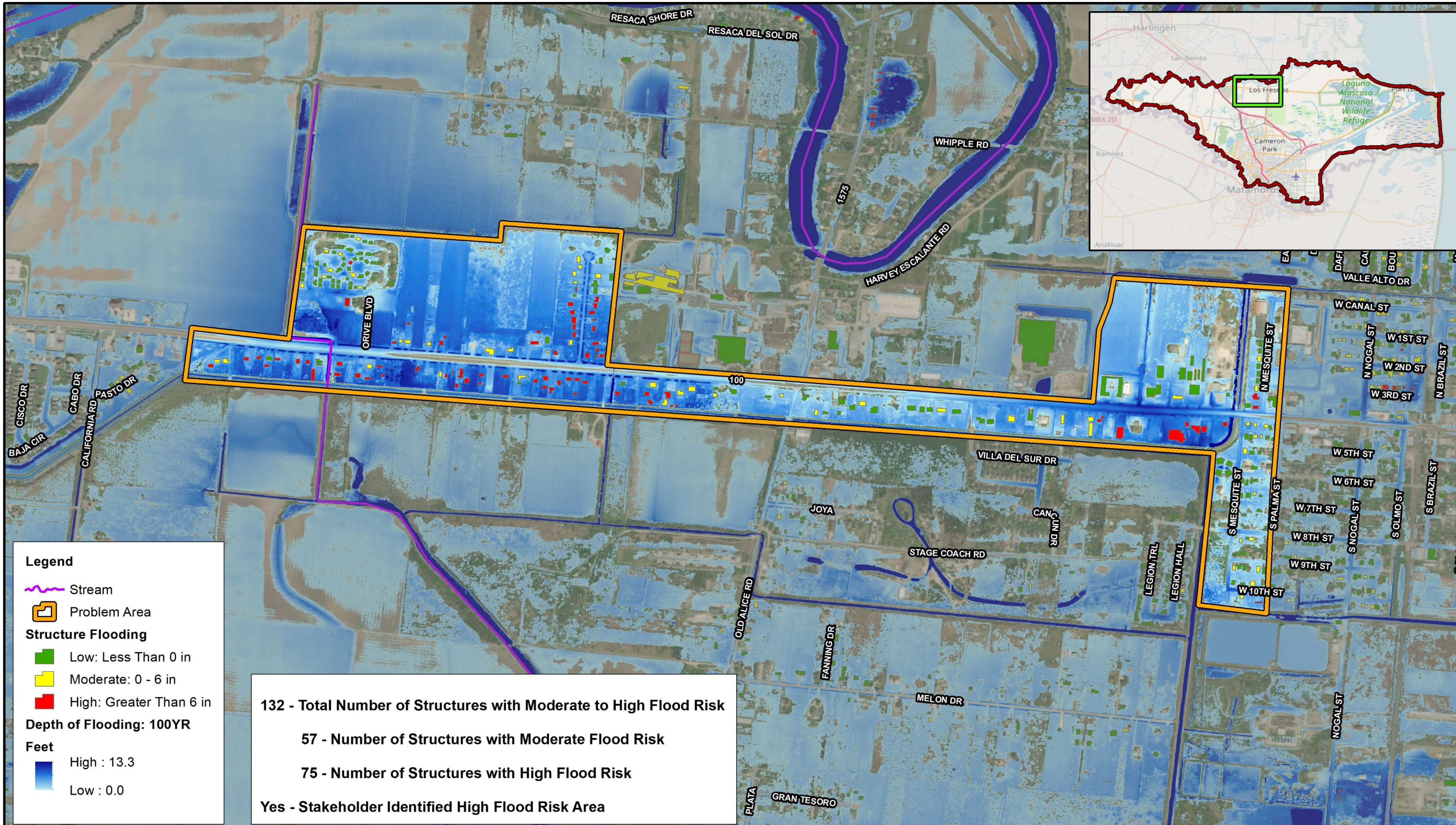
Problem Area Number 10

Brownsville to Port Isabel HUC-10 Watershed Study

0 600 1,200 Feet

1 in = 600 feet



132 - Total Number of Structures with Moderate to High Flood Risk

57 - Number of Structures with Moderate Flood Risk

75 - Number of Structures with High Flood Risk

Yes - Stakeholder Identified High Flood Risk Area

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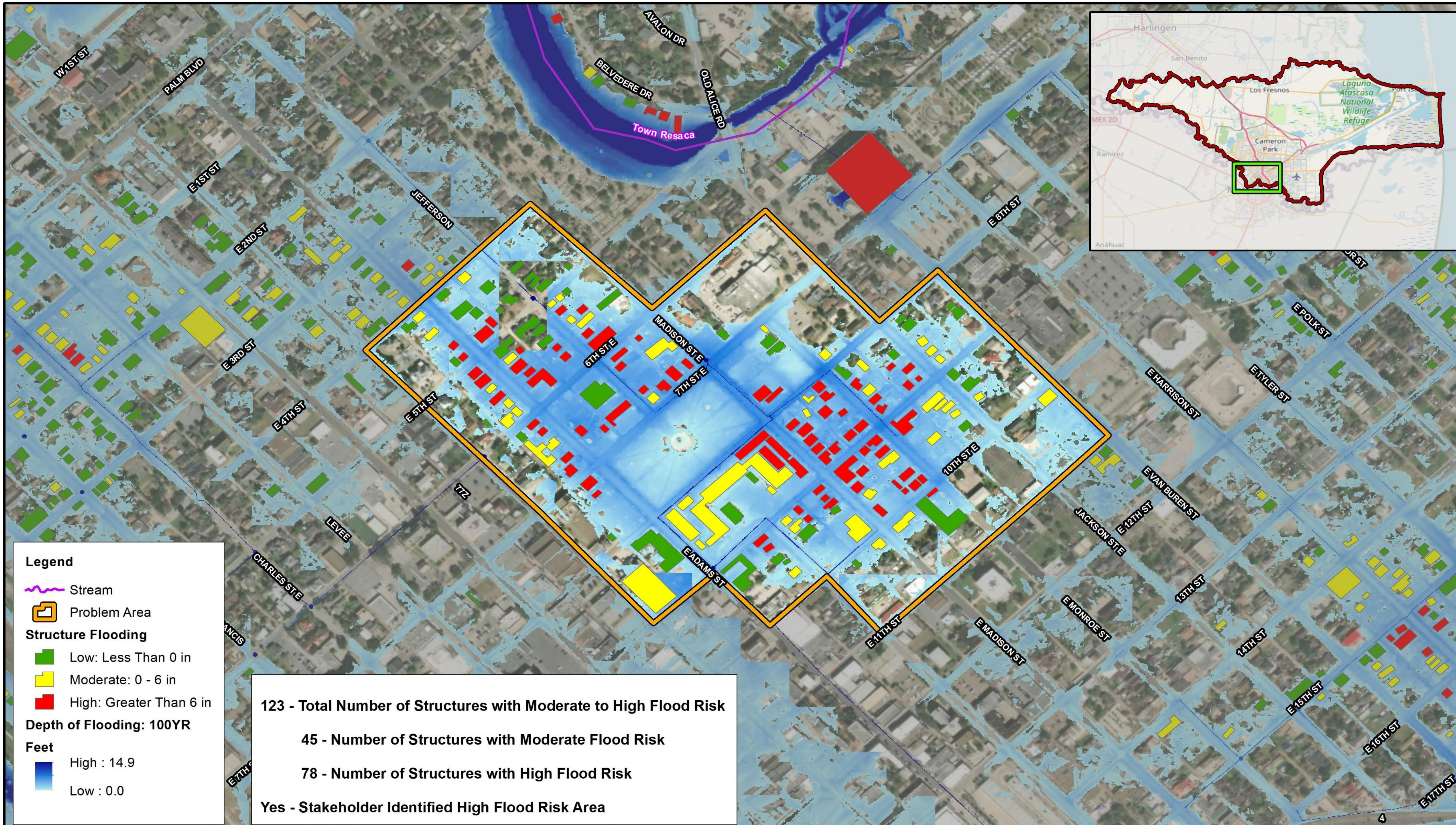
Problem Area Number 11

Brownsville to Port Isabel HUC-10 Watershed Study

0 1,000 2,000 Feet

1 in = 1,000 feet



123 - Total Number of Structures with Moderate to High Flood Risk

45 - Number of Structures with Moderate Flood Risk

78 - Number of Structures with High Flood Risk

Yes - Stakeholder Identified High Flood Risk Area

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Problem Area Number 12

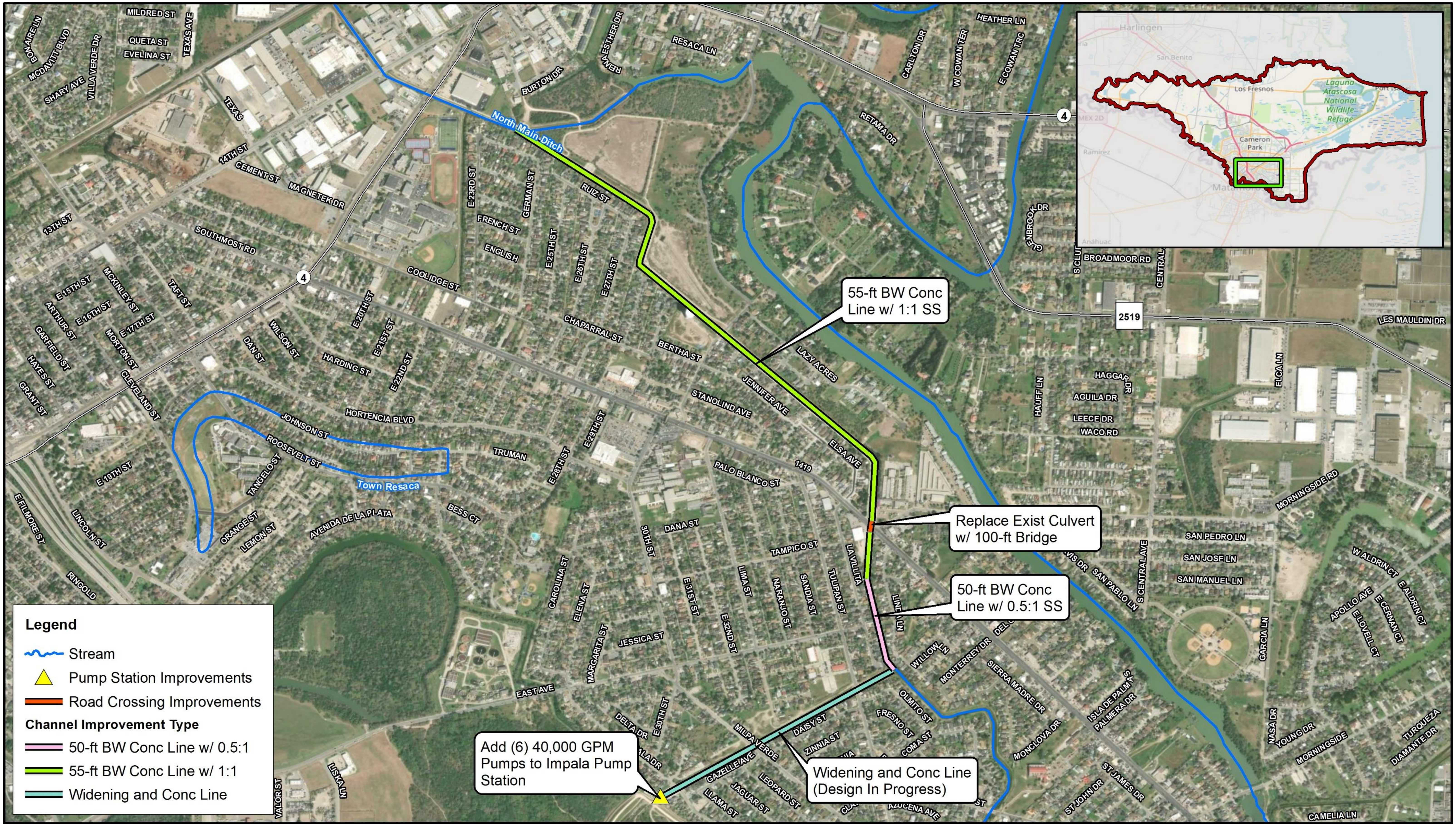
Brownsville to Port Isabel HUC-10 Watershed Study

0 400 800 Feet

1 in = 400 feet

Appendix E - Project Maps

1. Project Layout
2. Project Benefit



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PROJECT LAYOUT
Project 1A North Main Drain and Impala Ditch
Brownsville Port Isabel HUC-10 Watershed Study

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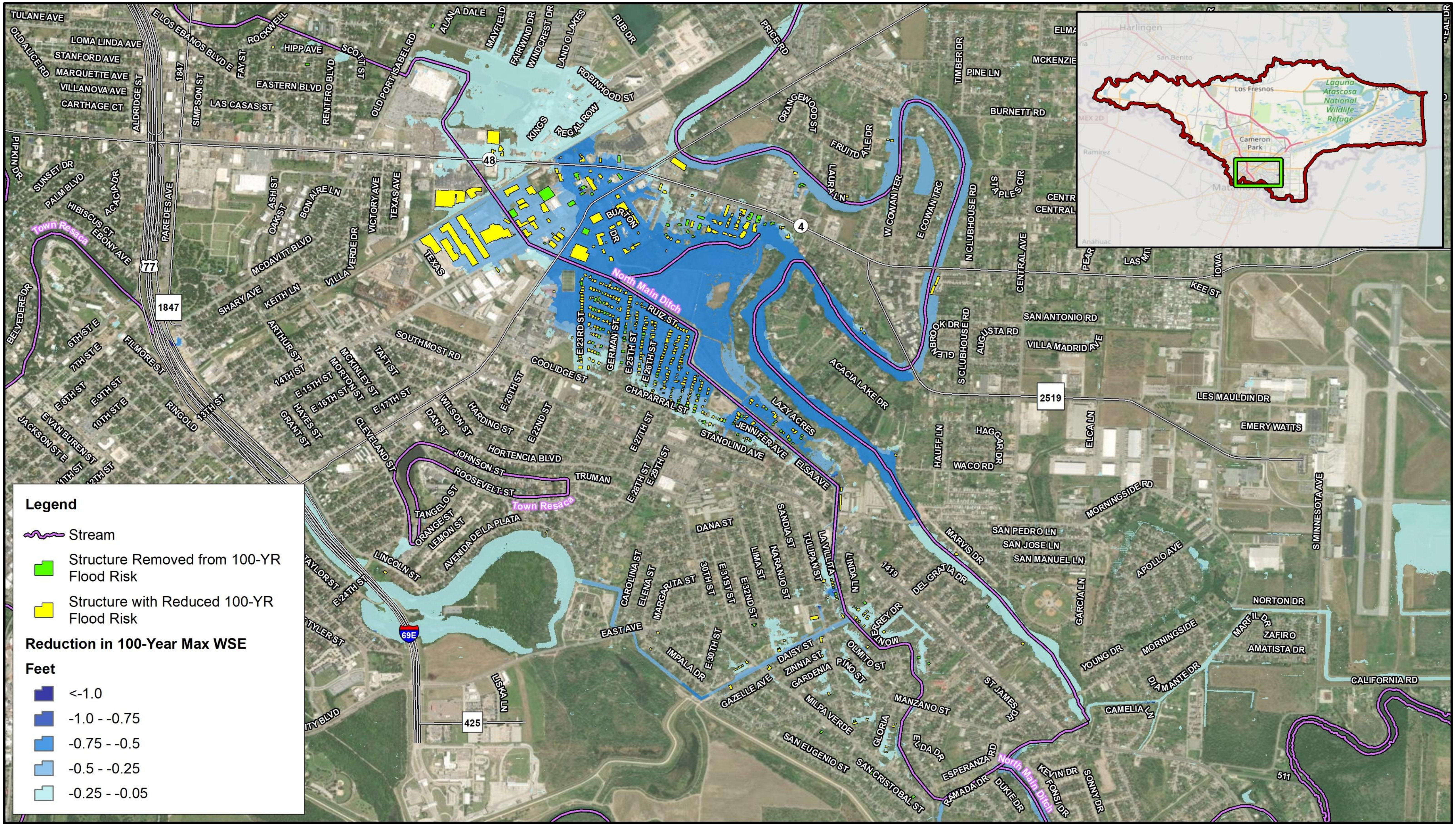

PROJECT BENEFITS

Project 1A North Main Drain and Impala Ditch

Brownsville to Port Isabel HUC-10 Watershed Study

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0 0.3 0.6 Miles

1 in = 0.3 miles

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectBenefits_Num1a.mxd

Date: 10/13/2023

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PROJECT LAYOUT

Project 1B North Main Drain and Four Corners

Brownsville to Port Isabel HUC-10 Watershed Study

0 400 800 Feet

1 in = 400 feet

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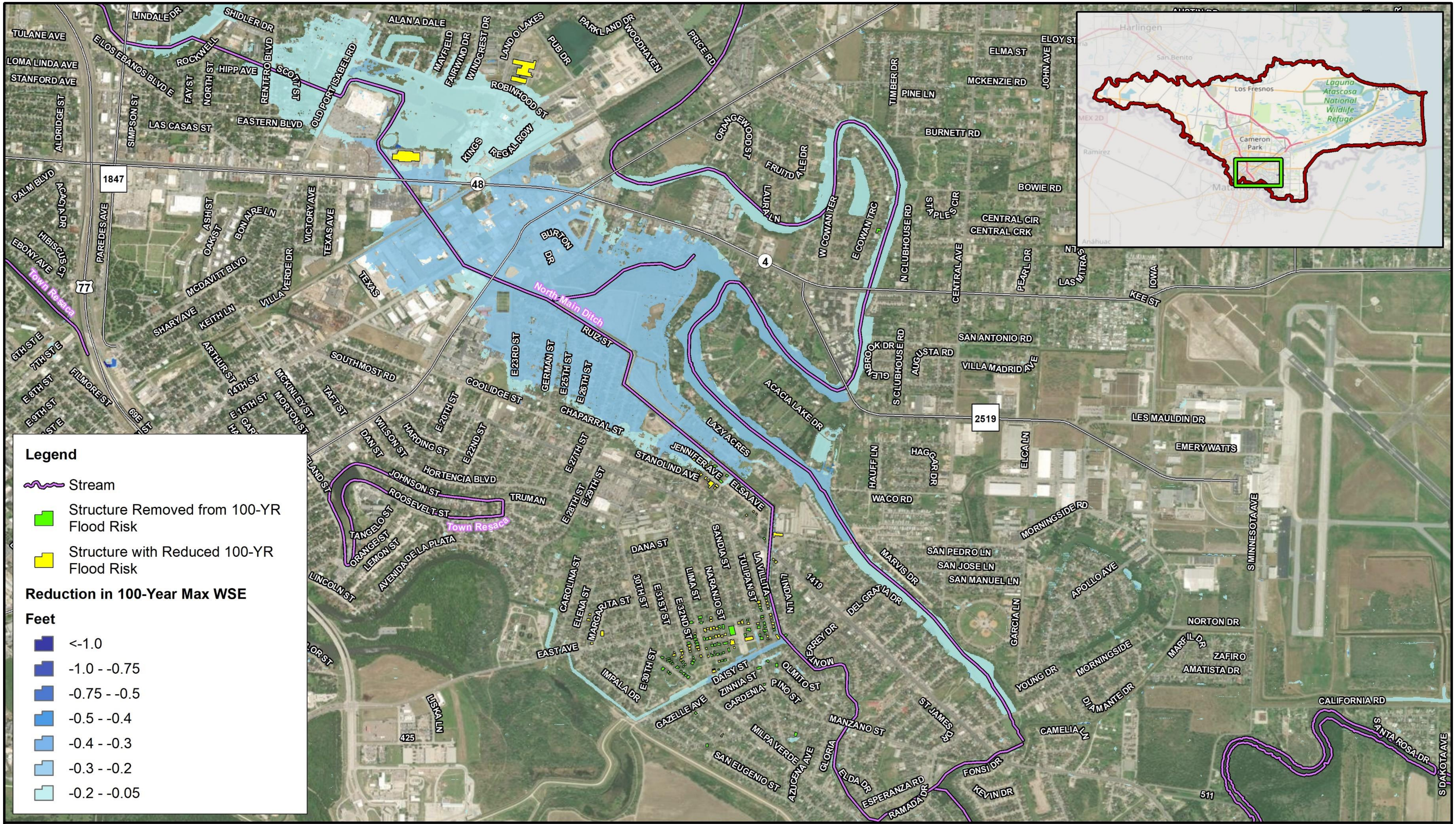
Date: 10/12/2023



PROJECT BENEFITS

Project 1B North Main Drain and Four Corners

Brownsville to Port Isabel HUC-10 Watershed Study

0 0.3 0.6
Miles

1 in = 0.3 miles

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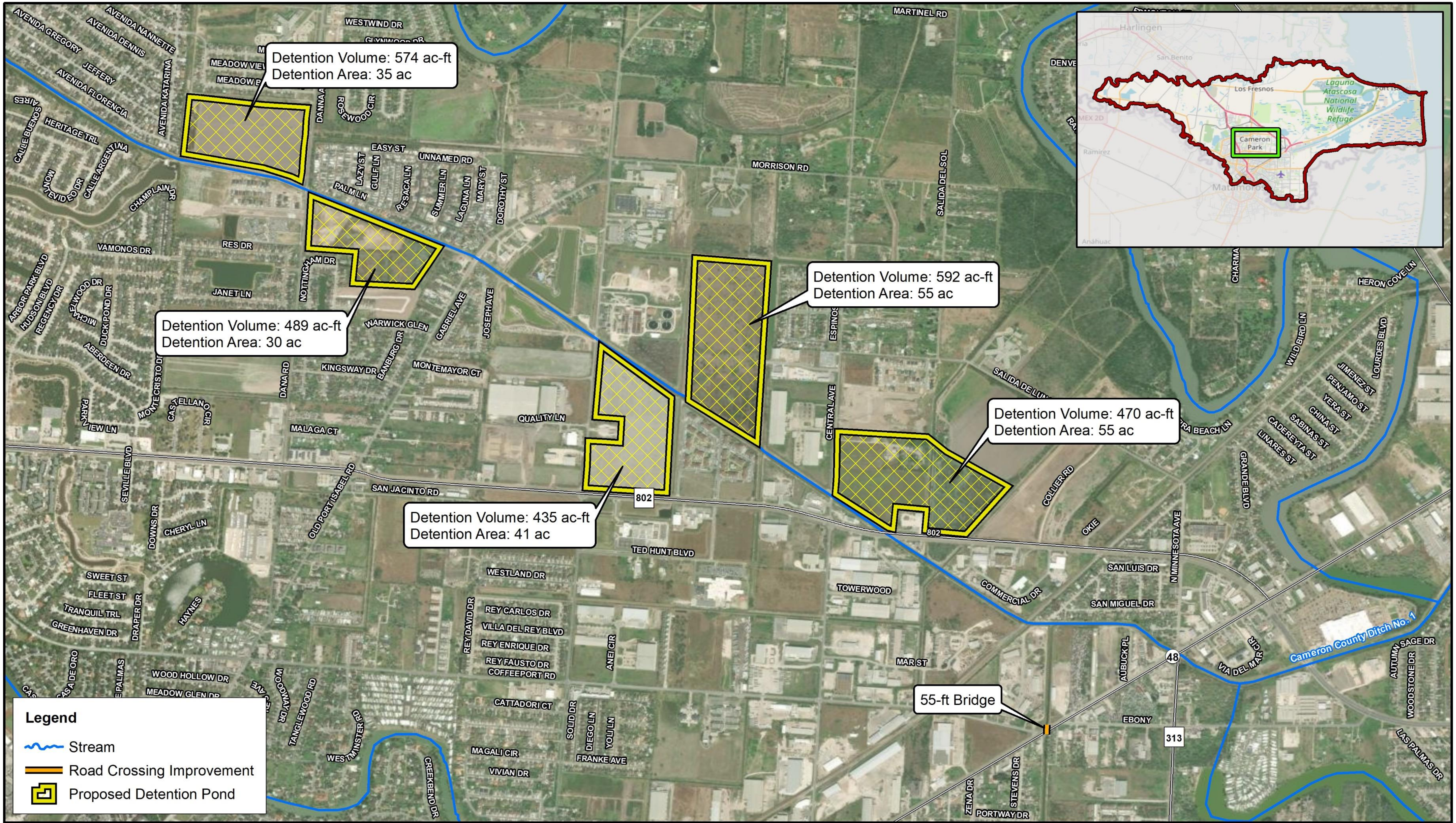

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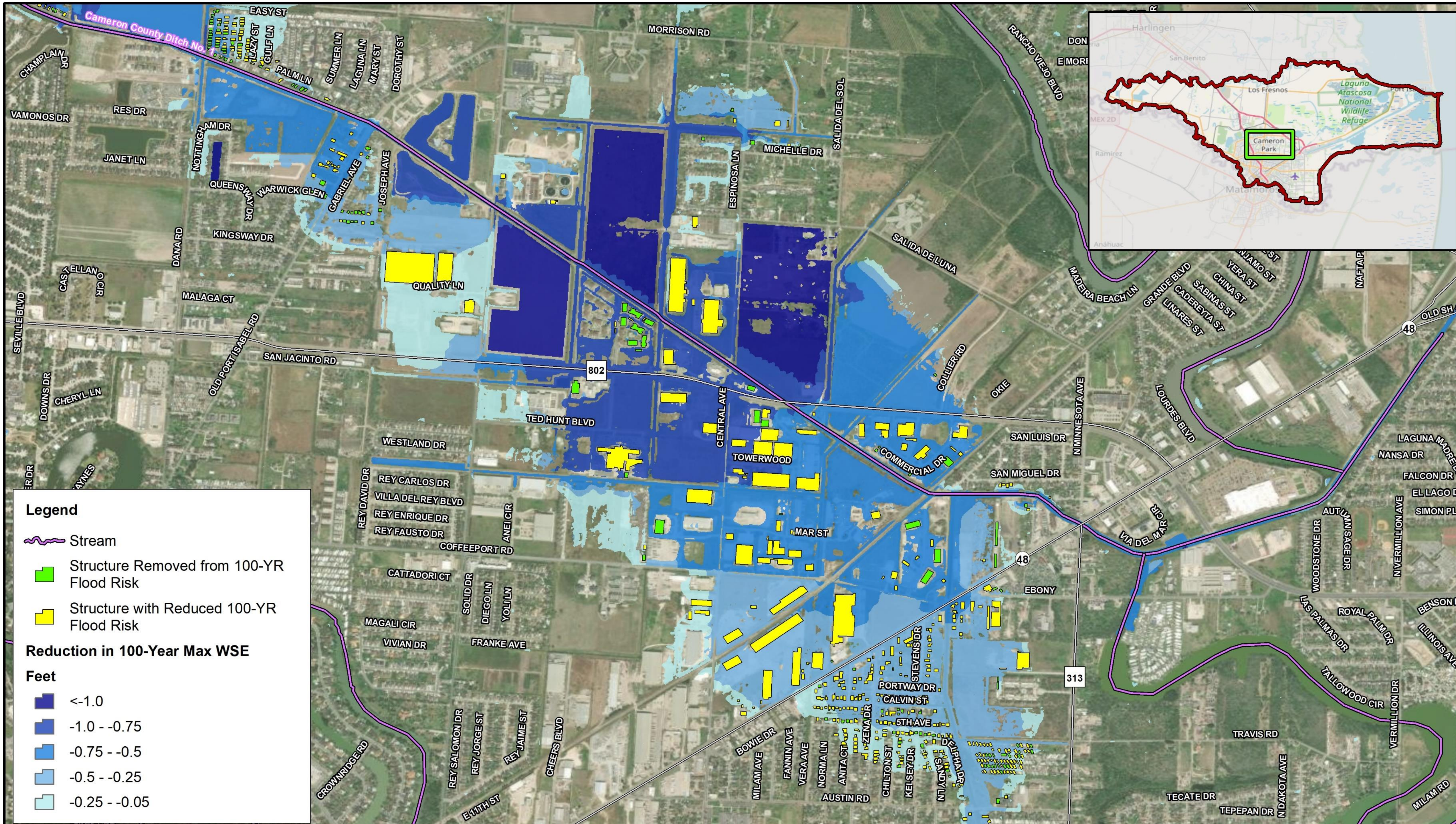
PROJECT LAYOUT

Project 2 Cameron County Ditch 1 at Confluence

Brownsville to Port Isabel HUC-10 Watershed Study

0 0.25 0.5 Miles

1 in = 0.25 miles



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PROJECT BENEFITS

Project 2 Cameron County Ditch 1 at Confluence

Brownsville to Port Isabel HUC-10 Watershed Study

0 0.25 0.5 Miles

1 in = 0.25 miles

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Date: 10/13/2023

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PROJECT LAYOUT

Project 3 Cameron County Ditch 1 at Cameron Park

Brownsville to Port Isabel HUC-10 Watershed Study

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectImprovements_Num3.mxd

Date: 10/12/2023

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PROJECT IMPROVEMENTS

Project 3 Cameron County Ditch 1 at Cameron Park

Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectBenefits_Num3.mxd

Date: 10/13/2023

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PROJECT LAYOUT

Project 4 Town Resaca at West 5th Street

Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet

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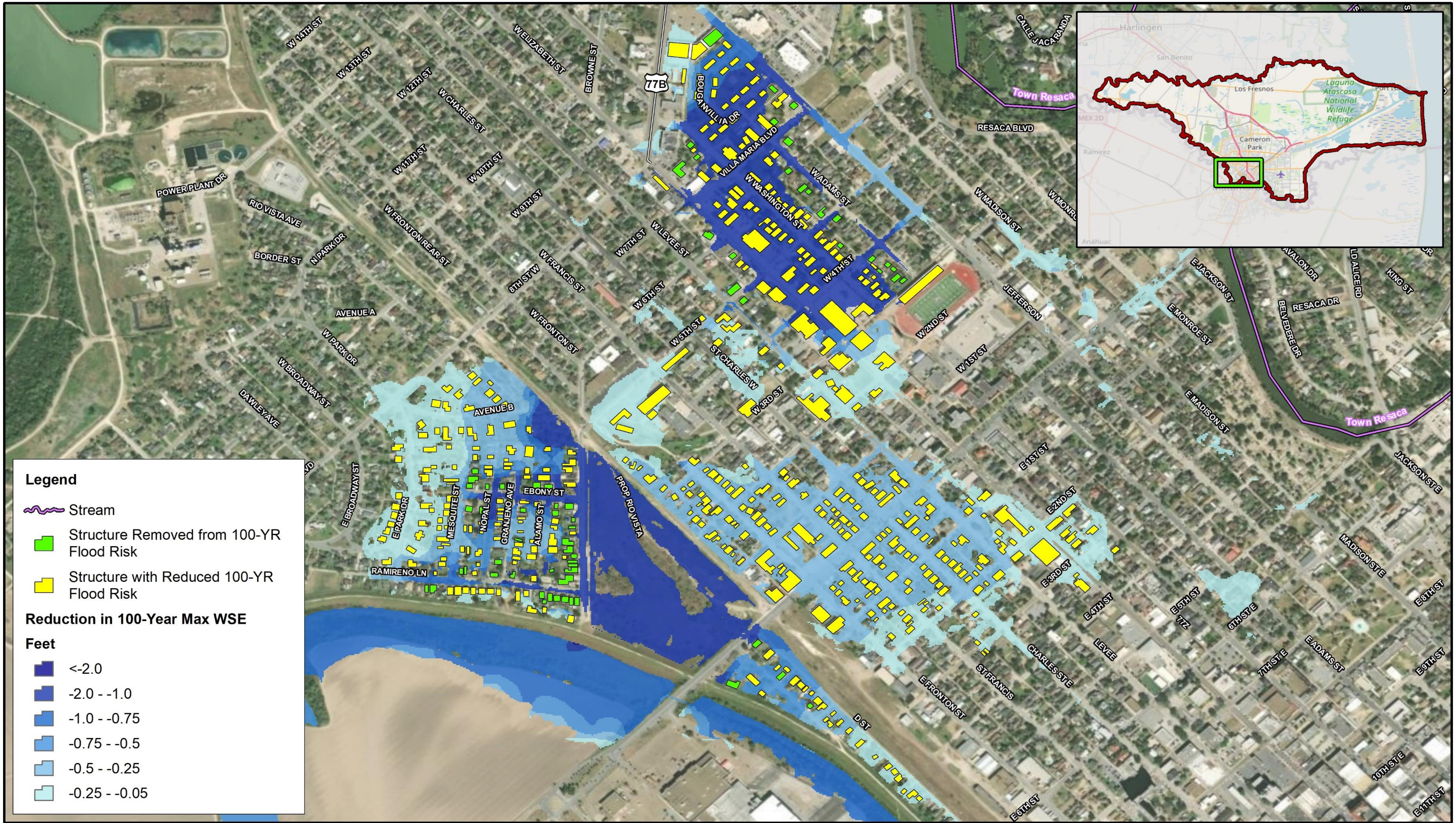


PROJECT BENEFITS

Project 4 Town Resaca at West 5th Street

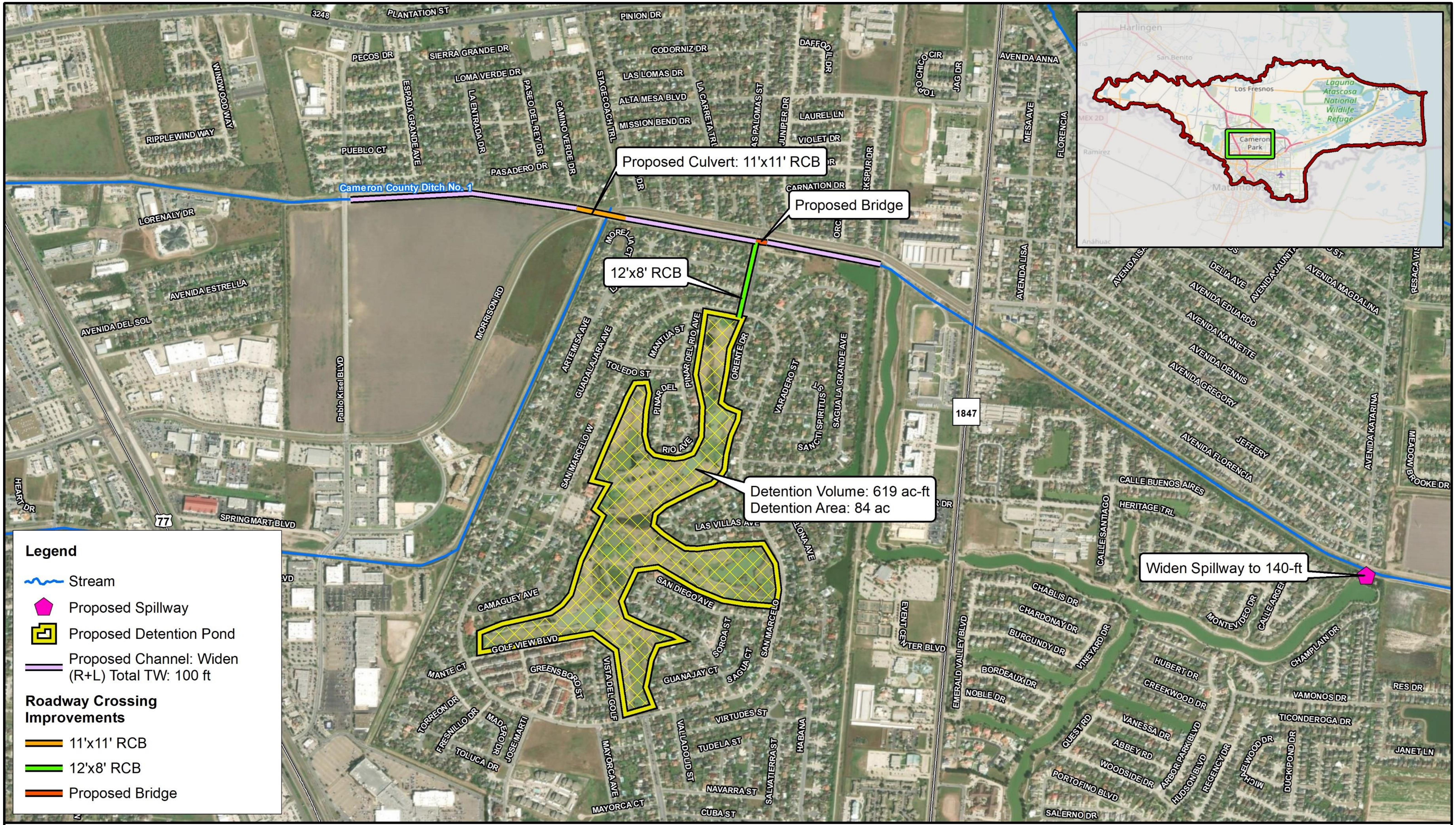
Brownsville to Port Isabel HUC-10 Watershed Study

0 600 1,200 Feet

1 in = 600 feet

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectBenefits_Num4.mxd

Date: 10/13/2023



PROJECT LAYOUT

Project 5 Cameron County Ditch 1 at Golf Center

Brownsville to Port Isabel HUC-10 Watershed Study

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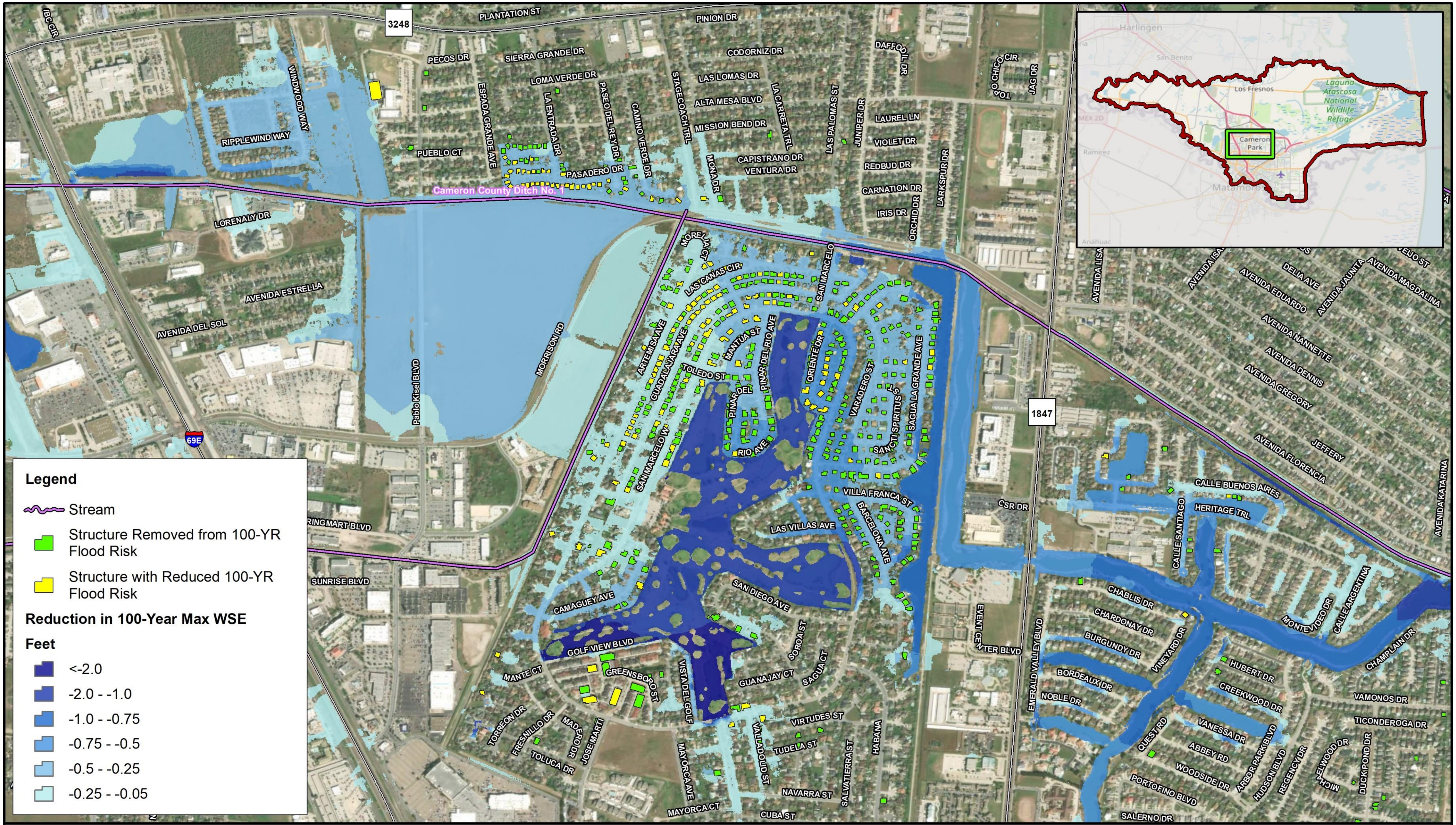
0 1,000 2,000 Feet

1 in = 1,000 feet



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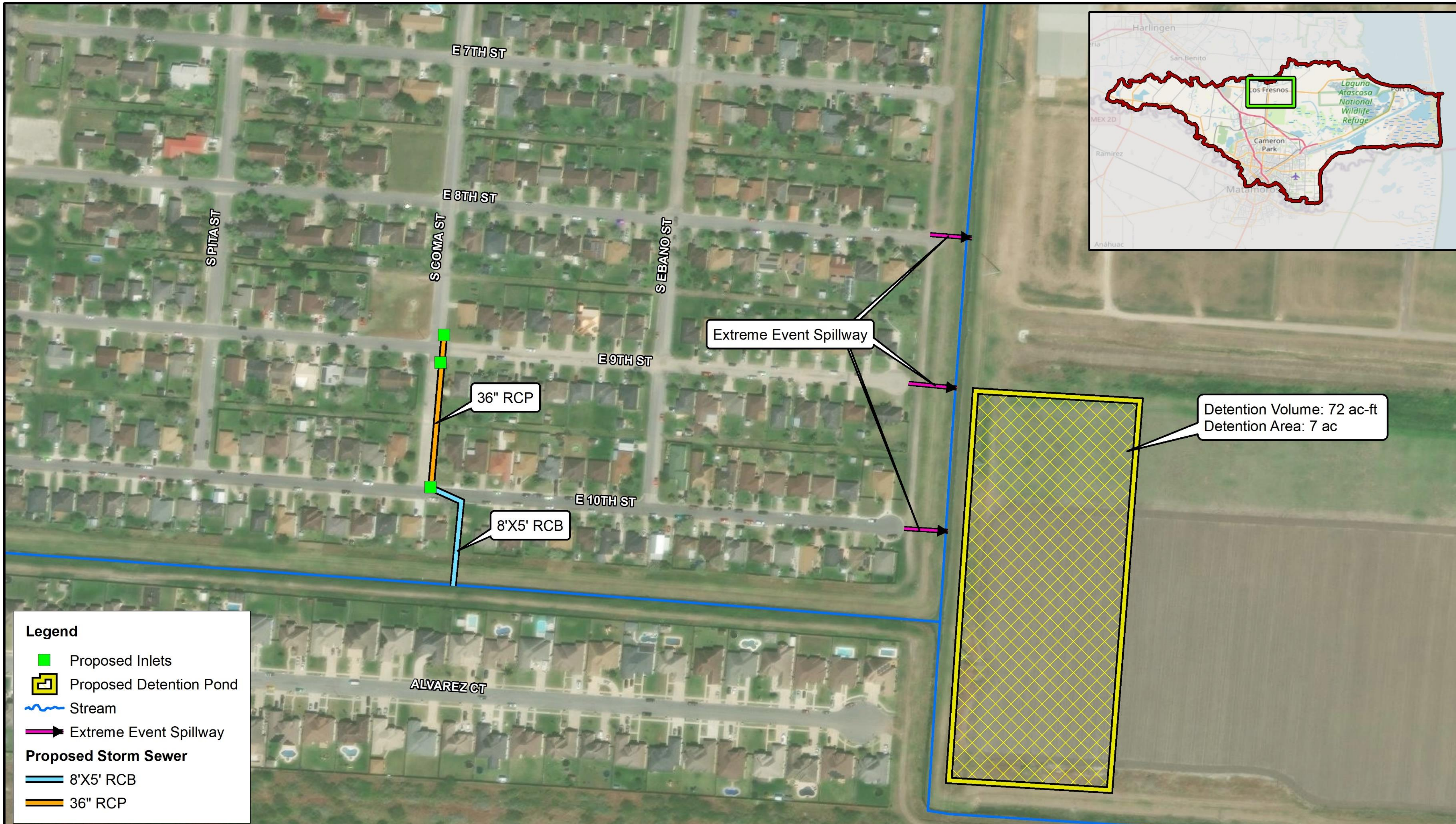
PROJECT BENEFITS

Project 5 Cameron County Ditch 1 at Golf Center

Brownsville to Port Isabel HUC-10 Watershed Study

0 1,000 2,000 Feet

1 in = 1,000 feet



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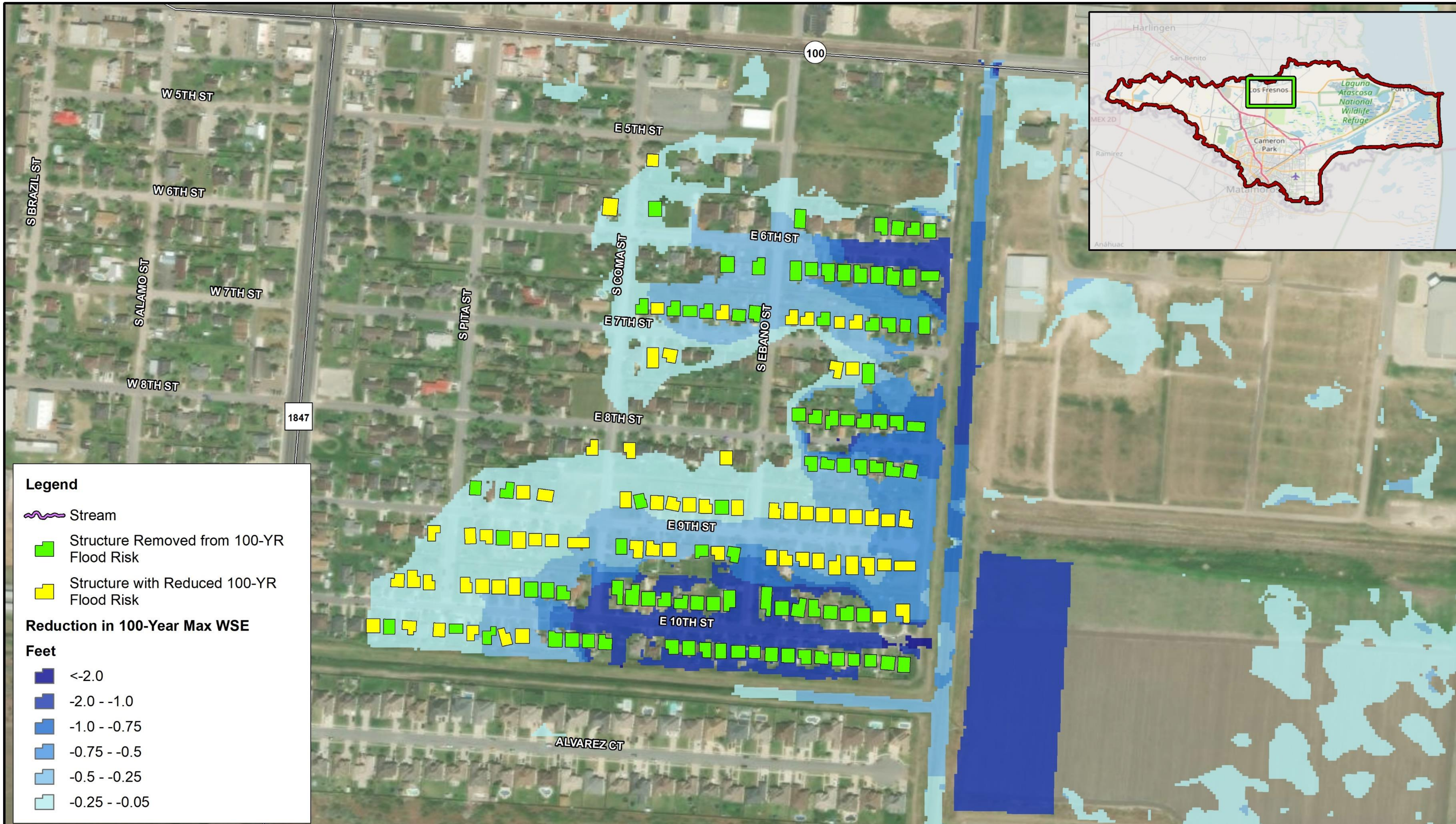
PROJECT LAYOUT

<u>Project 6 Los Fresnos at East 10th Street</u>

Brownsville to Port Isabel HUC-10 Watershed Study

0 200 400 Feet

1 in = 200 feet



PROJECT BENEFITS

Project 6 Los Fresnos at East 10th Street

Brownsville to Port Isabel HUC-10 Watershed Study

0 300 600 Feet

1 in = 300 feet

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PROJECT LAYOUT

Project 7 Cameron County Ditch 1 at Hwy 69E

Brownsville to Port Isabel HUC-10 Watershed Study

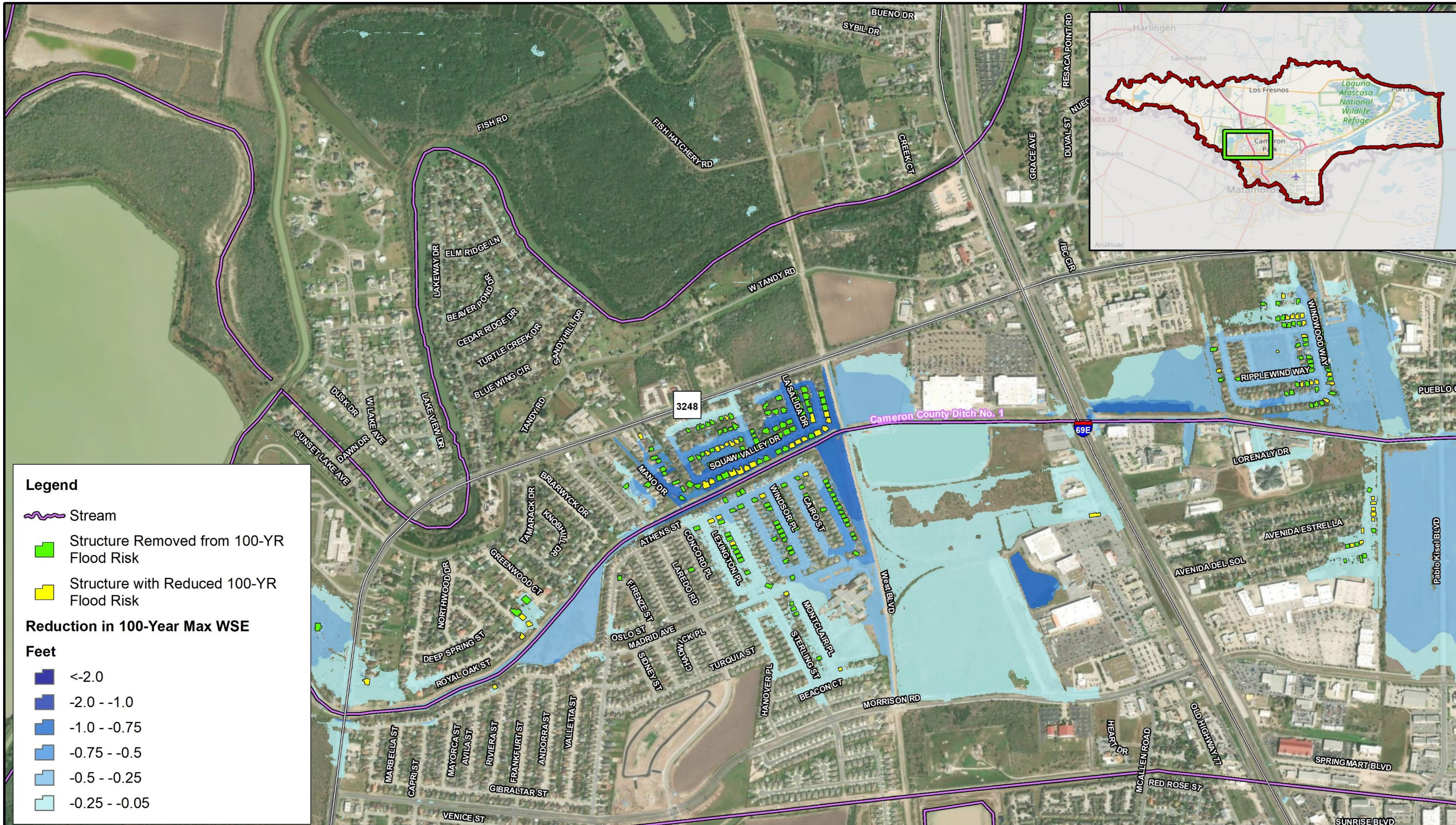
0 500 1,000 Feet

1 in = 500 feet

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectImprovements_Num7.mxd

Date: 10/12/2023



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PROJECT BENEFITS

Project 7 Cameron County Ditch 1 at Hwy 69E

Brownsville to Port Isabel HUC-10 Watershed Study

0 1,000 2,000 Feet

1 in = 1,000 feet

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectBenefits_Num7.mxd

Date: 10/13/2023

PROJECT LAYOUT

Project 9 North Main Drain and Hwy 69E

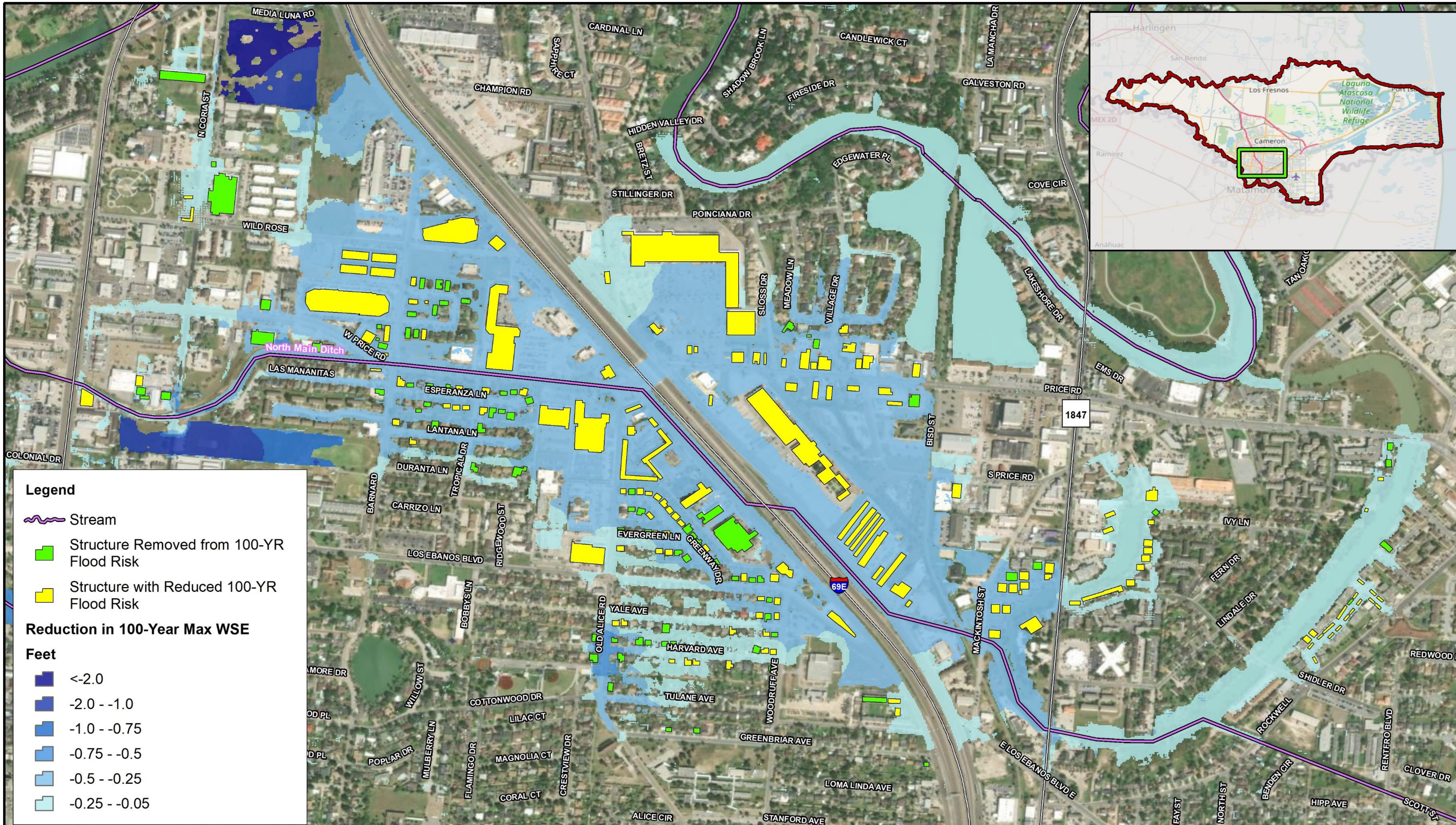
Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectImprovements_Num9.mxd

Date: 10/12/2023



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PROJECT BENEFITS

Project 9 North Main Drain and Hwy 69E

Brownsville to Port Isabel HUC-10 Watershed Study

0 700 1,400 Feet

1 in = 700 feet

N

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectBenefits_Num9.mxd

Date: 10/13/2023

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PROJECT LAYOUT

Project 11A Los Fresnos West Ocean Blvd

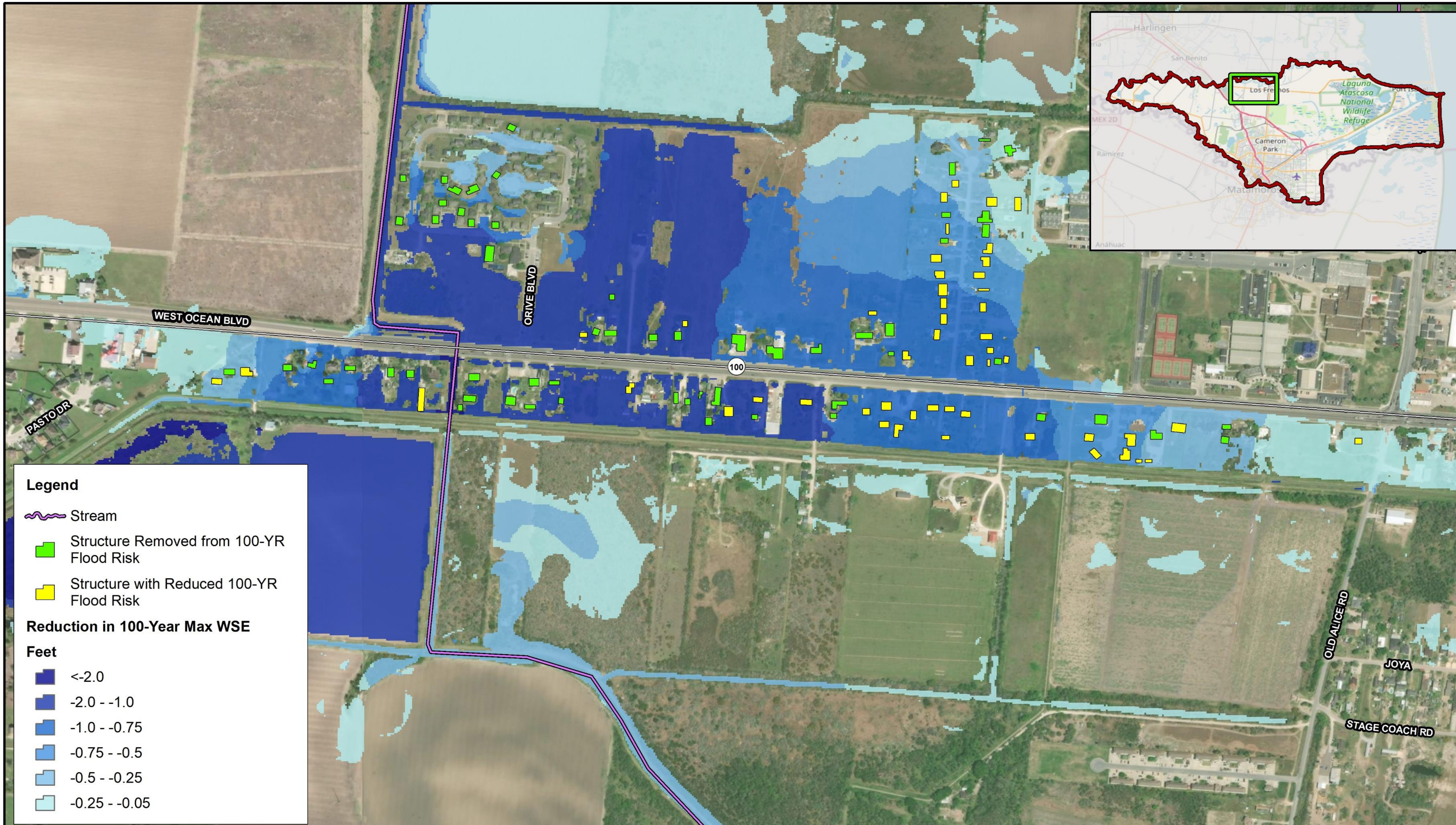
Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectImprovements_Num11a.mxd

Date: 10/12/2023



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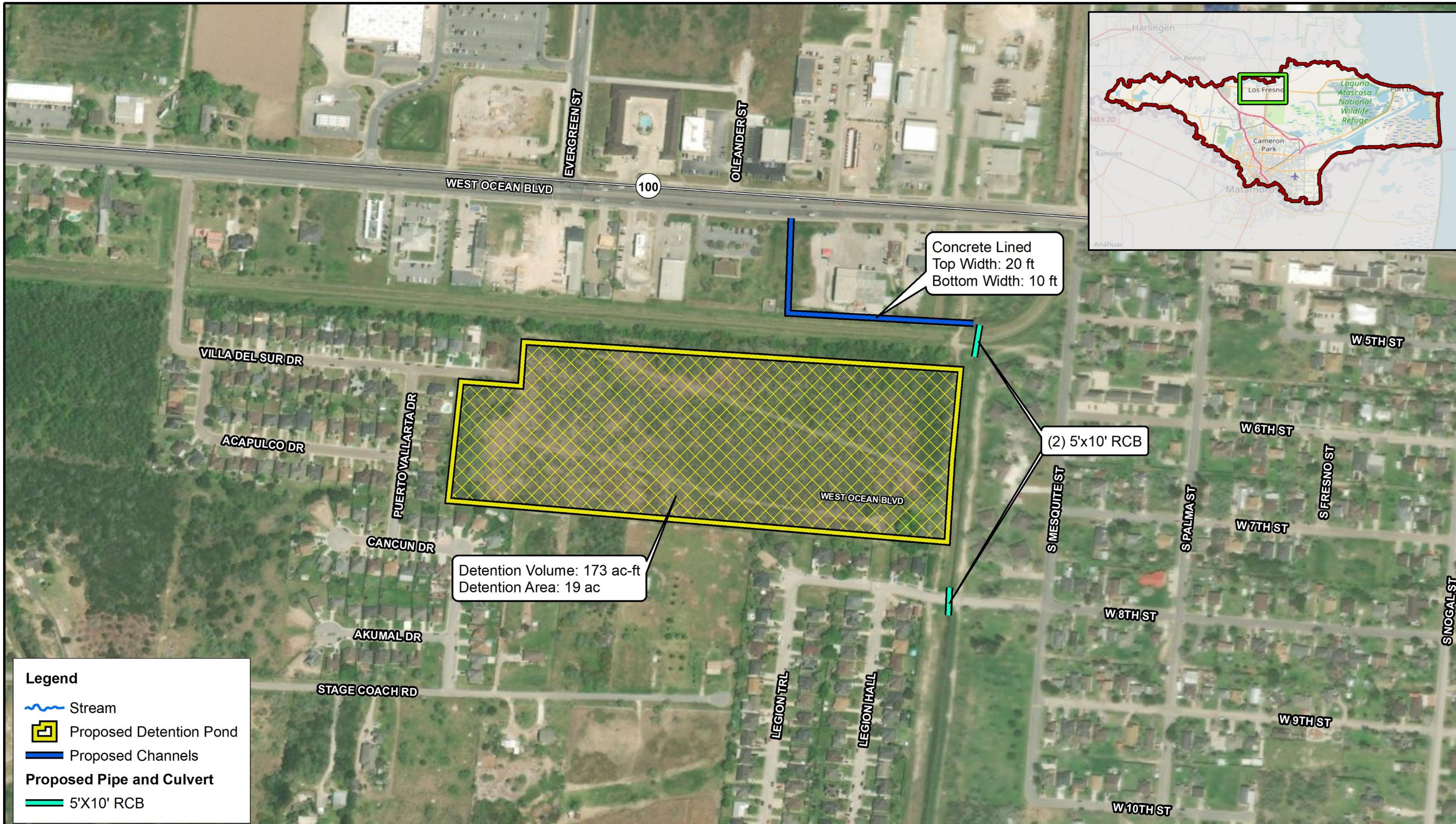
PROJECT BENEFITS

Project 11A Los Fresnos West Ocean Blvd

Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet



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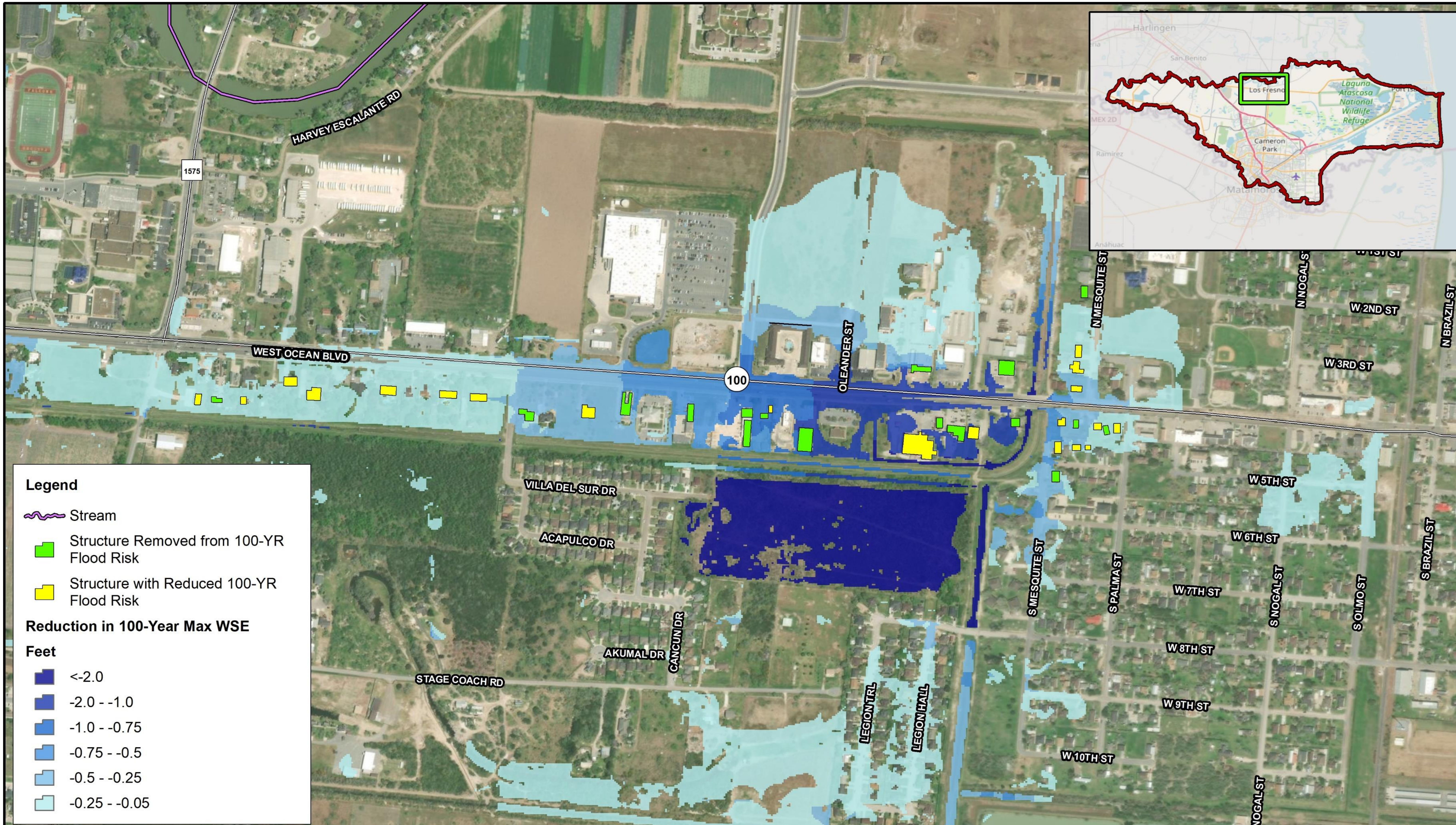
PROJECT LAYOUT

Project 11B Los Fresnos West Ocean Blvd

Brownsville to Port Isabel HUC-10 Watershed Study

0 300 600 Feet

1 in = 300 feet



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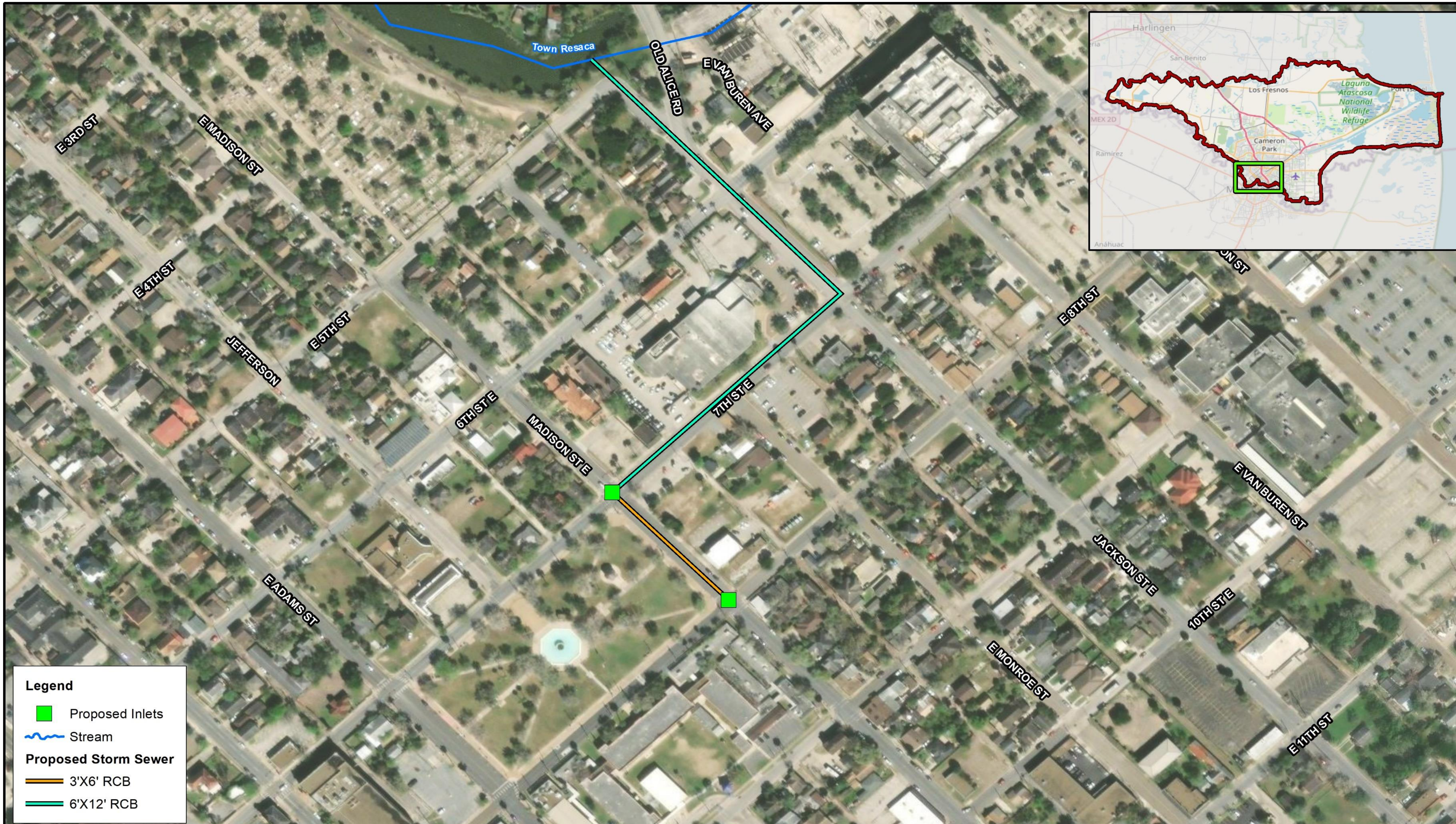
PROJECT BENEFITS

Project 11B Los Fresnos West Ocean Blvd

Brownsville to Port Isabel HUC-10 Watershed Study

0 500 1,000 Feet

1 in = 500 feet



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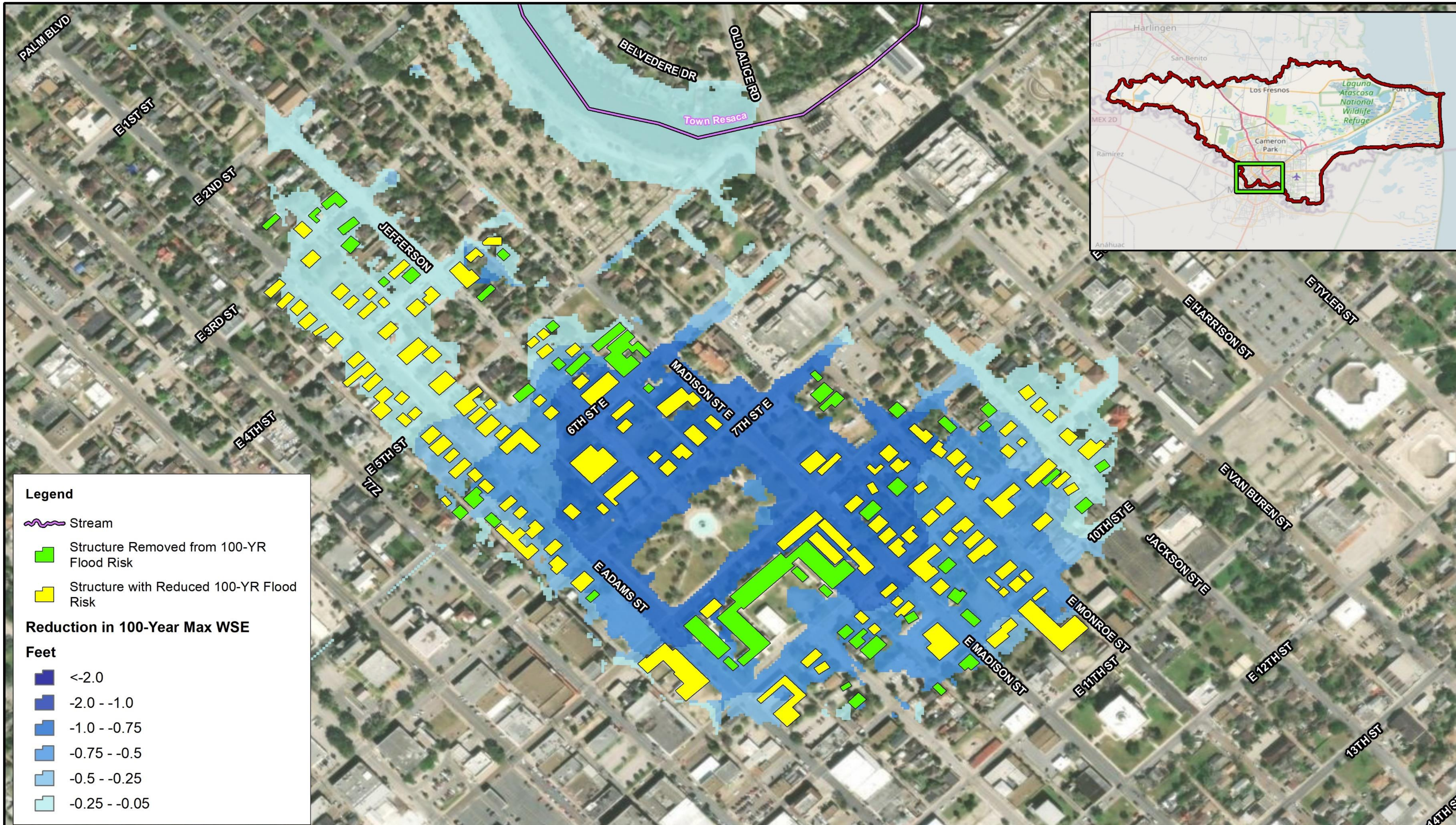
PROJECT LAYOUT

Project 12 Town Resaca at Washington Park

Brownsville to Port Isabel HUC-10 Watershed Study

Document Path: W:\Citrix\42000s\42407\001\GIS\MXD\ReportExhibits\ProjectImprovements_Num12.mxd

Date: 10/12/2023



Texas Water Development Board

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PROJECT BENEFITS

Project 12 Town Resaca at Washington Park

Brownsville to Port Isabel HUC-10 Watershed Study

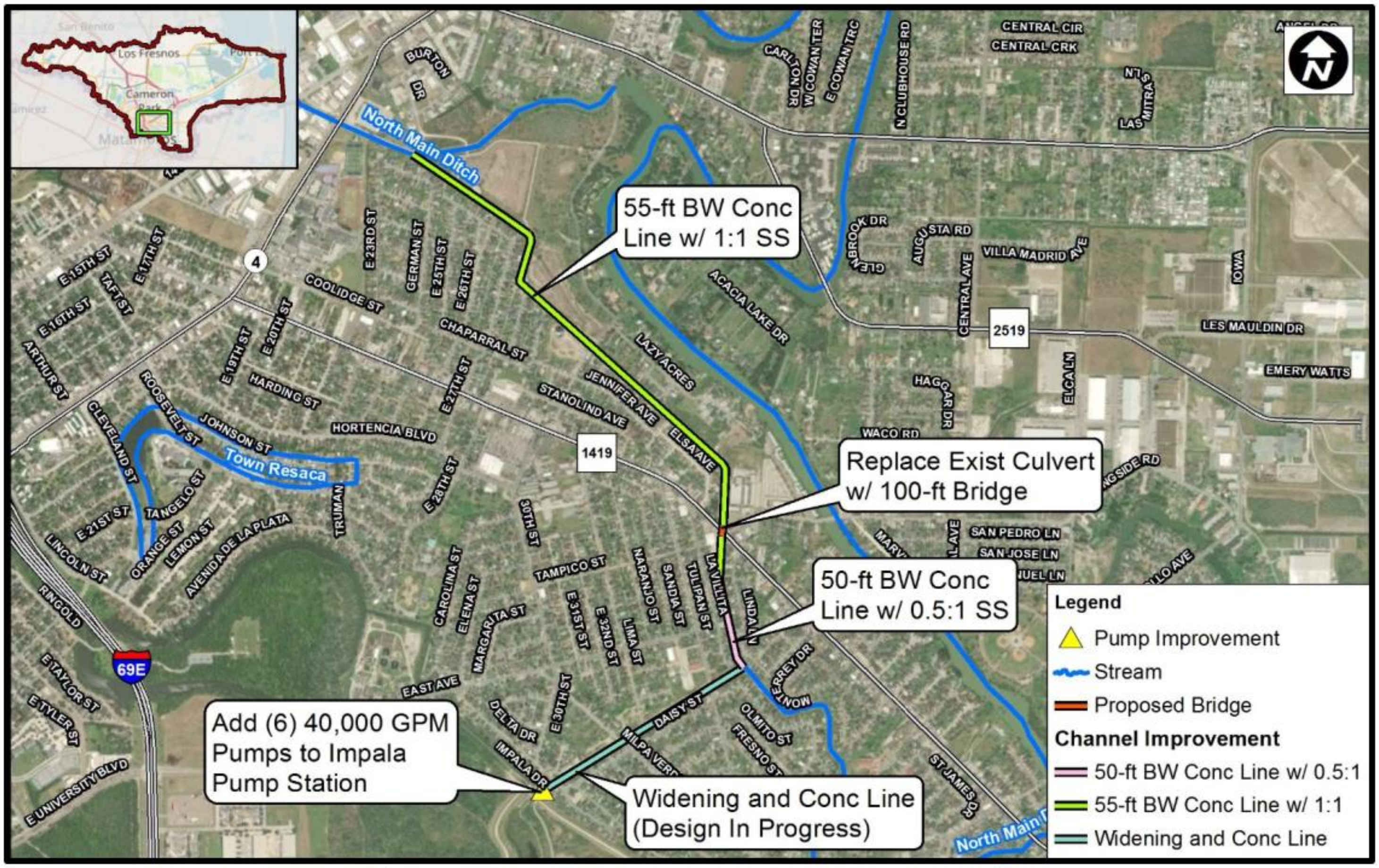
0 300 600 Feet

1 in = 300 feet

Appendix F - Project Fact Sheets

Project 1A North Main Drain and Impala Ditch

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Channel, culvert road crossing, and pump station improvements on North Main Drain and Impala Ditch between International Blvd and the Impala Pump Station

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 19600

BENEFITS:

Structures Removed from 100-YR Flooding: 131

Structures with Reduced 100-YR Flooding: 176

Benefit-Cost Ratio: 0.35

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 450

CONSTRAINTS:

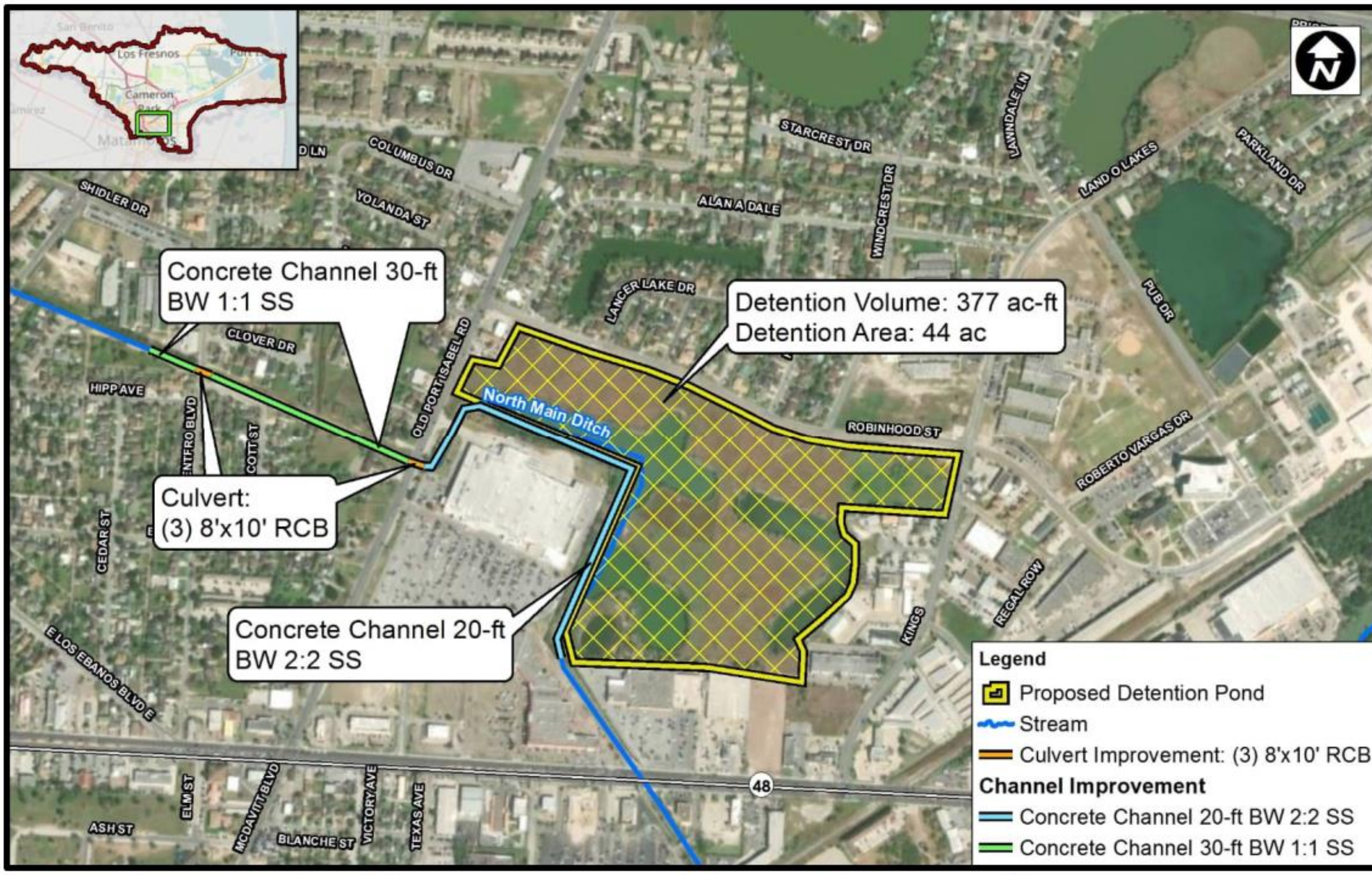
- Increase in flood risk if Impala Pump Station fails.
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures.

ESTIMATE COSTS

Overhead	$##M
Demolition	$122K
Construction	$36M
Contingency	$10M
Right of Way	$6.7M
Environmental	$1.1M
Engineering and Surveying	$3.6M
Total Construction	**$47M**

Project 1B North Main Drain and Four Corners

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Channel and culvert improvements along with one detention pond on North Main Drain between Rockwell Dr and Boca Chica Blvd

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 19600

BENEFITS:

Structures Removed from 100-YR Flooding: 83

Structures with Reduced 100-YR Flooding: 417

Benefit-Cost Ratio: 0.05

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 1

Estimated Population Removed from 100-YR Flooding: 289

CONSTRAINTS:

- Potential increase in downstream flood risk if detention pond is not maintained and, as a result, inflow structure fails.
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures.

ESTIMATE COSTS

Demolition	$891K
Construction	$11.3M
Contingency	$4.8M
Right of Way	$14.5M
Environmental	$499K
Engineering and Surveying	$1.7M
Total Construction	**$33M**

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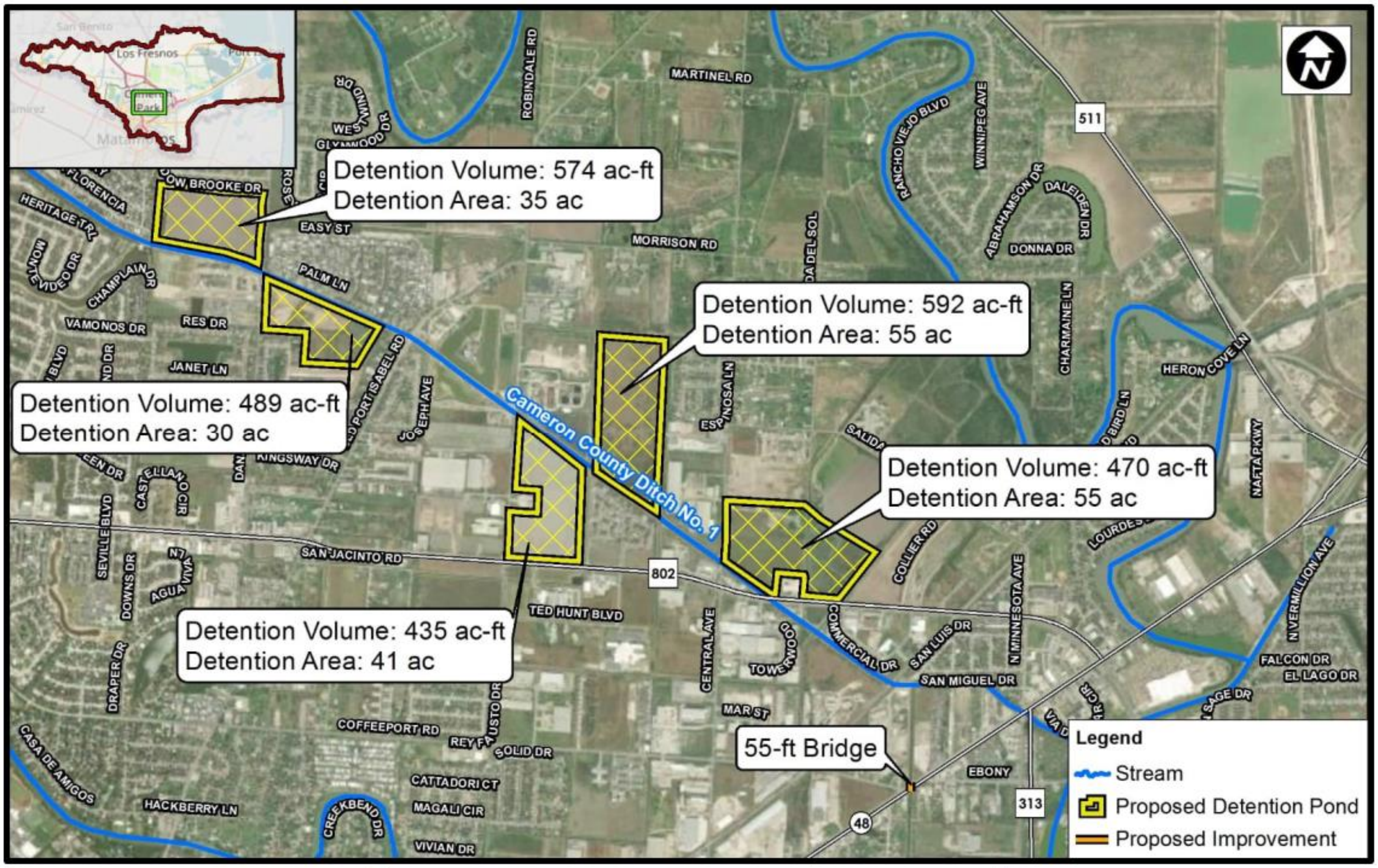
Project 2 Cameron County Ditch 1 at Confluence

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 50YR storm events

Description: Five large detention ponds on Cameron County Ditch 1 (CCD1) between Paredes Ln and Ruben Torres Blvd along with improvements to a culvert crossing on the CCD1 tributary

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 8750

BENEFITS:

Structures Removed from 100-YR Flooding: 281

Structures with Reduced 100-YR Flooding: 834

Benefit-Cost Ratio: 0.25

Level of Service Achieved: 50-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 1036

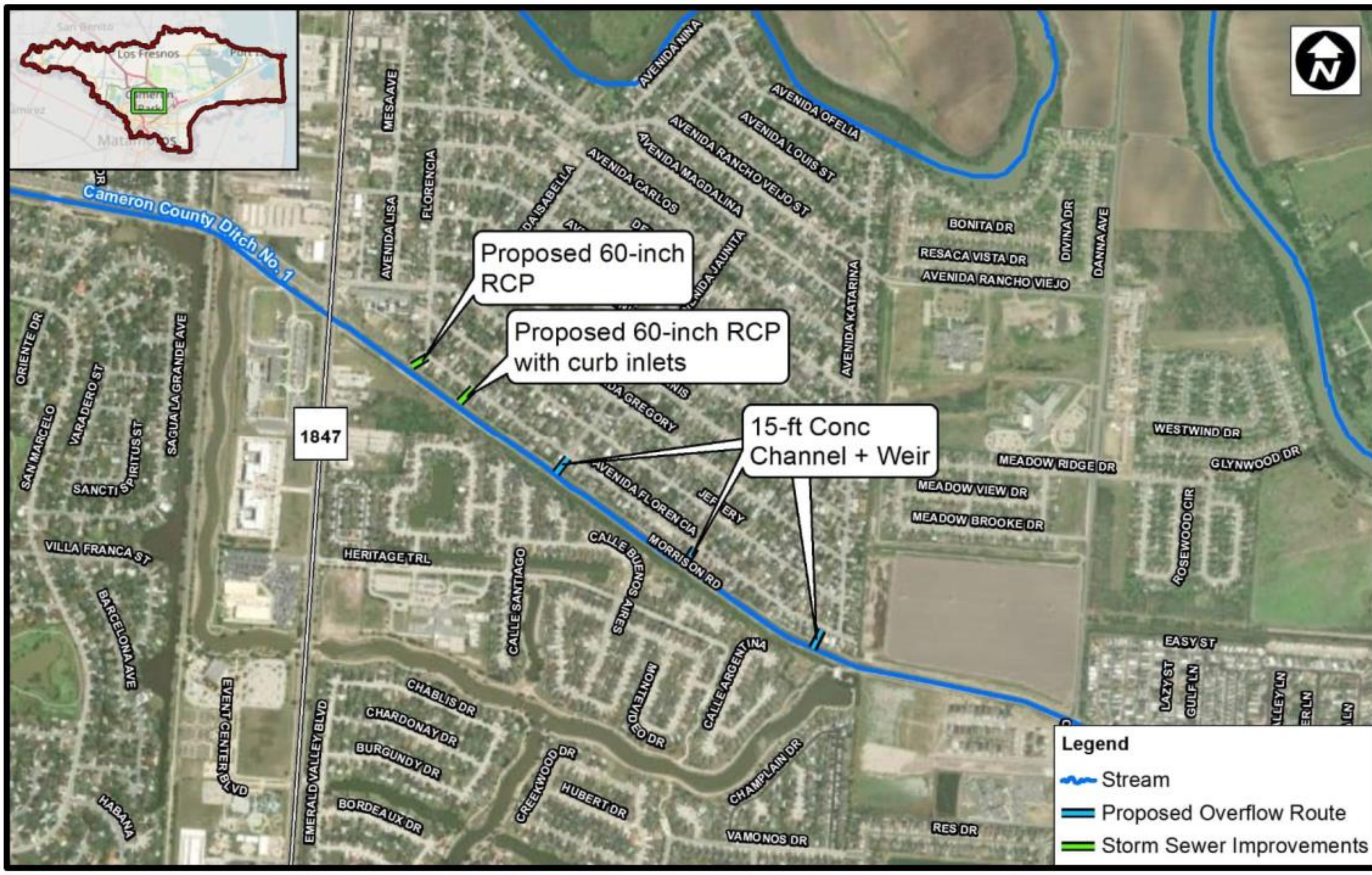
CONSTRAINTS:

- Environmental, Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures.

ESTIMATE COSTS

Demolition	$3.7M
Construction	$50M
Contingency	$21M
Right of Way	$15M
Environmental	$2.2M
Engineering and Surveying	$7.5M
Total Construction	**$99M**

Project 3 Cameron County Ditch 1 at Cameron Park Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 25YR storm events

Description: Five extreme event storm sewer and overflow routing improvements for the Cameron Park neighborhood along Avenida Florencia

Stakeholder Identified High Flood Risk Area: No

Benefit Area Population: 2170

BENEFITS:

Structures Removed from 100-YR Flooding: 130

Structures with Reduced 100-YR Flooding: 149

Benefit-Cost Ratio: 3.47

Level of Service Achieved: 25-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 655

CONSTRAINTS:

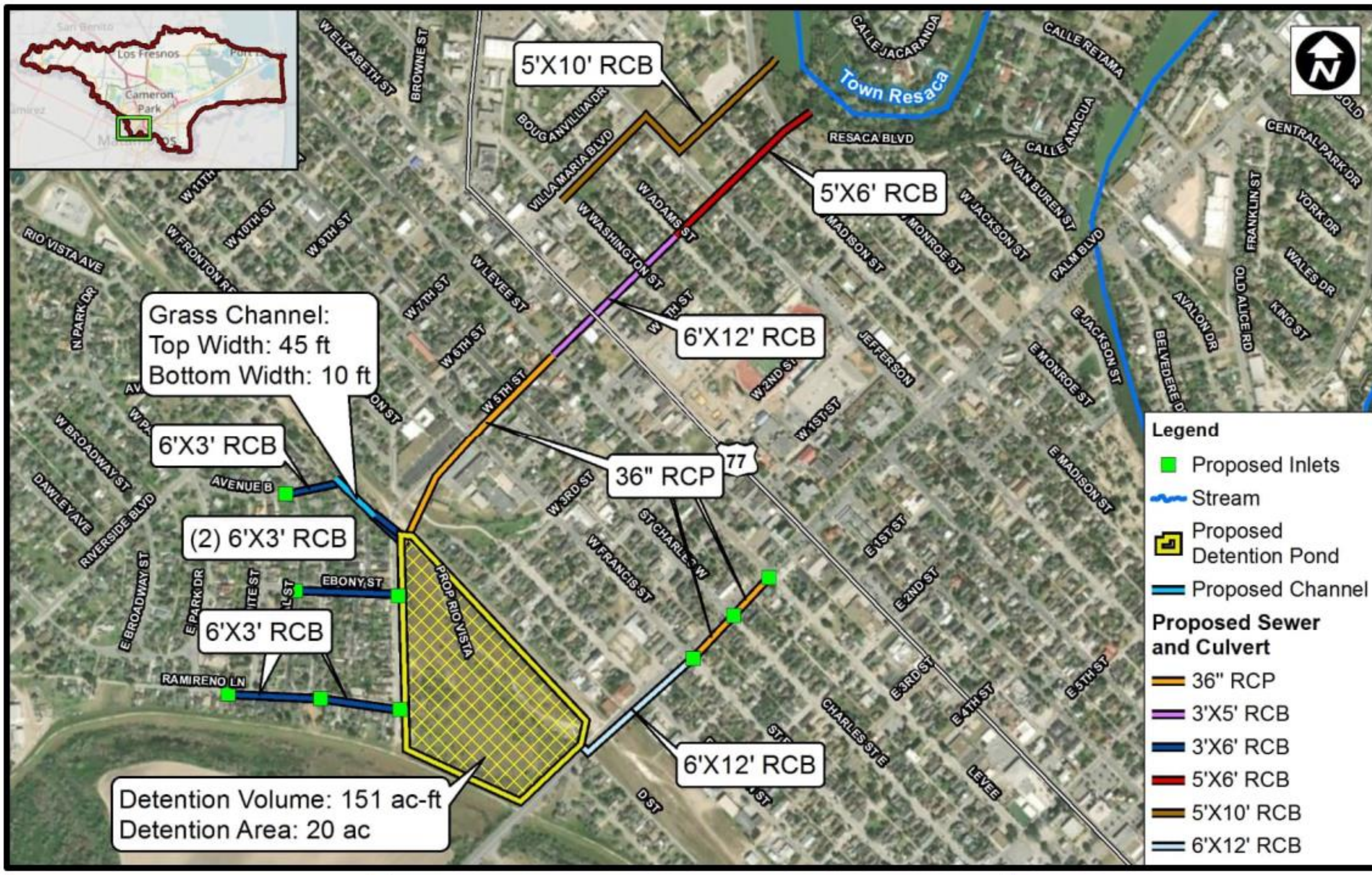
- ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures

ESTIMATE COSTS

Demolition	$35K
Construction	$800K
Contingency	$330K
Right of Way	$239K
Engineering and Surveying	$174K
Total Construction	**$1.6M**

Project 4 Town Resaca at West 5th St

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Storm sewer improvements near Palm Blvd, W 5th Street, Ebony St, and Ramireno Ln along with a detention pond

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 5800

BENEFITS:

Structures Removed from 100-YR Flooding: 71

Structures with Reduced 100-YR Flooding: 469

Benefit-Cost Ratio: 0.74

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 220

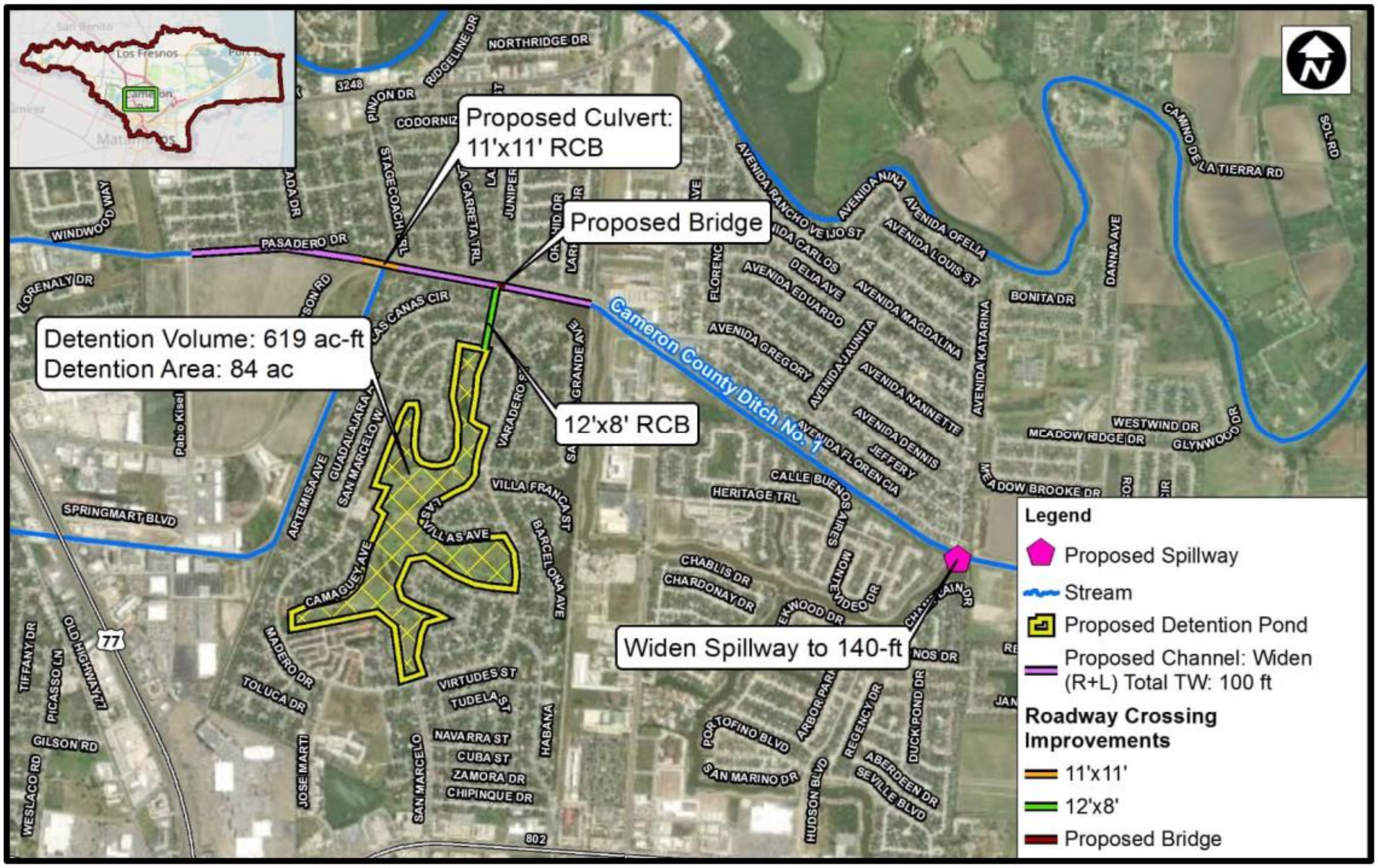
CONSTRAINTS:

- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures

ESTIMATE COSTS

Demolition	$908K
Construction	$20.4M
Contingency	$8.6M
Right of Way	$196K
Environmental	$900K
Engineering and Surveying	$3.0M
Total Construction	**$34M**

Project 5 Cameron County Ditch 1 at Golf Center Park Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Channel and roadway crossing improvements on Cameron County Ditch 1 between Pablo Kisel Blvd and Dana Ave. Also includes improvements to a man-made lake spillway and conversion of the city-owned golf course into a multi-use detention pond

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 13400

BENEFITS:

Structures Removed from 100-YR Flooding: 399

Structures with Reduced 100-YR Flooding: 214

Benefit-Cost Ratio: 0.22

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 1

Estimated Population Removed from 100-YR Flooding: 1038

CONSTRAINTS:

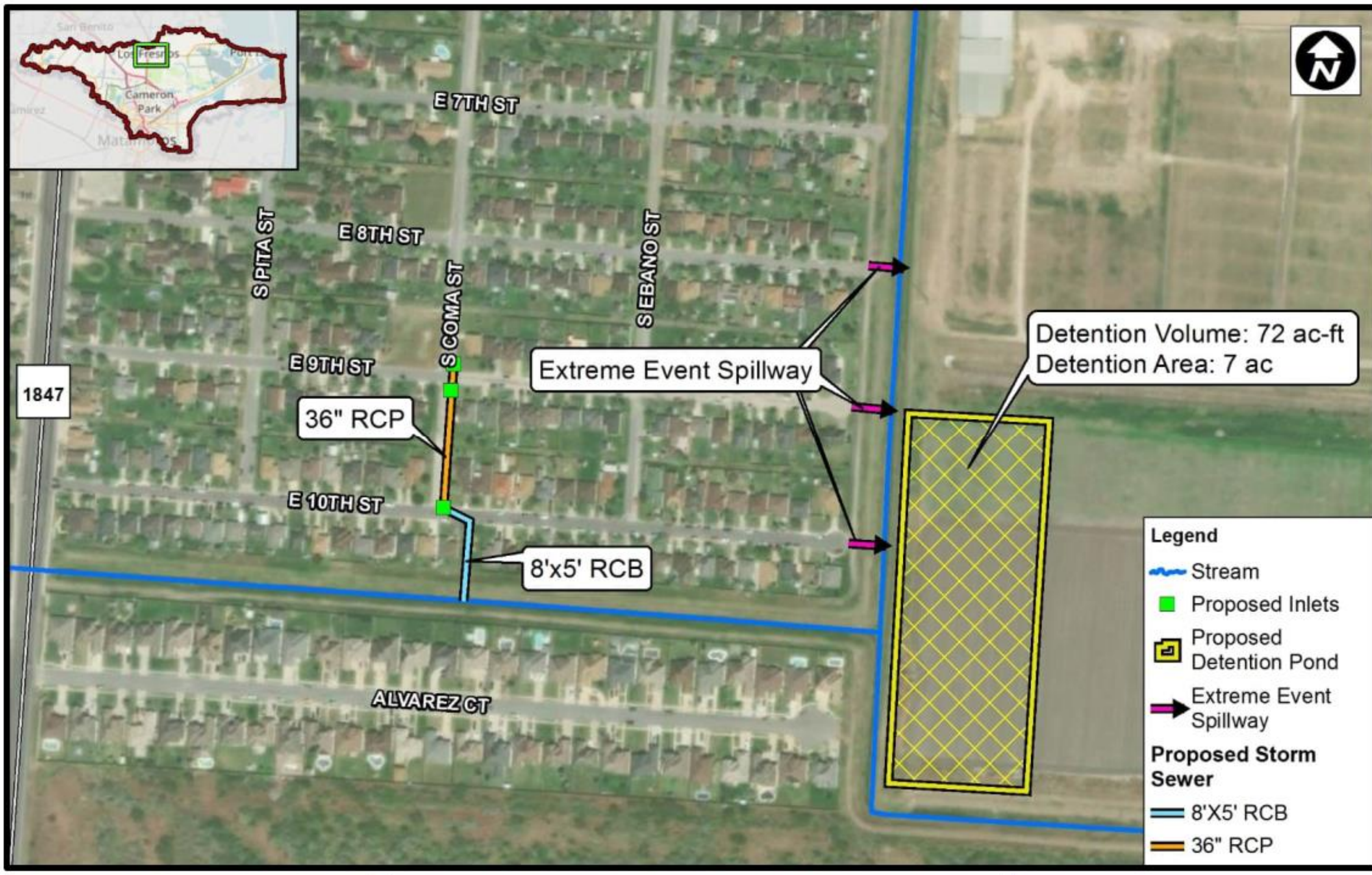
- Potential of increase in downstream flood risk if detention pond inflow structures is not regularly maintained.
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Coordination with Properties Along Golf Course, Temporary Road Closures.

ESTIMATE COSTS

Demolition	$2.5M
Construction	$26.7M
Contingency	$11M
Right of Way	$76K
Environmental	$1.2M
Engineering and Surveying	$4.0M
Total Construction	**$46M**

Project 6 Los Fresnos at East 10th St

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Four extreme event storm sewer and overflow routing improvements on E 8th, E 9th, and E 10th streets along with a detention pond

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 800

BENEFITS:

Structures Removed from 100-YR Flooding: 92

Structures with Reduced 100-YR Flooding: 100

Benefit-Cost Ratio: 1.10

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 240

CONSTRAINTS:

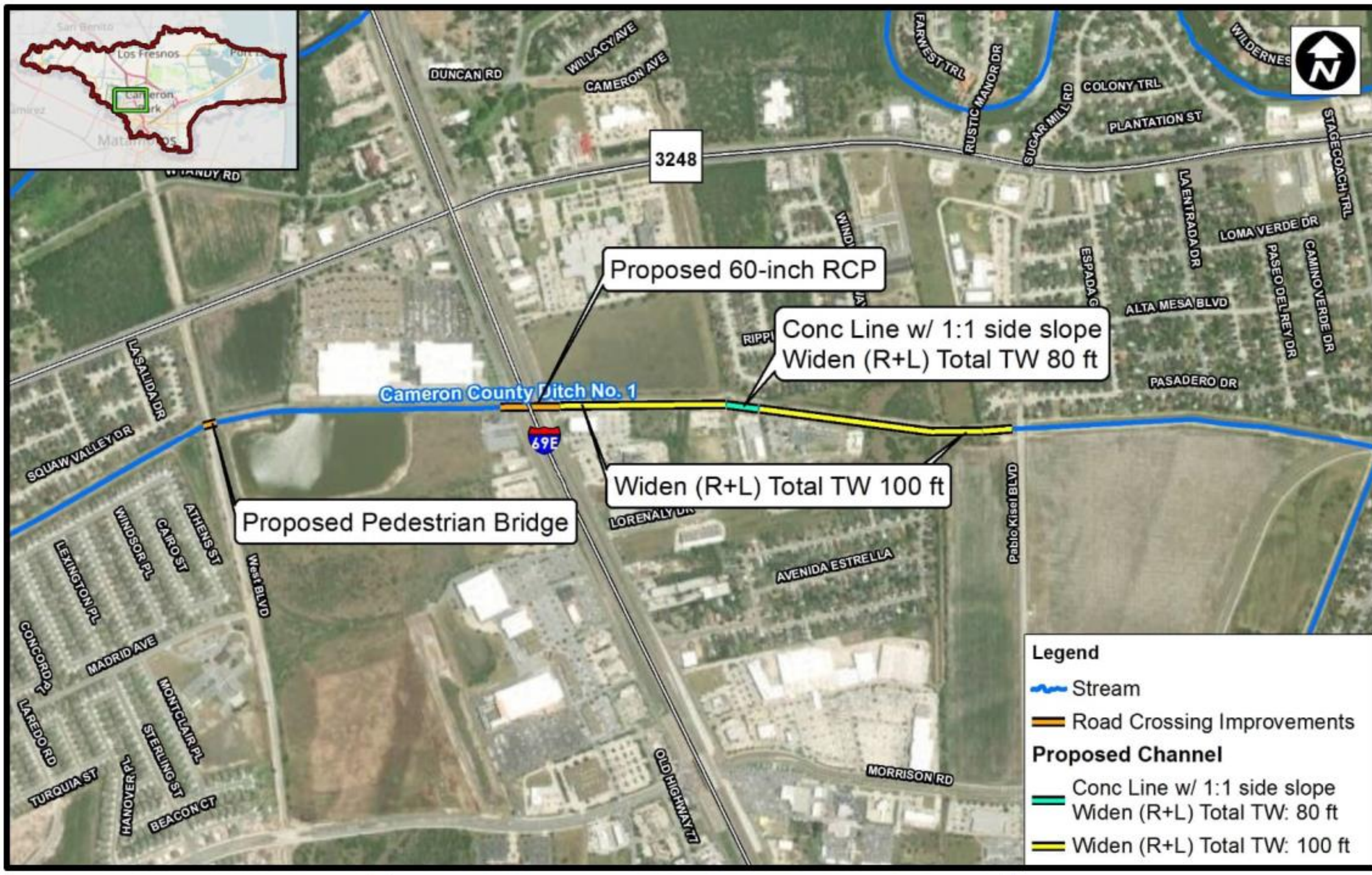
- Potential of increase in downstream flood risk if dentation pond inflow structure is not regularly maintained and, as a results, fails.
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures

ESTIMATE COSTS

Demolition	$20K
Construction	$2.7M
Contingency	$1.1M
Right of Way	$213K
Engineering and Surveying	$383K
Total Construction	**$4.4M**

Project 7 Cameron County Ditch 1 at Hwy 69E

Park Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 100YR storm events

Description: Channel and roadway crossing improvements on Cameron County Ditch 1 between Laredo Rd and Pablo Kissel Blvd

Stakeholder Identified High Flood Risk Area: No

Benefit Area Population: 7000

BENEFITS:

Structures Removed from 100-YR Flooding: 191

Structures with Reduced 100-YR Flooding: 152

Benefit-Cost Ratio: 0.63

Level of Service Achieved: 100-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 883

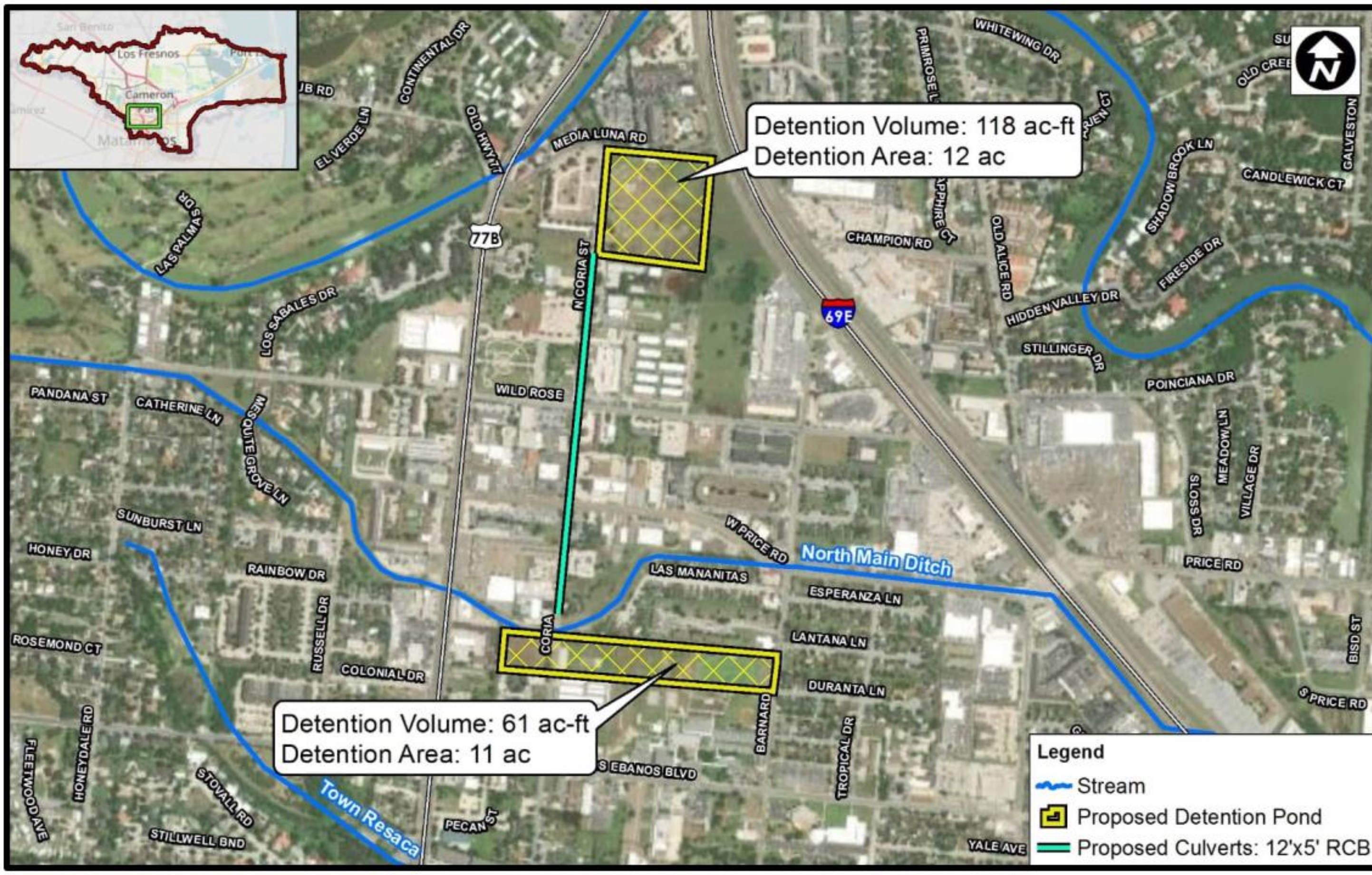
CONSTRAINTS:

- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT.

ESTIMATE COSTS

Demolition	$36K
Construction	$4.8M
Contingency	$1.9M
Right of Way	$31K
Environmental	$204K
Engineering and Surveying	$678K
Total Construction	**$7.7M**

Project 9 North Main Drain and Hwy 69E Park Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 10YR storm events

Description: Detention pond and storm sewer improvements on North Main Drain, west of Price Road and 69E

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 28400

BENEFITS:

Structures Removed from 100-YR Flooding: 84

Structures with Reduced 100-YR Flooding: 465

Benefit-Cost Ratio: 0.19

Level of Service Achieved: 10-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 753

CONSTRAINTS:

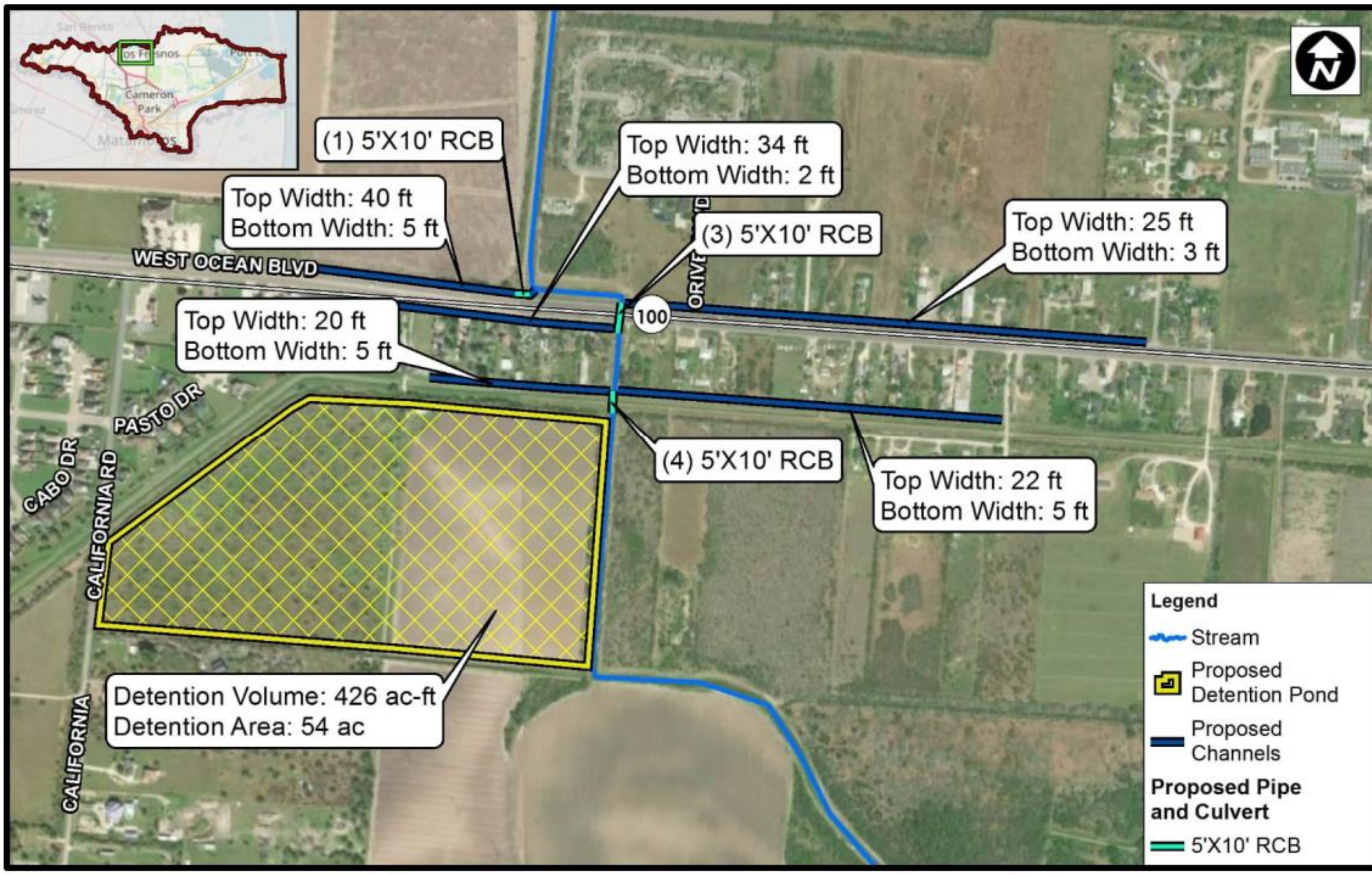
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures.

ESTIMATE COSTS

Demolition	$500K
Construction	$14.1M
Contingency	$5.8M
Right of Way	$9.5M
Environmental	$611K
Engineering and Surveying	$2.0M
Total Construction	**$33M**

Project 11A Los Fresnos West Ocean Blvd

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 25YR storm events

Description: Channel and culvert crossing improvements along with a detention pond near TX-100 and Orive Blvd

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population: 2800

BENEFITS:

Structures Removed from 100-YR Flooding: 60

Structures with Reduced 100-YR Flooding: 53

Benefit-Cost Ratio: 0.09

Level of Service Achieved: 25-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 149

CONSTRAINTS:

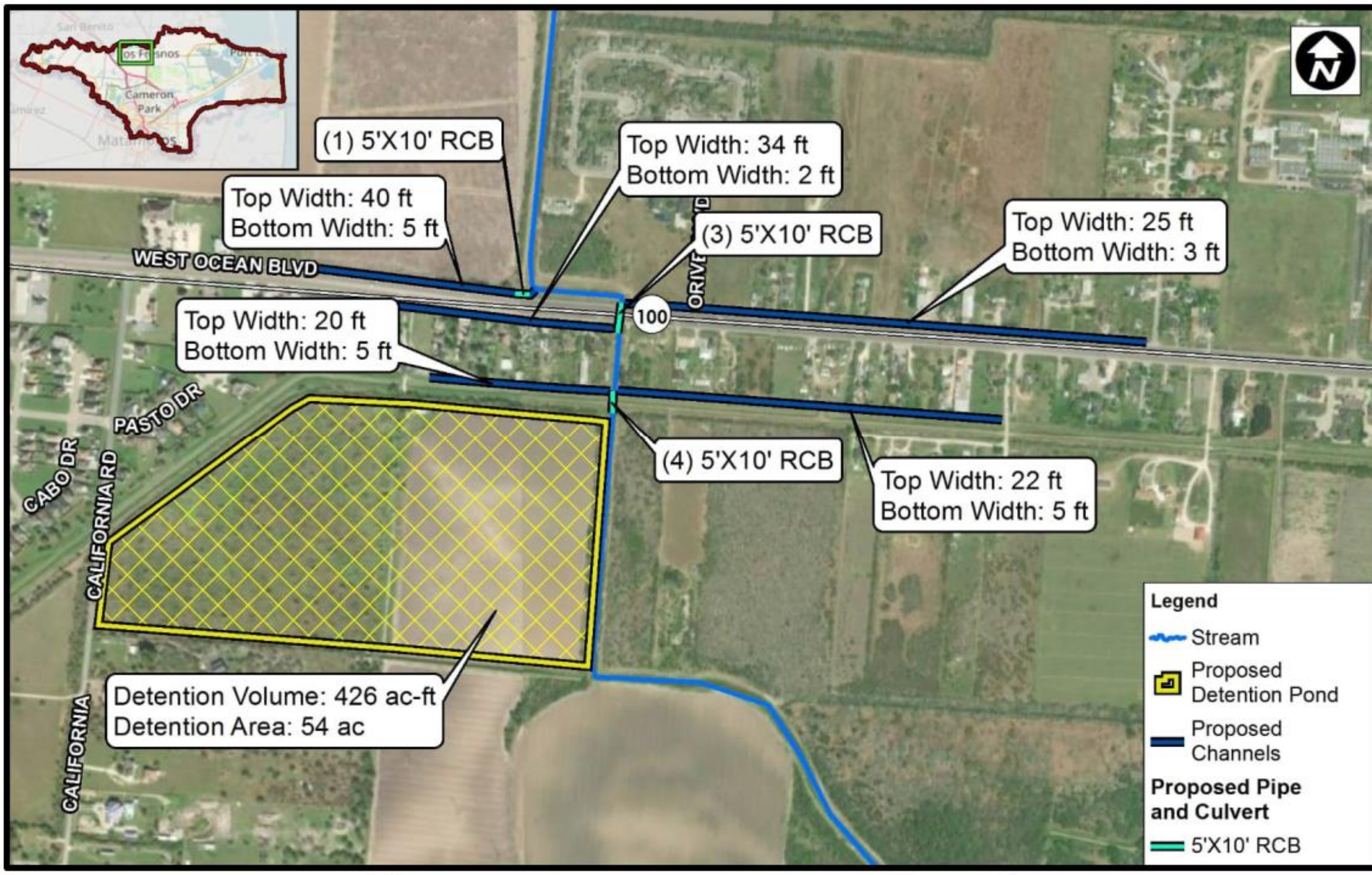
- Potential of increase in downstream flood risk if dentation pond inflow structure is not regularly maintained and, as a results, fails.
- Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT, Open Excavate a State Highway to Install Culverts.

ESTIMATE COSTS

Demolition	$988K
Construction	$15.4M
Contingency	$6.6M
Right of Way	$2.2M
Environmental	$691K
Engineering and Surveying	$3.5M
Total Construction	**$29M**

Project 11B Los Fresnos West Ocean Blvd

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 50YR storm events

Description: Channel and culvert crossing improvements along with a detention pond near TX-100 and Evergreen St

Stakeholder Identified High Flood Risk Area: **Yes**

Benefit Area Population: 2800

BENEFITS:

Structures Removed from 100-YR Flooding: 17

Structures with Reduced 100-YR Flooding: 22

Benefit-Cost Ratio: 0.14

Level of Service Achieved: 50-Year

Road Miles with Reduction in 100-YR Flooding: 2

Estimated Population Removed from 100-YR Flooding: 122

CONSTRAINTS:

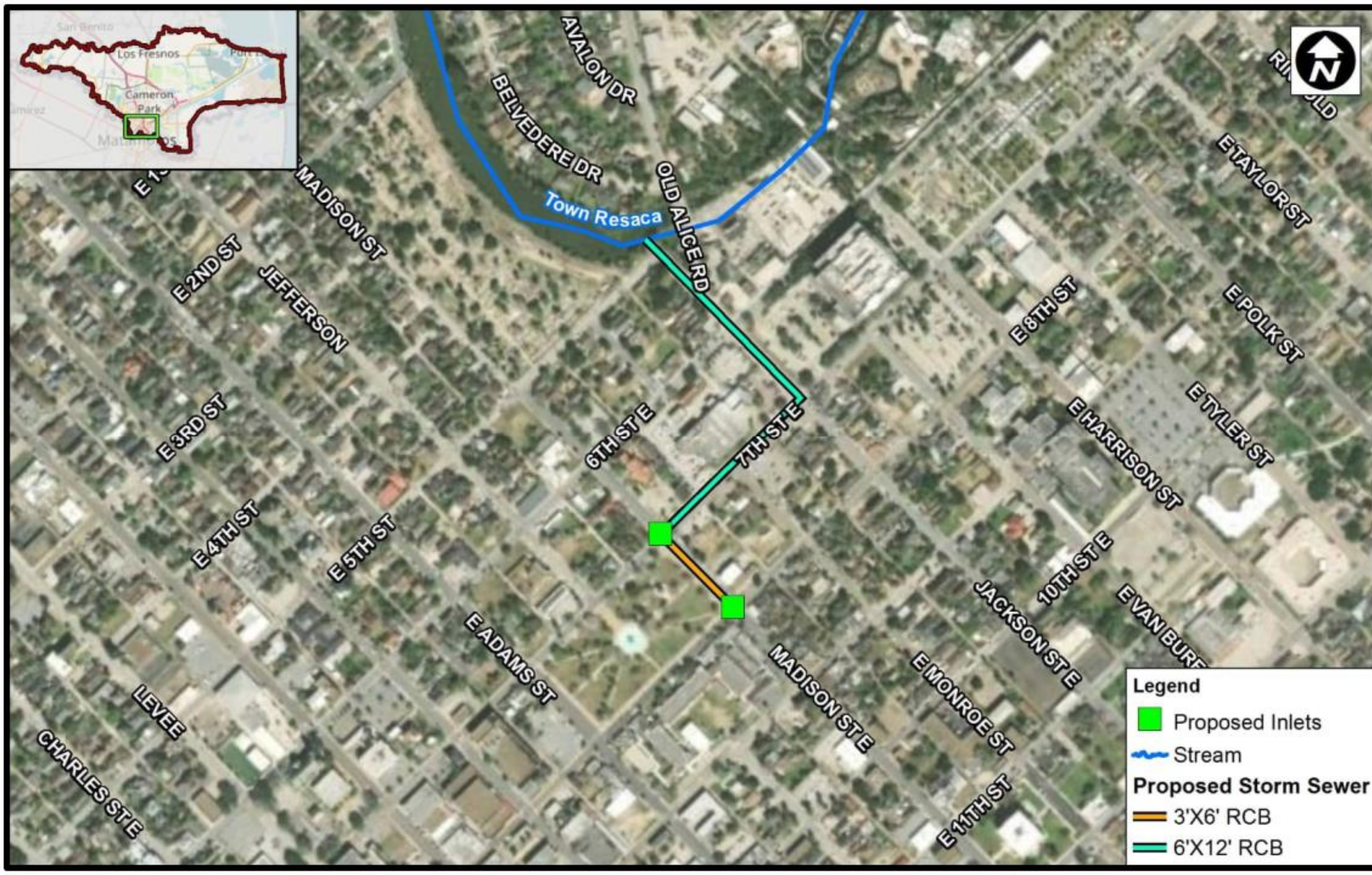
- Potential of increase in downstream flood risk if detention pond inflow structure is not regularly maintained and, as a result, fails.
- Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT, Open Excavate a State Highway to Install Culverts.

ESTIMATE COSTS

Demolition	$365K
Construction	$10M
Contingency	$4.1M
Right of Way	$695K
Environmental	$432K
Engineering and Surveying	$1.4M
Total Construction	**$17M**

Project 12 Town Resaca at Washington Park

Port Isabel HUC-10 Watershed Study



PROJECT LAYOUT

Problem: Reduce ponding in 25YR storm events

Description: Storm sewer improvements on E Madison St, E 7th St, and E Jackson St

Stakeholder Identified High Flood Risk Area: Yes

Benefit Area Population:

3000

BENEFITS:

Structures Removed from 100-YR Flooding: 48

Structures with Reduced 100-YR Flooding: 144

Benefit-Cost Ratio: 0.59

Level of Service Achieved: 25-Year

Road Miles with Reduction in 100-YR Flooding: 0

Estimated Population Removed from 100-YR Flooding: 627

CONSTRAINTS:

- Potential Utility Relocation, Temporary Road Closures

ESTIMATE COSTS

Demolition	$581K
Construction	$5.5M
Contingency	$1.8M
Engineering and Surveying	$790K
Total Construction	**$8.7M**

Appendix G - Cost Estimates

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 1A North Main Drain and Imapala Ditch **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 88,595.00	$ 88,595.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 50,000.00	$ 50,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 50,000.00	$ 50,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 50,000.00	$ 50,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
Demolition					
6	REMOVE AND DISPOSE OF ASPHALT	1100	SY	$ 20.00	$ 22,000.00
7	REMOVAL OF CONC CULV	270	LF	$ 370.00	$ 99,900.00
New Construction					
8	CONCRETE CHANNEL LINING	74,000	SY	$ 200.00	$ 14,800,000.00
9	BRIDGE	10,400	SF	$ 135.00	$ 1,404,000.00
10	PUMPS	6	EA	$ 1,000,000.00	$ 6,000,000.00
11	EXCAVATION (OFFSITE - DISPOSAL)	69,500	CY	$ 20.00	$ 1,390,000.00
Construction Totals					
				30% Contingency	**$ 7,636,349**
				Construction Subtotal	**$ 33,091,000**
Other					
	ROW ACQUISITION				$ 6,705,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 993,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 6,100,000.00
				Other Subtotal	$ 13,798,000.00
				Total Capital Cost	**$ 46,889,000**

Recurring Cost		
	DEBT SERVICE	$ 1,407,000.00
	STRUCTUAL IMPROVEMENTS	$ 112,000.00
	CHANNEL IMPROVEMENTS	$ 92,000.00
	DETENTION MAINTENANCE	$ -
	Total Recurring Cost	$ 1,611,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 1B North Main Drain and Four Corners **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 124,555.50	$ 124,555.50
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 50,000.00	$ 50,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 50,000.00	$ 50,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 50,000.00	$ 50,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
Demolition					
6	CLEARING AND GRUBBING	50	ACRE	$ 15,000.00	$ 750,000.00
7	REMOVE AND DISPOSE OF ASPHALT	773	SY	$ 20.00	$ 15,460.00
8	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	290	SY	$ 25.00	$ 7,250.00
9	REMOVAL OF CONC CULV	320	LF	$ 370.00	$ 118,400.00
New Construction					
10	CONC RCP (48")	100	LF	$ 250.00	$ 25,000.00
11	SPILLWAY	1100	SY	$ 200.00	$ 220,000.00
12	CONC RCB (10FT X 8FT)	585	LF	$ 1,275.00	$ 745,875.00
13	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	773	SY	$ 6.00	$ 4,638.00
14	10" FLEX BASE	773	SY	$ 30.00	$ 23,190.00
15	2" ASPHALT	773	SY	$ 50.00	$ 38,650.00
16	REINFORCED CONCRETE PAVEMENT 6-INCH THICK	290	SY	$ 250.00	$ 72,500.00
17	EXCAVATION (OFFSITE - DISPOSAL)	394,000	CY	$ 20.00	$ 7,880,000.00
18	HYDROMULCH SEEDING	50.0	AC	$ 4,000.00	$ 200,000.00
Construction Totals					
				30% Contingency	**$ 3,562,656**
				Construction Subtotal	**$ 15,439,000**
Other					
	ROW ACQUISITION				$ 14,530,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 464,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 2,850,000.00
				Other Subtotal	$ 17,844,000.00

Total Capital Cost	**$ 33,283,000**

Recurring Cost		
	DEBT SERVICE	$ 999,000.00
	STRUCTUAL IMPROVEMENTS	$ 5,000.00
	CHANNEL IMPROVEMENTS	$ 20,000.00
	DETENTION MAINTENANCE	$ 75,000.00
	Total Recurring Cost	$ 1,099,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 2 Cameron County Ditch 1 at Confluence **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 239,030.00	$ 239,030.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 100,000.00	$ 100,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 50,000.00	$ 50,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 50,000.00	$ 50,000.00
5	UTILITY RELOCATION	1	LS	$ 1,000,000.00	$ 1,000,000.00
Demolition					
6	CLEARING AND GRUBBING	240	ACRE	$ 15,000.00	$ 3,600,000.00
7	REMOVE AND DISPOSE OF ASPHALT	700	SY	$ 20.00	$ 14,000.00
8	REMOVAL OF CONC CULV	180	LF	$ 370.00	$ 66,600.00
New Construction					
9	SPILLWAY	6000	SY	$ 200.00	$ 1,200,000.00
10	CONC RCP (60")	420	LF	$ 350.00	$ 147,000.00
13	BRIDGE RAILING	200	LF	$ 35.00	$ 7,000.00
14	BRIDGE	6500	SF	$ 135.00	$ 877,500.00
15	EXCAVATION (OFFSITE - DISPOSAL)	3000000	CY	$ 15.00	$ 45,000,000.00
16	HYDROMULCH SEEDING	240.0	AC	$ 4,000.00	$ 960,000.00
Construction Totals					
				30% Contingency	**$ 15,993,339**
				Construction Subtotal	**$ 69,305,000**
Other					
	ROW ACQUISITION				$ 14,935,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 2,080,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 13,000,000.00
				Other Subtotal	$ 30,015,000.00
				Total Capital Cost	**$ 99,320,000**

Recurring Cost		
	DEBT SERVICE	$ 2,980,000.00
	STRUCTUAL IMPROVEMENTS	$ 12,000.00
	CHANNEL IMPROVEMENTS	$ 32,000.00
	DETENTION MAINTENANCE	$ 356,000.00
	Total Recurring Cost	$ 3,380,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 3 Cameron County Ditch 1 at Cameron Park **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 27,512.50	$ 27,512.50
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 15,000.00	$ 15,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	UTILITY RELOCATION	1	LS	$ 500,000.00	$ 500,000.00
Demolition					
5	CLEARING AND GRUBBING	1	ACRE	$ 15,000.00	$ 15,000.00
6	REMOVAL OF CONC CULV	135	LF	$ 150.00	$ 20,250.00
New Construction					
7	SPILLWAY	550	SY	$ 200.00	$ 110,000.00
8	CONC RCP (60")	270	LF	$ 350.00	$ 94,500.00
9	EXCAVATION (OFFSITE - DISPOSAL)	1300	CY	$ 20.00	$ 26,000.00
10	HYDROMULCH SEEDING	4400	SY	$ 0.50	$ 2,200.00
Construction Totals					
				30% Contingency	**$ 247,638.75**
				Construction Total	**$ 1,074,000.00**
Other					
	ROW ACQUISITION				$ 238,950.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 23% OF CONSTRUCTION COST)				$ 250,000.00
				Other Subtotal	$ 489,000.00
				Total Capital Cost	**$ 1,563,000.00**

Recurring Cost		
	DEBT SERVICE	$ 47,000.00
	STRUCTUAL IMPROVEMENTS	$ 2,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ -
	Total Recurring Cost	$ 49,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 4 Town Resaca at West 5th Street **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
	General Civil				
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 203,656.25	$ 203,656.25
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	UTILITY RELOCATION	1	LS	$ 3,000,000.00	$ 3,000,000.00
5	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 150,000.00	$ 150,000.00
	Demolition				
6	CLEARING AND GRUBBING	20	ACRE	$ 15,000.00	$ 300,000.00
7	REMOVE AND DISPOSE OF ASPHALT	29900	SY	$ 20.00	$ 598,000.00
8	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	405	SY	$ 25.00	$ 10,125.00
	New Construction				
9	GRASS CHANNEL FINAL GRADING	1900	SY	$ 10.00	$ 19,000.00
10	INLET STRUCTURE	44	EA	$ 10,000.00	$ 440,000.00
11	CONC RCP (36")	4900	LF	$ 150.00	$ 735,000.00
12	CONC RCB (6 FT X 3 FT)	2720	LF	$ 500.00	$ 1,360,000.00
13	CONC RCB (10 FT X 5 FT)	1950	LF	$ 1,500.00	$ 2,925,000.00
14	CONC RCB (12 FT X 6 FT)	1400	LF	$ 1,800.00	$ 2,520,000.00
15	CONC BOX CULV (6 FT X 3 FT)	550	LF	$ 500.00	$ 275,000.00
16	JUNCTION BOX	20	EA	$ 20,000.00	$ 400,000.00
17	CONC RCB (5 FT X 5 FT)	1040	LF	$ 600.00	$ 624,000.00
18	RCB BEND	5	EA	$ 10,000.00	$ 50,000.00
19	HEADWALL	8	EA	$ 30,000.00	$ 240,000.00
20	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	29900	SY	$ 6.00	$ 179,400.00
21	10" FLEX BASE	29900	SY	$ 30.00	$ 897,000.00
22	2" ASPHALT	29900	SY	$ 50.00	$ 1,495,000.00
23	EXCAVATION (OFFSITE - DISPOSAL)	245000	CY	$ 20.00	$ 4,900,000.00
24	HYDROMULCH SEEDING	98000	SY	$ 0.50	$ 49,000.00
	Construction Totals				
				30% Contingency	**$ 6,424,554**
				Construction Total	**$ 27,840,000**
	Other				
	ROW ACQUISITION				$ 196,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 836,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 5,200,000.00
				Other Subtotal	$ 6,232,000.00
				Total Capital Cost	**$ 34,072,000**

Recurring Cost		
	DEBT SERVICE	$ 1,023,000.00
	STRUCTUAL IMPROVEMENTS	$ 48,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ 30,000.00
	Total Recurring Cost	$ 1,101,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 5 Cameron County Ditch 1 at Golf Center **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 202,180.56	$ 202,180.56
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 50,000.00	$ 50,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 30,000.00	$ 30,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 30,000.00	$ 30,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
Demolition					
6	CLEARING AND GRUBBING	122	ACRE	$ 15,000.00	$ 1,830,000.00
7	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	4444	SY	$ 25.00	$ 111,111.11
8	REMOVAL OF CONC CULV	1550	LF	$ 350.00	$ 542,500.00
New Construction					
9	GRASS CHANNEL FINAL GRADING	32500	SY	$ 10.00	$ 325,000.00
10	CONC RCB (11 FT X 11 FT)	1000	LF	$ 1,500.00	$ 1,500,000.00
11	CONC RCB (12FT X 8FT)	950	LF	$ 1,800.00	$ 1,710,000.00
12	BRIDGE	7000	SF	$ 135.00	$ 945,000.00
13	BRIDGE RAILING	150	LF	$ 50.00	$ 7,500.00
14	SPILLWAY	2000	SY	$ 200.00	$ 400,000.00
15	HEADWALL	4	EA	$ 30,000.00	$ 120,000.00
16	HYDROMULCH SEEDING	122	AC	$ 4,000.00	$ 488,000.00
17	FLAP GATE (24")	2	EA	$ 10,000.00	$ 20,000.00
18	FLAP GATE (18")	3	EA	$ 7,000.00	$ 21,000.00
19	EXCAVATION (OFFSITE - DISPOSAL)	943900	CY	$ 20.00	$ 18,878,000.00
Construction Totals					
				30% Contingency	**$ 8,613,088**
				Construction Total	**$ 37,324,000**
Other					
	ROW ACQUISITION				$ 76,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 1,120,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 6,950,000.00
				Other Subtotal	$ 8,146,000.00
				Total Capital Cost	**$ 45,470,000**

Recurring Cost		
	DEBT SERVICE	$ 1,365,000.00
	STRUCTUAL IMPROVEMENTS	$ 24,000.00
	CHANNEL IMPROVEMENTS	$ 53,000.00
	DETENTION MAINTENANCE	$ 146,000.00
	Total Recurring Cost	$ 1,588,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 6 Los Fresnos at East 10th St. **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
	General Civil				
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 2,750.00	$ 2,750.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 20,000.00	$ 20,000.00
	Demolition				
5	REMOVE AND DISPOSE OF ASPHALT	1000	SY	$ 20.00	$ 20,000.00
	New Construction				
6	SPILLWAY	2000	SY	$ 200.00	$ 400,000.00
7	INLET STRUCTURE	8	EA	$ 10,000.00	$ 80,000.00
8	JUNCTION BOX STRUCTURE	2	EA	$ 30,000.00	$ 60,000.00
9	CONC RCB (8FT X 5FT)	630	LF	$ 550.00	$ 346,500.00
10	HEADWALL	1	EA	$ 30,000.00	$ 30,000.00
11	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	1000	SY	$ 6.00	$ 6,000.00
12	10" FLEX BASE	1000	SY	$ 30.00	$ 30,000.00
13	2" ASPHALT	1000	SY	$ 50.00	$ 50,000.00
14	EXCAVATION (OFFSITE - DISPOSAL)	82000	CY	$ 20.00	$ 1,640,000.00
	Construction Totals				
				30% Contingency	**$ 819,075**
				Construction Total	**$ 3,550,000**
	Other				
	ROW ACQUISITION				$ 213,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 640,000.00
				Other Subtotal	$ 853,000.00
				Total Capital Cost	**$ 4,403,000**

Recurring Cost		
	DEBT SERVICE	$ 133,000.00
	STRUCTURAL IMPROVEMENTS	$ 5,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ 11,000.00
	Total Recurring Cost	$ 149,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 7 Cameron County Ditch 1 at Hwy 69E **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 30,287.00	$ 30,287.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 50,000.00	$ 50,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 20,000.00	$ 20,000.00
5	UTILITY RELOCATION	1	LS	$ 500,000.00	$ 500,000.00
Demolition					
6	CLEARING AND GRUBBING	1	ACRE	$ 15,000.00	$ 15,000.00
7	REMOVE AND DISPOSE OF ASPHALT	75	SY	$ 20.00	$ 1,500.00
8	REMOVAL OF CONC CULV	52	LF	$ 370.00	$ 19,240.00
New Construction					
9	CONCRETE CHANNEL LINING	4050	SY	$ 200.00	$ 810,000.00
10	GRASS CHANNEL FINAL GRADING	22525	SY	$ 10.00	$ 225,250.00
11	JACK AND BORE (60")	740	LF	$ 3,800.00	$ 2,812,000.00
12	BRIDGE	1900	SF	$ 135.00	$ 256,500.00
13	HEADWALL	2	EA	$ 30,000.00	$ 60,000.00
14	HYDROMULCH SEEDING	22500	SY	$ 0.50	$ 11,250.00
Construction Totals					
				30% Contingency	**$ 1,452,308**
				Construction Total	**$ 6,294,000**
Other					
	ROW ACQUISITION				$ 31,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 189,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 1,200,000.00
				Other Subtotal	$ 1,420,000.00
				Total Capital Cost	**$ 7,714,000**

Recurring Cost		
	DEBT SERVICE	$ 232,000.00
	STRUCTUAL IMPROVEMENTS	$ 21,000.00
	CHANNEL IMPROVEMENTS	$ 23,000.00
	DETENTION MAINTENANCE	$ -
	Total Recurring Cost	$ 276,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 9 North Main Drain and Hwy 69E **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 106,262.50	$ 106,262.50
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 45,000.00	$ 45,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 25,000.00	$ 25,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 100,000.00	$ 100,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
Demolition					
6	CLEARING AND GRUBBING	24	ACRE	$ 15,000.00	$ 360,000.00
7	REMOVE AND DISPOSE OF ASPHALT	6300	SY	$ 20.00	$ 126,000.00
8	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	570	SY	$ 25.00	$ 14,250.00
New Construction					
9	CONC RCP (36")	90	LF	$ 150.00	$ 13,500.00
10	CONC RCP (48")	90	LF	$ 250.00	$ 22,500.00
11	CONC RCB (12FT X 5FT)	2600	LF	$ 1,500.00	$ 3,900,000.00
12	CONC RCB (10FT X 6FT)	150	LF	$ 1,275.00	$ 191,250.00
13	HEADWALL	2	EA	$ 30,000.00	$ 60,000.00
14	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	6300	SY	$ 6.00	$ 37,800.00
15	10" FLEX BASE	6300	SY	$ 30.00	$ 189,000.00
16	2" ASPHALT	6300	SY	$ 50.00	$ 315,000.00
17	EXCAVATION (OFFSITE - DISPOSAL)	366000	CY	$ 20.00	$ 7,320,000.00
18	REINFORCED CONCRETE PAVEMENT 6-INCH THICK	800	SY	$ 200.00	$ 160,000.00
19	HYDROMULCH SEEDING	114000	SY	$ 0.50	$ 57,000.00
Construction Totals					
				30% Contingency	**$ 4,362,769**
				Construction Total	**$ 18,906,000**
Other					
	ROW ACQUISITION				$ 9,461,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 568,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 3,600,000.00
				Other Subtotal	$ 13,629,000.00
				Total Capital Cost	**$ 32,535,000**

Recurring Cost		
	DEBT SERVICE	$ 977,000.00
	STRUCTUAL IMPROVMENTS	$ 21,000.00
	CHANNEL IMPROVMENTS	$ -
	DETENTION MAINTENANCE	$ 35,000.00
	Total Recurring Cost	$ 1,033,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 11A Los Fresnos West Ocean Blvd **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 127,650.00	$ 127,650.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 50,000.00	$ 50,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
Demolition					
6	CLEARING AND GRUBBING	62	ACRE	$ 15,000.00	$ 930,000.00
7	REMOVE AND DISPOSE OF ASPHALT	300	SY	$ 20.00	$ 6,000.00
8	REMOVAL OF CONC CULV	260	LF	$ 200.00	$ 52,000.00
New Construction					
9	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	300	SY	$ 6.00	$ 1,800.00
10	10" FLEX BASE	300	SY	$ 30.00	$ 9,000.00
11	2" ASPHALT	300	SY	$ 50.00	$ 15,000.00
12	CONC RCP (60")	120	LF	$ 350.00	$ 42,000.00
13	CONC RCB (10FT X 5FT)	1950	LF	$ 1,500.00	$ 2,925,000.00
14	HEADWALL	4	EA	$ 30,000.00	$ 120,000.00
15	EXCAVATION (OFFSITE - DISPOSAL)	520000	CY	$ 20.00	$ 10,400,000.00
16	SPILLWAY	300	SY	$ 200.00	$ 60,000.00
17	HYDROMULCH SEEDING	300000	SY	$ 0.50	$ 150,000.00
Construction Totals					
				30% Contingency	**$ 4,930,035**
				Construction Total	**$ 21,364,000**
Other					
	ROW ACQUISITION				$ 2,176,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 641,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 24% OF CONSTRUCTION COST)				$ 5,100,000.00
				Other Subtotal	$ 7,917,000.00
				Total Capital Cost	**$ 29,281,000**

Recurring Cost		
	DEBT SERVICE	$ 879,000.00
	STRUCTUAL IMPROVEMENTS	$ 16,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ 81,000.00
	Total Recurring Cost	$ 976,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 11B Los Fresnos West Ocean Blvd **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
	General Civil				
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 95,775.00	$ 95,775.00
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 35,000.00	$ 35,000.00
5	UTILITY RELOCATION	1	LS	$ 1,500,000.00	$ 1,500,000.00
	Demolition				
6	CLEARING AND GRUBBING	19	ACRE	$ 15,000.00	$ 285,000.00
7	REMOVE AND DISPOSE OF ASPHALT	400	SY	$ 20.00	$ 8,000.00
8	REMOVAL OF CONC CULV	350	LF	$ 200.00	$ 70,000.00
9	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	100	SY	$ 25.00	$ 2,500.00
	New Construction				
10	CONCRETE CHANNEL LINING	1016	SY	$ 200.00	$ 203,200.00
11	CONC RCB (10FT X 5FT)	764	LF	$ 1,500.00	$ 1,146,000.00
12	HEADWALL	4	EA	$ 30,000.00	$ 120,000.00
13	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	400	SY	$ 6.00	$ 2,400.00
14	10" FLEX BASE	400	SY	$ 30.00	$ 12,000.00
15	2" ASPHALT	400	SY	$ 50.00	$ 20,000.00
16	EXCAVATION (OFFSITE - DISPOSAL)	332000	CY	$ 20.00	$ 6,640,000.00
17	SPILLWAY	270	SY	$ 200.00	$ 54,000.00
18	HYDROMULCH SEEDING	90300	SY	$ 0.50	$ 45,150.00
	Construction Totals				
				30% Contingency	**$ 3,085,208**
				Construction Total	**$ 13,370,000**
	Other				
	ROW ACQUISITION				$ 695,000.00
	ENVIRONMENTAL MITIGATION (3% OF CONSTRUCTION COST)				$ 402,000.00
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 18% OF CONSTRUCTION COST)				$ 2,500,000.00
				Other Subtotal	$ 3,597,000.00
				Total Capital Cost	**$ 16,967,000**

Recurring Cost		
	DEBT SERVICE	$ 510,000.00
	STRUCTURAL IMPROVEMENTS	$ 8,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ 29,000.00
	Total Recurring Cost	$ 547,000.00

Brownsville FIF
Texas Water Development Board / City of Brownsville

PROJECT: Port Isabel to Brownsville FIF - Project 12 Town Resaca at Washington Park **DATE:** 07/26/23

BROWNSVILLE, TEXAS
OPINION OF PROBABLE CONSTRUCTION COSTS

SUMMARY OF QUANTITIES					
Item No.	**Description**	**Quantity**	**Unit**	**Unit Price**	**Total Price**
General Civil					
1	SITE PREPARATION (MOBILIZATION, UTILITY COORDINATION, FINAL GRADING) (N.T.E. 5% OF PROPOSED TOTAL)	1	EA	$ 132,330.69	$ 132,330.69
2	EROSION CONTROL, SWPPP & BMP MAINTENANCE	1	LS	$ 30,000.00	$ 30,000.00
3	CARE AND CONTROL OF WATER	1	LS	$ 15,000.00	$ 15,000.00
4	BARRICADES, SIGNS AND TRAFFIC HANDLING	1	LS	$ 50,000.00	$ 50,000.00
5	UTILITY RELOCATION	1	LS	$ 2,000,000.00	$ 2,000,000.00
Demolition					
6	CLEARING AND GRUBBING	1	ACRE	$ 15,000.00	$ 15,000.00
7	REMOVE AND DISPOSE OF ASPHALT	4694	SY	$ 20.00	$ 93,888.89
8	REMOVING AND DISPOSING OF CONCRETE PAVEMENTS (ALL THICKNESSES)	275	SY	$ 25.00	$ 6,875.00
9	REMOVAL OF CONC CULV	1331	LF	$ 350.00	$ 465,850.00
New Construction					
10	JUNCTION BOX STRUCTURE	2	EA	$ 30,000.00	$ 60,000.00
11	INLET STRUCTURE	12	EA	$ 10,000.00	$ 120,000.00
12	TRENCH SAFETY SYSTEM	1690	SY	$ 10.00	$ 16,900.00
13	CONC RCB (12 FT X 6 FT)	1331	LF	$ 1,800.00	$ 2,395,800.00
14	CONC RCB (6 FT X 3 FT)	359	LF	$ 500.00	$ 179,500.00
15	HEADWALL	1	EA	$ 30,000.00	$ 30,000.00
16	CEMENT COMPACTED STABILIZED SUBGRADE 6-INCH THICK	4694	SY	$ 6.00	$ 28,166.67
17	10" FLEX BASE	4694	SY	$ 30.00	$ 140,833.33
18	2" ASPHALT	4694	SY	$ 50.00	$ 234,722.22
19	REINFORCED CONCRETE PAVEMENT 6-INCH THICK	275	SY	$ 200.00	$ 55,000.00
20	HYDROMULCH SEEDING	5000	SY	$ 0.50	$ 2,500.00
Construction Totals					
				30% Contingency	**$ 1,821,710**
				Construction Total	**$ 7,895,000**
Other					
	ENGINEERING DESIGN FEE & SURVEY (APPROX. 11% OF CONSTRUCTION COST)				$ 850,000.00
				Other Subtotal	$ 850,000.00
				Total Capital Cost	**$ 8,745,000**

Recurring Cost		
	DEBT SERVICE	$ 263,000.00
	STRUCTUAL IMPROVEMENTS	$ 14,000.00
	CHANNEL IMPROVEMENTS	$ -
	DETENTION MAINTENANCE	$ -
	Total Recurring Cost	$ 277,000.00

Appendix H - TWDB Flood Mitigation Project Table

General Information																		
FMP ID	RFPG No.	RFPG Name	FMP Name	Description	Associated Goals (ID)	Counties	HUC 12s	Watersheds	Project Type	Project Source	Project Area	Flood Risk Type	Sponsor	Entities with Oversight	Emergency Need	Estimated Project Cost	Recurring Cost	Funded?
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1A North Main Drain and Imapala Ditch	Channel, culvert road crossing, and pump station improvements on North Main Drain and Impala Ditch between International Blvd and the Impala Pump Station	15000031, 15000032	Cameron County	121102080900	15000097	Channel	TWDB FIF	3.2	Riverine	City of Brownsville	City of Brownsville	No	$46,976,000	$1,614,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1B North Main Drain and Four Corners	Channel and culvert improvements along with one detention pond on North Main Drain between Rockwell Dr and Boca Chica Blvd	15000031, 15000032	Cameron County	121102080900	15000097	Detention	TWDB FIF	3.2	Riverine	City of Brownsville	City of Brownsville	No	$33,318,000	$1,100,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 2 Cameron County Ditch 1 at Confluence	Five large detention ponds on Cameron County Ditch 1 (CCD1) between Paredes Ln and Ruben Torress Blvd along with improvements to a culvert crossing on the CCD1 tributary.	15000031, 15000033	Cameron County	121102080900	15000097	Detention	TWDB FIF	0.2	Riverine	City of Brownsville	City of Brownsville, Cameron County Drainage District 1	No	$99,275,000	$3,379,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 3 Cameron County Ditch 1 at Cameron Park	Five extreme event storm sewer and overflow routing improvements for the Cameron Park neighborhood along Avenida Florencia.	15000031, 15000034	Cameron County	121102080900	15000097	Storm Drain	TWDB FIF	3.2	Riverine	City of Brownsville	City of Brownsville, Cameron County Drainage District 1	No	$1,569,000	$50,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 4 Town Resaca at West 5th Street	Storm sewer improvements near Palm Blvd, W 5th Street, Ebony St, and Ramireno Ln. along with a detention pond.	15000031, 15000035	Cameron County	121102080900	15000097	Storm Sewer	TWDB FIF	0.6	Local	City of Brownsville	City of Brownsville	No	$34,077,000	$1,101,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 5 Cameron County Ditch 1 at Golf Center	Channel and roadway crossing improvements on Cameron County Ditch 1 between Pablo Kisel Blvd and Dana Ave. Also incldes improvements to a man-made lake spillway andconversion of the city-owned golf course into a multi-use detention pond.	15000031, 15000036	Cameron County	121102080900	15000097	Detention	TWDB FIF	3.1	Riverine	City of Brownsville	City of Brownsville, Cameron County Drainage District 1	No	$45,497,000	$1,588,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 6 Los Fresnos at East 10th St.	Four extreme event storm sewer and overflow routing improvements on E 8th, E 9th, and E 10th streets along with a detention pond.	15000031, 15000037	Cameron County	121102080900	15000097	Storm Drain	TWDB FIF	0.2	Local	City of Los Fresnos	City of Los Fresnos	No	$4,419,000	$149,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 7 Cameron County Ditch 1 at Hwy 69E	Channel and roadway crossing improvements on Cameron County Ditch 1 between Laredo Rd and Pablo Kisel Blvd	15000031, 15000038	Cameron County	121102080900	15000097	Channel	TWDB FIF	1.8	Riverine	City of Brownsville	City of Brownsville, Cameron County Drainage District 1, TxDOT	No	$7,691,000	$275,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 9 North Main Drain and Hwy 69E	Detention pond and storm sewer improvements on North Main Drain, west of Price Road and 69E.	15000031, 15000039	Cameron County	121102080900	15000097	Detention	TWDB FIF	2.3	Riverine	City of Brownsville	City of Brownsville	No	$32,468,000	$1,031,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11A Los Fresnos West Ocean Blvd	Channel and culvert crossing improvements along with a detention pond near TX-100 and Orive Blvd	15000031, 15000040	Cameron County	121102080900	15000097	Comprehensive	TWDB FIF	0.7	Local	City of Los Fresnos	City of Los Fresnos, Cameron County, TxDOT	No	$29,326,000	$977,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11B Los Fresnos West Ocean Blvd	Channel and culvert crossing improvements along with a detention pond near TX-100 and Evergreen St	15000031, 15000041	Cameron County	121102080900	15000097	Comprehensive	TWDB FIF	0.3	Local	City of Los Fresnos	City of Los Fresnos, Cameron County, TxDOT	No	$16,965,000	$546,000	No
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 12 Town Resaca at Washington Park	Storm sewer improvements on E Madison St, E 7th St, and E Jackson St	15000031, 15000042	Cameron County	121102080900	15000097	Storm Drain	TWDB FIF	0.2	Local	City of Brownsville	City of Brownsville	No	$8,685,000	$275,000	No

				Flood Risk Information																						
				Flood Risk											Reduction in Flood Risk											
FMP ID	RFPG No.	RFPG Name	FMP Name	Area in 100-year (1% ACE) Floodplain (sq mi)	Area in 500-year (0.2% ACE) Floodplain (sq mi)	Estimated Number of Structures at 100-year (1% ACE) Flood Risk	Estimated Number of Structures at 500-year (0.2% ACE) Flood Risk	Residential Structures at 100-year (1% ACE) Flood Risk	Estimated Population at 100-year (1% ACE)Flood Risk	Critical Facilities at 100-year (1% ACE) Flood Risk	Number of Low Water Crossings 100-year (1% ACE) at Flood Risk	Estimated Length of Roads at 100-year (1% ACE) Flood Risk (mi)	Estimated Number of Road Closures	Estimated Farm & Ranch Land at 100-year (1% ACE) Flood Risk (ac)	Number of Structures with Reduced 100-year (1% ACE) Flood Risk	Number of Structures Removed from 100-year (1% ACE) Flood Risk	Number of Structures Removed from 500-year (0.2% ACE) Flood Risk	Residential Structures Removed from 100-year (1% ACE) Flood Risk	Estimated Population Removed from 100-year (1% ACE) Flood Risk	Critical Facilities Removed from 100-year (1% ACE) Flood Risk	Low Water Crossings Removed from 100-year (1% ACE) Flood Risk	Estimated Length of Roads Removed from 100-year (1% ACE) Flood Risk (mi)	Estimated Reduction in Road Closure Occurances	Estimated Farm & Ranch Land Removed from 100-year (1% ACE) Flood Risk	Estimated Reduction in Facilities (if available)	Estimated Reduction in Injuries (if available)
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1A North Main Drain and Imapala Ditch	1.69	2.20	1275	2,043	1,084	10,441	3	0	32.2	210	42.6	176	131	0	116	450	0	0	0	0	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1B North Main Drain and Four Corners	1.58	2.04	1384	2,132	1,171	10,867	3	0	27.8	165	30.3	417	83	0	83	289	0	0	1	41	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 2 Cameron County Ditch 1 at Confluence	2.63	3.00	1353	1,806	1,103	5,452	0	0	25.6	110	356.3	834	281	96	237	1,036	0	0	4	1	49.6	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 3 Cameron County Ditch 1 at Cameron Park	0.13	0.15	296	387	290	1,343	0	0	3.7	6	0.0	149	130	22	128	655	0	0	0	0	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 4 Town Resaca at West 5th Street	0.32	0.39	574	748	483	2,989	1	0	11.4	46	0.2	469	71	22	65	220	0	0	0	0	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 5 Cameron County Ditch 1 at Golf Center	1.86	2.19	697	1,437	666	3,190	2	0	44.6	221	170.8	214	399	242	390	1,038	0	0	1	0	5.2	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 6 Los Fresnos at East 10th St.	0.13	0.14	209	250	206	512	0	0	3.2	9	1.4	100	92	79	92	240	0	0	0	0	0.5	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 7 Cameron County Ditch 1 at Hwy 69E	1.12	1.36	458	1,143	430	2,428	1	0	18.9	61	107.5	152	191	215	187	883	0	0	0	0	2.1	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 9 North Main Drain and Hwy 69E	1.05	1.36	703	1,052	500	12,713	5	0	23.9	96	2.1	465	84	0	59	753	1	0	0	0	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11A Los Fresnos West Ocean Blvd	0.57	0.62	115	172	87	1,101	2	0	0.8	4	180.2	53	60	68	40	149	0	0	0	0	15.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11B Los Fresnos West Ocean Blvd	0.19	0.21	39	82	23	809	1	0	2.0	13	30.8	22	17	6	6	122	0	0	2	0	0.0	N/A	N/A
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 12 Town Resaca at Washington Park	0.10	0.12	203	224	166	1,845	1	0	3.8	18	0.9	144	48	14	35	627	1	0	0	0	0.2	N/A	N/A

				Other Benefits														
FMP ID	RFPG No.	RFPG Name	FMP Name	Pre-Project Level of Service	Post-Project Level of Service	Cost per Structure Removed	Percent Nature-Based Solution (by cost)	Negative Impact Caused by Project?	Negative Impact Mitigation	Water Supply Benefits	Other Benefits	Residual Risks	Issues	Recommended?	Reason for recommendation	Social Vulnerability Index (SVI)	Traffic Count for Low Water Crossings	Benefit Cost Ratio
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1A North Main Drain and Imapala Ditch	< 10-Year	< 10-Year	$358,600	0%	No	N/A	No	N/A	Increase in flood risk if Imapala Pump Station fails	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.92	N/A	0.35
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 1B North Main Drain and Four Corners	< 10-Year	< 10-Year	$401,400	0%	No	N/A	No	N/A	Pontential increase in downstream flood risk if detention pond is not maintaned and, as a result, inflow structure fails	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.94	N/A	0.05
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 2 Cameron County Ditch 1 at Confluence	10-Year	50-Year	$353,300	0%	No	N/A	No	N/A	N/A	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.90	N/A	0.25
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 3 Cameron County Ditch 1 at Cameron Park	<10-Year	25-Year	$12,070	0%	No	N/A	No	N/A	N/A	ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.93	N/A	3.47
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 4 Town Resaca at West 5th Street	<10-Year	10year	$480,000	0%	No	Detention	No	N/A	N/A	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.96	N/A	0.74
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 5 Cameron County Ditch 1 at Golf Center	10-Year	10-Year	$114,000	0%	No	N/A	No	N/A	Pontential of increase in downstream flood risk if detention pond inflow structures is not regularly maintained	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Coordination With Properties Along Golf Course, Temporary Road Closures	N/A	N/A	0.64	N/A	0.22
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 6 Los Fresnos at East 10th St.	<10-Year	10-Year	$48,000	0%	No	Detention	No	N/A	Pontential of increase in downstream flood risk if detention pond inflow structure is not regularly maintained and, as a result, fails	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.81	N/A	1.10
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 7 Cameron County Ditch 1 at Hwy 69E	25-Year	100-Year	$40,300	0%	No	N/A	No	N/A	N/A	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT	N/A	N/A	0.65	N/A	0.63
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 9 North Main Drain and Hwy 69E	10-Year	10-Year	$386,500	0%	No	N/A	No	N/A	N/A	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.92	N/A	0.19
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11A Los Fresnos West Ocean Blvd	10-Year	25-Year	$488,800	0%	No	Detention	No	N/A	Pontential of increase in downstream flood risk if detention pond inflow structure is not regularly maintained and, as a result, fails	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT, open excavate a state highway to install culverts	N/A	N/A	0.85	N/A	0.09
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 11B Los Fresnos West Ocean Blvd	10-Year	50-Year	$997,900	0%	No	Detention	No	N/A	Pontential of increase in downstream flood risk if detention pond inflow structure is not regularly maintained and, as a result, fails	Environmental Permitting, ROW Acquisition Required, Potential Utility Relocation, Temporary Road Closures, Permitting with TxDOT, open excavate a state highway to install culverts	N/A	N/A	0.83	N/A	0.14
	15	Lower Rio Grande	Port Isabel to Brownsville FIF - Project 12 Town Resaca at Washington Park	<10-Year	25-Year	$180,900	0%	No	N/A	No	N/A	N/A	Potential Utility Relocation, Temporary Road Closures	N/A	N/A	0.98	N/A	0.59

Appendix I - Supporting Data

1. GIS Data
2. As-builts Drawings
3. Site Visit Data
4. Survey Data
5. Previous Studies
6. Models
7. Calibration Data
8. Benefit Analysis Data