Espey Consultants, Inc.

Engineering Report

CITY OF LA FERIA
Flood Protection Plan



City of La Feria

July 5, 2011

Project No. 9068

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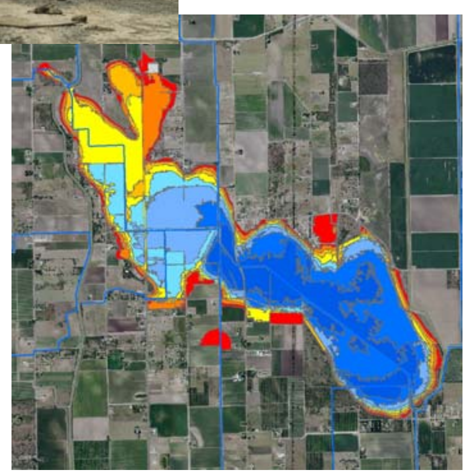

City of La Feria

July 5, 2011

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City of La Feria Flood Protection Plan
Engineering Report

Prepared for:

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EC Project No. 09038.00

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EXECUTIVE SUMMARY

SCOPE OF THE PROJECT

This document is a Flood Protection Plan for the City of La Feria which is located in west Cameron County. The study area includes unincorporated areas surrounding La Feria and a portion of the Town of Santa Rosa. In response to local concern over drainage problems and the need to approach the issues on a comprehensive, system-wide basis, La Feria and its community partners applied for and received funding assistance through the Flood Protection Planning Program of the Texas Water Development Board. The project was awarded funding in April of 2009 and contracts were executed in October of 2009.

The purpose of the project was to develop a comprehensive set of models for the City's main drainage-way system, to be utilized in developing flood protection alternatives, both structural and non-structural. A set of policy goals and a corresponding implementation action plan were developed on the basis of the hydrologic and hydraulic models, and Advisory Committee and citizen input.

QUANTIFYING THE FLOODING ISSUES

This study included the development of hydrologic models (HEC-HMS) to estimate peak discharges at various points of interest throughout the City's ditch network. These peak discharges were determined for several different scenarios representing the flood risk for both present and future conditions. In terms of annual chance exceedance, the following frequency events were modeled: 1%, 2%, 4%, 10%, 20%, and 50% for existing and the 1% ultimate development conditions. Given the extremely flat topography of Cameron County, specific methods of predicting runoff were used (Kerby-Kirpich timing equations and the application of a non-standard hydrograph PRF) and refined through a calibration to observed rainfall and high water mark data within an adjacent drainage district following the May 25, 2007 rainfall event.

To determine the flooding extents and depths in the community, a series of hydraulic models were developed using HEC-RAS to reflect the risk faced by the community in each of the modeled scenarios. Floodplain maps can be found in Appendix A.

FLOOD PROBLEM AREAS

The City of La Feria encompasses approximately 3.1 square miles. The study area for this FPP was 23.8 square miles and consists of the City of La Feria and areas north to Tio Cano Lake. The study area was divided into 18 subbasins to model the three sub-watersheds: AN-47, AN-49, and TC-01. These drains are described below:

AN-47 – This channel is the primary means of drainage for the City of La Feria. It starts on the west side of the City of La Feria and runs north across Business 83 and then U.S. Expressway 83 and continues north and east crossing F.M. 506 and then coming south to once again cross U.S. Expressway 83 and Business 83, extending from that point south and east until it intercepts the Arroyo Colorado. This channel drains all of the City of La Feria with the exception of a small portion at the southwest corner of the City which is drained through AN-49.

AN-49 – This channel is a small drain along the west limits of the La Feria Irrigation District reservoir, southwest of the City of La Feria and extends north to pick up some of the water from Business 83 in the west quadrant of the City of La Feria.

TC-01 – This is the Tio Cano Lake drainage area, which is not as much drain as a storm water storage area. The flood elevation debris line from Hurricane Beulah (1967) was approximately at an elevation of 46 ft. MSL and the bottom of the lake is shown on the 1932 USGS topographic maps as elevation 39 ft. MSL. This is consistent with the peak water surface elevation after Hurricane Dolly (2008) and the effective FEMA 100-Year flood elevation (dated 6/15/79). The lake has no natural outlet and water must be removed by pumping.

FLOOD PROTECTION GOALS

To approach the complex issues of flooding in the City's service area comprehensively, a set of goals were established in the planning process to guide the City's decision making. These goals were developed in consultation with the Advisory Committee and were used to prioritize flood problem areas and to guide alternative development. These goals are as follows:

Goal 1: Proactively address flood problem areas with targeted improvements that consider the entire drainage area for each of the studied drains.
Goal 2: Provide an outlet for areas with limited conveyance.
Goal 3: Ensure that new development does not adversely affect property downstream.
Goal 4: Reduce local flooding by ensuring positive drainage to the existing ditch network.
Goal 5: Protect and enhance available storage in the system. Valley storage in the ditch network is a critical resource from a hydraulic perspective.
Goal 6: Actively inform the community of the risk of flooding.
Goal 7: Update and refine the Flood Protection Plan on a bi-annual basis.

ALTERNATIVE ANALYSIS

This section provides a description and summary of estimated benefits and costs of the proposed alternatives to mitigate drainage and flooding issues in and around the City of La Feria.

Alternative 1: AN-47 Improvements

The primary component of this alternative is to remove the constriction at the Evans Canal crossing. The existing elevated canal crossing consists of two 54 inch reinforced concrete pipes (RCPs) and two 60 inch RCPs. There are actually two elevated irrigation canals in this location, one higher than the other. It has been proposed that a siphon would be added to take the lower canal under the AN-47 channel and the higher canal would be carried by an aerial crossing. The result would be similar to replacing these four culverts with a clear-span bridge with the low-chord higher than the 100-Year water surface elevation. This results in a huge increase in channel capacity in this location. This alternative also includes a series of drop structures downstream of Evans Canal, and improvements to the crossings at White Ranch Road and Beddoes Road. There are two tributaries to AN-47 that drain central La Feria, south of Business 83. AN-47 Tributary 1 was modeled as part of this study, and the proposed improvements to Beddoes Road and Kansas City Road on this tributary are also included in the proposed conditions analysis.

Alternative 2: AN-49 Improvements

The IBWC levee extends along the Arroyo Colorado from the confluence with the North Floodway to just upstream of the outlet of AN-47. AN-49 must drain through this levee and the current culvert located here is a single 24 inch RCP. This structure is also gated so it can be closed by the IBWC to prevent backflow if the Arroyo Colorado were in flood stage. This structure is proposed to be replaced with an 8 foot by 8 foot concrete box culvert that will continue to be gated. Similar to the situation on AN-47, this large increase in capacity results in a significant reduction in valley storage and an associated increase in total peak discharge. The peak flow rate for the 100-Year event is almost nine times the existing flow rate, but the increase in channel can generally accommodate this increase.

Alternative 3: Tio Cano Lake Improvements

Three different configurations were examined for the Tio Cano Lake area. All alternatives here include the construction of an outlet channel to the Arroyo Colorado. The alternatives examined looked a two different outlet channel alignments and possibilities for providing relief to other areas adjacent to Tio Cano Lake and the proposed outlet channel. Alternate C is a combined alternative that relocates the Tio Cano outlet channel to tie into AN-47 north of U.S. Expressway 83 and the combined flows then route through the improved AN-47 to the Arroyo Colorado. The Tio Cano area provides a large storage volume for flood flows and the intent of any improvement in this area is to maintain or even maximize available flood storage. This is not a suitable area to encourage residential development, so there is no intent in dramatically reducing existing flood elevations at Tio Cano Lake. Any alternative here also includes acquisition of flood prone properties. The descriptions below center on the hydrologic and hydraulic components of the alternatives.

ALTERNATIVE RANKING & IMPLEMENTATION

A HAZUS analysis was performed as well as a detailed FEMA BCA (Benefit Cost Analysis) for each of the alternatives and the combined alternative. The BCA shows that this improvement is cost justified with a benefit to cost ratio of approximately 1.10. It is recommended that these improvements be implemented as soon as funding is available.

1.0 INTRODUCTION

The City of La Feria encompasses approximately 3.1 square miles within Cameron County. The City is not within an established Drainage District and is generally responsible for construction and maintenance of the drainage facilities within its limits. The La Feria Irrigation District is responsible for the other major drainage ditches within the study area. The study area for this report covers roughly 18 square miles, generally west of the Adams Gardens Canal, east of the Willacy Main Canal, north of the Arroyo Colorado and south of the Town of Santa Rosa. The study area includes the drainage areas for the two main drainage ditches serving the City of La Feria and the area tributary to Tio Cano Lake, to the north of La Feria.

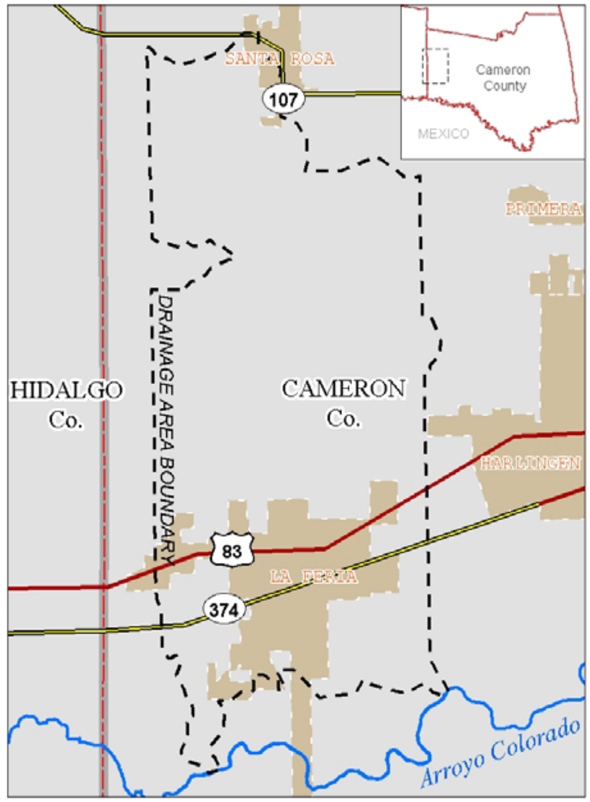

Figure 1. Location Map

The communities in the Lower Rio Grande Valley have undergone significant change and growth within the last thirty years, transforming small, agricultural communities with acres of undeveloped land into suburban communities within one of the fastest growing metropolitan regions in the State of Texas with approximately a 20% increase in population since 2000 (Source: Texas State Data Center, 2000-2009 population data and estimates). This economic growth translates into increased development pressures on remaining developable land within the area. Older residential areas were often developed without consideration for upstream hydrology or downstream impacts, and before the adoption of the National Flood Insurance Program (NFIP). Recent development has caused an increase in the magnitude and frequency of flood events, and projected growth will continue to exacerbate the problem. As land use changes with development, more impervious cover will increase the amount of rainfall runoff, leading to increased peak discharges. Previous efforts in planning and capital improvements have been undertaken mostly in response to specific problem areas, rather than as a comprehensive watershed flood protection plan.

The City of La Feria Flood Protection Plan (FPP) is made possible through the Texas Water Development Board's (TWDB) Research and Planning Fund Program which provides Flood Protection Planning grants to political subdivisions for the study and analysis of flooding hazards and development of flood mitigation measures in an effort for regional planning. Recipients of this grant are members of the NFIP and provide local matching funds. The goals set forth in this document will be combined with the goals set forth in the Arroyo Colorado Watershed Protection Plan (WPP) which was adopted in 2007. The numerical goals within the WPP for the period 2007-2017 are to reduce biochemical oxygen demand (7%), sediment (19%), total nitrogen (11%), and total phosphorous (9%).

1.1 OVERVIEW OF FLOODING PROBLEM

Cameron County is located in the Arroyo Colorado watershed. There are two major natural waterways in Cameron County, the Rio Grande, which acts as the county's southern boundary, and the Arroyo Colorado, which flows northeasterly across the county and south of La Feria. In 1935, the Rio Grande floodway, a system of dams, levees, and channels, was completed to reduce the extent of flooding from the Rio Grande. This system, operated by the International Boundary and Water Commission (IBWC), partially diverts flood flows from the Rio Grande into the Main Floodway. West of Mercedes, a divisor dike splits the Main Floodway flow between the Arroyo Colorado and the North Floodway. The divisor dike controls flow into the North Floodway and the Arroyo Colorado. Flooding from the Arroyo Colorado is not considered a risk to the City of La Feria and the study area. The IBWC operates levees along the Arroyo Colorado and these levees protect the south-western portion of the study area from inundation during high flow events in the Arroyo. However, the IBWC also is required to close the gates on any outlet structures during high flow events if it appears that water may begin to exit the floodway through that structure. This can and has resulted in long term flooding in La Feria.

Cameron County, located along the Gulf Coast, can be subjected to intense rainfalls from thunderstorms and tropical depressions. The climate is sub-tropical and semi-arid, with an average annual rainfall of 26 inches. These intense rains provide a significant potential for flooding. Slowly permeable loamy and clay soils are prevalent in this county, and limited grade provides poor drainage. Table 1 lists some historical rainfall events in Cameron County.

Table 1. Historical Rain Events

Date	Description	Max Depth (in.)	Damages
June 30, 2010	Rainfall produced by Hurricane Alex.	4-7	Extensive rainfall and wind, including several tornadoes. Rio Grande flooding from Mexico engaged the floodway.
July 23, 2008	Rainfall produced by Hurricane Dolly.	10-16	Extensive flooding and wind damage in excess of $1.05 billion
May 25, 2007	Excessive rain and flash flooding; 9-12 inches of rainfall within 24 hours.	12	Unknown
April 5-6, 1991	Extensive rainfall over Harlingen, Palm Valley, Combes, Primera, La Feria and San Benito. Most of rain fell within 6 hours.	17	In excess of $12.5 million in damages, including $3-5 million in public facilities and thousands of homes and cars.
September 16-18, 1988	Rainfall produced by Hurricane Gilbert	6.4	Minor damage reported in Texas: beach erosion and tornados; 327 deaths, mostly in Mexico; Total damage estimated at $5.5 billion
February 6, 1987	Torrential rains of 6-7 in. fell during a 2-hour period in parts of Brownsville in Cameron County.	7	Unknown
September 16-19, 1984	Heavy rains, some exceeding 20 in., drenched the lower Rio Grande Valley.	20	Worst flooding for Cameron County since Hurricane Beulah; approximately 50 percent of the eastern Cameron County flooded
February 18-21, 1982	Storms dumped 6 in of rain in less than 3 hours at Harlingen	7.42	$250,000 damage in Cameron County
September 15-25, 1967	Rainfall produced by Hurricane Beulah caused floods of record-breaking magnitude on many streams southern Texas and northeastern Mexico.	34	44 deaths total, 15 deaths in Texas: Estimated $145 million

Source: USGS, Major and Catastrophic Storms and Floods in Texas
(http://pubs.usgs.gov/of/2003/ofr03-193/cd_files/USGS_Storms/2001to1975.htm)

The analysis in the La Feria FPP is concerned with the hydraulic capacity of the main channels of the drainage ditch systems. This study does not analyze localized flooding issues.

1.2 PROJECT SCOPE

The purpose of this project is to identify flooding issues in the City of La Feria and Tio Cano Lake drainage systems and provide mitigation alternatives. The following tasks were performed in this study:

- Conduct an initial kick-off meeting with an appointed Advisory Committee

The Advisory Committee, consisting of representatives of the participating entities and city staff, met on November 10, 2009. The project schedule and responsibilities of participants were set at that time. The advisory committee meeting was held in the City of La Feria Town Hall at 12:00 PM. The second Advisory Committee meeting was held on January 21, 2010 at 12:00 PM and was followed by the first public meeting at 6:00 PM to explain the purpose of the study to the public.

The following entities participated in the study and many were represented at the Advisory Committee meetings:

City of La Feria
Cameron County
La Feria Independent School District
Harlingen Irrigation District (Cameron County No. 1)
Adams Gardens Irrigation District
La Feria Irrigation District (Cameron County No. 3)
City of Santa Rosa
Santa Rosa ISD
Cameron County Drainage District No. 5
Santa Maria ISD
City of Harlingen
International Boundary and Water Commission
Texas Water Development Board
Texas Department of Transportation
Cameron County Appraisal District
US Fish and Wildlife Service
Espey Consultants, Inc.
Sigler, Winston, Greenwood & Associates
Brown, Leal & Associates

- Data collection and review of flood and drainage problem areas

Flood-prone areas were identified based on citizen input and records. Available Geographic Information System (GIS) datasets, current and future land use maps, soil maps, cultural resource maps and materials, environmental resource maps and materials, Light Detection and Ranging (LIDAR) topography, digital orthophotography, cross-section data, existing Federal Emergency Management Agency (FEMA) information, and previous drainage, engineering, and geotechnical studies were assembled by the City and Espey Consultants, Inc. (EC) for base map creation. Information on previously identified critical environmental features was also obtained. The gathered information was reviewed. Flood prone areas were classified according to primary drainage system problems and secondary drainage system problems. The specific recommended problem areas for study were identified. Environmental constraints were researched and reviewed to identify possible critical environmental features that may need to be considered during alternative development.

- Collect field survey

A list of required field survey data was compiled identifying critical bridges and culverts and channel cross-sections. Twenty-five culverts and bridges and cross sections upstream and downstream of every structure were surveyed for this study.

- Develop hydrologic models

Hydrology is typically thought of as the science that encompasses the movement, occurrence, distribution, and properties of water. The La Feria FPP study area was divided into 18 subbasins to model the three sub-watersheds: AN-47, AN-49 and TC-01. Existing GIS coverages of the City of La Feria and Cameron County was analyzed in ArcGIS 9.3 to develop hydrologic parameters. The 1%, 2%, 4%, 10%, 20%, and 50% for existing conditions and the 1% ultimate development conditions peak flow rates were developed with HEC-HMS 3.4.

- Develop hydraulic model

Hydraulic model development occurs once hydrologic model development is completed. Hydraulics is an applied science that studies the mechanical and behavioral properties of water within closed conduit systems (pipes, pumps, tunnels, etc.) and free surface systems (rivers, canals, creeks, lakes, seas, etc.). HEC-RAS 4.1.0 was used to model the primary drainage ditches in and around La Feria. The HEC-RAS models were improved with collected field survey data and information from design plans. Hydraulic analyses were performed to evaluate the existing conditions 1%, 2%, 4%, 10%, 20%, and 50% existing conditions and the 1% ultimate development conditions annual chance storm. Floodplain maps and flooding depth grids for the existing conditions 1% event was developed.

- Review flood protection criteria and develop, analyze, and prioritize mitigation alternatives

Based on a review of existing design flood criteria and determination of acceptable level of flood protection with focus on problem areas, structural and non-structural flood control measures were developed. A cost-benefit analysis was performed for each alternative. Results of the Benefit-Cost Analysis were discussed and alternatives prioritized at an advisory committee meeting on October 14, 2010.

- Present initial findings at second Public Meeting

Based on review of the gathered information and initial modeling efforts, a preliminary summary of methodology and modeling approach was prepared and presented at the public meeting held on January 21, 2010. Results of the preliminary hydrology and hydraulic results were presented, as well as the next steps to be taken toward completing the floodplain protection plan.

- Develop plan for implementation and phasing

A plan with recommendations for the implementation and phasing of the improvements was developed. The implementation plan identifies potential funding sources for the improvements and coordinates with the City of La Feria current Capital Improvements Plan.

- Prepare final flood protection plan

A final plan was prepared and presented at a final public meeting on October 14, 2010 at 6:00 PM following the sixth Advisory Committee Meeting that same day at 12:00 PM. This document and attachments represent the final deliverables. The deliverable includes maps, technical analyses and supporting documentation, and the implementation and phasing plan.

The study provided in this FPP does not duplicate the FEMA re-study. FEMA, under the Map Modernization program, initially committed nearly $2M to update floodplain maps in Cameron County in FY2006. The FEMA re-study is part of a nation-wide effort to update coastal flood risk data, particularly 17 of 18 coastal counties within Texas. The FEMA re-study incorporates new topographic data, storm frequency data, and new storm surge modeling techniques. Currently the FEMA re-study is in the process of finalizing the storm surge modeling analysis. However, while the re-study effort will map portions of the Arroyo Colorado, there are no segments within La Feria which are included in the FEMA re-study. Thus, the La Feria FPP study complements the FEMA work. Furthermore, the La Feria FPP provides better detail than the limited detail studies proposed by FEMA in this part of Cameron County. For example, a more detailed and accurate rainfall-runoff model (HEC-HMS) was developed, while the FEMA re-study proposes to only use adjusted regression equations.

1.3 PREVIOUS FLOOD STUDIES

Several studies have been completed in the Cameron County area. These studies include Flood Insurance Studies (FIS) performed by FEMA and a Feasibility Study for Cameron County performed by the United States Army Corps of Engineers (USACE). A more complete list of existing area studies follows:

Espey Consultants 2010 Cameron County Drainage District #3 Flood Protection Plan

EC completed a FPP for the Cameron County Drainage District #3 (CCDD3) in 2010. CCDD3 is located in west-central Cameron County and includes the City of San Benito, and portions of the communities of Los Indios and Rio Hondo.

Civil Systems Engineering 2008 City of Harlingen Master Drainage Plan

The information presented within the Master Drainage Plan includes: detailed descriptions of the existing storm sewer and drainage ditch systems, existing flooding problem areas, hydraulic capacities of the City's drainage systems, a listing of inadequate systems, recommended improvements, associated probable costs, and CIP project priority. This study extended out into the Harlingen Extraterritorial Jurisdiction (ETJ) and included some limited data within the La Feria FPP study area.

Espey Consultants 2007 Cameron County Drainage District #5 Flood Protection Plan

EC completed a FPP for the Cameron County Drainage District #5 (CCDD5) in 2008. CCDD5 is located generally north-west of CCDD3 and includes portions of the City of Harlingen, and the Towns of Palm Valley, Primera, and Combes. The flatland hydrologic method developed in this study was used for the La Feria FPP.

FEMA FIS 1999 Unincorporated Areas of Cameron County, Texas

The study area included southeast portions of Cameron County. Three principal waterways in the county were studied including the Rio Grande, North Floodway and the Arroyo Colorado Floodway. Many of the drains and ditches studied in the La Feria FPP are included in this study; however the specific source of the shallow flooding shown on the Flood Insurance Rate Map (FIRM) is not always apparent. It should also be noted that the City of La Feria is not included in these maps. Copies of the models could not be located, and digital data was not available from FEMA.

USACE 1990 Feasibility Study of Cameron County, Texas

This study was done to determine the feasibility of Federal participation in flood control measures to reduce flood damages in Cameron County. This study analyzes the Arroyo Colorado, the North Floodway, and the Main Floodway. Several channels studied in the La Feria FPP are analyzed in detail in the 1990 Feasibility study, including AN-47 and AN-49. Copies of the models could not be located, and digital data was not available from the USACE.

FEMA FIS 1981 City of Harlingen, Texas

The study area includes the incorporated area of the City of Harlingen. The streams selected for detail study were the Arroyo Colorado and three tributaries to the Arroyo Colorado. A portion of Drain C-Left and Drain C-Right may be included in the Harlingen study, but the specific source of the shallow flooding shown on the FIRM is not always apparent. Copies of the models could not be located, and digital data was not available from FEMA.

FEMA FIS 1980 City of San Benito, Texas

The study area includes the incorporated area of the City of San Benito. This study included some of the tributaries to Main Drain A, including Drain B-1, Drain B-2 and the Railroad Drain; however the specific source of the shallow flooding shown on the FIRM is not always apparent. Copies of the models could not be located, and digital data was not available from FEMA.

1.4 LOCATION AND DESCRIPTION OF WATERSHED

The City of La Feria encompasses approximately 3.1 square miles. The study area for this FPP was 23.8 square miles and consists of the City of La Feria and areas north of La Feria tributary to Tio Cano Lake. The study area is bounded by the Arroyo Colorado on the south and the City of Santa Rosa on the north. The western boundary is generally contained by the Willacy Main Canal to the west and the Adams Gardens Canal to the east. The natural topography of the study area is typical of the Rio Grande Delta Plain with mildly sloping terrain. The elevations vary from approximately 55 ft in the southwest corner of the watershed to 0 ft at the Arroyo Colorado outfall. The terrain slopes at approximately one (1) foot per mile. Generally, the watershed drains to the northeast. The primary drainage system is provided by a network of man-made channels. The system names use in this study are consistent with those used in the 1990 USACE study. The receiving channel or body of water was given a two-letter identifier and the channels were numbered in increasing order going upstream. “AN” refers to Arroyo Colorado, North Side; and “TC” refers to Tio Cano Lake. The exact channel location and watershed limits were derived based on recent aerial photography and recent topographic data, as discussed further below. A brief description and diagram of the sub-watersheds and their respective network follows:

AN-47

This channel is the primary means of drainage for the City of La Feria. It starts on the west side of the City of La Feria and runs north across Business 83 and then U.S. Expressway 83 and continues north and east crossing F.M. 506 and then coming south to once again cross U.S. Expressway 83 and Business 83, extending from that point south and east until it intercepts the Arroyo Colorado. This channel drains all of the City of La Feria with the exception of a small portion at the southwest corner of the City which is drained through AN-49.

AN-49

This channel is a small drain along the west limits of the La Feria Irrigation District reservoir, southwest of the City of La Feria and extends north to pick up some of the water from Business 83 in the west quadrant of the City of La Feria.

TC-01

This is the Tio Cano Lake drainage area, which is not as much drain as a storm water storage area. The flood elevation debris line from Hurricane Beulah was approximately at an elevation of 46 ft. above Mean Sea Level (MSL) and the bottom of the lake is shown on the 1932 USGS topographic maps as elevation 39 ft.

MSL. This is consistent with the peak water surface elevation after Hurricane Dolly and the effective FEMA 100-Year flood elevation. The lake has no natural outlet and water must be removed by pumping.

Figure 2 illustrates the location of the La Feria FPP study area and the three sub-watersheds and respective ditch networks. The secondary drainage system includes minor ditches, storm sewer systems, and roadway gutters.

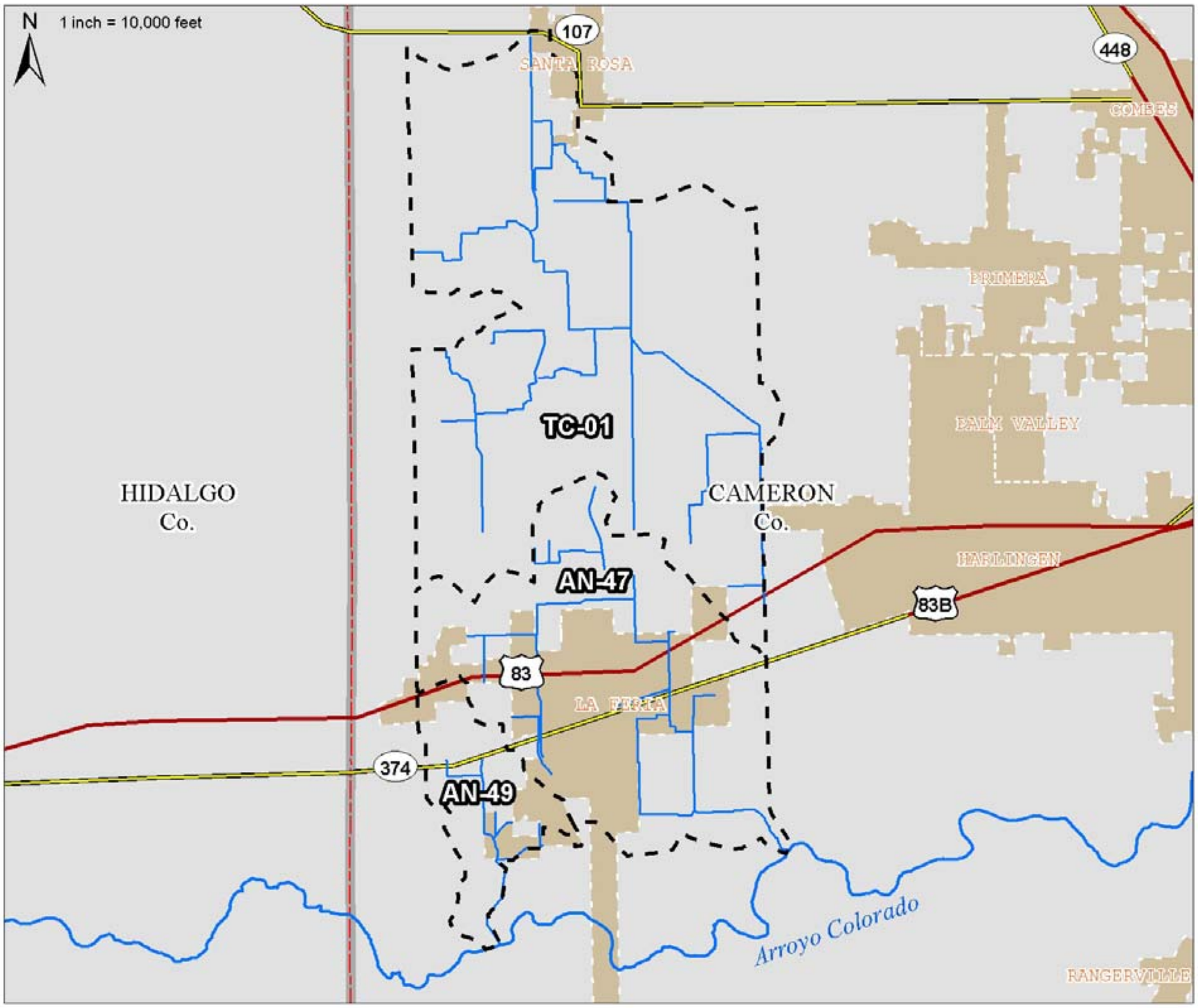

Figure 2. City of La Feria FPP Study Area

2.0 HYDROLOGIC ANALYSIS

The scope of this project includes a hydrologic study of the majority of the La Feria ETJ. The hydrologic analysis includes the evaluation of the existing conditions 50%, 20%, 10%, 4%, 2% and 1% (2-, 5-, 10-, 25-, 50 and 100-year) annual chance storm events. The hydrologic analysis also evaluates the ultimate conditions 1% annual chance event.

Version 3.4 of the HEC-HMS computer program developed by the Hydrologic Engineering Center of the USACE was used in this analysis to estimate peak flow rates along each reach. Peak flow rates are computed along the watercourses for the existing 50%, 20%, 10%, 4%, 2%, 1%, and ultimate 1% annual chance storm events. This hydrology section describes the input parameters used in this analysis, the calibration efforts, the correlation with frequency analyses, and the computed peak flow rates to be used in the floodplain analysis.

2.1 DRAINAGE AREA DELINEATION

The La Feria FPP study area was divided into 18 subbasins using United States Geological Survey (USGS) topographical survey data, aerial photography, IBWC LIDAR data, field visits, and the 1990 USACE Feasibility Report for Cameron County. The subbasins drain into one of the three main subwatersheds as described in Section 1.4. The AN-47 and AN-49 drains ultimately drain to the Arroyo Colorado and the TC-01 area drains to Tio Cano Lake. The drainage area map is included in Appendix A as Exhibit 1.

2.2 PRECIPITATION

The precipitation depths are taken from Figure 5.13 of Appendix A.5 in the Cameron County, Subdivision Rules and Regulations (May 2005). The precipitation depths for various durations for the studied events are shown in Table 2.

Table 2. Rainfall Frequency Data

Time	Time (min)	2-Year Storm Depth (in)	5-Year Storm Depth (in)	10-Year Storm Depth (in)	25-Year Storm Depth (in)	50-Year Storm Depth (in)	100-Year Storm Depth (in)
5 minutes	5	0.51	0.59	0.66	0.75	0.82	0.90
15 minutes	15	1.15	1.33	1.47	1.67	1.84	2.00
30 minutes	30	1.70	2.25	2.58	2.98	3.32	3.70
1 hour	60	2.22	2.82	3.25	3.77	4.18	4.70
2 hours	120	2.68	3.45	4.20	4.70	5.20	5.90
3 hours	180	2.90	3.80	4.45	5.15	5.85	6.50
6 hours	360	3.25	4.55	5.40	6.40	7.20	8.00
12 hours	720	3.90	5.40	6.45	7.45	8.80	10.00
24 hours	1440	4.70	6.40	7.40	9.00	10.20	11.15
48 hours	2880	5.30	7.00	8.40	10.60	11.40	13.00
72 hours*	4320	5.70	7.73	9.19	11.40	12.37	14.14
96 hours	5760	6.00	8.30	9.80	12.00	13.10	15.00

* logarithmically interpolated values

2.3 INFILTRATION LOSSES

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service, SCS) has developed a rainfall runoff index called the runoff curve number (CN). The runoff curve number takes into account such factors as soil characteristics, land use/land condition, and antecedent soil moisture. This number is used to derive a generalized rainfall/runoff relationship for a given area. A description of these components and the equations for calculating runoff depth from rainfall are provided below.

The NRCS classifies soils into four hydrologic soil groups: A, B, C, and D. These groups indicate the runoff potential of a soil, ranging from a low runoff potential (group A) to a high runoff potential (group D). Digital soil data is available from the Texas Natural Resource Information System (TNRIS) post-processed from the US Department of Agriculture Soil Survey Geographic (SSURGO) database into the Texas statewide mapping system. A map of the soils found in the La Feria study area is included as Exhibit 2 in Appendix A.

The NRCS provides runoff curve numbers for three Antecedent Moisture Conditions (AMC): I, II and III. AMC I represents dry soil conditions and AMC III represents saturated soil conditions. AMC I is used for areas that have the lowest runoff potential. In general, AMC II is considered to be the typical soil condition; however, studies have indicated that AMC II is not appropriate in all parts of Texas. Investigations have shown that the average condition ranges from AMC I in west Texas to between AMC II and III for east Texas. Runoff curve numbers vary from 0 to 100, with the smaller values representing soils with lower runoff potential and the larger values representing soils with higher runoff potential. This study assumes an AMC I to represent average condition as shown in Figure 3. This assumption was verified in a comprehensive calibration effort done for the CCDD5 FPP by EC in 2008.

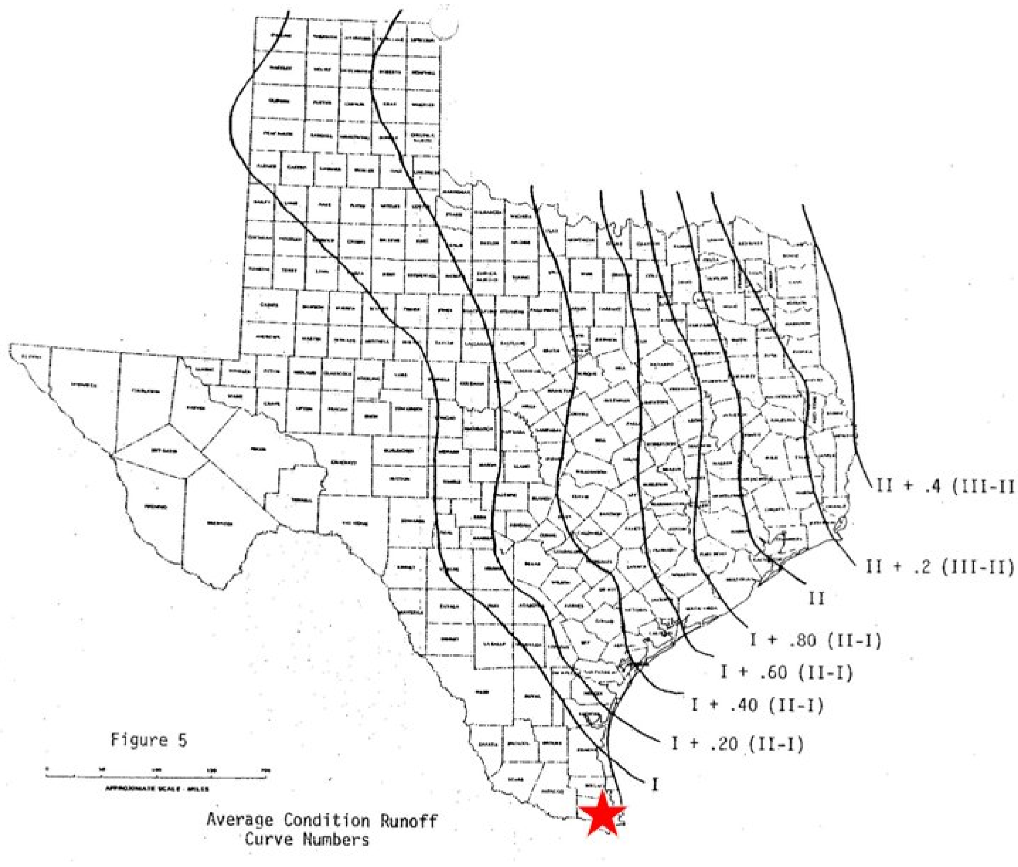

Figure 3: Antecedent Moisture Condition Determination
Source: SCS Technical Note *Estimating Runoff for Conservation Practices*

CN values were evaluated independent of impervious cover (i.e., these curve numbers reflect fair conditions, open spaces, brush cover) for this analysis. Table 3 lists the CN values used in La Feria.

Table 3. NRCS Curve Number Table

Curve Numbers (CN)			
Soil Groups	AMC I	AMC II	AMC III
A	18	35	55
B	35	56	75
C	49	70	84
D	58	77	89

Assumption: Brush-weed-grass mixture; Fair
Source: NRCS, TR-55

A composite CN is computed based on area weighting of each hydrologic soil group within each subbasin. Impervious cover values are entered separately from CN values into the HEC-HMS model. Calculations of the weighted curve number values for each subbasin are included in Appendix B. Weighted CN values under AMC I conditions were used for analysis.

HEC-HMS computes 100 percent runoff from impervious areas, while runoff from pervious areas is computed using the selected CN value and the following equations:

$$Q = (P - 0.2 \times S)^2 / (P + 0.8 \times S) \qquad \text{Equation 1}$$

And

$$CN = 1000 / (10 + S) \qquad \text{Equation 2}$$

Where:

Q	=	depth of runoff (in),
P	=	depth of precipitation (in),
S	=	potential maximum retention after runoff begins (in), and
CN	=	runoff curve number.

2.3.1 Existing Impervious Cover Determination

Impervious cover was determined using an existing land use map created by Sigler, Winston, Greenwood & Associates (SWGA) for the City of La Feria in 2007. This map was compared with and modified based on City zoning and 2009 aerial photography. Land uses in other areas of the study area were determined using City of Santa Rosa zoning and aerial photography. This data was merged with Cameron County Appraisal District Data for better correlation with current property boundaries and to the location of Transportation right-of-way. Typically undeveloped, open land uses such as parks and agricultural areas were assumed to contain some impervious cover to represent access areas, minor facilities and compacted earth. Fifteen major land uses were identified and assigned an impervious cover percentage, as shown in Table 4. The existing land use map is included in Appendix A as Exhibit 3.

Table 4. **Impervious Cover Assumptions**

Code	Description	Percent Impervious
Ag	Agricultural	5%
Comm	Commercial	80%
Drain	Drainage	0%
Duplex	Duplex - Residential	60%
Ind	Industrial	80%
LLR	Large Lot - Residential	10%
MF	Multi-Family - Residential	80%
MH	Mobile Home - Residential	70%
Parks	Parks	10%
Resev	Reservoir	100%
ROW	Transportation Right-of-Way	80%
RV	RV Park - Residential	90%
School	School	60%
SFR	Single Family - Residential	40%
Vacant	Vacant Areas - Residential	5%

2.3.2 Ultimate Impervious Cover Determination

The impervious cover values for each subbasin of the La Feria FPP were modified to reflect the projected ultimate land uses. In 2007, through the recommendation of City of La Feria staff, the Comprehensive Planning Steering Committee, and La Feria's planning consultant, a projected 2025 land use map for the City of La Feria was adopted as part of the Comprehensive Plan. It appears unlikely that the extensive development forecast in this map would be realized by the year 2025 but this appears to represent a reasonable ultimate condition. It is also likely that the City would require mitigation to reduce the impact of future development on peak flow rates. The ultimate conditions analysis does not include any potential mitigation and represents a worst-case scenario.

The ultimate land use map is included in Appendix A as Exhibit 4. A summary comparing existing and ultimate conditions impervious cover percentages is included in Appendix C.

2.4 UNIT HYDROGRAPH

A rainfall/runoff transformation is required to convert rainfall excess (total rainfall minus infiltration losses) into runoff from a particular subarea. Runoff hydrographs were generated for each defined subarea within the studied watershed. The unit hydrograph method represents a hydrograph for one unit [inch] of direct runoff and is a nationally accepted, standard engineering practice. Hydrographs were calculated using the user specified NRCS unit hydrograph and modified unit hydrograph methods. The following sections present each method. Further description of the unit hydrograph method with respect to calibration is described in Section 4.0.

2.4.1 User Specified Unit Hydrograph

The user specified unit hydrograph is a dimensionless unit hydrograph that incorporates a calculated peak discharge and time to peak. The dimensionless unit hydrograph developed by the NRCS, shown in Figure 4, was developed by Victor Mockus and presented in *National Engineering Handbook, Section 4, Hydrology*. The dimensionless unit hydrograph has its ordinate values expressed as a dimensionless ratio of discharge at time (t) to peak discharge (q/Qp), and its abscissa values as a dimensionless ratio time (t) and time to peak (Tp).

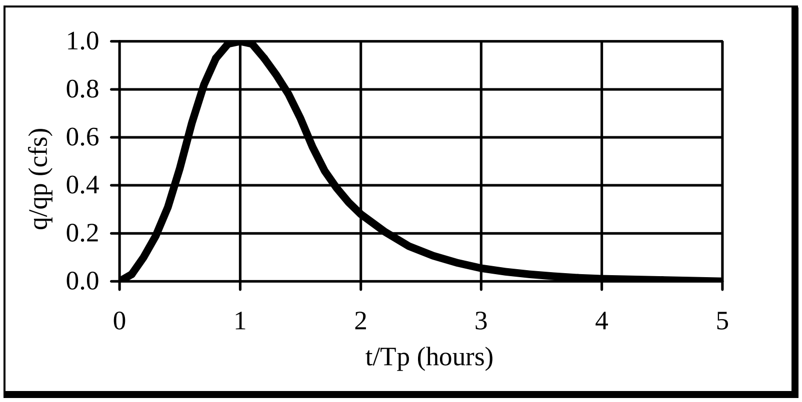

Figure 4. NRCS Standard Unit Graph

The user specified unit hydrograph requires two input parameters, lag time (T_{LAG}) and drainage area (A). T_{LAG} is the time between the center of mass of rainfall excess and the peak of the unit hydrograph (NRCS 1985). Lag is assume to be 60% of the time of concentration (Tc). Tc is discussed in more detail below in Section 2.5.

The time to peak is computed using the following equation:

$$T_P = \Delta t/2 + T_{LAG} \qquad \text{Equation 3}$$

Where:

T_P	=	time to peak of the unit graph (hours),
Δt	=	computation interval or duration of unit excess (hours), and
T_{LAG}	=	watershed lag (hours).

The peak flow rate of the standard NRCS unit graph is computed using the following equation:

$$Q_p = PRF*A/T_P \qquad \text{Equation 4}$$

Where:

Q_p	=	peak flow rate of the unit graph (cubic feet per second [cfs] / inch) and
A	=	watershed area (square miles).

PRF = peak rate factor (dimensionless)

Standard engineering practice uses a peak rate factor (PRF) of 484.

2.4.2 Modified NRCS Unit Hydrograph

Research in the paper *Revisit of NRCS Unit Hydrograph Procedures* (ASCE, 2005) examines the role of the PRF in the NRCS unit hydrograph method. This paper notes that the PRF value is correlated with the watershed's basin shape factor, which is defined as the drainage area divided by the square of the main channel length. Variability in shape factor implies variability in peak factor rate, but use of PFR value other than 484 will not maintain a unit hydrograph. This contradiction led researchers to examine an alternate method to develop a regional unit hydrograph based on a Gamma function. Research, presented in the Texas Department of Transportation (TxDOT) 2005 paper *Time-Parameter Estimation for Applicable Texas Watersheds*, was based on data from 1600 rainfall-runoff data sets for 90 USGS gage stations in central Texas watersheds.

The paper provided a two-parameter fitted Gamma based unit hydrograph in which the PRF reflects the watershed's topography. PRF values may vary from 600 for steep terrain to 100 for very flat terrain. After selection of the peak factor rate, the parameters phi (ϕ) and alpha (α) are calculated based on the following equations:

$$\phi(\alpha) = (T_p Q_p)/(645.33A) = PRF/645.33 \qquad \text{Equation 5}$$

and

$$\alpha = 5.53\,\phi(\alpha)^{1.75} + 0.04 \qquad \text{for } 0.01 < \phi(\alpha) < 0.35 \qquad \text{Equation 6}$$

$$\alpha = 6.29\,\phi(\alpha)^{1.998} + 0.157 \qquad \text{for } \phi(\alpha) > 0.35$$

Table 5 lists a description of terrain and their corresponding PRF with values of phi and alpha based on the Equations 5 and 6.

Table 5. PRF Values for Texas Watersheds (Gamma-Based Unit Hydrograph)

PRF	Description	Φ	α
100	Very Flat	0.15	0.26
200		0.31	0.80
300	Flat	0.46	1.52
370	Texas Mean PRF	0.57	2.23
400		0.62	2.58
484	Standard NRCS PRF	0.75	3.70
500		0.77	3.94
600	Steep, Mountain Terrain	0.93	5.60

Source: Fang et al, ASCE 2005

The ordinates of the gamma hydrograph are discharge (Q) and time (t). The discharge at any given time is computed using the following equation:

$$Q = Q_p * \left(\frac{t}{T_P}\right)^{\alpha * \exp\left(\frac{1-t}{Tp} * \alpha\right)} \qquad \text{Equation 7}$$

Where:

Q	=	flow rate (cfs) at time t
T_P	=	time to peak of the unit graph (hours),
Q_p	=	peak flow rate of the unit graph (cubic feet per second [cfs] / inch)
t	=	time (hours)
α	=	parameter based on chosen PRF

Figure 5 compares two hydrographs with the same drainage area and time of concentration but different PRFs. The hydrograph with the PRF of 200 has a lower peak discharge and less sharp decline of the receding limb than that with a standard PRF of 484. The flat terrain introduces unique challenges related to hydrograph timing, which is better accounted for with a PRF of 200 based upon a model validation exercise performed for the CCDD5 FPP (Espey Consultants, Inc., 2007). This is further discussed below in Section 4.0. The volume of both hydrographs is the same.

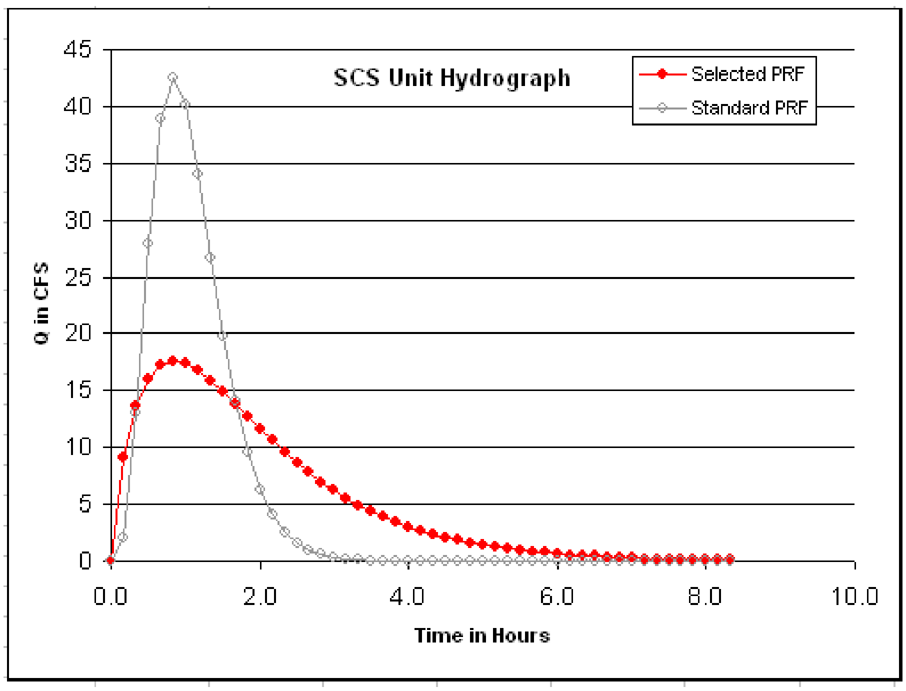

Figure 5. SCS Unit Hydrograph, Standard PRF = 484 v. Selected PRF =200

2.5 TIME OF CONCENTRATION

The time of concentration (Tc) is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed (NRCS 1985). Typically, the Tc may be estimated by calculating and summing the travel time for each subreach defined by the flow type. The Kerby-Kirpich method is applied to calculate the Tc for this project. The Kerby-Kirpich method was chosen based on work performed by USGS and TxDOT to assess the applicability of a variety Tc methods in Texas and on model validations performed in the CCDD5 FPP (Espey Consultants, Inc. 2007). This is further discussed below in Section 4.0.

The Kerby-Kirpich method estimates the Tc by calculating and totaling the travel time of two components of flow: overland flow and channel flow. The *Time-Parameter Estimation for Applicable Texas Watersheds* (TxDOT, 2005) report supports the use of the Kerby-Kirpich method for estimating Tc for Texas watersheds. Research concluded that times of concentration estimated with the Kirpich method were less variable than estimates made with the NRCS (TR-55) travel-time method. The Kirpich method was also easier to use and repeat than the NRCS method due the smaller number of parameters. Input parameters for the Kirpich method are more consistently applied, as these parameters are available from published resources, whereas the selection of NRCS parameters relies heavily on engineering judgment. Also, research showed the time to peak estimated with the Kerby-Kirpich method is consistent with actual observed storm hydrographs. Tc calculations with the Kerby-Kirpich method are included in Appendix D.

Overland Flow

The Kerby method is applicable for calculating the overland flow time for small watersheds where overland flow is an important component of overall travel time. The flow is considered shallow in depth and flows in a swale or gutter instead of a channel, which would have greater depth.

The Kerby equation is used to compute overland flow travel time:

$$Tc = K(L*N)^{0.467} S^{-0.235} \qquad \text{Equation 8}$$

Where:

Tc	=	overland flow time of concentration (min),
K	=	units conversion coefficient, K = 0.828 for traditional units
L	=	overland flow length (ft),
N	=	dimensionless retardance coefficient
S	=	dimensionless slope of terrain conveying the overland flow

Values of the retardance coefficient range from 0.02 for pavement to 0.1 for bare and packed soil to 0.8 dense grass or forest. A retardance coefficient of 0.02 was applied to fully developed subbasins. A retardance coefficient of 0.4 was applied to subbasins that are not fully developed. A maximum length of 1,200 feet was used for overland flow.

Channelized Flow

As the depth of flow increases, the overland flow evolves into channelized flow. For this analysis, it was assumed that channel flow either involves flow in man-made drainage ditches or flow in the natural channel. The Kirpich equation was used to estimate the channel-flow component of time of concentration.

The Kirpich equation is:

$$Tc = K*L^{0.770}S^{-0.385} \qquad \text{Equation 9}$$

Where:

Tc	=	time of concentration (min),
K	=	units conversion coefficient, K = 0.0078
L	=	channel flow length (ft),
S	=	dimensionless main-channel slope

2.6 HYDROGRAPH ROUTING

Channel routing simulates the movement of a flood wave through a reach, allowing for the prediction of variation in time and space. Hydrologic routing allows runoff hydrographs from multiple subbasins to be combined and routed to a point of interest. Three types of routing methodologies were used in this study; modified Puls, Lag, and Reservoir.

2.6.1 Modified Puls

The modified Puls method is a routing technique that relates storage, outflow, and water surface slope in a river reach. In a natural river, storage is a function of outflow and a function of water surface elevation. To define a unique storage-discharge relationship, the channel is broken into several segments, or steps, with each segment treated as a level pool reservoir.

The number of routing steps is defined as the wave travel time divided by the time step (HMS computation interval). Travel time is defined as the reach length divided by average wave celerity. Wave celerity can be estimated as the slope of the discharge rating curve divided by the top width of the water surface. As a rule of thumb this value of celerity can be approximated by multiplying 1.5 times the average flow velocity for natural channels.

As the number of time steps for a routing reach increase, the flood attenuation for that reach decreases. Typically, the number of steps is selected such that the travel time through the reach is approximately equal to the time step. As a result, reaches with a low velocity have a relatively large number of steps. The approach used by Tropical Storm Allison Recovery Project (TSARP) in *Recommendation for: Routing Steps with HEC-HMS* is to consider a reach as functioning as a linear reservoir with a time step of 1, if the average velocity is less than 1.0 feet per second. This model assumes that reaches with velocities less than 0.5 feet per second are considered linear reservoirs.

The modified Puls routing method accounts for channel and overbank storage. In flat areas, such as the Texas coast, channel and overbank storage has a significant influence on watershed hydrology. The modified Puls method was used through out the watershed.

2.6.2 Lag Routing

Lag routing represents the time lag in the translation of a flood wave. Lag routing does not represent any attenuation or diffusion of the routed hydrograph, but merely delays the hydrograph in time to represent the distance traveled. Lag routing was only used within the Tio Cano Lake watershed as no HEC-RAS models were available in this area to determine a storage-discharge relationship required for modified Puls routing. Furthermore, the potential variability in water surface elevation and related location of the lake extents make it difficult to define a distinct routing reach length applicable for all events. It was assumed that storage upstream of Tio Cano Lake was not significant when compared to the storage found within the lake itself.

2.6.3 Reservoir Routing

While modified Puls routing is intended to represent a series of cascading reservoirs, there were several instances within the study area where it was felt that the modified Puls assumptions did not adequately represent available storage and attenuation. In these areas, the routing reach is represented by a reservoir element. The areas modeled as reservoirs are typically areas that drain under elevated irrigation canals via significantly under-sized culverts. These significant restrictions create a scenario more similar to a reservoir than a channel system in these areas. Modified Puls routing in these locations can underestimate total storage volume and the number of subreaches calculated in these areas can further discount potential attenuation. The elevation-storage relationship for these areas was taken from the LIDAR topographic information and the outlets were defined as rating curves derived from the HEC-RAS model. In this way the outlet hydraulics are able to incorporate the significant tailwater effects experienced in this area.

2.7 DESIGN STORM ANALYSIS

The application of a design storm in the HEC-HMS model is used to generate runoff hydrographs and estimate peak flow rates along the watercourse for various storm frequencies. There are three major components to the design storm: depth, duration, and distribution. Precipitation depths that have been selected for this impact study are included in Section 2.2. The following subsections describe the analysis and selection of storm duration and distribution.

2.7.1 Design Storm Duration

Design storm duration is a significant consideration for hydrologic modeling. The peak flow of any given event must reach the mouth of the studied basin prior to the end of the rainfall duration. A 48-hour design storm was selected for this analysis. This design storm duration exceeds the largest Tc of the drainage areas. This duration also appears consistent with the most severe historic rainfall events. A 48-hour storm would typically produce slightly higher peak flow rates than a 24-hr storm. For this study the 48-hour peak flow rates were approximately 4% greater than 24-hour values. The 48-hour storm had a better correlation with previous studies, as further discussed below in Section 4.2.

2.7.2 Design Storm Distribution

A balanced and nested distribution is assumed for this analysis due to its flexibility with regard to storm duration. The distribution is balanced in that the precipitation is centered over the duration. The distribution is nested in that the precipitation depths are applied in an alternating block format (i.e., the 15-minute depth is applied as the hyetograph peak, the 30-minute depth is applied such that the peak 15-minute block and the adjacent 15-minute block sum to be the 30-minute depth).

2.8 ULTIMATE CONDITIONS ANALYSIS

The ultimate development conditions (fully developed conditions) analysis uses the validated existing conditions basin model and the balanced and nested distribution frequency storm to determine the flow rates for the watersheds at full development. As mentioned above in Section 2.3.2, as part of the City of La Feria's Comprehensive Plan a projected 2025 land use map was adopted in 2007. It appears unlikely that the extensive development forecast in this map would be realized by the year 2025 but this appears to represent a reasonable ultimate condition. It is also likely that the City would require mitigation to reduce the impact of future development on peak flow rates. The ultimate conditions analysis does not include any potential mitigation and represents a worst-case scenario.

The Tc was adjusted to reflect shorter watershed response times if the proposed changes occur in the uplands of the watershed through the Kerby equation's retardance coefficient. The existing conditions undeveloped drainage areas use a retardance coefficient of 0.3. The retardance coefficient was lowered to 0.02 for ultimate conditions if development would be expected in the upper reaches of the subbasin. Lowering the retardance coefficient represents the increase in flow velocity associated with the construction of impervious cover, roadways and drainage networks.

This ultimate watershed conditions analysis includes flow rates for the 1% annual chance (100-year) only. These ultimate conditions flow rates are used to determine the ultimate conditions floodplain for the 1% annual chance event.

3.0 HYDRAULIC ANALYSIS

The hydraulic analysis is conducted on reaches within the two major drainage ditch networks in the City of La Feria. There are 9.0 miles of stream included with this hydraulic analysis, which computes water surface elevations for the 50%, 20%, 10%, 4%, 2%, 1%, and ultimate 1% annual chance (2-, 5-, 10-, 25-, 50-, 100-, and ultimate 100-year, respectively) storm events. The hydraulic analysis includes the delineation of the 10% and 1% annual chance floodplains. The studied drainage networks include the following:

- AN-47, and
- AN-49.

No hydraulic analysis was done for the existing conditions in the Tio Cano Lake area as there is no primary drainage ditch in this area. The 100-year floodplain limits in the Tio Cano Lake area were calculated based on the maximum water surface elevation calculated in HEC-HMS.

The hydraulic analysis performed in this study does not assume any backwater effects from the Arroyo Colorado, as peak flows of the Arroyo Colorado and the drainage networks are not expected to coincide. This assumption is consistent with the 1990 USACE Feasibility Study of Cameron County.

The USACE HEC-RAS software version 4.1.0 is used for the hydraulic analyses. All modeling is one dimensional and steady state. The sections that follow describe the development of the hydraulic models both in general terms and specifics that apply to certain reaches.

3.1 DESCRIPTION OF HYDRAULIC MODEL GENERATION

Separate HEC-RAS models were generated for two primary drain ditches: AN-47 and AN-49. The hydraulic models were generated using 2006 TWDB/IBWC LIDAR data, field-surveyed cross sections, and field-surveyed structures. Each of these networks consists of man-made channels with mostly grass bottom and grass side slopes. Stream centerlines and cross sections were created with ArcMap and imported into HEC-RAS using Geo-RAS software. All cross sections are modeled from left to right looking downstream.

All networks were modeled under a subcritical flow regime, which is consistent with FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C.3.4.4*. Downstream boundary conditions were assumed to be normal depth with a slope of 0.5 percent.

3.2 HYDRAULIC MODEL DEVELOPMENT

3.2.1 Streamlines and Cross Sections

Study streamlines and cross sections are created using ArcGIS 9.2 and LIDAR. Cross sections along the streamlines were placed to capture natural cross sections and data for hydraulically significant structures, including bridges, culverts, and roads. Maps of cross section locations for each model are included in Appendix A as Exhibits 6 through 8. An extensive field survey of important hydraulic structures was conducted to help enhance the accuracy of the hydraulic model. This data was imported into HEC-RAS software using HEC-GeoRAS tools.

3.2.2 Parameter Estimation

Hydraulic models require several estimated parameters, including the Manning's roughness coefficients for channels and overbanks, contraction and expansion coefficients, and ineffective limits.

Manning roughness coefficient, n, is a measure of the roughness of channels and overbanks. The value n varies with flow depth, alignment, amount and type of vegetation, and flow obstructions. Table 6 lists typical values for Manning's n. For all hydraulic models in the La Feria FPP use a Manning's roughness coefficient of 0.045 for channels, and 0.055 for overbanks.

Table 6. Manning Roughness coefficients for various open channel surfaces

Material	Typical Manning roughness coefficient
Concrete	0.012
Gravel bottom with sides	
concrete	0.020
mortared stone	0.023
riprap	0.033
Natural stream channels	
Clean, straight stream	0.030
Clean, winding stream	0.040
Winding with weeds and pools	0.050
With heavy brush and timber	0.100
Flood Plains	
Pasture	0.035
Field crops	0.045
Light brush and weeds	0.050
Dense brush	0.070
Dense trees	0.100

Source: Chow, et al. 1988

Contraction and expansion coefficients are applied upstream and downstream, respectively, of culverts and bridges to model the contraction and expansion of flow. In this study, contraction and expansion coefficients of cross sections bounding bridges and culverts is 0.3 and 0.5, respectively. All other cross sections use the default contraction and expansion coefficients of 0.1 and 0.3. Table 7 lists values for hydraulic coefficients.

Table 7. Miscellaneous Hydraulic Coefficients Table

Coefficient Type	Value or Range
Bridge pier drag coefficient for momentum equation applications, Cd	2
Pressure and weir flow coefficient (submerged inlet and outlet), Cd	0.8
Expansion coefficients for bridges / culverts / in-line structures	0.3 to 0.5
Expansion coefficients for channels	0.3
Contraction coefficients for bridges / culverts / in-line structures	0.1 to 0.3
Contraction coefficients for channels	0.1
Weir coefficients (road deck)	2.6 to 3.0
Culvert entrance loss coefficient	0.4
Culvert exit loss coefficient	1

Ineffective flow limits are added to cross sections to accurately model any given section's inability to convey flow, such as cross sections that bound bridges and culverts. Ineffective limits were also set at the top of the channel banks to account for storage in overbanks that do not contribute to channel conveyance. Storage must be accounted for to accurately model with modified Puls routing.

4.0 MODEL VALIDATION

4.1 FLATLAND METHODOLOGY

Limited historical flow or rainfall data is available for the City of La Feria. This section shows the origins of the flatland hydrology methodology used in this study. This methodology is further validated by the strong correlation shown to the effective FEMA base flood elevations, as discussed below in Section 4.2.2. The methodology used in this study was selected based on that used by EC for the CCDD5 FPP in 2008. The CCDD5 is located roughly four miles northeast of La Feria, and the FPP for CCDD5 was similar in scope and purpose to this study. The CCDD5 FPP had the benefit of available rainfall data and observed high water marks for a significant rainfall event on May 25, 2007. The May 2007 storm in the CCDD5 area provided the most comprehensive data available for this area and a validation exercise was conducted based upon these data. The data collected for the May 25th event included measured high water marks taken along the North Main Drain, and 15-minute precipitation depths recorded at three rain gauges located at various Harlingen Irrigation District Pump Stations.

The hydrologic model for the North Main watershed was calibrated to simulate the May 25th event observed water surface elevations. Table 8 lists the seven hydrologic models created for calibration with the May 25th event.

Table 8. Calibration models for May 25th Event

	Calibration Number	Antecedent Moisture Condition	Time of Concentration	Channel Routing	Peak Rate Factor
	1	AMC I	TR-55	Muskingum-Cunge	484
Standard	**2**	**AMC II**	**TR-55**	**Muskingum-Cunge**	**484**
	3	AMC I	Kerby-Kirpich	Muskingum-Cunge	484
	4	AMC II	Kerby-Kirpich	Muskingum-Cunge	484
	5	AMC I	Kerby-Kirpich	Modified Puls	484
Selected	**6**	**AMC I**	**Kerby-Kirpich**	**Modified Puls**	**200**
	7	AMC II	Kerby-Kirpich	Modified Puls	150

Parameters analyzed for calibration are the antecedent moisture conditions, Tc calculation method, channel routing method, and the PRF of the unit hydrograph. Calibration model number six (6) was selected as the most appropriate. Parameters of the selected model are discussed below.

- **Antecedent Moisture Conditions**

Standard methodology uses curve numbers based on AMC II, which is valid for average soil conditions in the United States. The selected model uses AMC I, as it is more appropriate for the typically dry soil conditions with low runoff potential found in Cameron County. This is consistent with SCS recommendations for this area shown in Section 2.3, above.

- **Peak Rate Factor**

Standard methodology uses a PRF of 484 for the user-specified unit hydrograph. The flat terrain in this study area requires a lower PRF. The USACE study in Raymondville, just north of Cameron County, used a PRF of 150. A peak factor rate of 150 was used in calibration number seven (7), but the selected calibration uses 200, as it yielded water surface elevations for the May 25th event closer to those observed during the storm. A PRF of 200 was applied to the entire study area.

- **Time of Concentration**

Standard methodology in most of the United States uses the NRCS TR-55 method to calculate time of concentration. The selected model uses the Kerby-Kirpich method as it was found to be more accurate for Texas watersheds and used parameters that were less subjective, as discussed above in Section 2.5. The Kerby-Kirpich method was used to calculate time of concentrations for all the basins in the study.

- **Channel Routing**

The modified Puls routing was determined to be more appropriate to use in CCDD5 for the larger drain networks. Storage routing, including modified Puls and reservoir routing, is used for most of the La Feria study area. This method was compared with Muskingum-Cunge routing. Muskingum-Cunge routing could not capture the backwater effects and the significant overbank storage found within the study area.

The selected model's calculated water surface elevation lies closer to the observed water mark elevations than the standard methodologies. The parameters that best calibrate with the May 25th event are AMC I, Kerby-Kirpich method for time of concentration, modified Puls routing, and a PRF of 200. Figure 6 shows the calculated water surface profiles for several of the calibration runs.

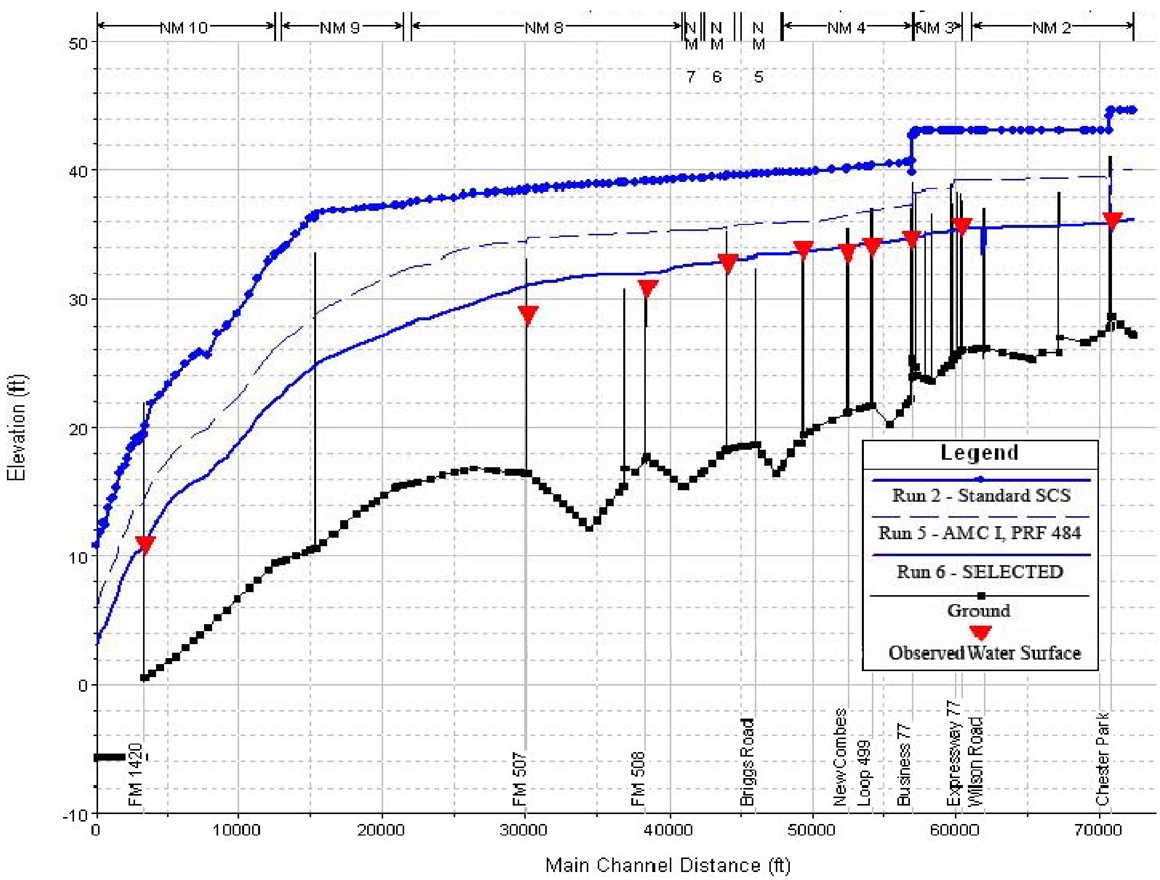

Figure 6. CCDD5 Calibration Results

4.2 COMPARISON WITH PREVIOUS STUDIES

4.2.1 USACE Feasibility Report

The objective of the 1990 USACE Feasibility Report for Cameron County, Texas was to determine the feasibility of Federal participation in flood control measures to reduce flood damages. In this study, HEC-1 and HEC-2 models were developed for several channels in Cameron County. HEC-1 models were used to determine peak flow rates. HEC-2 models were used to determine corresponding peak stage. Several channels studied in the La Feria FPP study area are analyzed in detail in the 1990 Feasibility study, including AN-47 and AN-49. However, copies of the models could not be located, and digital data was not available from the USACE.

4.2.1.1 Comparison of Hydrologic Data

Of the channels selected for the USACE Feasibility study, only the result for AN-47 could be found in the report, although AN-49 and TC-01 were also examined in some fashion. Under the feasibility study, these man-made channels are classified as tributaries in urban basins. Rainfall depths are taken from TP-40 and TP-49. The event duration of 96 hours with a computation interval varying from 15 minutes to 1 hour is used. The Standard Project flood used rainfall depths of 50 percent of probable maximum rainfall as taken from Hydrometeorological Report No. 51 (HMR 51) published by the National Weather Service. An average SCS curve number of 80 was originally used to estimate rainfall losses, but modified calibration revealed that a curve number of 65 was more reasonable. This modification is consistent with the AMC I assumption used in this La Feria FPP study. The modified Puls routing method was used. Peak flow rates for the no-project (existing) channel design in the feasibility study are listed in the table below for comparison with La Feria FPP existing peak flow discharges. In general, the USACE produced similar results when compared to this study. The difference might be a result of the development that has occurred over the last 25 years. Please note that there are slight differences in total drainage areas for the comparison points in Table 9. These comparison points are in the same general location.

Table 9. Peak Flow Rate (cfs) Comparison of 1990 USACE Feasibility Study and La Feria FPP

1990 USACE Feasibility Study AN-47 No Project							
NODE	**DA (sq mi)**	**2-YR**	**5-YR**	**10-YR**	**25-YR**	**50-YR**	**100-YR**
A	0.7	82	86	87	89	90	91
C	4.1	127	149	160	189	197	201
D	4.9	170	201	203	207	209	212
E	7.8	213	271	304	353	357	364
F	8.1	219	280	316	367	381	400
2010 City of La Feria FPP Existing Conditions							
NODE	**DA (sq mi)**	**2-YR**	**5-YR**	**10-YR**	**25-YR**	**50-YR**	**100-YR**
Basin-AN47B	0.9	42	44	45	47	48	51
AN-47-J3	4.6	49	57	62	68	77	103
AN-47-J4	5.2	98	134	166	208	238	276
AN-47-J6	7.9	249	397	447	484	508	520
AN-47-J7	8.2	252	411	470	514	548	577

4.2.1.2 Comparison of Hydraulic Data

The USACE Feasibility Study only presents the water surface elevations for the standard project flood which is defined as 50 percent of probable maximum rainfall as taken from HMR 51. The standard project flow was not studied in this analysis of the La Feria FPP.

The use of a normal depth boundary condition (at the Arroyo Colorado) in the La Feria FPP is consistent with modeling in the USACE Feasibility Study. The USACE feasibility uses a critical depth boundary condition, but backwater computations do not affect the upstream reaches because of the steep gradient in the first thousand feet of channel. Both models assume non-coincident peaks between the Arroyo Colorado and the drainage ditches (USACE, 1990).

As seen in Figure 7, the calculated water surface elevation between the 1990 USACE Feasibility Study and the La Feria FPP is very similar upstream of Business 83 (River Station 14300). The USACE profile is approximately 2 ft lower than the FPP profile between Business 83 and the Wilson/Evans Canal crossing (River Station 6600). The lower USACE study water surface elevations are mostly due to lower peak flow rates, as seen above in Section 4.2.1.1. Other specific differences between the models could not be determined.

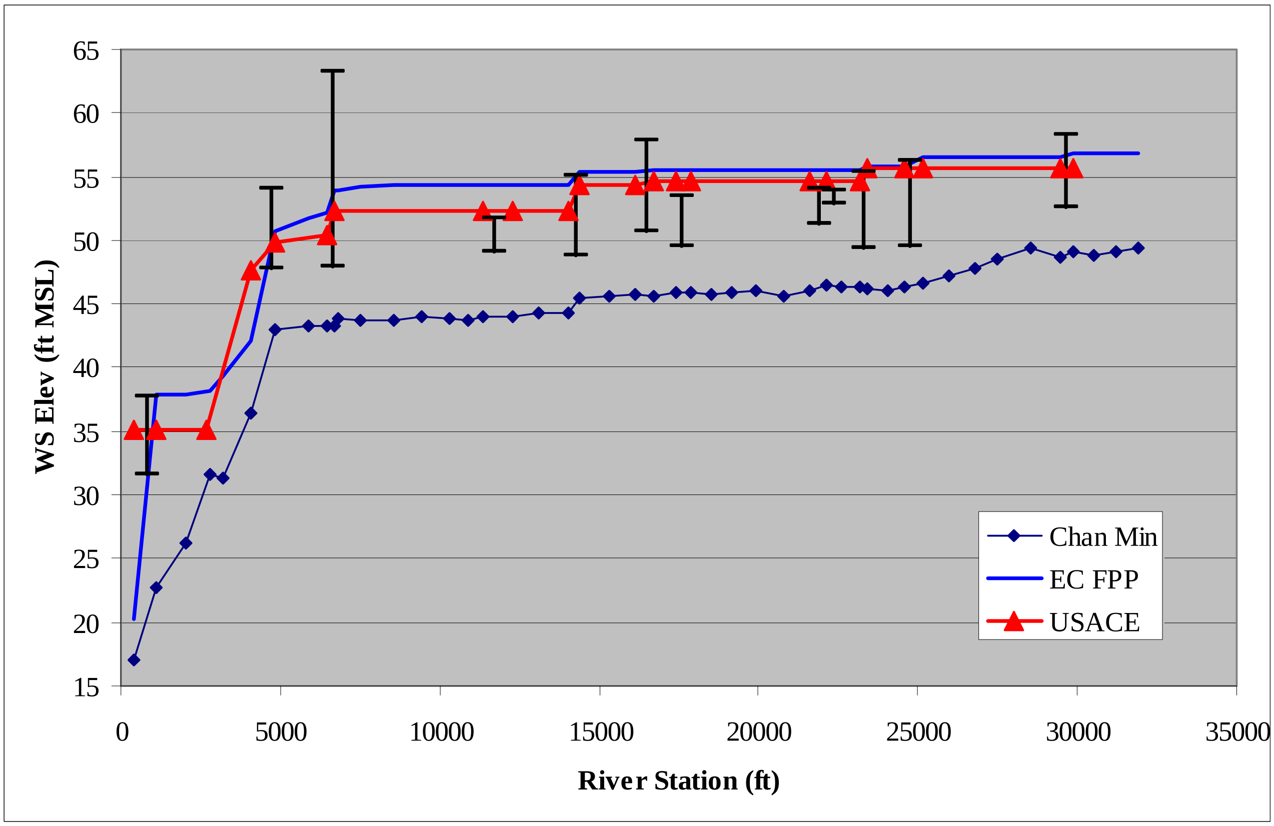

Figure 7. 100-YR Water Surface Comparison of 1990 USACE Feasibility Study and La Feria FPP

4.2.2 FEMA Flood Insurance Study

Three principal waterways in the county were studied in the *FEMA Flood Insurance Study, Unincorporated Areas of Cameron County, Texas, 1999*, including the Rio Grande, North Floodway and the Arroyo Colorado Floodway. Many of the drains and ditches studied in the La Feria FPP are included on the effective FIRM but do not appear to be mentioned in the FIS. It should also be noted that the Cities of La Feria and Santa Rosa are not included in these maps, but since the La Feria city limits were significantly smaller as of the effective date, much of the study area is mapped. The majority of the study area can be found on two FIRMs, 480101 0125B and 480101 0125B. Both of these panels have an effective date prior to the FIS of

September 15, 1983. Many of the floodplain limits shown on the effective map indicate they are based on an even earlier study from June 15, 1979. Copies of the models used to determine these limits could not be located, and digital data was not available from FEMA.

Due to the flat topography and the difficulty in modeling shallow flooding, the typical flood zones of A and AE are not found on the maps within the area of concern. The floodplain in the study area is designated as Zone AH, Zone B, or Zone C. These zones are defined as follows:

> **Zone AH** – Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
> **Zone B** – Areas between the limits of the 100-year flood and the 500-year flood; or certain areas subject to the 100-year flood with average depth less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood.
> **Zone C** – Areas of minimal flooding.

When compared with the results of the La Feria FPP, there was a very strong correlation with FPP results and the base flood elevations shown in the FIRM Zone AH, shown below in Table 10. The flooding extents of the Zone AH and Zone B are significantly larger in the FPP than as shown on the FIRM. A comparison of flooding extents can be seen on Exhibit 5 in Appendix A.

Table 10. 100-YR Flood Elevation Comparison of FEMA FIRM and La Feria FPP

Location	FEMA Zone	FEMA Elevation (ft)	Le Feria FPP Elevation (ft)
AN-47 @ Elevated Canal	AH	54.0	53.2*
AN-49 (Bus. 83 to levees)	AH	56.0	56.1
Lake Tio Cano	AH	46.0	46.2
North-West of Tio Cano	AH	51.0	51.5
South-West of Tio Cano	AH	53.0	54.4

* HEC-RAS shows this flood elevation at 53.95 ft

5.0 FLOODING ANALYSIS OF LA FERIA

5.1 EXISTING CONDITIONS FLOODING ANALYSIS

The hydrologic and hydraulic models were used to evaluate the existing conditions of the AN-47, AN-49 and TC-01. Water surface elevations for the 50%, 20%, 10%, 4%, 2%, and 1% (2-, 5-, 10-, 25-, 50-, and 100-year) annual chance storm events under existing conditions (current land use) are calculated with HEC-RAS, and processed with HEC-GeoRAS using GIS software (ESRI ArcMap 9.3) to identify out-of-bank flooding and flood depths. No hydraulic analysis was done for the existing conditions in the Tio Cano Lake area as there is no primary drainage ditch in this area. The 10- and 100-year floodplain limits in the Tio Cano Lake area were calculated based on the maximum water surface elevation calculated in HEC-HMS. The results of the existing conditions analysis are summarized in the following sections in terms of level of service provided by the ditches. The level of service of each reach is a measure of the magnitude of the storm event, in terms of frequency, that the roadway crossing (culvert) can generally contain without overbank flooding. The culvert crossings appear to be the primary limiting factor for overall channel conveyance. The majority of flooding can be attributed to limitations in a downstream culvert crossing. Please note that if a crossing is shown to have a 100-Year level of service that only means that the structure is not overtopped in the 100-Year event. There are still likely significant flooding issues in the vicinity of this structure during the 100-Year event. In general, the crossings that have 100-Year capacity have roadways/structures elevated above the floodplain. However, they generally have small capacity culverts and the result is ponding water upstream of these locations. While these structures do cause flooding, they also increase the storage within this system and effectively reduce the peak flow rates downstream. Similarly, culverts upstream of the most significant restrictions will show limited capacity due to the tailwater condition created by the structure downstream.

The existing conditions floodplain maps for each watershed for the 10% and 1% storm events (10-year and 100-year, respectively) are included in Appendix A as Exhibits 6 through 9. The floodplain maps may not represent the entire floodplain, just the calculated flooding to the limits of the modeled cross-sections. The floodplain is not contained by high ground in many locations, and apparent limits of the floodplain may only show the limits of the hydraulic model and not the full extent of flooding.

5.1.1 AN-47

As stated above, AN-47 is the primary means of drainage for the City of La Feria. The headwaters of AN-47 are in the vicinity of Dominguez Elementary School, east of the La Feria Main Canal and north of S. Park Drive. Flows generally follow the La Feria Main Canal to the north, traversing both Business 83 and Expressway 83. North of Expressway 83 the channel turns to the east just north of the current city limits. The channel crossed FM 506 and N Kansas City Road before turning back to the south. Here AN-47 again crosses Expressway 83 and Business 83 and continues south and east to the Arroyo Colorado. Just upstream of White Ranch Road is a crossing of two adjacent elevated irrigation canals.

The hydraulic capacity of each crossing on AN-47 varies and is shown in Table 11. As stated above, the culvert capacity generally shows the largest flood event that does not overtop the road. This ditch system has roughly a 2-Year capacity within its banks. During a 5-Year storm, significant overbank flooding is experienced along the length of AN-47. Much of the flooding can be associated with the structures that have the highest capacity, US Expressway 83 and the Elevated Canal Crossing. The fact that these structures are not overtopped means that the channel capacity upstream of these locations is limited to the capacity of the culverts only. There is very little capacity in the AN-47 channel for the entire north-bound reach from the headwaters to roughly Canal Street. In fact, in this area there is very little elevation difference between the 5-Year event and the 100-Year event. The La Feria High School is located within this area and it is interesting to note that while there is significant flooding in the area, the high school buildings and ball fields all appear to be located above the 100-Year inundation elevation.

Table 11. Existing Level of Service of AN-47

Bridge/Culvert	Level of Service
AN-47	
US Highway 83	100 -year
Canal Road	2 -year
FM 506/Dukes Hwy	10 -year
Farm Road	2 -year
N Parker Road	25 -year
N Kansas City Road	2 -year
US Highway 83	100 -year
Business 83	25 -year
Beddoes Road	2 -year
Elevated Canal Crossing	100 -year
S. White Ranch Road	25 -year
Adams Road	50 -year
AN-47 Trib 1	
S Kansas City Road	2 -year
Beddoes Road	10 -year

5.1.2 AN-49

This channel is a small drain along the west limits of the La Feria Irrigation District reservoir, southwest of the City of La Feria and extends north to pick up some of the water from Business 83 in the west quadrant of the City of La Feria. The existing flooding experienced in this area of this channel is primarily a result of the single 24 inch culvert with gate at the IBWC levee, just upstream of the outlet to the Arroyo Colorado. This crossing is shown to have a 100-year level of service, but this indicates only that the levee itself is not overtopped for a 100-year event. The severely limited capacity of this culvert results in water backing up to fill in overbanks for the entire length of the hydraulic model, all the way upstream to Business 83. The Business 83 crossing is upstream of the hydraulic model, but this location was modeled in the hydrologic model (HEC-HMS) as a storage area to assess the capacity of the existing culvert under Business 83 and the depth of flooding north of Business 83 for each event. Table 12 lists the existing level of service for crossings located in the AN-49 drainage area.

Table 12. Existing Level of Service of AN-49

Bridge/Culvert	Level of Service
AN-49	
Orange Grove Rd.	2 -year
Farm Road	5 -year
IBWC Levee	100 -year

5.1.3 Tio Cano Area

The area tributary to Tio Cano Lake is exceedingly flat and the limits of this area are difficult to precisely define. There is an existing drainage ditch that takes flow to the north on the east side of the Willacy Canal, at the western limit of the study area. There is a study currently in progress by TxDOT to determine the capacity and drainage area to this ditch. It is possible that some areas of TC-01C drain to the Willacy Canal ditch, but for the purposes of this study the entire area is assumed to flow to Tio Cano Lake. Another ditch with unknown capacity is that located within drainage area TC-01A, in the vicinity of Santa Rosa and to the west of FM 506. The general land slope within this basin appears to push flows to the north, but there is an existing ditch that will bring some flows south to Tio Cano. TC-01A is included in the hydrologic model but is not connected to Tio Cano Lake for the existing conditions. It is assumed that the existing channel capacity is not significant for the larger storm events and the majority of flows will follow the natural slope of the ground. Further refinement of this model could include portions of TC-01A and less of TC-01C. For the purposes of this study however, the assumed drainage assumptions correlate well with the FEMA FIRM and flooding observations as described above in Section 4.2.2.

At the end of 2009, the TxDOT began a project that would raise FM 506 (Dukes Highway), one of the main north-south connectors between La Feria and Santa Rosa, to an elevation higher than that seen during Hurricane Dolly and the 100-Year floodplain. FM 506 had as much as three feet of standing water after Hurricane Dolly and this road was not passable to normal traffic for some time. The roadway improvements have been completed, and the minimum elevation of FM 506 is now roughly 0.5 feet above the 100-Year floodplain and the culverts at the main channel crossing to the north of Hope Road have also been enlarged. The raising of FM 506 required a more detailed hydrologic model at this location to verify that the new culvert capacity was adequate. Elevating FM 506 above the 100-Year floodplain effectively separates the main body of Tio Cano Lake into two separate bodies of water. The concern was that a significant volume of water must traverse FM 506 during a flood and even if the roadway sits higher than the ultimate flood elevations, it is possible that the roadway could still be overtopped if the culvert capacity were to be exceeded.

The La Feria Main Canal, an elevated irrigation canal that runs north-south to the west to Tio Cano Lake, also has significant impact on the timing of flood flows. Approximately 5.4 square miles drain to Tio Cano Lake from west of the La Feria Main Canal through two relatively small culverts. There is significant flooding caused by these undersized culverts as shown on the effective FEMA FIRM. The La Feria Main Canal does not impact the total flooding extents of Tio Cano Lake, but the timing is important in determining if the culverts at FM 506 have adequate capacity. For the existing conditions analysis the Tio Cano Lake area included four reservoirs; two west of the La Feria Main Canal and two reservoirs comprising the main body of Tio Cano Lake divided by FM 506. Detailed analysis showed that the new existing culverts at FM 506 have adequate capacity for existing flows, but may need to be larger if the culverts under the La Feria Main Canal were improved. If the storage to the west of the La Feria Main Canal were eliminated then those flows would reach FM 506 much faster and increase the probability of overtopping the roadway. Preliminary analysis shows that the culverts, as constructed, are large enough to have adequate capacity even if the La Feria Main Canal crossings were improved.

5.2 ULTIMATE CONDITIONS FLOODING ANALYSIS

The hydrologic and hydraulic models were used to evaluate the ultimate conditions for the La Feria FPP study area. Ultimate conditions represent a fully developed watershed and are intended to represent maximum peak discharges that could be realized in the future. Ultimate conditions flow rates and floodplains include changes to impervious cover and the associated changes to runoff timing with no detention. It is unlikely that future development would be constructed without some flood mitigation features such as detention basins. For the purposes of the La Feria FPP, the ultimate conditions analysis can be utilized to determine potential right-of-way (ROW) needs and lend support for on-site detention or conveyance improvement regulations on new development.

The City of La Feria currently contains large areas of undeveloped agricultural and vacant land. The ultimate conditions land use assumptions are described above in Section 2.8. The future land use plan includes large areas of proposed commercial and residential development in and around the city. Generally, all areas within 1.5 miles of the current city limits are assumed to develop for the ultimate conditions. Only modest changes were made to the assumed land use conditions north of the City of La Feria. The Town of Santa Rosa was assumed to develop fully based on existing city limits and current zoning. No significant development changes are expected within the Tio Cano Lake watershed between Santa Rosa and La Feria.

Table 13, below, shows the ultimate conditions impacts on individual subbasin runoff. Very little impact is expected within the Tio Cano Lake watershed, but significant flow increases and flood duration are to be expected in AN-47 and AN-49 basins. The table below shows that runoff from some basins almost double while the average increase is on the order of 50%. While this represents a significant increase in the peak flow rate, the overall impact to flooding extents/depth would be relatively minor. This is mostly because the existing system has such limited capacity that the primary flooding impacts would be a result of the increase in storm runoff volume. While the increased volume is significant, the area flooded under existing conditions is so extensive that the resulting incremental change in water surface elevation would be minor. However, flood duration would be extended due to the increased volume of runoff. The ultimate conditions floodplain maps for each watershed for the 1% storm event (100-year) is included in Appendix A as Exhibit 10.

Table 13. Ultimate Conditions Impacts

Element	Existing Q(cfs)	Future Q(cfs)	% Change
AN-47-A	198.7	245.2	23%
AN-47-B	513.5	521.2	1%
AN-47-C	433.5	855.1	97%
AN-47-D	540.4	854.6	58%
AN-47-E	229.6	333.1	45%
AN-47-F	613.8	769.9	25%
AN-47-G	379.4	528.6	39%
AN-47-H	89.1	123.3	38%
AN-49-A	192.7	356.1	85%
AN-49-B	258.7	431.4	67%
AN-49-C	116.8	134.2	15%
AN-49-D	105.5	149.6	42%
TC-01-A	170.3	170.4	0%
TC-01-B	357.7	358.4	0%
TC-01-C	651.7	654.1	0%
TC-01-D	609.5	710.2	17%
TC-01-E	180.8	180.9	0%
TC-01-F	1729.6	1775.3	3%

6.0 ALTERNATIVES ANALYSIS

6.1 PLANNING A SYSTEM OF IMPROVEMENTS

The purpose of the FPP is to evaluate the relative benefits of the mitigation strategies developed herein to guide the City in selecting, prioritizing and implementing an optimized combination of strategies. Costs presented herein are preliminary and should only be used for comparison of potential capital improvement projects. To assist the City of La Feria in prioritizing which projects should be funded, the alternatives are assessed with a combination of cost of implementation and associated benefits. Evaluated projects include structural flood controls and non-structural measures.

Structural flood controls are potential construction projects that could be built in an effort to alter the flooding condition of a watershed. Examples of structural controls include culvert improvements, channel excavation, construction of detention ponds, and diversions. Structural controls mitigate flooding by rerouting, detaining, or altering the hydraulics of flow. These controls typically incur significant construction expenses and costs associated with right-of-way acquisition. Structural improvements that increase conveyance capacity (increased channel/culvert capacity) will typically reduce the amount of storage in the system by reducing ponding and overbank flooding. Changes to system storage must be carefully analyzed for this area since reductions in storage can reduce the amount of peak flood attenuation and dramatically increase flow rates downstream of improvements. The impacts of structural improvements need to be assessed for the entire system downstream of the improvement to ensure that no additional damage is caused as a result.

Non-structural flood control measures typically take the form of community-based initiatives and programs. They may prevent the worsening of flood problems and generally aim to prevent flood-induced hazards. Examples of non-structural flood control measures include flood alert systems, buy-outs in flood prone areas, and development regulations. Non-structural controls aim to control the land use of flood-prone areas and to restrict timing and reduce runoff. Much of the success of non-structural measures is found when they are implemented during the course of new development. Therefore, system-wide runoff control/impact fee policies for new development will likely be an important component for the City of La Feria, given the amount of undeveloped area in its jurisdiction.

Implementing both types of controls typically provides the best results. Structural controls are designed to optimize conveyance of peak flows. Non-structural controls often prevent future increases in runoff, maintaining the existing peak discharge, so that structural controls will continue to be effective. Non-structural controls can also seek solutions to other dimensions of the flooding problem, such as public awareness and response time.

Please note that the modeling undertaken for this study does not address or analyze the existing limitations of the local drainage network and stormdrains that deliver water to the main drain ditches. It is assumed that all areas are connected to the main drains and the hydraulic model analyzes just these drains. The floodplain maps show insufficient capacity on the main drains and not the local flooding that may occur as the runoff makes its way to the main drains. There are many locations within the study area that are not effectively connected to the drains, are sumps areas or where the stormdrains and roadside ditches do not effectively drain nuisance flooding. There are other areas such as the Green Bay South subdivision that has no all-weather outlet. This low area must currently employ pumps to remove storm runoff. There are a number of improvements planned by the City, City Council, County and/or Drainage District to local drainage infrastructure that are intended to alleviate nuisance flooding but cannot be effectively analyzed in this report. These issues are considered secondary to the main channel capacity for this study even though nuisance flooding is likely the primary concern of affected residents because of the frequency of these impacts.

Also note that all costs presented in Appendix G are organized by funding probability with Phase 1 and 1B being active applications, while Phases 2 and 3 are applications under development. Each alternative presented below, specifically Alternative 3, incorporate different phases based on funding probability. All cost estimates presented within this section and Appendix G use 2009 dollar values.

6.2 STRUCTURAL IMPROVEMENTS

6.2.1 Alternative 1: AN-47

As stated above, AN-47 is the main drain for the majority of the City of La Feria. This drainage ditch is relatively long and loops around downtown La Feria before discharging to the Arroyo Colorado. The ditch begins flowing north on the west side of town and ends flowing south on the east side of town. The watershed is crisscrossed by elevated irrigation canals and roadways. This ditch crosses both Business 83 and Expressway 83 twice. This drainage ditch is typically very flat with generally undersized crossings at the elevated roadways and canals. The result is extensive shallow flooding adjacent to the drainage ditch in events as frequent as a 5-Year storm. This shallow overbank flooding has the effect of providing a very large valley storage volume which greatly reduces the existing total peak flow rate in the channel. For this reason, as the channel capacity is increased the effective valley storage is reduced and the peak discharge increases. It is necessary to make improvements from downstream to upstream to ensure that the improvements and associated reductions in storage are not increasing flooding problems downstream. Therefore, the proposed improvements to AN-47 in this report focus on the downstream portion of the drain system. As capacity is increased in this section, then improvements in the upper portions of the watershed can be attempted with additional study at a later date. The primary component of this recommendation is the removal of the constriction at the Evans Canal crossing. The existing elevated canal crossing consists of two 54 inch RCPs and two 60 inch RCPs. There are actually two elevated irrigation canals in this location, one higher than the other. It is proposed that a siphon be added to take the lower canal under the AN-47 channel and the higher canal would be carried by an aerial crossing. The crossing is then similar to replacing the four culverts with a clear-span bridge that has a low-chord higher than the 100-Year water surface elevation. The benefit of this proposed improvement is an increase in channel capacity through the crossing. This alternative also includes a series of drop structures downstream of Evans Canal and improvements to the crossings at White Ranch Road and Beddoes Road. There are two tributaries to AN-47 that drain central La Feria, south of Business 83. AN-47 Tributary 1 was modeled as part of this study, and the proposed improvements to

Beddoes Road and Kansas City Road on this tributary are also included in the proposed conditions analysis. The proposed improvements are shown in Exhibit 11 in Appendix A. The summary of expected costs is included below in Table 14. The detailed cost estimates can be found in Appendix G.

Table 14. Alternative 1 Cost Estimate

AN-47	**Cost**	**Description**
Structure 1	$900,000	Drop Structures
Structure 2	$255,000	White Ranch Rd Crossing
Structure 3	$277,000	Evans Canal Crossing
Structure 4	$110,000	Beddoes Rd Crossing
AN-47 Trib 1	$190,000	Beddoes Rd Crossing
AN-47 Trib 1	$190,000	Kansas City Rd Crossing
AN-47 Trib 2	$90,000	Junction with AN-47
TOTAL	**$2,012,000**	

While this alternative produces significant increases in channel capacity downstream of Business 83, it also greatly reduces the storage volume available to flood flows in this area. As described in Section 6.1, above, improvements to the channel system can increase peak discharge rates by removing storage and reducing flood attenuation. The expected peak discharge during the 100-Year event is more than doubled with these improvements in place. The result is a very minor reduction in flood extents. This alternative produces much more significant impacts for the more frequent events. The 5-Year event currently produces significant overbank flooding and much of this is eliminated with this alternative in place. Another significant improvement is that the duration of flooding is greatly reduced for all events. Figure 8, below, shows the expected channel stage with time during a 100-Year event for both the existing and proposed condition. It can be seen that while the total depth of flooding is very similar, flows are only out of banks for approximately 8 hours. This represents a **significant** reduction when compared to the expected 26 hours of flooding fort the existing condition.

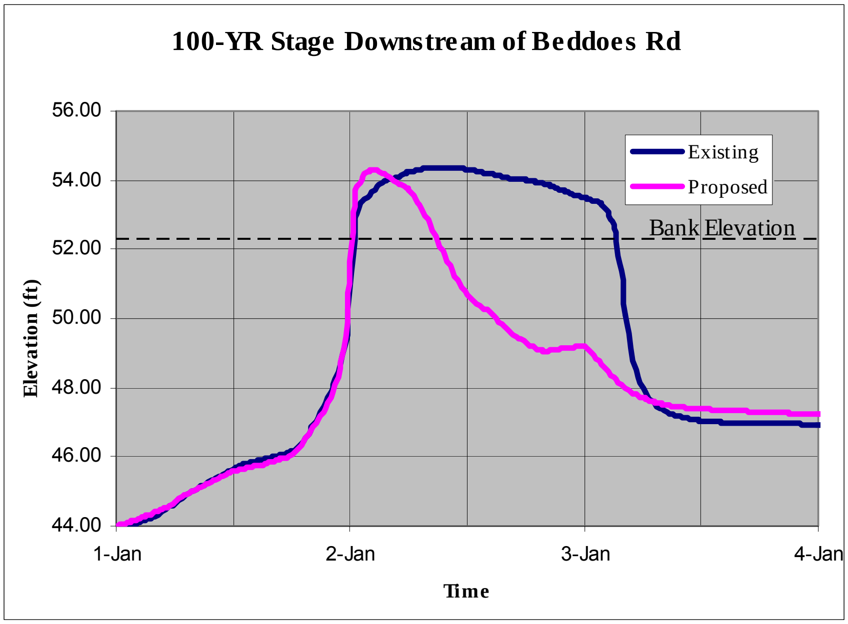

Figure 8. AN-47 Proposed Conditions Benefits

6.2.2 Alternative 2: AN-49

While the flooding on AN-47 is dominated by the existing restrictions at the Evans Canal crossing, a similar situation can be found on AN-49. The IBWC levee extends along the Arroyo Colorado from the confluence with the North Floodway to just upstream of the outlet of AN-47. AN-49 must drain through this levee and the current culvert found here is a single 24 inch RCP. This structure is also gated so it can be closed by IBWC to prevent backflow if the Arroyo Colorado were in flood stage. The levee structure is proposed to be replaced with an 8 foot by 8 foot concrete box culvert. Similar to the situation on AN-47, this large increase in capacity results in a significant reduction in valley storage, and an associated increase in total peak discharge. The peak flow rate for the 100-Year event is almost nine times the existing flow rate with this alternative, but the increase in channel can generally accommodate this increase. Upstream of the IBWC levee is an unnamed dirt road used for farm access. It is assumed that this road will be removed for the purposes of this alternative. Alternative 2 also includes increasing the culvert size on Orange Grove Road. The result of this alternative is almost total containment of the 100-Year floodplain within the AN-49 channel. Some shallow flooding would still be found in the vicinity of Business 83 and this could be resolved by adding fill to elevate new development and some additional minor increases to channel size. The proposed improvements are shown in Exhibit 11 in Appendix A. The summary of expected costs is included below in Table 15. The detailed cost estimates can be found in Appendix G.

Table 15. Alternative 2 Cost Estimate

AN-49	**Cost**	**Description**
Structure 1	$121,000	Orange Grove Rd Crossing
Levee Xing	$800,000	IBWC Levee Crossing
Farm Road	$50,000	Farm Road Removal
TOTAL	**$971,000**	

6.2.3 Alternative 3: Tio Cano Lake

Three different configurations were examined for the Tio Cano Lake area. All alternatives here include the construction of an outlet channel to the Arroyo Colorado. Two of the options were examined in detail for this study. The third, Option C, is a combined channel configuration being considered for grant funding. The alternatives examined looked at different outlet channel alignments and possibilities for providing relief to other areas adjacent to Tio Cano Lake and the proposed outlet channel. Tio Cano Lake itself provides a large storage volume for flood flows and the intent of any improvement in this area is to maintain or even maximize available flood storage. However, the Lake is not a suitable area to encourage residential development, so there is no intent in dramatically reducing existing flood elevations at Tio Cano Lake. Any alternative here would include acquisition of existing flood prone properties. The descriptions below center on the hydrologic and hydraulic components of the various options.

6.2.3.1 3A - Outlet Channel

The Tio Cano Lake alternative aims to reduce the duration of flooding in the Tio Cano area, particularly during the 100-year storm event. The primary component in achieving this goal involves the construction of an outlet channel from Tio Cano Lake to the Arroyo Colorado. The Lake Tio Cano outlet channel will provide an outlet for areas with limited conveyance along the proposed channel alignment. These areas include neighborhoods such as the Mariposa Ranch subdivision, Green Bay South subdivision, and Adams Garden area. The Figure 9 shows the proposed Lake Tio Cano outlet channel alignment.

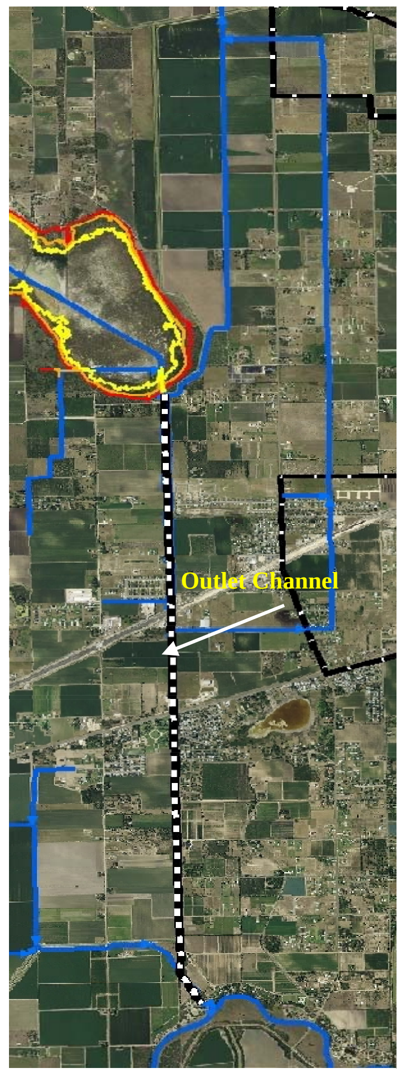

Figure 9. Tio Cano Outlet Channel Alignment

A proposed 50-foot wide spillway at the downstream area of Lake Tio Cano will convey floodwater from Lake Tio Cano to the proposed outlet channel. The proposed outlet channel, from the Lake Tio Cano spillway to Palis Drive, is modeled using the following design dimensions,

- Length – 350 feet
- Base Width – 75 feet
- Hydraulic Depth – 5.5 feet
- Existing 100-Year Flow – 831 cfs
- Channel Capacity – 878 cfs
- Side Slope – 2.5
- Grass-lined

The contributing drainage area, and subsequent floodwaters, continues to increase as the Lake Tio Cano outlet channel traverses south towards the Arroyo Colorado. This increase in contributing flow require that the proposed outlet channel increase in size as it makes its way towards the

Arroyo Colorado. The following design dimensions are modeled to adequately convey the 100-year storm. The outlet channel is grass-lined with 2.5 side slopes through its entirety.

Palis Drive to US Highway 83 (includes Mariposa Ranch drainage area)
- Length – 7,650 feet
- Base Width – 50 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 901 cfs
- Channel Capacity – 936 cfs
- Maximum Top Width – 150 feet

US Highway 83 to Business Highway 83
- Length – 3,000 feet
- Base Width – 60 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 1,071 cfs
- Channel Capacity – 1,096 cfs
- Maximum Top Width – 175 feet

Business Highway 83 to Arroyo Colorado (includes Green Bay South and Adams Garden drainage area)
- Length – 8,000 feet
- Base Width – 65 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 1,128 cfs
- Channel Capacity – 1,176 cfs
- Maximum Top Width – 205 feet

Proposed conditions utilize Bass Lake, located in the Adams Garden area, as a storage reservoir. The Bass Lake outflow structure is modeled as a 4-foot diameter, 2,100-foot long concrete pipe that discharges stored flood water from Bass Lake to the Lake Tio Cano outlet channel.

Culvert upgrades will also be incorporated as part of the proposed outlet channel construction. Table 16 summarizes culvert upgrades at specific road crossings.

Table 16. Lake Tio Cano Outlet Channel Culvert Upgrades

Location	Proposed Culverts
Palis Dr	2 - 9ft x 9ft MBC, 30 LF
US Highway 83	2 - 9ft x 9ft MBC, 330 LF
Business 83	2 - 9ft x 9ft MBC, 130 LF

Table 17 presents the cost of the proposed Lake Tio Cano outlet channel. Several of the assumptions used to estimate costs include:

Excavation: $3 per cubic yard
Box Culverts (various sizes): reflecting TxDOT 12-month statewide average low bid
Right of Way: $6,000 per acre

Mobilization: 5 %
Engineering & Surveying: 20 %
Contingency: 30 %.

Table 17. Cost of Lake Tio Cano Outlet Channel

Segment	Cost
Channel	
Arroyo Colorado to Business 83	$ 5,369,796
Business 83 to US Highway 83	$ 1,527,618
US Highway 83 to Palis Dr	$ 2,288,208
Palis Dr to Tio Cano	$ 126,872
Subtotal	*$ 9,312,494*
Culvert	
Business 83	$ 252,656
US Highway 83	$ 636,773
Palis Dr	$ 60,598
Subtotal	*$ 950,026*
Total	**$ 10,262,520**

6.2.3.2 3B - Outlet Channel with Portion of NF-13 Drainage Area

A second iteration of the Lake Tio Cano outlet channel was also modeled as part of this analysis. This iteration adds a portion of the NF-13 drainage area to the proposed outlet channel. Figure 10 displays the Tio Cano Lake outlet channel drainage area (blue/green) and the portion of the NF-13 drainage area (in red) that is reflected in the in design of the Lake Tio Cano outlet channel (with portion of NF-13 drainage area).

The additional floodwaters from the NF-13 drainage basin would not contribute to the outlet channel until just upstream of Palis Drive, thus allow the channel design from the Lake Tio Cano outfall structure to Palis Drive to identical to the channel design described above for the same location. As floodwaters from the NF-13 drainage area flow into the proposed outlet channel just upstream of Palis Drive, different design dimensions will be required for the remainder of the channel.

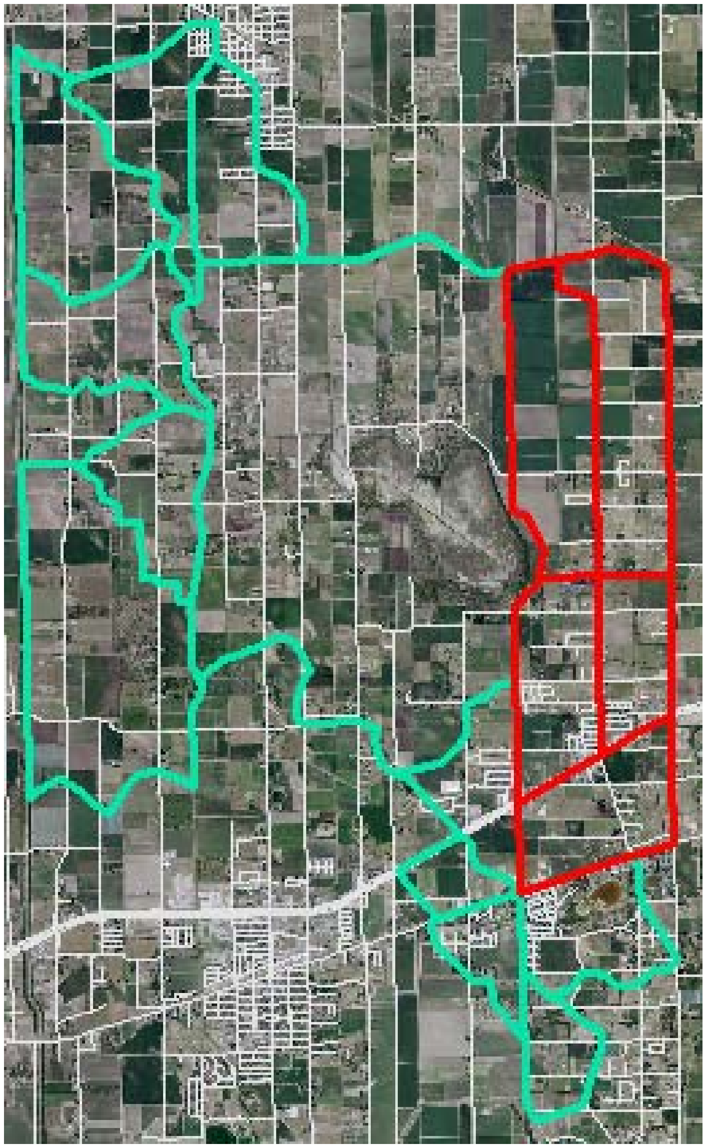

Figure 10. Tio Cano and NF-13 Drainage Areas

As previously stated, the outlet channel is designed to adequately convey the 100-year storm. The outlet channel, from Palis Drive to the Arroyo Colorado, is concrete-lined with 2.5 side slopes through its entirety. A concrete-lined channel is necessary due to the increase in flow from the additional drainage area and desire to maintain an approximate channel top width of 200 feet.

Palis Drive to US Highway 83 (includes Mariposa Ranch drainage area)

- Length – 7,650 feet
- Base Width – 35 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 2,374 cfs
- Channel Capacity – 2,415 cfs
- Maximum Top Width – 135 feet

US Highway 83 to Business Highway 83

- Length – 3,000 feet
- Base Width – 40 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 2,573 cfs
- Channel Capacity – 2,688 cfs
- Maximum Top Width – 155 feet

Business Highway 83 to Arroyo Colorado (includes Green Bay South and Adams Garden drainage area)

- Length – 8,000 feet
- Base Width – 40 feet
- Hydraulic Depth – 7 feet
- Existing 100-Year Flow – 2,645 cfs
- Channel Capacity – 2,688 cfs
- Maximum Top Width – 180 feet

Similar to the previous analysis (non-NF-13 contributing area), Bass Lake within the Adams Garden area would be utilized as a reservoir storage facility.

Culvert upgrades will also be incorporated as part of the proposed outlet channel construction. Table 18 summarizes culvert upgrades at specific road crossings.

Table 18. Lake Tio Cano Outlet Channel Culvert Upgrades (w/ NF-13 Drainage Area)

Location	Proposed Culverts
Palis Dr	3 - 10ft x 10ft MBC, 30 LF
US Highway 83	4 - 9ft x 9ft MBC, 330 LF
Business 83	4 - 9ft x 9ft MBC, 130 LF

Table 19 presents the cost of the proposed Lake Tio Cano outlet channel (w/ portion of NF-13 drainage basin contributing to channel). Cost estimate assumptions are identical to previously presented assumptions with the additional cost of concrete (6-inch slab, 1-foot freeboard) at $34.36 per square yard (TxDOT 12-month statewide average low bid).

Table 19. Cost of Lake Tio Cano Outlet Channel (w/ NF-13 Drainage Area)

Segment	Cost
Channel	
Arroyo Colorado to Business 83	$ 8,400,090
Business 83 to US Highway 83	$ 2,795,393
US Highway 83 to Palis Dr	$ 5,608,936
Palis Dr to Tio Cano	$ 126,872
Subtotal	*$ 16,931,290*
Culvert	
Business 83	$ 487,941
US Highway 83	$ 1,234,036
Palis Dr	$ 84,224
Subtotal	*$ 1,806,201*
Total	**$ 18,737,491**

6.2.3.3 3C - Revised Alignment/Interconnect to AN-47

The City of La Feria has proposed a third alternative configuration with the proposed outlet channel alignment sited to the west so it can interconnect with the existing AN-47 drainage ditch. This alignment was proposed because of uncertainty over whether the irrigation canal right-of-way would be available for use for drainage and its location, outside the current City limits of La Feria. This alignment could provide increased benefit to the City of La Feria. However, disadvantages to this alignment include increasing the number of property owners and crossings along this alignment. This option is also further from Reba Bass Lake, Mariposa Ranch and Green Bay South. These are three areas/subdivisions with limited drainage connections and a history of flooding problems. There are still plans to connect the proposed Tio Cano outlet channel to these areas. Interconnecting the Tio Cano outlet channel with AN-47 also complicates the required hydrologic and hydraulic analysis needed to show that flooding extents are not adversely impacted. This alignment was proposed by the City of La Feria after the hydrologic and hydraulic modeling for this study had been completed, so the design and analysis for this alternative will be submitted under separate cover by SWGA in the near future. The summary of expected costs is included below in Table 20. The detailed cost estimates can be found in Appendix G.

Table 20. Alternative 3C Cost Estimate

TC-01	**Cost**	**Description**
TC Drain	$9,054,672	Tio Cano Drainage Ditch
TCD Structure 1	$218,352	Arroyo L.N.
TCD Structure 2	$219,848	White Ranch Rd Crossing
TCD Structure 3	$436,000	Evans Canal Crossing
TCD Structure 4	$137,464	Business 83 Crossing
TCD Structure 5	$808,880	Kelly Dr Crossing
TCD Structure 6	$717,752	US Expressway 83 Crossing
TCD Structure 7	$497,176	Callaway Dr Crossing
TCD Structure 8	$139,128	County Rd 622 Crossing
Utility Relocation	$250,000	As required.
IC Structure	$600,000	TC NF-13 Interconnect
SWQ & Drainage	$800,000	White Ranch Lake
SWQ & Drainage	$600,000	Turtle Lake
Rabb Drain	$118,800	Widening Rabb Drain
AN-47 Tribs 1&2	$626,400	Widening AN-47 Tribs 1&2
Kansas City Rd	$633,720	Kansas City Rd Crossing
Acquisition	$22,000,000	Tio Cano Property Acquisition
ERDI	$600,000	East Rabb Drainage Improvements
IAB	$500,000	Imp. Along Business 83
AN-47 P2	$1,980,000	Deepening An-47 Phase 2
IRR-AN49	$415,000	Siphon under AN-49
TOTAL	**$41,353,192**	

6.2.4 Other Flood Problem Areas

Several other flood problem areas were examined in this study but were not analyzed in detail. These areas are discussed further below.

6.2.4.1 Western La Feria

The focus of this study has been on areas east of the Willacy Canal. The City of La Feria does extend west of the Willacy Canal for approximately 2,000 feet along US Expressway 83. The primary drains in this area are adjacent to the Willacy Canal and another drain that takes flows to the Arroyo Colorado west of the Willacy Canal. TxDOT is currently studying the drains adjacent to the Willacy Canal to determine the drainage area and capacity. TxDOT also has plans to increase the capacity of the other drain to the west, as shown below in Figure 11. The area within the City of La Feria is generally along the Expressway and this is in a locally high area meaning there is little runoff draining to this location. Increased downstream capacity and improved local drainage will help alleviate flooding in the area.

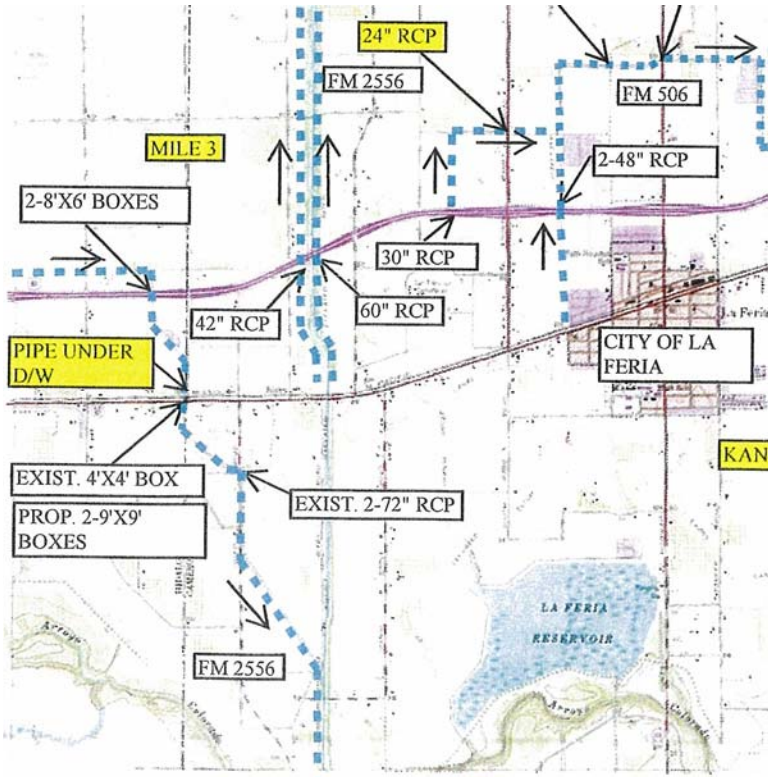

Figure 11. Proposed TxDOT Improvements

6.2.4.2 Santa Rosa and Areas North of Tio Cano

The Town of Santa Rosa is located in a locally high area with very limited drainage just north of the Tio Cano Lake area. A small portion of the Town of Santa Rosa currently drains to the south toward Tio Cano Lake. There is a possibility that additional areas of Santa Rosa could be drained to the Tio Cano area if an outlet to the Arroyo Colorado were to be constructed (Alternative 3, above). An outlet channel would allow capacity for additional areas to drain to Tio Cano Lake without increasing the flooding limits. The majority of Santa Rosa currently drains north toward the North Floodway. The North Floodway is described above in Section 1.1. The North Floodway is bounded by levees and when it is engaged with flood flows from the Rio Grande much of the flow would be at an elevation higher than adjacent ground level. The IBWC patrols the levee during every flood event and the gates on the drains that go through the levee are often closed to prevent water from within the North Floodway from backing up these drain ditches. The result of this action is that much of this area is left without a suitable outlet during any significant rain event. There is a proposal being considered by Cameron County that would retrofit these manual gates with TideFlex check valves. These gates would prevent backflow but would allow water to exit into the North Floodway whenever capacity was available.

6.3 NON-STRUCTURAL FLOOD PROTECTION MEASURES

Along with the channel improvements, culvert upgrades, and detention pond construction alternatives discussed above, the City can cost-effectively implement a series of non-structural measures as part of its overall flood protection planning efforts. These include: addressing illegal dumping, developing the City's rainfall and stream flow gauging network, establishing coordinated stormwater runoff control policies among jurisdictions, and acquisition of flood prone properties. Each is discussed in more detail in the sections below.

6.3.1 Addressing Illegal Dumping

Disposal of debris into the drainage ditches creates blockages, which increases flooding. This likely seems self-evident to the reader, but remarkably is an ongoing, chronic problem with severe consequences. Addressing the problem involves a regional, three-pronged approach: promoting awareness, expanding legal disposal opportunities, and enforcement. Coordination with the County, cities within the region, neighborhood associations, solid waste providers, the school districts, and the Lower Rio Grande Valley Development Council (LRGVDC) should be sought in an initiative to leverage resources and employ a coordinated approach. For instance, coordinating a media campaign involving radio, newspaper, movie theater screening ads, and a poster program at area middle schools would be a more cost effective means of reaching the regional audience than individual local entity efforts by themselves. Similarly, expanding legal disposal opportunities will require coordination with local solid waste service providers, and if coordinated with other entities in the area, the effort can reach a larger geographic area. Ultimately, tracking violators and prosecuting these offenses is necessary to deter the crime, but will require coordination among area law enforcement agencies.

6.3.2 Install Rainfall, Streamflow Gauging Network

The City of La Feria should consider installing a network of automated rainfall and streamflow gauges along the drainage ditches. This data could be made public through a web interface. Data collected from the rainfall and streamflow gauges could be used to monitor flooding conditions in a flood-alert system. This information would serve two purposes. First, it brings critical information to the City about potential problems, and would allow the City and other entities to see the problems in one central location simultaneously, as the issues develop. Second, the data collected from this network creates a record to monitor the behavior of the system in correlation with rainfall. This then enables the City to continually refine/calibrate its models of the ditch system.

6.3.3 Coordinated Stormwater Management Policy

The Lower Rio Grande Valley is experiencing tremendous growth. Without management practices, development increases impervious cover, which increases rainfall runoff, raises water surface elevations and increases flooding. Coordination with the Town of Santa Rosa and Cameron County is necessary to develop practical and enforceable policy. The rules developed under such an initiative may require limits on impervious cover and/or require on-site detention for future developments.

6.3.4 Voluntary Acquisition of Flood Prone Areas

Removing residents from flood-prone areas through the purchase of such properties reduces flooding risk. This is a key component of Alternative 3, above specifically in the Tio Cano Lake area. There may be other areas within the study area where property acquisition is the best method of reducing flood damages. Buying flood-prone structures through a voluntary acquisition or relocation program is a common practice among communities. The estimated cost of this solution will vary according to property value and cost of demolition. This alternative will potentially reduce the amount of property damage caused by flooding. Also, as undeveloped City-owned property, this land may serve as minor detention, recreational areas, and wildlife habitat. Funding may be available through the Flood Mitigation Assistance Program (FMA) for a targeted, voluntary acquisition and relocation program.

6.3.5 Impact Fees

Under Chapter 395 of the Texas Local Government Code, municipalities have the authority to plan and implement an impact fee program to fund improvements, including drainage. The biggest advantage of an impact fee is that it couples the cost of developing infrastructure with new growth and therefore capital costs are not borne by the existing general fund. Impact fees appear especially well suited to the AN-49 watershed. This area is primarily agricultural currently, and extensive development is expected in the future.

7.0 COST BENEFIT ANALYSIS

The viability of alternatives is primarily measured through a comparison of the relative costs and benefits. In most cases in order to be eligible for Federal funding assistance, a project must demonstrate that the expected costs do not outweigh the expected benefits. While there are numerous methods for comparing costs and benefits, for this project a limited Net Present Value Analysis (NPV) is performed to demonstrate the viability of a project given the strong benefits realized in more frequent events under this methodology.

7.1 METHODOLOGY

The NPV Analysis applies only to the structural alternatives described herein; the benefits of non-structural solutions are more difficult to measure in comparative terms. Most of the structural alternatives considered have a useful life of more than thirty years. In each year, a given project provides benefit and requires some level of maintenance. The greatest cost is usually the initial capital cost. Since over the life of a project the benefits and costs are unequally distributed, a means of accounting for the time value of money is necessary to provide useful decision making, i.e. the concept of present value (PV). To calculate PV, both the series of benefits accrued and the costs incurred each year are discounted using a compound interest procedure. This discount rate is typically between 3.5% and 7%. **FEMA requires the use of a 7% discount rate in analysis and application for its Federally-funded cost-sharing programs.** However, there is considerable debate about the appropriateness of this rate, given the intergenerational benefits of many flood control projects and a relatively low inflation rate, among other things. Nonetheless, the NPV analysis begins with an estimate of cost for the selected improvement and considers the estimated benefit stream associated with the improvement in-place. After the value streams are discounted, a viable project bears a net present value of at least $1. If the net present value is less than $1, the project is not cost-justified.

7.2 BENEFIT ANALYSIS

The benefit realized by an alternative is the relative monetary savings of a given improvement being “in-place”, compared to it “not being in-place”. This value is determined from the difference between estimated damages for existing condition and estimated damage with alternatives in-place for each of the 2-, 5-, 10-, 25-, 50- and 100-year events. The 100-year event is included, as this is the primary return interval used by the NFIP.

7.2.1 HAZUS Methodology

To estimate the risk associated with a given magnitude flood event, Hazards U.S. Multi-Hazard (HAZUS) software was employed. This software, developed by FEMA Hazard Mitigation Division under a contract with the National Institute of Building Sciences, integrates with ArcGIS 9.2 (the platform utilized for spatial data management and analysis in the overall study). HAZUS is increasingly a widely-accepted methodology for flood damage estimation. HAZUS provides an estimate of damages by taking spatial information about the depth of flooding, and correlating that information in an “overlay” analysis to data about the built environment and regional assumptions about the relationship between depth of inundation and damages. In addition to this information, HAZUS provides other useful emergency management data such as estimates of displaced households, disrupted critical facilities, and business use loss.

For the City's purposes, HAZUS was used to generate estimates of the relative benefit of the flood protection measures proposed. The results of the hydraulic analysis from HEC-RAS (see Section 3.0) are processed in HEC-GeoRAS into inundation depth grids for each event ("depth grid"). For each alternative, the resulting depth grid is evaluated in HAZUS to produce an estimate of damages. These damages "with the selected improvement in place" are then compared to an estimate of damages in the existing condition, for the same storm event. The difference in damages is then the relative benefit for that particular flood control measure and event. Relative benefit is calculated for all studied events.

For each HAZUS model run, the default Census and housing inventory databases are used. The USACE-Galveston District depth-damage curves are applied in deriving damage totals. Appendix H summarizes the HAZUS results for the 1% annual chance benefits for each alternative. The remaining HAZUS output reports can be found in Appendix K, Digital Data.

7.2.2 HAZUS Results

The net present value analysis requires a time series of benefits. While it is impossible to know what magnitude of event may occur in a given year, it is possible to represent that risk in the form of annualized damages and annualized benefit. The difference between the annualized damages with and without the project is a means of accounting for the lower frequency events that provides the requisite, probability-tempered benefit for the NPV analysis. The HAZUS results for AN-47 and AN-49 that were used in the Net Present Value Analysis are summarized Tables 21 and 22.

Table 21. AN-47 HAZUS Results

AN 47	Existing Damages	With-Project Damages	Benefit
2-Year	$340,000	$250,000	$90,000
5-Year	$5,150,000	$2,660,000	$2,490,000
10-Year	$6,420,000	$5,700,000	$720,000
25-Year	$8,070,000	$7,650,000	$420,000
50-Year	$8,790,000	$8,470,000	$320,000
100-Year	$9,730,000	$9,580,000	$150,000

Table 22. AN-49 HAZUS Results

AN 49	Existing Damages	With-Project Damages	Benefit
2-Year	$10,000	$10,000	$0
5-Year	$50,000	$20,000	$30,000
10-Year	$80,000	$20,000	$60,000
25-Year	$130,000	$40,000	$90,000
50-Year	$190,000	$50,000	$140,000
100-Year	$350,000	$80,000	$270,000

The maximum benefit for AN-47 would be realized in the 5-Year event. This represents the largest reduction to floodplain extents. As noted above, there is only a minor reduction in the flooding extents for the proposed conditions 100-Year event. The largest benefit for the 100-Year event is the reduction in the flood duration however, HAZUS does not quantify this benefit since damages are based solely on the total depth of flooding.

The AN-49 watershed is primarily composed of agricultural areas under the existing conditions. For this reason there are only minor expected damages in this area. The very large reduction in flooding extents in the proposed condition only shows benefits relative to existing land uses. It is expected that much of this area will develop in the future, so the primary benefit of improvements here is to reduce the areal extent of flooding and thereby allowing future development to occur.

7.2.3 Net Present Value Analysis

A Net Present Value analysis was conducted to compare the annualized benefit relative to the project cost. This analysis was conducted only for the HAZUS results. There are significant flood damages that are not represented in the HAZUS analysis, including duration of flooding, and electricity and transportation interruptions. Based on the estimated benefit from HAZUS, the net present benefit of Alternative 1 (AN-47) is $630,000. The net present benefit of Alternative 2 (AN-49) is $20,000. The net present cost of the improvements would depend on how they were paid for and an assumed project life. For a 50-Year project life and the total $2.012 Million paid upfront for Alternative 1, the project would be justified if a discount rate of 3.98% were used. There are only limited benefits of Alternative 2 to existing infrastructure and this is the cause of the relatively low annual benefit. The primary benefit to Alternative 2 is allowing future development. A copy of the Net Present Value calculations can be found in Appendix I.

7.2.4 Benefit Cost Analysis

Even though HAZUS is a FEMA project, a more detailed benefit analysis must be performed to seek grant funding. Grant funding is being sought by the City of La Feria for a combination of Alternatives 1, 2 and 3C, as discussed further in Section 8.2.4. Per the FEMA website, "FEMA has developed Benefit-Cost Analysis (BCA) software to facilitate the process of preparing a BCA. Using FEMA-approved BCA software will ensure that the calculations are prepared in accordance with OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs and FEMA's standardized methodologies." SWGA utilized the BCA software to assess the potential benefit of the combined alternative using actual damages incurred during Hurricane Dolly which totaled approximately $1.05 billon. The majority of this damage occurred within the La Feria FPP area. The La Feria FPP area lost power to 4,800 customers for approximately 100 days, while main arterials such as US 83 and FM 506 were inaccessible and/or shut down for five days or more. Table 23 summarizes the historic damages caused by Hurricane Dolly within the La Feria FPP area.

Table 23. Total Area Expected Infrastructure Damage

Infrastructure	Total Value of Service/Economic Loss of Function (Per Day)	Days w/o Service	Total Damage
Utilities	$604,800	100	$60,480,000
Roads	$6,952,000	5	$34,760,000
		Total	$95,240,000

As part of this FPP, a benefit-cost analysis has been conducted. The 25-year storm event was selected as the desired level of service to be achieved within the La Feria FPP area. Table 24 summarizes the damages before and after proposed flood mitigation.

Table 24. Expected Benefit

	Expected Damages		Benefit
	Before Mitigation	After Mitigation	
Annual	$3,809,590	$24,192	$3,785,398
Present Value	$52,575,185	$333,868	$52,241,317

Table 25 summarizes the benefits of the proposed mitigation projects versus expected damages.

Table 25. Benefit Cost Analysis

Mitigation Project Cost	Project Maintenance		Final Mitigation Project Cost	Benefit Minus Cost	Benefit Cost Ratio
	Annual Cost	Present Worth of Annual Costs			
$45,600,000	$130,000	$1,794,097	$47,394,097	$4,847,220	1.10

The present value is based on a project useful life of 50 years using an interest rate of approximately 3%. The full BCA analysis output is included as Appendix J.

8.0 FLOOD PROTECTION PLAN

The response to these flooding issues is directed by a series of policy goals, analyses and actions, as formulated below. A goal is a desired end or outcome. The analysis discusses the technical basis behind the goal, and supplies the impetus to the individual actions. The actions are specific projects, programs or activities which are recommended for implementation in order to achieve the goal. Taken all together, these goals represent the long term approach that the City of La Feria and its partners in floodplain management must take in order to address the flood hazard present along the City's network. In short these goals are as follows:

> **Goal 1**: Proactively address flood problem areas with targeted improvements that consider the entire drainage area for each of the studied drains.
> **Goal 2**: Provide an outlet for areas with limited conveyance.
> **Goal 3**: Ensure that new development does not adversely affect property downstream.
> **Goal 4**: Reduce local flooding by ensuring positive drainage to the existing ditch network.
> **Goal 5**: Protect and enhance available storage in the system. Valley storage in the ditch network is a critical resource from a hydraulic perspective.
> **Goal 6**: Actively inform the community of the risk of flooding.
> **Goal 7**: Update and refine the FPP on a bi-annual basis.

The following sections describe important analyses, considerations, and actions to be taken in furthering each goal.

8.1 FURTHERING FLOOD PROTECTION GOALS

<u>Goal 1</u>: Proactively address flood problem areas with targeted improvements that consider the entire drainage area for each of the studied drains. The engineering analysis has identified several structural improvement options that can provide immediate benefit to the study area. The following actions can be taken towards implementing this goal:

- <u>Action 1.1</u> – Improve conveyance and reduce flooding duration on AN-47 (Alternative 1).
- <u>Action 1.2</u> – Improve conveyance and reduce flooding duration on AN-49 (Alternative 2).
- <u>Action 1.3</u> – Construct an outlet from Tio Cano Lake and acquire flood prone property below elevation 46 ft MSL (Alternative 3).
- <u>Action 1.4</u> – Enlarge culverts at the La Feria Main Canal west of Tio Cano Lake to reduce flooding (Alternative 4).

<u>Goal 2</u>: Provide an outlet for areas with limited conveyance.

- <u>Action 2.1</u> – Connect the Mariposa Ranch subdivision to the Tio Cano Outlet Channel (see Action 1.3)
- <u>Action 2.2</u> – Connect the Adams Gardens area to the Tio Cano Outlet Channel (see Action 1.3)
- <u>Action 2.3</u> – Connect the Green Bay South subdivision to the Tio Cano Outlet Channel (see Action 1.3)

- Action 2.4 – Maximize the existing conveyance to the North Floodway. Support the County in its efforts to fund the construction of check valve outfalls at the North Floodway.

Goal 3: Ensure that new development does not adversely affect property downstream. This represents a "good neighbor" policy inasmuch as it reflects a very real limit on available conveyance capacity within the study area. The following actions can be taken towards implementing this goal:

- Action 3.1 – Evaluate the feasibility of requiring on-site detention for at least the 10% annual chance event to mitigate the impacts of development.
- Actions 3.2 – For new development, ensure conveyance to the established drain system using the FPP models (tailwater).
- Action 3.3 – Coordinate with local government partners such as Cameron County, the City of Harlingen, and the Town of Santa Rosa to establish common standards and hydrologic and hydraulic methods and assumptions.

Goal 4: Reduce local flooding by ensuring positive drainage to the existing ditch network. Many nuisance drainage problems can be alleviated if good, positive drainage exists.

Goal 5: Protect and enhance available storage in the system. Valley storage in the ditch network is a critical resource from a hydraulic perspective.

- Action 5.1 – Acquire (fee simple or easement) areas which are subject to high headwater conditions and where analysis indicates that increasing conveyance at that location will result in adverse downstream impacts.
- Action 5.2 – Acquire sufficient right-of-way to introduce a bench channel section for large channel construction (See Figure 12).
- Action 5.3 – Utilize a storage-based model when assessing project impacts

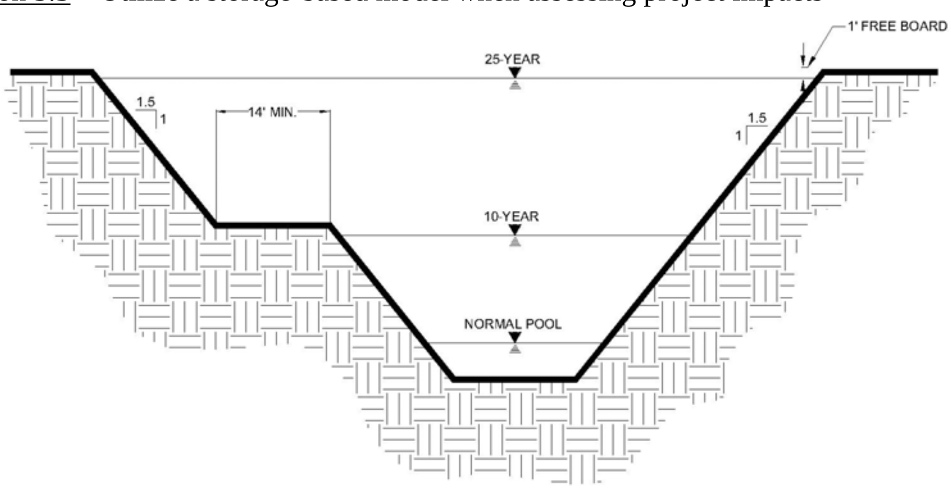

Figure 12. Example of a Bench Channel Section

Goal 6: Actively inform the community of the risk of flooding. It is important for the City to actively inform the community about the nature of flood risk, and the limits of what the City can do to mitigate that risk. The following actions can be taken towards implementing this goal:

- Action 6.1 – The City's ability to provide higher levels of flood protection are limited by regional topography, available right-of-way, and existing encroachment into the floodplain. The current level of risk for larger events should be made freely available through dissemination of floodplain maps, both paper and digital.
- Action 6.2 – Make an initial presentation to the Chamber of Commerce, and follow up with "annual update" presentations, or contribute articles to the Chamber's newsletter with updates on City flood related activities.
- Action 6.3 – Identify neighborhood leaders in flood-prone neighborhoods and develop a specific outreach campaign with their guidance.
- Action 6.4 – Work with private industry and other stakeholders to develop and implement a program to distribute NOAA All Hazards Weather Radios to the public.
- Action 6.5 – Working with other authorities, develop a specific plat note requirement to explain the limitations of flood protection in the Lower Rio Grande Valley.
- Action 6.6 – Coordinate and participate in public awareness activities about the NFIP through the Regional NFIP Coordinator (956-421-3214).

Goal 7: Update and refine the FPP on a bi-annual basis. Over time, the conditions in the watershed will change and the FPP will need to be updated and viewed as a living document. The following actions can be taken towards implementing this goal:

- Action 7.1 – Consider the installation of gauges to monitor flow, stage, and velocity.
- Action 7.2 – Perform a model update on a bi-annual basis to incorporate new development and calibration data, if available.
- Action 7.3 – Assess and prioritize the remaining construction projects, knowing that many conditions in the watershed will change over time.

8.2 FUNDING SOURCES

An important aspect of implementing any of the recommended alternatives is the funding mechanism. The summary below provides a description of the possible funding sources for the City to construct a project.

8.2.1 Local Entity Funding Sources

Capital Improvements Plan (CIP) - a long-range plan, usually four to six years, which identifies capital projects and equipment purchases, provides a planning schedule and identifies options for financing the plan. The City should prepare a CIP each year during its budget cycle.

Drainage Utility Fees - Municipal stormwater projects are funded by the assessment of a drainage utility fee for all developed projects based on amount of impervious cover, number of living units, or site area.

Development Impact Fees – In accordance with Chapter 395 of Texas Local Government Code, municipalities may impose an impact fee to cover the cost of improvements that are necessitated by new development.

General Fund – The primary operating fund of a governmental entity.

General Obligation Bond (GO) - A municipal bond that is backed by the credit and "taxing power" of the issuing jurisdiction, rather than the revenue from a given project. General obligation bonds are issued with the belief that a municipality will be able to repay its debt obligation through taxation or revenue from projects. No assets are used as collateral. These bonds are typically considered the most secure type of municipal bond, and therefore carry the lowest interest rate.

Revenue Bond - A municipal bond supported by a specified stream of future income, such as income generated by a water utility from payments by customers. This differs from general-obligation bonds, which can be repaid through a variety of tax sources. Revenue bonds are only payable from specified revenues. A main reason for using revenue bonds is that they allow the municipality to avoid reaching legislated debt limits.

Special Assessment Bond - A special type of municipal bond used to fund a development project based on property tax assessments of properties located within the issuer's boundaries.

Tax Increment Bond – A bond (also known as a “tax allocation bond”) payable from the incremental increase in tax revenues realized from any increase in property value resulting from capital improvements benefiting the properties that are financed with bond proceeds. Tax increment bonds often are used to finance the redevelopment of blighted areas.

8.2.2 Drainage District

Texas Water Code, Chapter 56 allows for the creation of a drainage district. The purpose of the drainage district is to construct, improve and maintain the open drain networks, as well as to provide adequate drainage and drainage outfalls. A drainage district may levy ad-valorem taxes upon the property contained within the district to fund this work. Table 26 shows the current tax rates for Drainage Districts in the vicinity of the study area.

Table 26. Existing Drainage District Tax Rates

Drainage District		Tax Rate
Cameron County Drainage District #5	CCDD5	0.1374%
Cameron County Drainage District #3	CCDD3	0.1472%
Cameron County Drainage District #1	CCDD1	0.0315%
Cameron County Drainage District #4	CCDD4	0.0413%
Hidalgo County Drainage District #1	HCDD1	0.0725%

CCDD5 is the closest existing drainage district to the study area. The tax base of the study area has been analyzed to assess the capacity to fund drainage work using the tax rate and annual maintenance cost found in CCDD5. The current tax rate within CCDD5 is $0.137364 per $100 of valuation and annual maintenance cost is approximately $1 for foot of drainage channel per year. Cameron County Appraisal District data from 2010 was used to determine that there are approximately 5,954 parcels located within the study area with a total appraised value in excess of $215 million. At the CCDD5 tax rate, this area would generate approximately $339,000 per year, or enough revenue to maintain 64 miles of drainage channels. There are currently approximately 41 miles of drainage channel within the study area, not including the roadside ditches or the drain ditch adjacent to the Willacy Canal. There is significant need to enlarge the existing ditches and construct new ditches, but even with significant expansion it can be shown that the tax base exists in the study area to support the formation of a new drainage district or the annexation into an existing drainage district. There is already the expectation that much of the undeveloped and agricultural areas will develop in the near future, especially along the Expressway 83 corridor. Not only would significant reduction to flooding problems encourage development, but increased property values would increase revenue and the ability of a drainage district to construct/maintain improvements.

8.2.3 State Funding Assistance Sources

TWDB (Texas Water Development Board)

- Clean Water State Revolving Fund - Provides perpetual funds to provide low interest loan assistance for the planning, design, and construction of stormwater pollution control projects.
- Research and Planning Fund Grants – The purpose is to provide financial assistance for research and feasibility studies into practical solutions to water-related problems.
- State Participation and Storage Acquisition Program – The purpose is to help finance regional water projects including water storage facilities and flood retention basins; and to allow for “right sizing” of projects in consideration of future growth.
- Texas Water Development Fund – The purpose is to provide loans for the planning, design, and construction of water supply, wastewater, and flood control projects.

TCEQ (Texas Commission on Environmental Quality)

- Texas Clean Rivers Program (CRP) – The purpose of these funds are to maintain and improve the quality of surface water resources within each river basin in Texas.

8.2.4 Federal Assistance Sources

FEMA (Federal Emergency Management Agency)

- Flood Hazard Mapping Program – Department of Homeland Security (DHS) funds are administered through FEMA to identify, publish, and update information on all flood-prone areas in the U.S. in order to inform the public on flooding risks, support sound floodplain management, and set flood insurance premium rates.
- Flood Mitigation Assistance Grants (FMA) – The purpose is to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured through the NFIP.
- Hazard Mitigation Grant Program (HMGP) – The purpose is to provide states and local governments financial assistance to permanently reduce or eliminate future damages and losses from natural hazards through safer building practices and improving existing structures and supporting infrastructure.
- Pre-Disaster Mitigation Grant Program (PDM) – The purpose is to provide funding for states and communities for cost-effective hazard mitigation activities that complement a comprehensive hazard mitigation program and reduce injuries, loss of life, and damage and destruction of property.

HUD (U.S. Department of Housing and Urban Development)

- Disaster Relief/ Urgent Needs Fund of Texas - To rebuild viable communities impacted by a natural disaster or urgent, unanticipated needs posing serious threats to health and safety by providing decent housing, suitable living environments and economic opportunities.
- Texas Community Development Program – The purpose is to build viable communities that meet "basic human needs" such as safe and sanitary sewer systems, clean drinking water, disaster relief and urgent needs, housing, drainage and flood control, passable streets, and economic development.

NRCS (Natural Resources Conservation Service)

- Watershed Protection and Flood Prevention Program – To protect, develop, and utilize the land and water resources in small watersheds of 250,000 acres or less. The program is Federally assisted and locally led.
- Watershed Surveys and Planning – Provides planning assistance to Federal, State, and local agencies for the development of coordinated water and related land resources programs in watersheds and river basins. Emphasis on flood damage reduction, erosion control, water conservation, preservation of wetlands, and water quality improvements.
- Wetlands Reserve Program – To protect and restore wetlands by enabling landowners to sell easements which take wetlands out of production.
- Emergency Watershed Protection Program – The purpose is to provide relief from imminent hazards and reduce the threat to life and property in the watersheds damaged by severe natural events. Hazards include floods and the products of erosion created by floods, fire, windstorms, earthquakes, drought, or other natural disasters.

USACE (United States Army Corps of Engineers)

- Emergency Advance Measures for Flood Prevention – The purpose is to protect against the loss of life or damages to property given an immediate threat of unusual flooding.
- Emergency Rehabilitation of Flood Control Works – The purpose of this program is to assist in the repair or restoration of flood control works damaged by flooding.
- Emergency Streambank and Shoreline Protection – The purpose is to prevent erosion damages to public facilities by the emergency construction or repair of streambank and shoreline protection works.
- Floodplain Management Services – The purpose is to promote appropriate recognition of flood hazards in land and water use planning and development through the provision of flood and floodplain related data, technical services, and guidance.
- Nonstructural Alternatives to Structural Rehabilitation of Damaged Flood Control Works – This program provides a nonstructural alternative to the structural rehabilitation of flood control works damaged in floods or coastal storms.
- Planning Assistance to States – The purpose is to assist states, local governments and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.
- Small Flood Control Projects – The purpose is to reduce flood damages through small flood control projects not specifically authorized by Congress.

8.2.5 Funding Leverage Strategies

Leveraging the efforts of various entities for debt instruments and grant funds requires mitigation alternative prioritization along with coordination between citizens and public officials.

With the creation of a drainage utility district this area will now have an ad valorem tax based revenue stream at which to purse state and federal grant opportunities or medium to long term debt bond issuance to fund local drainage improvement projects.

Leveraging strategies such as in-kind services and local match to grants should be employed as to help maximize the value of any funding that may be available.

Medium to long term debt bond issuance allows for communities to attain greater amounts of capital at lower rates and should be applied to more regional/public projects.

8.3 REGULATORY COMPLIANCE

Prior to commencement of construction, it will be necessary to submit the project and appropriate permit applications to regulatory agencies. A detailed review and acquisition of the necessary permits for the construction of these project(s) exceeds the scope of this contract. However, a partial list and brief discussion of permits is included in the following subsections. This following list of agencies and corresponding permit activities is intended to be general in nature and is not intended to represent a definitive list of required permit acquisitions and agency coordination.

8.3.1 Federal Emergency Management Agency (FEMA)

The National Flood Insurance Act of 1968 was enacted by Title XIII of the Housing and Urban Development Act of 1968 (Public Law 90-448, August 1, 1968) to provide previously unavailable flood insurance protection to property owners in flood prone areas. FEMA administers the NFIP; however, if a local community elects to participate in the NFIP, the local government is primarily responsible for enforcement. Participating communities are typically covered by FIS which define water surface profiles and floodplain boundaries through their communities.

The recommended drainage improvement projects summarized in this report are intended to reduce floodplain limits. However, if changes to the current effective FEMA floodplain elevations are desirable based on the results of this study, or from the proposed improvements, a request for a Letter of Map Revision (LOMR) from FEMA will be required.

8.3.2 U.S. Army Corps of Engineers (USACE)

Pursuant to Section 404 of the Clean Water Act and the Rules and Regulations promulgated there under by the United States Environmental Protection Agency (USEPA) and the USACE, the filling or excavation of waters of the United States, including wetlands, with dredged or fill material, requires the issuance of a permit from the USACE (33 CFR Parts 320-330). For purposes of administering the Section 404 permit program, the USACE defines wetlands as follows:

> *Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. (33 CFR 328.3)*

The *Corps of Engineers Wetlands Delineation Manual (Technical Report Y-87-1)*, issued by the USACE in 1987 states that wetlands must possess three essential characteristics. These characteristics include, under normal circumstances: 1) the presence of hydrophytic vegetation, 2) hydric soils, and 3) wetland hydrology. If all three of these criteria are present on a particular property in areas larger than one-third acre in size, then a permit (general permit or nationwide permit) must be issued by the USACE in order to fill all or a portion of those areas.

Section 404 (b)(1) guidelines (40 CFR Part 230), established by the USEPA, constitute the substantive environmental criteria used in the evaluating activities regulated under Section 404 of the Clear Water Act. The purpose of these guidelines is to restore and maintain the chemical physical and biological integrity of waters of the United States through the control of discharge of dredged or fill material.

All property owners within the United States and its territories must adhere to the provisions of the Clean Water Act. If any contemplated activity might impact waters of the United States, including adjacent or isolated wetlands a permit application must be made. If jurisdictional waters and/or wetlands are found to exist, then any activity which would involve filling, excavating, or dredging these wetlands would require the issuance of a permit. The final authority to determine whether or not jurisdictional waters exist lies with USACE.

8.3.3 U.S. Fish and Wildlife Service (USFWS)

The U.S. Fish and Wildlife Service (USFWS), in the Department of the Interior, and the National Marine Fisheries Service (NMFS), in the Department of Commerce, share responsibility for administration of the Endangered Species Act (ESA). Generally, the USFWS is responsible for terrestrial and freshwater species and migratory birds, while the NMFS deals with those species occurring in marine environments and anadromous fish.

Section 9 of the ESA prohibits take of federally listed endangered or threatened species without appropriate authorization. Take is defined in the ESA, in part as "killing, harming, or harassment" of a federally listed species, while incidental take is take that is "incidental to, and not the purpose of, otherwise lawful activities".

Section 10 of the ESA provides a means for non-Federal projects resulting in take of listed species to be permitted subject to carefully prescribed conditions. Application for an incidental take permit is subject to a number of requirements, including preparation of a Habitat Conservation Plan by the applicant. In processing an incidental take permit application, the USFWS must comply with appropriate environmental laws, including the National Environmental Policy Act. Review of the application under Section 7 of the ESA is also required to ensure that permit issuance is not likely to jeopardize listed species. Section 10 issuance criteria require the USFWS to issue and incidental take permit if, after opportunity for public comment, it finds that:

1. the taking will be incidental;
2. the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of the taking;
3. the applicant will ensure that adequate funding and means to deal with unforeseen circumstances will be provided;
4. the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
5. the applicant will ensure that other measures that the USFWS may require as being necessary or appropriate will be provided.

The U.S. Fish and Wildlife Service should be contacted to determine the potential occurrence of and consequent impacts to any federal threatened and endangered species. In addition, the USACE will require USFWS review of the project to ensure the project is in compliance with the Endangered Species Act prior to the issuance of a Section 404 permit.

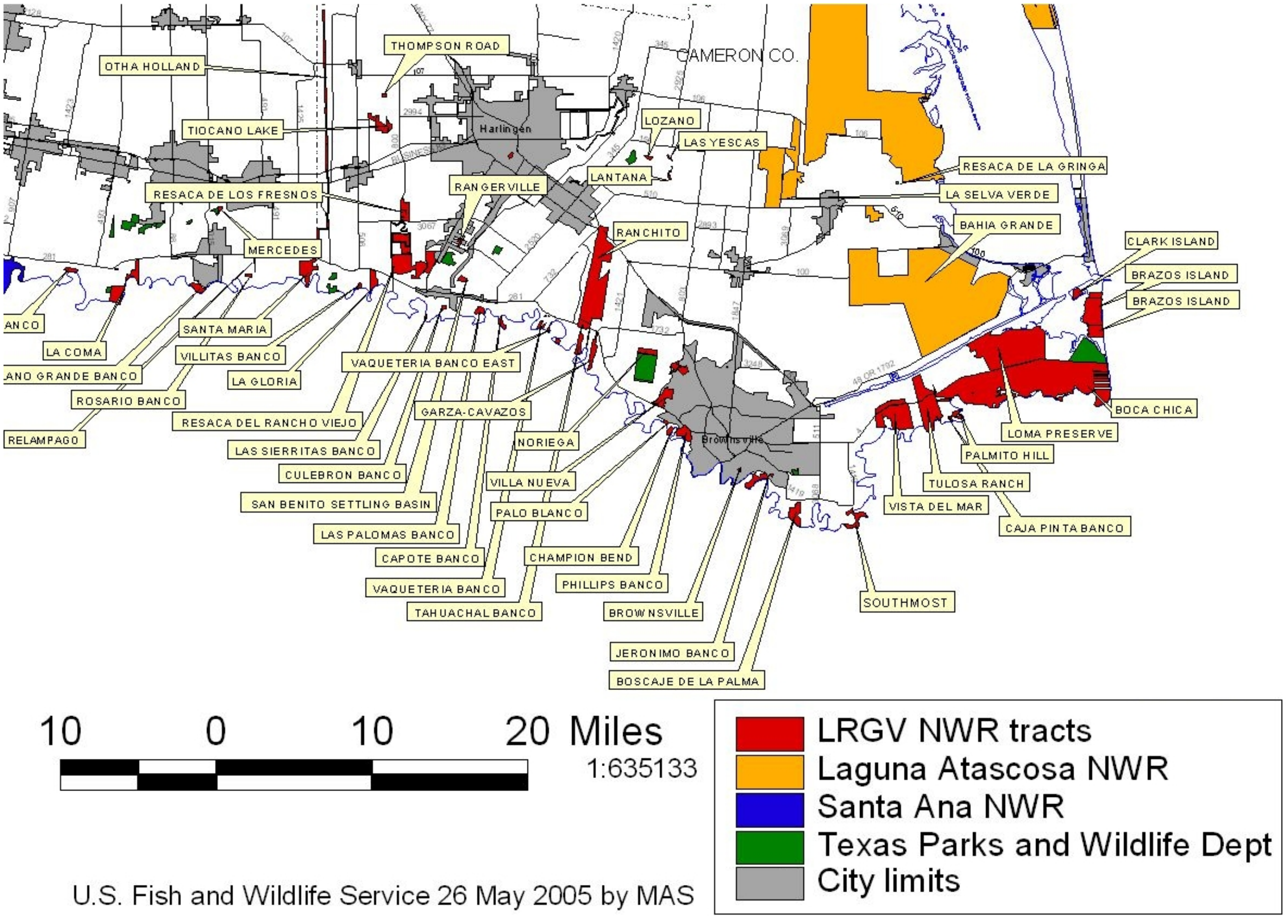

Figure 13: Wildlife Corridor – Lower Rio Grande Valley

USFWS plays a large role in the Lower Rio Grande Valley. There is a very concerted, on-going effort within Cameron County to preserve and enhance habitat, particularly for migratory birds. The Lower Rio Grande Valley Wildlife Corridor, comprised of various park, preserves and wildlife management areas as a joint effort of USFWS and TPWD, is an effort to create connected habitat areas that will permit the safe flow of animal and plant species (See Figure 13). As water is a critical part of any habitat function, the City's activities and undertakings should consider the USFWS efforts.

8.3.4 Texas Commission on Environmental Quality (TCEQ)

The Texas Commission on Environmental Quality (TCEQ) has regulatory authority over: dam safety, the Edwards Aquifer, water rights, Texas Pollutant Discharge Elimination System and Section 404(b)(1) guidelines for specification of disposal sites for dredged or fill material. The following sections briefly describe these regulations.

- Texas Pollutant Discharge Elimination System (TPDES)

On September 14, 1998, the USEPA authorized Texas to implement its Texas Pollutant Discharge Elimination System (TPDES) program. TPDES is the state program to carry out the National Pollutant

Discharge Elimination System (NPDES), a federal regulatory program to control discharges of pollutants to surface waters of the United States. The TCEQ administers the program, and a permit is required for any construction activity that disturbs one acre or more.

- Section 401 Water Quality Certification

Any activity requiring authorization under Section 404 of the Clean Water Act will also require a Section 401 water quality certification from the TCEQ. In Texas, these regulations are administered by the TCEQ.

8.3.5 Texas Historical Commission

The Division of Antiquities Protection of the Texas Historical Commission coordinates the program by identifying and protecting important archeological and historic sites that may be threatened by public construction projects. This department coordinates the nomination of numerous sites as State Archeological Landmarks or for listing in the *National Register of Historic Places*. Designation is often sought by interested parties as the most effective way to protect archeological sites threatened by new development or vandalism. Applicable rules are found in the Texas Administrative Code, Title 13-Cultural Resources, Part II-Texas Historical Commission, Chapters 24-28.

The USACE will require that the State Historical Preservation Officer (SHPO) review the project to ensure the project is in compliance with the National Historic Act prior to issuance of a Section 404 permit.

8.4 ENVIRONMENTAL INVENTORY

The environmental issues of this report have been developed by reference to existing information in published reports such as the Arroyo Colorado WPP, maps, aerial photography, unpublished documents and communications from government agencies, individuals, and private organizations. These issues have been summarized to provide a general review level area studied. Generally, this discussion presents a cursory, screening level perspective on the environmental issues that may affect the study area.

Important species may be considered the local dominant (most abundant) species, species having some economic or recreational importance, those exhibiting disproportionate habitat impacts (habitat formers) as well as species listed, or proposed for listing, by either the State of Texas or the federal government (protected species) or Texas Organization for Endangered Species (TOES). There are numerous unlisted species which are still of concern (due to their rarity, restricted distribution, direct exploitation, or habitat vulnerability), yet have not been included in this discussion. Typically, the level of detail required to obtain the distribution and life history of these species, so as to produce a substantive evaluation, would be beyond the scope of this screening level survey.

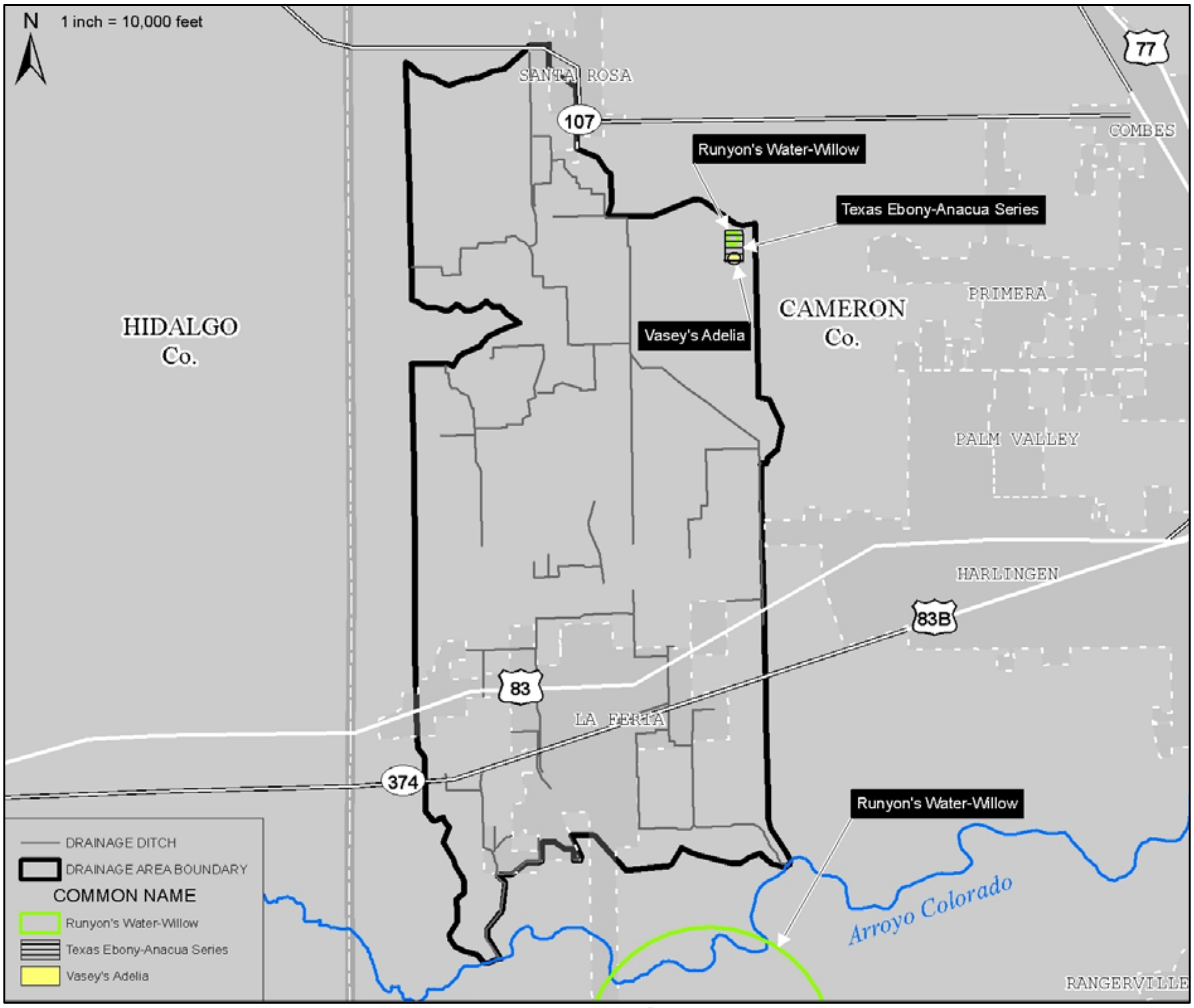

Figure 14: Environmental Inventory Map

There are several endangered and threatened species known to reside in the La Feria planning area. Figure 14 shows the possible range of these species. In connection with implementation of any structural alternative, a more detailed environmental analysis should be performed, to determine the presence of this species and an appropriate plan of action.

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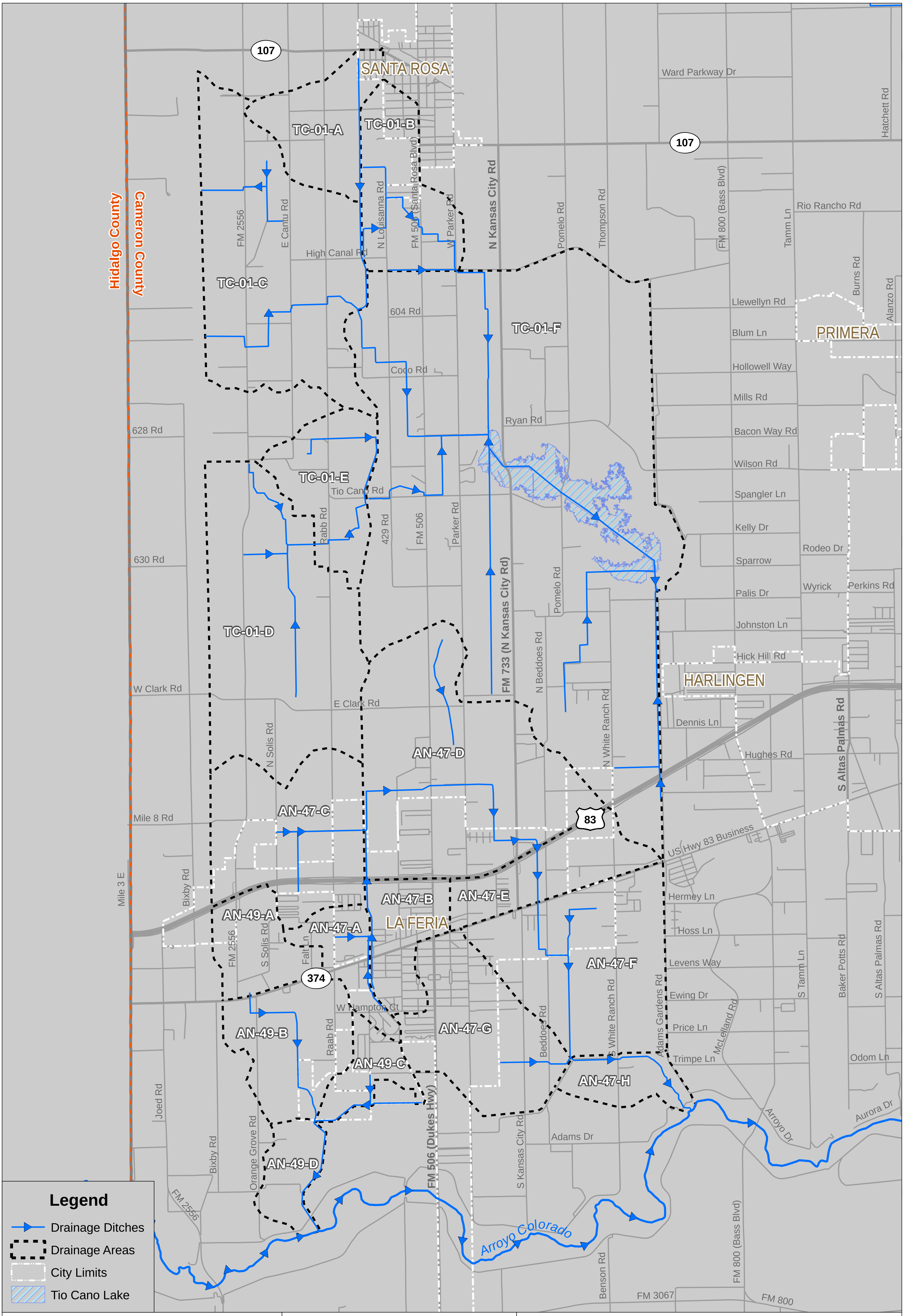
APPENDIX A
EXHIBITS



Espey Consultants, Inc.

Environmental & Engineering Services

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Feet

EXHIBIT 01

Drainage Area Map

LA FERIA FPP

CAMERON COUNTY, TEXAS

OCTOBER 2010

PROJECT NO. 09068.00

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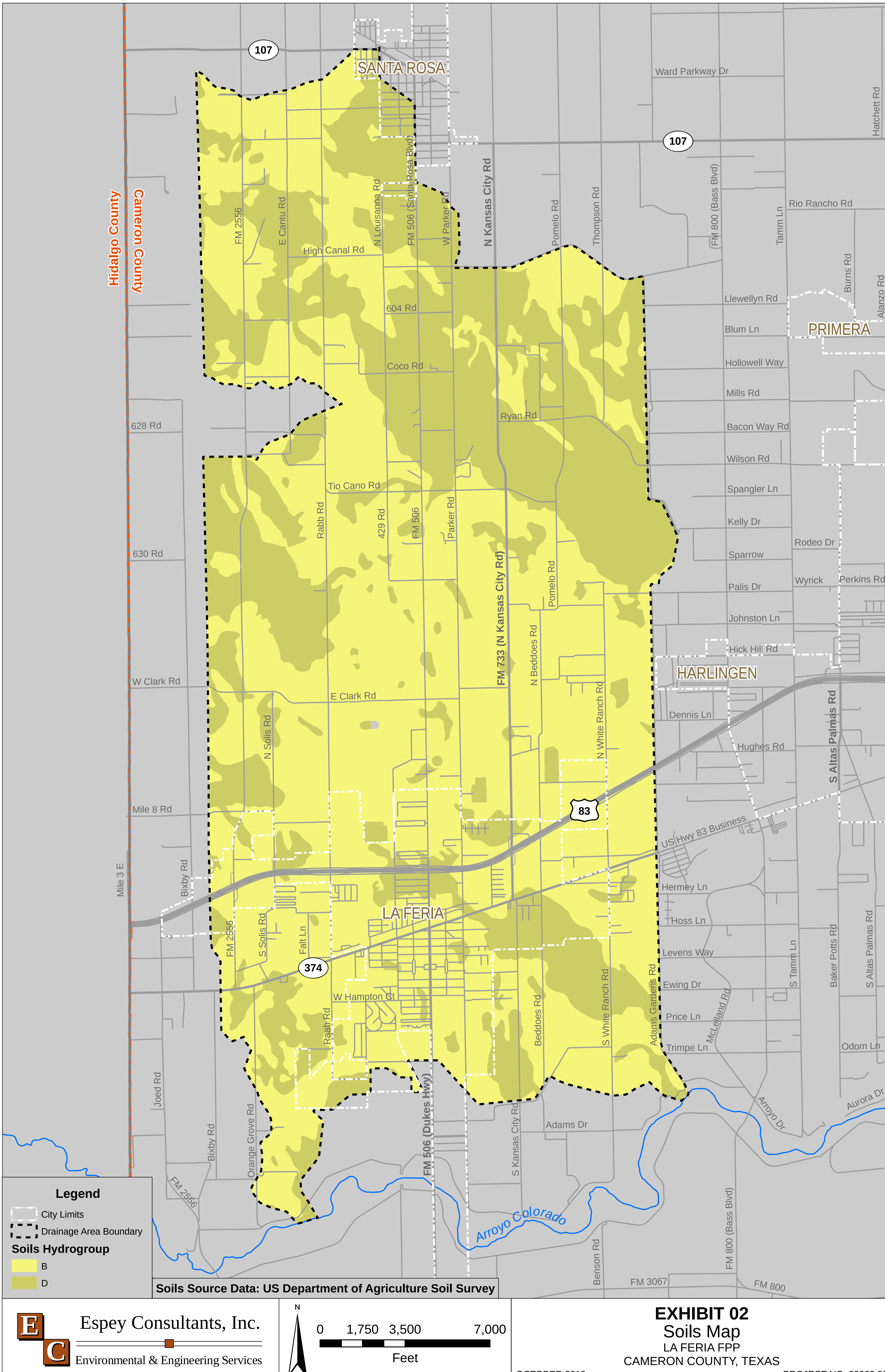

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EXHIBIT 02
Soils Map
LA FERIA FPP
CAMERON COUNTY, TEXAS

OCTOBER 2010

PROJECT NO. 09068.00

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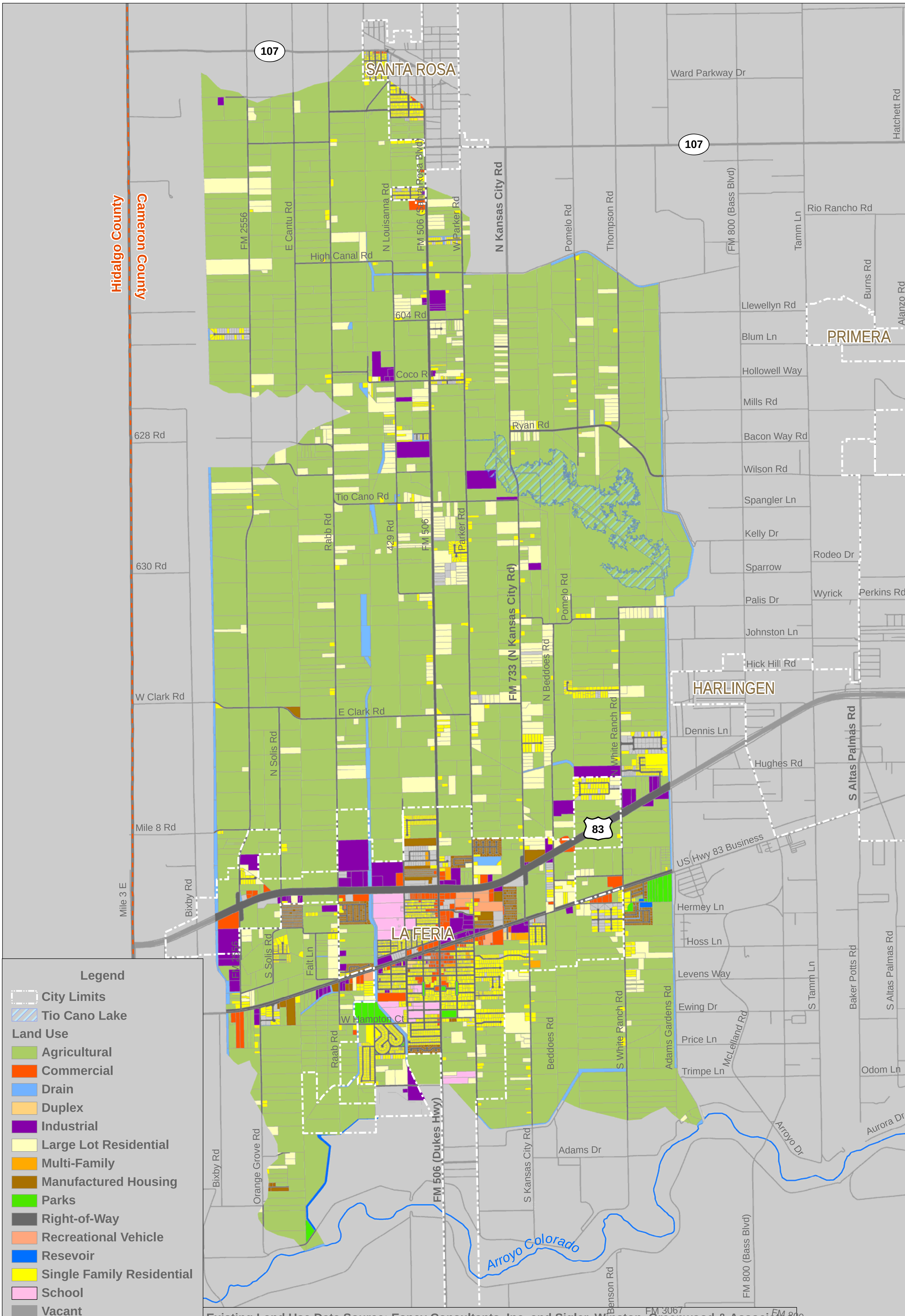

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EXHIBIT 03
Existing Land Use Map
LA FERIA FPP
CAMERON COUNTY, TEXAS

OCTOBER 2010
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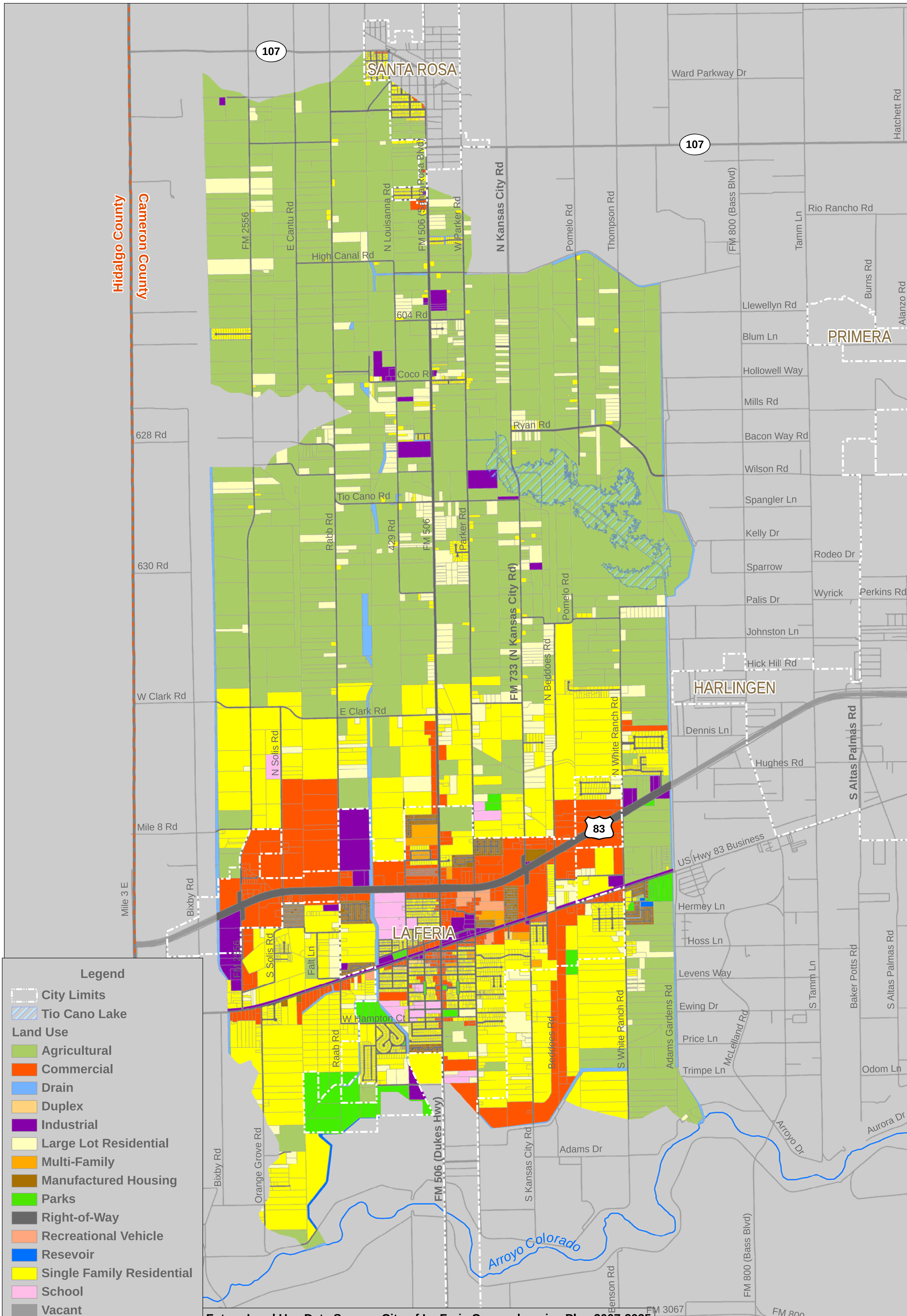

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EXHIBIT 04
Future Land Use Map
LA FERIA FPP
CAMERON COUNTY, TEXAS

OCTOBER 2010

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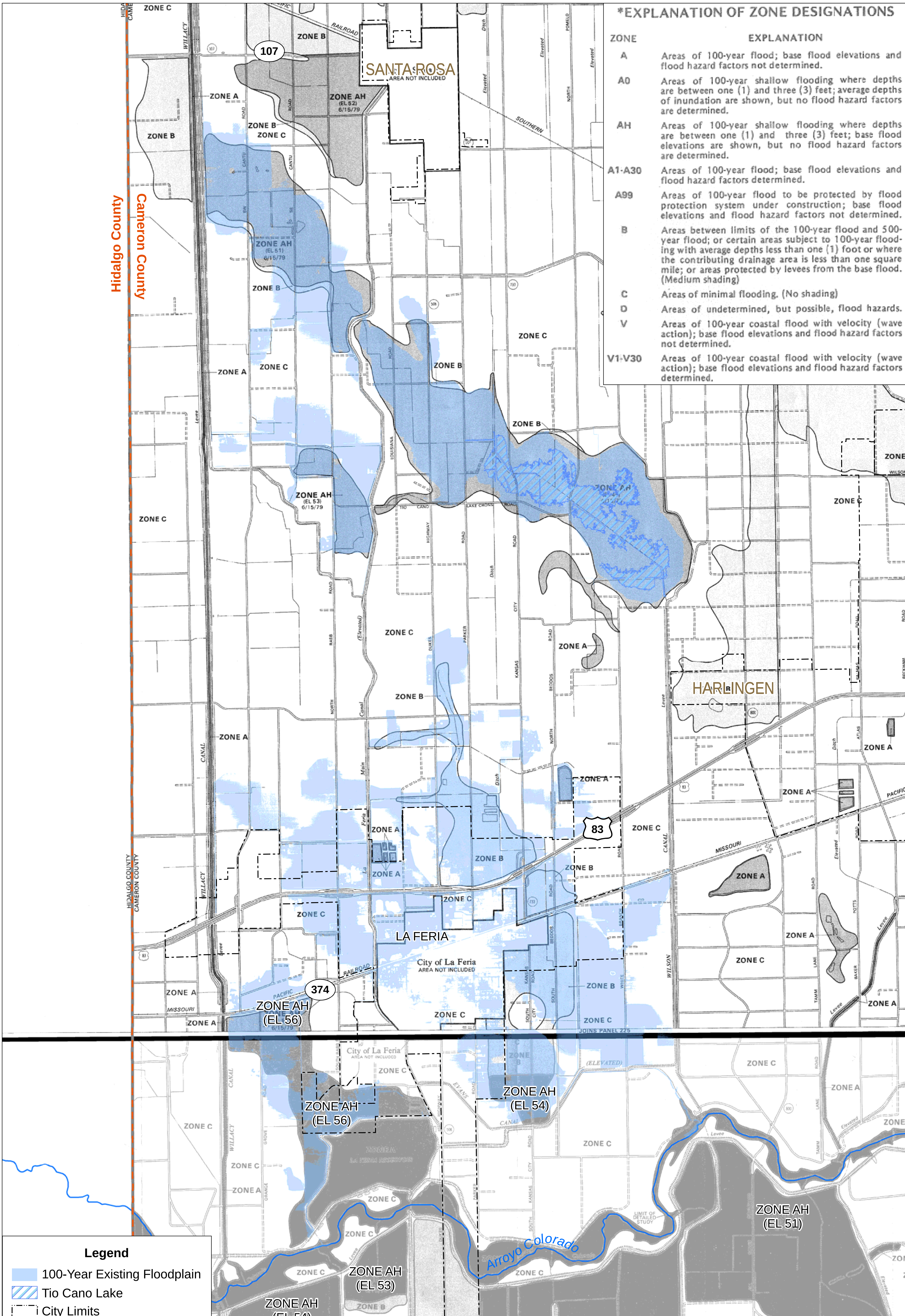

Espey Consultants, Inc.
Environmental & Engineering Services

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EXHIBIT 05
FEMA FIRM Comparison
LA FERIA FPP
CAMERON COUNTY, TEXAS

OCTOBER 2010
PROJECT NO. 09068.00

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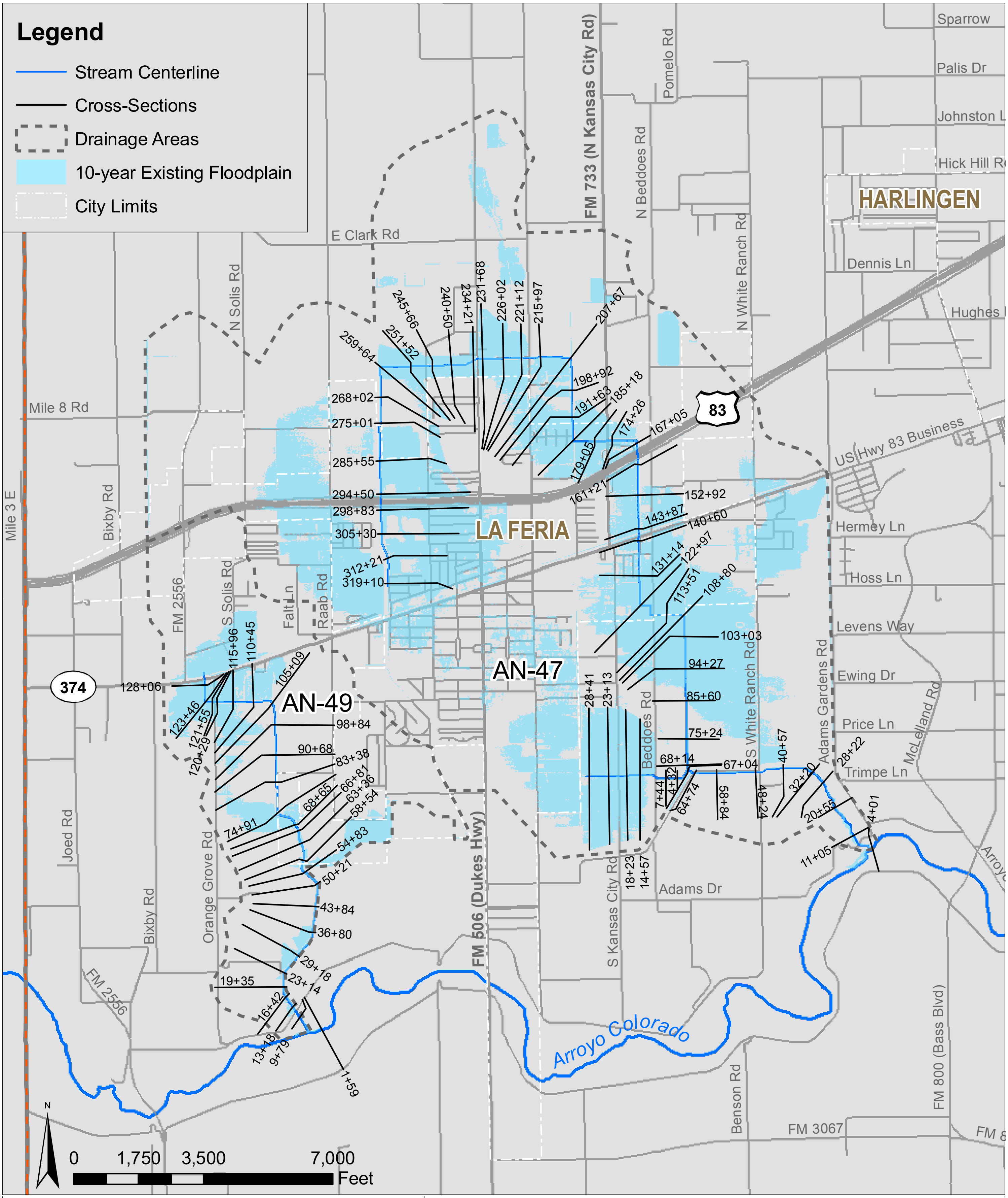

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EXHIBIT 06

10-YR Existing Cross-Section Location and Floodplain Map

LA FERIA FPP

OCTOBER 2010

PROJECT No. 09068.00

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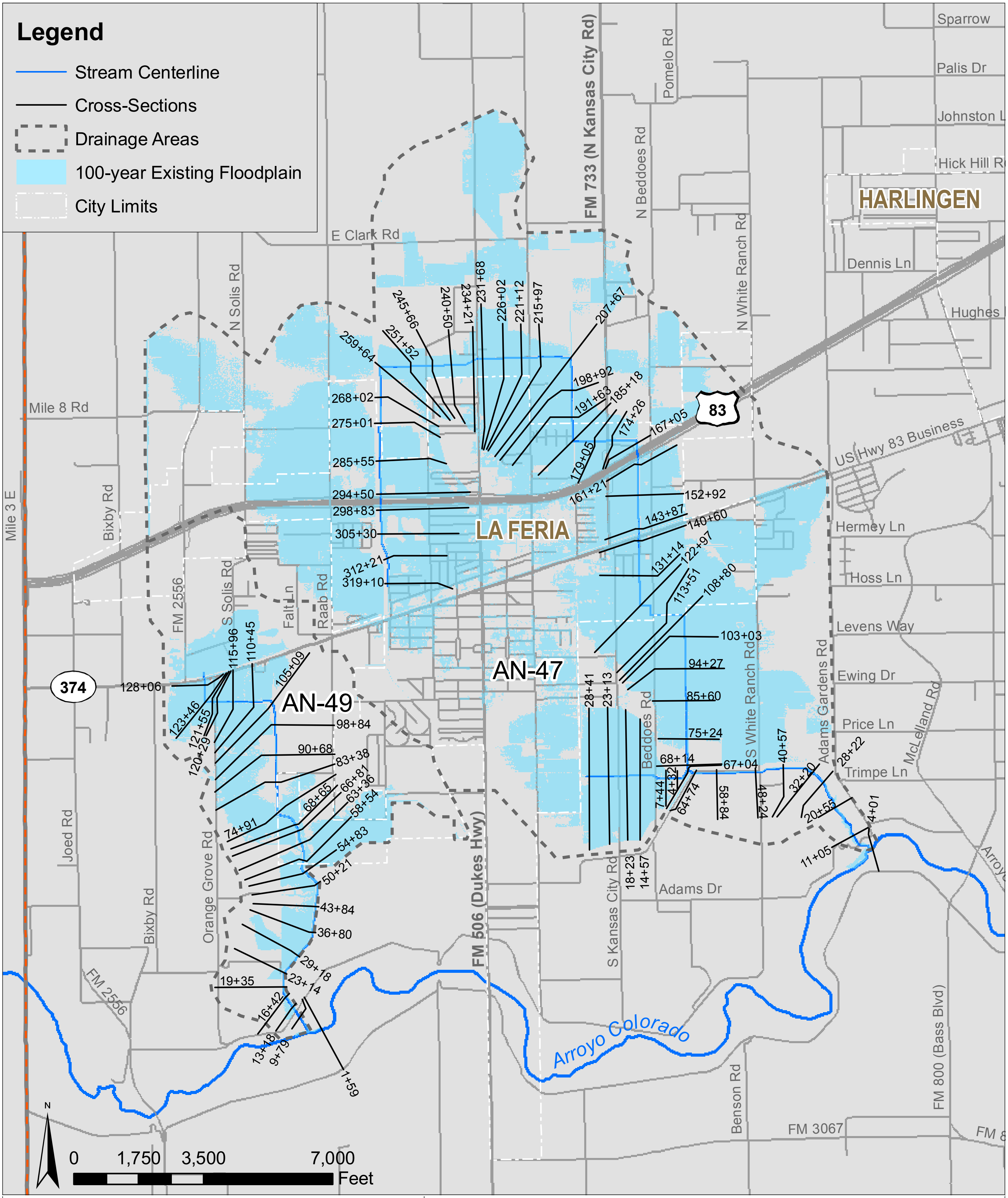

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EXHIBIT 07

100-YR Existing Cross-Section Location and Floodplain Map

LA FERIA FPP

OCTOBER 2010

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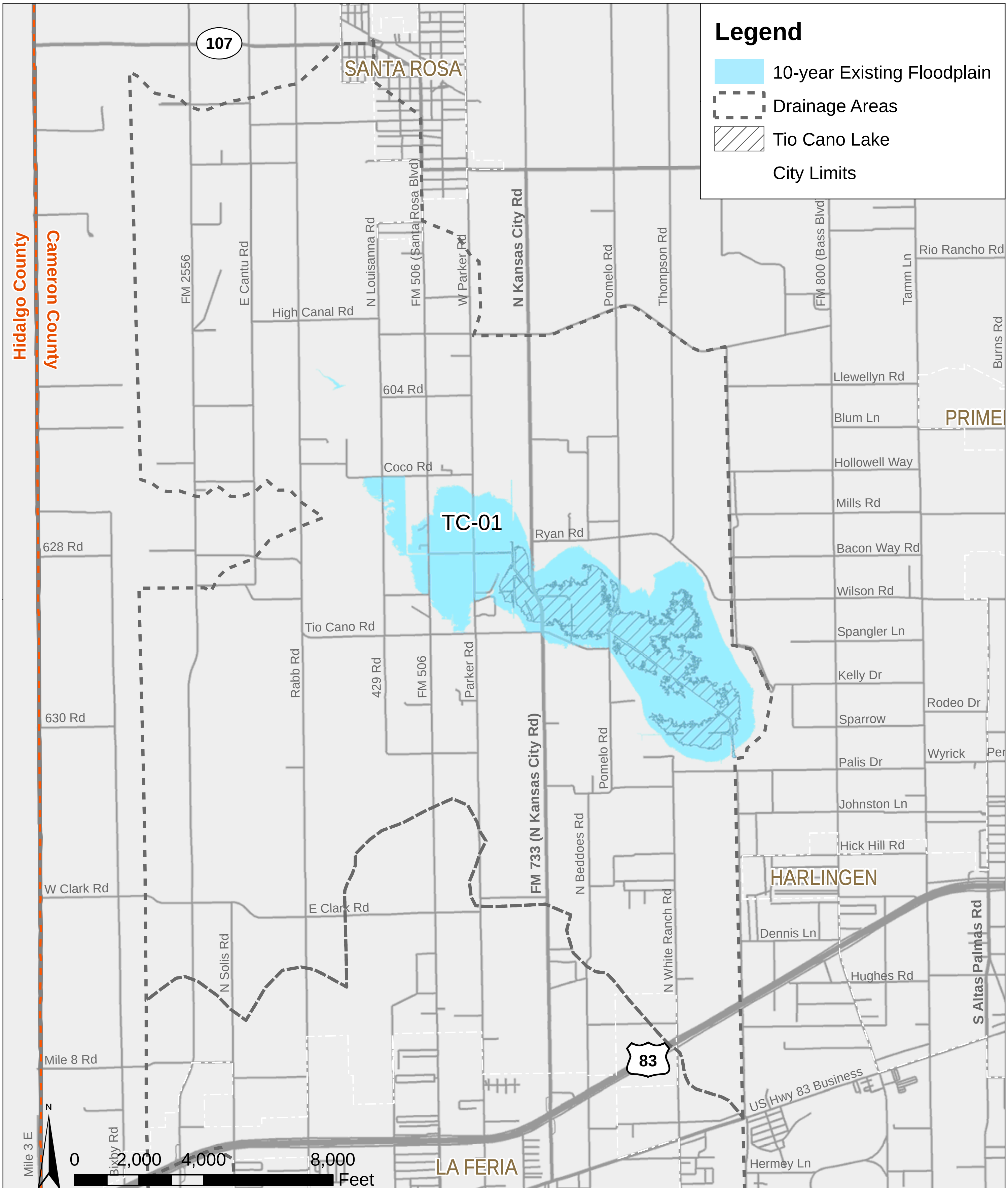

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EXHIBIT 08

10-YR Existing Tio Cano Lake Floodplain Map

LA FERIA FPP

OCTOBER 2010

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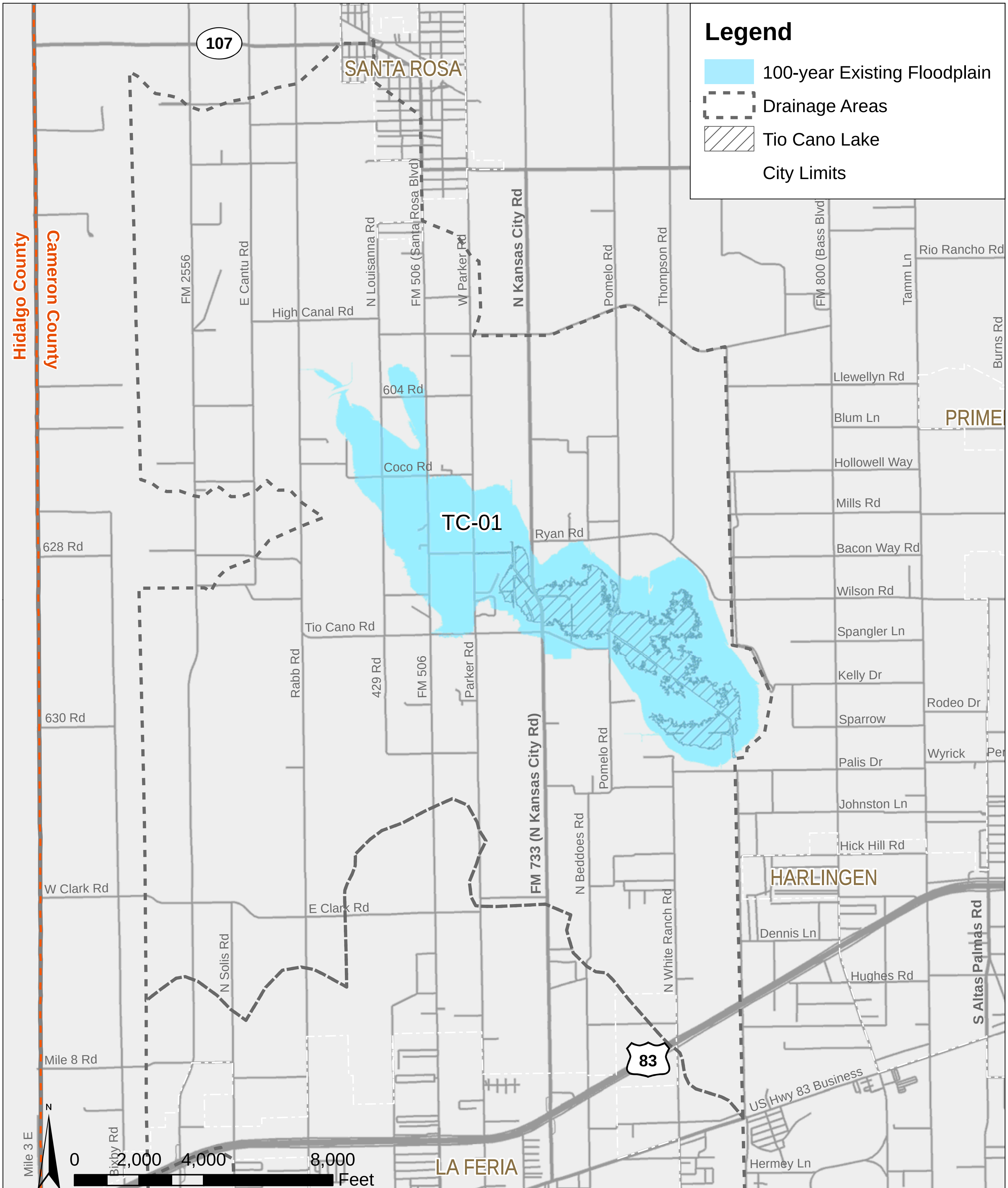

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EXHIBIT 09
100-YR Existing Tio Cano Lake Floodplain Map
LA FERIA FPP

OCTOBER 2010

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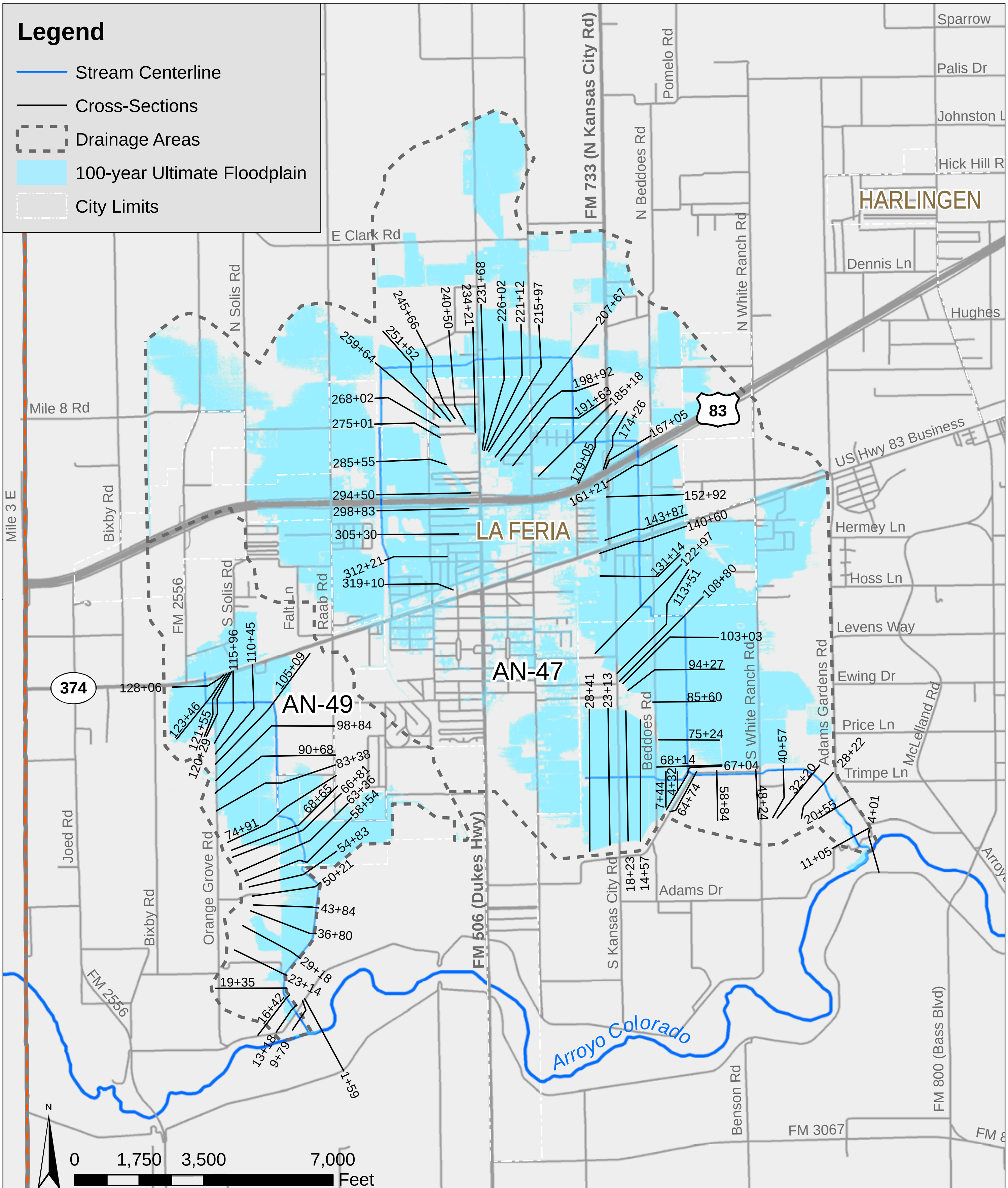

Espey Consultants, Inc.

Environmental & Engineering Services

EXHIBIT 10

100-YR Ultimate Cross-Section Location and Floodplain Map

LA FERIA FPP

OCTOBER 2010

PROJECT No. 09068.00

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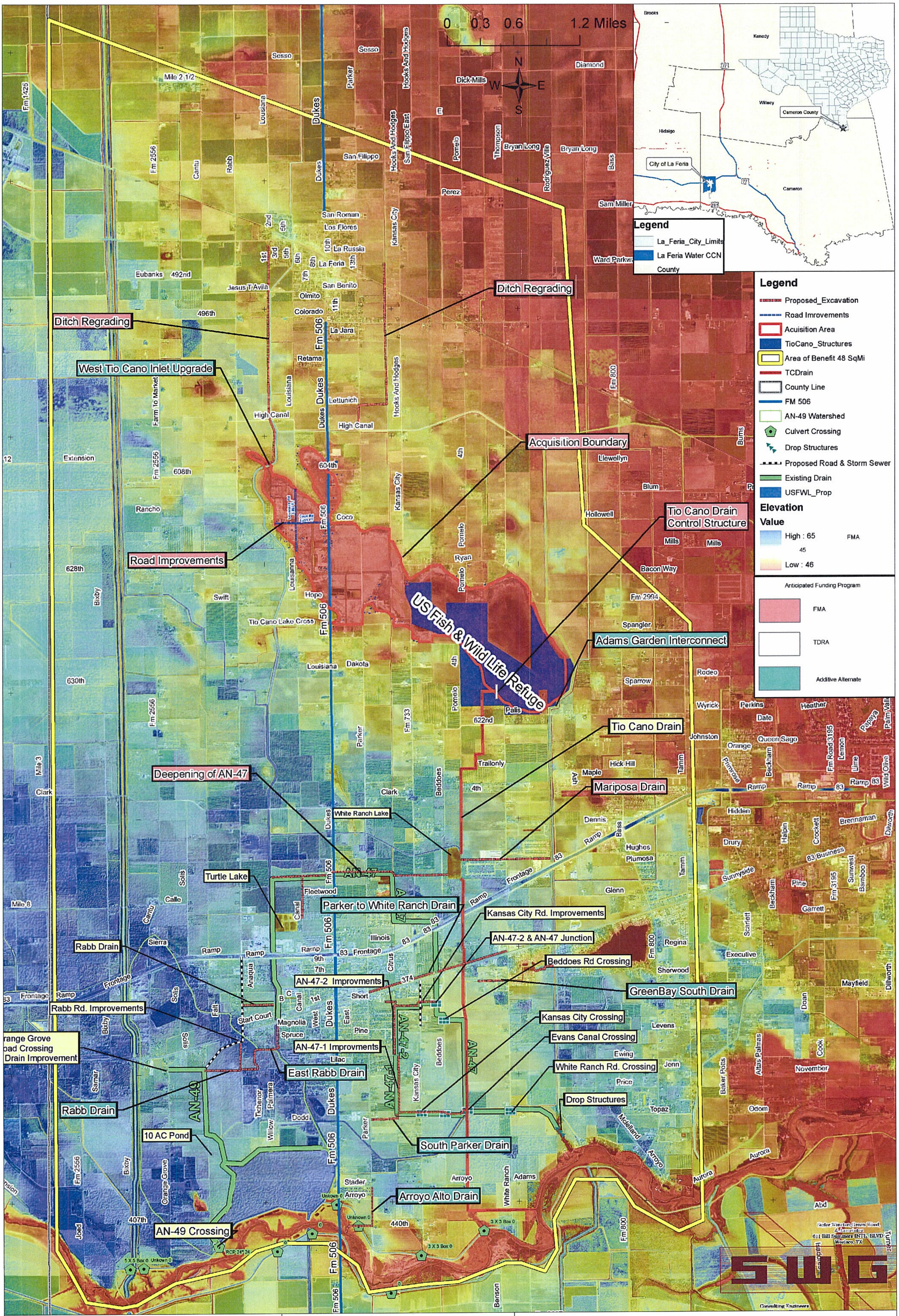

Espey Consultants, Inc.

Environmental & Engineering Services

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EXHIBIT 11

Alternative Location Map

LA FERIA FPP

CAMERON COUNTY, TEXAS

OCTOBER 2010

PROJECT NO. 09068.00

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APPENDIX B
CURVE NUMBER CALCULATIONS

LA FERIA FLOOD PROTECTION PLAN
Curve Number Calculations

Subbasin	Area of NRCS Group (acres) A	B	C	D	Total Area (acre)	Percent of Soil Type %A	%B	%C	%D	Weighted Curve Number (AMC I)	Weighted Curve Number (AMC II)
AN47A		224.72		2.93	227.66	0%	99%	0%	1%	35.3	56.3
AN47B		239.40		83.14	322.54	0%	74%	0%	26%	40.9	61.4
AN47C		656.92		182.87	839.79	0%	78%	0%	22%	40.0	60.6
AN47D		1326.84	2.21	203.43	1532.48	0%	87%	0%	13%	38.1	58.8
AN47E		375.21		23.93	399.14	0%	94%	0%	6%	36.4	57.3
AN47F		560.09		441.11	1001.20	0%	56%	0%	44%	45.1	65.3
AN47G		569.00		154.89	723.89	0%	79%	0%	21%	39.9	60.5
AN47H		182.08		36.08	218.16	0%	83%	0%	17%	38.8	59.5
AN49A		275.46		29.71	305.17	0%	90%	0%	10%	37.2	58.0
AN49B		319.34		206.83	526.18	0%	61%	0%	39%	44.0	64.3
AN49C		146.93		41.75	188.68	0%	78%	0%	22%	40.1	60.6
AN49D		157.83		53.56	211.39	0%	75%	0%	25%	40.8	61.3
TC01A		332.18255		89.653649	421.8362	0%	79%	0%	21%	39.9	60.5
TC01B		96.66		425.12	521.77	0%	19%	0%	81%	53.7	73.1
TC01C		873.69661		607.47217	1481.1688	0%	59%	0%	41%	44.4	64.6
TC01D		773.36		721.82	1495.19	0%	52%	0%	48%	46.1	66.1
TC01E		382.29		87.45	469.74	0%	81%	0%	19%	39.3	59.9
TC01F		2774.20		2356.51	5130.71	0%	54%	0%	46%	45.6	65.6

Soil Groups	AMC I	AMC II	AMC III
A	18	35	55
B	35	56	75
C	49	70	84
D	58	77	89

Assumption: Brush cover type; Fair condition
Source: TR-55

APPENDIX C
EXISTING AND ULTIMATE CONDITIONS
IMPERVIOUS COVER PERCENTAGES

LA FERIA FLOOD PROTECTION PLAN
Impervious Cover Calculations

Existing Conditions **Area in Acres**

DA_Name	Ag	Comm	Drain	Duplex	Ind	LLR	MF	MH	Parks	Resev	ROW	RV	School	SFR	Vacant	Total	% IC
AN-47-A	87.24	2.92	8.20		5.67	24.04		17.31	22.49		25.11	3.13	0.03	31.44	0.08	227.7	27.9%
AN-47-B		42.06	11.15	3.17	15.39	0.08		0.28	0.55		77.76	0.53	82.14	77.89	11.53	322.5	59.5%
AN-47-C	600.84	9.95	22.62		68.24	22.85		25.22			71.71			12.87	5.51	839.8	20.9%
AN-47-D	1036.51	10.40	24.98		50.64	155.27	4.64	53.20			110.31			59.80	26.73	1532.5	17.7%
AN-47-E	197.63	13.16	1.19		16.83	25.51		28.17			63.69	22.11		14.16	16.69	399.1	33.4%
AN-47-F	714.33	15.13	10.56	2.49	7.79	51.42	7.82	20.73	24.78	2.98	49.38	3.51		71.48	18.80	1001.2	15.9%
AN-47-G	409.21	18.61	7.04	1.02	0.32	52.39	3.96	9.06	6.08		72.47		13.93	127.35	2.44	723.9	23.3%
AN-47-H	201.67		10.31			1.17					2.47				2.54	218.2	5.6%
AN-49-A	181.91	10.42	9.55		38.26	13.03		0.00			32.18			15.90	3.91	305.2	26.8%
AN-49-B	440.95	13.84	9.93		7.61	6.01		11.39		0.09	17.43			14.23	4.70	526.2	12.9%
AN-49-C	89.02		2.72		12.33	16.84			0.27	1.96	11.89			33.97	19.68	188.7	22.3%
AN-49-D	181.05		1.36			7.63		3.96	4.15	9.31	3.42			0.51		211.4	11.9%
TC-01-A	369.77	0.94	0.75		0.00	6.67					23.94			19.34	0.42	421.8	11.1%
TC-01-B	393.24	7.33	4.77	0.65	0.39	22.90					43.12			46.08	3.28	521.8	15.6%
TC-01-C	1273.01	0.00	4.85		1.86	138.93					42.11			11.19	9.20	1481.2	7.9%
TC-01-D	1354.68		41.93			56.26		3.93			33.35			5.02		1495.2	7.0%
TC-01-E	394.27		3.46			56.75					14.29			0.97		469.7	7.9%
TC-01-F	4111.63		62.79		115.92	449.25					205.32			133.90	51.90	5130.7	11.0%

Impervious Cover Land-Use Assumptions

Land_Use	Description	% IC	Land_Use	Description	% IC
Ag	Agricultural	5%	Parks	Parks	10%
Comm	Commercial	80%	Resev	Reservoir	100%
Drain	Drainage	0%	ROW	Transportation ROW	80%
Duplex	Duplex - Residential	60%	RV	RV Park	90%
Ind	Industrial	80%	School	School	60%
LLR	Large Lot Residential	10%	SFR	Single Family	40%
MF	Multi-Family	80%	Vacant	Vacant	5%
MH	Mobile Home	70%			

LA FERIA FLOOD PROTECTION PLAN

Impervious Cover Calculations

Ultimate Conditions **Area in Acres**

DA_Name	Ag	Comm	Drain	Duplex	Ind	LLR	MF	MH	Parks	Resev	ROW	RV	School	SFR	Vacant	Total	% IC
AN-47-A		7.01	7.66		5.80	24.04	0.31	14.86	22.49		21.05	3.13	0.03	121.26		227.66	41.2%
AN-47-B		51.76	11.15	3.80	18.36	0.08			3.84		70.54	0.53	82.14	80.33		322.54	61.1%
AN-47-C	80.21	364.20	22.10		83.63	15.01		26.66			71.71		0.34	175.93		839.79	60.8%
AN-47-D	319.98	246.07	14.34		0.43	118.79	30.10	43.93	9.27		110.31		14.21	625.05		1532.47	41.0%
AN-47-E	44.09	141.65			37.05	23.14	10.52	19.52			46.47	22.11		54.59		399.14	62.3%
AN-47-F	262.69	115.62	10.56	2.49	2.97	48.67	8.33	20.73	35.95	2.98	47.07	3.51		439.62		1001.20	35.8%
AN-47-G	38.49	153.68	7.04	0.97	0.04	51.30	4.37	8.02	5.98		72.47		13.93	367.59		723.88	48.9%
AN-47-H	118.10		12.85			1.17					2.47			83.57		218.16	19.0%
AN-49-A	9.27	56.68	5.55		60.50	6.49		0.00			25.05			141.63		305.16	56.2%
AN-49-B	8.61	29.94	9.39		1.78	6.01		2.83	70.99	0.09	15.65			380.89		526.17	38.1%
AN-49-C	12.27		2.72		11.66	16.84			77.70	1.92	11.89			53.67		188.68	27.7%
AN-49-D	34.96		1.36			7.63			0.90	9.31	3.42			153.81		211.39	36.0%
TC-01-A	369.77	0.94	0.75		0.00	6.67					23.94			19.76		421.84	11.1%
TC-01-B	393.24	7.33	4.77	0.65	0.39	22.90					43.12			49.36		521.77	15.9%
TC-01-C	1273.01		4.85		1.86	138.93					42.11			20.40		1481.17	8.2%
TC-01-D	995.00	9.18	41.93			56.26					33.35		13.30	346.15		1495.18	15.8%
TC-01-E	394.27		3.46			56.75					14.29			0.97		469.74	7.9%
TC-01-F	3845.28	18.72	61.81		95.34	466.70			1.64		205.23			435.97		5130.69	13.0%

Impervious Cover Land-Use Assumptions

Land_Use	Description	% IC	Land_Use	Description	% IC
Ag	Agricultural	5%	Parks	Parks	10%
Comm	Commercial	80%	Resev	Reservoir	100%
Drain	Drainage	0%	ROW	Transportation ROW	80%
Duplex	Duplex - Residential	60%	RV	RV Park	90%
Ind	Industrial	80%	School	School	60%
LLR	Large Lot Residential	10%	SFR	Single Family	40%
MF	Multi-Family	80%	Vacant	Vacant	5%
MH	Mobile Home	70%			

APPENDIX D
TIME OF CONCENTRATION CALCULATIONS
KERBY-KIRPICH METHOD

LA FERIA FLOOD PROTECTION PLAN
Time of Concentration Calculations

Existing Conditions
Kerby-Kirpich Method of Computing
Time of Concentration

			AN47A	AN47B	AN47C	AN47D	AN47E	AN47F	AN47G	AN47H	AN49A
Kerby Overland Flow	variables	units									
Retardance Coefficient	N		0.02	0.02	0.30	0.20	0.30	0.02	0.02	0.30	0.30
Length	L	ft	200	500	500	500	490	500	500	300	320
Slope	S		0.0469	0.0015	0.0065	0.0127	0.0035	0.0065	0.0020	0.0010	0.0031
Kerby Sheet Flow Travel Time	Tc	min	3.2	11.1	28.1	19.8	32.1	7.9	10.5	34.3	27.1
Length	L	ft	500	600	500	650	700	700	700	900	500
Slope	S		0.0011	0.0010	0.0022	0.0010	0.0020	0.0016	0.0013	0.0010	0.0059
Kerby Shallow Concentrated Flow Travel Time	Tc	min	12.1	13.4	36.4	40.8	43.2	12.9	13.6	57.3	28.7
Kirpich Channelized Flow											
Length	L	ft	745	2,224	3,503	900	1,528	2,015	2,903	312	380
Slope	S		0.0011	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0340	0.0016
Kirpich Channel 1 Flow Travel Time	Tc	min	17.3	42.1	59.7	21.0	31.5	39.0	51.7	2.4	9.0
Length	L	ft	335	176	410	6,350	2,382	505	3,097	1,442	600
Slope	S		0.0100	0.0240	0.0139	0.0010	0.0010	0.0092	0.0010	0.0010	0.0010
Kirpich Channel 2 Flow Travel Time	Tc	min	4.0	1.8	4.2	94.5	44.4	5.7	54.3	30.2	15.4
Length	L	ft	3,090	176	3,236	6,143	1,016	6,410	2,864	4,392	3,401
Slope	S		0.0013	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0059	0.0010
Kirpich Channel 3 Flow Travel Time	Tc	min	49.6	6.0	56.2	92.1	23.0	95.1	51.2	36.0	58.4
Total Travel Time	**Tc**	**min**	**86.3**	**74.3**	**184.6**	**268.1**	**174.2**	**160.7**	**181.3**	**160.2**	**138.5**
Total Laf Time	**Tlag**	**min**	**51.8**	**44.6**	**110.8**	**160.9**	**104.5**	**96.4**	**108.8**	**96.1**	**83.1**

			AN49B	AN49C	AN49D	TC01A	TC01B	TC01C	TC01D	TC01E	TC01F
Kerby Overland Flow	variables	units									
Retardance Coefficient	N		0.30	0.30	0.40	0.30	0.02	0.30	0.30	0.30	0.40
Length	L	ft	500	500	300	500	440	250	450	200	500
Slope	S		0.0081	0.0090	0.0037	0.0010	0.0011	0.0017	0.0013	0.0255	0.0107
Kerby Sheet Flow Travel Time	Tc	min	26.7	26.0	28.9	43.6	11.4	28.0	39.2	13.3	28.5
Length	L	ft	600	700	700	700	700	50	700	800	700
Slope	S		0.0010	0.0013	0.0033	0.0021	0.0013	0.0026	0.0010	0.0010	0.0010
Kerby Shallow Concentrated Flow Travel Time	Tc	min	47.5	48.3	44.0	42.9	13.5	11.8	51.0	54.3	58.3
Kirpich Channelized Flow											
Length	L	ft	200	2,526	1,270	3,200	1,945	1,680	3,650	500	1,742
Slope	S		0.0163	0.0025	0.0019	0.0017	0.0010	0.0014	0.0010	0.0112	0.0029
Kirpich Channel 1 Flow Travel Time	Tc	min	2.2	32.6	21.5	45.9	38.0	29.9	61.7	5.3	23.1
Length	L	ft	3,700	2,274	3,680	812	3,799	1,508	600	4,500	4,038
Slope	S		0.0010	0.0028	0.0010	0.0015	0.0010	0.0030	0.0049	0.0010	0.0010
Kirpich Channel 2 Flow Travel Time	Tc	min	62.3	28.7	62.1	16.4	63.6	20.4	8.3	72.5	66.7
Length	L	ft	2,967	511	779	2,739	2,967	8,418	5,975	2,164	3,045
Slope	S		0.0010	0.0024	0.0247	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Kirpich Channel 3 Flow Travel Time	Tc	min	52.6	9.7	5.5	49.4	52.6	117.4	90.1	41.2	150.4
Total Travel Time	**Tc**	**min**	**191.3**	**145.2**	**162.0**	**198.2**	**179.0**	**207.5**	**250.3**	**186.5**	**327.0**
Total Laf Time	**Tlag**	**min**	**114.8**	**87.1**	**97.2**	**118.9**	**107.4**	**124.5**	**150.2**	**111.9**	**196.2**

LA FERIA FLOOD PROTECTION PLAN
Time of Concentration Calculations

Ultimate Conditions
Kerby-Kirpich Method of Computing
Time of Concentration

			AN47A	AN47B	AN47C	AN47D	AN47E	AN47F	AN47G	AN47H	AN49A
Kerby Overland Flow	variables	units									
Retardance Coefficient	N		0.02	0.02	0.02	0.02	0.30	0.02	0.02	0.20	0.02
Length	L	ft	200	500	500	500	490	500	500	300	320
Slope	S		0.0469	0.0015	0.0065	0.0127	0.0035	0.0065	0.0020	0.0010	0.0031
Kerby Sheet Flow Travel Time	Tc	min	3.2	11.1	7.9	6.8	32.1	7.9	10.5	28.4	7.7
Length	L	ft	500	600	500	650	700	700	700	900	500
Slope	S		0.0011	0.0010	0.0022	0.0010	0.0020	0.0016	0.0013	0.0010	0.0059
Kerby Shallow Concentrated Flow Travel Time	Tc	min	12.1	13.4	10.3	13.9	43.2	12.9	13.6	47.5	8.1
Kirpich Channelized Flow											
Length	L	ft	745	2,224	3,503	900	1,528	2,015	2,903	312	380
Slope	S		0.0011	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0340	0.0016
Kirpich Channel 1 Flow Travel Time	Tc	min	17.3	42.1	59.7	21.0	31.5	39.0	51.7	2.4	9.0
Length	L	ft	335	176	410	6,350	2,382	505	3,097	1,442	600
Slope	S		0.0100	0.0240	0.0139	0.0010	0.0010	0.0092	0.0010	0.0010	0.0010
Kirpich Channel 2 Flow Travel Time	Tc	min	4.0	1.8	4.2	94.5	44.4	5.7	54.3	30.2	15.4
Length	L	ft	3,090	176	3,236	6,143	1,016	6,410	2,864	4,392	3,401
Slope	S		0.0013	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0059	0.0010
Kirpich Channel 3 Flow Travel Time	Tc	min	49.6	6.0	56.2	92.1	23.0	95.1	51.2	36.0	58.4
Total Travel Time	**Tc**	**min**	**86.3**	**74.3**	**138.3**	**228.2**	**174.2**	**160.7**	**181.3**	**144.4**	**98.5**
Total Laf Time	**Tlag**	**min**	**51.8**	**44.6**	**83.0**	**136.9**	**104.5**	**96.4**	**108.8**	**86.7**	**59.1**

			AN49B	AN49C	AN49D	TC01A	TC01B	TC01C	TC01D	TC01E	TC01F
Kerby Overland Flow	variables	units									
Retardance Coefficient	N		0.02	0.20	0.40	0.30	0.02	0.30	0.20	0.30	0.40
Length	L	ft	500	500	300	500	440	250	450	200	500
Slope	S		0.0081	0.0090	0.0037	0.0010	0.0011	0.0017	0.0013	0.0255	0.0107
Kerby Sheet Flow Travel Time	Tc	min	7.5	21.5	28.9	43.6	11.4	28.0	32.4	13.3	28.5
Length	L	ft	600	700	700	700	700	50	700	800	700
Slope	S		0.0010	0.0013	0.0033	0.0021	0.0013	0.0026	0.0010	0.0010	0.0010
Kerby Shallow Concentrated Flow Travel Time	Tc	min	13.4	40.0	44.0	42.9	13.5	11.8	42.2	54.3	58.3
Kirpich Channelized Flow											
Length	L	ft	200	2,526	1,270	3,200	1,945	1,680	3,650	500	1,742
Slope	S		0.0163	0.0025	0.0019	0.0017	0.0010	0.0014	0.0010	0.0112	0.0029
Kirpich Channel 1 Flow Travel Time	Tc	min	2.2	32.6	21.5	45.9	38.0	29.9	61.7	5.3	23.1
Length	L	ft	3,700	2,274	3,680	812	3,799	1,508	600	4,500	4,038
Slope	S		0.0010	0.0028	0.0010	0.0015	0.0010	0.0030	0.0049	0.0010	0.0010
Kirpich Channel 2 Flow Travel Time	Tc	min	62.3	28.7	62.1	16.4	63.6	20.4	8.3	72.5	66.7
Length	L	ft	2,967	511	779	2,739	2,967	8,418	5,975	2,164	3,045
Slope	S		0.0010	0.0024	0.0247	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Kirpich Channel 3 Flow Travel Time	Tc	min	52.6	9.7	5.5	49.4	52.6	117.4	90.1	41.2	150.4
Total Travel Time	**Tc**	**min**	**138.1**	**132.4**	**162.0**	**198.2**	**179.0**	**207.5**	**234.7**	**186.5**	**327.0**
Total Laf Time	**Tlag**	**min**	**82.8**	**79.4**	**97.2**	**118.9**	**107.4**	**124.5**	**140.8**	**111.9**	**196.2**

APPENDIX E
HEC-RAS OUTPUT REPORTS

```
                         HEC-RAS Version 4.1.0 Jan 2010
                          U.S. Army Corps of Engineers
                         Hydrologic Engineering Center
                               609 Second Street
                               Davis, California

            X     X  XXXXXX    XXXX        XXXX       XX      XXXX
            X     X  X       X    X       X   X     X  X    X
            X     X  X       X            X   X    X    X   X
            XXXXXXX  XXXX    X       XXX  XXXX     XXXXXX    XXXX
            X     X  X       X            X  X     X    X        X
            X     X  X       X    X       X   X    X    X        X
            X     X  XXXXXX    XXXX       X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: AN-47
Project File : AN47.prj
Run Date and Time: 10/4/2010 3:50:58 PM

Project in English units

PLAN DATA

Plan Title: Existing Conditions
Plan File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-47\AN47.p03

Geometry Title: Existing Conditions
Geometry File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-47\AN47.g02

Flow Title : Existing Conditions
Flow File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-47\AN47.f03

Plan Summary Information:

Number of:				
	Cross Sections =	53	Multiple Openings =	0
	Culverts =	14	Inline Structures =	0
	Bridges =	0	Lateral Structures =	0

Computational Information
- Water surface calculation tolerance = 0.01
- Critical depth calculation tolerance = 0.01
- Maximum number of iterations = 20
- Maximum difference tolerance = 0.3
- Flow tolerance factor = 0.001

Computation Options
- Critical depth computed only where necessary
- Conveyance Calculation Method: At breaks in n values only
- Friction Slope Method: Average Conveyance
- Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Existing Conditions
Flow File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-47\AN47.f03

Flow Data (cfs)

River	Reach	RS	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR	Future 100yr	100-YR TW Test
AN-47	1	31910	51.3	48.3	46.8	44.9	43.5	41.8	51.9	51.3
AN-47	1	29450	102.7	77.3	68.3	61.6	57.2	49.1	156.7	102.7
AN-47	1	24050	102.7	77.3	68.3	61.6	57.2	49.1	156.7	102.7
AN-47	1	15292	276	237.7	208.1	165.6	134.2	98	387.3	276
AN-47	1	10880	519.8	507.4	483.3	446.4	396.1	247.8	543.2	519.8
AN-47	2	6704	519.8	507.4	483.3	446.4	396.1	247.8	543.2	519.8
AN-47	2	5884	576.9	547.4	513	470	410.3	251.2	613.2	576.9
AN-47 Trib 1	1	2841	379.4	311.5	261.3	185.5	131.7	74	528.6	379.4

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
AN-47	2	100-YR		Normal S = 0.005
AN-47	2	50-YR		Normal S = 0.005
AN-47	2	25-YR		Normal S = 0.005
AN-47	2	10-YR		Normal S = 0.005
AN-47	2	5-YR		Normal S = 0.005
AN-47	2	2-YR		Normal S = 0.005
AN-47	2	Future 100yr		Normal S = 0.005

SUMMARY OF MANNING'S N VALUES

River:AN-47

Reach	River Sta.	n1	n2	n3
1	31910	.055	.045	.055
1	31221	.055	.045	.055
1	30530	.055	.045	.055
1	29883	.055	.045	.055
1	29619	Culvert		
1	29450	.055	.045	.055
1	28555	.055	.045	.055
1	27501	.055	.045	.055
1	26802	.055	.045	.055
1	25964	.055	.045	.055
1	25152	.055	.045	.055
1	24744	Culvert		
1	24566	.055	.045	.055
1	24050	.055	.045	.055
1	23421	.055	.045	.055
1	23317	Culvert		
1	23168	.055	.045	.055
1	22602	.055	.045	.055
1	22389	Culvert		
1	22112	.055	.045	.055
1	21907	Culvert		
1	21597	.055	.045	.055
1	20767	.055	.045	.055
1	19892	.055	.045	.055
1	19163	.055	.045	.055
1	18518	.055	.045	.055
1	17905	.055	.045	.055
1	17594	Culvert		
1	17426	.055	.045	.055
1	16705	.055	.045	.055
1	16457	Culvert		
1	16121	.055	.045	.055
1	15292	.055	.045	.055
1	14387	.055	.045	.055
1	14266	Culvert		
1	14060	.055	.045	.055
1	13114	.055	.045	.055
1	12297	.055	.045	.055
1	11708	Culvert		
1	11351	.055	.045	.055
1	10880	.055	.045	.055
1	10303	.055	.045	.055
1	9427	.055	.045	.055
1	8560	.055	.045	.055
1	7524	.055	.045	.055
1	6814	.055	.045	.055
2	6704	.055	.045	.055
2	6640	Culvert		
2	6474	.055	.045	.055
2	5884	.055	.045	.055
2	4824	.055	.045	.055
2	4716	Culvert		
2	4057	.055	.045	.055
2	3220	.055	.045	.055
2	2822	.055	.045	.055
2	2055	.055	.045	.055
2	1105	.055	.045	.055
2	832	Culvert		
2	401	.06	.055	.06

River:AN-47 Trib 1

Reach	River Sta.	n1	n2	n3
1	2841	.055	.045	.055
1	2313	.055	.045	.055
1	2077	Culvert		
1	1823	.055	.045	.055
1	1457	.055	.045	.055
1	1033	Culvert		
1	744	.055	.045	.055
1	432	.055	.045	.055

SUMMARY OF REACH LENGTHS

River: AN-47

Reach	River Sta.	Left	Channel	Right
1	31910	669.99	689.19	708.38
1	31221	710.71	691.25	671.8
1	30530	646.65	647.47	648.28
1	29883	432.34	428.17	432.01
1	29619	Culvert		
1	29450	894.55	895.76	896.97
1	28555	1058.97	1053.2	1041.84
1	27501	698.62	699.31	700.01
1	26802	881.91	838.4	794.89
1	25964	868.32	812.11	755.9
1	25152	587.26	585.9	584.55
1	24744	Culvert		
1	24566	511.51	515.49	519.46
1	24050	634.11	625.71	625.31
1	23421	250.72	252.7	254.68
1	23317	Culvert		
1	23168	566.02	565.74	565.47
1	22602	490.76	490.49	490.23
1	22389	Culvert		
1	22112	512.98	514.78	516.59
1	21907	Culvert		
1	21597	868.98	829.4	797.23
1	20767	922.44	875.24	820.63
1	19892	729.27	728.81	728.34
1	19163	596.22	645.68	695.15
1	18518	563.82	612.5	660.36
1	17905	478.76	478.74	478.73
1	17594	Culvert		
1	17426	775	721.24	667.38
1	16705	613.52	584.61	555.21
1	16457	Culvert		
1	16121	824.74	828.26	831.78
1	15292	907.23	901.71	904.19
1	14387	326.24	326.24	326.24
1	14266	Culvert		
1	14060	946.36	945.9	945.45
1	13114	769.5	817.91	861.3
1	12297	884.81	945.44	995.17
1	11708	Culvert		
1	11351	510.77	471.4	432.03
1	10880	617.72	576.89	536.07
1	10303	874.66	875.57	876.49
1	9427	866.91	867.16	867.41
1	8560	1036.68	1035.84	1035
1	7524	708.27	709.95	711.63
1	6814	0	0	0
2	6704	198	230	187
2	6640	Culvert		
2	6474	561.31	589.72	618.12
2	5884	1058.78	1060.27	1061.75
2	4824	767.34	766.35	765.36
2	4716	Culvert		
2	4057	873.43	837.54	801.65
2	3220	399.4	397.56	395.72
2	2822	782.89	766.7	750.51
2	2055	951.24	950.17	949.11
2	1105	589.02	704.32	805.99
2	832	Culvert		
2	401	0	0	0

River: AN-47 Trib 1

Reach	River Sta.	Left	Channel	Right
1	2841	527.96	528.04	528.14
1	2313	490.74	490.7	490.8
1	2077	Culvert		
1	1823	366.11	365.94	365.74
1	1457	712.3	712.2	711.85
1	1033	Culvert		
1	744	312.74	312.88	313.05
1	432	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: AN-47

Reach	River Sta.	Contr.	Expan.
1	31910	.1	.3
1	31221	.1	.3
1	30530	.1	.3

1	29883	.3	.5
1	29619	Culvert	
1	29450	.3	.5
1	28555	.1	.3
1	27501	.1	.3
1	26802	.1	.3
1	25964	.1	.3
1	25152	.3	.5
1	24744	Culvert	
1	24566	.3	.5
1	24050	.1	.3
1	23421	.3	.5
1	23317	Culvert	
1	23168	.3	.5
1	22602	.3	.5
1	22389	Culvert	
1	22112	.3	.5
1	21907	Culvert	
1	21597	.3	.5
1	20767	.1	.3
1	19892	.1	.3
1	19163	.1	.3
1	18518	.1	.3
1	17905	.3	.5
1	17594	Culvert	
1	17426	.3	.5
1	16705	.3	.5
1	16457	Culvert	
1	16121	.3	.5
1	15292	.1	.3
1	14387	.3	.5
1	14266	Culvert	
1	14060	.3	.5
1	13114	.1	.3
1	12297	.3	.5
1	11708	Culvert	
1	11351	.3	.5
1	10880	.1	.3
1	10303	.1	.3
1	9427	.1	.3
1	8560	.1	.3
1	7524	.1	.3
1	6814	.1	.3
2	6704	.3	.5
2	6640	Culvert	
2	6474	.3	.5
2	5884	.1	.3
2	4824	.3	.5
2	4716	Culvert	
2	4057	.3	.5
2	3220	.1	.3
2	2822	.1	.3
2	2055	.1	.3
2	1105	.3	.5
2	832	Culvert	
2	401	.3	.5

River: AN-47 Trib 1

Reach	River Sta.	Contr.	Expan.
1	2841	.1	.3
1	2313	.3	.5
1	2077	Culvert	
1	1823	.3	.5
1	1457	.3	.5
1	1033	Culvert	
1	744	.3	.5
1	432	.1	.3

Profile Output Table - Standard Table 1

River	Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AN-47 Trib 1	1	2841	100-YR	379.40	47.63	54.98	52.81	54.98	0.000013	0.26	2764.79	3630.93	0.02
AN-47 Trib 1	1	2841	50-YR	311.50	47.63	54.60	52.42	54.60	0.000020	0.30	2135.72	3190.26	0.03
AN-47 Trib 1	1	2841	25-YR	261.30	47.63	54.59	52.10	54.59	0.000015	0.26	2108.23	3184.82	0.02
AN-47 Trib 1	1	2841	10-YR	185.50	47.63	54.57	51.52	54.57	0.000008	0.19	2081.10	3179.44	0.02
AN-47 Trib 1	1	2841	5-YR	131.70	47.63	53.86	51.03	53.94	0.001218	2.18	60.38	2804.13	0.22
AN-47 Trib 1	1	2841	2-YR	74.00	47.63	52.66	50.33	52.72	0.001212	1.88	39.28	15.71	0.21
AN-47 Trib 1	1	2841	Future 100yr	528.60	47.63	55.39	53.55	55.39	0.000012	0.27	3441.48	3639.81	0.02
AN-47 Trib 1	1	2841	100-YR TW Test	379.40	47.63	54.98	52.81	54.98	0.000013	0.26	2761.61	3630.89	0.02
AN-47 Trib 1	1	2313	100-YR	379.40	47.44	54.97	53.26	54.97	0.000074	0.64	1060.87	3649.32	0.06
AN-47 Trib 1	1	2313	50-YR	311.50	47.44	54.58	53.19	54.58	0.000101	0.70	837.85	3101.26	0.06
AN-47 Trib 1	1	2313	25-YR	261.30	47.44	54.57	52.10	54.57	0.000072	0.59	831.98	3099.69	0.05
AN-47 Trib 1	1	2313	10-YR	185.50	47.44	54.56	51.49	54.56	0.000037	0.42	827.23	3098.41	0.04

AN-47 Trib 1	1	2313		5-YR	131.70	47.44	53.76	50.97	53.76	0.000129	0.67	416.79	2517.19	0.07
AN-47 Trib 1	1	2313		2-YR	74.00	47.44	51.15	50.25	51.38	0.007805	3.84	19.28	10.38	0.50
AN-47 Trib 1	1	2313		Future 100yr	528.60	47.44	55.38	53.39	55.38	0.000025	0.40	2867.59	3658.53	0.03
AN-47 Trib 1	1	2313		100-YR TW Test	379.40	47.44	54.96	53.26	54.97	0.000075	0.65	1059.70	3649.27	0.06
AN-47 Trib 1	1	2077	S. Kansas City R		Culvert									
AN-47 Trib 1	1	1823		100-YR	379.40	46.65	54.97	51.18	54.97	0.000013	0.30	3606.65	3520.06	0.02
AN-47 Trib 1	1	1823		50-YR	311.50	46.65	54.58	50.78	54.58	0.000106	0.81	924.03	3503.27	0.07
AN-47 Trib 1	1	1823		25-YR	261.30	46.65	54.57	50.46	54.57	0.000077	0.69	915.85	3502.37	0.06
AN-47 Trib 1	1	1823		10-YR	185.50	46.65	54.56	49.89	54.56	0.000040	0.50	906.06	3501.34	0.04
AN-47 Trib 1	1	1823		5-YR	131.70	46.65	53.23	49.40	53.28	0.000622	1.72	76.36	85.09	0.16
AN-47 Trib 1	1	1823		2-YR	74.00	46.65	51.21	48.77	51.26	0.001008	1.81	40.86	14.95	0.19
AN-47 Trib 1	1	1823		Future 100yr	528.60	46.65	55.37	51.94	55.37	0.000009	0.26	5042.04	3520.06	0.02
AN-47 Trib 1	1	1823		100-YR TW Test	379.40	46.65	54.97	51.18	54.97	0.000013	0.30	3608.46	3520.06	0.02
AN-47 Trib 1	1	1457		100-YR	379.40	45.85	54.96	50.74	54.96	0.000016	0.37	3227.22	3271.22	0.03
AN-47 Trib 1	1	1457		50-YR	311.50	45.85	54.54	50.34	54.55	0.000093	0.83	1171.78	3192.29	0.06
AN-47 Trib 1	1	1457		25-YR	261.30	45.85	54.54	50.01	54.55	0.000065	0.70	1173.48	3192.58	0.05
AN-47 Trib 1	1	1457		10-YR	185.50	45.85	54.54	49.44	54.55	0.000033	0.50	1175.46	3192.92	0.04
AN-47 Trib 1	1	1457		5-YR	131.70	45.85	53.03	48.94	53.07	0.000513	1.63	80.73	20.36	0.14
AN-47 Trib 1	1	1457		2-YR	74.00	45.85	50.86	48.27	50.90	0.000920	1.75	42.27	15.16	0.18
AN-47 Trib 1	1	1457		Future 100yr	528.60	45.85	55.37	51.50	55.37	0.000011	0.31	4567.32	3271.22	0.02
AN-47 Trib 1	1	1457		100-YR TW Test	379.40	45.85	54.96	50.74	54.96	0.000016	0.37	3228.93	3271.22	0.03
AN-47 Trib 1	1	1033	Beddoes Road		Culvert									
AN-47 Trib 1	1	744		100-YR	379.40	46.18	54.79	50.85	54.96	0.001761	3.33	113.93	759.16	0.27
AN-47 Trib 1	1	744		50-YR	311.50	46.18	54.28	50.42	54.42	0.001574	3.05	101.99	97.76	0.25
AN-47 Trib 1	1	744		25-YR	261.30	46.18	53.72	50.07	53.85	0.001549	2.92	89.57	21.23	0.25
AN-47 Trib 1	1	744		10-YR	185.50	46.18	52.96	49.47	53.06	0.001259	2.49	74.36	19.04	0.22
AN-47 Trib 1	1	744		5-YR	131.70	46.18	52.13	48.97	52.21	0.001141	2.21	59.49	16.98	0.21
AN-47 Trib 1	1	744		2-YR	74.00	46.18	50.60	48.29	50.66	0.001341	2.04	36.25	13.34	0.22
AN-47 Trib 1	1	744		Future 100yr	528.60	46.18	55.25	51.65	55.37	0.001478	3.12	284.00	953.99	0.25
AN-47 Trib 1	1	744		100-YR TW Test	379.40	46.18	54.79	50.85	54.96	0.001760	3.33	113.95	760.10	0.27
AN-47 Trib 1	1	432		100-YR	379.40	46.50	53.91	51.20	54.19	0.003337	4.24	89.38	22.00	0.37
AN-47 Trib 1	1	432		50-YR	311.50	46.50	53.52	50.78	53.75	0.002858	3.84	81.19	20.62	0.34
AN-47 Trib 1	1	432		25-YR	261.30	46.50	52.95	50.44	53.17	0.002956	3.73	69.99	18.99	0.34
AN-47 Trib 1	1	432		10-YR	185.50	46.50	52.36	49.86	52.52	0.002326	3.13	59.22	17.55	0.30
AN-47 Trib 1	1	432		5-YR	131.70	46.50	51.58	49.37	51.70	0.002280	2.85	46.18	15.62	0.29
AN-47 Trib 1	1	432		2-YR	74.00	46.50	49.62	48.69	49.82	0.006615	3.65	20.26	10.80	0.47
AN-47 Trib 1	1	432		Future 100yr	528.60	46.50	54.43	51.96	54.85	0.004660	5.22	101.44	245.97	0.44
AN-47 Trib 1	1	432		100-YR TW Test	379.40	46.50	53.91	51.20	54.19	0.003335	4.24	89.41	22.00	0.37
AN-47	1	31910		100-YR	51.30	49.36	56.81	51.17	56.81	0.000000	0.03	3285.51	1711.90	0.00
AN-47	1	31910		50-YR	48.30	49.36	56.75	51.12	56.75	0.000000	0.03	3187.47	1710.23	0.00
AN-47	1	31910		25-YR	46.80	49.36	56.73	51.11	56.73	0.000000	0.03	3149.59	1709.59	0.00
AN-47	1	31910		10-YR	44.90	49.36	56.65	51.07	56.65	0.000000	0.03	3013.64	1707.28	0.00
AN-47	1	31910		5-YR	43.50	49.36	56.52	51.05	56.52	0.000000	0.03	2798.71	1703.62	0.00
AN-47	1	31910		2-YR	41.80	49.36	54.84	51.02	54.85	0.000131	0.70	60.02	651.63	0.07
AN-47	1	31910		Future 100yr	51.90	49.36	56.90	51.18	56.90	0.000000	0.03	3449.88	1734.39	0.00
AN-47	1	31910		100-YR TW Test	51.30	49.36	56.81	51.17	56.81	0.000000	0.03	3287.32	1711.93	0.00
AN-47	1	31221		100-YR	51.30	49.10	56.81	50.76	56.81	0.000012	0.29	175.83	1614.76	0.02
AN-47	1	31221		50-YR	48.30	49.10	56.75	50.73	56.75	0.000011	0.28	173.55	1613.83	0.02
AN-47	1	31221		25-YR	46.80	49.10	56.73	50.70	56.73	0.000011	0.27	172.68	1613.47	0.02
AN-47	1	31221		10-YR	44.90	49.10	56.65	50.67	56.65	0.000010	0.26	169.54	1612.17	0.02
AN-47	1	31221		5-YR	43.50	49.10	56.52	50.65	56.52	0.000010	0.26	164.62	1521.06	0.02
AN-47	1	31221		2-YR	41.80	49.10	54.80	50.63	54.80	0.000034	0.40	103.67	324.61	0.04
AN-47	1	31221		Future 100yr	51.90	49.10	56.90	50.77	56.90	0.000012	0.29	179.66	1616.33	0.02
AN-47	1	31221		100-YR TW Test	51.30	49.10	56.81	50.76	56.81	0.000012	0.29	175.87	1614.78	0.02
AN-47	1	30530		100-YR	51.30	48.79	56.80	49.73	56.80	0.000004	0.18	359.01	1588.31	0.01
AN-47	1	30530		50-YR	48.30	48.79	56.75	49.70	56.75	0.000004	0.18	345.86	1556.32	0.01
AN-47	1	30530		25-YR	46.80	48.79	56.73	49.69	56.73	0.000003	0.17	340.94	1543.76	0.01
AN-47	1	30530		10-YR	44.90	48.79	56.65	49.67	56.65	0.000003	0.17	323.81	1498.22	0.01
AN-47	1	30530		5-YR	43.50	48.79	56.52	49.65	56.52	0.000003	0.17	298.93	1424.84	0.01
AN-47	1	30530		2-YR	41.80	48.79	54.79	49.64	54.79	0.000009	0.25	168.66	366.18	0.02
AN-47	1	30530		Future 100yr	51.90	48.79	56.90	49.73	56.90	0.000004	0.18	382.42	1628.85	0.01
AN-47	1	30530		100-YR TW Test	51.30	48.79	56.81	49.73	56.81	0.000004	0.18	359.27	1588.75	0.01
AN-47	1	29883		100-YR	51.30	49.08	56.80	50.27	56.80	0.000000	0.04	3180.36	2378.97	0.00
AN-47	1	29883		50-YR	48.30	49.08	56.75	50.25	56.75	0.000000	0.04	3044.99	2376.11	0.00
AN-47	1	29883		25-YR	46.80	49.08	56.73	50.23	56.73	0.000000	0.04	2992.92	2370.30	0.00
AN-47	1	29883		10-YR	44.90	49.08	56.65	50.22	56.65	0.000000	0.04	2806.29	2312.55	0.00
AN-47	1	29883		5-YR	43.50	49.08	56.52	50.20	56.52	0.000003	0.15	528.17	2245.55	0.01
AN-47	1	29883		2-YR	41.80	49.08	54.78	50.19	54.78	0.000018	0.32	132.32	319.78	0.03
AN-47	1	29883		Future 100yr	51.90	49.08	56.90	50.28	56.90	0.000000	0.04	3409.10	2393.31	0.00
AN-47	1	29883		100-YR TW Test	51.30	49.08	56.81	50.27	56.81	0.000000	0.04	3182.90	2379.01	0.00
AN-47	1	29619	US Hwy 83		Culvert									
AN-47	1	29450		100-YR	102.70	48.74	56.59	51.11	56.60	0.000112	0.84	121.81	2205.98	0.07
AN-47	1	29450		50-YR	77.30	48.74	56.56	50.85	56.57	0.000064	0.64	120.90	2178.69	0.05
AN-47	1	29450		25-YR	68.30	48.74	56.55	50.75	56.55	0.000051	0.57	120.61	2170.27	0.05
AN-47	1	29450		10-YR	61.60	48.74	56.48	50.67	56.49	0.000043	0.52	118.81	2115.03	0.04
AN-47	1	29450		5-YR	57.20	48.74	56.36	50.61	56.37	0.000040	0.49	115.59	1991.18	0.04
AN-47	1	29450		2-YR	49.10	48.74	54.64	50.49	54.65	0.000094	0.66	74.09	24.61	0.06
AN-47	1	29450		Future 100yr	156.70	48.74	56.68	51.59	56.71	0.000247	1.26	124.36	2298.15	0.11

AN-47	1	29450		100-YR TW Test	102.70	48.74	56.59	51.11	56.60	0.000112	0.84	121.84	2207.41	0.07
AN-47	1	28555		100-YR	102.70	49.42	56.57	51.51	56.57	0.000012	0.28	1020.89	1743.71	0.02
AN-47	1	28555		50-YR	77.30	49.42	56.55	51.26	56.55	0.000007	0.22	988.50	1740.56	0.02
AN-47	1	28555		25-YR	68.30	49.42	56.54	51.15	56.54	0.000006	0.20	978.23	1739.56	0.02
AN-47	1	28555		10-YR	61.60	49.42	56.47	51.08	56.47	0.000006	0.20	894.94	1731.14	0.02
AN-47	1	28555		5-YR	57.20	49.42	56.35	51.02	56.35	0.000008	0.23	742.40	1721.76	0.02
AN-47	1	28555		2-YR	49.10	49.42	54.55	50.91	54.56	0.000111	0.69	71.05	22.78	0.07
AN-47	1	28555		Future 100yr	156.70	49.42	56.65	51.96	56.65	0.000022	0.39	1116.79	1752.98	0.03
AN-47	1	28555		100-YR TW Test	102.70	49.42	56.57	51.51	56.57	0.000012	0.28	1022.34	1743.85	0.02
AN-47	1	27501		100-YR	102.70	48.55	56.54	50.58	56.55	0.000046	0.59	172.88	541.31	0.05
AN-47	1	27501		50-YR	77.30	48.55	56.53	50.35	56.53	0.000026	0.45	172.38	531.84	0.04
AN-47	1	27501		25-YR	68.30	48.55	56.53	50.25	56.53	0.000020	0.40	172.21	528.65	0.03
AN-47	1	27501		10-YR	61.60	48.55	56.46	50.18	56.46	0.000017	0.36	169.90	473.08	0.03
AN-47	1	27501		5-YR	57.20	48.55	56.34	50.13	56.34	0.000016	0.35	165.56	393.62	0.03
AN-47	1	27501		2-YR	49.10	48.55	54.49	50.02	54.49	0.000040	0.47	105.58	29.34	0.04
AN-47	1	27501		Future 100yr	156.70	48.55	56.59	50.98	56.60	0.000104	0.90	174.51	607.55	0.07
AN-47	1	27501		100-YR TW Test	102.70	48.55	56.55	50.58	56.55	0.000046	0.59	172.92	542.08	0.05
AN-47	1	26802		100-YR	102.70	47.79	56.52	49.15	56.53	0.000023	0.46	221.92	388.84	0.03
AN-47	1	26802		50-YR	77.30	47.79	56.52	48.96	56.52	0.000013	0.35	221.72	382.58	0.03
AN-47	1	26802		25-YR	68.30	47.79	56.52	48.89	56.52	0.000010	0.31	221.64	380.05	0.02
AN-47	1	26802		10-YR	61.60	47.79	56.45	48.83	56.45	0.000008	0.28	219.20	302.52	0.02
AN-47	1	26802		5-YR	57.20	47.79	56.33	48.78	56.33	0.000008	0.27	214.55	153.43	0.02
AN-47	1	26802		2-YR	49.10	47.79	54.47	48.71	54.47	0.000015	0.33	149.44	32.26	0.03
AN-47	1	26802		Future 100yr	156.70	47.79	56.54	49.51	56.55	0.000053	0.70	222.65	411.91	0.05
AN-47	1	26802		100-YR TW Test	102.70	47.79	56.52	49.15	56.53	0.000023	0.46	221.97	390.33	0.03
AN-47	1	25964		100-YR	102.70	47.21	56.51	48.42	56.51	0.000011	0.34	302.13	1120.44	0.02
AN-47	1	25964		50-YR	77.30	47.21	56.51	48.26	56.51	0.000006	0.26	302.13	1120.42	0.02
AN-47	1	25964		25-YR	68.30	47.21	56.51	48.20	56.51	0.000005	0.23	302.10	1119.99	0.02
AN-47	1	25964		10-YR	61.60	47.21	56.45	48.15	56.45	0.000004	0.21	299.02	1071.71	0.01
AN-47	1	25964		5-YR	57.20	47.21	56.33	48.12	56.33	0.000004	0.20	293.06	813.24	0.01
AN-47	1	25964		2-YR	49.10	47.21	54.46	48.06	54.46	0.000007	0.24	207.51	41.13	0.02
AN-47	1	25964		Future 100yr	156.70	47.21	56.52	48.71	56.52	0.000025	0.52	302.30	1122.82	0.04
AN-47	1	25964		100-YR TW Test	102.70	47.21	56.51	48.42	56.51	0.000011	0.34	302.19	1121.31	0.02
AN-47	1	25152		100-YR	102.70	46.57	56.51	48.08	56.51	0.000002	0.15	1554.25	1605.38	0.01
AN-47	1	25152		50-YR	77.30	46.57	56.51	47.87	56.51	0.000001	0.11	1710.67	1606.57	0.01
AN-47	1	25152		25-YR	68.30	46.57	56.51	47.78	56.51	0.000001	0.10	1710.20	1606.30	0.01
AN-47	1	25152		10-YR	61.60	46.57	56.45	47.72	56.45	0.000001	0.09	1491.59	1514.10	0.01
AN-47	1	25152		5-YR	57.20	46.57	56.33	47.68	56.33	0.000001	0.10	1368.77	1359.54	0.01
AN-47	1	25152		2-YR	49.10	46.57	54.46	47.59	54.46	0.000010	0.29	170.50	33.70	0.02
AN-47	1	25152		Future 100yr	156.70	46.57	56.51	48.46	56.51	0.000005	0.23	1554.36	1605.55	0.02
AN-47	1	25152		100-YR TW Test	102.70	46.57	56.51	48.08	56.51	0.000002	0.15	1710.92	1606.71	0.01
AN-47	1	24744	Canal Road		Culvert									
AN-47	1	24566		100-YR	102.70	46.31	55.80		55.81	0.000003	0.18	1107.41	646.15	0.01
AN-47	1	24566		50-YR	77.30	46.31	55.68		55.68	0.000002	0.15	1025.40	644.91	0.01
AN-47	1	24566		25-YR	68.30	46.31	55.57		55.57	0.000002	0.14	955.98	643.87	0.01
AN-47	1	24566		10-YR	61.60	46.31	54.93		54.93	0.000004	0.19	591.14	438.67	0.01
AN-47	1	24566		5-YR	57.20	46.31	54.49		54.50	0.000006	0.23	428.92	343.77	0.02
AN-47	1	24566		2-YR	49.10	46.31	53.11		53.11	0.000015	0.34	146.35	29.32	0.03
AN-47	1	24566		Future 100yr	156.70	46.31	55.90		55.90	0.000007	0.26	1170.33	647.10	0.02
AN-47	1	24566		100-YR TW Test	102.70	46.31	55.80		55.80	0.000003	0.18	1102.28	646.07	0.01
AN-47	1	24050		100-YR	102.70	46.03	55.80	47.34	55.80	0.000003	0.18	1177.53	618.07	0.01
AN-47	1	24050		50-YR	77.30	46.03	55.68	47.17	55.68	0.000002	0.15	1099.38	617.09	0.01
AN-47	1	24050		25-YR	68.30	46.03	55.57	47.09	55.57	0.000002	0.14	1033.00	616.25	0.01
AN-47	1	24050		10-YR	61.60	46.03	54.93	47.04	54.93	0.000004	0.19	573.20	563.95	0.01
AN-47	1	24050		5-YR	57.20	46.03	54.49	47.00	54.49	0.000005	0.23	415.09	414.02	0.02
AN-47	1	24050		2-YR	49.10	46.03	53.10	46.93	53.10	0.000011	0.30	162.03	30.94	0.02
AN-47	1	24050		Future 100yr	156.70	46.03	55.90	47.66	55.90	0.000005	0.26	1237.25	655.80	0.02
AN-47	1	24050		100-YR TW Test	102.70	46.03	55.80	47.34	55.80	0.000003	0.18	1172.61	618.00	0.01
AN-47	1	23421		100-YR	102.70	46.20	55.80	47.26	55.80	0.000001	0.09	2718.05	1229.08	0.01
AN-47	1	23421		50-YR	77.30	46.20	55.68	47.10	55.68	0.000000	0.07	2562.89	1226.30	0.00
AN-47	1	23421		25-YR	68.30	46.20	55.57	47.03	55.57	0.000000	0.06	2431.04	1223.93	0.00
AN-47	1	23421		10-YR	61.60	46.20	54.93	46.99	54.93	0.000001	0.12	941.24	1204.07	0.01
AN-47	1	23421		5-YR	57.20	46.20	54.49	46.95	54.49	0.000002	0.15	724.91	1100.50	0.01
AN-47	1	23421		2-YR	49.10	46.20	53.09	46.90	53.10	0.000006	0.23	215.08	40.65	0.02
AN-47	1	23421		Future 100yr	156.70	46.20	55.90	47.55	55.90	0.000001	0.12	2835.20	1231.17	0.01
AN-47	1	23421		100-YR TW Test	102.70	46.20	55.79	47.26	55.79	0.000001	0.09	2708.26	1228.90	0.01
AN-47	1	23317	FM 506		Culvert									
AN-47	1	23168		100-YR	102.70	46.30	55.54	47.81	55.54	0.000000	0.04	5044.84	2901.95	0.00
AN-47	1	23168		50-YR	77.30	46.30	55.37	47.58	55.37	0.000000	0.04	4553.79	2868.44	0.00
AN-47	1	23168		25-YR	68.30	46.30	55.17	47.49	55.17	0.000000	0.04	4003.60	2587.48	0.00
AN-47	1	23168		10-YR	61.60	46.30	54.56	47.43	54.56	0.000000	0.05	2704.70	1822.22	0.00
AN-47	1	23168		5-YR	57.20	46.30	54.17	47.38	54.17	0.000001	0.06	1868.70	1552.51	0.01
AN-47	1	23168		2-YR	49.10	46.30	52.86	47.29	52.86	0.000027	0.41	120.99	703.08	0.04
AN-47	1	23168		Future 100yr	156.70	46.30	55.84	48.22	55.84	0.000000	0.05	5906.45	2934.68	0.00
AN-47	1	23168		100-YR TW Test	102.70	46.30	55.56	47.81	55.56	0.000000	0.04	5098.71	2905.60	0.00
AN-47	1	22602		100-YR	102.70	46.36	55.54	47.81	55.54	0.000000	0.05	4680.03	2769.41	0.00
AN-47	1	22602		50-YR	77.30	46.36	55.37	47.61	55.37	0.000000	0.04	4209.60	2759.80	0.00
AN-47	1	22602		25-YR	68.30	46.36	55.17	47.53	55.17	0.000000	0.04	3658.94	2748.51	0.00

AN-47	1	22602		10-YR	61.60	46.36	54.55	47.46	54.55	0.000014	0.32	189.99	2012.23	0.03
AN-47	1	22602		5-YR	57.20	46.36	54.16	47.42	54.16	0.000015	0.33	174.94	1056.93	0.03
AN-47	1	22602		2-YR	49.10	46.36	52.84	47.34	52.85	0.000023	0.38	129.51	557.53	0.03
AN-47	1	22602		Future 100yr	156.70	46.36	55.84	48.19	55.84	0.000000	0.06	5508.85	2862.48	0.00
AN-47	1	22602		100-YR TW Test	102.70	46.36	55.56	47.81	55.56	0.000000	0.05	4731.43	2770.46	0.00
AN-47	1	22389	Unnamed Street		Culvert									
AN-47	1	22112		100-YR	102.70	46.50	55.54	48.01	55.54	0.000003	0.16	1265.14	2723.51	0.01
AN-47	1	22112		50-YR	77.30	46.50	55.37	47.80	55.37	0.000003	0.14	1139.19	2705.26	0.01
AN-47	1	22112		25-YR	68.30	46.50	55.17	47.71	55.17	0.000015	0.32	212.94	2668.78	0.03
AN-47	1	22112		10-YR	61.60	46.50	54.51	47.65	54.52	0.000014	0.33	185.13	2056.79	0.03
AN-47	1	22112		5-YR	57.20	46.50	54.06	47.61	54.07	0.000015	0.34	168.87	724.81	0.03
AN-47	1	22112		2-YR	49.10	46.50	52.77	47.52	52.77	0.000025	0.39	125.92	30.85	0.03
AN-47	1	22112		Future 100yr	156.70	46.50	55.84	48.40	55.84	0.000001	0.08	4335.06	2755.08	0.01
AN-47	1	22112		100-YR TW Test	102.70	46.50	55.56	48.01	55.56	0.000003	0.16	1279.42	2725.57	0.01
AN-47	1	21907	N Parker Road		Culvert									
AN-47	1	21597		100-YR	102.70	46.02	55.54	47.22	55.54	0.000001	0.09	3521.07	3542.83	0.01
AN-47	1	21597		50-YR	77.30	46.02	55.37	47.05	55.37	0.000000	0.07	3087.63	2740.99	0.01
AN-47	1	21597		25-YR	68.30	46.02	55.02	46.98	55.02	0.000002	0.14	990.90	2498.97	0.01
AN-47	1	21597		10-YR	61.60	46.02	54.39	46.92	54.39	0.000004	0.19	656.02	1667.11	0.01
AN-47	1	21597		5-YR	57.20	46.02	53.96	46.89	53.96	0.000006	0.23	455.77	510.28	0.02
AN-47	1	21597		2-YR	49.10	46.02	52.69	46.82	52.69	0.000014	0.33	148.70	29.54	0.03
AN-47	1	21597		Future 100yr	156.70	46.02	55.84	47.55	55.84	0.000001	0.10	4404.81	3594.39	0.01
AN-47	1	21597		100-YR TW Test	102.70	46.02	55.56	47.22	55.56	0.000001	0.09	3579.55	3562.24	0.01
AN-47	1	20767		100-YR	102.70	45.66	55.54	46.74	55.54	0.000007	0.31	335.20	3481.30	0.02
AN-47	1	20767		50-YR	77.30	45.66	55.37	46.59	55.37	0.000004	0.24	327.08	3365.40	0.02
AN-47	1	20767		25-YR	68.30	45.66	55.02	46.53	55.02	0.000004	0.22	310.73	3220.91	0.01
AN-47	1	20767		10-YR	61.60	45.66	54.39	46.49	54.39	0.000004	0.22	282.73	1545.24	0.02
AN-47	1	20767		5-YR	57.20	45.66	53.95	46.45	53.96	0.000004	0.22	264.03	410.12	0.02
AN-47	1	20767		2-YR	49.10	45.66	52.68	46.39	52.69	0.000006	0.23	211.56	39.86	0.02
AN-47	1	20767		Future 100yr	156.70	45.66	55.83	47.01	55.84	0.000015	0.45	349.66	3618.79	0.03
AN-47	1	20767		100-YR TW Test	102.70	45.66	55.56	46.74	55.56	0.000007	0.31	336.16	3489.79	0.02
AN-47	1	19892		100-YR	102.70	46.07	55.53	47.13	55.53	0.000012	0.37	278.88	3133.26	0.02
AN-47	1	19892		50-YR	77.30	46.07	55.36	46.96	55.36	0.000007	0.28	271.73	3102.15	0.02
AN-47	1	19892		25-YR	68.30	46.07	55.01	46.91	55.01	0.000007	0.27	257.34	2947.63	0.02
AN-47	1	19892		10-YR	61.60	46.07	54.38	46.86	54.38	0.000007	0.26	232.82	1416.26	0.02
AN-47	1	19892		5-YR	57.20	46.07	53.95	46.83	53.95	0.000007	0.26	216.50	714.45	0.02
AN-47	1	19892		2-YR	49.10	46.07	52.68	46.76	52.68	0.000010	0.29	171.33	33.95	0.02
AN-47	1	19892		Future 100yr	156.70	46.07	55.83	47.43	55.83	0.000001	0.10	4388.81	3167.61	0.01
AN-47	1	19892		100-YR TW Test	102.70	46.07	55.55	47.13	55.55	0.000012	0.37	279.76	3135.98	0.02
AN-47	1	19163		100-YR	102.70	45.96	55.53	47.37	55.53	0.000000	0.08	3640.29	2997.02	0.01
AN-47	1	19163		50-YR	77.30	45.96	55.36	47.16	55.36	0.000000	0.07	3263.53	2992.71	0.00
AN-47	1	19163		25-YR	68.30	45.96	55.01	47.07	55.01	0.000001	0.08	2475.73	2874.90	0.01
AN-47	1	19163		10-YR	61.60	45.96	54.38	47.01	54.38	0.000008	0.27	224.48	2347.71	0.02
AN-47	1	19163		5-YR	57.20	45.96	53.94	46.97	53.94	0.000008	0.28	207.71	1793.82	0.02
AN-47	1	19163		2-YR	49.10	45.96	52.67	46.89	52.67	0.000012	0.30	162.03	33.84	0.02
AN-47	1	19163		Future 100yr	156.70	45.96	55.83	47.73	55.83	0.000001	0.09	4324.60	3020.23	0.01
AN-47	1	19163		100-YR TW Test	102.70	45.96	55.55	47.37	55.55	0.000000	0.07	3685.12	2997.54	0.00
AN-47	1	18518		100-YR	102.70	45.70	55.53	47.23	55.53	0.000001	0.12	1887.73	2039.50	0.01
AN-47	1	18518		50-YR	77.30	45.70	55.36	47.01	55.36	0.000001	0.10	1731.84	2032.57	0.01
AN-47	1	18518		25-YR	68.30	45.70	55.01	46.94	55.01	0.000001	0.11	1404.57	2013.07	0.01
AN-47	1	18518		10-YR	61.60	45.70	54.37	46.87	54.37	0.000004	0.18	826.03	1905.90	0.01
AN-47	1	18518		5-YR	57.20	45.70	53.94	46.83	53.94	0.000007	0.25	470.62	1500.69	0.02
AN-47	1	18518		2-YR	49.10	45.70	52.66	46.75	52.66	0.000018	0.35	138.80	29.80	0.03
AN-47	1	18518		Future 100yr	156.70	45.70	55.83	47.63	55.83	0.000002	0.15	2174.90	2068.01	0.01
AN-47	1	18518		100-YR TW Test	102.70	45.70	55.55	47.23	55.55	0.000001	0.12	1906.34	2040.37	0.01
AN-47	1	17905		100-YR	102.70	45.95	55.53	47.84	55.53	0.000001	0.10	2345.43	2126.48	0.01
AN-47	1	17905		50-YR	77.30	45.95	55.36	47.64	55.36	0.000001	0.09	2137.17	2119.30	0.01
AN-47	1	17905		25-YR	68.30	45.95	55.01	47.57	55.01	0.000001	0.10	1696.12	2103.61	0.01
AN-47	1	17905		10-YR	61.60	45.95	54.37	47.51	54.37	0.000013	0.34	182.07	1610.38	0.03
AN-47	1	17905		5-YR	57.20	45.95	53.93	47.48	53.93	0.000014	0.35	166.52	1314.11	0.03
AN-47	1	17905		2-YR	49.10	45.95	52.65	47.40	52.65	0.000023	0.39	126.51	34.98	0.03
AN-47	1	17905		Future 100yr	156.70	45.95	55.83	48.19	55.83	0.000001	0.13	2723.98	2140.65	0.01
AN-47	1	17905		100-YR TW Test	102.70	45.95	55.55	47.84	55.55	0.000001	0.10	2370.30	2127.33	0.01
AN-47	1	17594	N. Kansas City R		Culvert									
AN-47	1	17426		100-YR	102.70	45.87	55.53	47.46	55.53	0.000001	0.13	1816.95	1049.33	0.01
AN-47	1	17426		50-YR	77.30	45.87	55.36	47.28	55.36	0.000001	0.11	1644.75	1019.11	0.01
AN-47	1	17426		25-YR	68.30	45.87	55.01	47.20	55.01	0.000004	0.21	603.86	953.43	0.01
AN-47	1	17426		10-YR	61.60	45.87	54.25	47.15	54.25	0.000010	0.30	208.80	761.86	0.02
AN-47	1	17426		5-YR	57.20	45.87	53.70	47.11	53.70	0.000012	0.31	187.07	371.25	0.02
AN-47	1	17426		2-YR	49.10	45.87	52.47	47.04	52.48	0.000017	0.34	144.66	32.64	0.03
AN-47	1	17426		Future 100yr	156.70	45.87	55.83	47.80	55.83	0.000002	0.17	2139.05	1104.42	0.01
AN-47	1	17426		100-YR TW Test	102.70	45.87	55.55	47.46	55.55	0.000001	0.13	1837.40	1052.92	0.01
AN-47	1	16705		100-YR	102.70	45.60	55.52	47.30	55.52	0.000023	0.50	205.23	892.50	0.03
AN-47	1	16705		50-YR	77.30	45.60	55.36	47.10	55.36	0.000014	0.39	200.05	887.98	0.03
AN-47	1	16705		25-YR	68.30	45.60	55.00	47.03	55.00	0.000013	0.36	189.19	877.36	0.02
AN-47	1	16705		10-YR	61.60	45.60	54.24	46.97	54.24	0.000015	0.37	167.44	545.67	0.03
AN-47	1	16705		5-YR	57.20	45.60	53.69	46.92	53.69	0.000017	0.37	152.76	192.40	0.03
AN-47	1	16705		2-YR	49.10	45.60	52.46	46.83	52.46	0.000023	0.40	121.84	24.20	0.03

AN-47	1	16705		Future 100yr	156.70	45.60	55.81	47.67	55.82	0.000047	0.74	214.70	900.51	0.05
AN-47	1	16705		100-YR TW Test	102.70	45.60	55.54	47.30	55.54	0.000023	0.50	205.85	893.03	0.03
AN-47	1	16457	US Highway 83		Culvert									
AN-47	1	16121		100-YR	102.70	45.72	55.45	47.30	55.45	0.000020	0.47	223.35	2019.56	0.03
AN-47	1	16121		50-YR	77.30	45.72	55.32	47.09	55.32	0.000012	0.36	218.21	1934.75	0.02
AN-47	1	16121		25-YR	68.30	45.72	54.97	47.01	54.97	0.000011	0.34	205.19	1193.19	0.02
AN-47	1	16121		10-YR	61.60	45.72	54.21	46.94	54.21	0.000013	0.34	178.89	833.56	0.03
AN-47	1	16121		5-YR	57.20	45.72	53.66	46.90	53.67	0.000015	0.35	161.90	191.16	0.03
AN-47	1	16121		2-YR	49.10	45.72	52.44	46.82	52.45	0.000022	0.39	126.90	27.24	0.03
AN-47	1	16121		Future 100yr	156.70	45.72	55.64	47.67	55.65	0.000043	0.69	231.10	2030.45	0.05
AN-47	1	16121		100-YR TW Test	102.70	45.72	55.47	47.30	55.47	0.000020	0.47	224.12	2020.76	0.03
AN-47	1	15292		100-YR	276.00	45.61	55.43	48.28	55.44	0.000018	0.45	1440.22	1826.21	0.03
AN-47	1	15292		50-YR	237.70	45.61	55.25	48.07	55.27	0.000130	1.20	203.60	1801.33	0.08
AN-47	1	15292		25-YR	208.10	45.61	54.91	47.89	54.93	0.000119	1.11	191.35	1735.03	0.08
AN-47	1	15292		10-YR	165.60	45.61	54.15	47.63	54.17	0.000114	1.00	166.12	1335.71	0.07
AN-47	1	15292		5-YR	134.20	45.61	53.61	47.41	53.63	0.000099	0.89	150.51	339.70	0.07
AN-47	1	15292		2-YR	98.00	45.61	52.39	47.13	52.40	0.000100	0.83	118.52	24.81	0.07
AN-47	1	15292		Future 100yr	387.30	45.61	55.62	48.83	55.62	0.000026	0.56	1600.69	1836.22	0.04
AN-47	1	15292		100-YR TW Test	276.00	45.61	55.45	48.28	55.45	0.000017	0.45	1457.33	1827.31	0.03
AN-47	1	14387		100-YR	276.00	45.53	55.42	47.82	55.42	0.000014	0.41	1536.34	2131.82	0.03
AN-47	1	14387		50-YR	237.70	45.53	55.23	47.63	55.23	0.000014	0.40	1368.52	2121.82	0.03
AN-47	1	14387		25-YR	208.10	45.53	54.83	47.47	54.84	0.000074	0.89	235.54	2062.65	0.06
AN-47	1	14387		10-YR	165.60	45.53	54.08	47.24	54.09	0.000067	0.80	207.77	1700.21	0.06
AN-47	1	14387		5-YR	134.20	45.53	53.55	47.05	53.56	0.000056	0.71	189.54	941.48	0.05
AN-47	1	14387		2-YR	98.00	45.53	52.33	46.80	52.33	0.000057	0.65	149.98	32.73	0.05
AN-47	1	14387		Future 100yr	387.30	45.53	55.60	48.31	55.60	0.000022	0.51	1697.56	2152.59	0.03
AN-47	1	14387		100-YR TW Test	276.00	45.53	55.44	47.82	55.44	0.000014	0.40	1554.53	2132.73	0.03
AN-47	1	14266	Business 83		Culvert									
AN-47	1	14060		100-YR	276.00	44.33	54.38	47.62	54.41	0.000232	1.46	189.07	1777.59	0.10
AN-47	1	14060		50-YR	237.70	44.33	54.05	47.37	54.08	0.000200	1.33	178.88	1724.06	0.10
AN-47	1	14060		25-YR	208.10	44.33	53.91	47.17	53.93	0.000161	1.19	174.56	1660.76	0.09
AN-47	1	14060		10-YR	165.60	44.33	53.50	46.86	53.51	0.000124	1.02	162.55	1259.40	0.08
AN-47	1	14060		5-YR	134.20	44.33	53.17	46.59	53.18	0.000096	0.88	153.15	870.74	0.07
AN-47	1	14060		2-YR	98.00	44.33	52.13	46.25	52.13	0.000089	0.79	124.77	26.11	0.06
AN-47	1	14060		Future 100yr	387.30	44.33	54.89	48.26	54.95	0.000348	1.89	206.21	2336.73	0.13
AN-47	1	14060		100-YR TW Test	276.00	44.33	54.38	47.62	54.41	0.000232	1.46	189.11	1777.72	0.10
AN-47	1	13114		100-YR	276.00	44.27	54.39	47.33	54.39	0.000002	0.15	4401.69	2409.28	0.01
AN-47	1	13114		50-YR	237.70	44.27	54.06	47.11	54.06	0.000003	0.17	3604.90	2409.28	0.01
AN-47	1	13114		25-YR	208.10	44.27	53.91	46.93	53.91	0.000004	0.19	2539.10	2405.62	0.01
AN-47	1	13114		10-YR	165.60	44.27	53.49	46.66	53.49	0.000005	0.21	1957.70	2082.36	0.02
AN-47	1	13114		5-YR	134.20	44.27	53.16	46.43	53.16	0.000007	0.24	1492.82	1736.11	0.02
AN-47	1	13114		2-YR	98.00	44.27	52.06	46.14	52.07	0.000057	0.63	257.54	754.61	0.05
AN-47	1	13114		Future 100yr	387.30	44.27	54.91	47.89	54.91	0.000002	0.15	5667.38	2409.28	0.01
AN-47	1	13114		100-YR TW Test	276.00	44.27	54.39	47.33	54.39	0.000002	0.15	4404.39	2409.28	0.01
AN-47	1	12297		100-YR	276.00	44.07	54.39	46.68	54.39	0.000001	0.13	5418.71	3169.95	0.01
AN-47	1	12297		50-YR	237.70	44.07	54.05	46.51	54.05	0.000002	0.14	4405.27	2846.65	0.01
AN-47	1	12297		25-YR	208.10	44.07	53.91	46.35	53.91	0.000002	0.14	3999.43	2637.14	0.01
AN-47	1	12297		10-YR	165.60	44.07	53.49	46.13	53.49	0.000016	0.42	904.38	2456.50	0.03
AN-47	1	12297		5-YR	134.20	44.07	53.15	45.94	53.15	0.000026	0.52	277.88	2326.64	0.04
AN-47	1	12297		2-YR	98.00	44.07	52.03	45.71	52.03	0.000028	0.48	205.30	637.03	0.04
AN-47	1	12297		Future 100yr	387.30	44.07	54.91	47.15	54.91	0.000001	0.13	7116.40	3291.80	0.01
AN-47	1	12297		100-YR TW Test	276.00	44.07	54.39	46.68	54.39	0.000001	0.13	5422.27	3170.21	0.01
AN-47	1	11708	Beddoes Road		Culvert									
AN-47	1	11351		100-YR	276.00	43.99	54.39	46.56	54.39	0.000001	0.09	7223.34	3362.76	0.01
AN-47	1	11351		50-YR	237.70	43.99	54.05	46.35	54.05	0.000001	0.10	6131.91	3240.25	0.01
AN-47	1	11351		25-YR	208.10	43.99	53.91	46.18	53.91	0.000001	0.10	5654.16	3233.62	0.01
AN-47	1	11351		10-YR	165.60	43.99	53.49	45.90	53.49	0.000001	0.12	4302.73	3181.04	0.01
AN-47	1	11351		5-YR	134.20	43.99	53.12	45.68	53.12	0.000002	0.14	3163.97	3101.57	0.01
AN-47	1	11351		2-YR	98.00	43.99	51.82	45.39	51.83	0.000046	0.61	160.99	898.36	0.05
AN-47	1	11351		Future 100yr	387.30	43.99	54.91	47.12	54.91	0.000001	0.10	9003.66	3461.90	0.01
AN-47	1	11351		100-YR TW Test	276.00	43.99	54.39	46.56	54.39	0.000001	0.09	7226.58	3362.91	0.01
AN-47	1	10880		100-YR	519.80	43.75	54.38	47.41	54.39	0.000005	0.26	4933.71	3126.01	0.02
AN-47	1	10880		50-YR	507.40	43.75	54.05	47.36	54.05	0.000008	0.31	4142.81	2940.24	0.02
AN-47	1	10880		25-YR	483.30	43.75	53.90	47.27	53.91	0.000009	0.33	3809.96	2872.08	0.02
AN-47	1	10880		10-YR	446.40	43.75	53.48	47.12	53.48	0.000015	0.41	2914.09	2679.99	0.03
AN-47	1	10880		5-YR	396.10	43.75	53.12	46.92	53.12	0.000018	0.43	2200.26	2433.07	0.03
AN-47	1	10880		2-YR	247.80	43.75	51.74	46.19	51.77	0.000208	1.29	192.53	960.50	0.10
AN-47	1	10880		Future 100yr	543.20	43.75	54.91	47.49	54.91	0.000002	0.16	7904.98	3208.61	0.01
AN-47	1	10880		100-YR TW Test	519.80	43.75	54.39	47.41	54.39	0.000005	0.26	4936.08	3126.67	0.02
AN-47	1	10303		100-YR	519.80	43.86	54.38	48.47	54.38	0.000004	0.22	5881.02	3031.05	0.01
AN-47	1	10303		50-YR	507.40	43.86	54.05	48.42	54.05	0.000007	0.27	4881.47	2922.89	0.02
AN-47	1	10303		25-YR	483.30	43.86	53.90	48.32	53.90	0.000007	0.27	3959.42	2848.69	0.02
AN-47	1	10303		10-YR	446.40	43.86	53.48	48.16	53.48	0.000012	0.34	3147.39	2503.85	0.03
AN-47	1	10303		5-YR	396.10	43.86	53.11	47.92	53.11	0.000034	0.56	1627.69	2088.37	0.04
AN-47	1	10303		2-YR	247.80	43.86	51.55	47.13	51.59	0.000455	1.72	210.28	657.20	0.15
AN-47	1	10303		Future 100yr	543.20	43.86	54.91	48.56	54.91	0.000002	0.16	7475.44	3046.89	0.01
AN-47	1	10303		100-YR TW Test	519.80	43.86	54.38	48.47	54.38	0.000004	0.22	5883.95	3031.08	0.01

AN-47	1	9427		100-YR	519.80	44.00	54.38	47.74	54.38	0.000008	0.32	4292.19	2512.70	0.02
AN-47	1	9427		50-YR	507.40	44.00	54.04	47.69	54.04	0.000015	0.42	3446.43	2499.07	0.03
AN-47	1	9427		25-YR	483.30	44.00	53.89	47.60	53.89	0.000018	0.47	3073.43	2493.03	0.03
AN-47	1	9427		10-YR	446.40	44.00	53.45	47.45	53.45	0.000075	0.90	1256.13	2303.23	0.06
AN-47	1	9427		5-YR	396.10	44.00	52.97	47.23	53.03	0.000380	1.91	208.04	1810.72	0.14
AN-47	1	9427		2-YR	247.80	44.00	51.18	46.51	51.23	0.000391	1.69	146.48	30.84	0.14
AN-47	1	9427		Future 100yr	543.20	44.00	54.90	47.83	54.90	0.000004	0.24	5714.97	2800.74	0.02
AN-47	1	9427		100-YR TW Test	519.80	44.00	54.38	47.74	54.38	0.000008	0.32	4294.64	2512.74	0.02
AN-47	1	8560		100-YR	519.80	43.68	54.36	47.70	54.36	0.000032	0.60	1757.81	1683.53	0.04
AN-47	1	8560		50-YR	507.40	43.68	54.02	47.65	54.02	0.000050	0.73	1486.57	1643.92	0.05
AN-47	1	8560		25-YR	483.30	43.68	53.77	47.55	53.84	0.000464	2.18	223.92	1409.67	0.15
AN-47	1	8560		10-YR	446.40	43.68	53.24	47.38	53.31	0.000514	2.20	203.43	759.69	0.16
AN-47	1	8560		5-YR	396.10	43.68	52.55	47.15	52.63	0.000571	2.20	179.89	735.92	0.17
AN-47	1	8560		2-YR	247.80	43.68	50.75	46.36	50.81	0.000583	1.98	125.37	27.60	0.16
AN-47	1	8560		Future 100yr	543.20	43.68	54.90	47.80	54.90	0.000019	0.48	2174.95	1694.19	0.03
AN-47	1	8560		100-YR TW Test	519.80	43.68	54.36	47.70	54.37	0.000032	0.60	1758.58	1683.55	0.04
AN-47	1	7524		100-YR	519.80	43.78	54.22	47.61	54.28	0.000350	1.97	264.35	916.13	0.13
AN-47	1	7524		50-YR	507.40	43.78	53.84	47.56	53.90	0.000391	2.04	249.15	432.07	0.14
AN-47	1	7524		25-YR	483.30	43.78	53.30	47.47	53.37	0.000449	2.12	228.50	37.61	0.15
AN-47	1	7524		10-YR	446.40	43.78	52.71	47.33	52.78	0.000501	2.16	206.96	36.06	0.16
AN-47	1	7524		5-YR	396.10	43.78	51.96	47.13	52.04	0.000571	2.19	180.66	34.07	0.17
AN-47	1	7524		2-YR	247.80	43.78	50.11	46.46	50.17	0.000656	2.03	122.12	29.16	0.17
AN-47	1	7524		Future 100yr	543.20	43.78	54.79	47.69	54.84	0.000305	1.89	287.49	1293.62	0.13
AN-47	1	7524		100-YR TW Test	519.80	43.78	54.22	47.61	54.28	0.000350	1.97	264.39	917.39	0.13
AN-47	1	6814		100-YR	519.80	43.85	53.94	47.31	54.01	0.000406	2.13	244.36	35.27	0.14
AN-47	1	6814		50-YR	507.40	43.85	53.52	47.27	53.60	0.000458	2.21	229.80	34.39	0.15
AN-47	1	6814		25-YR	483.30	43.85	52.94	47.18	53.02	0.000530	2.30	210.00	33.17	0.16
AN-47	1	6814		10-YR	446.40	43.85	52.31	47.03	52.39	0.000598	2.35	189.56	31.87	0.17
AN-47	1	6814		5-YR	396.10	43.85	51.50	46.81	51.59	0.000695	2.41	164.43	30.18	0.18
AN-47	1	6814		2-YR	247.80	43.85	49.57	46.11	49.65	0.000824	2.25	110.20	26.17	0.19
AN-47	1	6814		Future 100yr	543.20	43.85	54.55	47.40	54.61	0.000349	2.04	266.87	878.82	0.13
AN-47	1	6814		100-YR TW Test	519.80	43.85	53.94	47.31	54.01	0.000406	2.13	244.41	35.27	0.14
AN-47	2	6704		100-YR	519.80	43.27	53.95	46.44	53.98	0.000134	1.32	392.35	55.37	0.09
AN-47	2	6704		50-YR	507.40	43.27	53.53	46.41	53.56	0.000149	1.37	369.61	53.53	0.09
AN-47	2	6704		25-YR	483.30	43.27	52.94	46.34	52.97	0.000172	1.43	338.68	51.80	0.10
AN-47	2	6704		10-YR	446.40	43.27	52.31	46.24	52.34	0.000194	1.46	306.61	49.94	0.10
AN-47	2	6704		5-YR	396.10	43.27	51.50	46.08	51.53	0.000225	1.48	266.94	47.55	0.11
AN-47	2	6704		2-YR	247.80	43.27	49.56	45.52	49.59	0.000269	1.37	180.36	41.85	0.12
AN-47	2	6704		Future 100yr	543.20	43.27	54.55	46.52	54.58	0.000119	1.27	426.88	58.83	0.08
AN-47	2	6704		100-YR TW Test	519.80	43.27	53.95	46.44	53.98	0.000134	1.32	392.42	55.38	0.09
AN-47	2	6640	Evans Canal Cros		Culvert									
AN-47	2	6474		100-YR	519.80	43.21	52.13	46.61	52.21	0.000517	2.18	238.91	43.71	0.16
AN-47	2	6474		50-YR	507.40	43.21	51.80	46.57	51.88	0.000581	2.26	224.70	42.51	0.17
AN-47	2	6474		25-YR	483.30	43.21	51.38	46.48	51.47	0.000650	2.33	207.16	40.54	0.18
AN-47	2	6474		10-YR	446.40	43.21	50.99	46.34	51.07	0.000677	2.33	191.50	38.69	0.18
AN-47	2	6474		5-YR	396.10	43.21	50.46	46.14	50.54	0.000697	2.30	171.91	36.06	0.19
AN-47	2	6474		2-YR	247.80	43.21	49.17	45.47	49.23	0.000599	1.93	128.44	31.58	0.17
AN-47	2	6474		Future 100yr	543.20	43.21	52.57	46.70	52.63	0.000457	2.10	258.18	45.29	0.16
AN-47	2	6474		100-YR TW Test	519.80	43.21	52.13	46.61	52.21	0.000516	2.18	238.96	43.72	0.16
AN-47	2	5884		100-YR	576.90	43.28	51.73	46.89	51.84	0.000709	2.60	222.09	38.79	0.19
AN-47	2	5884		50-YR	547.40	43.28	51.37	46.79	51.48	0.000763	2.63	208.25	37.89	0.20
AN-47	2	5884		25-YR	513.00	43.28	50.91	46.67	51.02	0.000856	2.69	190.78	36.72	0.21
AN-47	2	5884		10-YR	470.00	43.28	50.49	46.52	50.60	0.000904	2.67	175.76	35.69	0.21
AN-47	2	5884		5-YR	410.30	43.28	49.95	46.30	50.06	0.000946	2.61	156.96	34.35	0.22
AN-47	2	5884		2-YR	251.20	43.28	48.74	45.62	48.81	0.000813	2.14	117.23	31.33	0.20
AN-47	2	5884		Future 100yr	613.20	43.28	52.20	47.01	52.30	0.000642	2.55	240.56	39.97	0.18
AN-47	2	5884		100-YR TW Test	576.90	43.28	51.74	46.89	51.84	0.000708	2.60	222.15	38.80	0.19
AN-47	2	4824		100-YR	576.90	43.03	50.69	46.71	50.85	0.001263	3.25	177.57	33.98	0.25
AN-47	2	4824		50-YR	547.40	43.03	50.20	46.62	50.38	0.001478	3.39	161.38	32.70	0.27
AN-47	2	4824		25-YR	513.00	43.03	49.46	46.49	49.68	0.002009	3.72	137.91	30.90	0.31
AN-47	2	4824		10-YR	470.00	43.03	48.85	46.33	49.09	0.002532	3.94	119.27	29.38	0.34
AN-47	2	4824		5-YR	410.30	43.03	47.98	46.10	48.27	0.003689	4.33	94.82	27.26	0.41
AN-47	2	4824		2-YR	251.20	43.03	45.39	45.39	46.25	0.026296	7.44	33.77	19.57	1.00
AN-47	2	4824		Future 100yr	613.20	43.03	51.29	46.84	51.44	0.001062	3.09	198.66	35.95	0.23
AN-47	2	4824		100-YR TW Test	576.90	43.03	50.69	46.71	50.85	0.001263	3.25	177.57	33.98	0.25
AN-47	2	4716	S. White Ranch R		Culvert									
AN-47	2	4057		100-YR	576.90	36.44	42.18	40.75	42.75	0.007180	6.06	95.12	26.76	0.57
AN-47	2	4057		50-YR	547.40	36.44	42.06	40.64	42.61	0.007099	5.96	91.85	26.31	0.56
AN-47	2	4057		25-YR	513.00	36.44	41.88	40.50	42.41	0.007174	5.89	87.15	25.66	0.56
AN-47	2	4057		10-YR	470.00	36.44	41.60	40.32	42.13	0.007542	5.87	80.12	24.64	0.57
AN-47	2	4057		5-YR	410.30	36.44	41.23	40.05	41.74	0.007871	5.76	71.25	23.30	0.58
AN-47	2	4057		2-YR	251.20	36.44	40.04	39.22	40.50	0.009471	5.44	46.16	19.01	0.62
AN-47	2	4057		Future 100yr	613.20	36.44	42.37	40.89	42.95	0.007029	6.11	100.36	27.46	0.56
AN-47	2	4057		100-YR TW Test	576.90	36.44	45.22	40.75	45.36	0.001092	2.98	193.71	38.38	0.23
AN-47	2	3220		100-YR	576.90	31.39	39.28		39.51	0.002220	3.81	151.27	35.85	0.33
AN-47	2	3220		50-YR	547.40	31.39	38.96		39.20	0.002449	3.91	139.95	34.37	0.34
AN-47	2	3220		25-YR	513.00	31.39	38.77		39.00	0.002446	3.85	133.37	33.58	0.34
AN-47	2	3220		10-YR	470.00	31.39	38.68		38.88	0.002176	3.60	130.51	33.23	0.32
AN-47	2	3220		5-YR	410.30	31.39	38.35		38.53	0.002086	3.43	119.79	31.88	0.31

AN-47	2	3220		2-YR	251.20	31.39	37.26		37.39	0.001820	2.87	87.38	27.39	0.28
AN-47	2	3220		Future 100yr	613.20	31.39	39.60		39.82	0.002114	3.76	163.01	38.15	0.32
AN-47	2	3220		100-YR TW Test	576.90	31.39	45.06		45.08	0.000116	1.14	506.26	83.24	0.08
AN-47	2	2822		100-YR	576.90	31.55	38.13		38.41	0.003446	4.29	134.59	38.49	0.40
AN-47	2	2822		50-YR	547.40	31.55	37.28		37.71	0.006144	5.26	103.97	33.70	0.53
AN-47	2	2822		25-YR	513.00	31.55	36.49		37.14	0.011225	6.49	79.04	29.43	0.70
AN-47	2	2822		10-YR	470.00	31.55	35.61	35.61	36.74	0.024424	8.50	55.26	24.61	1.00
AN-47	2	2822		5-YR	410.30	31.55	35.35	35.35	36.44	0.025381	8.37	49.00	22.99	1.01
AN-47	2	2822		2-YR	251.20	31.55	34.63	34.63	35.49	0.026549	7.47	33.65	19.48	1.00
AN-47	2	2822		Future 100yr	613.20	31.55	38.62		38.87	0.002700	3.97	154.31	41.17	0.36
AN-47	2	2822		100-YR TW Test	576.90	31.55	45.03		45.04	0.000079	0.94	614.21	103.04	0.07
AN-47	2	2055		100-YR	576.90	26.18	37.90		37.94	0.000203	1.66	362.48	70.94	0.11
AN-47	2	2055		50-YR	547.40	26.18	36.95		37.00	0.000290	1.82	304.75	53.68	0.13
AN-47	2	2055		25-YR	513.00	26.18	36.06		36.12	0.000387	1.98	260.09	46.23	0.14
AN-47	2	2055		10-YR	470.00	26.18	34.92		35.00	0.000566	2.22	211.61	39.85	0.17
AN-47	2	2055		5-YR	410.30	26.18	33.62		33.72	0.000849	2.51	163.33	34.69	0.20
AN-47	2	2055		2-YR	251.20	26.18	30.75		30.91	0.002311	3.21	78.34	24.83	0.32
AN-47	2	2055		Future 100yr	613.20	26.18	38.42		38.46	0.000179	1.63	403.78	92.37	0.10
AN-47	2	2055		100-YR TW Test	576.90	26.18	45.01		45.02	0.000012	0.64	1242.50	174.69	0.03
AN-47	2	1105		100-YR	576.90	22.75	37.84	27.05	37.85	0.000047	0.85	681.00	88.05	0.05
AN-47	2	1105		50-YR	547.40	22.75	36.87	26.95	36.88	0.000062	0.92	597.49	83.98	0.06
AN-47	2	1105		25-YR	513.00	22.75	35.95	26.83	35.97	0.000079	0.98	522.44	79.79	0.07
AN-47	2	1105		10-YR	470.00	22.75	34.75	26.65	34.77	0.000114	1.09	430.49	73.85	0.08
AN-47	2	1105		5-YR	410.30	22.75	33.36	26.42	33.38	0.000179	1.23	332.30	66.37	0.10
AN-47	2	1105		2-YR	251.20	22.75	30.01	25.62	30.05	0.000454	1.62	154.66	40.56	0.15
AN-47	2	1105		Future 100yr	613.20	22.75	38.37	27.17	38.38	0.000044	0.84	728.32	90.71	0.05
AN-47	2	1105		100-YR TW Test	576.90	22.75	45.01	27.05	45.01	0.000005	0.41	1515.39	139.13	0.02
AN-47	2	832	Adams Road		Culvert									
AN-47	2	401		100-YR	576.90	17.00	20.24	18.90	20.45	0.005004	3.61	159.86	60.31	0.39
AN-47	2	401		50-YR	547.40	17.00	20.16	18.84	20.35	0.004998	3.54	154.51	59.91	0.39
AN-47	2	401		25-YR	513.00	17.00	20.05	18.78	20.23	0.005000	3.46	148.07	59.43	0.39
AN-47	2	401		10-YR	470.00	17.00	19.91	18.69	20.08	0.005002	3.36	139.84	58.80	0.38
AN-47	2	401		5-YR	410.30	17.00	19.71	18.56	19.87	0.005006	3.20	128.05	57.96	0.38
AN-47	2	401		2-YR	251.20	17.00	19.10	18.18	19.21	0.005005	2.68	93.69	55.67	0.36
AN-47	2	401		Future 100yr	613.20	17.00	20.35	18.96	20.56	0.005007	3.69	166.36	60.79	0.39
AN-47	2	401		100-YR TW Test	576.90	17.00	45.00	18.90	45.00	0.000000	0.08	8501.55	824.24	0.00

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

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X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
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PROJECT DATA
Project Title: AN-49
Project File : AN49.prj
Run Date and Time: 10/4/2010 4:01:24 PM

Project in English units

PLAN DATA

Plan Title: Existing Conditions
Plan File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-49\AN49.p03

Geometry Title: Existing Conditions
Geometry File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-49\AN49.g01

Flow Title : Existing Conditions
Flow File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-49\AN49.f02

Plan Summary Information:

Number of:				
Cross Sections =	26	Multiple Openings =	0
Culverts =	3	Inline Structures =	0
Bridges =	0	Lateral Structures =	0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Existing Conditions
Flow File : p:\Active\09068.00_LaFeria_FPP\HEC-RAS\AN-49\AN49.f02

Flow Data (cfs)

River	Reach	RS	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR	Future 100yr
AN-49	1	12806	63.4	29.2	22.3	19.8	17.6	14.4	219.5
AN-49	1	11045	279.3	227.7	191.7	131.5	90.5	45.4	589.5
AN-49	1	6336	55	54.2	53.7	52.2	49.9	40.9	55.8

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
AN-49	1	100-YR		Normal S = 0.005

SUMMARY OF MANNING'S N VALUES

River:AN-49

Reach	River Sta.	n1	n2	n3
1	12806	.055	.045	.055

1	12346	.055	.045	.055
1	12155	.055	.045	.055
1	12095	Culvert		
1	12029	.055	.045	.055
1	11596	.055	.045	.055
1	11045	.055	.045	.055
1	10509	.055	.045	.055
1	9884	.055	.045	.055
1	9068	.055	.045	.055
1	8338	.055	.045	.055
1	7491	.055	.045	.055
1	6865	.055	.045	.055
1	6779	Culvert		
1	6681	.055	.045	.055
1	6336	.055	.045	.055
1	5854	.055	.045	.055
1	5483	.055	.045	.055
1	5021	.055	.045	.055
1	4384	.055	.045	.055
1	3680	.055	.045	.055
1	2918	.055	.045	.055
1	2314	.055	.045	.055
1	1935	.055	.045	.055
1	1642	.055	.045	.055
1	1318	.055	.045	.055
1	1191	Culvert		
1	979	.055	.045	.055
1	159	.055	.045	.055

SUMMARY OF REACH LENGTHS

River: AN-49

Reach	River Sta.	Left	Channel	Right
1	12806	401.84	459.72	516.58
1	12346	152.34	191.83	232.34
1	12155	124.75	125.25	125.76
1	12095	Culvert		
1	12029	433.72	432.92	432.13
1	11596	550.04	551.42	552.79
1	11045	570.43	536.04	502.4
1	10509	674.35	624.57	574.06
1	9884	815.68	816.62	817.56
1	9068	730.8	730.02	729.23
1	8338	804.23	846.33	885.08
1	7491	650.91	626.34	602.75
1	6865	178.59	184.25	189.44
1	6779	Culvert		
1	6681	342.31	344.51	346.7
1	6336	516.08	482.18	448.29
1	5854	325.82	371.14	416.46
1	5483	459.07	462.3	466.62
1	5021	676.11	636.56	595.9
1	4384	702.04	703.92	705.8
1	3680	791.12	762.53	733.95
1	2918	593.69	603.29	612.89
1	2314	356.45	379.51	402.58
1	1935	252.74	292.49	332.24
1	1642	323.17	323.99	324.79
1	1318	329.77	339.08	348.42
1	1191	Culvert		
1	979	752.58	820.58	888.93
1	159	175.39	158.77	141.8

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: AN-49

Reach	River Sta.	Contr.	Expan.
1	12806	.1	.3
1	12346	.1	.3
1	12155	.3	.5
1	12095	Culvert	
1	12029	.3	.5
1	11596	.1	.3
1	11045	.1	.3
1	10509	.1	.3
1	9884	.1	.3
1	9068	.1	.3
1	8338	.1	.3
1	7491	.1	.3
1	6865	.3	.5

Existing Conditions

1	6779	Culvert	
1	6681	.3	.5
1	6336	.1	.3
1	5854	.1	.3
1	5483	.1	.3
1	5021	.1	.3
1	4384	.1	.3
1	3680	.1	.3
1	2918	.1	.3
1	2314	.1	.3
1	1935	.1	.3
1	1642	.1	.3
1	1318	.3	.5
1	1191	Culvert	
1	979	.3	.5
1	159	.1	.3

Profile Output Table - Standard Table 1

Reach	River Sta		Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	12806		100-YR	63.40	50.24	56.55		56.55	0.000001	0.05	2099.04	1304.91	0.01
1	12806		50-YR	29.20	50.24	56.42		56.42	0.000000	0.03	1941.73	1281.20	0.00
1	12806		25-YR	22.30	50.24	56.32		56.32	0.000000	0.02	1807.43	1248.43	0.00
1	12806		10-YR	19.80	50.24	56.06		56.06	0.000000	0.02	1490.81	1221.83	0.00
1	12806		5-YR	17.60	50.24	55.43		55.43	0.000000	0.04	828.56	873.68	0.00
1	12806		2-YR	14.40	50.24	53.68		53.68	0.000087	0.44	41.01	81.90	0.06
1	12806		Future 100yr	219.50	50.24	57.02		57.02	0.000004	0.15	2741.39	1488.46	0.01
1	12346		100-YR	63.40	50.11	56.55		56.55	0.000001	0.06	2208.11	1813.40	0.01
1	12346		50-YR	29.20	50.11	56.42		56.42	0.000000	0.03	1990.54	1772.47	0.00
1	12346		25-YR	22.30	50.11	56.32		56.32	0.000000	0.03	1805.49	1697.44	0.00
1	12346		10-YR	19.80	50.11	56.06		56.06	0.000000	0.03	1390.02	1536.35	0.00
1	12346		5-YR	17.60	50.11	55.43		55.43	0.000001	0.07	575.05	1008.15	0.01
1	12346		2-YR	14.40	50.11	53.64		53.64	0.000068	0.39	39.13	33.59	0.05
1	12346		Future 100yr	219.50	50.11	57.01		57.01	0.000003	0.14	3089.26	1933.86	0.01
1	12155		100-YR	63.40	49.83	56.55	51.85	56.55	0.000001	0.07	1909.44	1448.54	0.01
1	12155		50-YR	29.20	49.83	56.42	51.33	56.42	0.000000	0.04	1735.79	1417.05	0.00
1	12155		25-YR	22.30	49.83	56.32	51.19	56.32	0.000000	0.03	1586.64	1388.29	0.00
1	12155		10-YR	19.80	49.83	56.06	51.13	56.06	0.000000	0.04	1241.07	1293.69	0.00
1	12155		5-YR	17.60	49.83	55.43	51.08	55.43	0.000002	0.08	510.82	956.08	0.01
1	12155		2-YR	14.40	49.83	53.63	51.00	53.63	0.000061	0.38	38.15	24.73	0.05
1	12155		Future 100yr	219.50	49.83	57.01	53.18	57.01	0.000004	0.17	2617.45	1583.56	0.01
1	12095	Orange Grove Roa		Culvert									
1	12029		100-YR	63.40	49.41	56.54		56.54	0.000002	0.09	1570.27	1540.57	0.01
1	12029		50-YR	29.20	49.41	56.42		56.42	0.000001	0.05	1385.53	1496.62	0.00
1	12029		25-YR	22.30	49.41	56.32		56.32	0.000000	0.04	1228.93	1430.77	0.00
1	12029		10-YR	19.80	49.41	56.06		56.06	0.000001	0.06	894.67	1232.90	0.01
1	12029		5-YR	17.60	49.41	55.28		55.28	0.000008	0.19	203.54	392.41	0.02
1	12029		2-YR	14.40	49.41	52.99		53.00	0.000127	0.55	26.16	12.11	0.07
1	12029		Future 100yr	219.50	49.41	57.01		57.01	0.000007	0.19	2315.38	1629.06	0.02
1	11596		100-YR	63.40	49.27	56.54		56.54	0.000003	0.10	1564.94	1877.66	0.01
1	11596		50-YR	29.20	49.27	56.42		56.42	0.000001	0.06	1340.34	1828.92	0.01
1	11596		25-YR	22.30	49.27	56.32		56.32	0.000001	0.06	1148.42	1772.04	0.01
1	11596		10-YR	19.80	49.27	56.06		56.06	0.000001	0.08	737.64	1319.97	0.01
1	11596		5-YR	17.60	49.27	55.27		55.27	0.000025	0.32	69.43	210.69	0.03
1	11596		2-YR	14.40	49.27	52.92		52.93	0.000184	0.64	22.50	10.63	0.08
1	11596		Future 100yr	219.50	49.27	57.01		57.01	0.000008	0.19	2464.31	2080.24	0.02
1	11045		100-YR	279.30	49.29	56.54		56.54	0.000022	0.33	2142.62	2243.63	0.03
1	11045		50-YR	227.70	49.29	56.42		56.42	0.000022	0.32	1874.77	2222.23	0.03
1	11045		25-YR	191.70	49.29	56.31		56.31	0.000023	0.33	1639.06	2194.02	0.03
1	11045		10-YR	131.50	49.29	56.05		56.05	0.000031	0.38	1087.76	2064.48	0.04
1	11045		5-YR	90.50	49.29	55.12		55.15	0.000538	1.45	105.67	260.37	0.14
1	11045		2-YR	45.40	49.29	51.95		52.13	0.007509	3.39	13.40	8.69	0.48
1	11045		Future 100yr	589.50	49.29	57.00		57.00	0.000029	0.39	3208.42	2384.48	0.03
1	10509		100-YR	279.30	46.96	56.52		56.52	0.000027	0.56	1342.41	1752.29	0.04
1	10509		50-YR	227.70	46.96	56.40		56.41	0.000023	0.52	1141.44	1654.03	0.04
1	10509		25-YR	191.70	46.96	56.30		56.30	0.000020	0.49	969.78	1582.91	0.03
1	10509		10-YR	131.50	46.96	56.04		56.04	0.000016	0.42	587.12	1263.94	0.03
1	10509		5-YR	90.50	46.96	55.12		55.12	0.000014	0.37	244.10	41.37	0.03
1	10509		2-YR	45.40	46.96	52.03		52.03	0.000022	0.36	127.30	34.10	0.03
1	10509		Future 100yr	589.50	46.96	56.98		56.98	0.000044	0.74	2354.05	2448.39	0.05
1	9884		100-YR	279.30	48.82	56.49		56.49	0.000120	0.86	1090.04	1944.08	0.07
1	9884		50-YR	227.70	48.82	56.37		56.38	0.000134	0.90	866.81	1830.77	0.08
1	9884		25-YR	191.70	48.82	56.26		56.27	0.000159	0.97	675.71	1725.67	0.08
1	9884		10-YR	131.50	48.82	56.00		56.02	0.000236	1.15	277.17	1217.07	0.10
1	9884		5-YR	90.50	48.82	55.07		55.10	0.000323	1.24	73.00	23.34	0.12
1	9884		2-YR	45.40	48.82	51.91		51.98	0.002254	2.10	21.60	12.28	0.28
1	9884		Future 100yr	589.50	48.82	56.94		56.94	0.000106	0.83	2020.43	2146.77	0.07
1	9068		100-YR	279.30	47.62	56.40		56.41	0.000094	0.89	743.77	1309.58	0.07

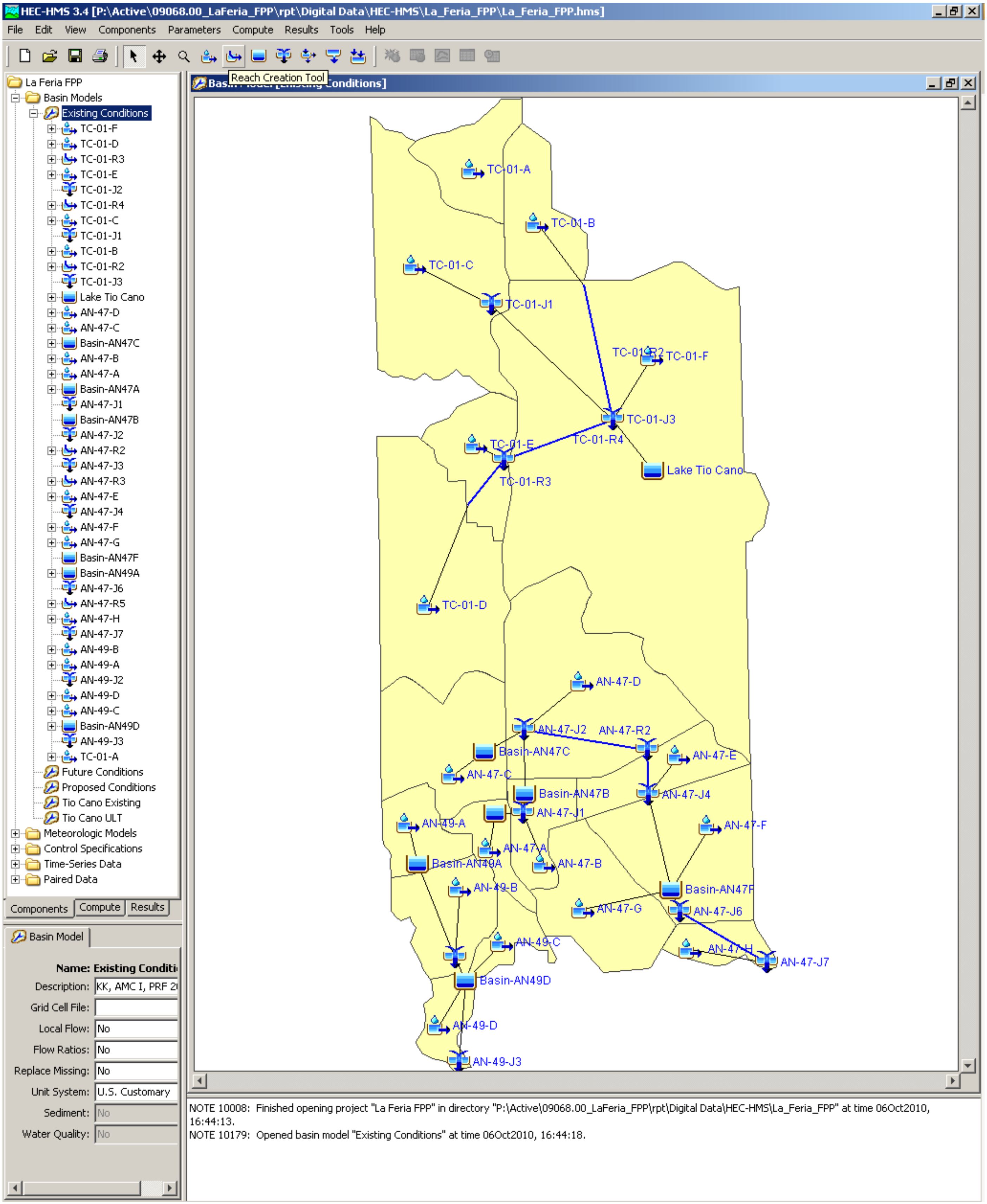
1	9068		50-YR	227.70	47.62	56.29		56.30	0.000077	0.80	631.60	716.19	0.06
1	9068		25-YR	191.70	47.62	56.19		56.19	0.000065	0.73	561.70	633.90	0.06
1	9068		10-YR	131.50	47.62	55.94		55.94	0.000045	0.59	427.26	467.51	0.05
1	9068		5-YR	90.50	47.62	54.97		54.98	0.000073	0.70	152.27	125.89	0.06
1	9068		2-YR	45.40	47.62	51.08		51.10	0.000609	1.25	36.39	17.64	0.15
1	9068		Future 100yr	589.50	47.62	56.82		56.83	0.000173	1.22	1543.62	2289.75	0.09
1	8338		100-YR	279.30	47.09	56.28		56.30	0.000256	1.39	528.89	1410.85	0.11
1	8338		50-YR	227.70	47.09	56.19		56.21	0.000217	1.28	408.93	1180.23	0.10
1	8338		25-YR	191.70	47.09	56.10		56.12	0.000186	1.18	313.54	946.52	0.09
1	8338		10-YR	131.50	47.09	55.88		55.89	0.000120	0.93	180.93	338.86	0.07
1	8338		5-YR	90.50	47.09	54.91		54.92	0.000106	0.82	112.49	32.45	0.07
1	8338		2-YR	45.40	47.09	50.57		50.61	0.000768	1.45	31.31	13.33	0.17
1	8338		Future 100yr	589.50	47.09	56.64		56.66	0.000350	1.66	1257.19	2515.11	0.12
1	7491		100-YR	279.30	45.82	56.21		56.22	0.000046	0.62	1334.87	1752.15	0.05
1	7491		50-YR	227.70	45.82	56.13		56.14	0.000038	0.56	1197.79	1715.79	0.04
1	7491		25-YR	191.70	45.82	56.05		56.05	0.000033	0.52	1059.63	1610.65	0.04
1	7491		10-YR	131.50	45.82	55.84		55.84	0.000028	0.48	748.74	1359.99	0.04
1	7491		5-YR	90.50	45.82	54.85		54.85	0.000056	0.63	148.74	45.03	0.05
1	7491		2-YR	45.40	45.82	50.06		50.08	0.000499	1.21	37.64	15.34	0.14
1	7491		Future 100yr	589.50	45.82	56.51		56.51	0.000092	0.89	1877.93	2044.60	0.07
1	6865		100-YR	279.30	44.69	56.18	47.46	56.19	0.000048	0.72	765.26	1252.91	0.05
1	6865		50-YR	227.70	44.69	56.11	47.17	56.11	0.000035	0.61	682.11	1095.23	0.04
1	6865		25-YR	191.70	44.69	56.03	46.95	56.04	0.000027	0.54	604.59	912.29	0.04
1	6865		10-YR	131.50	44.69	55.83	46.54	55.83	0.000015	0.40	468.85	429.32	0.03
1	6865		5-YR	90.50	44.69	54.84	46.21	54.84	0.000012	0.35	266.96	72.44	0.03
1	6865		2-YR	45.40	44.69	50.00	45.76	50.01	0.000050	0.50	91.32	26.27	0.05
1	6865		Future 100yr	589.50	44.69	56.42	48.80	56.44	0.000142	1.25	1130.25	1787.54	0.09
1	6779	Unnamed Road		Culvert									
1	6681		100-YR	279.30	45.14	56.00		56.00	0.000014	0.45	842.39	723.46	0.03
1	6681		50-YR	227.70	45.14	55.58		55.58	0.000012	0.41	605.95	418.55	0.03
1	6681		25-YR	191.70	45.14	55.31		55.31	0.000010	0.36	535.55	123.35	0.02
1	6681		10-YR	131.50	45.14	54.54		54.54	0.000006	0.28	474.56	74.77	0.02
1	6681		5-YR	90.50	45.14	53.40		53.40	0.000005	0.23	392.65	69.18	0.02
1	6681		2-YR	45.40	45.14	49.64		49.65	0.000017	0.28	162.28	53.64	0.03
1	6681		Future 100yr	589.50	45.14	56.43		56.44	0.000044	0.81	1446.92	2069.31	0.05
1	6336		100-YR	55.00	44.09	56.00		56.00	0.000000	0.04	1492.64	1123.73	0.00
1	6336		50-YR	54.20	44.09	55.58		55.58	0.000000	0.05	1160.42	495.74	0.00
1	6336		25-YR	53.70	44.09	55.31		55.31	0.000000	0.05	1098.61	140.72	0.00
1	6336		10-YR	52.20	44.09	54.54		54.54	0.000000	0.05	992.84	134.83	0.00
1	6336		5-YR	49.90	44.09	53.40		53.40	0.000000	0.06	842.39	128.98	0.00
1	6336		2-YR	40.90	44.09	49.64		49.64	0.000002	0.10	392.42	111.40	0.01
1	6336		Future 100yr	55.80	44.09	56.43		56.43	0.000000	0.04	2101.32	1736.91	0.00
1	5854		100-YR	55.00	44.83	56.00		56.00	0.000001	0.09	1666.70	2157.60	0.01
1	5854		50-YR	54.20	44.83	55.58		55.58	0.000001	0.12	899.55	1457.30	0.01
1	5854		25-YR	53.70	44.83	55.31		55.31	0.000002	0.14	552.22	1198.32	0.01
1	5854		10-YR	52.20	44.83	54.54		54.54	0.000002	0.16	335.25	101.30	0.01
1	5854		5-YR	49.90	44.83	53.40		53.40	0.000003	0.18	273.47	47.27	0.01
1	5854		2-YR	40.90	44.83	49.64		49.64	0.000023	0.34	118.72	35.03	0.03
1	5854		Future 100yr	55.80	44.83	56.43		56.43	0.000000	0.06	2694.10	2476.03	0.00
1	5483		100-YR	55.00	44.98	56.00		56.00	0.000002	0.15	614.70	691.60	0.01
1	5483		50-YR	54.20	44.98	55.57		55.58	0.000003	0.18	340.68	412.47	0.01
1	5483		25-YR	53.70	44.98	55.31		55.31	0.000003	0.18	291.67	70.17	0.01
1	5483		10-YR	52.20	44.98	54.54		54.54	0.000004	0.20	256.34	43.65	0.01
1	5483		5-YR	49.90	44.98	53.40		53.40	0.000007	0.24	208.74	40.01	0.02
1	5483		2-YR	40.90	44.98	49.62		49.63	0.000070	0.52	78.61	28.59	0.06
1	5483		Future 100yr	55.80	44.98	56.43		56.43	0.000001	0.12	920.25	723.05	0.01
1	5021		100-YR	55.00	45.17	56.00		56.00	0.000002	0.15	496.09	472.08	0.01
1	5021		50-YR	54.20	45.17	55.57		55.57	0.000002	0.17	355.99	250.82	0.01
1	5021		25-YR	53.70	45.17	55.31		55.31	0.000003	0.17	310.34	79.69	0.01
1	5021		10-YR	52.20	45.17	54.54		54.54	0.000004	0.19	271.36	48.29	0.01
1	5021		5-YR	49.90	45.17	53.39		53.40	0.000006	0.23	218.52	44.13	0.02
1	5021		2-YR	40.90	45.17	49.59		49.60	0.000068	0.52	79.34	28.46	0.05
1	5021		Future 100yr	55.80	45.17	56.43		56.43	0.000001	0.13	791.71	847.52	0.01
1	4384		100-YR	55.00	45.15	56.00		56.00	0.000003	0.18	366.47	258.59	0.01
1	4384		50-YR	54.20	45.15	55.57		55.57	0.000003	0.19	286.78	115.51	0.01
1	4384		25-YR	53.70	45.15	55.31		55.31	0.000004	0.20	267.29	42.86	0.01
1	4384		10-YR	52.20	45.15	54.53		54.53	0.000005	0.22	235.03	40.45	0.02
1	4384		5-YR	49.90	45.15	53.39		53.39	0.000008	0.26	190.79	37.03	0.02
1	4384		2-YR	40.90	45.15	49.53		49.54	0.000128	0.63	64.66	27.82	0.07
1	4384		Future 100yr	55.80	45.15	56.43		56.43	0.000002	0.16	636.28	939.59	0.01
1	3680		100-YR	55.00	44.67	56.00		56.00	0.000001	0.11	1022.97	899.72	0.01
1	3680		50-YR	54.20	44.67	55.57		55.57	0.000002	0.15	644.02	816.45	0.01
1	3680		25-YR	53.70	44.67	55.31		55.31	0.000003	0.17	458.14	589.86	0.01
1	3680		10-YR	52.20	44.67	54.53		54.53	0.000004	0.20	258.83	46.70	0.02
1	3680		5-YR	49.90	44.67	53.38		53.39	0.000007	0.24	208.44	41.05	0.02
1	3680		2-YR	40.90	44.67	49.47		49.47	0.000066	0.53	77.39	25.70	0.05
1	3680		Future 100yr	55.80	44.67	56.43		56.43	0.000001	0.08	1418.62	931.11	0.01
1	2918		100-YR	55.00	44.09	56.00		56.00	0.000001	0.12	1052.22	1330.60	0.01

Existing Conditions

1	2918		50-YR	54.20	44.09	55.57		55.57	0.000001	0.12	812.29	512.81	0.01
1	2918		25-YR	53.70	44.09	55.30		55.30	0.000002	0.14	677.96	504.23	0.01
1	2918		10-YR	52.20	44.09	54.53		54.53	0.000003	0.18	330.73	286.91	0.01
1	2918		5-YR	49.90	44.09	53.38		53.38	0.000005	0.22	230.04	42.23	0.02
1	2918		2-YR	40.90	44.09	49.43		49.43	0.000044	0.45	90.70	28.11	0.04
1	2918		Future 100yr	55.80	44.09	56.43		56.43	0.000001	0.08	1633.05	1343.19	0.01
1	2314		100-YR	55.00	43.97	55.99		56.00	0.000003	0.17	399.56	243.97	0.01
1	2314		50-YR	54.20	43.97	55.57		55.57	0.000004	0.19	313.01	162.14	0.01
1	2314		25-YR	53.70	43.97	55.30		55.30	0.000004	0.20	277.41	95.89	0.01
1	2314		10-YR	52.20	43.97	54.52		54.53	0.000006	0.22	237.37	46.47	0.02
1	2314		5-YR	49.90	43.97	53.38		53.38	0.000011	0.27	186.05	42.24	0.02
1	2314		2-YR	40.90	43.97	49.39		49.40	0.000084	0.61	67.01	19.87	0.06
1	2314		Future 100yr	55.80	43.97	56.43		56.43	0.000002	0.15	521.88	319.27	0.01
1	1935		100-YR	55.00	43.43	55.99		55.99	0.000002	0.15	367.76	51.62	0.01
1	1935		50-YR	54.20	43.43	55.57		55.57	0.000002	0.16	345.97	50.23	0.01
1	1935		25-YR	53.70	43.43	55.30		55.30	0.000002	0.16	332.81	49.37	0.01
1	1935		10-YR	52.20	43.43	54.52		54.52	0.000003	0.18	295.37	46.83	0.01
1	1935		5-YR	49.90	43.43	53.37		53.37	0.000004	0.20	243.78	42.75	0.02
1	1935		2-YR	40.90	43.43	49.38		49.38	0.000028	0.39	104.27	28.05	0.04
1	1935		Future 100yr	55.80	43.43	56.43		56.43	0.000002	0.14	397.36	96.20	0.01
1	1642		100-YR	55.00	43.40	55.99		55.99	0.000001	0.12	519.26	130.66	0.01
1	1642		50-YR	54.20	43.40	55.57		55.57	0.000001	0.13	464.93	122.68	0.01
1	1642		25-YR	53.70	43.40	55.30		55.30	0.000001	0.13	433.31	115.28	0.01
1	1642		10-YR	52.20	43.40	54.52		54.52	0.000002	0.15	350.59	79.62	0.01
1	1642		5-YR	49.90	43.40	53.37		53.37	0.000003	0.17	288.65	48.83	0.01
1	1642		2-YR	40.90	43.40	49.37		49.37	0.000020	0.33	123.00	33.96	0.03
1	1642		Future 100yr	55.80	43.40	56.43		56.43	0.000001	0.11	579.29	150.39	0.01
1	1318		100-YR	55.00	42.58	55.99	43.70	55.99	0.000000	0.08	982.38	393.45	0.01
1	1318		50-YR	54.20	42.58	55.57	43.69	55.57	0.000001	0.09	822.23	364.81	0.01
1	1318		25-YR	53.70	42.58	55.30	43.68	55.30	0.000001	0.10	728.41	336.81	0.01
1	1318		10-YR	52.20	42.58	54.52	43.66	54.52	0.000001	0.12	513.40	200.29	0.01
1	1318		5-YR	49.90	42.58	53.37	43.64	53.37	0.000002	0.14	369.13	58.30	0.01
1	1318		2-YR	40.90	42.58	49.37	43.53	49.37	0.000010	0.24	167.08	42.38	0.02
1	1318		Future 100yr	55.80	42.58	56.43	43.71	56.43	0.000000	0.07	1154.00	395.96	0.00
1	1191	Levee		Culvert									
1	979		100-YR	55.00	32.89	34.73	34.73	35.23	0.033818	5.63	9.77	10.21	1.01
1	979		50-YR	54.20	32.89	34.73	34.73	35.21	0.033511	5.59	9.70	10.17	1.01
1	979		25-YR	53.70	32.89	34.72	34.72	35.20	0.033551	5.58	9.63	10.13	1.01
1	979		10-YR	52.20	32.89	34.70	34.70	35.18	0.033770	5.55	9.40	10.02	1.01
1	979		5-YR	49.90	32.89	34.66	34.66	35.13	0.034040	5.51	9.06	9.83	1.01
1	979		2-YR	40.90	32.89	34.52	34.52	34.96	0.035075	5.30	7.72	9.09	1.01
1	979		Future 100yr	55.80	32.89	34.75	34.75	35.24	0.033763	5.64	9.88	10.27	1.01
1	159		100-YR	55.00	23.52	24.71	24.32	24.77	0.005005	1.99	27.66	34.96	0.39
1	159		50-YR	54.20	23.52	24.71	24.31	24.77	0.005005	1.98	27.41	34.93	0.39
1	159		25-YR	53.70	23.52	24.70	24.31	24.76	0.005005	1.97	27.25	34.91	0.39
1	159		10-YR	52.20	23.52	24.69	24.30	24.75	0.005005	1.95	26.77	34.86	0.39
1	159		5-YR	49.90	23.52	24.67	24.29	24.72	0.005006	1.92	26.03	34.77	0.39
1	159		2-YR	40.90	23.52	24.58	24.24	24.63	0.005001	1.78	23.00	34.41	0.38
1	159		Future 100yr	55.80	23.52	24.72	24.33	24.78	0.005004	2.00	27.91	34.99	0.39

APPENDIX F
HEC-HMS OUTPUT REPORT

La Feria FPP
HEC-HMS Schematic



LA FERIA FLOOD PROTECTION PLAN
HEC-HMS Output

EXISTING		100-yr	50-YR	25-YR	10-YR	5-YR	2-YR	Future 100-yr
Element	DA (sq mi)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)
AN-47-A	0.356	198.7	161.9	137.6	102.9	75.4	49.6	245.2
AN-47-B	0.504	513.5	441.4	388.9	318.9	248.6	167.1	521.2
AN-47-C	1.312	433.5	353.6	295.5	206.3	144.1	78.9	855.1
AN-47-D	2.395	540.4	435.2	358.5	245.3	168.2	89.4	854.6
AN-47-E	0.624	229.6	192.6	163.3	123	92.8	58.5	333.1
AN-47-F	1.564	613.8	498.3	416.7	284	190.5	91.8	769.9
AN-47-G	1.131	379.4	311.5	261.3	185.5	131.7	74	528.6
AN-47-H	0.341	89.1	68.3	54.7	32.1	18.1	6.4	123.3
AN-47-J1	0.86	541.3	468.7	415.8	345.3	274.7	192.9	550.1
AN-47-J2	4.567	630.5	523.7	445.1	330	250.9	169.4	944.8
AN-47-J3	4.567	102.7	77.3	68.3	61.6	57.2	49.1	156.7
AN-47-J4	5.191	276	237.7	208.1	165.6	134.2	98	387.3
AN-47-J6	7.886	519.8	507.4	483.3	446.4	396.1	247.8	543.2
AN-47-J7	8.227	576.9	547.4	513	470	410.3	251.2	613.2
AN-47-R2	4.567	102.7	77.3	68.3	61.6	57.2	49.1	156.7
AN-47-R3	4.567	102.1	77.3	68.3	61.5	57.2	49.1	149.2
AN-47-R5	7.886	519.2	506.9	482.6	446.1	394.6	245.6	542.6
AN-49-A	0.477	192.7	158.7	133.3	97.4	71.2	43.7	356.1
AN-49-B	0.822	258.7	208.3	173.4	114.9	75	33.8	431.4
AN-49-C	0.295	116.8	95.3	79.7	56.4	39.7	22.4	134.2
AN-49-D	0.33	105.5	83.6	68.7	44.5	28.5	13.1	149.6
AN-49-J2	1.299	279.3	227.7	191.7	131.5	90.5	45.4	589.5
AN-49-J3	1.924	55	54.2	53.7	52.2	49.9	40.9	55.8
Basin-AN47A	0.356	31.8	31.1	30.5	29.1	27.6	26.3	32.8
Basin-AN47B	0.86	51.3	48.3	46.8	44.9	43.5	41.8	51.9
Basin-AN47C	1.312	44	43.4	43	42.3	41.1	39.3	45.5
Basin-AN47F	7.886	519.8	507.4	483.3	446.4	396.1	247.8	543.2
Basin-AN49A	0.477	63.4	29.2	22.3	19.8	17.6	14.4	219.5
Basin-AN49D	1.924	55	54.2	53.7	52.2	49.9	40.9	55.8
Lake Tio Cano	14.216	0	0	0	0	0	0	0
TC-01-A	0.659	170.3	134.7	110.3	70.6	44.7	20.1	170.4
TC-01-B	0.815	357.7	296.6	252.1	177.7	122.4	58.5	358.4
TC-01-C	2.314	651.7	517.6	426.7	271.6	168.2	63.8	654.1
TC-01-D	2.336	609.5	485.3	399.4	256.8	159.9	59.4	710.2
TC-01-E	0.734	180.8	140.7	114.1	69.8	41.8	16.7	180.9
TC-01-F	8.017	1729.6	1383.6	1130	758.1	493.2	210.5	1775.3
TC-01-J1	2.314	651.7	517.6	426.7	271.6	168.2	63.8	654.1
TC-01-J2	3.07	782.3	619.8	508.3	323.5	199.7	74.3	886.9
TC-01-J3	14.216	3461.7	2773.1	2288.8	1507.3	968.4	400.3	3618.4
TC-01-R2	0.815	357.7	296.6	252.1	177.7	122.4	58.5	358.4
TC-01-R3	2.336	609.4	485.2	399.4	256.8	159.9	59.4	710.1
TC-01-R4	3.07	782.2	619.7	507.9	323.3	199.6	74.3	886.6

LA FERIA FLOOD PROTECTION PLAN
HEC-HMS Output

PROPOSED		100-yr	50-YR	25-YR	10-YR	5-YR	2-YR
Element	DA (sq mi)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)	Q(cfs)
AN-47-A	0.356	198.6	161.9	137.6	102.9	75.4	49.6
AN-47-B	0.504	513.4	441.3	388.8	318.8	248.5	167.1
AN-47-C	1.312	433.4	353.6	295.5	206.3	144.1	78.9
AN-47-D	2.395	540.3	435.2	358.4	245.3	168.2	89.4
AN-47-E	0.624	229.6	192.6	163.3	123	92.8	58.5
AN-47-F	1.564	613.7	498.2	416.7	283.9	190.5	91.8
AN-47-G	1.131	379.4	311.5	261.3	185.4	131.7	73.9
AN-47-H	0.341	89.1	68.3	54.7	32.1	18.1	6.4
AN-47-J1	0.86	541.2	468.6	415.8	345.3	274.6	192.9
AN-47-J2	4.567	630.4	523.7	445.1	330	250.9	169.4
AN-47-J3	4.567	102.7	77.3	68.3	61.6	57.2	49.1
AN-47-J4	5.191	276.2	237.8	208.2	165.6	134.2	98.2
AN-47-J5	6.755	889	736	624.9	449.5	324.7	189.9
AN-47-J6	7.886	1138	1007.3	868.3	628.3	451.5	259.9
AN-47-J7	8.227	1217.3	1069.9	919.3	634.6	462.1	262.9
AN-47-R2	4.567	102.7	77.3	68.3	61.6	57.2	49.1
AN-47-R3	4.567	102.7	77.3	68.3	61.6	57.2	49.1
AN-47-R5	7.886	1137.2	1004.7	866.2	603.9	444.3	256.9
AN-49-A	0.477	192.7	158.6	133.2	97.4	71.2	43.7
AN-49-B	0.822	258.7	208.3	173.3	114.8	75	33.8
AN-49-C	0.295	116.8	95.3	79.7	56.4	39.7	22.4
AN-49-D	0.33	105.5	83.6	68.7	44.5	28.5	13.1
AN-49-J2	1.299	270.1	218.8	183.8	123	81.6	37.8
AN-49-J2A	1.594	383.4	311.2	260.9	176.9	118.9	59.3
AN-49-J3	1.924	486.9	393.1	328.2	220.1	146.2	71
AN-49-R1	0.477	47.8	29.3	17.2	15.3	13.6	11.2
AN-49-R2	1.594	382.7	310.4	260.1	176.2	118.4	58.4
Basin-AN47A	0.356	31.8	31.1	30.5	29.1	27.6	26.3
Basin-AN47B	0.86	51.3	48.3	46.7	44.9	43.5	41.8
Basin-AN47C	1.312	44	43.4	43	42.3	41.1	39.3
Basin-AN49A	0.477	69.4	32.7	17.2	15.5	13.7	11.5
Lake Tio Cano	14.216	399.7	291.1	234.8	102.2	32.1	0
Prop AN47F	7.886	1138	1007.3	868.3	628.3	451.5	259.9
TC-01-A	0.659	170.3	134.7	110.3	70.6	44.7	20.1
TC-01-B	0.815	357.6	296.5	252.1	177.7	122.4	58.5
TC-01-C	2.314	651.7	517.6	426.7	271.6	168.2	63.8
TC-01-D	2.336	609.5	485.3	399.4	256.8	159.9	59.4
TC-01-E	0.734	180.8	140.7	114.1	69.8	41.8	16.7
TC-01-F	8.017	1729.5	1383.6	1130	758.1	493.2	210.5
TC-01-J1	2.314	651.7	517.6	426.7	271.6	168.2	63.8
TC-01-J2	3.07	782.3	619.8	508.3	323.5	199.7	74.3
TC-01-J3	14.216	3461.5	2773	2288.8	1507.3	968.4	400.3
TC-01-R2	0.815	357.6	296.5	252.1	177.7	122.4	58.5
TC-01-R3	2.336	609.4	485.2	399.4	256.8	159.9	59.4
TC-01-R4	3.07	782.2	619.7	507.9	323.3	199.6	74.3

APPENDIX G
COST ESTIMATE CALCULATIONS

Engineer's Cost Estimate Summary 10/5/2010

La Feria Flood Protection Plan

Engineer: Sigler, Winston, Greenwood & Assoc. Juan M. Gamez EIT

Drainage Improvements

Unit	FPP Phase	Designation	Description	Total
1	1	Tio Cano Drain (TCD)	Proposed Tio Cano Drainage Ditch	$ 9,054,672
2	1	AN-47 Structure 1	Drop Structures	$ 900,000
3	1	AN-47 Structure 2	White Ranch Rd. Crossing	$ 255,000
4	1	AN-47 Structure 3	Evans Canal Crossing	$ 277,000
5	1	AN-47 Structure 4	Beddoes Rd. Crossing	$ 110,000
6	1	AN-47-1	Beddoes Rd. Crossing	$ 190,000
7	1	AN-47-1	Kansas City Rd. Crossing	$ 190,000
8	1	AN-47-2 & AN-47 Junction	Junction of AN-47-2 & AN-47	$ 90,000
9	1	Rabb Rd. Improvements	Rabb Rd. Drainage Improvements	$ 1,313,000
11	1	Orange Grove Road Crossing & Drain Improvements	Orange Grove Road Drain	$ 121,000
12	1	AN-49 Crossing	Levee Crossing of AN-49 Drain	$ 800,000
13	1B	TCD Structure 1	Arroyo L.N.	$ 218,352
14	1B	TCD Structure 2	White Ranch Rd. Crossing	$ 219,848
15	1B	TCD Structure 3	Evans Canal Crossing	$ 436,000
16	1B	TCD Structure 4	Business 83 Crossing	$ 137,464
17	1B	TCD Structure 5	Kelly Dr. Crossing	$ 808,880
18	1B	TCD Structure 6	U.S. Expressway 83 Crossing	$ 717,752
19	1B	TCD Structure 7	Callaway Dr. Crossing	$ 497,176
20	1B	TCD Structure 8	County Rd. 622 Crossing	$ 139,128
21	1B	Utilities Relocation	Utilites Adjustments as required	$ 250,000
22	1B	IC Structure	TC-NF-13 Interconnect	$ 600,000
23	2	SWQ & Drainage Improvements	White Ranch Lake	$ 800,000
24	2	SWQ & Drainage Improvements	Turtle Lake	$ 600,000
25	2	Rabb Drain	Widening of Rabb Drain	$ 118,800
26	2	AN-47-1 & AN-47-2 Improvements	Widening of AN-47-1 & AN-47-2	$ 626,400
27	2	Kansas City Rd. Improvements	Kansas City Rd. Drainage Improvements	$ 633,720
28	3	TCAA	Tio Cano Acquisition Area & Drainage Imrovements	$ 22,000,000
29	3	ERDI	East Rabb Drainage Improvements	$ 600,000
30	3	IAB	Improvements Along Business 83	$ 500,000
31	3	DAN47P2	Deepening of AN-47 Phase 2	$ 1,980,000
32		IRR-AN49	Siphon Under AN-49	$ 415,000

Total Estimated Project Budget Cost **$45,599,192**

Preliminary Engineers Cost Estimate

I A. 1. Beddoes Road of AN-47 Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total	
1	10'x5' Box Culvert	72	LF	$	1,280.00	$	92,160.00
2	Headwalls (one at each end)	2	ea	$	3,000.00	$	6,000.00

Subtotal	$98,160
Estimated Construction Cost	$98,160
Engineering Fee	$11,840

I A. 1. Beddoes Road Crossing Total Estimated Project Cost $110,000

Sigler, Winston, Greenwood
Associates, Inc.
1604 E. HWY. 83
Weslaco, TX 78596

Preliminary Engineers Cost Estimate

I A. 2. White Ranch Rd Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	10'x7'- Twin Boxed Culvert	84	LF	$	2,590.00	$217,560
2	Headwalls (one at each end)	2	LS	$	5,000.00	$10,000
	Subtotal					$227,560
	Estimated Construction Cost					$227,560
	Engineering Fee					$27,440

I A. 2. White Ranch Rd Crossing Total Estimated Project Cost $255,000

Preliminary Engineers Cost Estimate

I B. Evans Canal Crossing

December 15, 2008

Item	Description	Qty		Unit Price	Total
1	Earth Work	3500	CY	$15.00	$52,500
2	48" Steel Aerial Crossing	150	LF	$250.00	$37,500
3	72" RCP Siphon	125	LF	$500.00	$62,500
4	gravel	100	CY	$40.00	$4,000
5	72" water tight collar joints	2	ea	$6,700.00	$13,400
6	Canasta	2		$30,000.00	$60,000
7	dewatering	40	day	$450.00	$18,000
	Subtotal				$247,900
	Estimated Construction Cost				$247,900
	Engineering Fee				$29,100

I B. Evans Canal Crossing Total Estimated Project Cost **$277,000**

Preliminary Engineers Cost Estimate

I C. Drop Structures on AN-47

February 15, 2009

Item	Description	Qty			Unit Price	Total
1	3 Drop Structures Including Bank Protection	1320	CY	$	427.00	$563,640
2	3 Retaining Walls	300	CY	$	800.00	$240,000
	Subtotal					$803,640
	Estimated Construction Cost					$803,640
	Engineering Fee					$96,360

I C. Drop Structures on AN-47 Total Estimated Project Cost $900,000

Preliminary Engineers Cost Estimate

I A. 1. Beddoes Road Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	7'x7' Twin Box Culvert	84	LF	$	1,900.00	$159,600
2	Headwalls (one at each end)	2	ea	$	5,000.00	$10,000
	Subtotal					$169,600
	Estimated Construction Cost					$169,600
	Engineering Fee					$20,400

I A. 1. Beddoes Road Crossing Total Estimated Project Cost $190,000

Preliminary Engineers Cost Estimate

II A. 2.Kansas City Rd Crossing

February 15, 2008

Item	Description	Qty		Unit Price		Total
1	7'x7' Twin Box Culvert	84	LF	$	1,900.00	$159,600
2	2- Headwalls (one at each end)	2	ea	$	5,000.00	$10,000

Subtotal	$169,600
Estimated Construction Cost	$169,600
Engineering Fee	$20,400

II A. 2.Kansas City Rd Crossing Total Estimated Project Cost $190,000

Preliminary Engineers Cost Estimate

III A. Junction of AN-47-2 to AN-47

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	5'x5' Box Culvert	64	LF	$	1,130.00	$72,320
2	2- Headwalls (one at each end)	2	ea	$	4,000.00	$8,000

Subtotal	$80,320
Estimated Construction Cost	$80,320
Engineering Fee	$9,680

II A. 2.Kansas City Rd Crossing Total Estimated Project Cost $90,000

Preliminary Engineers Cost Estimate

IV. Orange Grove Road Drainage Improvements

December 15, 2008

Item	Description	Qty		Unit Price	Total
1.	Cleaning & re-grading of Drainage ditch	2400	LF	$18.00	$43,200
2.	Remove existing Headwalls & 30" pipe under Orange Grove Rd.	1	LS	$6,000.00	$6,000
3.	Install 36" RCP with safety end treatments under Orange Groove Rd. " 60' LF	1	LS	$12,000.00	$12,000
4.	Cut and replace pavement	24	LF	$48.00	$1,152
5.	Guard railing and markers	200	LF	$78.00	$15,600
6.	Concrete rip-rap protection at outlet AN-49	1	LS	$6,000.00	$6,000
7.	Grading of Roadside Ditches Either side of Orange Grove Rd. North & South of Drain Crossing	4000	LF	$6.00	$24,000
	Subtotal				$107,952
	Estimated Construction Cost				$107,952
	Engineering Fee				$13,048

Orange Grove Rd. Total Estimated Project Cost $121,000

Preliminary Engineers Cost Estimate

V. AN-49 Drain Crossing

December 15, 2008

Item	Description	Qty		Unit Price	Total
1	Earth Work	5536	CY	$35.00	$193,760
2	Gate Structure	258.333	CY	$1,200.00	$310,000
3	10X10 Gate	1	LS	$150,000.00	$150,000
4	Canasta	110	CY	500	$55,000
	Subtotal				$708,760
	Estimated Construction Cost				$708,760
	Engineering Fee				$91,240

AN-49 Drain Crossing Total Estimated Project Cost **$800,000**

Preliminary Engineers Cost Estimate

VI. Rabb Road Drainage Improvements

December 15, 2008

Item Description	Qty	Unit Price	Total
1. 24" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 4-6' cut	400 LF	$45.60	$18,240
2. 30" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 4-6' cut	700 LF	$60.00	$42,000
3. 36" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 6-8' cut	2,050 LF	$78.00	$159,900
4. 36" RCP Class III, ASTM C-76, Rubber Gasket Joint Pipe, 8-10' cut	1,180 LF	$84.00	$99,120
5. 36" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 10-12' cut	1,550 LF	$90.00	$139,500
6. 5' diameter reinforced concrete Pre-Cast manholes 4-6' depth	3 Ea.	$2,400.00	$7,200
7. 5' diameter reinforced concrete Pre-Cast manholes 6-8' depth	4 Ea.	$2,640.00	$10,560
8. 5' diameter reinforced concrete Pre-Cast manholes 8-10' depth	2 Ea.	$3,000.00	$6,000
9. 5' diameter reinforced concrete Pre-Cast manholes 10-12' depth	2 Ea.	$3,600.00	$7,200
” pre-cast concrete Inlets 0-4' depth	2 Ea.	$2,400.00	$4,800
11. Type “A” pre-cast concrete Inlets 4-6' depth	4 Ea.	$2,640.00	$10,560

12. Type "A" pre-cast concrete Inlets 6-8' depth	4	$3,120.00	$12,480
13. Type "A" pre-cast concrete Inlets 8-10' depth	2 Ea.	$3,600.00	$7,200
14. Trench excavation protection	5,880	$6.00	$35,280
15. Boring on Grade under the Railroad	80 LF	$360.00	$28,800
16. Boring on Grade under U.S. 83 Business Highway	100 LF	$360.00	$36,000
17. Headwall for 36" pipe	1	$6,000.00	$6,000
18. Storm Water Pollution Prevention Plan	1 Ea.	$6,000.00	$6,000
19. Traffic Control Plan	1 LS	$6,000.00	$6,000
18. Re-Paving of Rabb Road - 40' B-13	1 LS		$500,000

Subtotal	$1,142,840
Engineering Fee	$143,159.80
Improvement Total	**$1,285,999.80**

Additional Services

1. Purchase of Right-of-Way 2,500' x 20') 43,560 x $20,00.00/Acre	$23,000
2. Legal Fees- estimate two Tracts x $3,000/tract	$6,000
3. Survey, plat & preparation of description 2 x $2,000.00	$4,000
Additional Services Total	**$33,000**

Rabb RD. Total Estimated Project Cost **$1,319,000**

Engineer's Cost Estimate 8/11/2010

La Feria Flood Protection Plan

Engineer: Sigler, Winston, Greenwood & Assoc. Juan M. Gamez EIT

Tio Cano Drain & Road Crossings

Item	Description	Qty	Unit		Unit Price			Total
I	**FPP Phase 1 - Tio Cano Drain**							
	Excavation	1183668	CY	$	4.00		$	4,734,672
	Lining	180000	SY	$	14.00		$	2,520,000
	ROW Acquisition	90	AC	$	20,000.00		$	1,800,000
						Sub-total =	**$**	**9,054,672**
II	**FPP Phase 1B - Road Crossings**							
	1. Arroyo Ln. Crossing	50'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	200	LF	$	600.00		$	120,000
	Excavation	5,678	CY	$	4.00		$	22,712
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	91	CY	$	40.00		$	3,640
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**218,352**
	2. White Ranch Rd. Crossing	50'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	200	LF	$	600.00		$	120,000
	Excavation	6,052	CY	$	4.00		$	24,208
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	91	CY	$	40.00		$	3,640
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**219,848**
	3. Evans Canal Crossing	120'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	480	LF	$	600.00		$	288,000
	Excavation	7,000	CY	$	4.00		$	28,000
	Aerial Crossings	2	EA	$	60,000.00		$	120,000
						Sub-total =	**$**	**436,000**
	4. Business 83 Crossing	160'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	320	LF	$	400.00		$	128,000
	Excavation	12,386	CY	$	4.00		$	49,544
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	148	CY	$	40.00		$	5,920
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
	Railroad Crossing Permit	1	LS	$	10,000.00		$	10,000
						Sub-total =	**$**	**137,464**
	5. Kelly Dr. Crossing	475'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	950	LF	$	600.00		$	570,000
	Excavation	37,350	CY	$	4.00		$	149,400
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	437	CY	$	40.00		$	17,480
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**808,880**
	6. U.S. Expressway 83 Crossing	300'	x 3 Culverts					
	3 - 10' x 10' Box Culvert	900	LF	$	600.00		$	540,000
	Excavation	22,378	CY	$	4.00		$	89,512
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	406	CY	$	40.00		$	16,240
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**717,752**
	7. Callaway Dr. Crossing	300'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	600	LF	$	600.00		$	360,000
	Excavation	13,534	CY	$	4.00		$	54,136
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	276	CY	$	40.00		$	11,040
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**497,176**
	8. County Rd. 622 Crossing	50'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	100	LF	$	600.00		$	60,000
	Excavation	1,322	CY	$	4.00		$	5,288
	Concrete Headwall and Wingwalls (one at each end	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	46	CY	$	40.00		$	1,840
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**139,128**

Total Estimated Project Budget Cost **$12,229,272**

Preliminary Engineers Cost Estimate

FPP Phase 1B - TC-NF-13 Interconnect

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	6'x6' Box Culvert	200	LF	$	1,500.00	$300,000
2	2 - Headwalls (one at each end)	2	EA	$	10,000.00	$20,000
3	Excavation	31,111	CY	$	5.00	$155,555
4	Gate Structure	1	EA	$	60,000.00	$60,000
5	Gate	1	EA	$	20,000.00	$20,000
	Subtotal					$555,555
	Estimated Construction Cost					$555,555
	Engineering Fee					$44,444

TC-NF-13 Interconnect Total Estimated Project Cost **$600,000**

Sigler, Winston, Greenwood
Associates, Inc.
1604 E. HWY. 83
Weslaco, TX 78596

Engineer's Cost Estimate

City of La Feria

FPP Phase 2 - VIII. Storm Water Quality & Drainage Improvements

April 3, 2009

Item	Description	Qty		Unit Price	Sub Total	Total
I.	**White Ranch Lake**					
	Property Acquisition	24	Ac.	$10,000.00	$240,000	
	Control Structure	1	LS	$300,000.00	$300,000	
	Drain Excavation	23,273	CY	$5.00	$116,365	
	60" RCP	625	LF	$135.00	$84,375	
						$740,740
				Engineering	8%	$59,259
					Total	**$800,000**
II.	**Turtle Lake**					
	Property Acquisition	20	Ac.	$10,000.00	$200,000	
	Berm Construction	11,111	CY	$5.00	$55,555	
	Control Structure	1	LS	$300,000.00	$300,000	
						$555,555
				Engineering	8%	$44,444
					Total	**$600,000**
III.	**Widening of Rabb Drain**					
	Drain Excavation	22,000	CY	$5.00	$110,000	
						$110,000
				Engineering	8%	$8,800
					Total	**$118,800**
IV.	**Widening of AN-47-1&2**					
	Property Acquisition	10	Ac.	$8,000.00	$80,000	
	Drain Excavation	125,000	CY	$4.00	$500,000	
						$580,000
				Engineering	8%	$46,400
					Total	**$626,400**

Preliminary Engineers Cost Estimate

FPP Phase 3 - East Rabb Drainage Improvements

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	Small Channel Excavation	26,311	CY	$	5.00	$131,555
2	Crossing under Canal with 36" - Jack and Bore	250	LF	$	200.00	$50,000
3	Medium Channel Excavation	41,000	CY	$	6.00	$246,000
4	48" RCP Class III, C-76, Rubber Gasket Joint	800	LF	$	160.00	$128,000
	Subtotal					$555,555
	Estimated Construction Cost					$555,555
	Engineering Fee					$44,444
	East Rabb Drainage Improvements Total Estimated Project Cost					**$600,000**

Preliminary Engineers Cost Estimate

FPP Phase 2 - VII. Kansas City Rd Drainage Improvements

February 15, 2009

Item	Description	Qty		Unit Price	Total
1	Station Grading:	20.40	Sta.	$ 1,000.00	$ 20,400.00
2	EN-1 Stabilization	9520.00	S.Y.	$ 1.35	$ 12,852.00
3	Tensar	9520.00	S.Y.	$ 3.55	$ 33,796.00
4	8" of compated Caliche Base	9066.67	S.Y.	$ 8.50	$ 77,066.70
5	2.00" HMAC Pavement	8386.67	S.Y.	$ 10.75	$ 90,156.70
6	Standard Curb & Gutter	4080.00	L.F.	$ 7.50	$ 30,600.00
7	Laydown Gutter	50.00	L.F.	$ 8.25	$ 412.50
8	Valley Gutter	50.00	L.F.	$ 22.00	$ 1,100.00
9	Driveway Repair		Lump Sum	--------------------	$ 5,000.00
10	Adjust Manholes		Lump Sum	--------------------	$ 2,500.00
11	Adjust Water Valves		Lump Sum	--------------------	$ 1,500.00
12	Reclocated Traffic Signs		Lump Sum	--------------------	$ 1,500.00
13	48" RCP, Class III, ASTM C-76	1660.00	L.F.	$ 160.00	$ 265,600.00
14	Inlets	13.00	Ea	$ 1,800.00	$ 23,400.00
Subtotal					$565,884
Estimated Construction Cost					$565,884
Engineering Fee					$67,836

Kansas City RD Total Estimated Project Cost **$633,720**

Sigler, Winston, Greenwood
Associates, Inc.
1604 E. HWY. 83
Weslaco, TX 78596

Preliminary Engineers Cost Estimate

FPP Phase 3 - Improvements Along Business 83

February 15, 2009

Item	Description	Qty			Unit Price	Total
	Cleaning of Drain Ditch along North side of Railroad from White Ranch Road to AN-47					
1	Drain Ditch Excavation	22,523	CY	$	4.00	$90,092
2	Drop Structure @ AN-47	1	EA	$	5,000.00	$5,000
3	Purchase of R.O.W.	7.4	AC	$	20,000.00	$148,000
4	48" RCP Class III, C-76, Rubber Gasket Joint under Beddoes Road	72	LF	$	160.00	$11,520
5	Safety End Treatment	2	EA	$	950.00	$1,900
6	36" RCP Class III, C-76, Rubber Gasket Joint under White Ranch Road	55	LF	$	90.00	$4,950
7	36" RCP Class III, C-76, Rubber Gasket Joint from Beddoes Road to 900 feet east	900	LF	$	90.00	$81,000
	Clean existing drain just North of Railroad from Parker Road East to AN-47					
1	Drain Ditch Excavation	24,400	CY	$	4.00	$97,600
2	Drop Structure @ AN-47	1	EA	$	5,000.00	$5,000
3	Allowance for adjusting Road Crossing @ Citrus Dr. & Kansas City - place safety ends	1	LS	$	7,500.00	$7,500
4	48" RCP Class III, C-76, Rubber Gasket Joint under Kansas City Road	65	LF	$	160.00	$10,400
	Subtotal					$462,962
	Estimated Construction Cost					$462,962
	Engineering Fee					$37,037
	Improvements Along Business 83 Total Estimated Project Cost					**$500,000**

Engineer's Cost Estimate

City of La Feria

FPP Phase 3 - Drainage Improvements

April 3, 2009

Item	Description	Qty		Unit Price	Sub Total	Total
I.	**Tio Cano Acquisition Area**					
	Property Acquisition	910	Ac.	$21,900.00	$19,929,000	
						$19,929,000
				Engineering & Surveying	10.4%	$2,072,616
					Total	**$22,000,000**
II.	**Deepening of AN-47 Phase 2**					
	Property Acquisition	32	Ac.	$8,000.00	$256,000	
	Drain Excavation	315,467	CY	$5.00	$1,577,335	
						$1,833,335
				Engineering	8%	$146,667
					Total	**$1,980,000**
III.	**Irrigation Siphon Under AN-49**					
	Twin 6'x6' Box Culvert	180	LF	$1,500.00	$270,000	
	Standpipes	2	EA	$30,000.00	$60,000	
	Drain Excavation	10,852	CY	$5.00	$54,260	
						$384,260
				Engineering	8%	$30,741
					Total	**$415,000**

APPENDIX H
ALTERNATIVE BENEFIT CALCULATIONS
HAZUS

HAZUS-MH: Flood Event Report

Region Name: Cameron County

Flood Scenario: AN47_E_100year

Print Date: Monday, August 09, 2010

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social

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General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Texas

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 901 square miles and contains 8,764 census blocks. The region contains over 97 thousand households and has a total population of 335,227 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 116,617 buildings in the region with a total building replacement value (excluding contents) of 14,092 million dollars (2006 dollars). Approximately 93.57% of the buildings (and 75.73% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 116,617 buildings in the region which have an aggregate total replacement value of 14,092 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	10,671,039	75.7%
Commercial	2,326,882	16.5%
Industrial	483,266	3.4%
Agricultural	40,496	0.3%
Religion	184,542	1.3%
Government	104,308	0.7%
Education	281,093	2.0%
Total	**14,091,626**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	130,548	82.2%
Commercial	17,706	11.2%
Industrial	3,940	2.5%
Agricultural	1,364	0.9%
Religion	1,310	0.8%
Government	306	0.2%
Education	3,555	2.2%
Total	**158,729**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 6 hospitals in the region with a total bed capacity of 884 beds. There are 156 schools, 9 fire stations, 18 police stations and 1 emergency operation center.

Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Cameron County
Scenario Name:	AN47_E_100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Building Damage

General Building Stock Damage

HAZUS estimates that about 107 buildings will be at least moderately damaged. This is over 19% of the total number of buildings in the scenario. There are an estimated 33 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	13	12.15	57	53.27	0	0.00	4	3.74	33	30.84
Total	**1**		**13**		**57**		**0**		**4**		**33**	

Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	4	10.81	33	89.19
Masonry	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00	0	0.00
Steel	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Wood	0	0.00	13	19.70	53	80.30	0	0.00	0	0.00	0	0.00

Essential Facility Damage

Before the flood analyzed in this scenario, the region had hospital beds available for use. On the day of the scenario flood event, the model estimates that hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	9	0	0	0
Hospitals	6	0	0	0
Police Stations	18	0	0	0
Schools	156	1	0	1

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 2,490 tons of debris will be generated. Of the total amount, Finishes comprises 36% of the total, Structure comprises 19% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 100 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 394 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 1,038 people (out of a total population of 335,227) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 116.81 million dollars, which represents 7.06 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 9.54 million dollars. 2% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 68.40% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	4.28	0.36	0.13	0.11	4.88
	Content	2.32	1.34	0.27	0.61	4.54
	Inventory	0.00	0.02	0.09	0.01	0.12
	Subtotal	**6.60**	**1.73**	**0.48**	**0.73**	**9.54**
Business Interruption						
	Income	0.00	0.03	0.00	0.01	0.04
	Relocation	0.04	0.01	0.00	0.00	0.05
	Rental Income	0.01	0.00	0.00	0.00	0.01
	Wage	0.00	0.04	0.00	0.05	0.09
	Subtotal	**0.06**	**0.07**	**0.00**	**0.07**	**0.19**
ALL	**Total**	**6.66**	**1.80**	**0.48**	**0.79**	**9.73**

Appendix A: County Listing for the Region

Texas

- Cameron

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Texas				
Cameron	335,227	10,671,039	3,420,587	14,091,626
Total	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**
Total Study Region	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**

HAZUS-MH: Flood Event Report

Region Name:	Cameron County
Flood Scenario:	AN47_P_100year
Print Date:	Thursday, September 30, 2010

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social

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General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Texas

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 901 square miles and contains 8,764 census blocks. The region contains over 97 thousand households and has a total population of 335,227 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 116,617 buildings in the region with a total building replacement value (excluding contents) of 14,092 million dollars (2006 dollars). Approximately 93.57% of the buildings (and 75.73% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 116,617 buildings in the region which have an aggregate total replacement value of 14,092 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	10,671,039	75.7%
Commercial	2,326,882	16.5%
Industrial	483,266	3.4%
Agricultural	40,496	0.3%
Religion	184,542	1.3%
Government	104,308	0.7%
Education	281,093	2.0%
Total	**14,091,626**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	130,548	82.2%
Commercial	17,706	11.2%
Industrial	3,940	2.5%
Agricultural	1,364	0.9%
Religion	1,310	0.8%
Government	306	0.2%
Education	3,555	2.2%
Total	**158,729**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 6 hospitals in the region with a total bed capacity of 884 beds. There are 156 schools, 9 fire stations, 18 police stations and 1 emergency operation center.

Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Cameron County
Scenario Name:	AN47_P_100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Building Damage

General Building Stock Damage

HAZUS estimates that about 104 buildings will be at least moderately damaged. This is over 19% of the total number of buildings in the scenario. There are an estimated 33 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	13	12.50	55	52.88	0	0.00	3	2.88	33	31.73
Total	**1**		**13**		**55**		**0**		**3**		**33**	

Table 4: Expected Building Damage by Building Type

Building Type	**1-10**		**11-20**		**21-30**		**31-40**		**41-50**		**Substantially**	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	3	8.33	33	91.67
Masonry	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	0	0.00
Steel	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Wood	0	0.00	13	20.00	52	80.00	0	0.00	0	0.00	0	0.00

Essential Facility Damage

Before the flood analyzed in this scenario, the region had hospital beds available for use. On the day of the scenario flood event, the model estimates that hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	9	0	0	0
Hospitals	6	0	0	0
Police Stations	18	0	0	0
Schools	156	1	0	1

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 2,453 tons of debris will be generated. Of the total amount, Finishes comprises 36% of the total, Structure comprises 19% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 98 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 391 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 1,033 people (out of a total population of 335,227) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 229.90 million dollars, which represents 13.72 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 9.39 million dollars. 2% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 68.02% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	4.19	0.36	0.13	0.11	4.79
	Content	2.28	1.33	0.27	0.61	4.48
	Inventory	0.00	0.02	0.09	0.01	0.12
	Subtotal	**6.46**	**1.72**	**0.48**	**0.73**	**9.39**
Business Interruption						
	Income	0.00	0.03	0.00	0.01	0.04
	Relocation	0.04	0.01	0.00	0.00	0.05
	Rental Income	0.01	0.00	0.00	0.00	0.01
	Wage	0.00	0.04	0.00	0.05	0.09
	Subtotal	**0.05**	**0.07**	**0.00**	**0.06**	**0.19**
ALL	**Total**	**6.52**	**1.79**	**0.48**	**0.79**	**9.58**

Appendix A: County Listing for the Region

Texas

- Cameron

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars) Residential	Non-Residential	Total
Texas				
Cameron	335,227	10,671,039	3,420,587	14,091,626
Total	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**
Total Study Region	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**

HAZUS-MH: Flood Event Report

Region Name: Cameron County

Flood Scenario: AN49_e_100year

Print Date: Friday, August 13, 2010

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social

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The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

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There are an estimated 116,617 buildings in the region with a total building replacement value (excluding contents) of 14,092 million dollars (2006 dollars). Approximately 93.57% of the buildings (and 75.73% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 116,617 buildings in the region which have an aggregate total replacement value of 14,092 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

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Industrial	483,266	3.4%
Agricultural	40,496	0.3%
Religion	184,542	1.3%
Government	104,308	0.7%
Education	281,093	2.0%
Total	**14,091,626**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	7,268	96.0%
Commercial	305	4.0%
Industrial	0	0.0%
Agricultural	0	0.0%
Religion	0	0.0%
Government	0	0.0%
Education	0	0.0%
Total	**7,573**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 6 hospitals in the region with a total bed capacity of 884 beds. There are 156 schools, 9 fire stations, 18 police stations and 1 emergency operation center.

Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Cameron County
Scenario Name:	AN49_e_100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Building Damage

General Building Stock Damage

HAZUS estimates that about 0 buildings will be at least moderately damaged. This is over 0% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**0**		**0**		**0**		**0**		**0**		**0**	

Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Masonry	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Wood	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Essential Facility Damage

Before the flood analyzed in this scenario, the region had hospital beds available for use. On the day of the scenario flood event, the model estimates that hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	9	0	0	0
Hospitals	6	0	0	0
Police Stations	18	0	0	0
Schools	156	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 57 tons of debris will be generated. Of the total amount, Finishes comprises 44% of the total, Structure comprises 19% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 2 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 37 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 101 people (out of a total population of 335,227) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 6.26 million dollars, which represents 0.37 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 0.34 million dollars. 2% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 88.79% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	0.20	0.01	0.00	0.00	0.21
	Content	0.10	0.03	0.00	0.00	0.13
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.31**	**0.04**	**0.00**	**0.00**	**0.34**
Business Interruption						
	Income	0.00	0.00	0.00	0.00	0.00
	Relocation	0.00	0.00	0.00	0.00	0.00
	Rental Income	0.00	0.00	0.00	0.00	0.00
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**
ALL	**Total**	**0.31**	**0.04**	**0.00**	**0.00**	**0.35**

Appendix A: County Listing for the Region

Texas

- Cameron

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		
		Residential	Non-Residential	Total
Texas				
Cameron	335,227	10,671,039	3,420,587	14,091,626
Total	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**
Total Study Region	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**

HAZUS-MH: Flood Event Report

Region Name: Cameron County

Flood Scenario: AN49_p_100yearr

Print Date: Monday, August 16, 2010

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social

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General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Texas

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 901 square miles and contains 8,764 census blocks. The region contains over 97 thousand households and has a total population of 335,227 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 116,617 buildings in the region with a total building replacement value (excluding contents) of 14,092 million dollars (2006 dollars). Approximately 93.57% of the buildings (and 75.73% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 116,617 buildings in the region which have an aggregate total replacement value of 14,092 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	10,671,039	75.7%
Commercial	2,326,882	16.5%
Industrial	483,266	3.4%
Agricultural	40,496	0.3%
Religion	184,542	1.3%
Government	104,308	0.7%
Education	281,093	2.0%
Total	**14,091,626**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	7,152	95.9%
Commercial	305	4.1%
Industrial	0	0.0%
Agricultural	0	0.0%
Religion	0	0.0%
Government	0	0.0%
Education	0	0.0%
Total	**7,457**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 6 hospitals in the region with a total bed capacity of 884 beds. There are 156 schools, 9 fire stations, 18 police stations and 1 emergency operation center.

Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Cameron County
Scenario Name:	AN49_p_100yearr
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Building Damage

General Building Stock Damage

HAZUS estimates that about 0 buildings will be at least moderately damaged. This is over 0% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**0**		**0**		**0**		**0**		**0**		**0**	

Table 4: Expected Building Damage by Building Type

Building Type	**1-10**		**11-20**		**21-30**		**31-40**		**41-50**		**Substantially**	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Masonry	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Wood	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Essential Facility Damage

Before the flood analyzed in this scenario, the region had hospital beds available for use. On the day of the scenario flood event, the model estimates that hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	9	0	0	0
Hospitals	6	0	0	0
Police Stations	18	0	0	0
Schools	156	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 17 tons of debris will be generated. Of the total amount, Finishes comprises 36% of the total, Structure comprises 20% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 1 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 18 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 32 people (out of a total population of 335,227) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 1.97 million dollars, which represents 0.11 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 0.08 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 90.24% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	0.05	0.00	0.00	0.00	0.05
	Content	0.02	0.01	0.00	0.00	0.03
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.07**	**0.01**	**0.00**	**0.00**	**0.08**
Business Interruption						
	Income	0.00	0.00	0.00	0.00	0.00
	Relocation	0.00	0.00	0.00	0.00	0.00
	Rental Income	0.00	0.00	0.00	0.00	0.00
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
ALL	**Total**	**0.07**	**0.01**	**0.00**	**0.00**	**0.08**

Appendix A: County Listing for the Region

Texas

- Cameron

APPENDIX I
NET PRESENT VALUE CALCULATIONS

LA FERIA FLOOD PROTECTION PLAN

Net Present Value - Alternative 1 (AN-47) Annualized Damage Calculation

AN 47	Existing Damages	With-Project Damages	Benefit
2-Year	$340,000	$250,000	$90,000
5-Year	$5,150,000	$2,660,000	$2,490,000
10-Year	$6,420,000	$5,700,000	$720,000
25-Year	$8,070,000	$7,650,000	$420,000
100-Year	$9,730,000	$9,580,000	$150,000

Existing Condition	
Storm Frequency Event	Damage
0.5	$340,000
0.2	$5,150,000
0.1	$6,420,000
0.04	$8,070,000
0.01	$9,730,000

Storm Frequency Event	Damage w/ 6.75% Inflation Adjustment	Incremental Frequency	Damage A	Damage B	Area Under Curve
0.5	$362,955				
0.2	$5,497,697	0.3	$5,497,697	$362,955	$879,098
0.1	$6,853,440	0.1	$6,853,440	$5,497,697	$617,557
0.04	$8,614,838	0.06	$8,614,838	$6,853,440	$464,048
0.01	$10,386,911	0.03	$10,386,911	$8,614,838	$285,026
				Total Area	$2,245,729

With Project Damages	
Storm Frequency Event	Damage
0.5	$250,000
0.2	$2,660,000
0.1	$5,700,000
0.04	$7,650,000
0.01	$9,580,000

Storm Frequency Event	Damage w/ 6.75% Inflation Adjustment	Frequency Difference	Damage A	Damage B	Area Under Curve
0.5	$266,879				
0.2	$2,839,587	0.3	$2,839,587	$266,879	$465,970
0.1	$6,084,830	0.1	$6,084,830	$2,839,587	$446,221
0.04	$8,166,482	0.06	$8,166,482	$6,084,830	$427,539
0.01	$10,226,784	0.03	$10,226,784	$8,166,482	$275,899
				Total Area	$1,615,629

Difference / Annualized Benefit **$630,100**

LA FERIA FLOOD PROTECTION PLAN
Net Present Value - Alternative 1 (AN-47)

Discount Rate	3.98% (9/30/10 T-bill yield)

YEAR	COST	ANNUALIZED DAMAGE W/O PROJECT	ANNUALIZED DAMAGE W/PROJECT	ANNUALIZED BENEFIT	cost-benefit
2010	($2,012,000)	$2,245,729	$1,615,629	$630,100	($1,381,900)
2011	$0	$2,245,729	$1,615,629	$630,100	$630,100
2012	$0	$2,245,729	$1,615,629	$630,100	$630,100
2013	$0	$2,245,729	$1,615,629	$630,100	$630,100
2014	$0	$2,245,729	$1,615,629	$630,100	$630,100
2015	$0	$2,245,729	$1,615,629	$630,100	$630,100
2016	$0	$2,245,729	$1,615,629	$630,100	$630,100
2017	$0	$2,245,729	$1,615,629	$630,100	$630,100
2018	$0	$2,245,729	$1,615,629	$630,100	$630,100
2019	$0	$2,245,729	$1,615,629	$630,100	$630,100
2020	$0	$2,245,729	$1,615,629	$630,100	$630,100
2021	$0	$2,245,729	$1,615,629	$630,100	$630,100
2022	$0	$2,245,729	$1,615,629	$630,100	$630,100
2023	$0	$2,245,729	$1,615,629	$630,100	$630,100
2024	$0	$2,245,729	$1,615,629	$630,100	$630,100
2025	$0	$2,245,729	$1,615,629	$630,100	$630,100
2026	$0	$2,245,729	$1,615,629	$630,100	$630,100
2027	$0	$2,245,729	$1,615,629	$630,100	$630,100
2028	$0	$2,245,729	$1,615,629	$630,100	$630,100
2029	$0	$2,245,729	$1,615,629	$630,100	$630,100
2030	$0	$2,245,729	$1,615,629	$630,100	$630,100
2031	$0	$2,245,729	$1,615,629	$630,100	$630,100
2032	$0	$2,245,729	$1,615,629	$630,100	$630,100
2033	$0	$2,245,729	$1,615,629	$630,100	$630,100
2034	$0	$2,245,729	$1,615,629	$630,100	$630,100
2035	$0	$2,245,729	$1,615,629	$630,100	$630,100
2036	$0	$2,245,729	$1,615,629	$630,100	$630,100
2037	$0	$2,245,729	$1,615,629	$630,100	$630,100
2038	$0	$2,245,729	$1,615,629	$630,100	$630,100
2039	$0	$2,245,729	$1,615,629	$630,100	$630,100
2040	$0	$2,245,729	$1,615,629	$630,100	$630,100
2041	$0	$2,245,729	$1,615,629	$630,100	$630,100
2042	$0	$2,245,729	$1,615,629	$630,100	$630,100
2043	$0	$2,245,729	$1,615,629	$630,100	$630,100
2044	$0	$2,245,729	$1,615,629	$630,100	$630,100
2045	$0	$2,245,729	$1,615,629	$630,100	$630,100
2046	$0	$2,245,729	$1,615,629	$630,100	$630,100
2047	$0	$2,245,729	$1,615,629	$630,100	$630,100
2048	$0	$2,245,729	$1,615,629	$630,100	$630,100
2049	$0	$2,245,729	$1,615,629	$630,100	$630,100
2050	$0	$2,245,729	$1,615,629	$630,100	$630,100
2051	$0	$2,245,729	$1,615,629	$630,100	$630,100
2052	$0	$2,245,729	$1,615,629	$630,100	$630,100
2053	$0	$2,245,729	$1,615,629	$630,100	$630,100
2054	$0	$2,245,729	$1,615,629	$630,100	$630,100
2055	$0	$2,245,729	$1,615,629	$630,100	$630,100
2056	$0	$2,245,729	$1,615,629	$630,100	$630,100
2057	$0	$2,245,729	$1,615,629	$630,100	$630,100
2058	$0	$2,245,729	$1,615,629	$630,100	$630,100
2059	$0	$2,245,729	$1,615,629	$630,100	$630,100

APPENDIX J
BENEFIT COST ANALYSIS (BCA)

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		
		Residential	Non-Residential	Total
Texas				
Cameron	335,227	10,671,039	3,420,587	14,091,626
Total	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**
Total Study Region	**335,227**	**10,671,039**	**3,420,587**	**14,091,626**

Total Benefits: **$52,241,317** Total Costs: **$47,394,097** BCR: **1.10**

Project Number: Disaster #: Program: FMA Agency: **City of La Feria**

State: **Texas** Point of Contact: Sunny K. Philip Analyst: Juan M. Gamez E.I.T

Project Summary:

Project Number: Disaster #:

Program: FMA Agency: City of La Feria

Analyst: Juan M. Gamez E.I.T

Point of Contact: Sunny K. Philip Phone Number: 956-797-2261

Address: 115 E. Commercial Ave, La Feria, Texas, 78559

Email: skphilip@rgv.rr.com

Comments:

Structure Summary For:

Copy Of Drainage Improvements, 115 E. Commercial Ave, La Feria, Texas, 78559, Cameron

Structure Type: Utility Historic Building: No Contact: Sunny Philip

Benefits: $52,241,317 Costs: $47,394,097 BCR: 1.10

Mitigation	Hazard	BCR	Benefits	Costs
Drainage Improvement	Damage-Frequency Assessment	1.10	$52,241,317	$47,394,097

Structure and Mitigation Details For: Copy Of Drainage Improvements, 115 E. Commercial Ave, La Feria, Texas, 78559, Cameron

Benefits: $52,241,317 Costs: $47,394,097 BCR: 1.10

Hazard: **Damage-Frequency Assessment - Flood**

Mitigation Option: Drainage Improvement

Latitude: Longitude: Project Useful Life: 50

Mitigation Information

Basis of Damages: Historical Damages

Number of Estimated Damage Events: 2

Number of Events with Know Recurrence Intervals: 2

Utilities

Type of Service: Electrical

Other:

Number of Customers: Served: 4,800

Value per Unit of Service: 126.00

Total Value of Service per Day: $604,800

Facility Description:

Electrical service was absent to the entire City of La Feria as a result of damaged power lines in a

Total Benefits:	**$52,241,317**	Total Costs:	**$47,394,097**	BCR:	**1.10**
Project Number:		Disaster #:	Program: FMA	Agency:	**City of La Feria**
State:	**Texas**	Point of Contact:	Sunny K. Philip	Analyst:	Juan M. Gamez E.I.T

Roads And Bridges

Estimated Number of One-Way Traffic Trips Per Day:	79,000
Additional Time per One-Way Trip:	02:00
Number of Additional Miles:	20.0
Federal Rate:	0.585
Economic Loss Per Day of Loss of Function:	$6,952,000

Facility Description:

US 83 & ;FM 506;Bus 83

Total Benefits: **$52,241,317** Total Costs: **$47,394,097** BCR: **1.10**

Project Number: Disaster #: Program: FMA Agency: **City of La Feria**

State: **Texas** Point of Contact: Sunny K. Philip Analyst: Juan M. Gamez E.I.T

Historic Damages Before and After Mitigation

Analysis Year: 2009
Year Built: 1950

Analysis Duration: 60
User Input Analysis Duration: 0

Utilities ($/day): $604,800.00
Buildings ($/day):
Roads/Bridges ($/day): $6,952,000.00

Damages Before Mitigation

Damage Year: 2008
RI: 25.00
Are Damages In Current Dollars? No
Buildings (Days):
Utilities (Days): 100.0
Roads (Days): 5.0

Total	$95,240,000
Total Inflated	$95,240,000

Damage Year: 2005
RI: 10.00
Are Damages In Current Dollars? No
Buildings (Days):
Utilities (Days):
Roads (Days): 0.0

Total	$0
Total Inflated	$0

Damages After Mitigation

RI: 25.00
Are Damages In Current Dollars? Yes
Buildings (Days):
Utilities (Days): 1.0
Roads(Days): 0.0

Total	$604,800

RI: 5.00
Are Damages In Current Dollars? Yes
Buildings (Days):
Utilities (Days):
Roads(Days): 0.0

Total	$0

Total Benefits:	**$52,241,317**	Total Costs:	**$47,394,097**	BCR:	**1.10**
Project Number:		Disaster #:	Program: FMA	Agency:	**City of La Feria**
State:	**Texas**	Point of Contact:	Sunny K. Philip	Analyst:	Juan M. Gamez E.I.T

Summary Of Benefits

Expected Annual Damages Before Mitigation		Expected Annual Damages After Mitigation		Expected Avoided Damages After Mitigation (Benefits)	
Annual:	$3,809,590	Annual:	$24,192	Annual:	$3,785,398
Present Value:	$52,575,185	Present Value:	$333,868	Present Value:	$52,241,317

Mitigation Benefits:	$52,241,317	Mitigation Costs:	$47,394,097
Benefits Minus Costs:	$4,847,220	Benefit-Cost Ratio:	1.10

Cost Estimate

Project Useful Life (years):	50	Construction Type:	
Mitigation Project Cost:	$45,600,000	Detailed Scope of Work:	Yes
Annual Project Maintenance Cost:	$130,000	Detailed Estimate for Entire Project:	Yes
Final Mitigation Project Cost:	$47,394,097	Years of Maintenance:	50
Cost Basis Year:		Present Worth of Annual Maintenance Costs:	$1,794,097
Construction Start Year:		Estimate Reflects Current Prices:	Yes
Construction End Year:		Project Escalation:	

05 Oct 2010	Project: **La Feria Flood Projection Plan**		
Total Benefits: **$52,241,317**	Total Costs: **$47,394,097**		BCR: **1.10**
Project Number:	Disaster #:	Program: FMA	Agency: **City of La Feria**
State: **Texas**	Point of Contact: Sunny K. Philip		Analyst: Juan M. Gamez E.I.T

Justification/Attachments

Field	Description	Attachments
Additional Time per One-Way Trip	See attached Figure 2 in facility description	
Analysis Year	The 2008 event resulted in a Water Surface Elevation of 46 ft rendering all utilities and roads inaccessible as the respective Tio Cano area does not have an outlet.	
Estimated Number of One-Way Traffic Trips Per Day	Attached TxDOT Map Figure 3: TxDOT State Wide Planning Map	F3 TxDOT Statewide Planning Map.pdf
Facility Description	The La Feria Flood Protection Plan area lost power to 4,800 customers for about 100 days as per AEP as FM506 was inaccessible. Also US 83 was shut down from 7/24/08 to 7/28/08 as a major NAFTA Trade Arterial.	TxDOT Letter.pdf; F2 Detour and Traffic Damages.pdf
Federal Rate	Federal Rate	
Mitigation Project Cost	Improvements Proposed are targeted to alleviate flooding along US 83, a major interstate functioning as a main arterial to national free trade traffic. The Projects are discussed in detail in the section for Damages After Mitigation	La Feria FPP TC.pdf; La Feria FPP.pdf
Number of Additional Miles	See attached Figure 2 in facility description	
Number of Customers Served	AEP inquiry response has indicated an estimated number of customers to be 4,800, with a total outage of 145,232 minutes over 4 circuits that translates to 100 days of over the whole area.	Gmail - La Feria Electrical...pdf
Project useful life	Drainage & Culvert Systems are designed on a 50 year life cycle as attached TxDOT Hydraulic Manual	Project Life.pdf
Unknown Frequency - Damages After Mitigation	The control structure for the Tio Cano Area control a new outlet. The attached results modeled indicate that the pool elevation will be drastically reduced. The utilities may experience a 24 hr delay. Corridors are not expected to loose function.	La Feria Flood Protection Plan Site Plan4.pdf; Tio Cano Water Elevation Curve.pdf

Unknown Frequency - Damages Before Mitigation	US 83 was shut down from 7/24/08 to 7/28/08 as a result of the 25 yr storm event as classified by the Attachments Figure 4-10 (developed from National Weather Service Online Data and Technical Publication 40 (Figure 7)).	F5 Dolly 25yr TP40.pdf; F4 La Feria Dolly Rain Fall.pdf; F10 6.22.04 10yr.pdf; F9 Storm Event 6.22.04.pdf; F8 Weather Station.pdf; F7 TechnicalPaper_No40.pdf; F6 Dolly 24hr precipitation.pdf

Section 1
Conduit Durability

Introduction

When designing a culvert or storm drainage system, you must evaluate aspects of structural design, hydraulic design, and durability design. The first two disciplines are quite familiar to most civil engineers. Durability design, however, is generally beyond the scope of civil engineering and is more closely aligned with the field of chemistry. Experience has shown that culverts most frequently fail as a result of durability problems. This is usually due to improper selection of materials to meet the project design life and site conditions.

Service Life

For permanent TxDOT hydraulic facilities, an ideal service life expectancy is generally 50 years. However, the scope and intended use of the facility and economic considerations may warrant longer or shorter service life. Many factors affect durability, each independently affecting different aspects of the facility:

- corrosion
- abrasion
- choice of material
- design of the facility
- maintenance practices
- consistency of the local site environment

With knowledge of these factors, the designer should exercise some control over choice of material, design of the facility, and maintenance practices.

Relative service life of conduit material is a function of the corrosion/abrasion cycle. You can predict the relative service life based on the evaluation of soil and water site characteristics such as the following:

- Acidity/alkalinity -- The universal measure for acidity/alkalinity is the pH scale. Acidity can result from either mineral or organic sources. Mineral acidity can be the result of leaching of acidic soil, runoff from mining activities, and acidic rainfall. Organic acidity may result from organic decay such as runoff from a large feedlot. Relative service life of materials used in conduits is a function of the pH value of the soil and water. High acidic values in the soil and water ($pH< 4$) represent a greater threat to the conduit material service life. High alkalinity values in the soil and water ($pH> 9$) also represent a significant threat to the conduit material service life.
- Resistivity -- Resistivity is a measure of the electrical current carrying capacity of a material. If the resistivity value (expressed in ohm-cm) is low, the current carrying capacity is high. In such a case, the potential for corrosion is also high. In general, the higher the resistivity, the lower the potential for corrosion due to resistivity.

Engineer's Cost Estimate Summary 10/5/2010

La Feria Flood Protection Plan

Engineer: Sigler, Winston, Greenwood & Assoc. Juan M. Gamez EIT

Drainage Improvements

Unit	FPP Phase	Designation	Description	Total
1	1	Tio Cano Drain (TCD)	Proposed Tio Cano Drainage Ditch	$ 9,054,672
2	1	AN-47 Structure 1	Drop Structures	$ 900,000
3	1	AN-47 Structure 2	White Ranch Rd. Crossing	$ 255,000
4	1	AN-47 Structure 3	Evans Canal Crossing	$ 277,000
5	1	AN-47 Structure 4	Beddoes Rd. Crossing	$ 110,000
6	1	AN-47-1	Beddoes Rd. Crossing	$ 190,000
7	1	AN-47-1	Kansas City Rd. Crossing	$ 190,000
8	1	AN-47-2 & AN-47 Junction	Junction of AN-47-2 & AN-47	$ 90,000
9	1	Rabb Rd. Improvements	Rabb Rd. Drainage Improvements	$ 1,313,000
11	1	Orange Grove Road Crossing & Drain Improvements	Orange Grove Road Drain	$ 121,000
12	1	AN-49 Crossing	Levee Crossing of AN-49 Drain	$ 800,000
13	1B	TCD Structure 1	Arroyo L.N.	$ 218,352
14	1B	TCD Structure 2	White Ranch Rd. Crossing	$ 219,848
15	1B	TCD Structure 3	Evans Canal Crossing	$ 436,000
16	1B	TCD Structure 4	Business 83 Crossing	$ 137,464
17	1B	TCD Structure 5	Kelly Dr. Crossing	$ 808,880
18	1B	TCD Structure 6	U.S. Expressway 83 Crossing	$ 717,752
19	1B	TCD Structure 7	Callaway Dr. Crossing	$ 497,176
20	1B	TCD Structure 8	County Rd. 622 Crossing	$ 139,128
21	1B	Utilities Relocation	Utilites Adjustments as required	$ 250,000
22	1B	IC Structure	TC-NF-13 Interconnect	$ 600,000
23	2	SWQ & Drainage Improvements	White Ranch Lake	$ 800,000
24	2	SWQ & Drainage Improvements	Turtle Lake	$ 600,000
25	2	Rabb Drain	Widening of Rabb Drain	$ 118,800
26	2	AN-47-1 & AN-47-2 Improvements	Widening of AN-47-1 & AN-47-2	$ 626,400
27	2	Kansas City Rd. Improvements	Kansas City Rd. Drainage Improvements	$ 633,720
28	3	TCAA	Tio Cano Acquisition Area & Drainage Imrovements	$ 22,000,000
29	3	ERDI	East Rabb Drainage Improvements	$ 600,000
30	3	IAB	Improvements Along Business 83	$ 500,000
31	3	DAN47P2	Deepening of AN-47 Phase 2	$ 1,980,000
32		IRR-AN49	Siphon Under AN-49	$ 415,000

Total Estimated Project Budget Cost **$45,599,192**

Engineer's Cost Estimate 8/11/2010

La Feria Flood Protection Plan

Engineer: Sigler, Winston, Greenwood & Assoc. Juan M. Gamez EIT

Tio Cano Drain & Road Crossings

Item	Description	Qty	Unit		Unit Price			Total
I	**Tio Cano Drain**							
	Excavation	1183668	CY	$	4.00		$	4,734,672
	Lining	180000	SY	$	14.00		$	2,520,000
	ROW Acquistion	90	AC	$	20,000		$	1,800,000
							$	**9,054,672**
II	**Road Crossings**							
	1. Arroyo Ln. Crossing	50'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	200	LF	$	600.00		$	120,000
	Excavation	5,678	CY	$	4.00		$	22,712
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	91	CY	$	40.00		$	3,640
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**218,352**
	2. White Ranch Rd. Crossing	50'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	200	LF	$	600.00		$	120,000
	Excavation	6,052	CY	$	4.00		$	24,208
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	91	CY	$	40.00		$	3,640
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**219,848**
	3. Evans Canal Crossing	120'	x 4 Culverts					
	4 - 10' x 10' Box Culvert	480	LF	$	600.00		$	288,000
	Excavation	7000	CY	$	4.00		$	28,000
	Aerial Crossings	2	EA	$	60,000.00		$	120,000
							$	436,000
	3. Business 83 Crossing	160'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	320	LF	$	600.00		$	192,000
	Excavation	12,386	CY	$	4.00		$	49,544
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	148	CY	$	40.00		$	5,920
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
	Railroad Crossing Permit	1	LS	$	10,000.00		$	10,000
						Sub-total =	**$**	**137,464**
	4. Kelly Dr. Crossing	475'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	950	LF	$	600.00		$	570,000
	Excavation	37,350	CY	$	4.00		$	149,400
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	437	CY	$	40.00		$	17,480
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**808,880**
	5. U.S. Expressway 83 Crossing	300'	x 3 Culverts					
	3 - 10' x 10' Box Culvert	900	LF	$	600.00		$	540,000
	Excavation	22,378	CY	$	4.00		$	89,512
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	406	CY	$	40.00		$	16,240
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**717,752**
	6. Callaway Dr. Crossing	300'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	600	LF	$	600.00		$	360,000
	Excavation	13,534	CY	$	4.00		$	54,136
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	276	CY	$	40.00		$	11,040
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**497,176**
	7. County Rd. 622 Crossing	50'	x 2 Culverts					
	2 - 10' x 10' Box Culvert	100	LF	$	600.00		$	60,000
	Excavation	1,322	CY	$	4.00		$	5,288
	Concrete Headwall and Wingwalls (one at each end)	2	EA	$	6,000.00		$	12,000
	12" Min. Gravel Bedding	46	CY	$	40.00		$	1,840
	Concrete Canasta	2	EA	$	30,000.00		$	60,000
						Sub-total =	**$**	**139,128**

Total Estimated Project Budget Cost **$12,229,272**

City of La Feria

AN-47 & AN-49 Improvements Engineers Budget Summary

Swg Project 08-174

March 26, 2009

Item	Description	Total
I	**AN47**	
	A. Road Crossing	
	1. Beddoes Road - (Army Corp of Engineers Station 110 + 45).	$ 110,000.00
	2. White Ranch Road- (Army Corps of Engineers Station 45 + 50).	$ 255,000.00
	(B.) Evans Canal Crossing - (Army Corp of Engineers Station 65 + 50).	$ 277,000.00
	(C.) Drop Structures and Bank Protection	$ 900,000.00
II	**AN47-1**	
	(A.) Road Crossings	
	1. Beddoes Road - (Army Corp of Engineers Station 39 + 60).	$ 190,000.00
	2. Kansas City Road - (Army Corp of Engineers Station 29 + 47).	$ 190,000.00
III.	**AN47-2**	
	(A.) Junction of AN47-02 with AN47	$ 90,000.00
IV.	**Orange Grove Road Drain.**	$ 121,000.00
V.	**Levee Crossing of AN49 Drain**	$ 800,000.00
VI.	**Rabb Road Improvements**	$ 1,313,000.00
VII.	**Kansas City Rd Improvements**	$ 447,800.00

Total Estimated Project Budget Cost **$4,693,800**

Sigler, Winston, Greenwood
Associates, Inc.
1604 E. HWY. 83
Weslaco, TX 78596

Preliminary Engineers Cost Estimate

I A. 1. Beddoes Road of AN-47 Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total	
1	10'x5' Box Culvert	72	LF	$	1,280.00	$	92,160.00
2	Headwalls (one at each end)	2	ea	$	3,000.00	$	6,000.00

Subtotal	$98,160
Estimated Construction Cost	$98,160
Engineering Fee	$11,840

I A. 1. Beddoes Road Crossing Total Estimated Project Cost $110,000

Preliminary Engineers Cost Estimate

I A. 2. White Ranch Rd Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	10'x7'- Twin Boxed Culvert	84	LF	$	2,590.00	$217,560
2	Headwalls (one at each end)	2	LS	$	5,000.00	$10,000
	Subtotal					$227,560
	Estimated Construction Cost					$227,560
	Engineering Fee					$27,440

I A. 2. White Ranch Rd Crossing Total Estimated Project Cost $255,000

Sigler, Winston, Greenwood
Associates, Inc.
1604 E. HWY. 83
Weslaco, TX 78596

Preliminary Engineers Cost Estimate

I B. Evans Canal Crossing

December 15, 2008

Item	Description	Qty		Unit Price	Total
1	Earth Work	3500	CY	$15.00	$52,500
2	48" Steel Aerial Crossing	150	LF	$250.00	$37,500
3	72" RCP Siphon	125	LF	$500.00	$62,500
4	gravel	100	CY	$40.00	$4,000
5	72" water tight collar joints	2	ea	$6,700.00	$13,400
6	Canasta	2		$30,000.00	$60,000
7	dewatering	40	day	$450.00	$18,000
	Subtotal				$247,900
	Estimated Construction Cost				$247,900
	Engineering Fee				$29,100

I B. Evans Canal Crossing Total Estimated Project Cost **$277,000**

Preliminary Engineers Cost Estimate

I C. Drop Structures on AN-47

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	3 Drop Structures Including Bank Protection	1320	CY	$	427.00	$563,640
2	3 Retaining Walls	300	CY	$	800.00	$240,000
	Subtotal					$803,640
	Estimated Construction Cost					$803,640
	Engineering Fee					$96,360

I C. Drop Structures on AN-47 Total Estimated Project Cost **$900,000**

Preliminary Engineers Cost Estimate

I A. 1. Beddoes Road Crossing

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	7'x7' Twin Box Culvert	84	LF	$	1,900.00	$159,600
2	Headwalls (one at each end)	2	ea	$	5,000.00	$10,000
	Subtotal					$169,600
	Estimated Construction Cost					$169,600
	Engineering Fee					$20,400

I A. 1. Beddoes Road Crossing Total Estimated Project Cost **$190,000**

Preliminary Engineers Cost Estimate

II A. 2.Kansas City Rd Crossing

February 15, 2008

Item	Description	Qty		Unit Price		Total
1	7'x7' Twin Box Culvert	84	LF	$	1,900.00	$159,600
2	2- Headwalls (one at each end)	2	ea	$	5,000.00	$10,000
	Subtotal					$169,600
	Estimated Construction Cost					$169,600
	Engineering Fee					$20,400

II A. 2.Kansas City Rd Crossing Total Estimated Project Cost $190,000

Preliminary Engineers Cost Estimate

III A. Junction of AN-47-2 to AN-47

February 15, 2009

Item	Description	Qty		Unit Price		Total
1	5'x5' Box Culvert	64	LF	$	1,130.00	$72,320
2	2- Headwalls (one at each end)	2	ea	$	4,000.00	$8,000

Subtotal	$80,320
Estimated Construction Cost	$80,320
Engineering Fee	$9,680

II A. 2.Kansas City Rd Crossing Total Estimated Project Cost **$90,000**

Preliminary Engineers Cost Estimate

IV. Orange Grove Road Drainage Improvements

December 15, 2008

Item	Description	Qty		Unit Price	Total
1.	Cleaning & re-grading of Drainage ditch	2400	LF	$18.00	$43,200
2.	Remove existing Headwalls & 30" pipe under Orange Grove Rd.	1	LS	$6,000.00	$6,000
3.	Install 36" RCP with safety end treatments under Orange Groove Rd. " 60' LF	1	LS	$12,000.00	$12,000
4.	Cut and replace pavement	24	LF	$48.00	$1,152
5.	Guard railing and markers	200	LF	$78.00	$15,600
6.	Concrete rip-rap protection at outlet AN-49	1	LS	$6,000.00	$6,000
7.	Grading of Roadside Ditches Either side of Orange Grove Rd. North & South of Drain Crossing	4000	LF	$6.00	$24,000
	Subtotal				$107,952
	Estimated Construction Cost				$107,952
	Engineering Fee				$13,048

Orange Grove Rd. Total Estimated Project Cost **$121,000**

Preliminary Engineers Cost Estimate

V. AN-49 Drain Crossing

December 15, 2008

Item	Description	Qty		Unit Price	Total
1	Earth Work	5536	CY	$35.00	$193,760
2	Gate Structure	258.333	CY	$1,200.00	$310,000
3	10X10 Gate	1	LS	$150,000.00	$150,000
4	Canasta	110	CY	500	$55,000
	Subtotal				$708,760
	Estimated Construction Cost				$708,760
	Engineering Fee				$91,240

AN-49 Drain Crossing Total Estimated Project Cost **$800,000**

Preliminary Engineers Cost Estimate

VI. Rabb Road Drainage Improvements

December 15, 2008

Item Description	Qty		Unit Price	Total
1. 24" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 4-6' cut	400	LF	$45.60	$18,240
2. 30" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 4-6' cut	700	LF	$60.00	$42,000
3. 36" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 6-8' cut	2,050	LF	$78.00	$159,900
4. 36" RCP Class III, ASTM C-76, Rubber Gasket Joint Pipe, 8-10' cut	1,180	LF	$84.00	$99,120
5. 36" RCP, Class III, ASTM C-76, Rubber Gasket Joint Pipe, 10-12' cut	1,550	LF	$90.00	$139,500
6. 5' diameter reinforced concrete Pre-Cast manholes 4-6' depth	3	Ea.	$2,400.00	$7,200
7. 5' diameter reinforced concrete Pre-Cast manholes 6-8' depth	4	Ea.	$2,640.00	$10,560
8. 5' diameter reinforced concrete Pre-Cast manholes 8-10' depth	2	Ea.	$3,000.00	$6,000
9. 5' diameter reinforced concrete Pre-Cast manholes 10-12' depth	2	Ea.	$3,600.00	$7,200
” pre-cast concrete Inlets 0-4' depth	2	Ea.	$2,400.00	$4,800
11. Type “A” pre-cast concrete Inlets 4-6' depth	4	Ea.	$2,640.00	$10,560

Gmail by Google BETA

Juan Manuel Gamez <gamez.3@gmail.com>

La Feria Electrical Outages during Dolly

3 messages

Juan Manuel Gamez <Juan@gamezconstruction.com> **Mon, Mar 9, 2009 at 4:25 PM**
To: hdunlap@aep.com

Hague,

I need to find out how much of the outlined area in the map was out and for approximately for how long in terms of customers and days during and after the Hurricane Dolly event. A letter stating these facts or any information rendered would be much appreciated. I need this for a Fema application.

Feel free to mark up the map if need be with the PDF commenting tools.

Thanks,
Juan M. Gamez
Sigler, Winston, Greenwood, and Assoc.
956-968-2194

Juan Manuel Gamez <Juan@gamezconstruction.com> **Mon, Mar 9, 2009 at 4:28 PM**
To: hdunlap@aep.com

Sorry,

I forgot to attach the file.
[Quoted text hidden]

La Feria Electrical Outage.pdf
2406K

hdunlap@aep.com <hdunlap@aep.com> **Wed, Mar 25, 2009 at 4:16 PM**
To: Juan Manuel Gamez <Juan@gamezconstruction.com>

In the area you have defined, our company serves approximately 4,800 customers. We serve them by the use of four distribution circuits. Two of the circuits, 1240 and 1215 originate at our South Santa Rosa Substation which is just south of the town of Santa Rosa on FM 506. The other two circuits originate from our Rangerville substation which is southeast of La Feria and north of SH 281. Our historical outage information indicates our customers in this area experienced interruptions due to damage from Hurricane Dolly starting on July 23, 2009 and continuing through August 5, 2009. A outage summary by circuit is provided as follows:

Circuit Number	Number of Interruptions	Total Outage Duration Minutes	Total Customers Affected	Total Customer Minutes Interrupted
1215	25	52,273	2,554	7,201,151
1240	11	11,379	2,939	6,761,515
3420	9	9,532	1,533	5,221,215
4060	12	72,048	1,344	6,415,513

A customer could have had more than one interruption during the timeframe stated previously. That is the reason why the sum of the customers in the column "Total Customers Affected" is greater than 4,800 customers.

As I have mentioned in our earlier telephone conversations, flooding north of Highway 83 along Rabb Road and the Tio Cano area caused restoration of electrical service to affected customers to be delayed drastically.

Let me know if I can provide any other information or clarification. Thank you.

Bailey Hague Dunlap IV, P.E.
Supervisor, Customer Design
San Benito District
Phone: 956 361-2046, Audinet 8 734-2046
Fax: 956 361-2017
-... . l ... .- ..-. .

Juan Manuel Gamez <Juan@gamezconstruction.com>
Sent by: gamez.3@gmail.com

03/09/2009 04:28 PM

To hdunlap@aep.com
cc
Subject Re: La Feria Electrical Outages during Dolly

[Quoted text hidden]

La Feria Electrical Outage.pdf
2406K

12. Type “A” pre-cast concrete Inlets 6-8' depth	4		$3,120.00	$12,480
13. Type “A” pre-cast concrete Inlets 8-10' depth	2	Ea.	$3,600.00	$7,200
14. Trench excavation protection	5,880		$6.00	$35,280
15. Boring on Grade under the Railroad	80	LF	$360.00	$28,800
16. Boring on Grade under U.S. 83 Business Highway	100	LF	$360.00	$36,000
17. Headwall for 36" pipe	1		$6,000.00	$6,000
18. Storm Water Pollution Prevention Plan	1	Ea.	$6,000.00	$6,000
19. Traffic Control Plan	1	LS	$6,000.00	$6,000
18. Re-Paving of Rabb Road - 40' B-13	1	LS		$500,000

Subtotal	$1,142,840
Engineering Fee	$143,159.80
Improvement Total	**$1,285,999.80**

Additional Services

1. Purchase of Right-of-Way
   2,500' x 20') 43,560 x $20,00.00/Acre — $23,000

2. Legal Fees- estimate two
   Tracts x $3,000/tract — $6,000

3. Survey, plat & preparation of description — $4,000
   2 x $2,000.00

Additional Services Total **$33,000**

Rabb RD. Total Estimated Project Cost $1,319,000

Preliminary Engineers Cost Estimate

VII Kansas City Rd Drainage Improvements

February 15, 2009

Item	Description	Qty		Unit Price		Total	
1	Station Grading:	20.40	Sta.	$	1,000.00	$	20,400.00
2	EN-1 Stabilization	9520.00	S.Y.	$	1.35	$	12,852.00
3	Tensar	9520.00	S.Y.	$	3.55	$	33,796.00
4	8" of compated Caliche Base	9066.67	S.Y.	$	8.50	$	77,066.70
5	2.00" HMAC Pavement	8386.67	S.Y.	$	10.75	$	90,156.70
6	Standard Curb & Gutter	4080.00	L.F.	$	7.50	$	30,600.00
7	Laydown Gutter	50.00	L.F.	$	8.25	$	412.50
8	Valley Gutter	50.00	L.F.	$	22.00	$	1,100.00
9	Driveway Repair		Lump Sum	---------------------		$	5,000.00
10	Adjust Manholes		Lump Sum	---------------------		$	2,500.00
11	Adjust Water Valves		Lump Sum	---------------------		$	1,500.00
12	Reclocated Traffic Signs		Lump Sum	---------------------		$	1,500.00
13	24" RCP, Class III, ASTM C-76	1660.00	L.F.	$	60.00	$	99,600.00
14	Inlets	13.00	Ea	$	1,800.00	$	23,400.00
Subtotal							$399,884
Estimated Construction Cost							$399,884
Engineering Fee							$47,916

AN-49 Drain Crossing Total Estimated Project Cost $447,800

Gmail by Google BETA

Juan Manuel Gamez <gamez.3@gmail.com>

La Feria Electrical Outages during Dolly

3 messages

Juan Manuel Gamez <Juan@gamezconstruction.com> **Mon, Mar 9, 2009 at 4:25 PM**
To: hdunlap@aep.com

Hague,

I need to find out how much of the outlined area in the map was out and for approximately for how long in terms of customers and days during and after the Hurricane Dolly event. A letter stating these facts or any information rendered would be much appreciated. I need this for a Fema application.

Feel free to mark up the map if need be with the PDF commenting tools.

Thanks,
Juan M. Gamez
Sigler, Winston, Greenwood, and Assoc.
956-968-2194

Juan Manuel Gamez <Juan@gamezconstruction.com> **Mon, Mar 9, 2009 at 4:28 PM**
To: hdunlap@aep.com

Sorry,

I forgot to attach the file.
[Quoted text hidden]

La Feria Electrical Outage.pdf
2406K

hdunlap@aep.com <hdunlap@aep.com> **Wed, Mar 25, 2009 at 4:16 PM**
To: Juan Manuel Gamez <Juan@gamezconstruction.com>

In the area you have defined, our company serves approximately 4,800 customers. We serve them by the use of four distribution circuits. Two of the circuits, 1240 and 1215 originate at our South Santa Rosa Substation which is just south of the town of Santa Rosa on FM 506. The other two circuits originate from our Rangerville substation which is southeast of La Feria and north of SH 281. Our historical outage information indicates our customers in this area experienced interruptions due to damage from Hurricane Dolly starting on July 23, 2009 and continuing through August 5, 2009. A outage summary by circuit is provided as follows:

Circuit Number	Number of Interruptions	Total Outage Duration Minutes	Total Customers Affected	Total Customer Minutes Interrupted
1215	25	52,273	2,554	7,201,151
1240	11	11,379	2,939	6,761,515
3420	9	9,532	1,533	5,221,215
4060	12	72,048	1,344	6,415,513

A customer could have had more than one interruption during the timeframe stated previously. That is the reason why the sum of the customers in the column "Total Customers Affected" is greater than 4,800 customers.

As I have mentioned in our earlier telephone conversations, flooding north of Highway 83 along Rabb Road and the Tio Cano area caused restoration of electrical service to affected customers to be delayed drastically.

Let me know if I can provide any other information or clarification. Thank you.

Bailey Hague Dunlap IV, P.E.
Supervisor, Customer Design
San Benito District
Phone: 956 361-2046, Audinet 8 734-2046
Fax: 956 361-2017
-... . l ... .- ..-. .

Juan Manuel Gamez <Juan@gamezconstruction.com>
Sent by: gamez.3@gmail.com

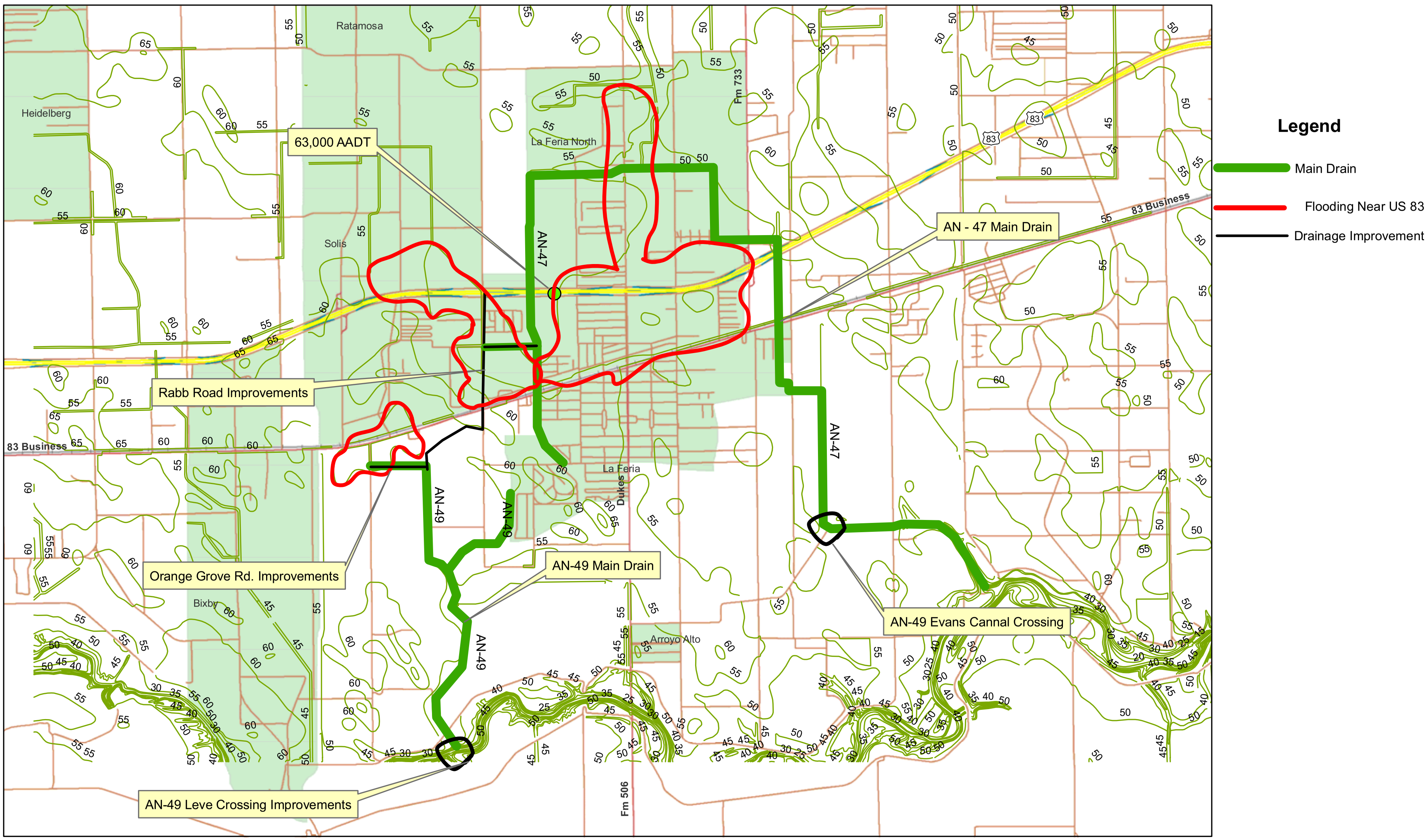
03/09/2009 04:28 PM

To hdunlap@aep.com
cc
Subject Re: La Feria Electrical Outages during Dolly

[Quoted text hidden]

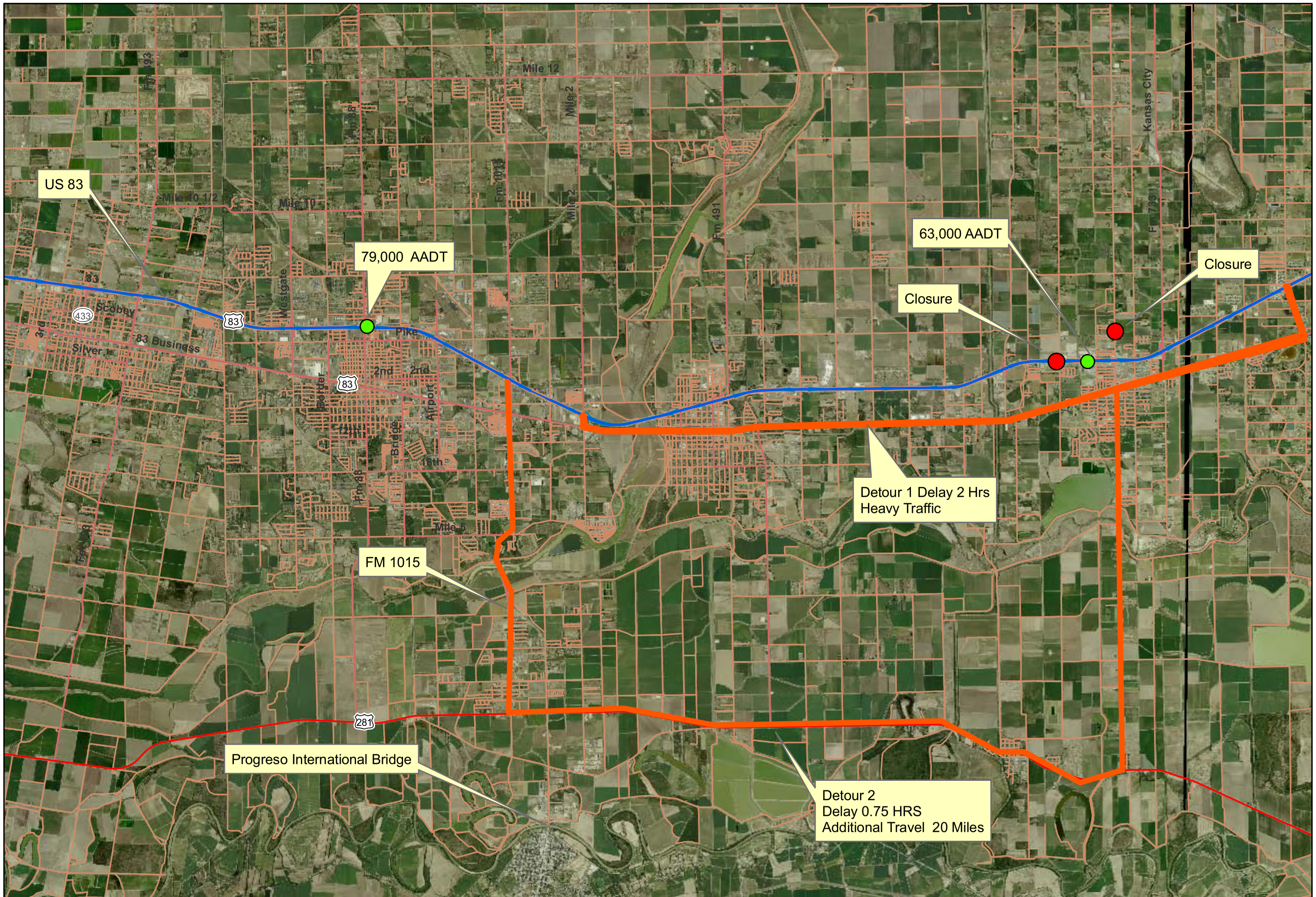
La Feria Electrical Outage.pdf
2406K

Figure 1: Major Flooding Around US 83 and Improvements



In Cooperation With

Figure 2: Hurricane Dolly Detours as a Result of Road Closures



Legend

Detour

Abbreviations

AADD - Anual Average Daily Traffic
As per TXDOT Traffic Planning Map

In Cooperation With

Texas Department of Transportation

PO BOX 1717 • PHARR TEXAS 78577-1717 • (956) 702-6100

January 29, 2009

Governor's Division of Emergency Management
Texas Department of Public Safety
Hazard Mitigation Grant Program
P.O. Box 4087
Austin, Tx 78773-0220

To Whom It May Concern:

The Texas Department of Transportation, Pharr District, fully supports the City of La Feria's application to the Hazard Mitigation Grant Program. The City of La Feria was severely impacted by Hurricane Dolly and the associated heavy rains. To fully determine the extent of the damage, the City commissioned a study. The impact not only on La Feria, but the entire Rio Grande Valley was substantial. Expressway 83, our main east-west corridor was under floodwater for more than a week, causing a severe traffic disruption. This traffic disruption affected everyone including emergency first responders, social service agencies such as Red Cross and Salvation Army and government agencies such as Army National Guard and the Texas State Guard. La Feria was also without electricity for more than one week, further hampering recovery efforts.

The City, through this extensive study has identified several mitigation projects that will alleviate the flooding situation. We fully support this application and their efforts to protect life and property during future disasters.

Should you have any questions or need additional information, please don't hesitate to call me at (956) 702-6101.

Sincerely,

Mario R. Jorge, P.E.
District Engineer

Figure 3: TxDOT Traffic Planning Map

TEXAS DEPARTMENT OF TRANSPORTATION

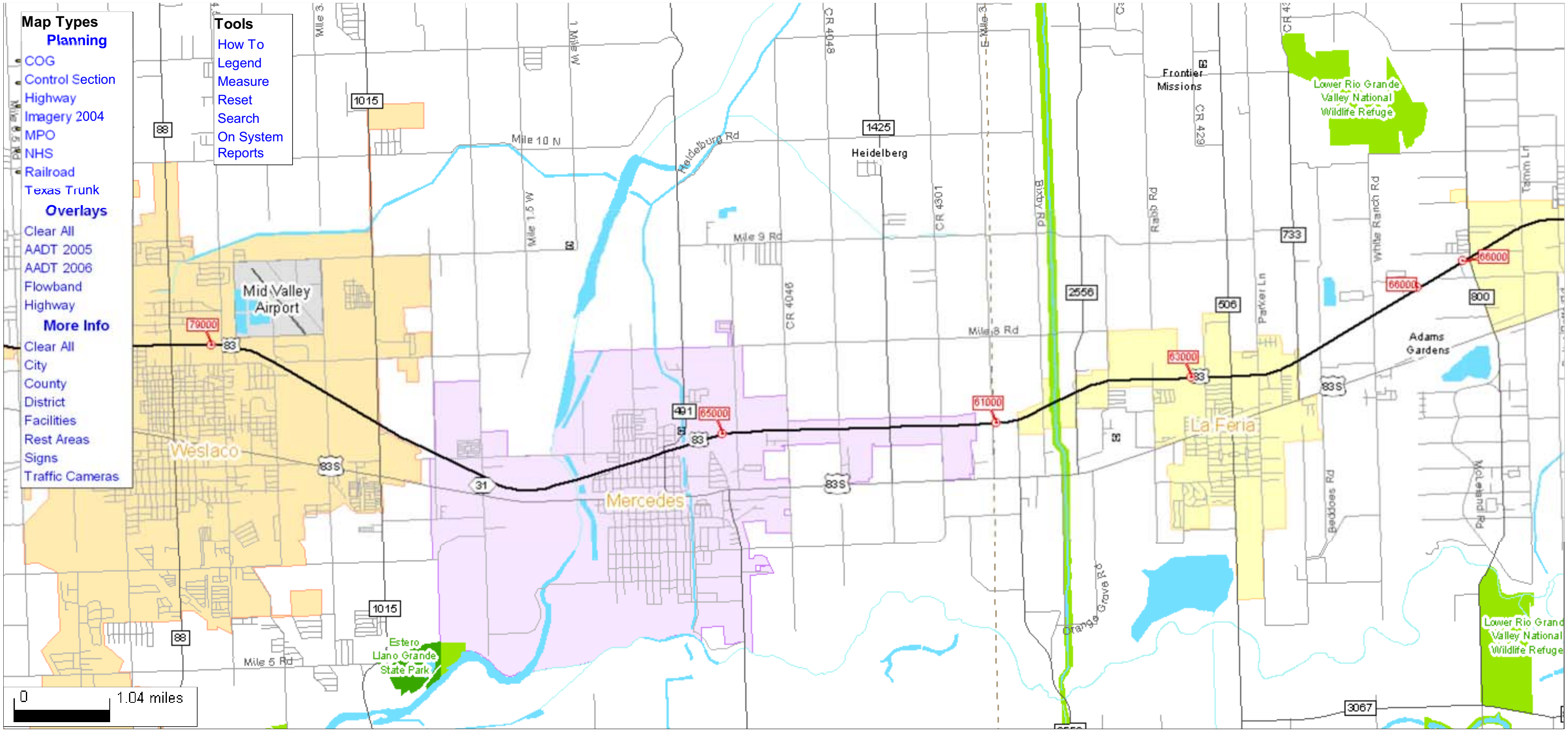
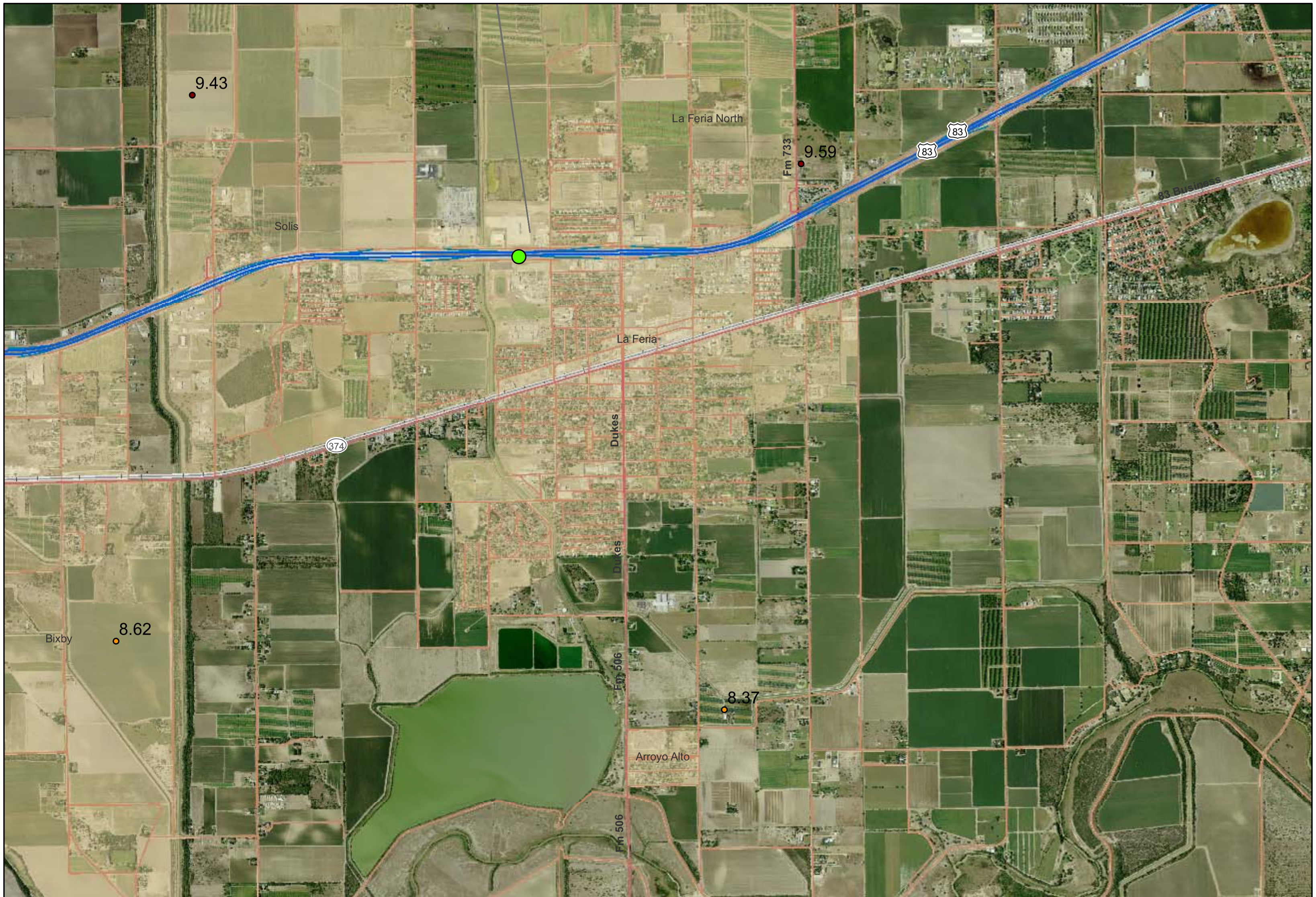


Figure 4: Hurricane Dolly Precipitation on 7/24/08

As per National Weather Service GIS Download
http://water.weather.gov/download.php



Precipitation on July 24 2008

nws_precip_20080724

Globvalue

- 0.00 - 2.00
- 2.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00

In Cooperation With

Figure 5

25-YEAR 24-HOUR RAINFALL (INCHES)

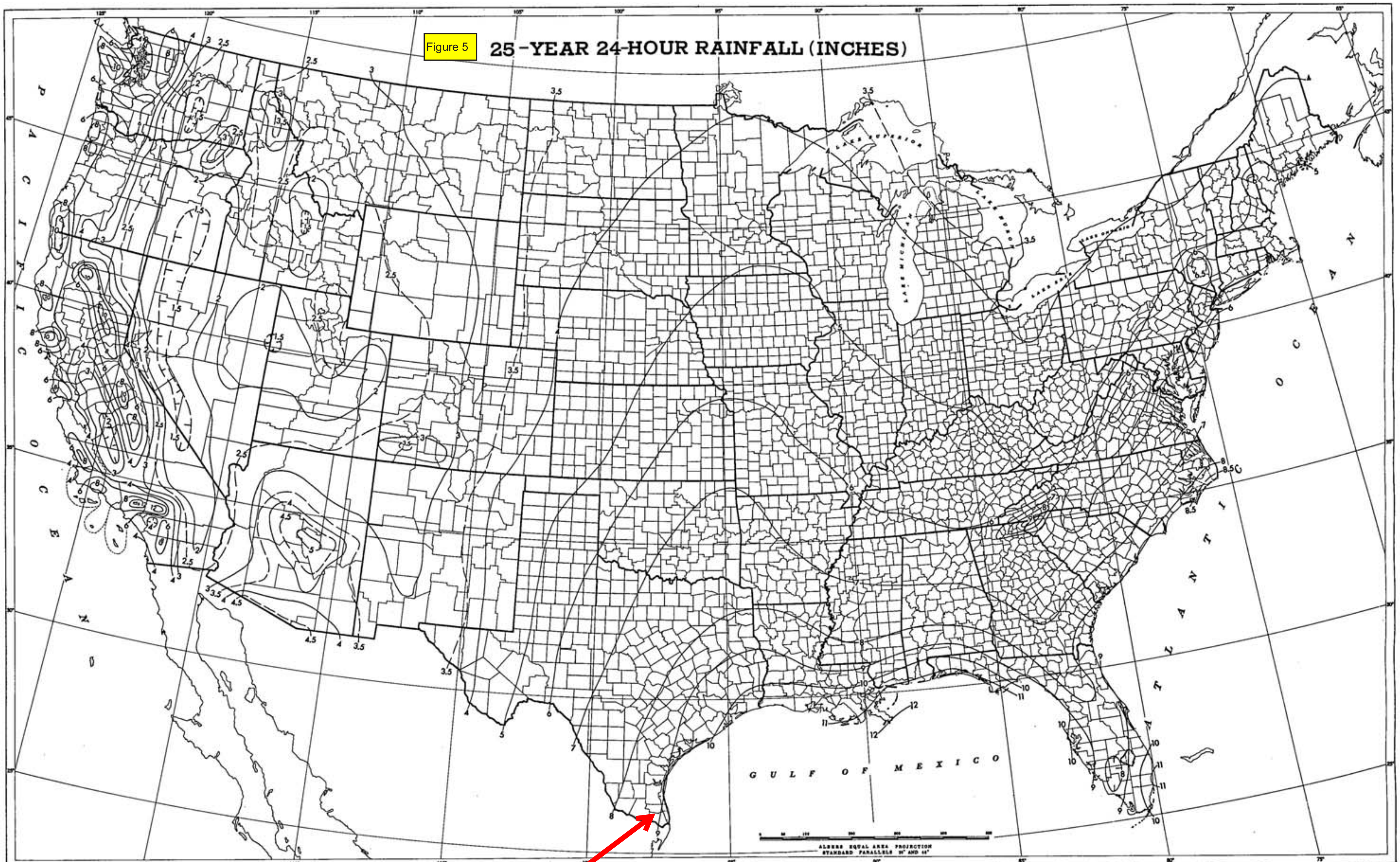
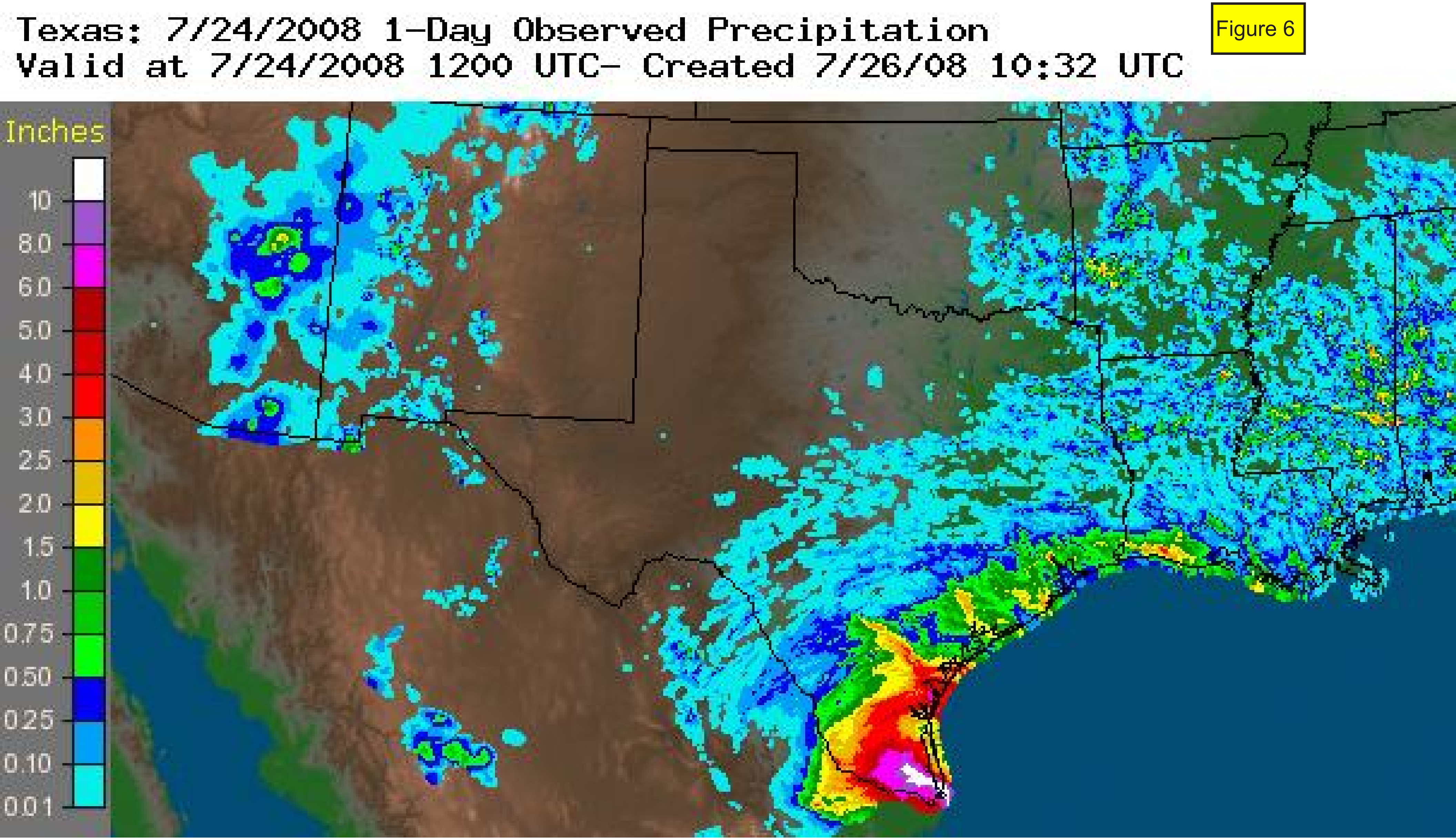


Figure 6



Texas: 7/24/2008 1-Day Observed Precipitation
Valid at 7/24/2008 1200 UTC- Created 7/26/08 10:32 UTC
Inches
10
8.0
6.0
5.0
4.0
3.0
2.5
2.0
1.5
1.0
0.75
0.50
0.25
0.10
0.01

U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

Figure 7: TP-40

TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division

for

Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

WASHINGTON, D.C.
May 1961
Repaginated and Reprinted January 1963

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.25

Figure 8.0 Weslaco TAES Weather Station Monthly Precipitation
NOAA Coop ID: 419588

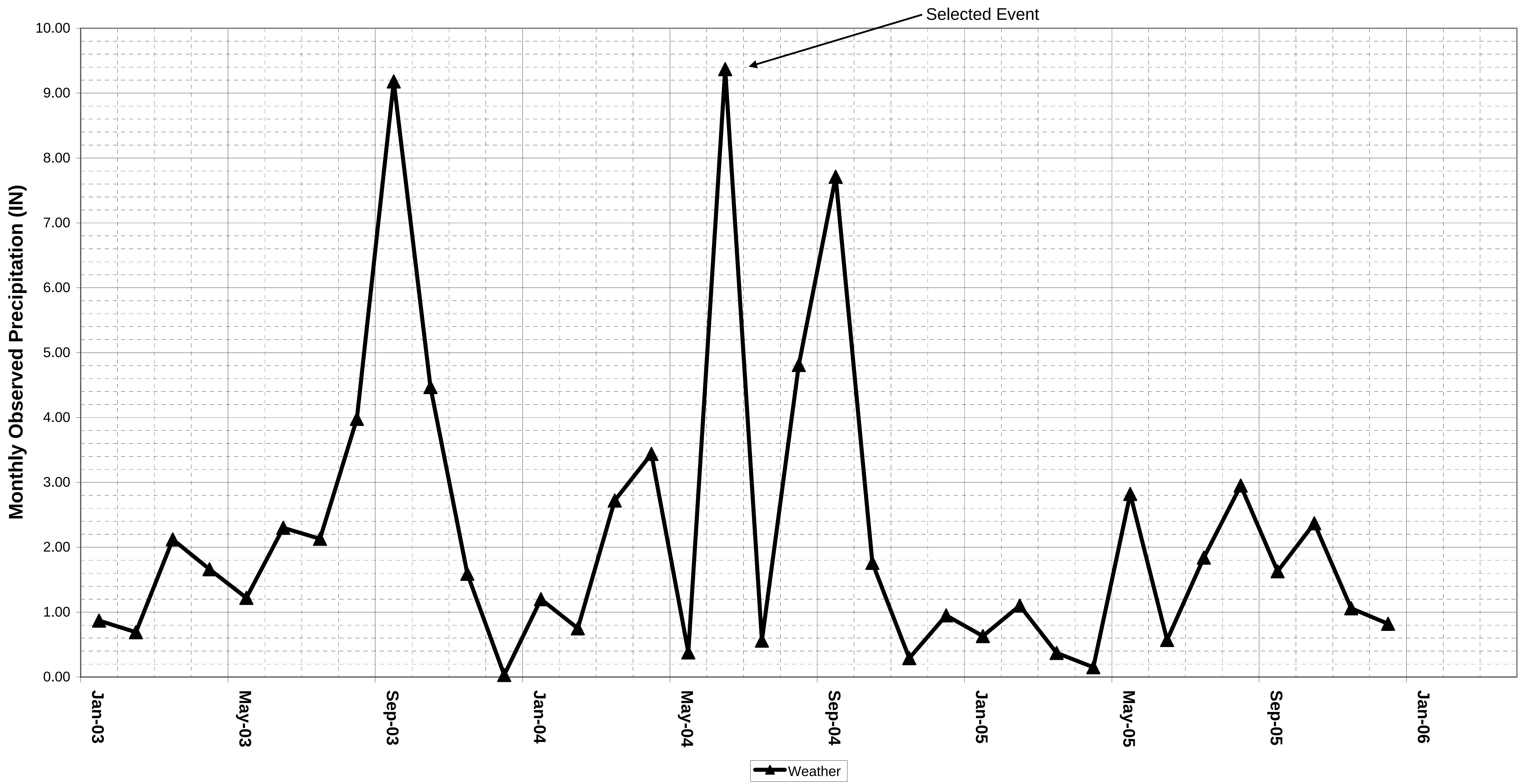


Figure 9. June 22 Rain Fall Event

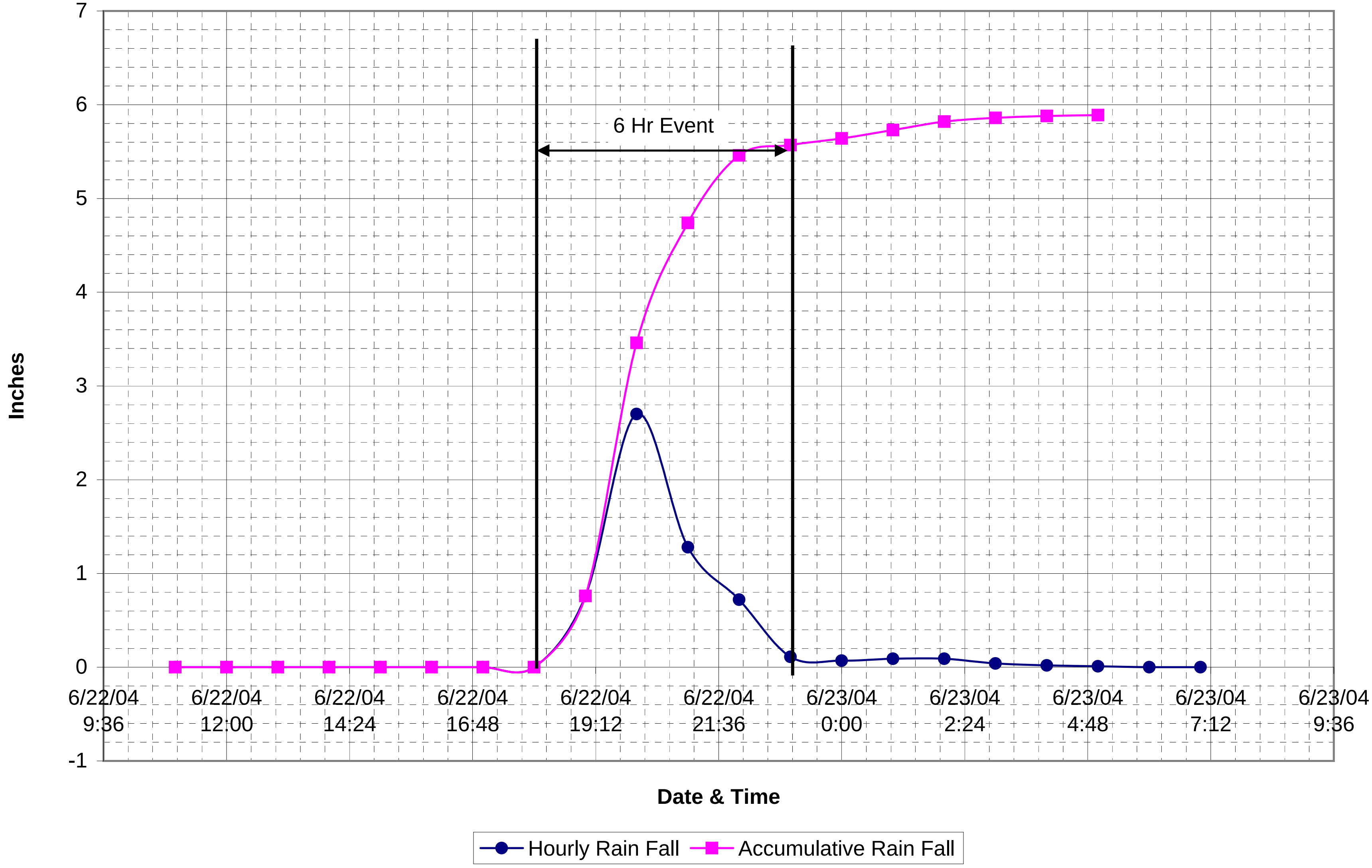
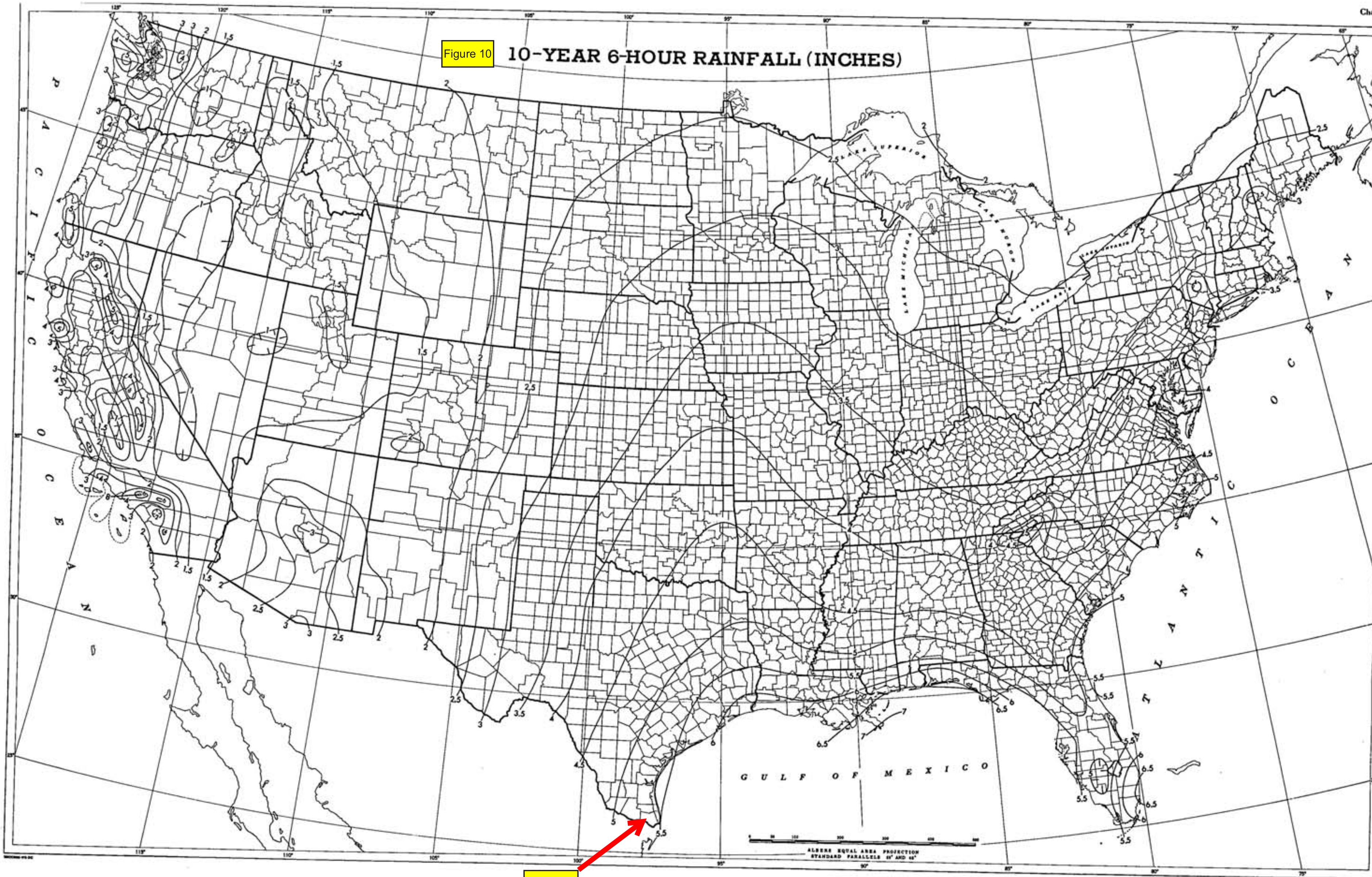


Figure 10

10-YEAR 6-HOUR RAINFALL (INCHES)



APPENDIX K
DIGITAL DATA

APPENDIX L
TEXAS WATER DEVELOPMENT BOARD COMMENTS

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.state.tx.us
Phone (512) 463-7847, Fax (512) 475-2053

March 14, 2011

Sunny K. Philip
City Manager
City of La Feria
115 E. Commercial Ave.
La Feria, Texas 78559

Re: Flood Protection Planning Grant Contract between the Texas Water Development Board (TWDB) and the City of La Feria (City); TWDB Contract No. 0904830949, Draft Report Comments

Dear Mr. Philip:

Staff members of the TWDB have completed a review of the draft report prepared under the above-referenced contract. ATTACHMENT I provides the comments resulting from this review. As stated in the TWDB contract, the City will consider incorporating draft report comments from the EXECUTIVE ADMINISTRATOR as well as other reviewers into the final report. In addition, the City will include a copy of the EXECUTIVE ADMINISTRATOR'S draft report comments in the Final Report.

The TWDB looks forward to receiving one (1) electronic copy of the entire Final Report in Portable Document Format (PDF) and six (6) bound double-sided copies. The City shall also submit one (1) electronic copy of any computer programs or models, and, if applicable, an operations manual developed under the terms of this Contract.

If you have any questions concerning the contract, please contact Kathy Hopkins, the TWDB's designated Contract Manager for this project at (512) 463-6198.

Sincerely,

Carolyn L. Brittin
Deputy Executive Administrator
Water Resources Planning and Information

Enclosures

c: Kathy Hopkins, TWDB

ATTACHMENT I

Review of Draft Report for Contract No. 0904830949

City of La Feria Flood Protection Plan

1) Please conduct a final edit for typos, grammar, inconsistent usage of acronyms and abbreviations, etc. For example; in Section 6.1, 4th paragraph, please amend to read "non-structural" rather than "N-S".

2) Section 1.0, 3rd paragraph; the grant program providing funding for this study is incorrectly referenced. Please amend to state that the "...Plan is made possible through the Texas Water Development Board's Research and Planning Fund Program which provides Flood Protection Planning grants to political subdivisions...".

3) In Section 1.2, please add the Texas Water Development Board to the entities represented at the Advisory Committee meetings. Also within this section, please verify that all public meeting dates are listed and correctly cited.

4) Please insure references to Tables are cited by Table Number. As an example, in Section 2.3 on page 11, the sentence reads "The table below lists...". Please amend to read, "Table 3 lists...".

5) Section 3 and Section 4; the last paragraph of Section 3.2.2 and Table 7 have been placed in Section 4.0 of the report. Please amend by moving to the end of Section 3.

6) Please provide corrections to the Appendix A Exhibits as follows:

a. Exhibit 1, 3, 4, 5, and 9; please label Tio Cano Lake on the maps and/or reference in the legend as appropriate.
b. Exhibit 3 and 4; please revise the color palette between "Reservoir" and "School" to more easily distinguish between the two areas.
c. Exhibit 5; please include in the legend a reference to the areas appearing on the map as dark blue.
d. Exhibit 7 and 8; there appears to be only a small difference between the existing and ultimate floodplain. Please verify and reconcile this in the report discussion for these exhibits. Amend exhibits, if needed.
e. Exhibit 9; many labels on the map and in the legend are difficult to read. Please revise.

7) Section 5.1; please confirm that hydraulic modeling was not performed on the Tio Cano Lake sub-watershed (TC-01) and restate in Section 5.1 the reasons modeling was not performed (a similar statement is provided in Section 3.0 of the report).

8) Section 5.2, Table 13; the "% Change" calculated values appear to be incorrect. For example, AN-47A has an Existing Discharge of 198.7 cubic feet per second (cfs) and a Future Discharge of 245.2 cfs. The calculated per cent change should be about 23% however the report shows 123%. Please correct the "% Change" value for all entries.

9) Appendix A; please include a 10-year and 100-year floodplain map for TC-01.

10) Appendix G lists construction activities and is organized by Phase 1, 1B, 2 and 3; however a discussion of construction actions by Phase is not provided in the text of the report. Section 6 describes Alternative 1, 2 and 3A, 3B and 3C but the costs provided in Appendix G are not compiled by alternatives as described in Section 6. In addition, the Alternative 3C discussion refers the reader to Appendix G for detailed cost estimates however Appendix G does not provide additional detail. Please add additional discussion to Section 6 and reorganize Appendix G.

11) Appendix G lists 32 specific items or construction activities and their estimated costs, however construction costs detail is only provided for the items designated as "Phase 1". Please provide cost detail for the other items on the list. In addition, there is a cost detail provided for the "Kansas City Road Drainage Improvements" of $447,800 however this item is not part of the list of 32 project activities being assessed. Please amend as necessary.

12) Section 6.0 and Appendix G; please provide a statement which describes the year's dollar value used to calculate the cost estimates for the alternatives.

13) Section 6.2.2, Table 15; please include the cost associated with the "clear span bridge" activity as described in Alternative 2 for AN-49.

14) Section 6.2.3.1 and Section 6.2.3.2; the cost of Alternative 3B is greater than that of Alternative 3A however the channel dimensions of Alternative 3A appear to be larger than the dimensions of 3B. Please explain or amend if necessary.

15) Section 6.2.3.3 provides a description for Alternative 3C and states that the analysis was submitted "under separate cover by Sigler, Winston, Greenwood, Inc." Please provide this alternative analysis as an appendix to this report.

16) Section 7.2.3; please provide the "Net Present Value Calculations" in this section or as an Appendix.

17) Section 7.2.4 states that the City is seeking FEMA grant funding for a "combination of Alternatives 1, 2 and 3C, as described above." This description could not be located in the text. Please include this discussion in the final report.

18) Section 8.2; Task J of the Project Scope of Work states "The Funding Mechanisms section will also discuss leverage strategies for debt instruments and grant funds". It does not appear that leverage strategies were discussed. Please include this discussion in the final report.

19) In general, the study follows standard methodologies and practice. Mitigation alternatives identified by the study are eligible for funding under the Board's financial assistance programs. Application requirements and eligibility criteria is identified by Board rules specified in Section 363 of the Texas Administrative Code. The report would be appropriate for use in support of an application to the Board for financing the proposed improvements. All additional information required by Board rules, 31 TAC 363.401-404, as well as necessary information to make legal findings as required by Texas Water Code Chapter 17.771-776, would be required at the time of loan application.

CITY OF LA FERIA, TEXAS
115 E. COMMERCIAL AVENUE LA FERIA, TEXAS 78559
PHONE (956) 797-2261 FAX (956) 797-1898

Sunny K. Philip – City Manager

July 5, 2011

Ms. Carolyn L. Brittin
Deputy Executive Administrator
Water Resources Planning and Information
Texas Water Development Board
P.O. Box 13231
1700 North Congress Ave.
Austin, Texas 78711-3231

RE: Comment Response No. 1
City of La Feria Flood Protection Plan
Contract No. 0904830949
EC Project No. 10014.01

Dear Ms. Brittin:

Please accept this letter as our response to comments issued by your office on March 14, 2011, regarding the above-referenced project. A copy of the comments generated by your office is attached to the Final Report. The Flood Protection Plan and all pertinent exhibits have been updated to reflect your comments. One (1) electronic copy of the Final Report in Portable Document Format (PDF) and six (6) bound double-sided copies have been included with this response. One (1) electronic copy of all computer models has also been included with this response.

Responses to individual comments are shown below:

1. A final edit has been conducted to correct all typos, grammar inaccuracies, and inconsistent usage of acronyms and abbreviations.

2. Section 1.0, 3rd paragraph, has been amended to state that the "…Plan is made possible through the Texas Water Development Board's Research and Planning Fund Program which provides Flood Protection Planning grants to political subdivisions…".

3. In Section 1.2, the Texas Water Development Board has been added to the list of entities represented at the Advisory Committee meeting. All public meeting dates are listed and correctly cited.

4. All tables and figures within the report are now cited by table/figure number rather than "The table/figure below".

5. The last paragraph of Section 3.2.2 and Table 7 from Section 4 has been moved to the correct location at the end of Section 3.

6. Appendix A exhibits:

    a. Exhibits 1, 3, 4, 5, and 9 have been modified to include Tio Cano Lake on the map and legend.

b. Exhibits 3 and 4 have been revised to make color palette between “Reservoir” and “School” more distinguishable.
c. The dark blue areas appearing on Exhibit 5 are areas where the 100-year existing floodplain overlaps with various Effective FEMA floodplain zones. Dark blue and light blue are both 100-Year Existing Floodplain areas.
d. The existing and ultimate 100-year floodplain analysis results have been reviewed and verified as correct. It is noted in Section 5.2 that under ultimate conditions the increased flood volume is significant, but that the area flooded under existing conditions is so extensive that the resulting incremental change in water surface elevation would be minor. It is also noted that under ultimate conditions the flood duration would be extended due to the increased volume of runoff.
e. Exhibit 9 has been revised accordingly.

7. A statement confirming that hydraulic modeling was not performed on the Tio Cano Lake subwatershed (TC-01) has been added to Section 5.1. The statement reads as follows, “No hydraulic analysis was done for the existing conditions in the Tio Cano Lake area as there is no primary drainage ditch in this area. The 100-year floodplain limits in the Tio Cano Lake area were calculated based on the maximum water surface elevation calculated in HEC-HMS.”

8. The “% Change” values presented in Section 5.2, Table 13 have been corrected.

9. The 10-year and 100-year existing floodplain map for TC-01 has been added to Appendix A. Due to the unchanging nature of the land uses in this area, hydrograph volume difference between existing and ultimate conditions at Tio Cano is negligible. As a result, there is no volumetric difference in the stage storage curve between the two conditions producing the same floodplain limits to elevation 46 for the Tio Cano Lake area.

10. Within Appendix G, the drainage recommendations are labeled as “phases”. The phases are organized by funding probability with Phase 1 being an active application and Phases 2 and 3 being applications that are under development. Within Section 6, the drainage recommendations are grouped as “Alternatives”, each linked by a specific area of interest. In turn, some recommendations grouped within each alternative may not be grouped together within each phase. To clarify this response the following text has been added to Section 6.1 of the report, “Also note that all costs presented in Appendix G are organized by funding probability with Phase 1 and 1B being active applications, while Phases 2 and 3 are applications under development. Each alternative presented below, specifically Alternative 3, incorporate different phases based on funding probability.”

    In addition, all detailed cost estimates for Alternative 3C drainage improvement recommendations have been added to Appendix G.

11. Cost details for all items found on the drainage improvements list have been added to Appendix G. A cost detail for the “Kansas City Road Drainage Improvements” has been modified to reflect the correct cost estimate of $633,720.

12. To reflect the year’s dollar value, the following statement was added to Section 6.1, “All cost estimates presented within this section and Appendix G use 2009 dollar values.

13. The cost associated with the “clear span bridge” activity, as described in Alternative 2 for AN-49, is included as “Siphon Under AN-49” and is a part of the Alternative 3C cost estimate. Section 6.2.2 has been modified to remove all references to “clear span bridge”.

Austin
4801 Southwest Parkway
Parkway 2, Suite 150
Austin, Texas 78735
(512) 326-5659 T
(512) 326-5723 F

Dallas
2777 North Stemmons Freeway
Suite 1102
Dallas, Texas 75207
(214) 951-0807 T
(214) 951-0906 F

Houston
450 Gears Road
Suite 205
Houston, Texas 77067
(281) 872-4500 T
(281) 872-4505 F

Laredo
707 East Calton Road
Suite 202-141
Laredo, Texas 78041
(956) 764-8106 T
(956) 753-1505 F

New Braunfels
468 S. Seguin
Suite 200
New Braunfels, Texas 78130
(830) 643-5960 T
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Amarillo
PO Box 31870
Amarillo, Texas 79120-1870
(806) 681-8275 T
(512) 326-5723 F