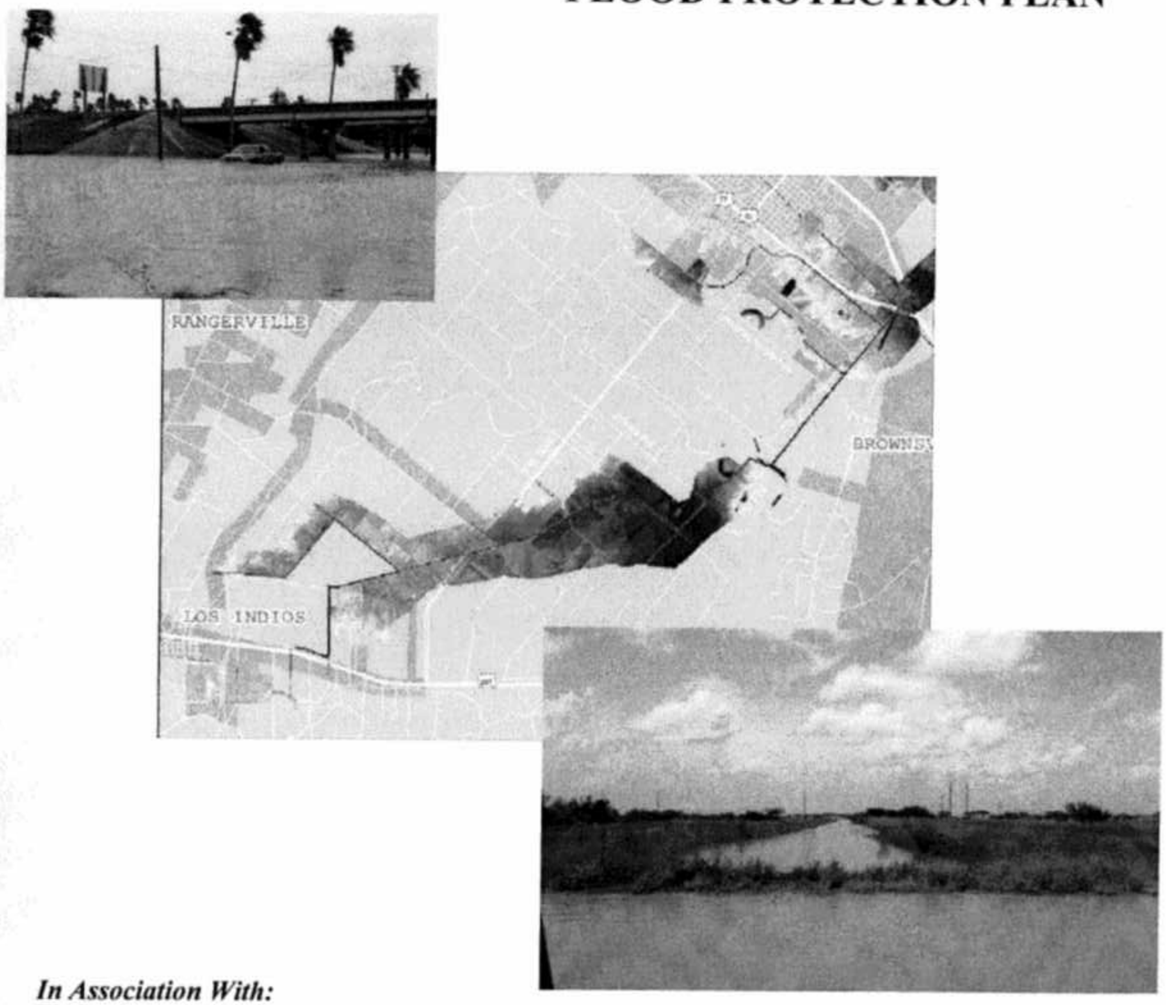
Espey Consultants, Inc.

CAMERON COUNTY DRAINAGE DISTRICT #3
FLOOD PROTECTION PLAN



In Association With:
Texas Water Development Board
Cameron County Drainage District #3
Cameron County
City of San Benito
Town of Los Indios

-FINAL- January 13, 2010

Project No. 7035

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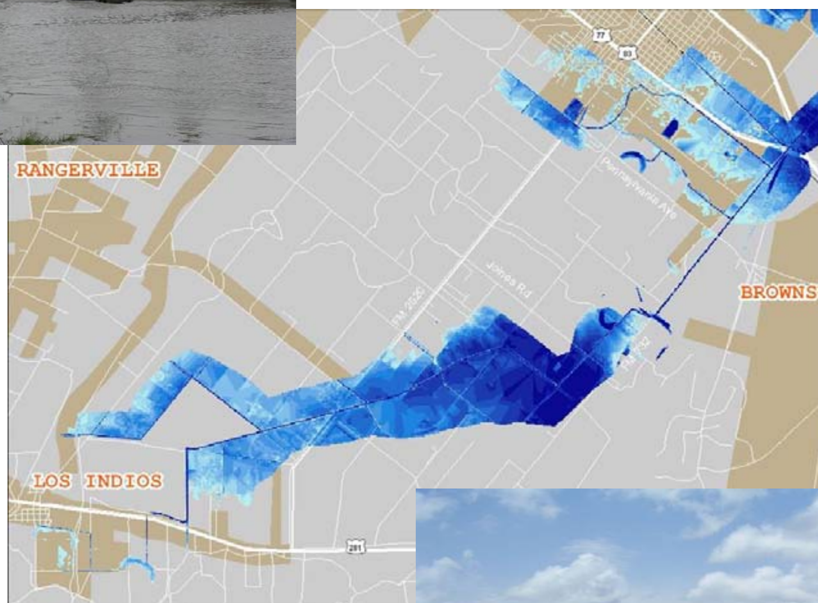

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Cameron County Drainage District #3
Cameron County
City of San Benito
Town of Los Indios

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CAMERON COUNTY DRAINAGE DISTRICT #3
FLOOD PROTECTION PLAN

Prepared for:

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EXECUTIVE SUMMARY

SCOPE OF THE PROJECT

This document is a Flood Protection Plan for Cameron County Drainage District #3 (CCDD3) which 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. The CCDD3 functions as a custodian of the drainage network in this area, responsible for construction, improvements, and maintenance of open drains. In response to local concern over drainage problems and the need to approach the issues on a comprehensive, system-wide basis, CCDD3 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 2007 and contracts were executed in June of 2007.

The purpose of the project was to develop a comprehensive set of models for the District'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 District'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%, 4%, 10%, 20%, and 50% for existing and 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 peak rate factor) 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

Cameron County Drainage District #3 encompasses approximately 148 square miles. The study area for this FPP was 78 square miles and consisted of the southern portion of the district. CCDD3 was divided into 57 subbasins to model the six sub-watersheds: Main Drain A, Drain C Right, Drain C Left, Drain D, Drain E, and Drain F23. These drains are described below:

Main Drain A – This drain is the principal drain which services the City of San Benito, Los Indios and Encantada-Ranchito El Calaboz.

Drain C-Left – This drain can be found in the north-west section of the study area. Much of this drainage basin is within the City of Harlingen.

Drain C-Right - The headwaters of Drain C-Right are within the City of San Benito. Drain C-Right is located just to the east of Drain C-Left and it outlets to the Arroyo Colorado.

Drain D – This drain serves the City of San Benito and is located just to the east of Drain C-Right.

Drain E - This network serves the City of San Benito with an outfall into the Arroyo Colorado. Drain E flows adjacent to San Benito High School, just to the north of US Highway 77.

Drain F23 - This drain serves residents upstream of State Hwy 345 and the Arroyo Colorado Estates Subdivisions with an outfall into the Arroyo Colorado.

FLOOD PROTECTION GOALS

To approach the complex issues of flooding in the District's service area comprehensively, a set of goals were established in the planning process to guide the District'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 District's service area

Goal 2: Ensure that new development does not adversely affect property downstream

Goal 3: Upstream of the District's ditch network, local development should ensure positive drainage to the District's network; the District should ensure the lowest possible tailwater conditions to facilitate local drainage

Goal 4: Protect and enhance available storage in the system

Goal 5: Actively inform the community of the risk of flooding

Goal 6: Aggressively pursue a regional approach to curb illegal dumping

Goal 7: Update and refine the Flood Protection Plan on a bi-annual basis

Goal 8: Support San Benito's efforts to develop a local system Master Drainage Plan

ALTERNATIVES ANALYSIS

This section provides a description and summary of estimated benefits and costs of the proposed alternatives to mitigate drainage and flooding issues in CCDD3. The figure below provides the general location of alternatives within CCDD3. The study area was examined with the intent of providing a 25-year level of service throughout the area of detailed study.

Alternative 1: Los Indios Diversion - Los Indios is located just north of the Rio Grande and a diversion channel less than one mile long is proposed to discharge flows directly to the Rio Grande.

Alternative 2: Main Drain A Downstream Improvements - Alternative 2 focuses on increasing the capacity of Main Drain A from US Highway 77 to the crossing of the Resaca de los Fresnos. Channel capacity was increased by enlarging the channel and associated bridges.

Alternative 3: Main Drain A Detention - Alternative 3 was an attempt to quantify the effect of increasing storage upstream (south) of the Resaca Del Rancho Viejo by further restricting the culverts at FM 732.

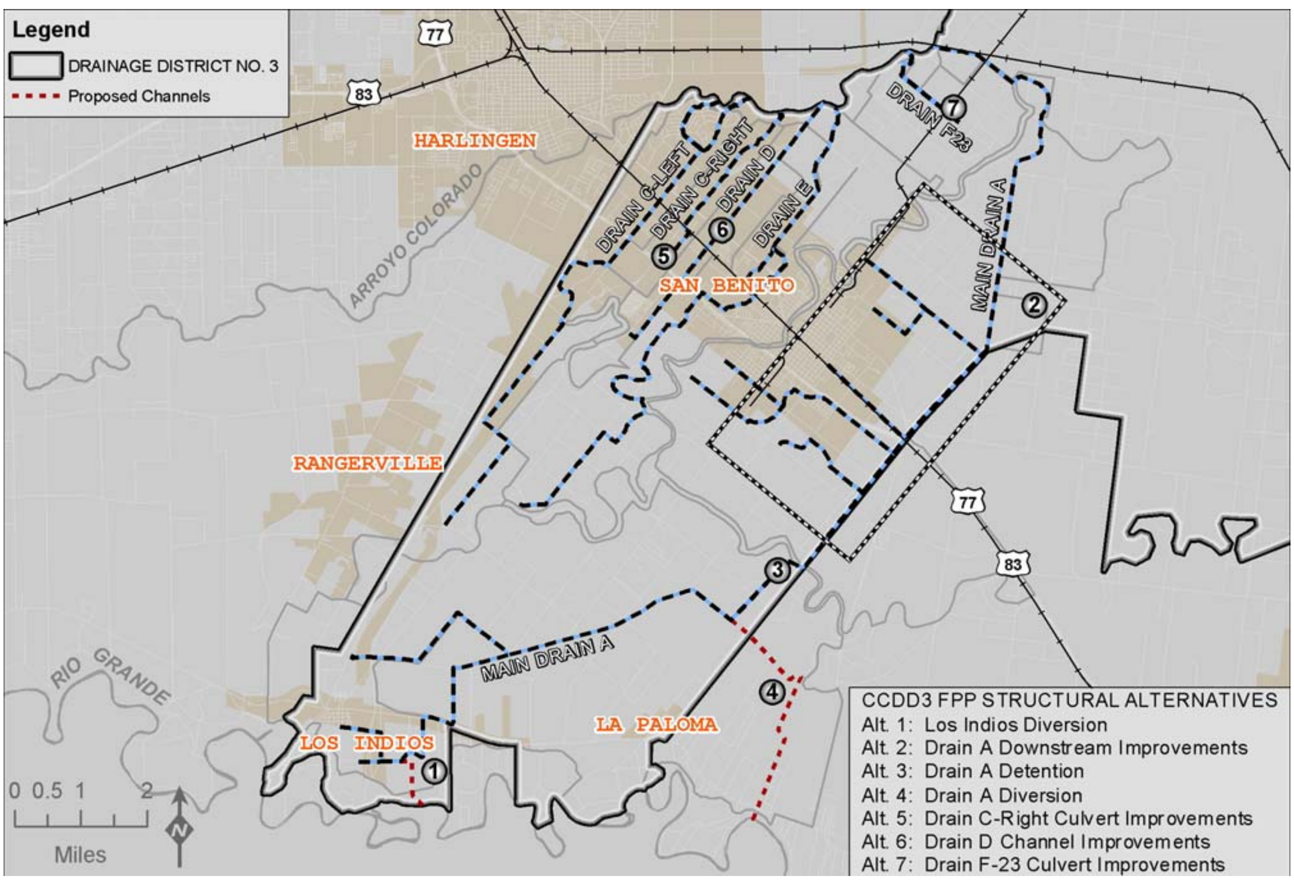
Alternative 4: La Paloma Diversion - This alternative would consist of a diversion channel from Main Drain A to the Rio Grande in the La Paloma area.

Alternative 5: Drain C-Right Culvert Improvements - Drain C-Right currently passes through a small culvert between the railroad tracks and Business 77. This pipe extends roughly one third of a mile and has only a 2-year capacity. This alternative attempts to increase the capacity of this reach to a 25-year level.

Alternative 6: Drain D Channel Improvements - This alternative involved increasing the channel size, without improving the existing roadway crossings, to achieve a 25-year level of service.

Alternative 7: Drain F-23 Culvert Improvements - The primary flooding problems on Drain F-23 appear to be caused by undersized culverts at Williams Road (FM 1846) and Irene Street. This alternative includes increasing the culvert size at both of these locations.

Combination Alternative: Alternatives 1, 2 and 4 - This alternative offers the best possible diversions of flows upstream of San Benito as well and maximizing conveyance along Main Drain A through San Benito.



ALTERNATIVE RANKING & IMPLEMENTATION

Prioritization Ranking Factors
Benefits existing ratepayers
Keeps water off of critical public facilities (Hospital, fire station, etc.)
Shortens flood duration
Potential for leveraged funds
Damage Reduction (Relative dollar benefit)
Maximizes Conveyance
Benefits future development
Provides at least a 25-year level of protection
Low O&M Costs
Enchances water quality
Promote Orderly Development or Improve Economic dev./redev. Potential
Can be implemented independent of other projects
Permitting resistance or difficulty
Time to implement / construct
Environmental or habitat enchancement
Potential for Recreational use

The alternatives ranking was accomplished through a scoring of each potential project in each of sixteen prioritization factors. The prioritization factors are weighted, to offer higher possible point totals for factors which are more important to the District and its objectives. To determine how much weight each factor should possess, the Advisory Committee performed an exercise in which they were individually asked to weight the sixteen factors based on a defined budget. The aggregate result of these individual weightings determined the prioritization factors of highest importance to CCDD3. The prioritization factors, in order of the Advisory Committee Preference, are listed in the table above. Based on the aggregate score, the factors were grouped into five groups and received weights from one to five.

Each alternative was then evaluated with respect to each prioritization factor and given a score of one, two, or three, depending on the degree to which the alternative met the priority. Based on the scoring exercise, the top priority project for the District to complete is the Combination Alternative. The Detention Alternative (Alternative 3) scores the lowest and is not recommended for implementation.

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LIST OF APPENDICES

1.0 INTRODUCTION

Cameron County Drainage District #3 (CCDD3) encompasses approximately 148 square miles within Cameron County and includes the City of San Benito, and portions of the communities of Los Indios and Rio Hondo. 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. The study area for this report covers roughly 78 square miles, and consists of the southern half of the drainage district.

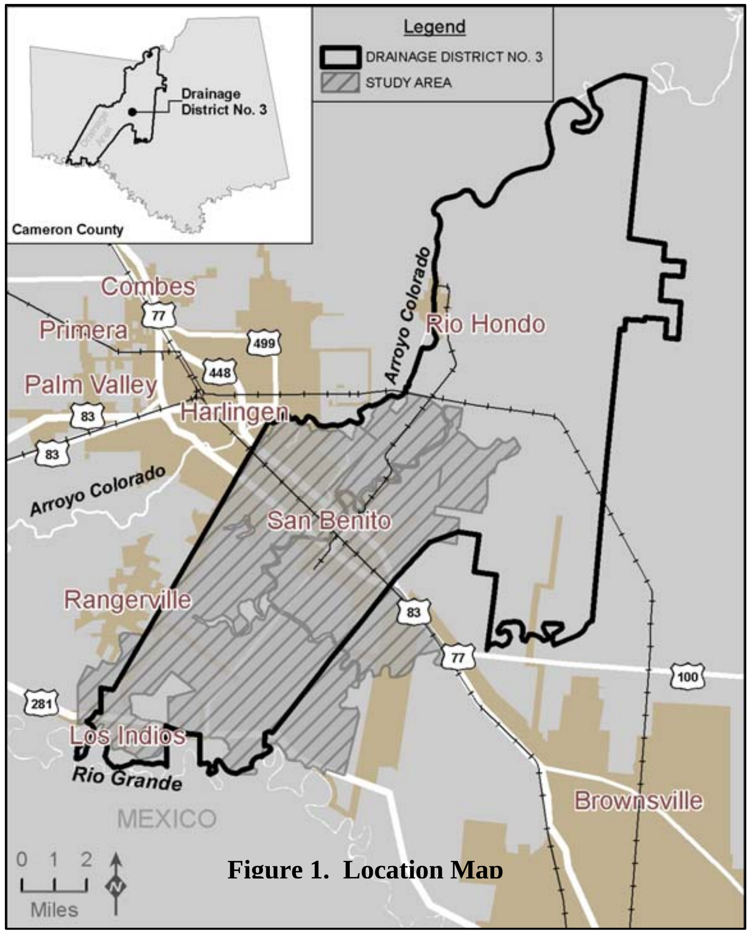

Figure 1. Location Map

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 the fourth-fastest growing metropolitan region in the State of Texas (Source: Texas State Data Center, 1990-2004 population data and estimates). This economic growth translates into increased development pressures on remaining developable land within the CCDD3 jurisdictions. 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 Cameron County Drainage District #3 Flood Protection Plan (CCDD3 FPP) is made possible through the Texas Water Development Board Flood Prevention Planning Program, a program that offers 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 National Flood Insurance Program and provide local matching funds.

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 north of San Benito. 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 Water and Boundary 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 San Benito and the adjacent communities in the CCDD3 jurisdiction.

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. The table below lists some historical rainfall events in Cameron County. This table does not include the significant rainfall experienced in the summer of 2008, including Hurricane Dolly. Hurricane Dolly struck Cameron County on July 23, 2008 and produced between 10 and 16 inches of rainfall within CCDD3.

Table 1. Historical Rain Events

Date	Description	Max Depth (in.)	Damages
May 25, 2007	Excessive rain and flash flooding; 9-12 inches of rainfall within 24 hours	12	Unknown
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	Estimated $250,000 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. Estimated 34 in.of rainfall on the Nueces River Basin.	34	44 deaths total, 15 deaths in Texas: Estimated $100 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 CCDD3 FPP is concerned with the hydraulic capacity of main channels of the drainage ditches. This study does not analyze localized flooding issues.

1.2 PROJECT SCOPE

The purpose of this project is to identify flooding issues in the CCDD3 drainage system 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 members of the CCDD3 Board of Directors, met on September 13, 2007. The project schedule and responsibilities of participants were set at this time. The advisory committee meeting was held in the CCDD3 offices at 4:00 PM and was followed by the first public meeting at 6:00 PM.

- Data collection and review of flood and drainage problem areas

Flood-prone areas were identified based on citizen input and records. Available GIS datasets, current and future land use maps, soil maps, cultural resource maps and materials, environmental resource maps and materials, LIDAR topography, digital orthophotography, cross-section data, existing FEMA information, and previous drainage, engineering, and geotechnical studies were assembled by the District and Espey Consultants (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. 103 culverts and bridges and cross sections upstream and downstream of every structure were surveyed for this study.

- Develop hydrologic models

CCDD3 was divided into 57 subbasins to model the six sub-watersheds: Drain A, Drain F23, Drain E, Drain D, Drain C Right and Drain C Left. Existing GIS coverages of the City of San Benito and Cameron County was analyzed in ArcGIS 9.2 to develop hydrologic parameters. The 50%, 20%, 10%, 4%, and 1% annual chance storm events and the ultimate conditions 1% annual chance event peak flow rates were developed with HEC-HMS 3.1.0.

- Develop hydraulic model

HEC-RAS 3.1.3 was used to model the primary drainage ditches and laterals in CCDD3. 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 50%, 20%, 10%, 4%, and 1% annual chance storm events and the ultimate conditions 1% annual chance event floodplain limits and flooding depths. Floodplain maps and flooding depth grids for the 50%, 20%, 10%, 4%, and 1% annual chance storm events and the ultimate conditions 1% annual chance event were 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 August 13, 2008

- 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 August 27, 2008. 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 CCDD3 current Capital Improvements Plan.

- Prepare final flood protection plan

A final plan was prepared and scheduled for presentation at a final public meeting on September 17, 2008. This document and attachments represent the final deliverables. The deliverables include maps, technical analyses and supporting documentation, and the implementation and phasing plan.

The study provided in this Flood Protection Plan does not duplicate the FEMA re-study. The Federal Emergency Management Agency, under the Map Modernization program, initially committed nearly $2M to update floodplain maps in Cameron County in FY2005 and FY2006. However, while the re-study effort will map portions of the Arroyo Colorado, there are no segments within CCDD3 which are included in the FEMA re-study. Thus, the CCDD3 FPP study complements the FEMA work. Furthermore, the CCDD3 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 the Federal Emergency Management Agency (FEMA) and a Feasibility Study for Cameron County performed by the United States Army Corps of Engineers (USACE):

Espey Consultants 2007 Cameron County Drainage District #5 Flood Protection Plan
Espey Consultants completed a Flood Protection Plan for the Cameron County Drainage District #5 (CCDD5) in 2007. 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. None of the area studied in the CCDD3 FPP is included in this study; however the general study methodology is the same.

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 CCDD3 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 Unincorporated Areas of the County were studied at a different time than the Cities of San Benito and Harlingen, and the maps are not generally consistent. Copies of the models could not be located, and digital data was not available from FEMA.

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.

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 CCDD3 FPP are analyzed in detail in the 1990 Feasibility study, including Main Drain A, Drain B-3, Drain C-Left, and Drain E. The report shows that Drain C-Right and Drain D were also included, but results for these drains could not be found within the report or appendix. Copies of the models could not be located, and digital data was not available from the USACE.

1.4 LOCATION AND DESCRIPTION OF WATERSHED

The CCDD3 study area is approximately 78.2 square miles. The district boundaries generally represent the limits of the watershed, with minimal areas outside the district draining into the studied drains. The watershed is bounded by the Rio Grande River on the south and the Arroyo Colorado on the north. The western boundary is generally contained by Nixon Road (FM 801) and N. Ed Carey Drive (State Loop 499). The eastern boundary runs along FM 1577, the Resaca Del Rancho Viejo south of US 77 and west of Green Valley Farms. The natural topography of CCDD3 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 1 foot per mile. Generally, the watershed drains to the northeast. The primary drainage system is provided by a network of man-made channels. A brief description and diagram of the six main sub-watersheds and their respective network follows:

Main Drain A

The Drain A watershed drains approximately 53.5 square miles. Drain A is the principal drain which services the City of San Benito, and counties of Los Indios and Encantada-Ranchito El Calaboz. The main stem initially drains Los Indios. As the drain continues northeast, it traverses the Resaca Del Rancho Viejo, passes along the southeastern boundary of the City of San Benito, and outfalls into the Arroyo Colorado. Several tributaries drain the City of San Benito and outfall into the main stem. The northwest boundary of the watershed is contained by the Resaca de los Fresnos.

Drain C-Left

The Drain C-Left watershed drains approximately 7.1 square miles in the northwest section of the study area. Much of this drainage basin is within the City of Harlingen. The downstream portion of this drain generally follows N. Whalen Road before entering into Emerald Lake in the Treasure Hills area of Harlingen. Drain C-Left outfalls to the Arroyo Colorado via the two outlet of Emerald Lake.

Drain C-Right

The Drain C-Right watershed drains approximately 1.7 square miles. The headwaters of Drain C-Right are within the City of San Benito. Drain C-Right is located just to the east of Drain C-Left and it outlets to the Arroyo Colorado just east of the Treasure Hills Golf Course.

Drain D

The Drain D watershed drains approximately 2.3 square miles. This network serves the City of San Benito and is located just to the east of Drain C-Right. Drain D generally follows Mayfield Road and flows to the northeast before it outfalls to the Arroyo Colorado.

Drain E

The Drain E watershed drains approximately 10.5 square miles. This network serves the City of San Benito with an outfall into the Arroyo Colorado. Drain E flows adjacent to San Benito High School, just to the north of US Highway 77. Drain E also flows adjacent to the La Palma Power Station between La Palma Street and W Stenger Street. The southeast boundary of the watershed is generally contained by the Resaca de los Fresnos.

Drain F23

The Drain F23 watershed drains approximately 3.1 square miles. This drain serves residents upstream of State Hwy 345 and the Arroyo Colorado Estates Subdivisions with an outfall into the Arroyo Colorado. The southeast boundary of the watershed is generally contained by the Resaca de los Fresnos.

The figure below illustrates the location of the CCDD3 area relative to the Arroyo Colorado and the six sub-watersheds and respective ditch networks. The secondary drainage system includes minor ditches, storm sewer systems, and roadway gutters. The hydraulics of the secondary system is not analyzed.

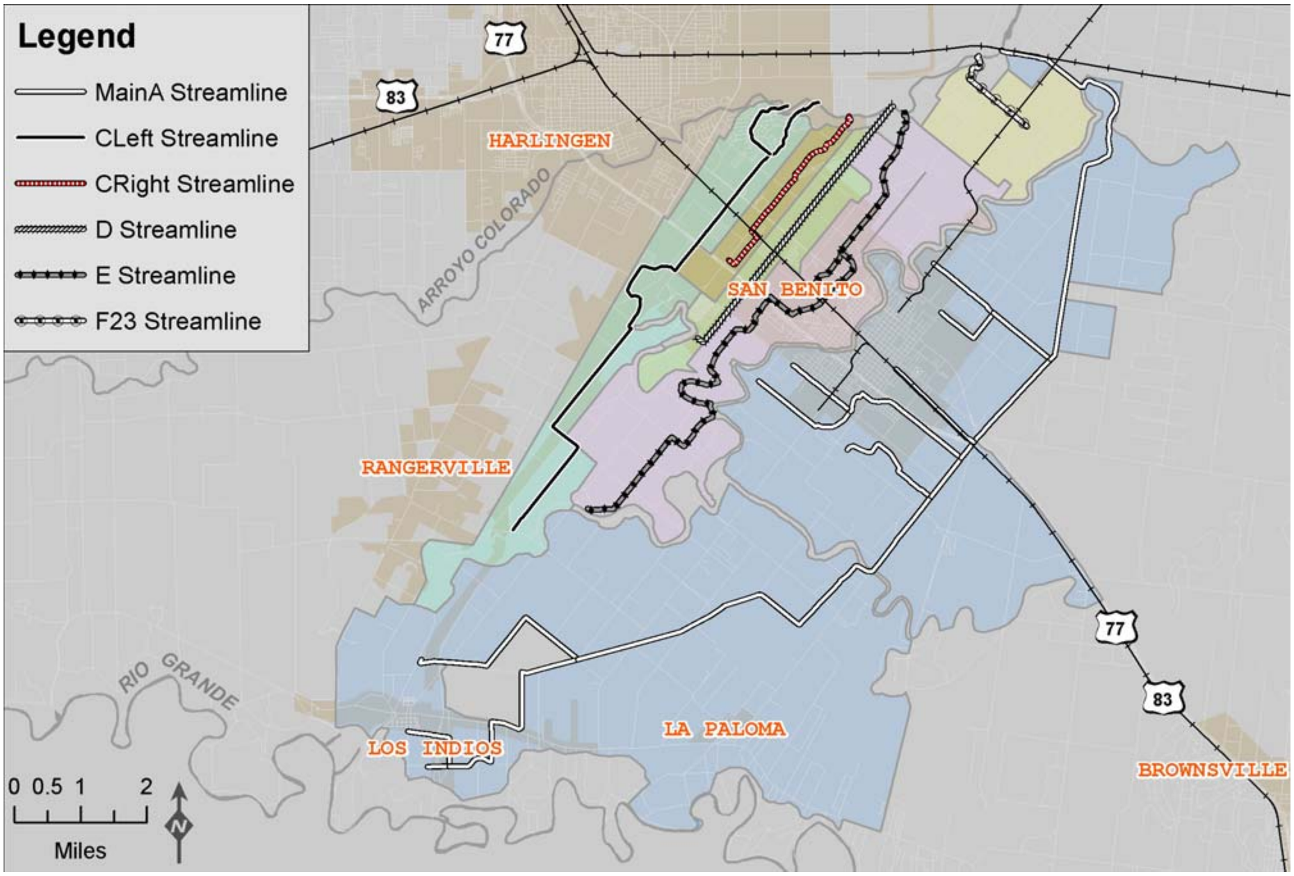

Figure 2. Cameron County Drainage District #3 Study Area

2.0 HYDROLOGIC ANALYSIS

The scope of this project includes a hydrologic study of CCDD3. The hydrologic analysis includes the evaluation of the existing conditions 50%, 20%, 10%, 4%, and 1% (2-, 5-, 10-, 25-, and 100-year) annual chance storm events. The hydrologic analysis also evaluates the ultimate conditions 1% annual chance event.

Version 3.1.0 of the HEC-HMS computer program developed by the Hydrologic Engineering Center of the U. S. Army Corps of Engineers (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%, 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 CCDD3 watershed was divided into 58 subbasins using United States Geological Survey (USGS) topographical survey data, aerial photography, IBWC LIDAR data, field visits, and the 1990 U.S. Army Corps of Engineers Feasibility Report for Cameron County. The subbasins drain into one of the six main subwatersheds, described in Section 1.5, and ultimately drain to the Arroyo Colorado. The drainage area map is included in Appendix A as Exhibit 1.

2.2 PRECIPITATION

The precipitation depths are taken from a USGS publication by Asquith and Roussel, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004. The precipitation depths for various durations for the studied events are shown in Table 2.

Table 2. USGS Storm Depths for the CCDD3 Flood Protection Plan

		USGS Cumulative Depth (in)				
Time	Time (min)	50%	20%	10%	4%	1%
15 minutes	15	1.0	1.4	1.6	1.9	2.3
1 hour	60	1.9	2.5	3.0	3.5	4.5
2 hours	120	2.4	3.1	3.7	4.5	5.8
3 hours	180	2.5	3.3	3.9	4.6	6.2
6 hours	360	2.8	3.8	4.6	5.7	8.0
12 hours	720	3.2	4.4	5.3	6.5	9.0
24 hours	1440	3.5	5.1	6.0	7.5	10.0
48 hours	2880	4.1	6.0	7.0	9.0	12.0

2.3 INFILTRATION LOSSES

The U.S. Department of Agriculture Natural Resource 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 CCDD3 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.

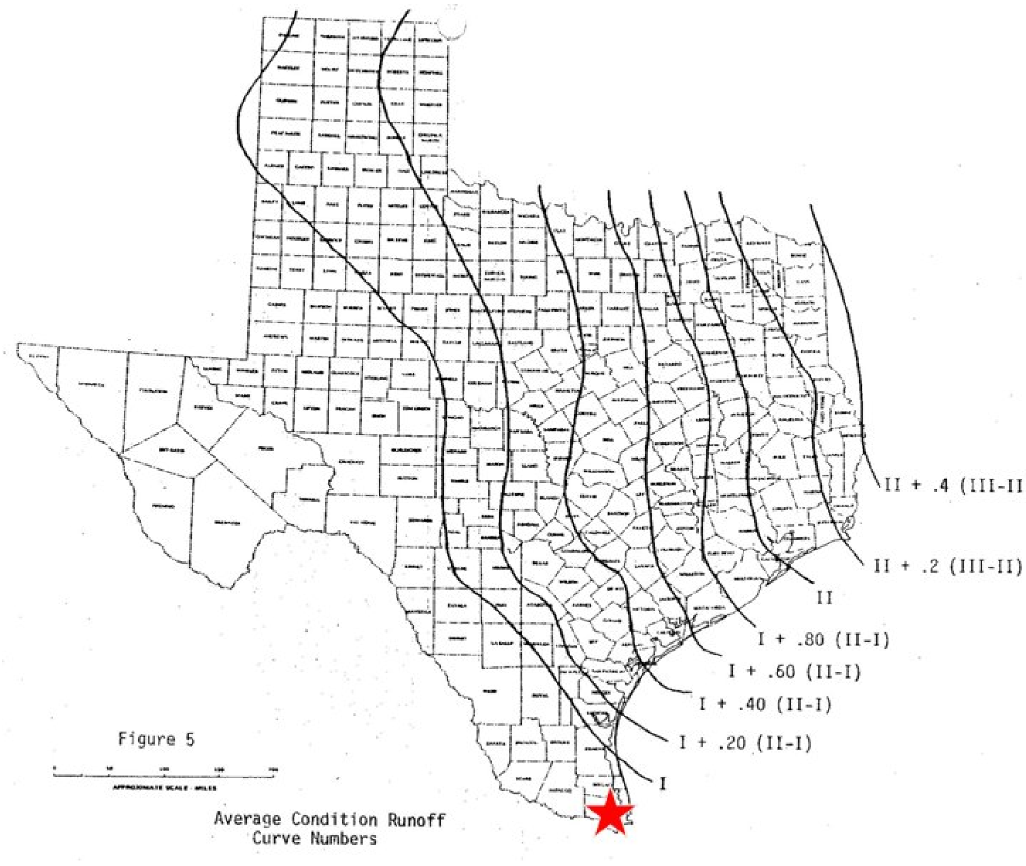

Figure 3: Antecedent Moisture Condition Determination
Source: SCS Technical Note *Estimating Runoff for Conservation Practices*

Curve numbers (CN) were evaluated independent of impervious cover (i.e., these curve numbers reflect fair conditions, open spaces, brush cover) for this analysis. The table below lists the CN values for CCDD3.

Table 3. NRCS Curve Number Table

Curve Numbers (CN)			
Soil Group	AMC I	AMC II	AMC III
A	19	35	55
B	36	56	75
C	51	70	84
D	59	77	89

Key Assumptions: brush cover type, fair hydrologic condition
Source: 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 existing land uses obtained from the National Agriculture Imagery Program (NAIP), and verified using aerial photography. The 2004 NAIP one-meter resolution and 2005 NAIP two-meter resolution aerial photography were used. Twelve major land uses were identified and assigned an impervious cover percentage, as shown in the table below.

Table 4. Impervious Cover Assumptions

Land Use Type	Impervious Cover Percent
Commercial	90%
Cultivated	2%
Dense Vegetation (Dense)	5%
Ditch	0%
Industrial	80%
Multifamily	70%
Rangeland	10%
Road	90%
Single Family 0-2 units per acre (SF02)	12%
Single Family 2-4 units per acre (SF24)	24%
Single Family 4-6 units per acre (SF46)	40%
Water	100%

Commercial development, industrial development, road, and water are expected to provide the greatest amounts of rainfall runoff. Residential areas are categorized as single family or multifamily. Single family areas are categorized by the number of units per acre: SF02, SF24, and SF46. Undeveloped areas are categorized as cultivated, dense vegetation, or rangeland. The studied drainage ditches are considered completely pervious. The existing land use map is included in Appendix A as Exhibit 3.

2.3.2 Ultimate Impervious Cover Determination

The impervious cover values for each subbasin of CCDD3 were modified to reflect the projected ultimate land use assuming a 30-year planning horizon. Based on input from the Advisory Committee, twelve major land uses were identified. The following table lists the assigned impervious cover percent for each land use category found for ultimate conditions.

Table 5. Ultimate Impervious Cover Percentages for CCDD3

Land Use Type	Impervious Cover Percent
Agriculture	5%
Commercial	90%
Industrial	90%
Light Industrial	90%
Multifamily	80%
Mobile Homes	60%
Park	0%
Public Facility	85%
Retail	90%
Road	90%
Single Family (SF)	40%
Water	100%

Commercial, retail, public facility, industrial, and light industrial areas, roads, and water provide the greatest impervious cover percentage. Residential development is identified as single family, multifamily, or mobile homes. Single family density was not broken out as it was for the existing conditions analysis. It was assumed that all single family areas could ultimately develop to a maximum density around 40% impervious cover. Undeveloped areas are identified as park or agriculture. The agriculture land use represents an average impervious cover percent for all types of vegetation. 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 approach. 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, t/Tp.

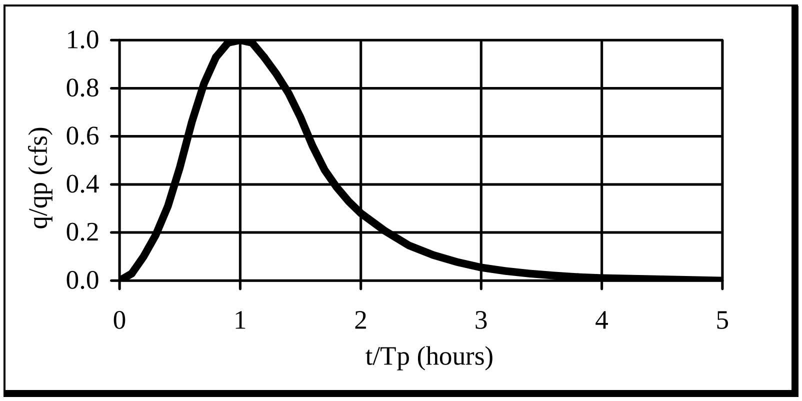

Figure 4. NRCS Standard Unit Graph

The user specified unit hydrograph requires two input parameters, 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 this delay in time after a rain event before the runoff reaches its maximum peak.

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 peak rate factor (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, delivered in TxDOT's 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 provides 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 $\phi(\alpha)$ and α are calculated based on the following equations:

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

and

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

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

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

Table 6. 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 a given time t are computed using the following equation:

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

The figure below 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 in Section 4.0. The volume of both hydrographs is the same.

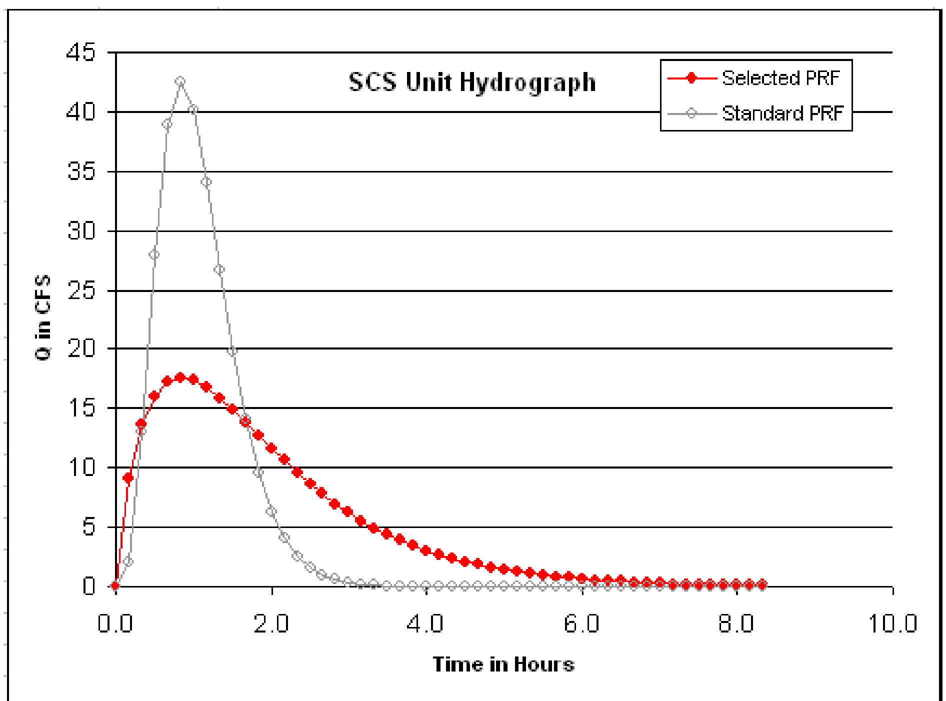

Figure 5. SCS Unit Hydrograph, Standard PRF = 484 v. Selected PRF =200

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 time of concentration 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 time of concentration 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 Cameron County Drainage District 5 Flood Protection Plan (Espey Consultants, Inc. 2007). This is further discussed in Section 4.0.

The Kerby-Kirpich method estimates the time of concentration 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 time of concentration for Texas watersheds. Research concluded that times of concentration estimated with the Kirpich method were less variable than estimates made with the NRCS 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 storm hydrographs. Time of concentration 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 has greater depth.

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

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

Where:

Tc	=	overland flow time of concentration (min),
K	=	units conversion coefficient, K = 0.828
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 0.1 for bare and packed soil to 0.8 dense grass or forest. A retardance coefficient of 0.1 was applied to fully developed subbasins. A retardance coefficient of 0.3 was applied to subbasins that are not fully developed. A maximum length of 1,200 feet was used as a maximum overland flow length.

Channelized Flow

As the depth of flow increases, the overland flow evolves into channelized flow. In the case of this analysis, 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.

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. The following section describes the modified Puls routing method. This method is classified as a hydrologic method of routing, which uses the continuity equation and a relationship between reach storage and discharge at the outlet.

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.

2.7 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 time of concentration of the drainage areas.

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 from the USGS publication 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 SPLIT FLOW RELATIONSHIPS

Due to the very flat nature of the watershed, there are many opportunities for flows to travel to other drainage ditches in the event of overflow. Analysis of the shallow overbank flooding was beyond the scope of this study, with the exception of flooding caused by the overtopping of one of the studied drainage ditches. In general, flows were assumed to remain within the limits of each respective drainage subbasin, and outlet only via the drain ditch contained within that basin. In other words, rainfall within one of the Drain D subbasins would never be assumed to overtop internal watershed divides and exit to the Arroyo Colorado via Drain C-Right or Drain E. However, there are several split flow locations found within the study area where ditches and/or culverts physically cross drainage divides. These are described in more detail below:

> **Drain B-2 and Drain B-1:** There is an existing lateral that connects Drain B-2 with the upstream portion of Drain B-1, under Gamble Road. The connection consists of a lateral ditch and a single 48 or 52 inch reinforced concrete pipe. This connection was not included in the hydrologic analysis since a HEC-RAS model was not generated for the lateral connection to Drain B-2 or this portion of

Drain B-1. It was determined that the impact of this lateral was likely minor and in the absence of a detailed hydraulic analysis there was no way to adequately determine the split flow magnitude. In addition, it was more conservative to assume all flows remained in Drain B-2 and subsequently in Drain B-3.

Drain C-Left and Drain C-Right: There is an existing lateral connection between Drain C-Left and Drain C-Right downstream of Business 77. This open ditch traverses both N. Whalen Road and Helen Moore Road in two 10ft by 7ft box culverts. This lateral is generally flat and flows can travel either direction, depending on which drain has a higher water surface elevation. For the purposes of this study, even rainfall is assumed over the entire watershed. As such, since Drain C-Left has a larger watershed upstream of this point, flows are expected to travel from C-Left to C-Right in all cases. A HEC-RAS model was constructed for this lateral, and relative water surface elevations were compared for similar events on Drain C-Left and Drain C-Right. A split flow relationship was included in the HEC-HMS model to represent the transfer of flow from Drain C-Left to Drain C-Right. No connection exists within the HEC-RAS model and no floodplain is mapped on this lateral.

North Outlet to Emerald Lake: There is an existing split flow location at the inlet to Emerald Lake. Some flows enter the northern arm of Emerald Lake in the Treasure Hills area and outlets directly to the Arroyo Colorado. There is an 18-inch concrete culvert at this location that significantly limits the amount of flow that enters the north arm of the lake. The full north outlet channel and associated crossings, culverts, and outlet weir were included in the Drain C-Left HEC-RAS model. A split flow optimization in HEC-RAS was performed to establish the relative capacities of the two arms of Emerald Lake. This relationship was then included in the HEC-HMS model and the split flow optimization was removed from the HEC-RAS model. This methodology produced a slight difference from the HEC-RAS results, but was needed to accurately predict flow rates and storage attenuation for the section of Drain C-Left downstream of Emerald Lake (on the southern/main outlet). It should also be noted that Emerald Lake is modeled within HEC-HMS as a storage basin, and no modified Puls routing is calculated in this area. While the relationship did differ for each return interval, roughly a quarter to a third of flows that enter Emerald Lake exit to the Arroyo via the north outlet channel.

2.9 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. For the purposes of this analysis, full development is equivalent to a 30-year time horizon (i.e., the development status in the year 2038).

The time of concentration was adjusted to reflect shorter watershed response times, specifically 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 0.1 for ultimate conditions if development would be expected in the upper reaches of the subbasin.

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 six major drainage ditch networks in the CCDD3 watershed. There are 66.5 miles of stream included with this hydraulic analysis, which computes water surface elevations for the 50%, 20%, 10%, 4%, 1%, and ultimate 1% annual chance (2-, 5-, 10-, 25-, 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:

- Drain A
- Drain C-Left
- Drain C-Right
- Drain D
- Drain E,
- And Drain F-23.

An overall drainage map showing the extent of the studied reaches is included as Exhibit 1 in Appendix A of this report. In total, there are 26 hydraulic reaches that include 103 modeled structures. The specific studied reaches are included as Exhibits 5 through 8 in Appendix A.

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 3.1.3 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 the six subwatersheds: Main A, C-Left, C-Right, D, E, and F-23. 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 0.4 percent. The table below lists the stream length and number of reaches, cross sections, culverts, bridges, and weirs modeled for each network in HEC-RAS.

Table 7. CCDD3 HEC-RAS Models

HEC-RAS Model	Stream Length (mi)	Quantity				
		Reaches	Cross Sections	Culverts	Bridges	Weirs
Main A	35.3	17	319	41	16	0
C-Left	3.2	3	96	10	4	1
C-Right	10.4	1	29	4	1	0
D	4.7	1	47	7	0	0
E	11.3	3	98	8	9	0
F23	1.6	1	16	2	0	0
Total	**66.5**	**26**	**605**	**72**	**30**	**1**

3.2 HYDRAULIC MODEL DEVELOPMENT

3.2.1 Streamlines and Cross Section

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. A map of cross section location for each model is included in Appendix A as Exhibits 5 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. The table below lists typical values for Manning's n. For all hydraulic models in the CCDD3 FPP use a Manning's roughness coefficient of 0.045 for channels, and 0.08 for overbanks.

Table 8. 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 9. 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 HYDROLOGIC VALIDATION

Limited historical flow or rainfall data is available for CCCD3. The methodology used in this study was selected based on that used by Espey Consultants, Inc. (EC) for the recent Cameron County Drainage District #5 Flood Protection Plan (CCDD5 FPP). The CCDD5 is located roughly two miles northwest of CCDD3, 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 North Main drainage, and 15-minute precipitation depths recorded at three rain gauges located at various Harlingen Irrigation District #1 Pump Stations.

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

Table 10. 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
Selected	**5**	**AMC I**	**Kerby-Kirpich**	**Modified Puls**	**200**
	6	AMC II	Kerby-Kirpich	Modified Puls	150

Parameters analyzed for calibration are the antecedent moisture conditions, time of concentration calculation method, channel routing method, and the peak rate factor of the unit hydrograph. Calibration model number five (5) 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.

- **Peak Rate Factor**

Standard methodology uses a peak rate factor of 484 for the user-specified unit hydrograph. The flat terrain in this study area requires a lower peak rate factor. A peak factor rate of 150 was used in calibration number six, 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 peak rate factor of 200 was applied to the entire study area.

- **Time of Concentration**

Standard methodology 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. 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. Modified Puls is used for the entire CCDD3 study area. This method was compared with Muskingum-Cunge routing. Muskingum-Cunge routing cannot 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

4.2 COMPARISON WITH PREVIOUS STUDIES

The objective of the 1990 US Army Corps of Engineers (USACE) Feasibility Report for Cameron County, Texas as 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 CCDD3 FPP are analyzed in detail in the 1990 Feasibility study, including Main Drain A, Drain B-3, Drain C-Left, and Drain E. The report shows that Drain C-Right and Drain D were also included, but results for these drains could not be found within the report or appendix. Copies of the models could not be located, and digital data was not available from the USACE. A description of the model created and a comparison with the CCDD3 FPP models are discussed in the following sections.

4.2.1 Comparison of Hydrologic Data

Of the channels selected for the USACE Feasibility study, several of the main drainage ditches in CCDD 3 are included. 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. The modified Puls routing method was used. Peak flow rates for the 100-year, no-project (existing) channel design in the feasibility study are listed in the table below for comparison with CCDD3 FPP 100-year existing peak flow discharges. In general, the USACE produced similar results when compared to this study. The largest differences in flow rates appear to be where there is a significant difference in total drainage area caused by slightly different locations of control points and different topographic data.

Table 11. Peak Flow Rate Comparison of 1990 USACE Feasibility Study and CCDD3 FPP

USACE				Espey			
Reach	**Node**	**Drainage Area (sq mi)**	**100-Year Discharge (cfs)**	**Reach**	**Node**	**Drainage Area (sq mi)**	**100-Year Discharge (cfs)**
AS-31	1	48.2	2074	Drain A	J-A18	53.46	2307.4
AS-31	2	44.2	1821	Drain A	J-A17	53.203	2307.4
AS-31	3	41.6	2003	Drain A	J-A13	45.636	2292.5
AS-31	4	35.9	1870	Drain A	J-A10	40.253	2066.3
AS-31	5	24.1	688	Drain A	J-A07	27.949	1435.8
AS-31	6	16.1	766	Drain A	J-A04	11.858	700
AS-31	7	11.9	972	Drain A	J-A03	9.668	1235.6
AS-31-06	4	4.1	951	Drain B-3	J-B03	4.071	462.9
AS-31-06	9	1.7	725	Drain B-3	J-B01	2.055	434.5
AS-41	1	7.3	815	Drain C-Left	J-CL05	7.099	652.8
AS-41	2	6.8	617	Drain C-Left	J-CL04	6.968	797.8
AS-41	3	5.8	570	Drain C-Left	J-CL01	4.895	448.9
AS-36	5	8.6	1218	Drain E	J-E06	8.623	1820.1
AS-36	4	6.2	460	Drain E	J-E04	7.36	1343.2
AS-36	3	4.6	463	Drain E	J-E01	5.393	804.8
AS-36	2	3.5	125	Drain E	E-01	4.31	645.2

4.2.2 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 CCDD3 FPP.

The use of a normal depth boundary condition (at the Arroyo Colorado) in the CCDD3 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).

4.3 HYDROLOGIC ANALYSIS SUMMARY AND CONCLUSIONS

This hydrologic analysis evaluates the CCDD3 watershed tributary to the Arroyo Colorado. Based on the results of this analysis, the most appropriate design storm for this study is the balanced and nested distribution with a 48-hour duration. The nested USGS precipitation depths are applied to this distribution. The most appropriate basin model for this analysis is the validated methodology discussed above. For ultimate watershed conditions, the existing conditions basin model is revised to reflect projected future impervious cover based on the composite future land use map. Results of this hydrologic analysis are used to delineate the floodplains discussed later in this report.

5.0 FLOODING ANALYSIS OF CCDD3

5.1 EXISTING CONDITIONS FLOODING ANALYSIS

The hydrologic and hydraulic models were used to evaluate the existing conditions of the Drain A and tributaries, Drain C-Left, Drain C-Right, Drain D, Drain E, and Drain F-23. Water surface elevations for the 50%, 20%, 10%, 4%, and 1% (2-, 5-, 10-, 25-, 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 9.2) to identify out-of-bank flooding and flood depths. 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 ditch can generally contain without overbank flooding. The existing conditions floodplain maps for each watershed for the 4% and 1% storm events (25-year and 100-year, respectively) are included in Appendix A as Exhibits 5 through 8. The floodplain maps do 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 show only the limits of the hydraulic model and not the full extent of flooding. In addition, this level-of-service analysis is contained within the area of detailed study. This was the area in which bridges and other significant structures were surveyed. The detailed study area is generally downstream of US Highway 77.

5.1.1 Drain A and Tributaries

The hydraulic capacity of the Drain A main stem and its tributaries varies along the network. Along the main stem, areas providing the highest level of service include the reaches in the Los Indios area, the segment from FM 732 to the confluence with Drain B-1, and the segment downstream of CR 596 to the Arroyo Colorado.

Areas along the main stem providing low level of service include the segment extending from La Paloma Cutoff Road to the Resaca Del Rancho Viejo at FM 732; the segment just downstream of Railroad Drain, and the segment just downstream of FM 510.

The level of service along the tributaries also varies. The performance of the tributaries to Main Drain A through the City of San Benito are affected by tailwater from Drain A main stem. The City SB Drain, along Turner Road upstream of Drain B-3, contains thirteen small culverts and each only provides a 2-year level of service. Table 12 summarizes the level of service of Drain A and its tributaries.

Table 12. Existing Level of Service of Drain A and Tributaries

Drain A Main Stem		**Level of Service**
Reach 1	700 ft US of FM 509 to confluence with Drain A Trib	100-yr
Reach 2	Confluence with Drain A Trib to confluence with Drain A-2	25-yr
Reach 3	Drain A-2 to Joines Rd	2-yr
	Joines Rd to FM 732	10-yr
	FM 732 to confluence with Drain B-1	100-yr
Reach 4	Confluence with Drain B-1 to confluence with B-2-3	25-yr
Reach 5	Confluence with Drain B-2-3 to confluence with Railroad Drain	10-yr
Reach 6	Confluence with Railroad Drain to Loop 448	5-yr
	Loop 448 to Drain B-5	25-yr
Reach 7	Confluence with Drain B-5 to FM 510	10-yr
	FM 510 to 2,800 ft downstream of FM 510	5-yr
	2,800 ft downstream of FM 510 to CR 596	25-yr
	CR 596 to Arroyo Colorado	100-yr
Drain B-5		**Level of Service**
Reach 1	Top of reach to 1,300 ft upstream of Norma Linda Rd	100-yr
	1,300 ft upstream of Norma Linda Rd to confluence with Drain B-5A	2-yr
Reach 2	Confluence with B-5A to confluence with Drain A	10-yr
Drain B-5A		**Level of Service**
	McCullough St to confluence with Drain B5	5-yr
Railroad Drain		**Level of Service**
	McCullough St to Stokey Rd	100-yr
	Stokey Rd to Scaief Rd	10-yr
	Scaief Rd to confluence with Drain A	10-yr
Drain B-2-3		**Level of Service**
Reach 1	Marydale Rd to 3,000 ft downstream of Maryland Rd	2-yr
	3,000 ft downstream of Maryland Rd to 2,000 ft upstream of Drain City SB confluence	5-yr
	Field Access Rd to confluence with Drain City SB	100-yr
Reach 2	Drain City SB confluence to Jay St	2-yr
	Jay St to 8th St	5-yr
	8th St to Scaief Rd	100-yr
	Scaief Rd to confluence with Main A	10-yr
Drain City SB		**Level of Service**
	Leal St to confluence with Drain B-2-3	2-yr
Drain B-1		**Level of Service**
	Pennsylvania Ave to 2,000 ft downstream of Pennsylvania Ave	5-yr
	2,000 ft downstream of Pennsylvania Ave to confluence with Main A	25-yr
Drain A Trib		**Level of Service**
	Robertson St to confluence with Drain A	100 yr
Drain A-2		**Level of Service**
	FM 509 to La Paloma Cutoff Rd	5-yr
	La Paloma Cutoff Rd to confluence with Drain A	25-yr

5.1.2 Drain C-Left

Drain C-Left channel and structures generally provide a 100-year level of service from US Hwy 77 to the Arroyo Colorado. The reach splitting north from the drain at Emerald Lake, labeled as North Outlet, also has a 100-year level of service.

Table 13. Existing Level of Service of Drain C-Left

Drain C-Left		**Level of Service**
Reach 1	US Hwy 77 to Diversion	100-yr
Reach 2	Diversion to Arroyo Colorado	100-yr
North Outlet		**Level of Service**
	Diversion to Arroyo Colorado	100-yr

5.1.3 Drain C-Right

From Business 77 to Arroyo Colorado, Drain C-Right channel and structures have a 100-year level of service. The 1,660 ft culvert at the railroad extending to Business 77 has a level of service of roughly a 2-year event.

Table 14. Existing Level of Service of Drain C-Right

Drain C-Right		**Level of Service**
	Railroad to Business 77	2-yr
	Business 77 to Arroyo Colorado	100-yr

5.1.4 Drain D

The hydraulic capacity of Drain D varies, with channel capacity improving as the reach proceeds downstream. Culverts along Drain D generally have a 100-year level of service, with the exception of Business 77 and US Hwy 77, which generally have a 5 to 10-year level of service.

Table 15. Existing Level of Service of Drain D

Drain D		**Level of Service**
	150 ft upstream of US Hwy 77	5-yr
	US Hwy 77 to Russell Ln	10-yr
	Russell Ln to Arroyo Colorado	100-yr

5.1.5 Drain E

From US Hwy 77 to Business 77 the Drain E has generally a 25-year level of service. Drain E has 100-year channel capacity downstream of Business 77. The Drain E Tributary provides a 25-year level of service, and is affected by tailwater from Drain E. Drain E functioned well during Hurricane Dolly, with limited flooding in the overbanks.

Structures located along the reach between US Hwy 77 to La Palma Street have generally a 25-year level of service. Structures downstream of La Palma provide a 100-year level of service.

Table 16. Existing Level of Service of Drain E

Drain E		**Level of Service**
Reach 1	US Hwy 77 to Business 77	25-yr
	Business 77 to confluence with Drain E Tributary	100-yr
Reach 2	Confluence with Drain E Tributary to Arroyo Colorado	100-yr
Drain E Tributary		**Level of Service**
	Railroad to confluence with Drain E	25-yr

5.1.6 Drain F-23

Drain F-23 provides a 100-year level of service downstream of Williams Road/FM 1846. Upstream of 1846, the level of service is roughly a 10-year event. Currently, the area upstream of FM 1846 is agricultural. Culverts at FM 1846 and at Irene Street provide roughly a l0-year level of service.

Table 17. Existing Level of Service of Drain F-23

Drain F-23	Level of Service
50 ft upstream of FM 1846 to FM 1846	10-yr
FM 1846 to Arroyo Colorado	100-yr

5.2 ULTIMATE CONDITIONS FLOODING ANALYSIS

The hydrologic and hydraulic models were used to evaluate the ultimate conditions of the Drain A, Drain C-Left, Drain C-Right, Drain D, Drain E, and Drain F-23 drainage networks. Ultimate conditions represent a fully developed watershed and are intended to represent maximum peak discharges that could be realized in the future. For the purposes of the CCDD3 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 regulations. These findings are summarized in the following table.

Table 18. Ultimate Conditions Impacts

100-Year Peak Flow Rate (cfs)		Percent Change	
Existing	Ultimate	(%)	Location along Drain A Main Stem
239	379	59%	US Hwy 281
1236	1659	34%	FM 2520
1436	1928	34%	FM 732
1570	2129	36%	Confluence with Drain B-1
2066	2790	35%	US Hwy 77
2296	2846	24%	Bus 77
2322	2926	26%	Iowa Gardens
2346	3158	35%	Confluence with Drain B-5
2305	3159	37%	CR 596
2307	3168	37%	State Hwy 345
			Location along Drain B-1
481	545	13%	State Hwy 100
			Location along Drain B-2-3 and Tributary
435	470	8%	FM 2520
463	500	8%	Yost Rd
			Location along Railroad Drain
458	497	8%	Scaief Rd
			Location along Drain B-5 and Tributary
181	206	14%	Line 17 Rd
121	170	41%	McCullough Rd
163	173	6%	FM 510
			Location along Drain C-Left
260	391	51%	US Hwy 77
704	885	26%	Business 77
798	1046	31%	Russell Ln
622	835	34%	Diversion to North Outlet reach
250	294	18%	Downstream of diversion to Drain C-Left
			Location along Drain C-Right
222	313	41%	Shafer Rd
508	640	26%	Business 77
724	964	33%	Russell Ln
			Location along Drain D
280	299	7%	US Hwy 77
385	459	19%	Business 77
584	640	9%	Russell Ln
			Location along Drain E
909	1079	19%	US Hwy 77
1081	1252	16%	Business 77
1343	1589	18%	Downstream of confluence with E Tributary
1533	1833	20%	Russell Ln/ Haige Rd
1820	2239	23%	FM 1846
			Location along Drain F-23
331	665	101%	FM 1846
452	812	79%	Irene St

6.0 ALTERNATIVES ANALYSIS

6.1 PLANNING A SYSTEM OF IMPROVEMENTS

The purpose of the Flood Protection Plan is to evaluate the relative benefits of the mitigation strategies developed herein, in order to guide the District in selecting, prioritizing and implementing an optimized combination of strategies. Costs presented herein are for comparison of potential capital improvement projects. To assist CCDD3 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 maintenance, 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 size) 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 in the form of community-based initiatives and programs, may prevent the worsening of flood problems and aim to prevent flood-induced hazards. Examples of non-structural flood control measures include flood alert systems and buy-outs in flood prone areas. Non-structural controls aim to control the land use of flood-prone areas and to restrict timing and reduce runoff. As much of the success of non-structural measures is found when implemented during the course of new development, system-wide runoff control/impact fee policies for new development will likely be an important component for CCDD3, 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 an increase in runoff, maintaining the peak discharge, so that structural controls will continue to be effective; or, these controls seek solutions to other dimensions of the flooding problem, such as public awareness and response time.

6.2 STRUCTURAL IMPROVEMENTS

This section provides a description and summary of the estimated benefits and costs of the proposed alternatives to mitigate drainage and flooding issues in CCDD3. The figure below provides the general location of alternatives within CCDD3. The study area was examined with the intent of providing a 25-year level of service throughout the area of detailed study. Please note that the detailed study area is generally downstream of US 77. It is difficult to accurately assess alternative benefits in areas that did not have detailed structure surveys performed. HEC-RAS models were created for the entire watershed, but the models beyond the detailed study area are primarily to provide valley storage volumes for modified Puls routing. In general, Drain C-Left and Drain E were found to have a 25-year capacity within the detailed study area. No alternatives are proposed for these drains. There are also very few alternatives proposed on the tributary to Main Drain A, in the San Benito area. It was found that the largest issue for these ditches was flooding caused by a high tailwater condition on Main Drain A. The alternatives examined herein focus on reducing the tailwater for these tributary ditches.

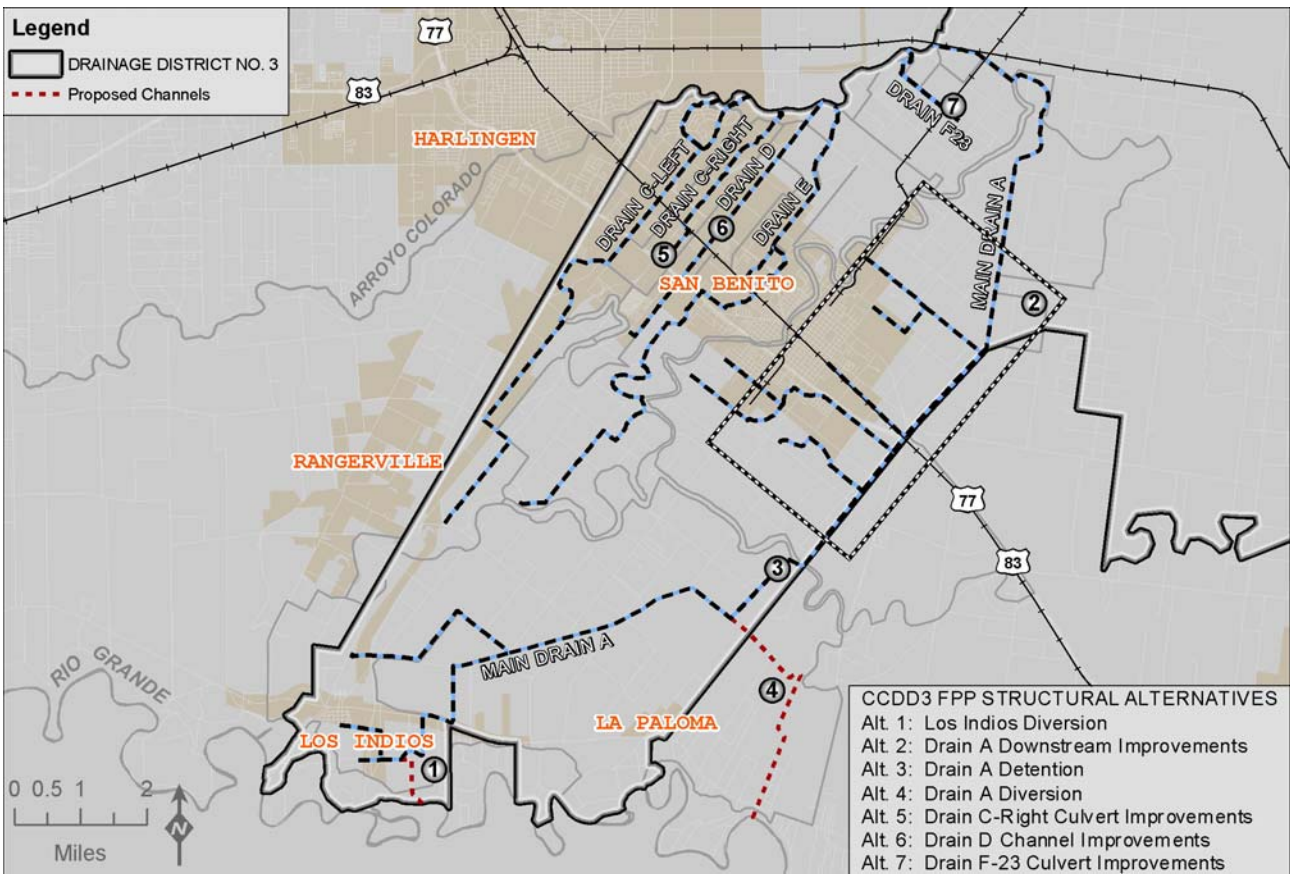

Figure 6. Location Map of CCDD3 Structural Alternatives

6.2.1 Alternative 1: Los Indios Diversion

The Town of Los Indios is located in the southern-most extent of CCDD3. Los Indios currently drains to Main Drain A, which ultimately outfalls to the Arroyo Colorado. Main Drain A is in excess of 19 miles long and drains a total area of approximately 53 square miles. Los Indios is located just north of the Rio Grande and a diversion channel less than one mile long is proposed to discharge flows directly to the Rio Grande. This alternative is currently under construction, with the diversion channel already in place. The appropriate permits and permissions have been obtained, and the outlet works to the Rio Grande will be constructed once the 2008 hurricane season ends. The outlet consists of culverts through the levee adjacent to the Rio Grande, and gates to prevent flood flows on the Rio Grande from backing up beyond the levee. A location map of Alternative 1 and areas impacted is included as Exhibit 9 in Appendix A.

Initially, only the Los Indios area will drain via this outlet channel. The next phase of construction would be to direct additional areas to this outlet by changing the flow direction of the Drain A portion of the channel south of the reservoir. The intent is to drain as much as 10 square miles of area through the Los Indios outlet. The benefits of Alternative 1 are difficult to quantify. While the total diversion of 10 square miles of area would certainly reduce the volume of water flowing through San Benito, the peak flow rate would be virtually unchanged. It is important to note that the duration of flood events would be shortened by as much as four days with Alternative 1 in place. The largest benefits and reduction in peak flood elevations would be found immediately downstream of the area diverted to the Los Indios outlet on Main Drain A.

The estimated cost of Alternative 1 is $1.6 million. Detailed estimates of costs can be found in Appendix G.

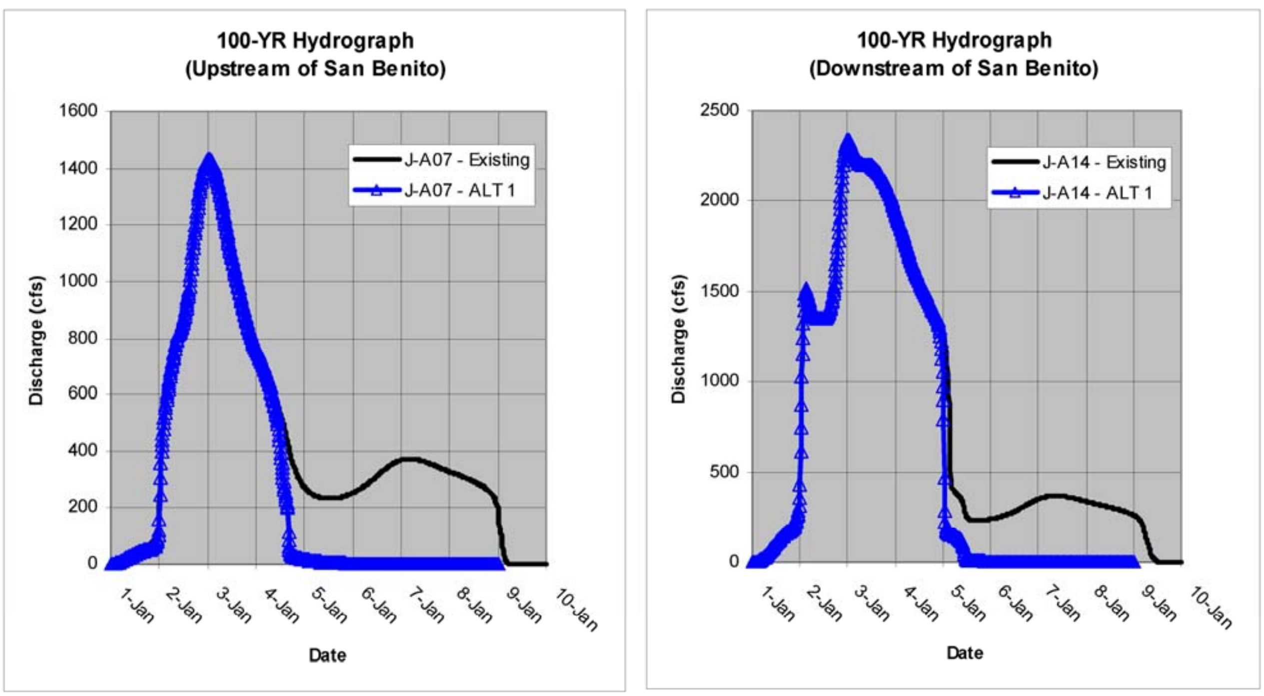

Figure 7. Impact of Alternative 1

6.2.2 Alternative 2: Main Drain A Downstream Improvements

The highest population density within CCDD3 is within the city limits of San Benito. Areas of San Benito north and west of the Resaca de los Fresnos generally drain directly to the Arroyo Colorado. Areas south and east of the Resaca de los Fresnos drain to Main Drain A approximately eight miles upstream of its outfall into the Arroyo Colorado. The tributaries to Main Drain A that extend into San Benito were modeled in detail. The drains modeled include Drain B-1, Drain B-2, Drain B-3, Railroad Drain, City SB Drain and Drain B-5 (these drains are collectively referred to as the "B Drains" for the purposes of this report). The modeling effort in this area included survey data for all structures on these drains. While many of the structures on the B Drains were found to be undersized, it was determined that the main cause of flooding in this area was caused by the tailwater condition on Main Drain A. Essentially, increasing channel capacity in the B Drains would have limited impact on flood elevation due to the high water surface elevation on Main Drain A, at the outlet of the B Drains. Alternative 2 focuses on increasing the capacity of Main Drain A from US Highway 77 to the crossing of the Resaca de los Fresnos. Channel capacity was increased by enlarging the channel and associated bridges. A location map of Alternative 2 is found in Appendix A as Exhibit 10.

As discussed earlier, increasing channel capacity and engineering a more efficient drainage system will generally reduce the amount of available storage in a system. Reducing the frequency and depth of overbank flooding not only reduces storage, but is accompanied by associated increases in peak discharges. This creates a scenario where the channel design discharge becomes something of a moving target, whereby the greater the system capacity, the higher the associated design discharge. The intent of Alternative 2 was to contain the 25-Year flood with limited overbank flooding on Main Drain A. Improvements are not proposed all the way to the outfall with the Arroyo Colorado since there appears to be adequate channel capacity downstream of CR 596 and the Resaca de los Fresnos. Flood depths and discharge rates would increase in these locations as a result of this alternative, but the existing channel is large enough to accommodate these increases.

In addition to the proposed modifications on Main Drain A, two culvert upgrades are proposed within the B Drains as a part of Alternative 2. As mentioned above, many of the culverts found within the B Drains are undersized but little benefit would be realized by increasing culvert sizes here without significantly lowering flood flow elevations on Main Drain A. The two exceptions to this were the crossing at FM 732 on Drain B-1 and the irrigation canal crossing on Drain B-2.

> **Drain B-1**: The crossing at FM 732 is currently a single 60-inch reinforced concrete pipe. It was found that water surface elevations could be significantly reduced upstream of this crossing on Drain B-1 if this culvert was increased to an 8-foot by 8-foot concrete box culvert.
>
> **Drain B-2**: Just downstream of S. Sam Houston Boulevard (FM 2520), Drain B-2 crosses an irrigation canal through a single 4-foot by 3-foot box culvert. While this culvert is larger than many in the area, this one has a significant impact on flooding due to the fact that the irrigation canal is significantly elevated above the surrounding area. An 8-foot by 8-foot concrete box culvert is proposed to replace the existing box.

Two levels of improvement were investigated for this alternative. Alternative 2A represents a more limited improvement with a 45-foot bottom width proposed for Main Drain A through San Benito. Alternative 2B represents a more aggressive strategy, proposing a longer section of enlarged channel with a bottom width as large as 100 feet. The specifics of each alternative are presented below.

Alternative 2A: Alternative 2A would consist of increasing the channel bottom width to 45 feet from Business 77 to CR 596. This alternative would involve enlarging to replacing both the northbound and southbound bridges at Business 77, FM 510, and CR 596. The bridge at Iowa Gardens Road was found to be generally large enough for this alternative. There is a flume downstream of Iowa Gardens Road in which the irrigation canal waters traverse the drainage ditch. It is proposed that this flume be replaced with an inverted siphon due to the significant impediment to flows represented by this crossing.

Alternative 2B: Alternative 2B increases the channel size and length of proposed improvements. This alternative would include modifications from the railroad track crossing at US Highway 77 to the irrigation canal flume crossing at the Resaca de los Fresnos. This alternative involves increasing the channel bottom width to 100 feet. In addition to the bridges impacted in Alternative 2A, this alternative adds Iowa Gardens Road and the railroad tracks.

Both Alternative 2A and 2B generally reduce flood elevations in San Benito between the Resaca Del Rancho Viejo (FM 732) and FM 510. It is important to note that the result of implementing these alternatives is a significant increase in peak flow rates (due to loss of storage) and some associated impacts downstream of the proposed improvements. It is also important to note that these options would involve significant upgrades to existing bridge structures. Table 19 shows the impacts of these alternatives on the 100-year flood peak discharges at the outfall of Main Drain A to the Arroyo Colorado.

Table 19. Peak Discharge for Main Drain A at the Arroyo Colorado

	Flow Rate		Percent Increase	
	25-Year	100-Year	25-Year	100-Year
Existing	1505	2307		
Alternative 2A	2130	3047	42%	32%
Alternative 2B	2667	3648	77%	58%

The estimated benefit of Alternative 2A during the 25-year storm is $280,000 and during the 100-year storm is $ 550,000. The estimated benefit of Alternative 2B during the 25-year storm is $6.6 million and during the 100-year storm is $ 4.2 million. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 2A is $5.3 million and Alternative 2B is $14.4 million. An estimate of costs can be found in Appendix G.

6.2.3 Alternative 3: Main Drain A Detention

Before entering the City of San Benito, Main Drain A must pass through a significant constriction at the crossing of FM 732 and the Resaca Del Rancho Viejo. The Resaca banks are significantly elevated above the surrounding land, and there are currently two 72-inch reinforced concrete pipes at this crossing. Limited conveyance capacity in this location results in overbank flooding as well as significant system storage. Alternative 3 was an attempt to quantify the effect of increasing storage in this location by further restricting the crossing at FM 732. One of the two 72-inch RCPs was removed from the hydraulic model and the roadway was raised by three feet. This greatly increased the water surface elevation south of the Resaca Del Rancho Viejo and added significant storage to the system. This did have the desired benefit of reducing peak discharges downstream of this location, but there were too many practical difficulties associated with this alternative for additional investigation. The ultimate extent of flooding was difficult to determine as the floodplain is not simply contained to the south of this location. The construction of a traditional detention basin at this location is impractical. The specific area impacted would need to be determined to assess right-of-way requirements for a detailed cost estimate. As such, neither a cost estimate nor benefit assessment were prepared for this alternative. A conceptual location map of Alternative 3 is found in Appendix A as Exhibit 11.

6.2.4 Alternative 4: La Paloma Diversion

This alternative would consist of a diversion channel from Main Drain A to the Rio Grande in the La Paloma area. This alternative would divert approximately 18 square miles of area to the Rio Grande, in addition to the 10 square miles diverted in Alternative 1. The diversion channel would be approximately 3.8 miles long.

La Paloma is located in the vicinity of the junction of US Highway 281 and FM 732, roughly five miles southwest of San Benito. La Paloma is located in a relatively low area between the levees on the banks of the Rio Grande and the Resaca Del Rancho Viejo. This area is currently connected to Main Drain A, but is a sump located at a lower elevation than Drain A. This area is not currently within Drainage District 3 due to the fact that Main Drain A does not provide positive drainage for this area. A diversion at this location from Main Drain A to the Rio Grande could not only provide relief to Main Drain A and San Benito, but also greatly improve the drainage in the La Paloma area. This could also lead to the annexation of this area into the Drainage District, possibly producing revenue to offset future maintenance needs.

The historic drainage path for this area was to the Gulf of Mexico via the Resaca Del Rancho Viejo. Repurposing the resaca for irrigation water storage removed this flow path and the current drainage ditch (Main Drain A) was cut to the Arroyo Colorado in its place. The Drainage District still owns drainage easements in this area that could be used for part of the proposed diversion. In addition, the Las Palomas Wildlife Management Area is located in this vicinity, and this alternative would provide the opportunity to divert additional flows to this area for habitat enhancement as desired by the US Fish and Wildlife Service. A location map of Alternative 4 is found in Appendix A as Exhibit 12.

It is difficult to calculate benefits for this alternative as the flooding damages in the La Paloma area are not comprehensively calculated in the existing condition. Benefits are calculated based upon the differences in riverine flooding between the existing condition and with the alternative in place. This area floods as a result of insufficient local drainage and is outside the limits of the Main Drain A floodplain calculated in the existing condition. The benefit shown is calculated as the difference of inundation along the Main Drain A alignment only. It is expected that providing positive drainage to the existing development in the La Paloma area would have significant positive benefit that can not be quantified with the current analysis procedure. The estimated benefit of Alternative 4 during the 25-year storm is $3.2 million and during the 100-year storm is $ 2.6 million. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 4 is $5.1 million. An estimate of costs can be found in Appendix G.

6.2.5 Alternative 5: Drain C-Right Culvert Improvements

Drain C-Right currently passes through a single 54-inch reinforced concrete pipe (RCP) between the railroad tracks and Business 77, adjacent to Helen Moore Road. This pipe extends roughly one third of a mile and has a 2-year capacity. This alternative attempts to increase the capacity of this reach to a 25-year level. Due to proximity of existing structures, it did not appear to convert this reach to an open channel. Therefore, it is recommended that additional culverts be added to increase the capacity. This alternative would consist of the addition of three 72-inch RCPs for a total length of 1,660 feet. A location map of Alternative 5 is found in Appendix A as Exhibit 13.

The estimated benefit of Alternative 5 during the 25-year storm is $610,000 and during the 100-year storm is $ 410,000. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 5 is $4.7 million. An estimate of costs can be found in Appendix G.

6.2.6 Alternative 6: Drain D Channel Improvements

Drain D generally parallels an elevated irrigation canal for the majority of the study reach. This canal is located southeast of the drain ditch; as a result, the flooding found in this area is generally on the northwest side of the drain. This alternative involved increasing the channel size, without improving the existing roadway crossings, to achieve a 25-year level of service. The proposed channel would have a 12 foot bottom-width and side-slopes of 1.5 to 1. It is likely that a concrete transition would be needed at each roadway crossing. A location map of Alternative 6 is found in Appendix A as Exhibit 14.

The estimated benefit of Alternative 6 during the 25-year storm is $1.3 million and during the 100-year storm is $ 840,000. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 6 is $2.2 million. An estimate of costs can be found in Appendix G.

6.2.7 Alternative 7: Drain F-23 Culvert Improvements

The primary flooding problems on Drain F-23 appear to be caused by undersized culverts at Williams Road (FM 1846) and Irene Street. The existing 48-inch RCP at Williams Road and the 36-inch RCP at Irene Street would each be replaced by a single 6-foot by 6-foot reinforced concrete box. This modification would generally give this drain a 25-year level of service. A location map of Alternative 7 is found in Appendix A as Exhibit 15.

Due to limited existing development in the vicinity of Drain F-23, only negligible benefits were calculated in this location. The largest benefit would be allowing future development in these areas. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 7 is $140,000. An estimate of costs can be found in Appendix G.

6.2.8 Combination Alternative: Alternatives 1, 2 and 4

The Combination Alternative would consist of Alternatives 1, 2 and 4. This alternative offers the best possible diversions of flows upstream of San Benito as well as maximizing conveyance along Main Drain A through San Benito. Alternatives 1 and 4 would be constructed as described above. Alternative 2 would be further modified to limit modifications to existing structures. It was assumed that it would be difficult and costly to extend/replace the bridges at the railroad tracks (under US Highway 77) and Business 77; therefore, the channel bottom width was limited to the available openings at existing structures. The channel in the reach from the railroad tracks to Iowa Gardens Road would be increased to a 30-foot bottom width and lined with concrete slope paving to maximize capacity. This could generally be constructed leaving the existing bridges in place. Downstream of Iowa Gardens Road, the channel would be increased to a 50 foot bottom-width earthen channel. This would require enlarging the bridge at FM 510. Further investigation into the bridge at CR 596 revealed that this may not be a county-owned facility. As such, it is proposed that with no apparent owner available to cost-share improvements, this crossing simply be removed. Concrete channel lining would be much more cost effective than bridge replacements or extensions, with similar impacts on channel conveyance.

The estimated benefit of Alternative 5 during the 25-year storm is $6.7 million and during the 100-year storm is $ 7.9 million. Calculations supporting the estimated benefit can be found in Appendix H.

The estimated cost of Alternative 5 is $12.2 million. An estimate of costs can be found in Appendix G.

6.3 NON-STRUCTURAL FLOOD PROTECTION MEASURES

Along with the channel improvements, culvert upgrades, and detention pond construction alternatives discussed above, the District 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 District'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

CCDD3 should consider installing a network of automated rainfall and streamflow gages along the District's drainage ditches. The streamflow gages will tie into the existing telemetry system that collects rainfall gage data. This data can be made public through a web interface. Data collected from the rainfall and streamflow gages may be used to monitor flooding conditions in a flood-alert system. This information serves two purposes. First, it brings critical information to the District about potential problems, and allows the District 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 District to continually refine 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 Los Indios, City of San Benito, Cameron County and other Districts 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. 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 District-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. CCDD3 would need to work through an NFIP-community sponsor to utilize these funds, since the District is not an NFIP community in and of itself.

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 ad valorem base. This may be an appealing mechanism for smaller, high growth communities inside the district's service area. Care should be taken to differentiate those capital projects which are funded through the District's ad valorem levy from those which are necessitated by and attributable to new growth.

7.0 COST BENEFIT ANALYSIS

The viability of alternatives is primarily measured through a comparison of the relative costs and benefits, and 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.

7.1 METHODOLOGY

The NPV Analysis applies only to the structural alternatives described herein; the benefits of non-structural solutions are 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 amount 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 COST ANALYSIS

The estimated costs for each alternative include materials and construction costs, which are based on recent bid tabulations and unit prices for similar regional construction projects, as well as soft costs, assumed to be as follows:

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

In addition to recent bid tabulations for CCDD3 and CCDD5 projects, bid tabulations from the Texas Department of Transportation (Pharr District) were evaluated to determine the most appropriate unit prices for construction items. A summary of costs for each of the structural alternatives is provided in Appendix G.

7.3 BENEFIT ANALYSIS

The benefit of the 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 the 25-year and 100-year events. The 25-year event was selected as this is the desired level of service that the District would like to achieve with their drainage system. The 100-year event is also analyzed, as this is the primary return interval used by the NFIP.

7.3.1 HAZUS Methodology

To estimate the risk associated with a given magnitude flood event, HAZUS-MH 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 District'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. Relative benefit is calculated for the 4% (25-year) and 1% (100-year) annual chance 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 4% annual chance and 1% annual chance benefits for each alternative.

7.3.2 Estimated Annual Damages

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. In addition to the 4% and 1% annual chance benefits, a 10% event set of HAZUS results were calculated for both the existing condition and with the improvement in-place. This additional result describes an additional facet to the benefit assessment – the importance of improved levels of service in more frequent events. Thus, 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. Figure 8 shows how annual damages are estimated for the Combination Alternative.

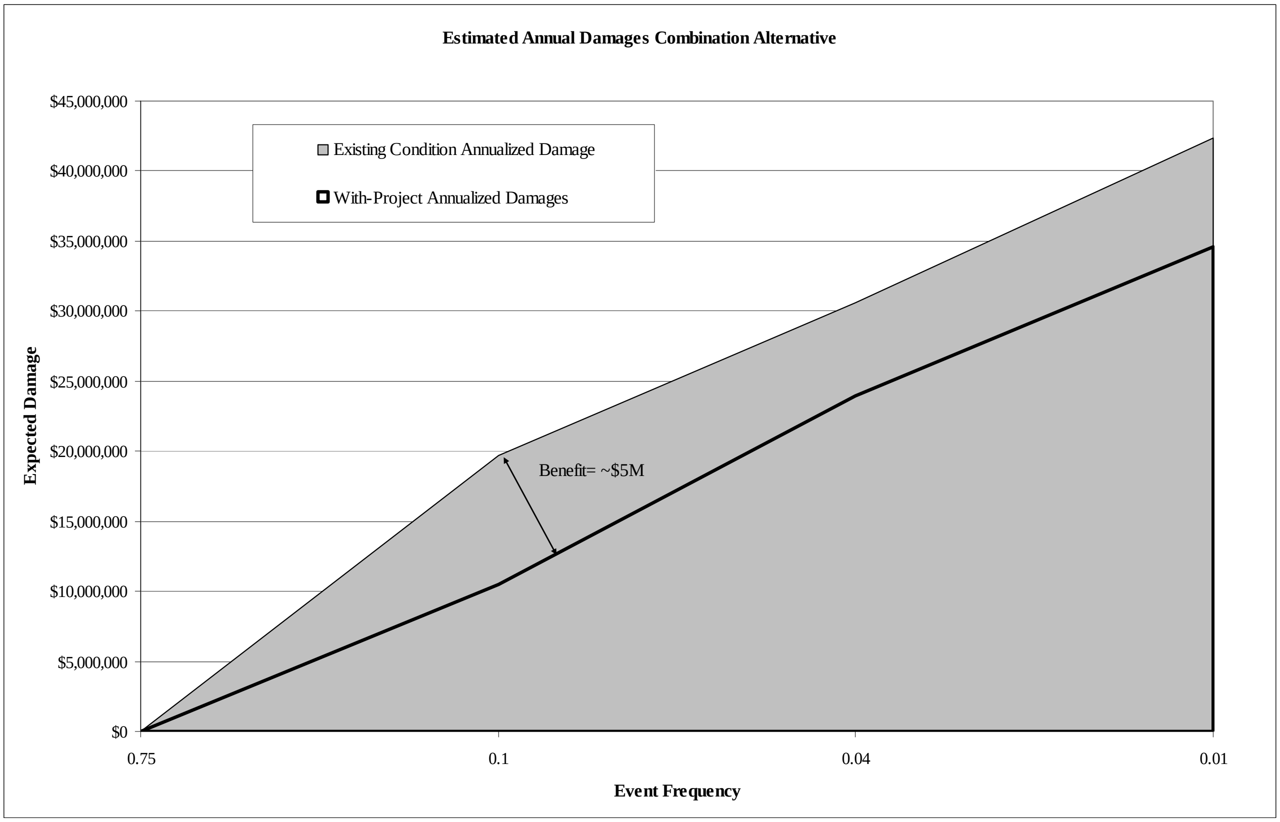

Figure 8: Derivation of Annualized Damage for Combination Alternative

7.3.3 Net Present Value Analysis

Assuming a multi-year implementation of the project and annualized benefits as calculated above, the Combination Alternative is a viable project assuming a discount rate of 5%.

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 CCDD3 and its partners in floodplain management must take in order to address the flood hazard present along the District's network. In short these goals are as follows:

Goal 1: Proactively address flood problem areas with targeted improvements that consider the entire District's service area
Goal 2: Ensure that new development does not adversely affect property downstream
Goal 3: Upstream of the District's ditch network, local development should ensure positive drainage to the District's network; the District should ensure the lowest possible tailwater conditions to facilitate local drainage
Goal 4: Protect and enhance available storage in the system
Goal 5: Actively inform the community of the risk of flooding
Goal 6: Aggressively pursue a regional approach to curb illegal dumping
Goal 7: Update and refine the Flood Protection Plan 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 District's service area**. The engineering analysis has identified several structural improvement options that can provide immediate benefit to the District. The following actions can be taken towards implementing this goal:

- <u>Action 1.1</u> – Complete construction of Phases II and III of Alternative 1, Los Indios Diversion.
- <u>Action 1.2</u> – Begin design, right-of-way acquisition, permitting and construction of the La Paloma Diversion (Alternative 4).
- <u>Action 1.3</u> – Begin design, right-of-way acquisition, permitting and construction on the Drain 'D' Channel Improvements (Alternative 6).
- <u>Action 1.4</u> – Begin design, right-of-way acquisition, permitting and construction on the Drain 'A' Channel Improvements (Alternative 2).
- <u>Action 1.5</u> – Begin design, right-of-way acquisition, permitting and construction on the Drain F-23 Culvert Improvements (Alternative 7).
- <u>Action 1.6</u> - Begin design, right-of-way acquisition, permitting and construction on the Drain C-Right Culvert Improvements (Alternative 5).

<u>Goal 2</u>: **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 District. The following actions can be taken towards implementing this goal:

- <u>Action 2.1</u> – Evaluate the feasibility of requiring on-site detention for at least the 10% annual chance event to mitigate the impacts of development.
- <u>Action 2.2</u> – Coordinate with local government partners such as Cameron County, the City of San Benito, the City of Harlingen, and the City of Los Indios to establish common standards and hydrologic and hydraulic methods and assumptions.

<u>Goal 3</u>: **Upstream of the District's ditch network, local development should ensure positive drainage to the District's network; the District should ensure the lowest possible tailwater conditions to facilitate local drainage**. Many nuisance drainage problems can be alleviated if good, positive drainage exists. For CCDD3's part, measures to reduce any tailwater in the ditches will further this goal:

- <u>Action 3.1</u> – Implementation of the Combination Alternative will bring the most reduction of tailwater to Drain A, and therefore to the B-Drains.
- <u>Action 3.2</u> – Publish the benchmark system established during the course of this study; this will bring greater efficiency to the design process for the District, its local partners, and private development.

<u>Goal 4</u>: **Protect and enhance available storage in the system**. Valley storage in the ditch network is a critical resource from a hydraulic perspective.

- <u>Action 4.1</u> – 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.
- <u>Action 4.2</u> – Acquire sufficient right-of-way to introduce a bench channel section in implementing Alternative 2.

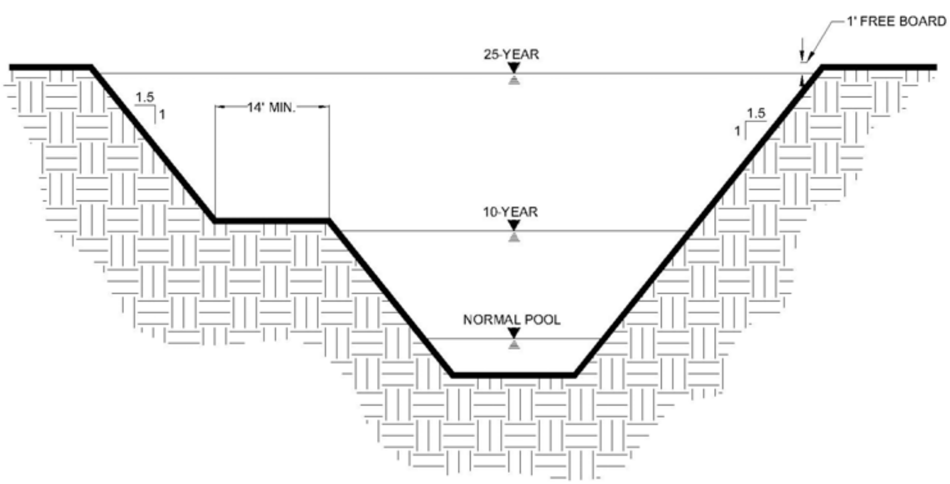

Figure 9. Example of a Bench Channel Section

Goal 5: Actively inform the community of the risk of flooding. It is important for the District to actively inform the community about the nature of flood risk, and the limits of what the District can do to mitigate that risk. The following actions can be taken towards implementing this goal:

- Action 5.1 – The District's ability to provide higher levels of flood protection are limited by regional topography, available right-of-way, and existing encroachment into the floodplain. While especially true for large events (100-year and 25-year), the improvements contemplated by the District will have significant effect on smaller events (2-year through 25-year). The current level of risk for larger events should be made freely available through dissemination of floodplain maps, both paper and digital.
- Action 5.2 – 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 CCDD3 activities.
- Action 5.3 – Identify neighborhood leaders in flood-prone neighborhoods and develop a specific outreach campaign with their guidance.
- Action 5.4 – Work with private industry and other stakeholders to develop and implement a program to distribute NOAA All Hazards Weather Radios to the public.
- Action 5.5 – Working with other authorities, develop a specific plat note requirement to explain the limitations of flood protection in the Lower Rio Grande Valley.
- Action 5.6 – Coordinate and participate in public awareness activities about the National Flood Insurance Program through the Regional NFIP Coordinator (956-421-3214).

Goal 6: Aggressively pursue a regional approach to curb illegal dumping. This is probably the most preventable cause of flooding, but will require a coordinated effort with other entities, and a multi-pronged approach. The following actions can be taken towards implementing this goal:

- Action 6.1 – Recognizing that the illegal dumping problem is a regional issue, work with the Lower Rio Grande Valley Development Council to find the best long-term solutions.
- Action 6.2 – Pursue grant funded opportunities through TCEQ and LRGVDC to host "clean-up" activities.
- Action 6.3 – Develop a public awareness program using signs at access points to CCDD3 ditches. Slogans and posters in two languages could be developed by working with area middle schools (school-wide competition, for example). Examples of such slogans: "You dump, we have to pump" and "Basura tirada, casa inundada"
- Action 6.4 – Install gates at access points
- Action 6.5 – Reach out to neighborhood leaders to explain the issue and risks, and solicit their input on ways to curb the problem and raise awareness.

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

- Action 7.1 – Begin the installation of telemetry-based gages 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.

Goal 8: **Support San Benito's efforts to develop a local system Master Drainage Plan**. Many of the drainage issues facing San Benito are localized legacy problems and will take many years to correct. Following are a series of actions that can be undertaken by San Benito to begin to correct these problems. Where noted, the District can offer a significant supporting role.

- Action 8.1 – The District should make the information contained within this study freely available to the City of San Benito and the development community. For instance, post-processed LiDAR data and the hydraulic models bring significant value to new and redevelopment projects under consideration.
- Action 8.2 – Initiate a program to map stormwater outfalls and infrastructure (inlets, culverts, flumes, pipes, etc.). This effort can also be the foundation of a TPDES MS4 Compliance Plan.[1]
- Action 8.3 – Form a Citizens Advisory Committee for Drainage. The purpose of this committee would be to prioritize local drainage problems in the City, working with the City's Public Works Department as the lead entity in connection with Action 8.4 below.
- Action 8.4 – Seek EPA and CDBG funds to assist in the development of a Master Drainage Plan. The purpose of the Plan would be to develop a complete hydraulic model of the City's local drainage system that would enable the formulation of alternatives and provide the technical guidance for capital project implementation.

8.2 PRIORITIZATION, IMPLEMENTATION AND PHASING

Each alternative that was studied offers specific benefits and costs, as well as specific policy implications. However, there are generally many other factors which should be considered in prioritizing and selecting various alternatives beyond the benefit-cost ratio. The process of how the alternatives were scored and ranked, how the various factors were weighted, and how the Action Plan is to be implemented is described in the following sections.

Table 20: Prioritization Ranking Factors

Benefits existing ratepayers
Keeps water off of critical public facilities (Hospital, fire station, etc.)
Shortens flood duration
Potential for leveraged funds
Damage Reduction (Relative dollar benefit)
Maximizes Conveyance
Benefits future development
Provides at least a 25-year level of protection
Low O&M Costs
Enchances water quality
Promote Orderly Development or Improve Economic dev./redev. Potential
Can be implemented independent of other projects
Permitting resistance or difficulty
Time to implement / construct
Environmental or habitat enchancement
Potential for Recreational use

[1] http://www.tceq.state.tx.us/permitting/water_quality/stormwater/storm-water-navigation/ms4.html

8.2.1 Prioritization Factors

The alternatives ranking is accomplished through a scoring of each potential project in each of sixteen prioritization factors. The prioritization factors are weighted to offer higher possible point totals for factors which are more important to the District and its objectives. To determine how much weight each factor should possess, the Advisory Committee performed an exercise in which they were individually asked to weight the sixteen factors based on a defined budget. This was accomplished in a simulated board game which asked the players to place different value chips on the play table according to their preference for the best value spent on flood protection. The aggregate result of these individual gameboards determined the prioritization factors of highest importance to CCDD3. The prioritization factors, in order of the Advisory Committee Preference, are listed in Table 20. Based on the aggregate score, the factors were grouped into five groups and received weights from one to five. The steps of this methodology are included in Appendix J, Ranking & Prioritization.

Each alternative was then evaluated with respect to each prioritization factor and given a score of one, two, or three, depending on the degree to which the alternative met the priority. Appendix J summarizes the scoring for each alternative. A maximum of 141 points is possible.

Based on the scoring exercise, the top priority project for the District to complete is the Combination Alternative. The Detention Alternative (Alternative 3) scores the lowest and is not recommended for implementation. The following section describes the Implementation Plan for the recommended actions.

8.3 IMPLEMENTATION PLAN

The mechanisms for funding of the recommended actions vary and in some instances are specific to the action. The intent of this section is to identify funding sources for each action, as well as strategies to leverage funding mechanisms, and provide an idea of implementation timeline and lead entities for the action. These items are summarized in Appendix K: Implementation Plan.

8.4 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 District to construct a project.

8.4.1 Local Entity Funding Sources

Many of these local funding sources are limited to municipalities, as determined by the State Legislature. The District can cooperatively work with the municipalities in its service area to implement projects which are in part funded by these 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 District 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.

8.4.2 State Funding Assistance Sources

TWDB (Texas Water Development Board)

- <u>Clean Water State Revolving Fund</u> - Provides perpetual funds to provide low interest loan assistance for the planning, design, and construction of stormwater pollution control projects.
- <u>Research and Planning Fund Grants</u> – The purpose is to provide financial assistance for research and feasibility studies into practical solutions to water-related problems.
- <u>State Participation and Storage Acquisition Program</u> – 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.
- <u>Texas Water Development Fund</u> – 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.

8.4.3 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 National Flood Insurance Program (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.

8.5 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.

8.5.1 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 National Flood Insurance Program (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.

8.5.2 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 United States Army Corps of Engineers (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.

8.5.3 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 Corps of Engineers 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.

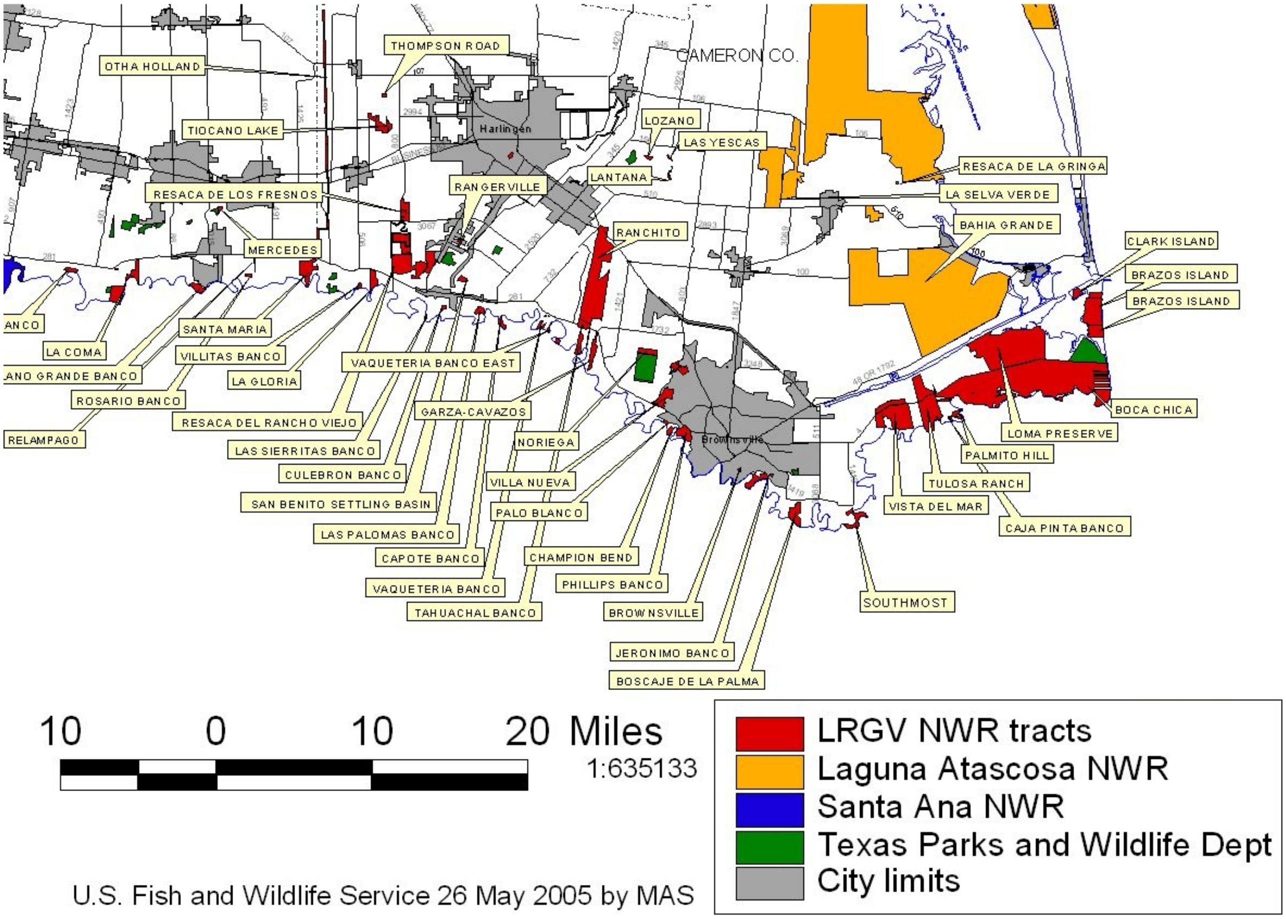

Figure 10: Wildlife Corridor – Lower Rio Grande Valley

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. As water is a critical part of any habitat function, the District's activities and undertakings should consider the USFWS efforts.

8.5.4 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.

8.5.5 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 Corps of Engineers 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.

8.6 ENVIRONMENTAL INVENTORY

The environmental issues of this report have been developed by reference to existing information in published reports, 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.

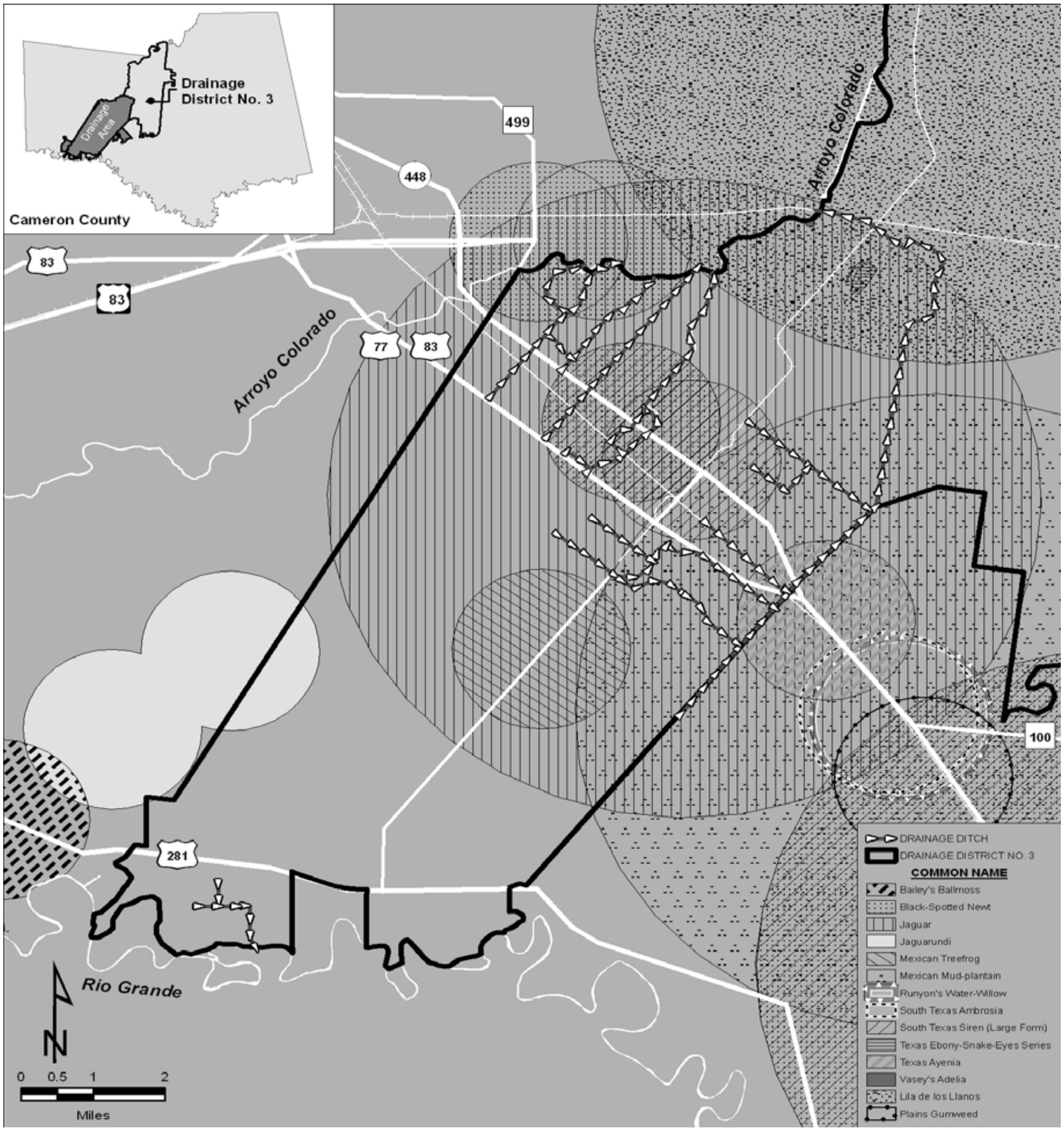

Figure 11: Environmental Inventory Map

There are several endangered and threatened species known to occur in the CCDD#3 planning area. This figure below 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.

9.0 REFERENCES

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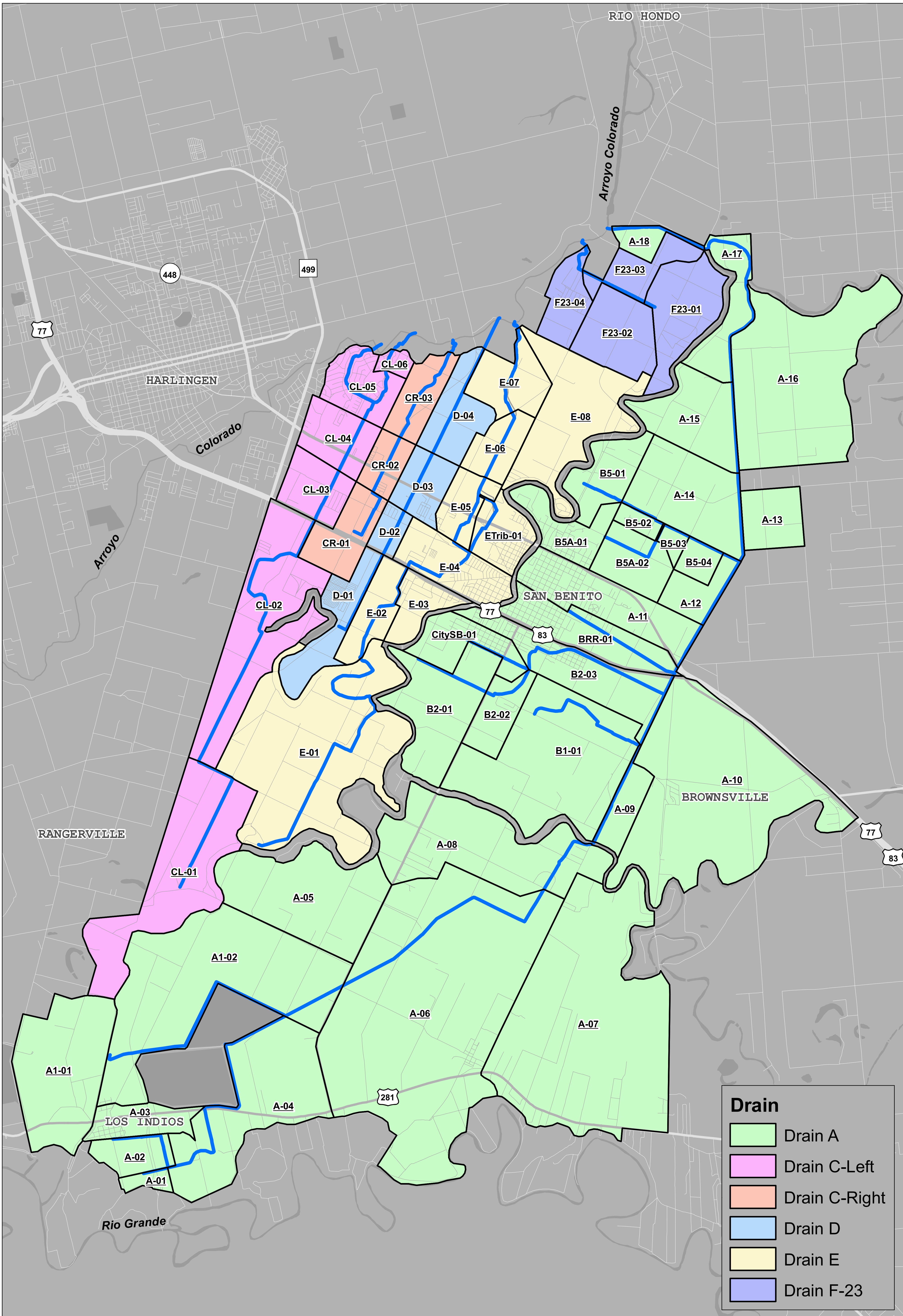
Accessed October 2007

APPENDIX A
EXHIBITS

Exhibit 1 – Drainage Area Map
Exhibit 2 – Soils Map
Exhibit 3 – Existing Land Use Map
Exhibit 4 – Future Land Use Map
Exhibit 5 – Cross-Section Location and Floodplain Map (1)
Exhibit 6 – Cross-Section Location and Floodplain Map (2)
Exhibit 7 – Cross-Section Location and Floodplain Map (3)
Exhibit 8 – Cross-Section Location and Floodplain Map (4)
Exhibit 9 – Alternative 1 Map
Exhibit 10 – Alternative 2 Map
Exhibit 11 – Alternative 3 Map
Exhibit 12 – Alternative 4 Map
Exhibit 13 – Alternative 5 Map
Exhibit 14 – Alternative 6 Map
Exhibit 15 – Alternative 7 Map



Espey Consultants, Inc.
Environmental & Engineering Services

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EXHIBIT 1
DRAINAGE AREA MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008 PROJECT # 7035

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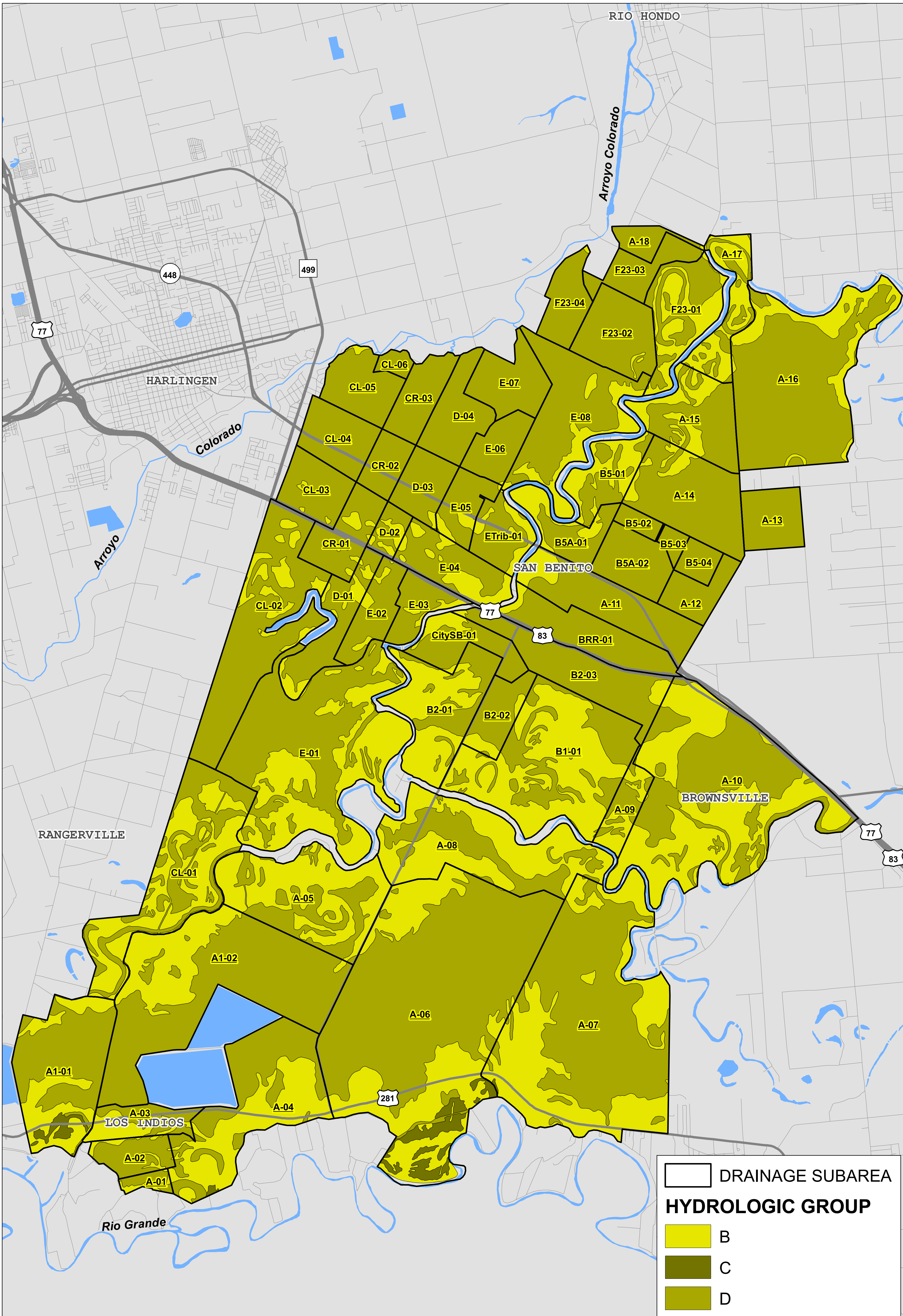

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Environmental & Engineering Services

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EXHIBIT 2
SOILS MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS
SEPTEMBER 2008
PROJECT # 7035

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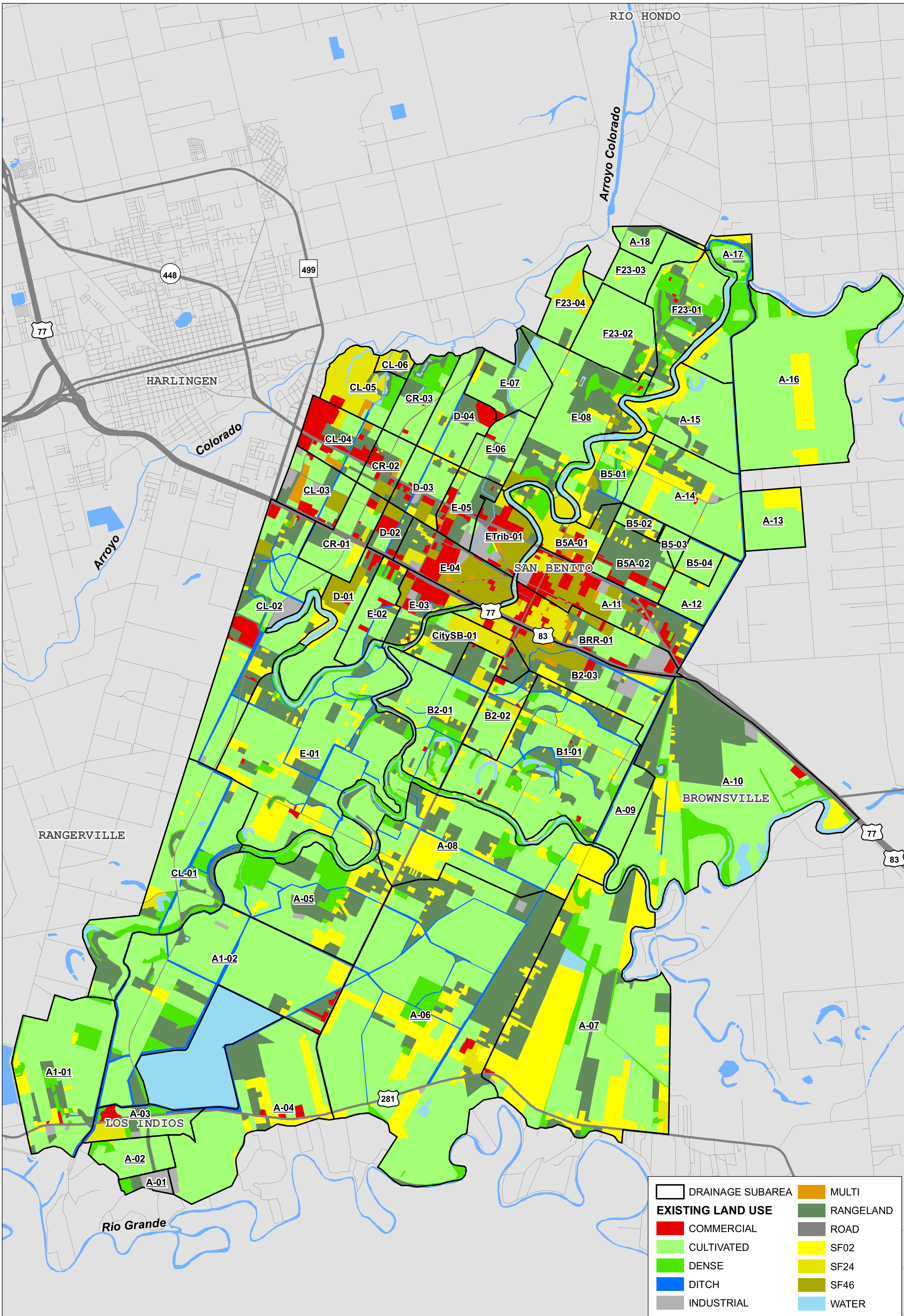

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EXHIBIT 3

EXISTING LAND USE MAP

CAMERON COUNTY DRAINAGE DISTRICT #3

CAMERON COUNTY, TX

SEPTEMBER 2008

PROJECT # 7035

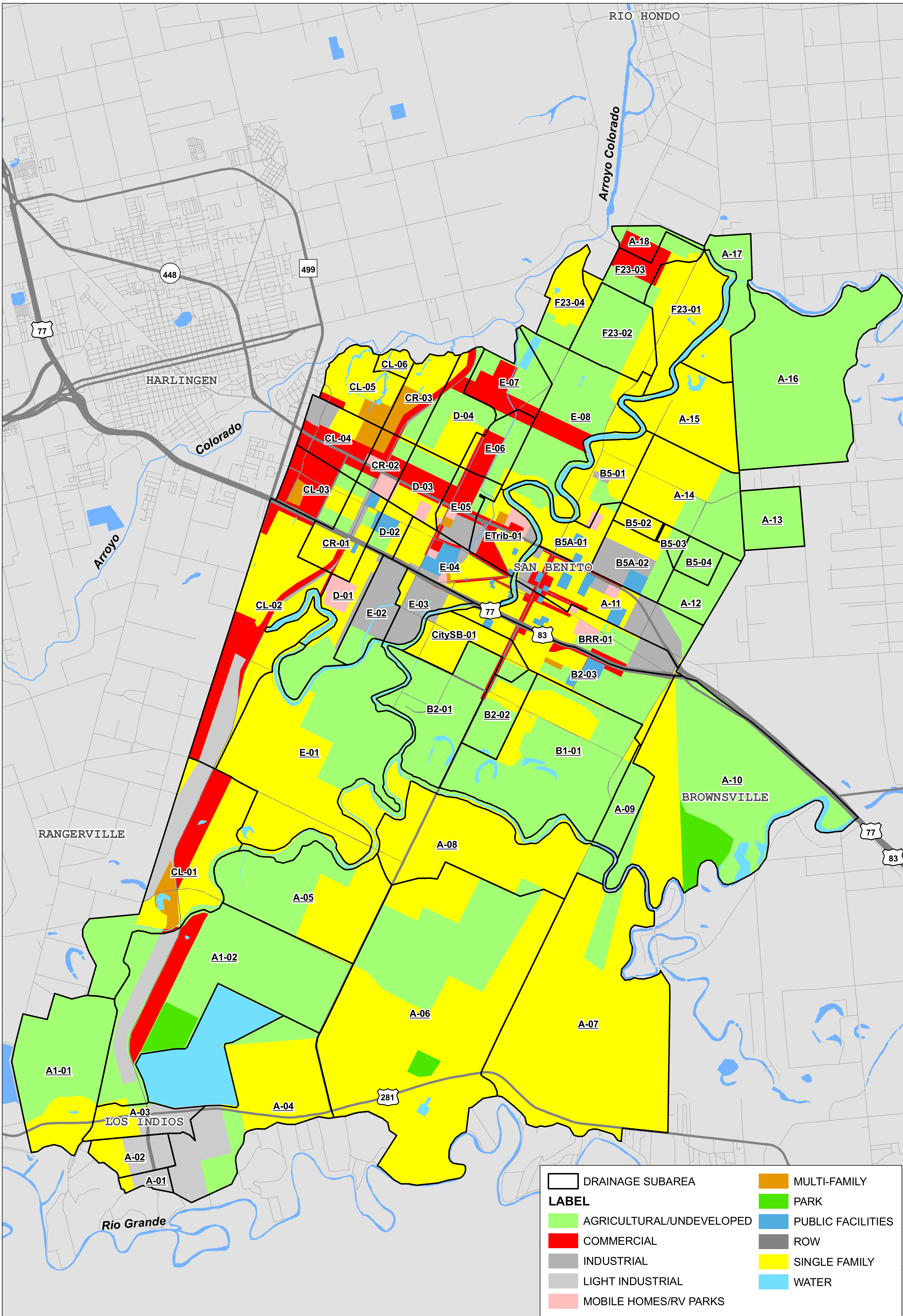

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EXHIBIT 4
FUTURE LAND USE MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

PROJECT # 7035

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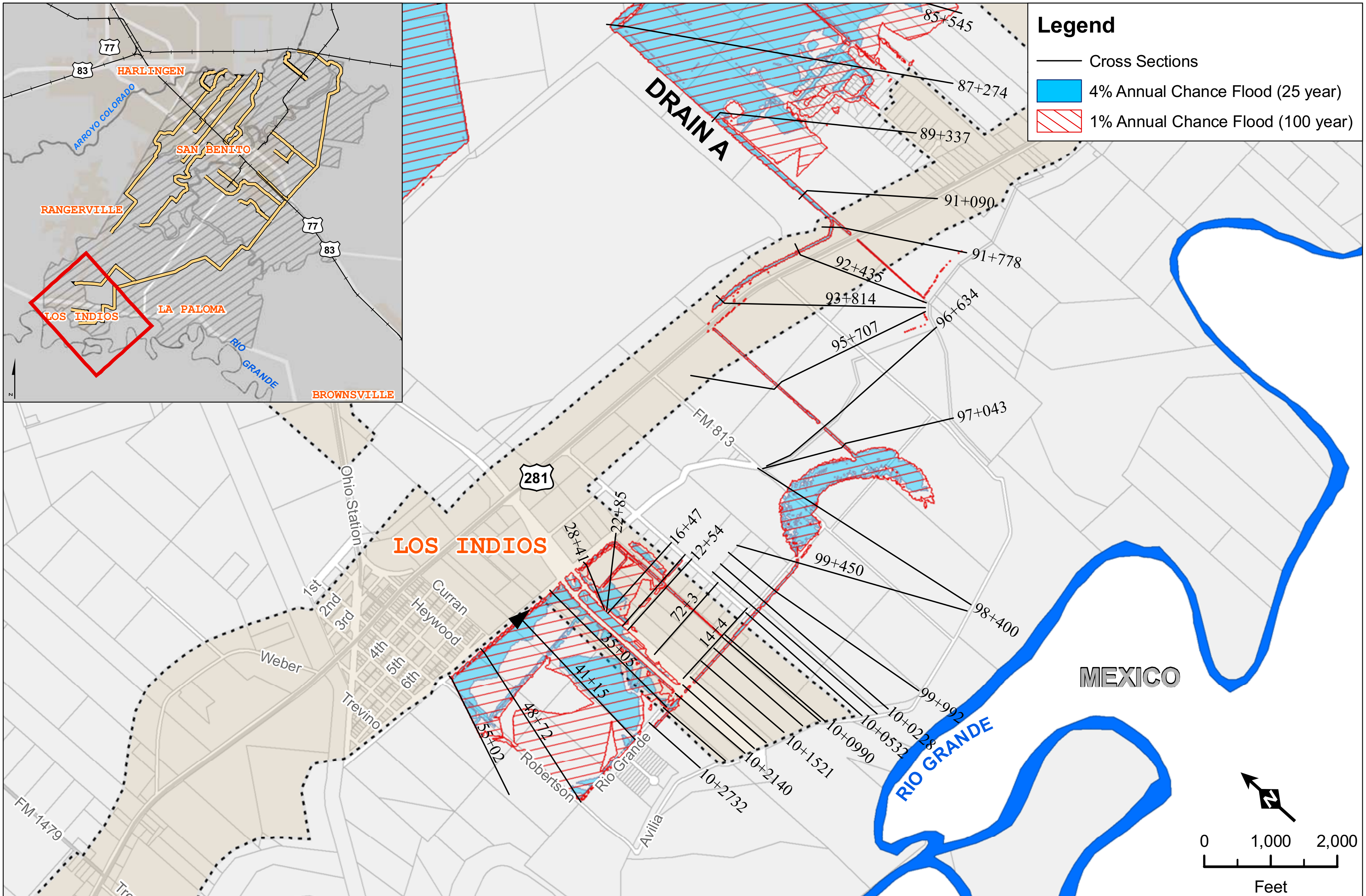

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EXHIBIT 5
Cross-Section Location and Floodplain Map (1)
UPPER MAIN DRAIN A (LOS INDIOS)
CAMERON COUNTY DRAINAGE DISTRICT #3 FPP
September 2008 CAMERON COUNTY, TEXAS Project # 7035.00

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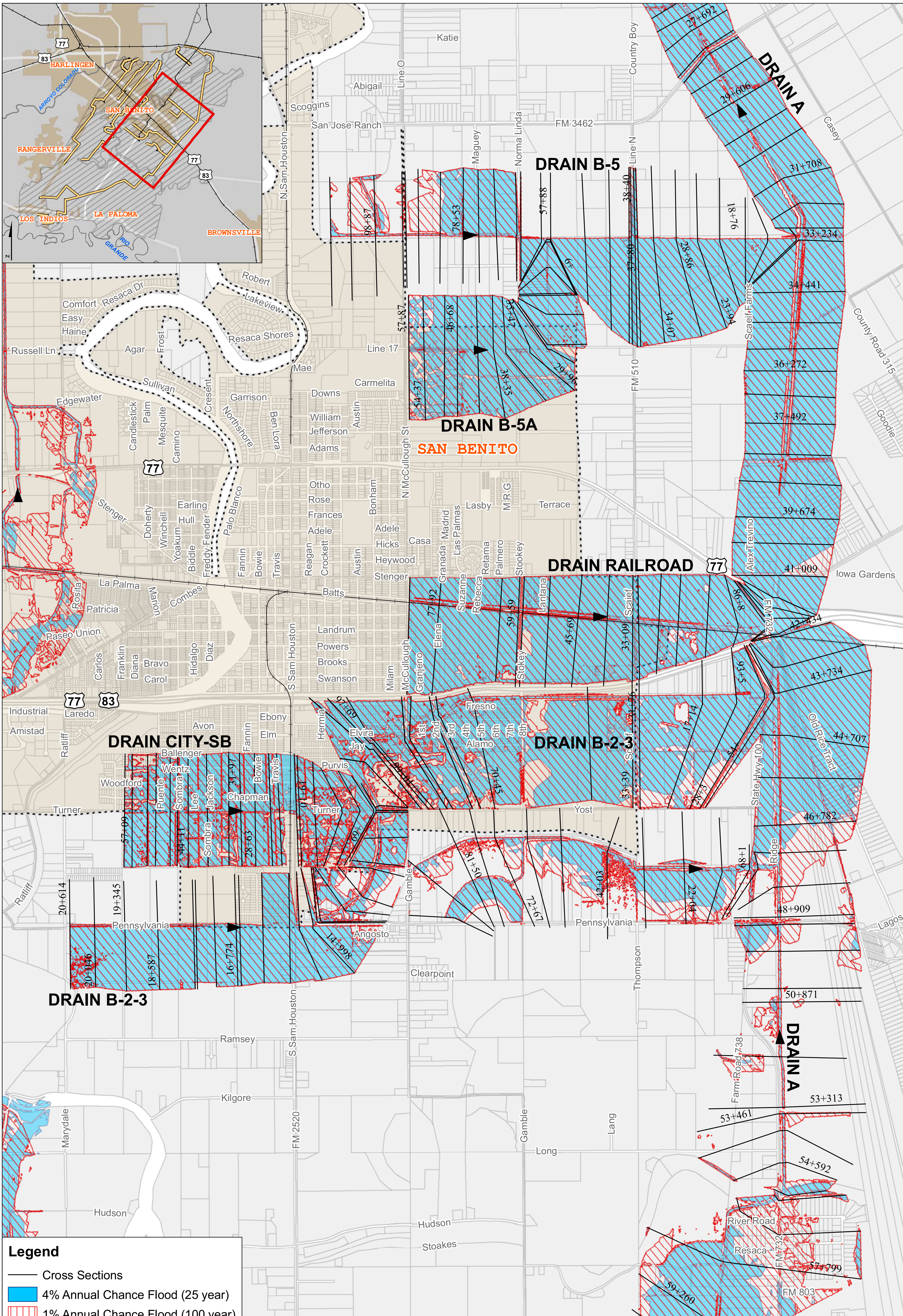

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EXHIBIT 6

Cross-Section Location and Floodplain Map (2)

CENTRAL MAIN DRAIN A (SAN BENITO)

CAMERON COUNTY DRAINAGE DISTRICT #3 FPP

September 2008 CAMERON COUNTY, TEXAS Project # 7035.00

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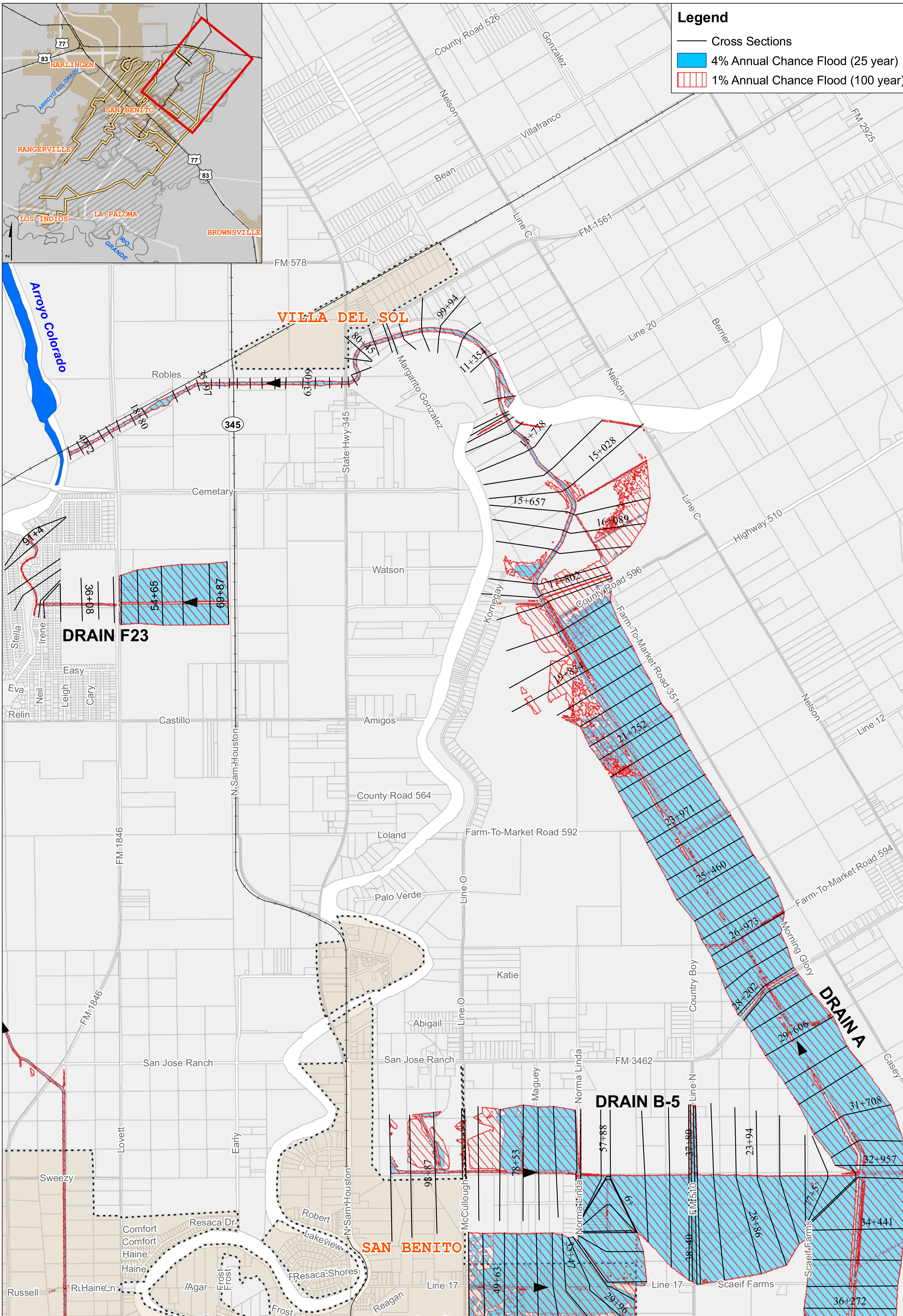

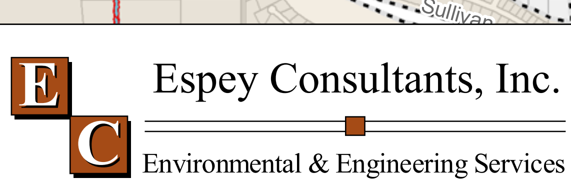

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EXHIBIT 7

Cross-Section Location and Floodplain Map (3)

LOWER MAIN DRAIN A and DRAIN F-23

CAMERON COUNTY DRAINAGE DISTRICT #3 FPP

September 2008 CAMERON COUNTY, TEXAS Project # 7035.00

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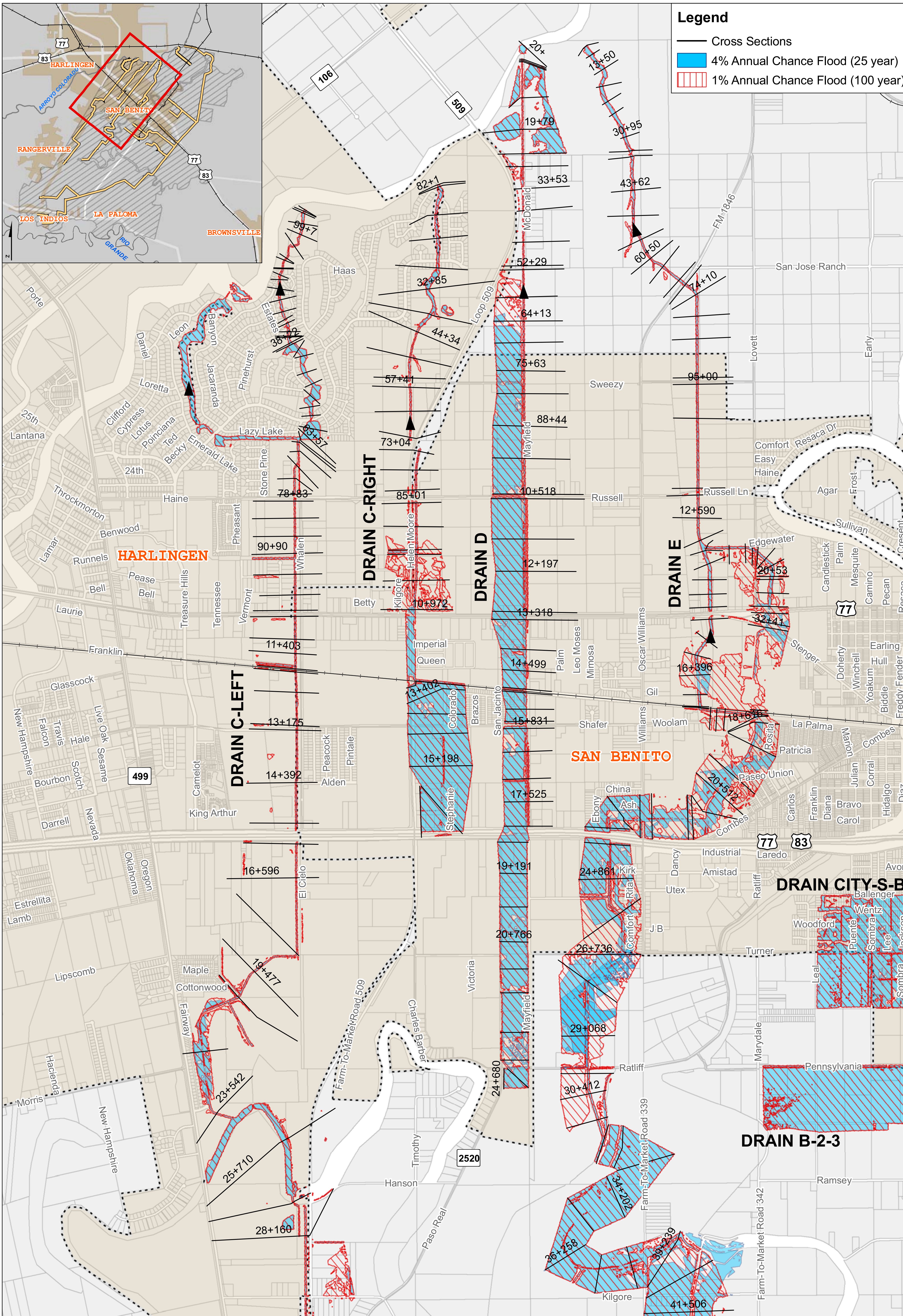

EXHIBIT 8

Cross-Sections Location and Floodplain Map (4)

DRAINS C-LEFT, C-RIGHT, D, & E

CAMERON COUNTY DRAINAGE DISTRICT #3 FPP

CAMERON COUNTY, TEXAS

September 2008

Project # 7035.00

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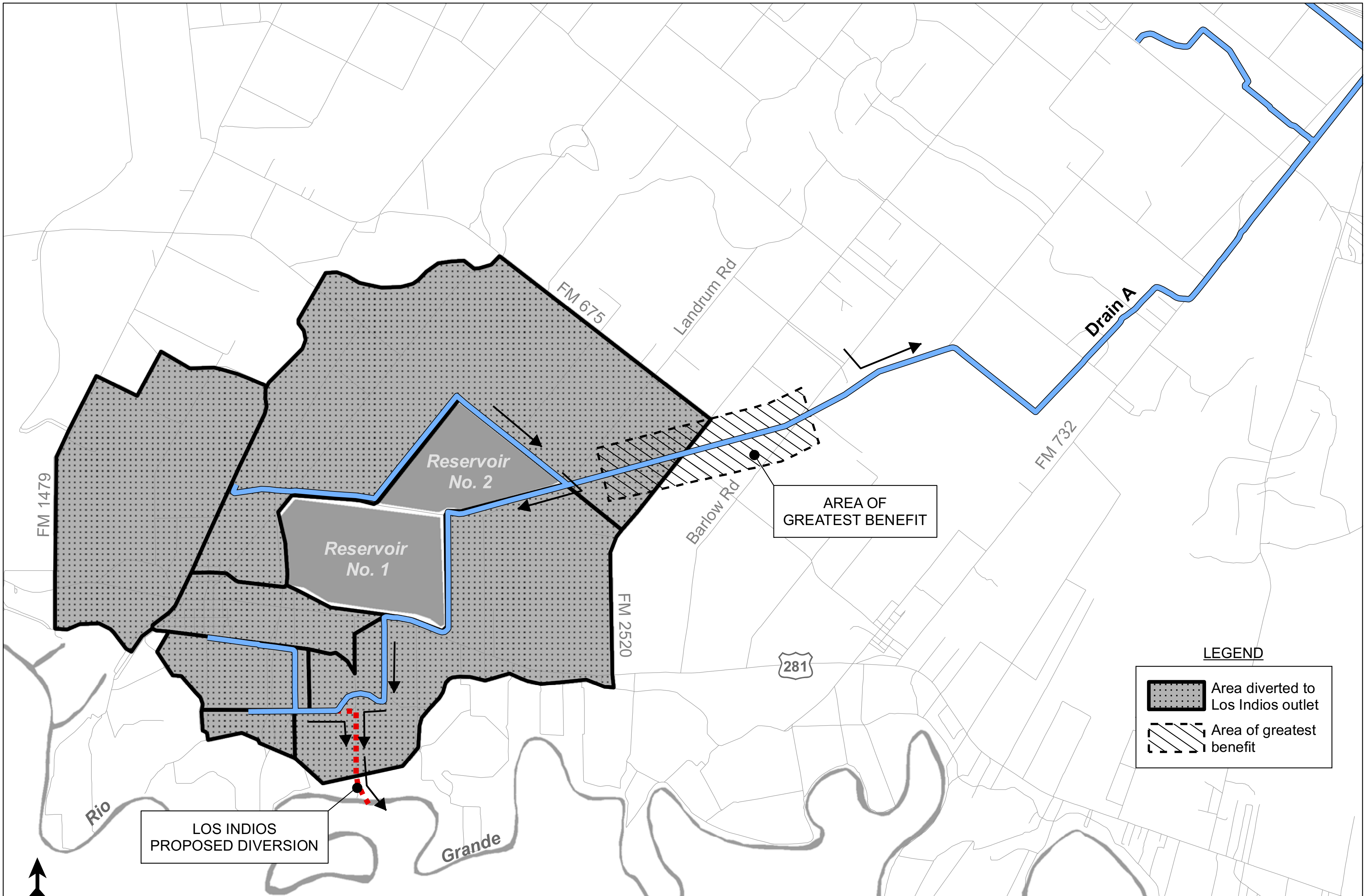

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EXHIBIT 9
ALTERNATIVE 1 MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

PROJECT # 7035

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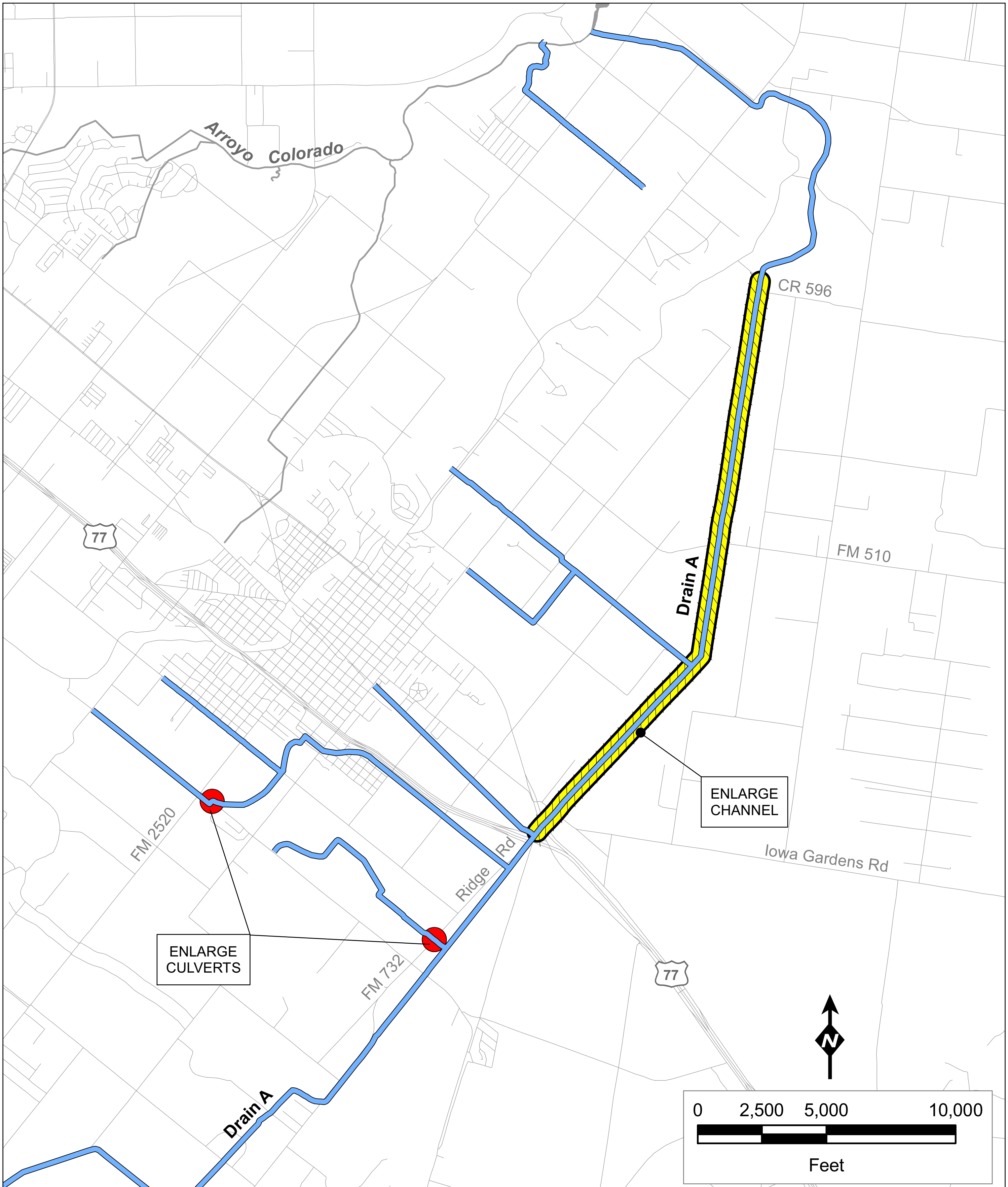

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EXHIBIT 10
ALTERNATIVE 2
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

PROJECT # 7035

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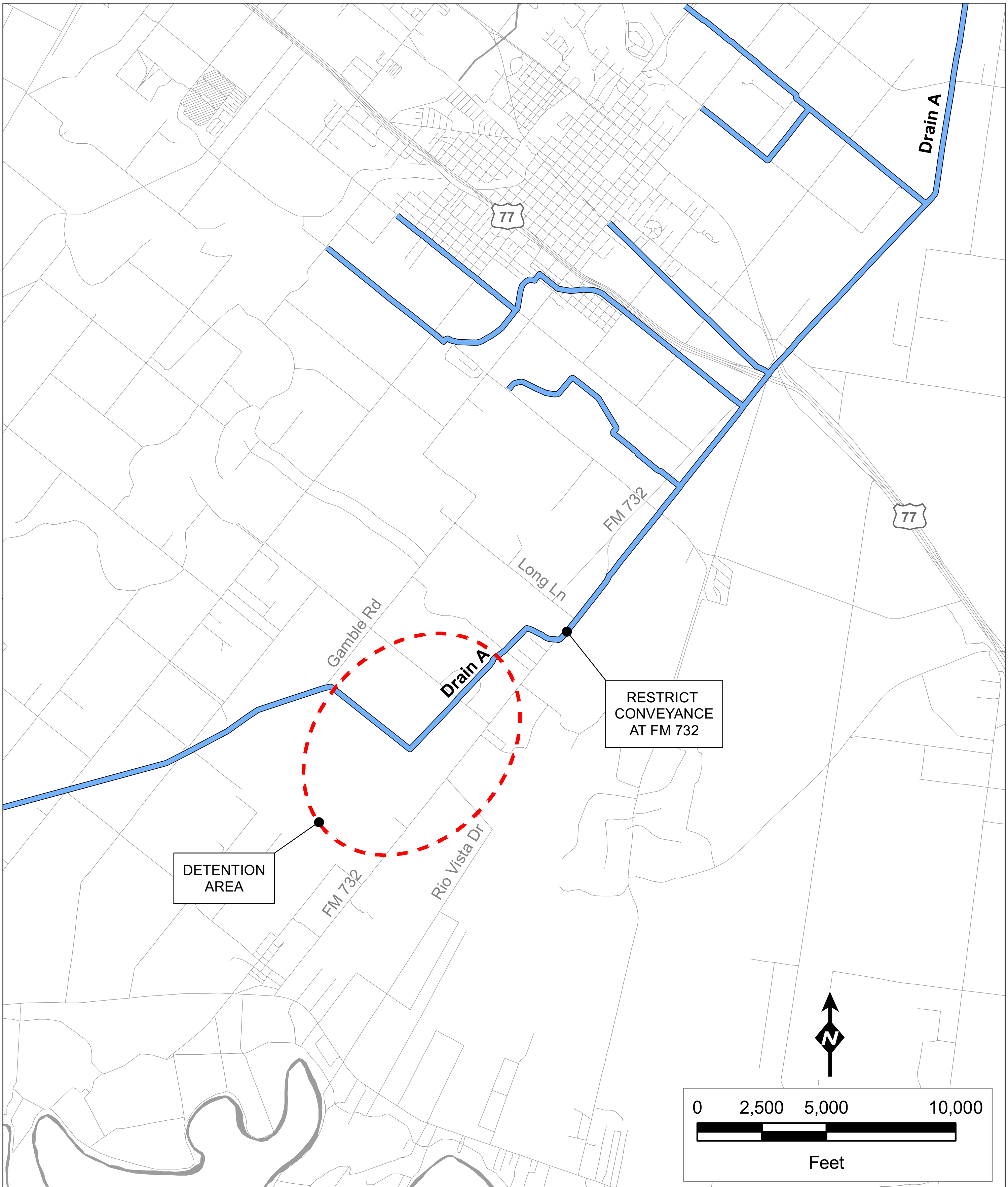

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EXHIBIT 11
ALTERNATIVE 3
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

PROJECT # 7035

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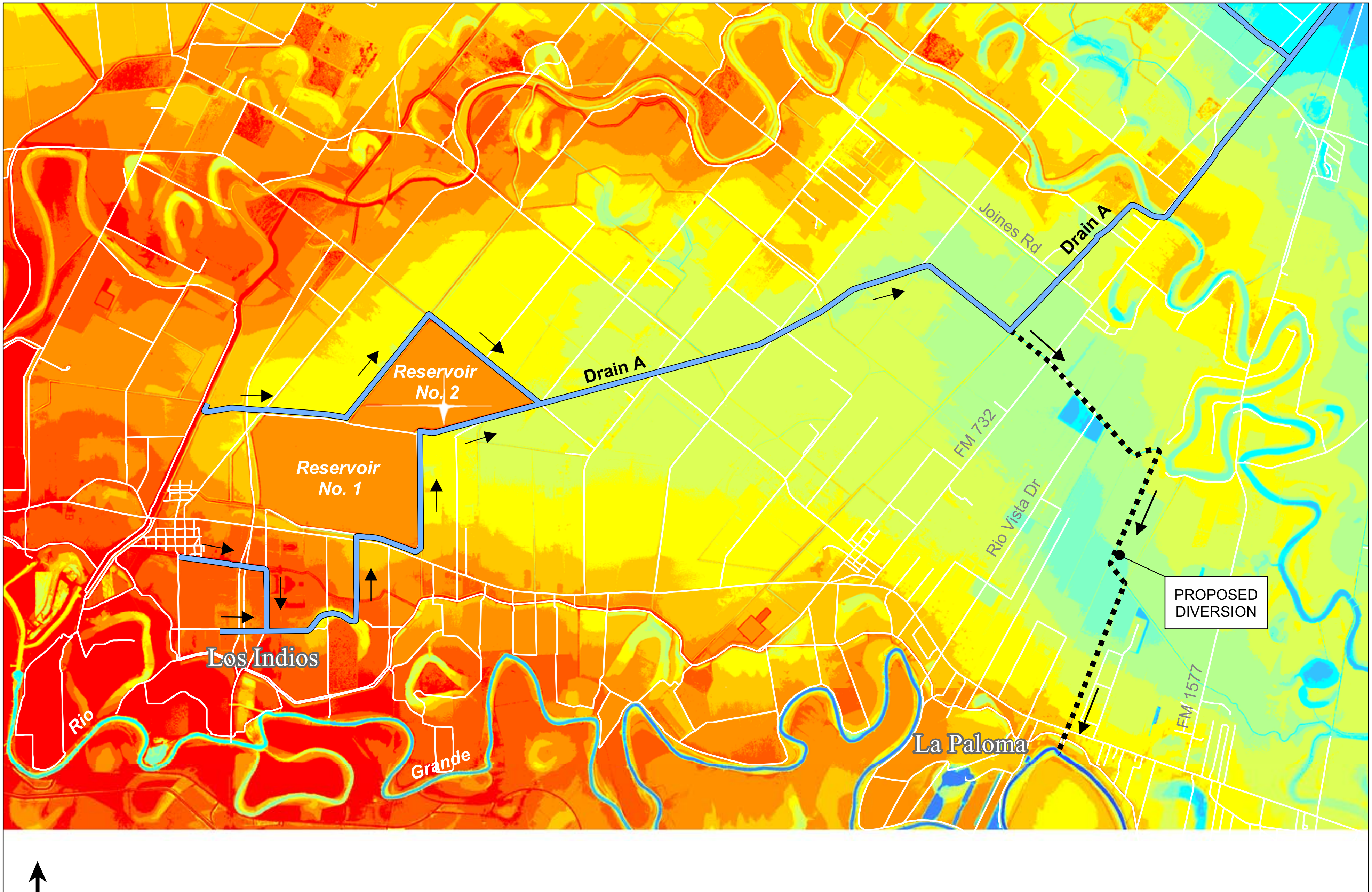

Espey Consultants, Inc.
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EXHIBIT 12
ALTERNATIVE 4 MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

PROJECT # 7035

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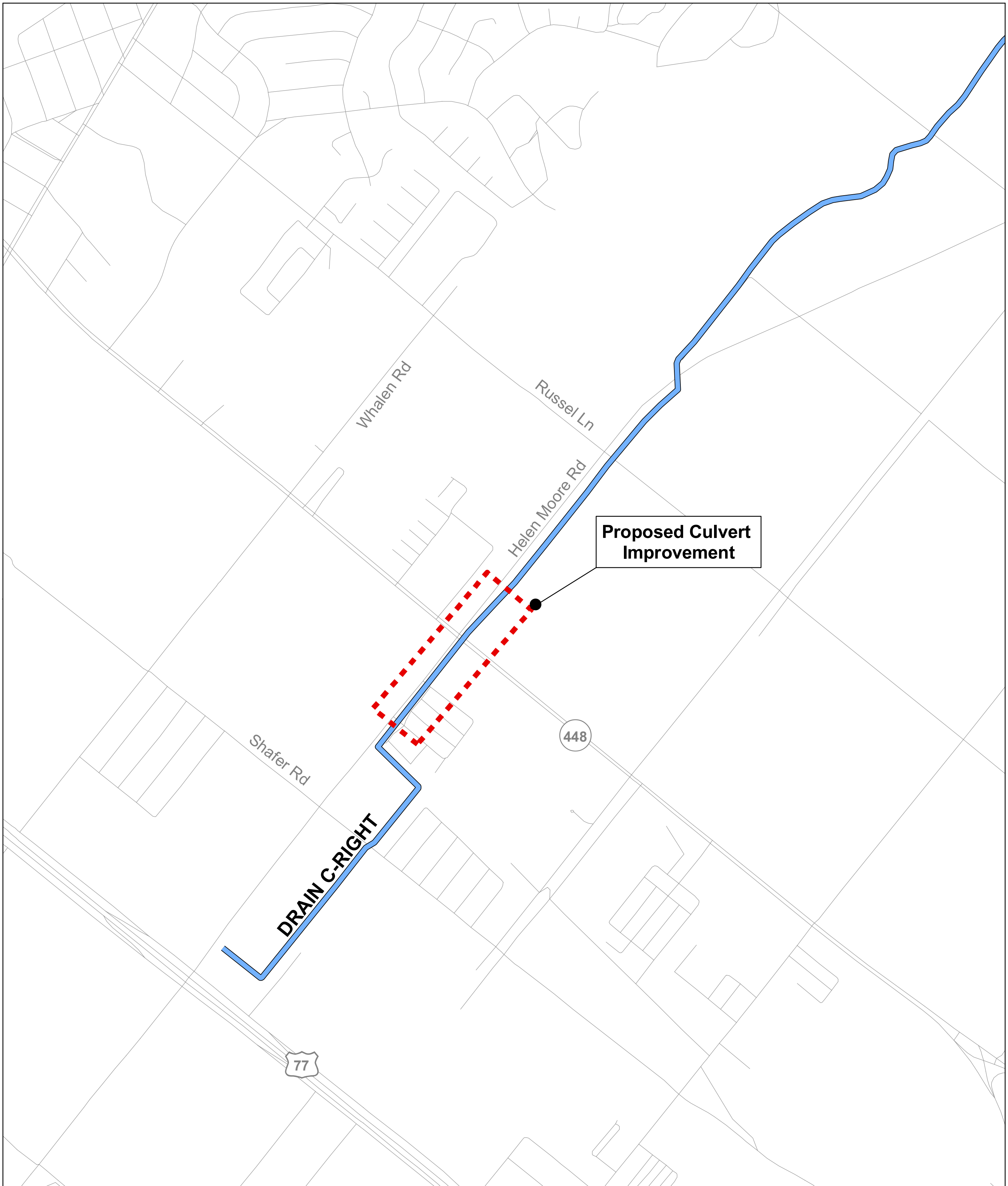

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EXHIBIT 13

ALTERNATIVE 5

CAMERON COUNTY DRAINAGE DISTRICT #3 FPP

CAMERON COUNTY, TEXAS

September 2008

Project # 7035.00

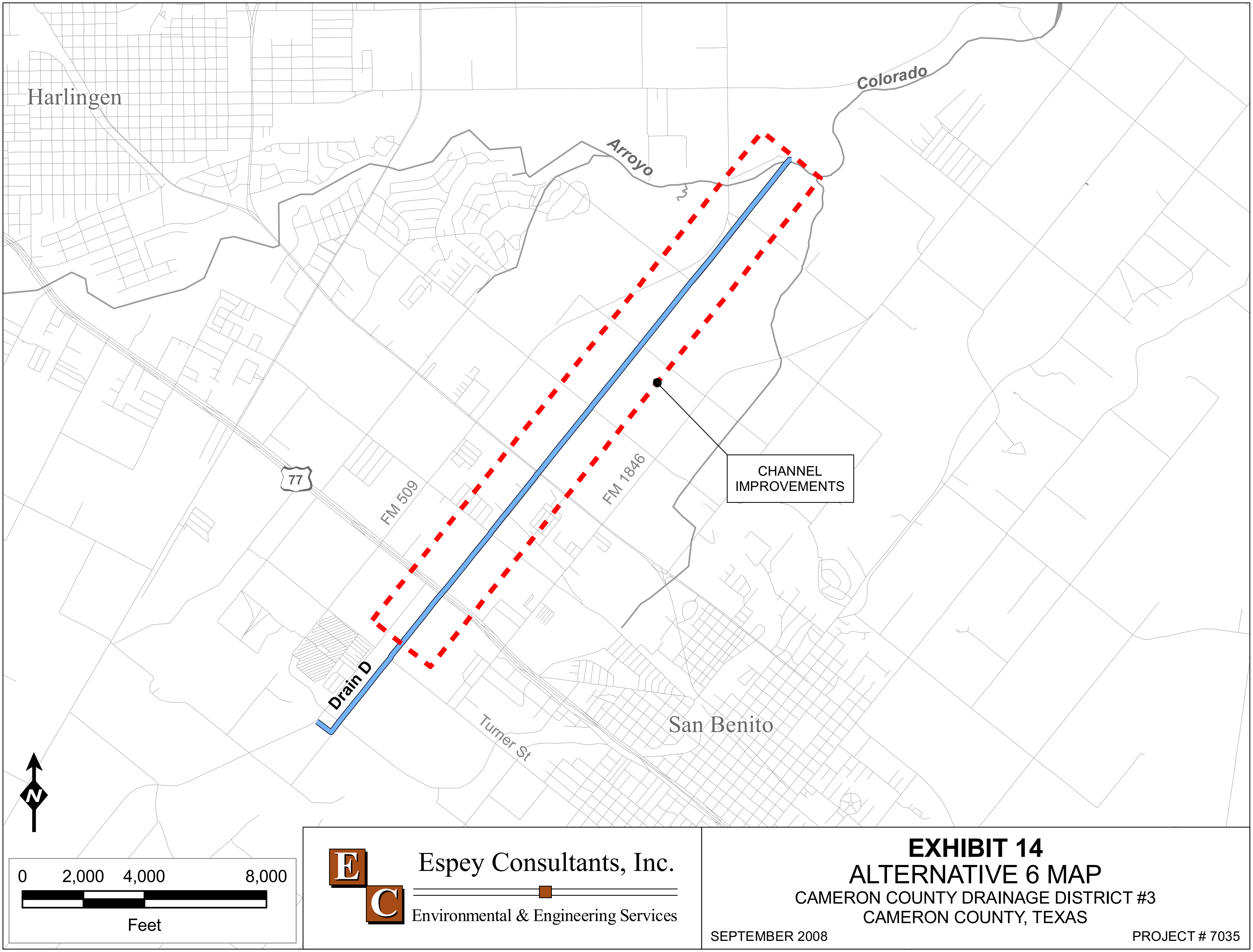

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EXHIBIT 14
ALTERNATIVE 6 MAP
CAMERON COUNTY DRAINAGE DISTRICT #3
CAMERON COUNTY, TEXAS

SEPTEMBER 2008

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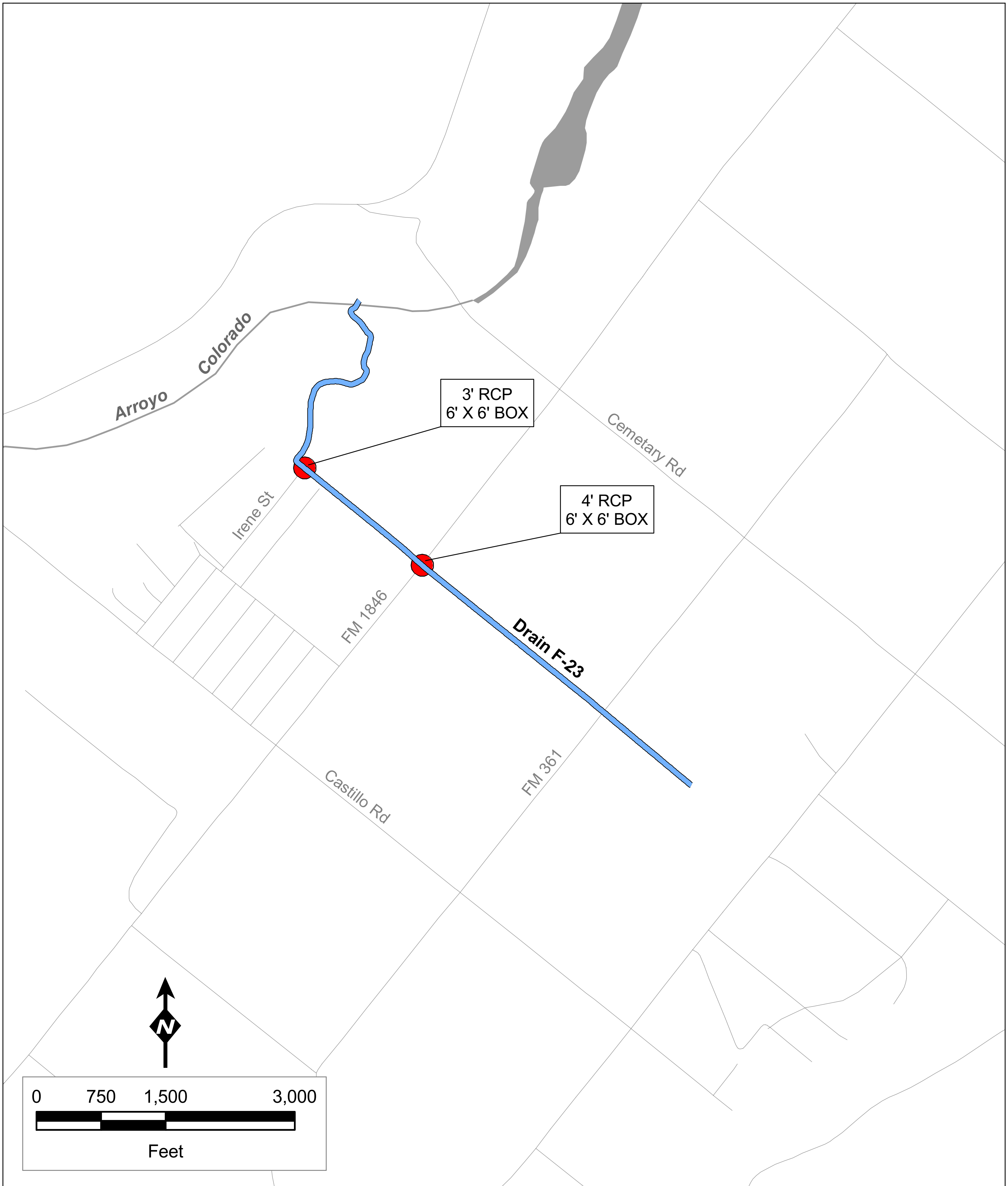

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EXHIBIT 15

ALTERNATIVE 7

CAMERON COUNTY DRAINAGE DISTRICT #3 FPP

CAMERON COUNTY, TEXAS

September 2008 Project # 7035.00

APPENDIX B
CURVE NUMBER CALCULATIONS

		Area of NRCS Group (SF)					Percent of Soil Type				Weighted Curve Number (AMC I)
	Subbasin	A	B	C	D	Total Area (SF)	%A	%B	%C	%D	
Main Drain A and Tributaries	A-01		1,023,300		3,096,869	4,120,168	0%	25%	0%	75%	52
	A-02		1,819,628		11,035,124	12,854,752	0%	14%	0%	86%	55
	A-03		7,094,552		8,147,274	15,241,827	0%	47%	0%	53%	47
	A-04		33,651,891	360,497	33,505,267	67,517,656	0%	50%	1%	50%	46
	A-05		38,436,007		22,623,735	61,059,742	0%	63%	0%	37%	44
	A-06	1,489,393	57,536,554	10,784,349	147,440,675	217,250,972	1%	26%	5%	68%	51
	A-07		64,940,520	197,658	96,065,774	161,203,953	0%	40%	0%	60%	49
	A-08		45,956,111		24,192,940	70,149,052	0%	66%	0%	34%	43
	A-09		6,267,733		6,064,500	12,332,233	0%	51%	0%	49%	46
	A-10		70,866,570		59,789,263	130,655,833	0%	54%	0%	46%	46
	A1-01		18,729,042	2,924,551	36,230,889	57,884,482	0%	32%	5%	63%	50
	A1-02		27,279,293		84,615,989	111,895,282	0%	24%	0%	76%	52
	A-11		5,193,472		31,248,726	36,442,198	0%	14%	0%	86%	55
	A-12				12,773,538	12,773,538	0%	0%	0%	100%	58
	A-13				17,232,981	17,232,981	0%	0%	0%	100%	58
	A-14		4,078,519		38,183,739	42,262,258	0%	10%	0%	90%	56
	A-15		10,528,630		21,379,130	31,907,761	0%	33%	0%	67%	50
	A-16		19,275,585		78,825,958	98,101,543	0%	20%	0%	80%	53
	A-17		14,158,425		7,270,699	21,429,124	0%	66%	0%	34%	43
	A-18		86,541		7,088,044	7,174,585	0%	1%	0%	99%	58
	B1-01		56,800,571		29,726,927	86,527,497	0%	66%	0%	34%	43
	B2-01		28,164,879		13,698,586	41,863,465	0%	67%	0%	33%	43
	B2-02		2,955,269		12,454,611	15,409,881	0%	19%	0%	81%	54
	B2-03		2,391,830		34,568,749	36,960,579	0%	6%	0%	94%	57
	B5-01		10,346,766		9,537,735	19,884,501	0%	52%	0%	48%	46
	B5-02				4,451,931	4,451,931	0%	0%	0%	100%	58
	B5-03				3,296,909	3,296,909	0%	0%	0%	100%	58
	B5-04				6,695,281	6,695,281	0%	0%	0%	100%	58
	B5A-01		6,747,498		10,838,455	17,585,953	0%	38%	0%	62%	49
	B5A-02				19,520,724	19,520,724	0%	0%	0%	100%	58
	BRR-01		1,704,678		27,721,056	29,425,734	0%	6%	0%	94%	57
	CitySB-01		3,507,315		15,733,976	19,241,292	0%	18%	0%	82%	54

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

	Subbasin	Area of NRCS Group (SF) A	B	C	D	Total Area (SF)	Percent of Soil Type %A	%B	%C	%D	Weighted Curve Number (AMC I)
C Left Drain	CL-01		37,917,951		31,110,314	69,028,265	0%	55%	0%	45%	45
	CL-02		9,798,193		57,625,820	67,424,013	0%	15%	0%	85%	55
	CL-03		547,715		17,367,615	17,915,330	0%	3%	0%	97%	57
	CL-04				19,600,672	19,600,672	0%	0%	0%	100%	58
	CL-05		533,854		19,735,992	20,269,847	0%	3%	0%	97%	57
	CL-06				3,652,413	3,652,413	0%	0%	0%	100%	58
C Right Drain	CR-01		2,095,367		18,062,385	20,157,751	0%	10%	0%	90%	56
	CR-02				10,943,624	10,943,624	0%	0%	0%	100%	58
	CR-03				16,263,435	16,263,435	0%	0%	0%	100%	58
D Drain	D-01		5,099,907		16,700,877	21,800,785	0%	23%	0%	77%	53
	D-02		2,374,509		4,522,024	6,896,533	0%	34%	0%	66%	50
	D-03		506,118		14,926,529	15,432,647	0%	3%	0%	97%	57
	D-04				21,028,819	21,028,819	0%	0%	0%	100%	58
E Drain	E-01		52,489,721		67,668,570	120,158,292	0%	44%	0%	56%	48
	E-02		1,888,661		14,841,686	16,730,347	0%	11%	0%	89%	55
	E-03		1,870,133		11,605,424	13,475,557	0%	14%	0%	86%	55
	E-04		8,690,575		15,994,170	24,684,745	0%	35%	0%	65%	50
	E-05		2,275,313		11,443,351	13,718,664	0%	17%	0%	83%	54
	E-06		73,861		14,316,906	14,390,767	0%	1%	0%	99%	58
	E-07				20,821,204	20,821,204	0%	0%	0%	100%	58
	E-08		12,632,560		38,855,254	51,487,814	0%	25%	0%	75%	52
	ETrib-01		4,711,407		11,746,353	16,457,760	0%	29%	0%	71%	51
F23 Drain	F23-01		15,265,510		15,394,805	30,660,315	0%	50%	0%	50%	47
	F23-02		511,827		25,833,511	26,345,339	0%	2%	0%	98%	58
	F23-03		47,713		14,837,907	14,885,621	0%	0%	0%	100%	58
	F23-04		155,429		15,504,323	15,659,752	0%	1%	0%	99%	58

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

Basin	Impervious Cover Percent Existing Conditions	Impervious Cover Percent Ultimate Conditions	Basin	Impervious Cover Percent Existing Conditions	Impervious Cover Percent Ultimate Conditions
A-01	54	79	B5A-02	16	58
A-02	6	71	BRR-01	41	54
A-03	19	63	CitySB-01	17	41
A-04	7	46	CL-01	7	51
A-05	6	21	CL-02	15	62
A-06	6	30	CL-03	30	72
A-07	9	38	CL-04	46	77
A-08	7	38	CL-05	27	52
A-09	3	7	CL-06	21	41
A-10	13	18	CR-01	14	52
A1-01	5	13	CR-02	27	56
A1-02	5	24	CR-03	9	54
A-11	43	63	D-01	16	36
A-12	3	5	D-02	40	70
A-13	4	5	D-03	19	43
A-14	6	26	D-04	13	19
A-15	7	42	E-01	7	27
A-16	3	5	E-02	11	70
A-17	5	19	E-03	47	81
A-18	5	45	E-04	50	70
B1-01	8	15	E-05	32	53
B2-01	8	11	E-06	6	20
B2-02	11	18	E-07	10	47
B2-03	27	35	E-08	10	22
B5-01	10	39	ETrib-01	55	65
B5-02	7	39	F23-01	8	40
B5-03	3	15	F23-02	4	14
B5-04	3	6	F23-03	3	42
B5A-01	26	39	F23-04	10	32

Existing		Ultimate	
Land Use Type	Impervious Cover	Land Use Type	Impervious Cover
Commercial	90%	Agriculture	5%
Cultivated	2%	Commercial	90%
Dense Vegetation (Dense)	5%	Industrial	90%
Ditch	0%	Light Industrial	90%
Industrial	80%	Multifamily	80%
Multifamily	70%	Mobile Homes	60%
Rangeland	10%	Park	0%
Road	90%	Public Facility	85%
Single Family 0-2 units per acre (SF02)	12%	Retail	90%
Single Family 2-4 units per acre (SF24)	24%	Right of Way (ROW)	90%
Single Family 4-6 units per acre (SF46)	40%	Single Family (SF)	40%
Water	100%	Water	100%

APPENDIX D
TIME OF CONCENTRATION CALCULATIONS
KERBY-KIRPICH METHOD

Existing Conditions
Kerby-Kirpich Method of Computing

Time of Concentration			**A01**	**A02**	**A03**	**A04**	**A05**	**A06**	**A07**	**A08**	**A09**	**A10**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.30	0.30	0.10	0.30	0.30	0.30	0.10	0.30	0.30	0.30
Length	L	ft	600	500	500	500	500	500	500	500	500	500
Slope	S		0.0028	0.0045	0.0034	0.0014	0.0068	0.0001	0.0017	0.0047	0.0026	0.0012
Sheet Flow Travel Time	Tc	min	37.1	30.4	19.4	39.7	27.6	74.0	22.7	30.0	34.7	41.4
Length	L	ft	500	700	500	700	700	700	700	700	700	700
Slope	S		0.0055	0.0023	0.0016	0.0004	0.0007	0.0002	0.0023	0.0011	0.0011	0.0010
Shallow Conc. Travel Time	Tc	min	29.0	41.7	23.3	62.0	55.1	70.6	24.8	49.1	49.3	50.6
Kirpich Channelized Flow												
Length	L	ft	999	860	350	905	2,860	1,845	3,516	2,518	4,864	1,900
Slope	S		0.0002	0.0010	0.0013	0.0025	0.0014	0.0013	0.0019	0.0009	0.0014	0.0043
Channel 1 Flow Travel Time	Tc	min	40.6	20.3	9.1	14.9	44.5	33.0	46.4	47.4	67.6	21.3
Length	L	ft	980	2,654	2,647	6,207	2,965	9,785	7,284	5,417	916	5,790
Slope	S		0.0017	0.0005	0.0011	0.0012	0.0013	0.0012	0.0010	0.0009	0.0035	0.0009
Channel 2 Flow Travel Time	Tc	min	18.4	63.9	46.7	85.8	47.9	121.4	103.1	86.6	13.1	91.1
Length	L	ft	737	2,654	3,567	11,383	2,567	20,672	3,239	9,183	780	6,869
Slope	S		0.0004	0.0004	0.0016	0.0002	0.0004	0.0003	0.0001	0.0006	0.0006	0.0002
Channel 3 Flow Travel Time	Tc	min	24.6	68.9	50.6	257.8	65.3	392.5	164.6	156.7	22.2	172.4
Total Travel Time	**Tc**	**min**	**149.7**	**225.1**	**149.2**	**460.2**	**240.5**	**691.5**	**361.6**	**369.8**	**186.8**	**376.8**

			A101	**A102**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.30	0.30	0.10	0.30	0.30	0.30	0.30	0.30	0.10	0.30
Length	L	ft	500	500	500	500	250	250	500	500	500	500
Slope	S		0.0018	0.0014	0.0031	0.0010	0.0015	0.0068	0.0045	0.0043	0.0065	0.0017
Sheet Flow Travel Time	Tc	min	37.6	40.0	19.9	43.3	28.5	19.9	30.4	30.7	16.7	38.2
Length	L	ft	700	630	700	700	50	750	700	700	700	700
Slope	S		0.0010	0.0009	0.0027	0.0020	0.0406	0.0020	0.0007	0.0011	0.0002	0.0010
Shallow Conc. Travel Time	Tc	min	50.6	48.9	24.0	43.0	6.2	44.4	54.4	49.8	43.5	50.6
Kirpich Channelized Flow												
Length	L	ft	2,681	1,140	5,063	2,049	822	905	2,341	1,417	2,371	2,743
Slope	S		0.0009	0.0003	0.0010	0.0001	0.0025	0.0040	0.0018	0.0002	0.0026	0.0002
Channel 1 Flow Travel Time	Tc	min	50.7	41.4	78.6	110.6	13.8	12.4	34.9	56.7	30.4	102.1
Length	L	ft	3,724	5,000	5,088	3,484	779	5,909	2,410	3,190	6,300	764
Slope	S		0.0009	0.0014	0.0015	0.0001	0.0012	0.0001	0.0023	0.0000	0.0009	0.0031
Channel 2 Flow Travel Time	Tc	min	65.7	68.9	67.6	128.2	17.6	213.7	32.7	302.6	96.4	12.0
Length	L	ft	2,670	9,127	3,369	1,318	1,416	1,210	1,414	4,097	7,023	573
Slope	S		0.0005	0.0003	0.0006	0.0001	0.0003	0.0013	0.0009	0.0000	0.0002	0.0086
Channel 3 Flow Travel Time	Tc	min	62.3	195.8	68.7	72.1	49.5	24.1	30.8	419.0	176.1	6.5
Total Travel Time	**Tc**	**min**	**266.8**	**395.0**	**258.9**	**397.3**	**115.7**	**314.5**	**183.3**	**858.9**	**363.1**	**209.3**

			B101	**B201**	**B202**	**B203**	**B501**	**B502**	**B503**	**B504**	**B5A01**	**B5A02**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Length	L	ft	500	500	500	500	500	500	500	239	700	968
Slope	S		0.0010	0.0017	0.0050	0.0056	0.0003	0.0044	0.0014	0.0001	0.0001	0.0007
Sheet Flow Travel Time	Tc	min	43.2	38.2	29.7	28.9	57.5	30.5	39.9	52.4	86.5	63.1
Length	L	ft	700	700	700	700	330	700	700	960	700	1,325
Slope	S		0.0010	0.0009	0.0031	0.0010	0.0027	0.0016	0.0001	0.0004	0.0001	0.0007
Shallow Conc. Travel Time	Tc	min	50.6	52.5	38.8	50.6	28.3	45.5	86.5	71.3	86.5	73.7
Kirpich Channelized Flow												
Length	L	ft	5,082	3,222	1,350	5,010	2,513	2,102	1,433	1,401	2,100	2,904
Slope	S		0.0016	0.0015	0.0025	0.0010	0.0008	0.0013	0.0008	0.0007	0.0012	0.0005
Channel 1 Flow Travel Time	Tc	min	66.3	48.2	20.3	78.1	51.1	36.8	32.4	34.0	37.9	68.1
Length	L	ft	7,325	2,525	1,960	6,198	545	245	404	2,063	2,750	1,522
Slope	S		0.0008	0.0013	0.0048	0.0003	0.0103	0.0025	0.0001	0.0013	0.0009	0.0007
Channel 2 Flow Travel Time	Tc	min	114.4	42.3	20.8	148.6	5.8	5.4	27.5	36.2	52.2	36.5
Length	L	ft	5,504	1,160	3,282	4,726	1,830	318	835	1,221	1,854	897
Slope	S		0.0012	0.0006	0.0008	0.0006	0.0003	0.0018	0.0004	0.0005	0.0017	0.0010
Channel 3 Flow Travel Time	Tc	min	77.9	31.5	62.3	90.3	58.5	7.5	29.0	33.7	29.8	21.0
Total Travel Time	**Tc**	**min**	**352.3**	**212.6**	**172.0**	**396.4**	**201.2**	**125.7**	**215.4**	**227.6**	**293.1**	**262.4**

Existing Conditions
Kerby-Kirpich Method of Computing
Time of Concentration

	variables	units	BRR01	CitySB01	CL01	CL02	CL03	CL04	CL05	CL06	CR01	CR02
Kerby Overland Flow												
Retardance Coefficient	N		0.10	0.30	0.30	0.30	0.30	0.30	0.10	0.30	0.30	0.30
Length	L	ft	300	500	400	300	400	500	200	350	500	500
Slope	S		0.0062	0.0019	0.0029	0.0005	0.0002	0.0002	0.0092	0.0001	0.0016	0.0001
Sheet Flow Travel Time	Tc	min	13.3	37.2	30.3	40.3	54.5	63.5	10.0	62.6	38.6	74.0
Length	L	ft	900	700	600	900	800	700	1,000	600	700	700
Slope	S		0.0027	0.0030	0.0009	0.0001	0.0001	0.0001	0.0001	0.0020	0.0008	0.0003
Shallow Conc. Travel Time	Tc	min	26.9	39.3	48.7	89.3	92.1	86.5	61.2	40.2	52.7	66.4
Kirpich Channelized Flow												
Length	L	ft	3,284	2,670	985	1,015	3,450	1,150	2,300	625	3,799	1,100
Slope	S		0.0013	0.0004	0.0021	0.0002	0.0003	0.0001	0.0006	0.0113	0.0004	0.0009
Channel 1 Flow Travel Time	Tc	min	52.1	72.4	17.0	47.5	89.0	61.5	53.5	6.2	89.4	25.8
Length	L	ft	5,107	3,040	2,934	7,656	673	664	630	403	1,743	1,907
Slope	S		0.0010	0.0008	0.0013	0.0008	0.0003	0.0037	0.0003	0.0059	0.0006	0.0012
Channel 2 Flow Travel Time	Tc	min	79.6	58.5	47.0	120.1	26.7	10.1	24.2	5.7	42.3	34.9
Length	L	ft	3,316	2,767	8,000	11,671	628	1,941	749	960	2,190	588
Slope	S		0.0008	0.0008	0.0004	0.0000	0.0001	0.0004	0.0000	0.0038	0.0004	0.0011
Channel 3 Flow Travel Time	Tc	min	62.0	54.4	168.0	641.6	33.5	55.0	136.7	13.1	60.6	14.7
Total Travel Time	**Tc**	**min**	**233.9**	**261.7**	**311.0**	**938.9**	**295.8**	**276.6**	**285.6**	**127.9**	**283.6**	**215.8**

	variables	units	CR03	D01	D02	D03	D04	E01	E02	E03	E04	E05
Kerby Overland Flow												
Retardance Coefficient	N		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.10
Length	L	ft	400	100	445	500	500	500	500	500	630	300
Slope	S		0.0025	0.0198	0.0048	0.0001	0.0001	0.0023	0.0001	0.0006	0.0079	0.0040
Sheet Flow Travel Time	Tc	min	31.4	10.2	28.4	74.0	74.0	35.6	74.0	48.8	29.7	14.7
Length	L	ft	900	350	755	700	700	700	700	695	275	500
Slope	S		0.0001	0.0208	0.0005	0.0005	0.0003	0.0032	0.0001	0.0026	0.0099	0.0040
Shallow Conc. Travel Time	Tc	min	97.3	18.0	62.4	60.0	66.9	38.6	86.5	40.3	19.1	18.7
Kirpich Channelized Flow												
Length	L	ft	577	4,025	405	1,503	353	3,895	577	1,271	945	2,558
Slope	S		0.0006	0.0006	0.0004	0.0014	0.0004	0.0006	0.0001	0.0010	0.0012	0.0002
Channel 1 Flow Travel Time	Tc	min	18.7	83.1	15.8	27.2	14.2	79.3	33.6	27.8	20.4	87.2
Length	L	ft	560	1,084	1,226	1,315	4,481	5,025	4,879	2,371	2,674	920
Slope	S		0.0031	0.0036	0.0021	0.0000	0.0009	0.0004	0.0006	0.0005	0.0005	0.0025
Channel 2 Flow Travel Time	Tc	min	9.4	14.9	20.1	95.2	74.8	111.6	92.4	55.8	63.7	15.0
Length	L	ft	4,539	5,236	829	1,453	2,669	5,746	2,525	1,499	3,885	2,034
Slope	S		0.0023	0.0006	0.0001	0.0003	0.0008	0.0001	0.0003	0.0001	0.0004	0.0003
Channel 3 Flow Travel Time	Tc	min	53.3	97.0	49.8	50.3	51.8	195.1	78.9	79.4	96.2	62.3
Total Travel Time	**Tc**	**min**	**210.1**	**223.1**	**176.5**	**306.6**	**281.6**	**460.3**	**365.4**	**252.1**	**229.0**	**198.0**

	variables	units	E06	E07	E08	ETrib01	F2301	F2302	F2303	F2304
Kerby Overland Flow										
Retardance Coefficient	N		0.30	0.30	0.30	0.10	0.30	0.30	0.30	0.30
Length	L	ft	300	500	200	155	560	500	300	500
Slope	S		0.0085	0.0007	0.0029	0.0044	0.0001	0.0001	0.0084	0.0001
Sheet Flow Travel Time	Tc	min	20.7	47.4	21.9	10.6	87.1	74.0	20.7	74.0
Length	L	ft	830	700	300	200	640	700	900	700
Slope	S		0.0001	0.0006	0.0002	0.0025	0.0003	0.0007	0.0001	0.0012
Shallow Conc. Travel Time	Tc	min	93.7	55.9	52.7	13.6	64.5	55.5	99.0	48.7
Kirpich Channelized Flow										
Length	L	ft	750	1,887	4,200	3,145	2,640	1,280	1,330	1,140
Slope	S		0.0015	0.0037	0.0009	0.0016	0.0011	0.0011	0.0014	0.0004
Channel 1 Flow Travel Time	Tc	min	15.4	22.4	71.4	45.7	45.9	26.6	25.2	34.6
Length	L	ft	2,474	3,839	4,770	630	4,164	2,450	4,810	1,152
Slope	S		0.0026	0.0033	0.0007	0.0031	0.0002	0.0006	0.0003	0.0023
Channel 2 Flow Travel Time	Tc	min	31.5	40.6	87.3	10.3	124.6	53.9	127.7	18.4
Length	L	ft	887	620	5,230	2,463	997	2,385	4,120	3,943
Slope	S		0.0004	0.0029	0.0009	0.0006	0.0002	0.0009	0.0010	0.0040
Channel 3 Flow Travel Time	Tc	min	28.9	10.5	86.4	56.7	44.7	47.1	67.3	38.3
Total Travel Time	**Tc**	**min**	**190.2**	**176.9**	**319.8**	**136.9**	**366.8**	**257.1**	**340.0**	**213.9**

Ultimate Conditions
Kerby-Kirpich Method of Computing

Time of Concentration			**A01**	**A02**	**A03**	**A04**	**A05**	**A06**	**A07**	**A08**	**A09**	**A10**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.10	0.10	0.10	0.10	0.30	0.10	0.10	0.10	0.30	0.30
Length	L	ft	600	500	500	500	500	500	500	500	500	500
Slope	S		0.0028	0.0045	0.0034	0.0014	0.0068	0.0001	0.0017	0.0047	0.0026	0.0012
Sheet Flow Travel Time	Tc	min	22.2	18.2	19.4	23.7	27.6	44.3	22.7	18.0	34.7	41.4
Length	L	ft	500	700	500	700	700	700	700	700	700	700
Slope	S		0.0055	0.0023	0.0016	0.0004	0.0007	0.0002	0.0023	0.0011	0.0011	0.0010
Shallow Conc. Travel Time	Tc	min	17.4	25.0	23.3	37.1	55.1	42.3	24.8	29.4	49.3	50.6
Kirpich Channelized Flow												
Length	L	ft	999	860	350	905	2860	1845	3516	2518	4864	1900
Slope	S		0.0002	0.0010	0.0013	0.0025	0.0014	0.0013	0.0019	0.0009	0.0014	0.0043
Channel 1 Flow Travel Time	Tc	min	40.6	20.3	9.1	14.9	44.5	33.0	46.4	47.4	67.6	21.3
Length	L	ft	980	2654	2647	6207	2965	9785	7284	5417	916	5790
Slope	S		0.0017	0.0005	0.0011	0.0012	0.0013	0.0012	0.0010	0.0009	0.0035	0.0009
Channel 2 Flow Travel Time	Tc	min	18.4	63.9	46.7	85.8	47.9	121.4	103.1	86.6	13.1	91.1
Length	L	ft	737	2654	3567	11383	2567	20672	3239	9183	780	6869
Slope	S		0.0004	0.0004	0.0016	0.0002	0.0004	0.0003	0.0001	0.0006	0.0006	0.0002
Channel 3 Flow Travel Time	Tc	min	24.6	68.9	50.6	257.8	65.3	392.5	164.6	156.7	22.2	172.4
Total Travel Time	**Tc**	**min**	**123.2**	**196.2**	**149.2**	**419.4**	**240.5**	**633.5**	**361.6**	**338.1**	**186.8**	**376.8**

			A101	**A102**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.10	0.30	0.10	0.30	0.30	0.10	0.10	0.30	0.10	0.30
Length	L	ft	500	500	500	500	250	250	500	500	500	500
Slope	S		0.0018	0.0014	0.0031	0.0010	0.0015	0.0068	0.0045	0.0043	0.0065	0.0017
Sheet Flow Travel Time	Tc	min	22.5	40.0	19.9	43.3	28.5	11.9	18.2	30.7	16.7	38.2
Length	L	ft	700	630	700	700	50	750	700	700	700	700
Slope	S		0.0010	0.0009	0.0027	0.0020	0.0406	0.0020	0.0007	0.0011	0.0002	0.0010
Shallow Conc. Travel Time	Tc	min	30.3	48.9	24.0	43.0	6.2	26.6	32.6	49.8	43.5	50.6
Kirpich Channelized Flow												
Length	L	ft	2681	1140	5063	2049	822	905	2341	1417	2371	2743
Slope	S		0.0009	0.0003	0.0010	0.0001	0.0025	0.0040	0.0018	0.0002	0.0026	0.0002
Channel 1 Flow Travel Time	Tc	min	50.7	41.4	78.6	110.6	13.8	12.4	34.9	56.7	30.4	102.1
Length	L	ft	3724	5000	5088	3484	779	5909	2410	3190	6300	764
Slope	S		0.0009	0.0014	0.0015	0.0001	0.0012	0.0001	0.0023	0.0000	0.0009	0.0031
Channel 2 Flow Travel Time	Tc	min	65.7	68.9	67.6	128.2	17.6	213.7	32.7	302.6	96.4	12.0
Length	L	ft	2670	9127	3369	1318	1416	1210	1414	4097	7023	573
Slope	S		0.0005	0.0003	0.0006	0.0001	0.0003	0.0013	0.0009	0.0000	0.0002	0.0086
Channel 3 Flow Travel Time	Tc	min	62.3	195.8	68.7	72.1	49.5	24.1	30.8	419.0	176.1	6.5
Total Travel Time	**Tc**	**min**	**231.4**	**395.0**	**258.9**	**397.3**	**115.7**	**288.7**	**149.3**	**858.9**	**363.1**	**209.3**

			B101	**B201**	**B202**	**B203**	**B501**	**B502**	**B503**	**B504**	**B5A01**	**B5A02**
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.30	0.30	0.30	0.10	0.10	0.10	0.30	0.30	0.30	0.10
Length	L	ft	500	500	500	500	500	500	500	239	700	968
Slope	S		0.0010	0.0017	0.0050	0.0056	0.0003	0.0044	0.0014	0.0001	0.0001	0.0007
Sheet Flow Travel Time	Tc	min	43.2	38.2	29.7	17.3	34.4	18.3	39.9	52.4	86.5	37.8
Length	L	ft	700	700	700	700	330	700	700	960	700	1325
Slope	S		0.0010	0.0009	0.0031	0.0010	0.0027	0.0016	0.0001	0.0004	0.0001	0.0007
Shallow Conc. Travel Time	Tc	min	50.6	52.5	38.8	30.3	16.9	27.2	86.5	71.3	86.5	44.1
Kirpich Channelized Flow												
Length	L	ft	5082	3222	1350	5010	2513	2102	1433	1401	2100	2904
Slope	S		0.0016	0.0015	0.0025	0.0010	0.0008	0.0013	0.0008	0.0007	0.0012	0.0005
Channel 1 Flow Travel Time	Tc	min	66.3	48.2	20.3	78.1	51.1	36.8	32.4	34.0	37.9	68.1
Length	L	ft	7325	2525	1960	6198	545	245	404	2063	2750	1522
Slope	S		0.0008	0.0013	0.0048	0.0003	0.0103	0.0025	0.0001	0.0013	0.0009	0.0007
Channel 2 Flow Travel Time	Tc	min	114.4	42.3	20.8	148.6	5.8	5.4	27.5	36.2	52.2	36.5
Length	L	ft	5504	1160	3282	4726	1830	318	835	1221	1854	897
Slope	S		0.0012	0.0006	0.0008	0.0006	0.0003	0.0018	0.0004	0.0005	0.0017	0.0010
Channel 3 Flow Travel Time	Tc	min	77.9	31.5	62.3	90.3	58.5	7.5	29.0	33.7	29.8	21.0
Total Travel Time	**Tc**	**min**	**352.3**	**212.6**	**172.0**	**364.5**	**166.7**	**95.2**	**215.4**	**227.6**	**293.1**	**207.5**

Ultimate Conditions
Kerby-Kirpich Method of Computing
Time of Concentration

			BRR01	CitySB01	CL01	CL02	CL03	CL04	CL05	CL06	CR01	CR02
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.10	0.10	0.10	0.10	0.10	0.30	0.10	0.10	0.10	0.30
Length	L	ft	300	500	400	300	400	500	200	350	500	500
Slope	S		0.0062	0.0019	0.0029	0.0005	0.0002	0.0002	0.0092	0.0001	0.0016	0.0001
Sheet Flow Travel Time	Tc	min	13.3	22.3	18.1	24.1	32.6	63.5	10.0	37.5	23.1	74.0
Length	L	ft	900	700	600	900	800	700	1000	600	700	700
Slope	S		0.0027	0.0030	0.0009	0.0001	0.0001	0.0001	0.0001	0.0020	0.0008	0.0003
Shallow Conc. Travel Time	Tc	min	26.9	23.5	29.1	53.4	55.1	86.5	61.2	24.1	31.6	66.4
Kirpich Channelized Flow												
Length	L	ft	3284	2670	985	1015	3450	1150	2300	625	3799	1100
Slope	S		0.0013	0.0004	0.0021	0.0002	0.0003	0.0001	0.0006	0.0113	0.0004	0.0009
Channel 1 Flow Travel Time	Tc	min	52.1	72.4	17.0	47.5	89.0	61.5	53.5	6.2	89.4	25.8
Length	L	ft	5107	3040	2934	7656	673	664	630	403	1743	1907
Slope	S		0.0010	0.0008	0.0013	0.0008	0.0003	0.0037	0.0003	0.0059	0.0006	0.0012
Channel 2 Flow Travel Time	Tc	min	79.6	58.5	47.0	120.1	26.7	10.1	24.2	5.7	42.3	34.9
Length	L	ft	3316	2767	8000	11671	628	1941	749	960	2190	588
Slope	S		0.0008	0.0008	0.0004	0.0000	0.0001	0.0004	0.0000	0.0038	0.0004	0.0011
Channel 3 Flow Travel Time	Tc	min	62.0	54.4	168.0	641.6	33.5	55.0	136.7	13.1	60.6	14.7
Total Travel Time	**Tc**	**min**	**233.9**	**231.0**	**279.3**	**886.9**	**236.9**	**276.6**	**285.6**	**86.6**	**247.0**	**215.8**

			CR03	D01	D02	D03	D04	E01	E02	E03	E04	E05
Kerby Overland Flow	variables	units										
Retardance Coefficient	N		0.10	0.30	0.30	0.10	0.30	0.10	0.30	0.10	0.10	0.10
Length	L	ft	400	100	445	500	500	500	500	500	630	300
Slope	S		0.0025	0.0198	0.0048	0.0001	0.0001	0.0023	0.0001	0.0006	0.0079	0.0040
Sheet Flow Travel Time	Tc	min	18.8	10.2	28.4	44.3	74.0	21.3	74.0	29.2	17.8	14.7
Length	L	ft	900	350	755	700	700	700	700	695	275	500
Slope	S		0.0001	0.0208	0.0005	0.0005	0.0003	0.0032	0.0001	0.0026	0.0099	0.0040
Shallow Conc. Travel Time	Tc	min	58.3	18.0	62.4	35.9	66.9	23.1	86.5	24.1	11.5	18.7
Kirpich Channelized Flow												
Length	L	ft	577	4025	405	1503	353	3895	577	1271	945	2558
Slope	S		0.0006	0.0006	0.0004	0.0014	0.0004	0.0006	0.0001	0.0010	0.0012	0.0002
Channel 1 Flow Travel Time	Tc	min	18.7	83.1	15.8	27.2	14.2	79.3	33.6	27.8	20.4	87.2
Length	L	ft	560	1084	1226	1315	4481	5025	4879	2371	2674	920
Slope	S		0.0031	0.0036	0.0021	0.0000	0.0009	0.0004	0.0006	0.0005	0.0005	0.0025
Channel 2 Flow Travel Time	Tc	min	9.4	14.9	20.1	95.2	74.8	111.6	92.4	55.8	63.7	15.0
Length	L	ft	4539	5236	829	1453	2669	5746	2525	1499	3885	2034
Slope	S		0.0023	0.0006	0.0001	0.0003	0.0008	0.0001	0.0003	0.0001	0.0004	0.0003
Channel 3 Flow Travel Time	Tc	min	53.3	97.0	49.8	50.3	51.8	195.1	78.9	79.4	96.2	62.3
Total Travel Time	**Tc**	**min**	**158.5**	**223.1**	**176.5**	**252.8**	**281.6**	**430.5**	**365.4**	**216.3**	**209.5**	**198.0**

			E06	E07	E08	ETrib01	F2301	F2302	F2303	F2304
Kerby Overland Flow	variables	units								
Retardance Coefficient	N		0.30	0.10	0.30	0.10	0.10	0.10	0.30	0.30
Length	L	ft	300	500	200	155	560	500	300	500
Slope	S		0.0085	0.0007	0.0029	0.0044	0.0001	0.0001	0.0084	0.0001
Sheet Flow Travel Time	Tc	min	20.7	28.4	21.9	10.6	52.2	44.3	20.7	74.0
Length	L	ft	830	700	300	200	640	700	900	700
Slope	S		0.0001	0.0006	0.0002	0.0025	0.0003	0.0007	0.0001	0.0012
Shallow Conc. Travel Time	Tc	min	93.7	33.5	52.7	13.6	38.6	33.2	99.0	48.7
Kirpich Channelized Flow										
Length	L	ft	750	1887	4200	3145	2640	1280	1330	1140
Slope	S		0.0015	0.0037	0.0009	0.0016	0.0011	0.0011	0.0014	0.0004
Channel 1 Flow Travel Time	Tc	min	15.4	22.4	71.4	45.7	45.9	26.6	25.2	34.6
Length	L	ft	2474	3839	4770	630	4164	2450	4810	1152
Slope	S		0.0026	0.0033	0.0007	0.0031	0.0002	0.0006	0.0003	0.0023
Channel 2 Flow Travel Time	Tc	min	31.5	40.6	87.3	10.3	124.6	53.9	127.7	18.4
Length	L	ft	887	620	5230	2463	997	2385	4120	3943
Slope	S		0.0004	0.0029	0.0009	0.0006	0.0002	0.0009	0.0010	0.0040
Channel 3 Flow Travel Time	Tc	min	28.9	10.5	86.4	56.7	44.7	47.1	67.3	38.3
Total Travel Time	**Tc**	**min**	**190.2**	**135.4**	**319.8**	**136.9**	**306.0**	**205.2**	**340.0**	**213.9**

APPENDIX E
HEC-RAS OUTPUT REPORTS

Summary of Project:
Project: DrainA_7035.prj
Project Title: Drain A _CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan (current)
Title: Existing Conditions
Short ID: Exist Cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p03
Geometry:
Title: Existing Conditions Drain A Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g07
Flow:
Title: Existing and Ultimate Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f04

Plan
Title: Alternative 1+2+4: Combination
Short ID: Alt 1+2+4
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p13
Geometry:
Title: Alt 1+2+4 Combination Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g13
Flow:
Title: Alt 1+2+4 Combination Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f11

Plan
Title: Alternative 1: Los Indios Diversion
Short ID: Alt 1
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p07
Geometry:
Title: Alt 1 Los Indios Diversion Main Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g04
Flow:
Title: Alt 1 Los Indios Diversion Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f05

Plan
Title: Alternative 2A: DS Improvements (45' bw)
Short ID: Alt 2A
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p09
Geometry:
Title: Alt 2A DS Improvements (45' BW) Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g05
Flow:
Title: Alt 2A DS Improvements (45' BW) Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f08

Plan
Title: Alternative 3: Detention
Short ID: Alt 3
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p01
Geometry:

Title: Alt 3 Detention Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g01
Flow:
Title: Alt 3 Detention Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f07

Plan
Title: Alternative 4: Diversion
Short ID: Alt 4
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p06
Geometry:
Title: Alt 4 Diversion Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g03
Flow:
Title: Alt 4 Diversion Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f06

Plan
Title: Alternative 2B:DS Improvements (100' bw)
Short ID: Alt 2B
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.p10
Geometry:
Title: Alternative-100 ft Channel BW
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.g06
Flow:
Title: Alternative - 100 ft BW Channel
File: p:\active\7035 CCDD#3\HEC RAS\DrainA_7035.f09

Current Plan Statistics

Number of:
Rivers 9
Reaches 17

Cross Sections 319
User Input XSs 319
Interpolated 0
Culverts 41
Bridges 16
Multiple Openings 0
Inline Structures 0
Lateral Structures 0

Storage Areas 0
SA Connections 0

Summary of Project:
Project: DrainCLeft.prj
Project Title: DrainCLeft_CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan (current)
Title: Existing Conditions
Short ID: Exist Cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainCLeft.p07
Geometry:
Title: Existing Conditions Drain CLeft Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainCLeft.g01
Flow:
Title: Existing and Ultimate Conditions Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainCLeft.f04

Current Plan Statistics

Number of:
Rivers 2
Reaches 3

Cross Sections 96
User Input XSs 96
Interpolated 0
Culverts 10
Bridges 4
Multiple Openings 0
Inline Structures 1
Lateral Structures 0

Storage Areas 0
SA Connections 0

Summary of Project:
Project: DrainCRight_7035.prj
Project Title: DrainCRight_CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan (current)
Title: Existing Conditions
Short ID: Exist Cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.p03
Geometry:
Title: Existing Conditions Drain C-Right Geo
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.g04
Flow:
Title: Existing and Ultimate Conditions Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.f03

Plan
Title: Alternative 5: Drain CRight Culv Improv
Short ID: Alt 5
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.p04
Geometry:
Title: Alt 5: Drain CRight Culv Improv Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.g01
Flow:
Title: Alt 5: Drain CRight Culv Improv Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainCRight_7035.f04

Current Plan Statistics

Number of:
Rivers 1
Reaches 1

Cross Sections 29
User Input XSs 29
Interpolated 0
Culverts 4
Bridges 1
Multiple Openings 0
Inline Structures 0
Lateral Structures 0

Storage Areas 0
SA Connections 0

Summary of Project:
Project: DrainD_7035.prj
Project Title: DrainD_CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan
Title: Alternative 6: Drain D Channel Improv
Short ID: Alt 6
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.p06
Geometry:
Title: Alt 6 Drain D Channel Improvements Geo
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.g04
Flow:
Title: Alt 6 Drain D Channel Improvements Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.f05

Plan (current)
Title: Existing Condtions
Short ID: Exist Cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.p03
Geometry:
Title: Existing Conditions Drain D Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.g03
Flow:
Title: Existing and Ultimate Conditions Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainD_7035.f03

Current Plan Statistics

Number of:
Rivers 1
Reaches 1

Cross Sections 47
User Input XSs 47
Interpolated 0
Culverts 7
Bridges 0
Multiple Openings 0
Inline Structures 0
Lateral Structures 0

Storage Areas 0
SA Connections 0

Summary of Project:
Project: DrainE_7035.prj
Project Title: DrainE_CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan (current)
Title: Existing Conditions
Short ID: Exist Cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p04
Geometry:
Title: Existing Conditions Drain E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g03
Flow:
Title: Existing and Ultimate Conditions Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f04

Plan
Title: Alt-Channel and Culv Improv
Short ID: alt E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p10
Geometry:
Title: Alt-Channel and Culv Improv Drain E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g07
Flow:
Title: Alt-Channel Improvement
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f08

Plan
Title: Alt-ConcreteChannelUSofRR
Short ID: concretech
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p07
Geometry:
Title: Alt-Concrete Channel US of Trib Drain E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g05
Flow:
Title: Alt-Concrete Channel US of RR
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f06

Plan
Title: Alt Puls Routing Chan Improv
Short ID: puls alt cha
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p02
Geometry:
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g01
Flow:
Title: Pulse Routing
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f02

Plan
Title: Puls Routing
Short ID: Puls
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p03
Geometry:
Title: Existing Conditions Drain E

File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g03
Flow:
Title: Pulse Routing
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f02

Plan
Title: Split Flow Optimization
Short ID: Split
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p05
Geometry:
Title: Existing Conditions w/ Split Drain E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g04
Flow:
Title: Existing Conditions w/ Split Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f05

Plan
Title: Alt Pulse Routing Concrete
Short ID: pul concrete
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.p08
Geometry:
Title: Alt-Concrete Channel US of Trib Drain E
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.g05
Flow:
Title: Pulse Routing
File: p:\active\7035 CCDD#3\HEC RAS\DrainE_7035.f02

Current Plan Statistics

Number of:
Rivers 2
Reaches 3

Cross Sections 98
User Input XSs 98
Interpolated 0
Culverts 8
Bridges 9
Multiple Openings 0
Inline Structures 0
Lateral Structures 0

Storage Areas 0
SA Connections 0

Summary of Project:
Project: DrainF23.prj
Project Title: DrainF23_CCDD3_EC
Project Directory:p:\active\7035 CCDD#3\HEC RAS\

Project Plans

Plan (current)
Title: Existing Condtions
Short ID: exist cond
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.p03
Geometry:
Title: Existing Conditions Drain F23 Geometry
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.g03
Flow:
Title: Existing and Ultimate Conditions Flow
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.f03

Plan
Title: Alternative 7: Drain F23 Culvert Improv
Short ID: Alt 7
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.p06
Geometry:
Title: Alt7: Drain F23 Culv Improv Geo
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.g04
Flow:
Title: Alt7: Drain F23 Culv Improv Flows
File: p:\active\7035 CCDD#3\HEC RAS\DrainF23.f05

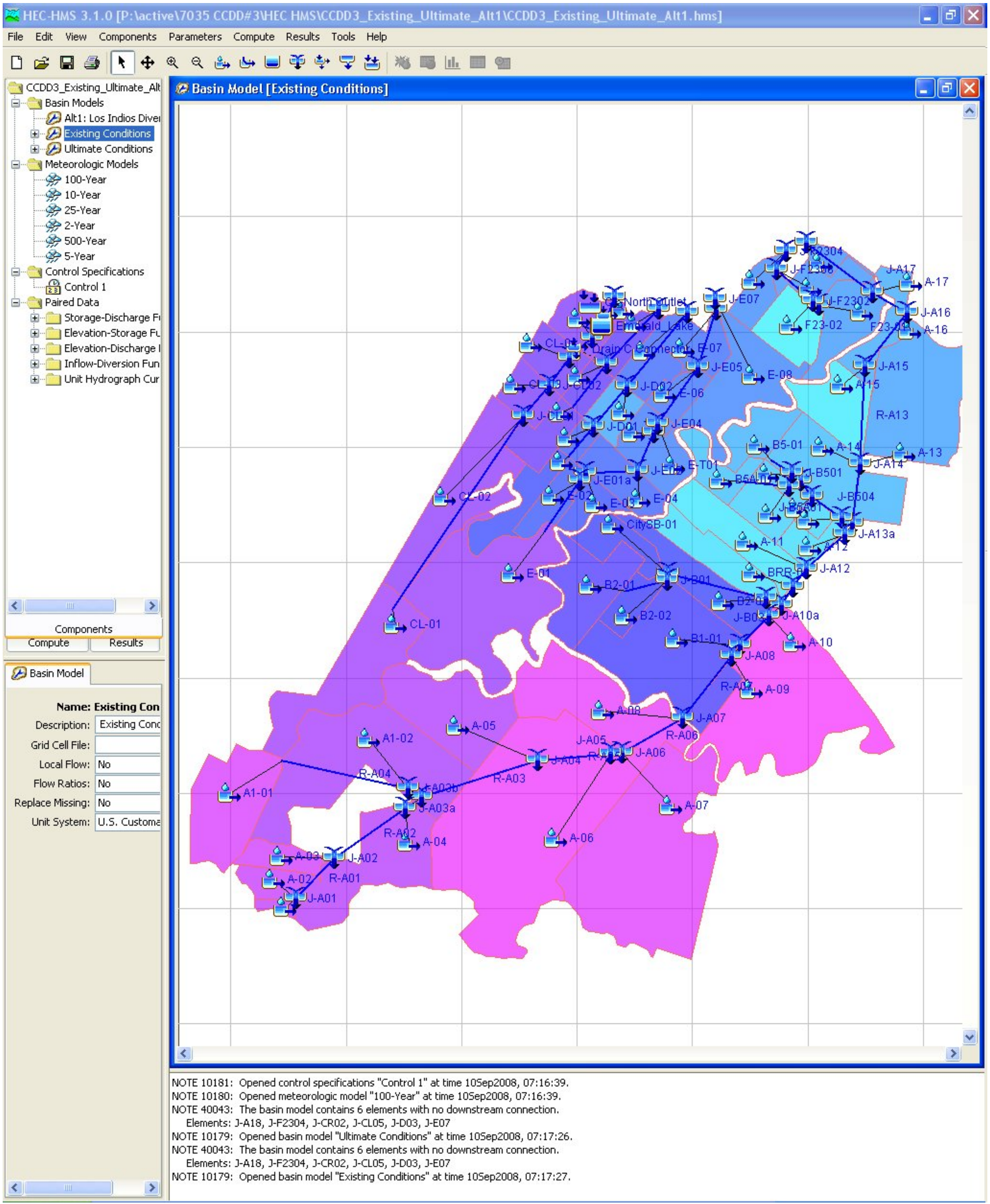
Current Plan Statistics

Number of:
Rivers 1
Reaches 1

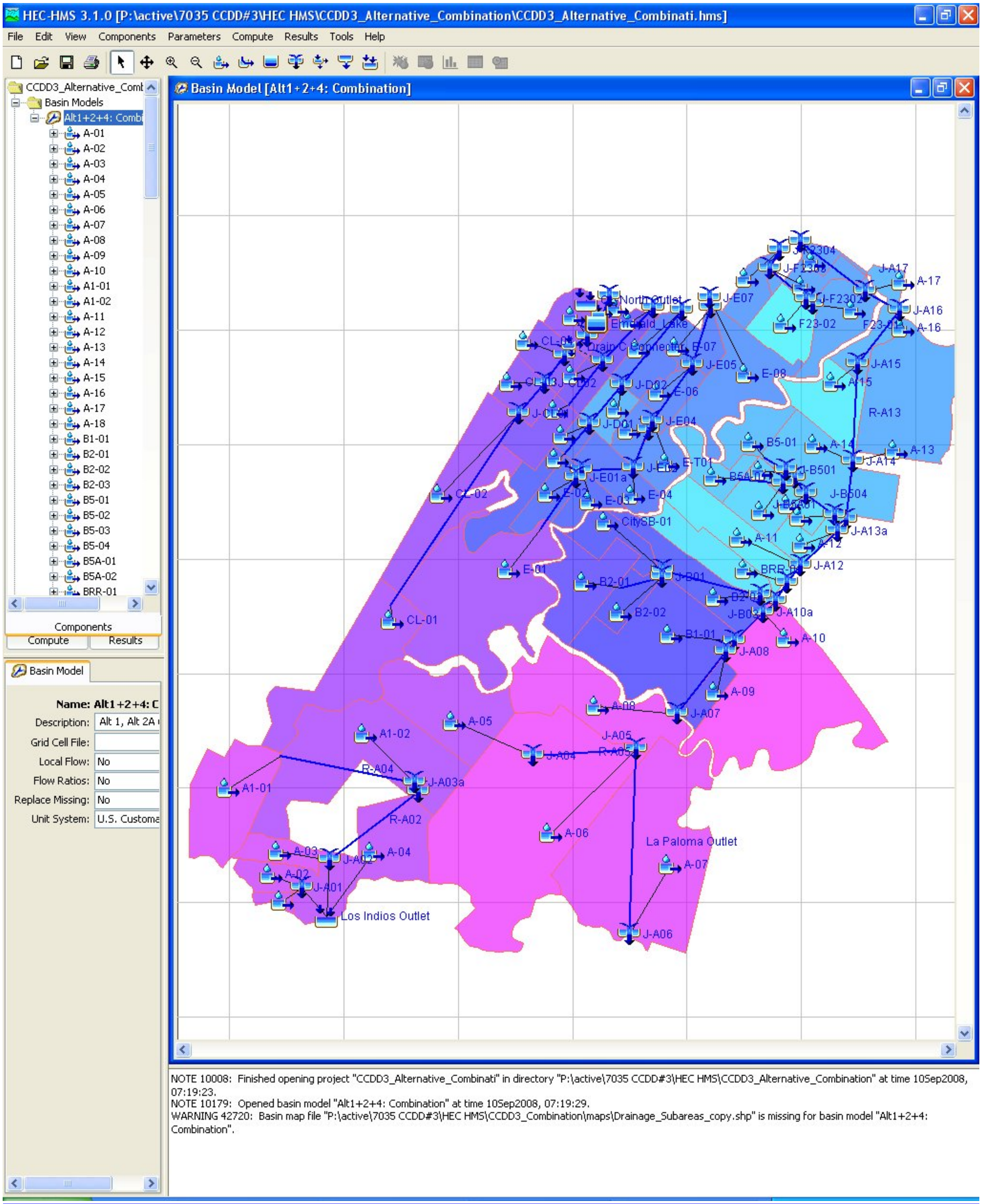
Cross Sections 16
User Input XSs 16
Interpolated 0
Culverts 2
Bridges 0
Multiple Openings 0
Inline Structures 0
Lateral Structures 0

Storage Areas 0
SA Connections 0

APPENDIX F
HEC-HMS OUTPUT REPORT



Existing Conditions HEC-HMS Model



Combination Alternative HEC-HMS Model

APPENDIX G
COST ESTIMATE CALCULATIONS

CCDD#3 Flood Protection Plan
Cost Estimate

Alternative 1: Los Indios Diversion

Item	Item Description	Qty	Unit	Unit Cost	Total Amount
Phase I					
	Construction of Outlet Drain	1	LS	$ 276,300	$ 276,300
Phase II					
	Mobilization / Demobilization	1	LS	$ 50,000	$ 50,000
	8' X 5' Concrete Box Culvert	100	LF	$ 480	$ 48,000
	8' X 5' Concrete Box Culvert	90	LF	$ 446	$ 40,140
	8' X 5' Concrete Box Culvert	800	LF	$ 320	$ 256,000
	8' X 5' Concrete Box Culvert	100	LF	$ 320	$ 32,000
	10' X 8' (Inside) Gate Well Structure	1	LS	$ 81,500	$ 81,500
	1' -0" Thick Reinforced Concrete Cut-Off Wall	1	LS	$ 3,000	$ 3,000
	1' -0" Thick Reinforced Concrete Cut-Off Wall	1	LS	$ 3,500	$ 3,500
	Remove & Restore Irrigation Canal	1	LS	$ 27,800	$ 27,800
	Irrigation Structure	1	LS	$ 5,500	$ 5,500
	Concrete Canasta at Box Culvert Entrance	1	LS	$ 19,000	$ 19,000
	8' X 5' Concrete Wing Wall	1	LS	$ 9,200	$ 9,200
	Concrete Rubble Rip-Rap at Outfall	300	CY	$ 55	$ 16,500
	Trench Protection System	1,100	LF	$ 38	$ 41,800
	SWPPP Implementation	1	LS	$ 5,000	$ 5,000
				SUBTOTAL	**$ 638,940**
Mobilization/ Demobilization (5%)					$ 31,947
Engineering and Surveying (20%)					$ 127,788
Project Management (2%)					$ 12,779
Construction Inspection (4%)					$ 25,558
				TOTAL PHASE II COST	**$ 837,011**
Phase III					
	Redirecting Drain A and related construction	1	LS	$ 500,000	$ 500,000
				TOTAL ESTIMATED COST	**$ 1,613,311**

Note: Costs from Brown, Leal and Associates

CCDD#3 Flood Protection Plan
Cost Estimate

Alternative 2A: Drain A Downstream Improvements (45 ft BW)

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Demolition							
	Demolish/Remove Flume downstream Iowa Gardens (Main A)	1	LS	$	15,000	$	15,000
	Removal of Culvert at SH100 (Drain B-1): 60" RCP	95	lf	$	40	$	3,800
	Removal of Culvert at Irrigation ditch (Drain B2-3): 4'x3' Box	70	lf	$	40	$	2,800
Culvert							
	1-8' x 8' Box Culvert @ 95 LF	95	lf	$	800	$	76,000
	1-8' x 8' Box Culvert @ 70 LF	70	lf	$	800	$	56,000
Excavation/Fill							
	Channel Excavation	430,478	cy	$	3	$	1,291,434
Right of Way							
	Additional Right-of-Way	25	ac	$	20,000	$	500,000
Erosion/Sedimentation Controls							
	Revegetation	178,667	sy	$	3.50	$	625,335
	SWPPP Compliance	1	LS	$	7,000	$	7,000
Bridge Improvements							
	Irrigation Canal Siphon	1	LS	$	110,000	$	110,000
	Bridge Extension: Business US 77 Westbound (Main A)	1,680	sf	$	118	$	198,509
	Bridge Extension: Business US 77 Eastbound (Main A)	1,680	sf	$	118	$	198,509
	Bridge Extension: FM 510 (Main A)	1,800	sf	$	118	$	212,688
	Bridge Extension: CR596 (Main A)	700	sf	$	118	$	82,712
Contingency (20%)						$	675,957
					SUBTOTAL	**$**	**4,055,743**
Mobilization/ Demobilization (5%)						$	202,787
Engineering and Surveying (20%)						$	811,149
Project Management (2%)						$	81,115
Construction Inspection (4%)						$	162,230
					TOTAL ESTIMATED COST	**$**	**5,313,024**

Note: Does not include relocation of any utilities

CCDD#3 Flood Protection Plan
Cost Estimate

Alternative 2B: Drain A Downstream Improvements (100 ft BW)

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Demolition							
	Demolish/Remove Flume downstream Iowa Gardens (Main A)	1	LS	$	15,000	$	15,000
	Removal of Culvert at SH100 (Drain B-1): 60" RCP	95	lf	$	40	$	3,800
	Removal of Culvert at Irrigation ditch (Drain B2-3): 4'x3' Box	70	lf	$	40	$	2,800
Culvert							
	1-8' x 8' Box Culvert @ 95 LF	95	lf	$	800	$	76,000
	1-8' x 8' Box Culvert @ 70 LF	70	lf	$	800	$	56,000
Excavation/Fill							
	Channel Excavation	1,805,169	cy	$	3	$	5,415,507
Right of Way							
	Additional Right-of-Way	25	ac	$	20,000	$	500,000
Erosion/Sedimentation Controls							
	Revegetation	257,778	sy	$	3.50	$	902,223
	SWPPP Compliance	1	LS	$	12,000.00	$	12,000
Bridge Improvements							
	Irrigation Canal Siphon	1	LS	$	110,000	$	110,000
	Bridge Extension: Railroad Crossing at US 77 (Main A)	750	sf	$	118	$	88,620
	Bridge Extension: Business US 77 Westbound (Main A)	4,320	sf	$	118	$	510,451
	Bridge Extension: Business US 77 Eastbound (Main A)	4,320	sf	$	118	$	510,451
	Bridge Extension: Iowa Gardens (Main A)	2,000	sf	$	118	$	236,320
	Bridge Extension: FM 510 (Main A)	4,500	sf	$	118	$	531,720
	Bridge Extension: CR596 (Main A)	1,700	sf	$	118	$	200,872
Contingency (20%)						$	1,834,353
					SUBTOTAL	**$**	**11,006,117**
Mobilization/ Demobilization (5%)						$	550,306
Engineering and Surveying (20%)						$	2,201,223
Project Management (2%)						$	220,122
Construction Inspection (4%)						$	440,245
					TOTAL ESTIMATED COST	**$**	**14,418,014**

Note: Does not include relocation of any utilities

CCDD#3 Floodplain Protection Plan
Cost Estimate

Alternative 4: La Paloma Diversion

Item	Item Description	Qty	Unit	Unit Cost	Total Amount
Culvert					
	2-10' x 10' Box Culvert @ 550 LF	1,100	lf	$ 1,200	$ 1,320,000
	2-10' x 10' Box Culvert Gates	2	LS	$ 200,000	$ 400,000
Excavation/Fill					
	Channel Excavation	250,000	cy	$ 3	$ 750,000
Right of Way					
	Additional Right-of-Way	30	ac	$ 10,000	$ 300,000
Erosion/Sedimentation Controls					
	Revegetation	66,667	sy	$ 3.50	$ 233,333
	SWPPP Compliance	1	LS	$ 15,000	$ 15,000
Irrigation Canal Rerouting					
	30" PVC and appurtenances	2,300	lf	$ 85	$ 195,500
Contingency (20%)					$ 642,767
				SUBTOTAL	**$ 3,856,600**
Mobilization/ Demobilization (5%)					$ 192,830
Engineering and Surveying (20%)					$ 771,320
Project Management (2%)					$ 77,132
Construction Inspection (4%)					$ 154,264
				TOTAL ESTIMATED COST	**$ 5,052,146**

Note: Does not include relocation of any utilities or coordination with outside entities

CCDD#3 Flood Protection Plan
Cost Estimate

Alternative 5: Drain C-Right Culvert Improvements

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Culvert							
	3-6' RCP @ 1660 LF	4,980	lf	$	600	$	2,988,000
Erosion/Sedimentation Controls							
	Revegetation	222	sy	$	5	$	1,110
	SWPPP Compliance	1	LS	$	8,000	$	8,000
Contingency (20%)						$	599,422
					SUBTOTAL	**$**	**3,596,532**
Mobilization/ Demobilization (5%)						$	179,827
Engineering and Surveying (20%)						$	719,306
Project Management (2%)						$	71,931
Construction Inspection (4%)						$	143,861
					TOTAL ESTIMATED COST	**$**	**4,711,457**

Note: Does not include relocation of any utilities

CCDD#3 Flood Protection Plan
Cost Estimate

Alterntive 6: Drain D Channel Improvements

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Excavation/Fill							
	Channel Excavation	103,105	cy	$	2	$	206,210
Right of Way							
	Additional Right-of-Way	14.4	ac	$	20,000	$	288,000
Erosion/Sedimentation Controls							
	Revegetation	162,800	sy	$	5	$	814,000
	SWPPP Compliance	1	LS	$	12,000	$	12,000
Channel Lining							
	Concrete Slope Paving - 9 Bridge Transitions (50' U/S and 50' D/S)	7,500	sy	$	8	$	60,000
Contingency (20%)						$	276,042
				SUBTOTAL		**$**	**1,656,252**
Mobilization/ Demobilization (5%)						$	82,813
Engineering and Surveying (20%)						$	331,250
Project Management (2%)						$	33,125
Construction Inspection (4%)						$	66,250
				TOTAL ESTIMATED COST		**$**	**2,169,690**

Note: Does not include relocation of any utilities

CCDD#3 Flood Protection Plan
Cost Estimate

Alterntive 7: Drain F-23 Culvert Improvements

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Demolition							
	Removal of Culvert at FM 1846	85	lf	$	40	$	3,400
	Removal of Culvert at Irene St	50	lf	$	40	$	2,000
Culvert							
	1-6' x 6' Box Culvert @ 85 LF	85	lf	$	600	$	51,000
	1-6' x 6' Box Culvert @ 40 LF	40	lf	$	600	$	24,000
Erosion/Sedimentation Controls							
	Revegetation	778	sy	$	3.50	$	2,723
	SWPPP Compliance	1	LS	$	5,000	$	5,000
Contingency (20%)						$	17,625
					SUBTOTAL	**$**	**105,748**
Mobilization/ Demobilization (5%)						$	5,287
Engineering and Surveying (20%)						$	21,150
Project Management (2%)						$	2,115
Construction Inspection (4%)						$	4,230
					TOTAL ESTIMATED COST	**$**	**138,529**

CCDD#3 Flood Protection Plan
Cost Estimate

Alternative 1+2+4: Combination Alternative

Item	Item Description	Qty	Unit	Unit Cost		Total Amount	
Alternative 1							
	Los Indios Diversion					$	1,613,311
Alternative 4							
	La Paloma Diversion					$	5,052,146
Alternative 2	Modified Downstream Main A Improvements						
Demolition							
	Demolish/Remove Flume downstream Iowa Gardens (Main A)	1	LS	$	15,000	$	15,000
	Removal of Culvert at SH100 (Drain B-1): 60" RCP	95	lf	$	40	$	3,800
	Removal of Culvert at Irrigation ditch (Drain B2-3): 4'x3' Box	70	lf	$	40	$	2,800
	Removal of Bridge at CR596 (Main A)	1	LS	$	25,000	$	25,000
Culvert							
	1-8' x 8' Box Culvert @ 95 LF	95	lf	$	800	$	76,000
	1-8' x 8' Box Culvert @ 70 LF	70	lf	$	800	$	56,000
Excavation/Fill							
	Channel Excavation	675,103	cy	$	3	$	2,025,309
Right of Way							
	Additional Right-of-Way	15	ac	$	20,000	$	300,000
Erosion/Sedimentation Controls							
	Revegetation	178,667	sy	$	3.50	$	625,335
	SWPPP Compliance	1	LS	$	8,500	$	8,500
Bridge Improvements							
	Irrigation Canal Siphon	1	LS	$	110,000	$	110,000
	Bridge Extension: FM 510 (Main A)	1,800	sf	$	118	$	212,688
Channel Lining							
	Concrete Slope Paving - Expy 77 to Iowa Gardens	5500	sy	$	8	$	44,000
Contingency (20%)						$	692,086
					SUBTOTAL	**$**	**4,196,518**
Mobilization/ Demobilization (5%)						$	209,826
Engineering and Surveying (20%)						$	839,304
Project Management (2%)						$	83,930
Construction Inspection (4%)						$	167,861
					TOTAL ESTIMATED COST	**$**	**12,162,896**

Note: Does not include relocation of any utilities

APPENDIX H
ALTERNATIVE BENEFIT CALCULATIONS

CCDD#3 Flood Protection Plan
Benefit Summary

Drain	Model	Displaced Households		Residential Property Losses ($ Millions)		Total Property Losses ($ Millions)		Business Interruptions Losses ($ Millions)		Total Benefits* ($ Millions)	
		25-year event	100-year event	25-year event	100-year event	25-year event	100-year event	25-year event	100-year event	25-year event	100-year event
Drain A	Existing Conditions	1,509	1,649	21.04	29.72	30.58	42.38	0.34	0.4		
	Alternative 2A: Drain A Downstream Improvements (45' BW)	1,540	1,657	21.78	29.61	30.29	41.83	0.35	0.4	0.28	0.55
	Alternative 2B: Drain A Downstream Improvements (100' BW)	1,432	1,638	18.59	27.69	24.05	38.21	0.31	0.38	6.56	4.19
	Alternative 4: Drain A Diversion**	1,460	1,623	19.19	28.06	27.37	39.81	0.32	0.38	3.23	2.59
	Alternative 1+2+4: Combination***	1,386	1,541	18.12	24.6	23.91	34.56	0.31	0.36	6.7	7.86
Drain C-Left	Existing Conditions	34	42	1.43	1.78	1.83	2.29	0	0		
Drain C-Right	Existing Conditions	78	90	1.38	1.56	1.66	1.88	0.01	0.02		
	Alternative 5: Drain C-Right Culvert Improvements	68	84	0.86	1.21	1.05	1.47	0.01	0.02	0.61	0.41
Drain D	Existing Conditions	73	77	1.02	1.66	1.34	2.22	0.01	0.01		
	Alternative 6: Drain D Channel Improvements	6	70	0.03	1.07	0.07	1.38	0	0.01	1.28	0.84
Drain E	Existing Conditions	143	323	2.12	4.82	3.33	7.6	0.05	0.12		
Drain F23	Existing Conditions	0	0	0.02	0.02	0.02	0.02	0	0		
	Alternative 7: Drain F-23 Culvert Improvements	0	0	0.01	0.02	0.01	0.02	0	0	0.01	0

*Total benefits is defined as the difference between existing conditions and alternative total property losses and business interruption losses.
** Property losses, business interruptions and household displacements represent damages downstream of FM 732 only.
*** Benefits do not account for damages in the La Paloma area.

Quick Assessment Report

July 25, 2008

Study Region :	Cameron_County
Scenario :	Drain F23_25-year_Existing
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	0
Short Term Shelter (# People)	0

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.02
Total Property (Capital Stock) Losses ($ Millions)	0.02
Business Interruptions (Income) Losses ($ Millions)	0.00

Disclaimer:

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain E_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	323
Short Term Shelter (# People)	829

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	4.82
Total Property (Capital Stock) Losses ($ Millions)	7.60
Business Interruptions (Income) Losses ($ Millions)	0.12

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain E_25-year_Existing
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	143
Short Term Shelter (# People)	309

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	2.12
Total Property (Capital Stock) Losses ($ Millions)	3.33
Business Interruptions (Income) Losses ($ Millions)	0.05

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain D_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	77
Short Term Shelter (# People)	189

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.66
Total Property (Capital Stock) Losses ($ Millions)	2.22
Business Interruptions (Income) Losses ($ Millions)	0.01

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain D_25-year_Existing
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	73
Short Term Shelter (# People)	178

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.02
Total Property (Capital Stock) Losses ($ Millions)	1.34
Business Interruptions (Income) Losses ($ Millions)	0.01

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain C_Right_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	90
Short Term Shelter (# People)	229

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.56
Total Property (Capital Stock) Losses ($ Millions)	1.88
Business Interruptions (Income) Losses ($ Millions)	0.02

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Quick Assessment Report

July 18, 2008

Study Region :	Cameron County, TX
Scenario :	Drain C_Right_25-year_Existing
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	78
Short Term Shelter (# People)	204

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.38
Total Property (Capital Stock) Losses ($ Millions)	1.66
Business Interruptions (Income) Losses ($ Millions)	0.01

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Quick Assessment Report

July 28, 2008

Study Region :	Cameron_County
Scenario :	Drain Cleft_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	42
Short Term Shelter (# People)	56

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.78
Total Property (Capital Stock) Losses ($ Millions)	2.29
Business Interruptions (Income) Losses ($ Millions)	0.00

Disclaimer:

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Quick Assessment Report

July 28, 2008

Study Region :	Cameron_County
Scenario :	Drain Cleft_25-year_Existing
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	34
Short Term Shelter (# People)	48

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.43
Total Property (Capital Stock) Losses ($ Millions)	1.83
Business Interruptions (Income) Losses ($ Millions)	0.00

Disclaimer:

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Quick Assessment Report

July 25, 2008

Study Region :	Cameron_County
Scenario :	Drain A_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,649
Short Term Shelter (# People)	4,009

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	29.72
Total Property (Capital Stock) Losses ($ Millions)	42.38
Business Interruptions (Income) Losses ($ Millions)	0.40

Disclaimer:

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

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Quick Assessment Report

August 12, 2008

Study Region :	Cameron County, Texas
Scenario :	Drain_A_25_Ecorr
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,509
Short Term Shelter (# People)	3,519

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	21.04
Total Property (Capital Stock) Losses ($ Millions)	30.58
Business Interruptions (Income) Losses ($ Millions)	0.34

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 and economic losses following a specific flood. These results can be improved by using enhanced inventory data and flood hazard information.

Quick Assessment Report

July 28, 2008

Study Region :	Cameron_County
Scenario :	Drain F23_100-year_Alternative
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	0
Short Term Shelter (# People)	0

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.02
Total Property (Capital Stock) Losses ($ Millions)	0.02
Business Interruptions (Income) Losses ($ Millions)	0.00

Disclaimer:

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

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Quick Assessment Report

July 28, 2008

Study Region :	Cameron_County
Scenario :	Drain F23_25-year_Alternative
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	0
Short Term Shelter (# People)	0

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.01
Total Property (Capital Stock) Losses ($ Millions)	0.01
Business Interruptions (Income) Losses ($ Millions)	0.00

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Quick Assessment Report

July 25, 2008

Study Region :	Cameron_County
Scenario :	Drain D_100-year_Alternative
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	70
Short Term Shelter (# People)	171

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.07
Total Property (Capital Stock) Losses ($ Millions)	1.38
Business Interruptions (Income) Losses ($ Millions)	0.01

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Quick Assessment Report

July 25, 2008

Study Region :	Cameron_County
Scenario :	Drain D_25-year_Alternative
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	6
Short Term Shelter (# People)	1

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.03
Total Property (Capital Stock) Losses ($ Millions)	0.07
Business Interruptions (Income) Losses ($ Millions)	0.00

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Quick Assessment Report

July 31, 2008

Study Region :	Cameron County, Texas
Scenario :	Drain Cright_100-year_Alternative
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	84
Short Term Shelter (# People)	212

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	1.21
Total Property (Capital Stock) Losses ($ Millions)	1.47
Business Interruptions (Income) Losses ($ Millions)	0.02

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Quick Assessment Report

July 21, 2008

Study Region :	Cameron County, TX
Scenario :	Drain C_Right_25-year_Alternative
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	68
Short Term Shelter (# People)	182

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.86
Total Property (Capital Stock) Losses ($ Millions)	1.05
Business Interruptions (Income) Losses ($ Millions)	0.01

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Quick Assessment Report

September 8, 2008

Study Region :	Cameron County
Scenario :	Diversion_a_100
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,623
Short Term Shelter (# People)	3,926

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	28.06
Total Property (Capital Stock) Losses ($ Millions)	39.81
Business Interruptions (Income) Losses ($ Millions)	0.38

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Quick Assessment Report

September 5, 2008

Study Region :	Cameron County, Texas
Scenario :	A_diversion_25yr
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,460
Short Term Shelter (# People)	3,380

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	19.19
Total Property (Capital Stock) Losses ($ Millions)	27.37
Business Interruptions (Income) Losses ($ Millions)	0.32

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Quick Assessment Report

July 31, 2008

Study Region :	Cameron County, Texas
Scenario :	Drain A_100-year_BW100ft
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,638
Short Term Shelter (# People)	4,048

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	27.69
Total Property (Capital Stock) Losses ($ Millions)	38.21
Business Interruptions (Income) Losses ($ Millions)	0.38

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Quick Assessment Report

July 31, 2008

Study Region :	Cameron County, Texas
Scenario :	Drain A_25-year_BW100ft
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,432
Short Term Shelter (# People)	3,362

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	18.59
Total Property (Capital Stock) Losses ($ Millions)	24.05
Business Interruptions (Income) Losses ($ Millions)	0.31

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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 and economic losses following a specific flood. These results can be improved by using enhanced inventory data and flood hazard information.

Quick Assessment Report

July 31, 2008

Study Region : Cameron County, Texas
Scenario : Drain A_100-year_Cuts
Return Period: 100
Analysis Option: 0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,657
Short Term Shelter (# People)	4,057

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	29.61
Total Property (Capital Stock) Losses ($ Millions)	41.83
Business Interruptions (Income) Losses ($ Millions)	0.40

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Quick Assessment Report

July 31, 2008

Study Region : Cameron County, Texas
Scenario : Drain A_25-year_Cuts
Return Period: 25
Analysis Option: 0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,540
Short Term Shelter (# People)	3,690

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	21.78
Total Property (Capital Stock) Losses ($ Millions)	30.29
Business Interruptions (Income) Losses ($ Millions)	0.35

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Quick Assessment Report

September 5, 2008

Study Region :	Cameron County, Texas
Scenario :	A_combototal_100
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,563 *
Short Term Shelter (# People)	3,773

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	24.90 **
Total Property (Capital Stock) Losses ($ Millions)	34.87 ***
Business Interruptions (Income) Losses ($ Millions)	0.36 ****

* Excluding La Paloma area damages: 1,541
** Excluding La Paloma area damages: 24.6
*** Excluding La Paloma area damages: 34.56
**** Excluding La Paloma area damages: 0.36

Disclaimer:

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Quick Assessment Report

September 5, 2008

Study Region :	Cameron County, Texas
Scenario :	A_Combotot_25
Return Period:	25
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	1,395 *
Short Term Shelter (# People)	3,306

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	18.26 **
Total Property (Capital Stock) Losses ($ Millions)	24.05 ***
Business Interruptions (Income) Losses ($ Millions)	0.31 ****

* Excluding La Paloma area damages: 1,386
** Excluding La Paloma area damages: 1*8.12*
*** Excluding La Paloma area damages: *23.91*
**** Excluding La Paloma area damages: *0.31*

Disclaimer:

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Quick Assessment Report

July 25, 2008

Study Region :	Cameron_County
Scenario :	Drain F23_100-year_Existing
Return Period:	100
Analysis Option:	0

Regional Statistics

Area (Square Miles)	901
Number of Census Blocks	8,764
Number of Buildings	
Residential	110,526
Total	118,025
Number of People in the Region (x 1000)	335
Building Exposure ($ Millions)	
Residential	10,687
Total	14,108

Scenario Results

Shelter Requirements

Displaced Population (# Households)	0
Short Term Shelter (# People)	0

Economic Loss

Residential Property (Capital Stock) Losses ($Millions)	0.02
Total Property (Capital Stock) Losses ($ Millions)	0.02
Business Interruptions (Income) Losses ($ Millions)	0.00

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APPENDIX I
NET PRESENT VALUE ANALYSIS

Net Present Value **Discount Rate** **0.05** **$212,709.38**

YEAR	ALT. 1 COSTS	ALT. 4 COSTS	ALT. 2 COSTS	ANNUALIZED COST	ANNUALIZED DAMAGE W/O PROJECT	ANNUALIZED DAMAGE W/PROJECT	ANNUALIZED BENEFIT
2008				$0	$9,015,950	$4,004,750	$5,011,200
2009	($400,000)	($500,000)	($1,000,000)	($1,900,000)	$9,015,950	$4,004,750	$5,011,200
2010		($1,000,000)	($1,000,000)	($2,000,000)	$9,015,950	$4,004,750	$5,011,200
2011		($1,000,000)	($1,000,000)	($2,000,000)	$9,015,950	$4,004,750	$5,011,200
2012		($1,000,000)	($1,000,000)	($2,000,000)	$9,015,950	$4,004,750	$5,011,200
2013		($1,000,000)		($1,000,000)	$9,015,950	$4,004,750	$5,011,200
2014		($500,000)		($500,000)	$9,015,950	$4,004,750	$5,011,200
2015				$0	$9,015,950	$4,004,750	$5,011,200
2016				$0	$9,015,950	$4,004,750	$5,011,200
2017				$0	$9,015,950	$4,004,750	$5,011,200
2018				$0	$9,015,950	$4,004,750	$5,011,200
2019				$0	$9,015,950	$4,004,750	$5,011,200
2020				$0	$9,015,950	$4,004,750	$5,011,200
2021				$0	$9,015,950	$4,004,750	$5,011,200
2022				$0	$9,015,950	$4,004,750	$5,011,200
2023				$0	$9,015,950	$4,004,750	$5,011,200
2024				$0	$9,015,950	$4,004,750	$5,011,200
2025				$0	$9,015,950	$4,004,750	$5,011,200
2026				$0	$9,015,950	$4,004,750	$5,011,200
2027				$0	$9,015,950	$4,004,750	$5,011,200
2028				$0	$9,015,950	$4,004,750	$5,011,200
2029				$0	$9,015,950	$4,004,750	$5,011,200
2030				$0	$9,015,950	$4,004,750	$5,011,200
2031				$0	$9,015,950	$4,004,750	$5,011,200
2032				$0	$9,015,950	$4,004,750	$5,011,200
2033				$0	$9,015,950	$4,004,750	$5,011,200
2034				$0	$9,015,950	$4,004,750	$5,011,200
2035				$0	$9,015,950	$4,004,750	$5,011,200
2036				$0	$9,015,950	$4,004,750	$5,011,200
2037				$0	$9,015,950	$4,004,750	$5,011,200
2038				$0	$9,015,950	$4,004,750	$5,011,200
2039				$0	$9,015,950	$4,004,750	$5,011,200
2040				$0	$9,015,950	$4,004,750	$5,011,200
2041				$0	$9,015,950	$4,004,750	$5,011,200
2042				$0	$9,015,950	$4,004,750	$5,011,200
2043				$0	$9,015,950	$4,004,750	$5,011,200
2044				$0	$9,015,950	$4,004,750	$5,011,200
2045				$0	$9,015,950	$4,004,750	$5,011,200
2046				$0	$9,015,950	$4,004,750	$5,011,200
2047				$0	$9,015,950	$4,004,750	$5,011,200
2048				$0	$9,015,950	$4,004,750	$5,011,200
2049				$0	$9,015,950	$4,004,750	$5,011,200
2050				$0	$9,015,950	$4,004,750	$5,011,200
2051				$0	$9,015,950	$4,004,750	$5,011,200
2052				$0	$9,015,950	$4,004,750	$5,011,200
2053				$0	$9,015,950	$4,004,750	$5,011,200
2054				$0	$9,015,950	$4,004,750	$5,011,200
2055				$0	$9,015,950	$4,004,750	$5,011,200
2056				$0	$9,015,950	$4,004,750	$5,011,200
2057				$0	$9,015,950	$4,004,750	$5,011,200

Annualized Damage calculation

Existing Condition		with Combination Alternative	
freq	damage	freq	damage
0.75	0	0.5	0
0.1	$19,730,000	0.1	$10,480,000
0.04	$30,580,000	0.04	$23,910,000
0.01	$42,380,000	0.01	$34,560,000
0.00099	$480,639,303	0.00099	$480,639,303

x	y	h	a	b	Area
0.75	0				
0.1	$19,730,000	0.65	$19,730,000	0	$6,412,250
0.04	$30,580,000	0.06	$30,580,000	$19,730,000	$1,509,300
0.01	$42,380,000	0.03	$42,380,000	$30,580,000	$1,094,400
				Total Area	$9,015,950

x	y	h	a	b	Area
0.5	0				
0.1	$10,480,000	0.4	$10,480,000	0	$2,096,000
0.04	$23,910,000	0.06	$23,910,000	$10,480,000	$1,031,700
0.01	$34,560,000	0.03	$34,560,000	$23,910,000	$877,050
				Total Area	$4,004,750

Difference / Annualized Benefit $5,011,200

APPENDIX J
RANKING & PRIORITIZATION

Where is your flood protection money BEST spent?

Benefits existing ratepayers	Maximizes Conveyance	Shortens flood duration	Keeps water off of critical public facilities (hospital, fire station, etc.)
Benefits future development	Permitting resistance or difficulty	Time to implement / construct	Provides at least a 25-year level of protection
Can be implemented independent of other projects	Potential for leveraged funds	Environmental or habitat enhancement	Damage Reduction (Relative dollar benefit)
Enhances water quality	Potential for Recreational use	Promotes orderly development or improve economic development potential	Low O&M Costs

Blue chips - Highest Priority

Red chips - Medium Priority

Yellow chips - Lowest Priority

Prioritization Factors Weighting	Number of Bets			Value of Bets			
	Blue	Red	Yellow	Blue	Red	Yellow	Total
	Highest	Medium	Lowest	***10***	***5***	***1***	
Benefits existing ratepayers	5	1	0	50	5	0	*55*
Maximizes Conveyance	3	2	1	30	10	1	*41*
Shortens flood duration	4	2	0	40	10	0	*50*
Keeps water off of critical public facilities (Hospital, fire station, etc.)	5	0	1	50	0	1	*51*
Benefits future development	3	2	1	30	10	1	*41*
Permitting resistance or difficulty	0	2	4	0	10	4	*14*
Time to implement / construct	0	2	4	0	10	4	*14*
Provides at least a 25-year level of protection	1	5	0	10	25	0	*35*
Can be implemented independent of other projects	0	3	3	0	15	3	*18*
Potential for leveraged funds	4	2	0	40	10	0	*50*
Environmental or habitat enchancement	0	2	4	0	10	4	*14*
Damage Reduction (Relative dollar benefit)	4	2	0	40	10	0	*50*
Enchances water quality	0	4	2	0	20	2	*22*
Potential for Recreational use	0	0	6	0	0	6	*6*
Promotes orderly development or improve economic development potential	0	4	2	0	20	2	*22*
Low O&M Costs	1	3	2	10	15	2	*27*

Prioritization factors (sorted by value of bets)		Weight
Benefits existing ratepayers	55	5
Keeps water off of critical public facilities (Hospital, fire station, etc.)	51	5
Shortens flood duration	50	5
Potential for leveraged funds	50	5
Damage Reduction (Relative dollar benefit)	50	5
Maximizes Conveyance	41	4
Benefits future development	41	4
Provides at least a 25-year level of protection	35	3
Low O&M Costs	27	2
Enchances water quality	22	2
Promotes orderly development or improve economic development potential	22	2
Can be implemented independent of other projects	18	1
Permitting resistance or difficulty	14	1
Time to implement / construct	14	1
Environmental or habitat enchancement	14	1
Potential for Recreational use	6	1

Prioritization Ranking Factors	Ranking Factor Weight	Alt. 1: Los Indios Diversion		Alt. 2: Drain 'A' Downstream Improvements		Alt.3: Drain 'A' Detention		Alt. 4: La Paloma Diversion		Alt. 5: Drain C-Right Culvert Improvements	
		Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Benefits existing ratepayers	5	3	15	3	15	1	5	3	15	3	15
Keeps water off of critical public facilities (Hospital, fire station, etc.)	5	2	10	3	15	1	5	3	15	3	15
Shortens flood duration	5	3	15	1	5	1	5	3	15	2	10
Potential for leveraged funds	5	1	5	3	15	1	5	3	15	1	5
Damage Reduction (Relative dollar benefit)	5	1	5	2	10	1	5	3	15	1	5
Maximizes Conveyance	4	3	12	3	12	1	4	3	12	3	12
Benefits future development	4	3	12	2	8	2	8	3	12	3	12
Provides at least a 25-year level of protection	3	2	6	3	9	1	3	3	9	3	9
Low O&M Costs	2	1	2	2	4	3	6	2	4	3	6
Enchances water quality	2	1	2	1	2	3	6	2	4	1	2
Promotes orderly development or improve economic development potential	2	3	6	1	2	1	2	3	6	1	2
Can be implemented independent of other projects	1	3	3	3	3	2	2	3	3	3	3
Permitting resistance or difficulty	1	1	1	2	2	2	2	1	1	2	2
Time to implement / construct	1	2	2	1	1	2	2	2	2	2	2
Environmental or habitat enchancement	1	1	1	1	1	3	3	3	3	1	1
Potential for Recreational use	1	1	1	1	1	3	3	1	1	1	1
			98		105		66		132		102

Prioritization Ranking Factors	Ranking Factor Weight	Alt. 6: Drain D Channel		Alt. 7: Drain F-23 Culvert		Combination Alternative:		Maximum	
		Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score	Project Specific Score	Project Specific Weighted Score
Benefits existing ratepayers	5	3	15	3	15	3	15	3	15
Keeps water off of critical public facilities (Hospital, fire station, etc.)	5	3	15	3	15	3	15	3	15
Shortens flood duration	5	3	15	2	10	3	15	3	15
Potential for leveraged funds	5	2	10	1	5	3	15	3	15
Damage Reduction (Relative dollar benefit)	5	2	10	1	5	3	15	3	15
Maximizes Conveyance	4	3	12	3	12	3	12	3	12
Benefits future development	4	2	8	3	12	3	12	3	12
Provides at least a 25-year level of protection	3	2	6	3	9	3	9	3	9
Low O&M Costs	2	1	2	2	4	2	4	3	6
Enchances water quality	2	1	2	1	2	2	4	3	6
Promotes orderly development or improve economic development potential	2	2	4	2	4	3	6	3	6
Can be implemented independent of other projects	1	2	2	3	3	2	2	3	3
Permitting resistance or difficulty	1	2	2	3	3	1	1	3	3
Time to implement / construct	1	2	2	3	3	2	2	3	3
Environmental or habitat enchancement	1	1	1	1	1	3	3	3	3
Potential for Recreational use	1	1	1	1	1	3	3	3	3
			107		104		133		141

APPENDIX K
IMPLEMENTATION PLAN

Implementation Plan

Action Item	Funding Source / Regulation / Effort Type / Lead Entities	Priority
Action 1.1 : Complete construction of Phases II and III of Alternative 1, Los Indios Diversion	Capital Outlay	Immediate
Action 1.2 : Begin design, right-of-way acquisition, permitting and construction of the La Paloma Diversion (Alternative 4).	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Immediate
Action 1.3 : Begin design, right-of-way acquisition, permitting and construction on the Drain 'D' Channel Improvements (Alternative 6).	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Short-Term
Action 1.4 : Begin design, right-of-way acquisition, permitting and construction on the Drain 'A' Channel Improvements (Alternative 2).	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Short-Term
Action 1.5 : Begin design, right-of-way acquisition, permitting and construction on the Drain F-23 Culvert Improvements (Alternative 7).	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Short-Term
Action 1.6: Begin design, right-of-way acquisition, permitting and construction on the Drain C-Right Culvert Improvements (Alternative 5).	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Short-Term
Action 2.1 : Evaluate the feasibility of requiring on-site detention for at least the 10% annual chance event to mitigate the impacts of development.	Regulation	Immediate; Ongoing
Action 2.2 : Coordinate with local government partners such as Cameron County, the City of San Benito, the City of Harlingen, and the City of Los Indios to establish common standrads and hydrologic and hydraulic methods and assumptions.	Regulation / Coordination	Immediate; Ongoing
Action 3.1 : Implementation of the Combination Alternative will bring the most reduction of tailwater to Drain A, and therefore to the B-Drains.	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Immediate
Action 3.2 : Publish the benchmark system established during the course of this study; this will bring greater efficiency to the design process for the District, its local partners, and private development.	District Engineer / Administration	Short-Term
Action 4.1 : 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.	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Short-Term; Ongoing
Action 4.2 : Acquire sufficient right-of-way to introduce a bench channel section in implementing Alternative 2. (insert diagram)	Capital Outlay; ROW Dedication; HMGP and FMA Grant Funds	Immediate; Ongoing
Action 5.1 : The District's ability to provide higher levels of flood protection are limited by regional topography, available right-of-way, and existing encroachment into the floodplain. While especially true for large events (100-year and 25-year), the improvements contemplated by the District will have significant effect on smaller events (2-year through 25-year). The current level of risk for larger events should be made freely available through dissemination of floodplain maps, both paper and digital.	District Engineer / Administration	Short-Term; Ongoing
Action 5.2 : 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 CCDD#3 activities.	Coordination / GM / Board	Short-Term
Action 5.3: Identify neighborhood leaders in flood-prone neighborhoods and develop a specific outreach campaign with their guidance.	Coordination / GM / Board	Short-Term
Action 5.4: Work with private industry and other stakeholders to develop and implement a program to distribute NOAA All Hazards Weather Radios to the public.	Coordination / GM / private partners	Long-Term
Action 5.5: Working with other authorities, develop a specific plat note requirement to explain the limitations of flood protection in the Lower Rio Grande Valley.	Coordination / GM / County / Cities & Towns / other Districts	Short-Term
Action 5.6: Coordinate and participate in public awareness activities about the National Flood Insurance Program through the Regional NFIP Coordinator (956-421-3214)	Coordination / GM / TWDB	Immediate
Action 6.1 : Recognizing that the illegal dumping problem is a regional issue, work with the Lower Rio Grande Valley Development Council to find the best long-term solutions.	Coordination / GM / County / Cities & Towns / other Districts / LRGVDC	Long-Term
Action 6.2 : Pursue grant funded opportunities through TCEQ and LRGVDC to hast "clean-up"activities.	Coordination / GM / County / Cities & Towns / other Districts / LRGVDC	Long-Term
Action 6.3 : Develop a public awareness program using signs at access pointsto CCDD#3 ditches. Slogans and posters in two languages could be developed by working with area middle schools (school-wide competition, for example). Examples of such slogans: "You dump, we have to pump" and "Basurs tirada, casa inundada"	Coordination / GM / County / Cities & Towns / other Districts / LRGVDC / School Districts	Long-Term
Action 6.4 : Install gates at access points.	Capital Outlay; Grant Funds	Short-Term
Action 6.5 : Reach out to neighborhood leaders to explain the issue and risks, and solicit their input on ways to curb the problem and raise awareness.	Coordination / GM / Board / Public	Long-Term; Ongoing
Action 7.1 : Begin the installation of telemetry-based gages to monitor flow, stage, and velocity.	Capital Outlay	Long-Term
Action 7.2 : Perform a model update on a bi-annual basis to incorporate new developemnt and calibration data, if available.	-	Long-Term
Action 7.3 : Assess and prioritize the remaining construction projects, knowing that many conditions in the watershed will change over time.	-	Long-Term

Implementation Plan

Action 8.1 : The District should make the information contained within this study freely available to the City of San Benito and the development community. For instance, post-processed LiDAR data and the hydraulic models bring significant vaalue to new and revelopment projects under consideration.	Coordination / GM / District Engineer / San Benito / Outside Entities	Immediate; Ongoing
Action 8.2 : (San Benito) Initiate a program to map stormwater outfalls and infrastructure (inlets, culverts, flumes, pipes, etc.) This effort can also be the foundation of a TPDES MS4 Compliance Plan.1	San Benito / Capital Projects Fund / Utility Fund / TCEQ Grant Funds	Immediate; Ongoing
Action 8.3 : Form a citizens Advisory Committee for Drainage. The purpose of this committee would be to prioritize local drainage problems in the City, working with the City's Public Works Department as the lead entity, in connection with Action 8.4 below.	Coordination / San Benito Public Works Dept. / City Council / Public	Ongoing
Action 8.4 : Seek EPA and CDBG Funds to assist in the development of Master Drainage Plan. The Purpose of the Plan would be to develop a complete hydraulic model of the City's local drainage system that would enable the formulation of alternative and provide the technical guidance for capital project implementation.	City of San Benito / EPA/ CDBG/TCEQ	Ongoing

APPENDIX L
DIGITAL DATA

APPENDIX M
TWDB COMMENTS

CAMERON COUNTY DRAINAGE DISTRICT NO. THREE

1301 FM 510 P.O. BOX 937 SAN BENITO, TEXAS 78586
Phone (956) 399-7637 Fax (956) 399-7156

Sonia Lambert - General Manager

February 1, 2010

Ms. Kathy Hopkins, CFM
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

Re: Flood Protection Planning Contract between the Texas Water Development Board (TWDB) and the Cameron County Drainage District No. 3 (CCDD#3),, TWDB Contract No. 0704830723, Final Report Comments

Dear Ms. Hopkins:

Thank you for your time in review of the above-referenced report, and for the TWDB's support of this project of CCDD#3. Following is an itemized response (*italics*) to the comments dated December 3, 2009:

1. Page 2, Section 1.2, Table 1; the description of February 18-21, 1982 continues into the next storm event description. Please correct. *This table has been corrected.*

2. Section 1.3, Pages 3-5, this section provides a discussion of the 2nd and 3rd public meeting, but does not mention the 1st public meeting. Please include a discussion of the 1st public meeting. *This section has been re-written to clarify the discussion of the 1st public meeting.*

3. Correct all punctuation, grammar, and formatting errors throughout the document. For example, Page 4, the period is missing at the end of the second paragraph and the next bullet should be moved down a space. *The document has been revised throughout to correct miscellaneous punctuation, grammar, and formatting errors.*

4. Section 8.1, Page 49, label the figure. *The figure has been labeled.*

5. Section 8.5.3 and Section 8.6, the scale of the Figures 9 and 10 are difficult to read. Please consider enlarging. *These figures have been enlarged.*

6. Provide an executive summary for the plan which gives a general description of the scope of the study and the alternatives derived. *An executive summary has been provided.*

7. 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. *Noted, Thank you!*

Attached please find six (6) bound double-sided copies of the final report, as well as one (1) CD-ROM containing the entire Final Report and related computer models. The Board of Directors adopted the Flood Protection Plan on November 11, 2009.

Please feel free to contact me if you have any questions.

Cordially,

Sonia K. Lambert

Sonia K. Lambert
General Manager

Encl.

Cc: Mr. Chris Stewart, AICP, Espey Consultants, Inc.

TEXAS WATER DEVELOPMENT BOARD

December 3, 2009

Ms. Sonia Lambert
General Manager
Cameron County Drainage Dist. No. 3
P.O. Box 937
San Benito, Texas 78586

Re: Flood Protection Planning Contract between the Texas Water Development Board (TWDB) and the Cameron County Drainage District No. 3 (CCDD#3), TWDB Contract No. 0704830723, Draft Final Report Comments

Dear Ms. Lambert:

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 CCDD#3 will consider incorporating draft report comments from the EXECUTIVE ADMINISTRATOR as well as other reviewers into the final report. In addition, the CCDD#3 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 CCDD#3 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,

Dan Harden
for 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. 0704830723
Cameron County Drainage District # 3 Flood Protection Plan

1) Page 2, Section 1.2, Table 1; the description of February 18-21, 1982 continues into the next storm event description. Please correct.

2) Section 1.3, Pages 3-5, this section provides a discussion of the 2nd and 3rd public meeting, but does not mention the 1st public meeting. Please include a discussion of the 1st public meeting.

3) Correct all punctuation, grammar, and formatting errors throughout the document. For example, Page 4, the period is missing at the end of the second paragraph and the next bullet should be moved down a space.

4) Section 8.1, Page 49, label the figure.

5) Section 8.5.3 and Section 8.6, the scale of the Figures 9 and 10 are difficult to read. Please consider enlarging.

6) Provide an executive summary for the plan which gives a general description of the scope of the study and the alternatives derived.

7) 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.