Appendix A-1 – Halff Reports

Lower Guadalupe Feasibility Study
(Guadalupe and Blanco Rivers), TX
Integrated Draft Feasibility Report and Environmental Impact Assessment

December 2019

US Army Corps
of Engineers®
Fort Worth District

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US Army Corps of Engineers
Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study – Phase 1

Technical Report Notebook (TRN)
Appendix A
Topographic Data Development

Lower Guadalupe, Blanco, and San Marcos River Watersheds

Submitted to:

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AVO 28411/28411B
March 2014

Topographic Data Development
TECHNICAL REPORT NOTEBOOK

APPENDIX A
TABLE OF CONTENTS

TOPOGRAPHIC DATA TECHNICAL REPORT NOTEBOOK INTRODUCTION

This Technical Report Notebook (TRN) presents the Topographic Data Development of the flooding sources related to the Guadalupe-Blanco River Authority (GBRA) Interim Feasibility Study. The study area includes Comal, Caldwell, Dewitt, Guadalupe, Gonzales, Hays, and Victoria Counties (Figure 1). This TRN supports the creation of a continuous topographic model of the Lower Guadalupe River Watershed as part of Phase 1 of the study.

TASK SUMMARY

Following is the task summary for the Topographic Data Feasibility Study TRN in the Lower Guadalupe, Blanco, and San Marcos River Watersheds. Existing topographic and elevation data (previously flown and processed) will be used to produce a basin wide terrain dataset. Multiple sources of data will be utilized including, but not limited to data from U.S. Army Corps of Engineers (USACE), Federal Emergency Management Association (FEMA), Capital Area Council of Governments (CAPCOG), Texas Natural Resource Information System (TNRIS), United States Geological Survey (USGS), and the City of Austin (COA).

The terrain data set utilizes the best available topographic information. Halff Associates compiled LiDAR data from previous studies and sources within the GBRA study area. These data were processed to create a terrain dataset and were used for hydrologic analysis, hydraulic analysis, and floodplain mapping. Where there was overlapping LiDAR data, the LiDAR with the highest quality was used. This project follows Halff Associates stringent quality assurance and quality control procedures and meets all policies and guidelines.

Detailed descriptions of the data from the different sources, where available, are included in Appendix A.1. Source input files used in the terrain dataset creation and the terrain data set itself are available upon request due to large file size.

METHODOLOGY

Acquisitions

LiDAR data was acquired from several different sources for most of the Lower Guadalupe River Basin. A list of acquired datasets is presented in Table 1 including age, accuracy, source, and approximate coverage. High quality LiDAR data was acquired for all counties in the study area except DeWitt County. County-wide LiDAR has not been flown for DeWitt County to date. However, the Corps of Engineers did acquire a strip of LiDAR along the Guadalupe River for approximately half the river length within the County. A USGS Digital Elevation Model (DEM) acquired from TNRIS was used for the remaining area of DeWitt County. A map of the topographic data coverage can be seen in Figure 2.

Table 1: LiDAR Data Source

County	Age	Accuracy	Source & Contact	Approximate Footprint (sq mi)
Bastrop	2008	0.70m	CAPCOG	65
Caldwell	2007	1.40m	CAPCOG	750
	2008	0.70m	CAPCOG	150
Comal	2011	0.61m	FEMA	600
Dewitt		DEM	TNRIS	350
	2012	0.51m	USACE	50
Fayette	2008	0.70m	CAPCOG	120
Guadalupe	2008	1.40m	CAPCOG	10
	2007	1.40m	CAPCOG	90
	2011	0.61m	FEMA	600
Gonzales	2009	1.00m	TNRIS	1200
Hays	2008	0.70m	CAPCOG	750
	2003	1.70m	COA	130
	2011	0.61m	FEMA	25
Victoria	2006	1.40m	FEMA	650

Processing

The LiDAR data throughout the study area was provided in LAS format. The LAS files were converted to multipoint files and used to create the Digital Terrain Model (DTM) using Environmental System Research Institute (ESRI) ArcGIS software. Where applicable, a Z-scale of 3.28 was used for the conversion of elevation data in meters to feet. The original LAS files were in State Plane Texas Central 4203 projection and State Plane Texas South Central 4204. LAS files in State Plan Texas Central 4203 were converted into State Plane Texas South Central 4204. The LAS files were processed to create a terrain for use in hydraulic and hydrologic analysis and floodplain mapping. The terrain uses North American Datum (NAD) 1983 with elevations in North American Vertical Datum (NAVD) 1988. Six different resolutions or thresholds were defined for each Z-tolerance pyramid level as shown in Table 2.

Table 2: GBRA Terrain Database Z Tolerance

No	Z Tolerance	Maximum Scale
1	0.25	3600
2	0.50	4800
3	1.00	6000
4	2.00	12000
5	5.00	24000
6	10.0	36000

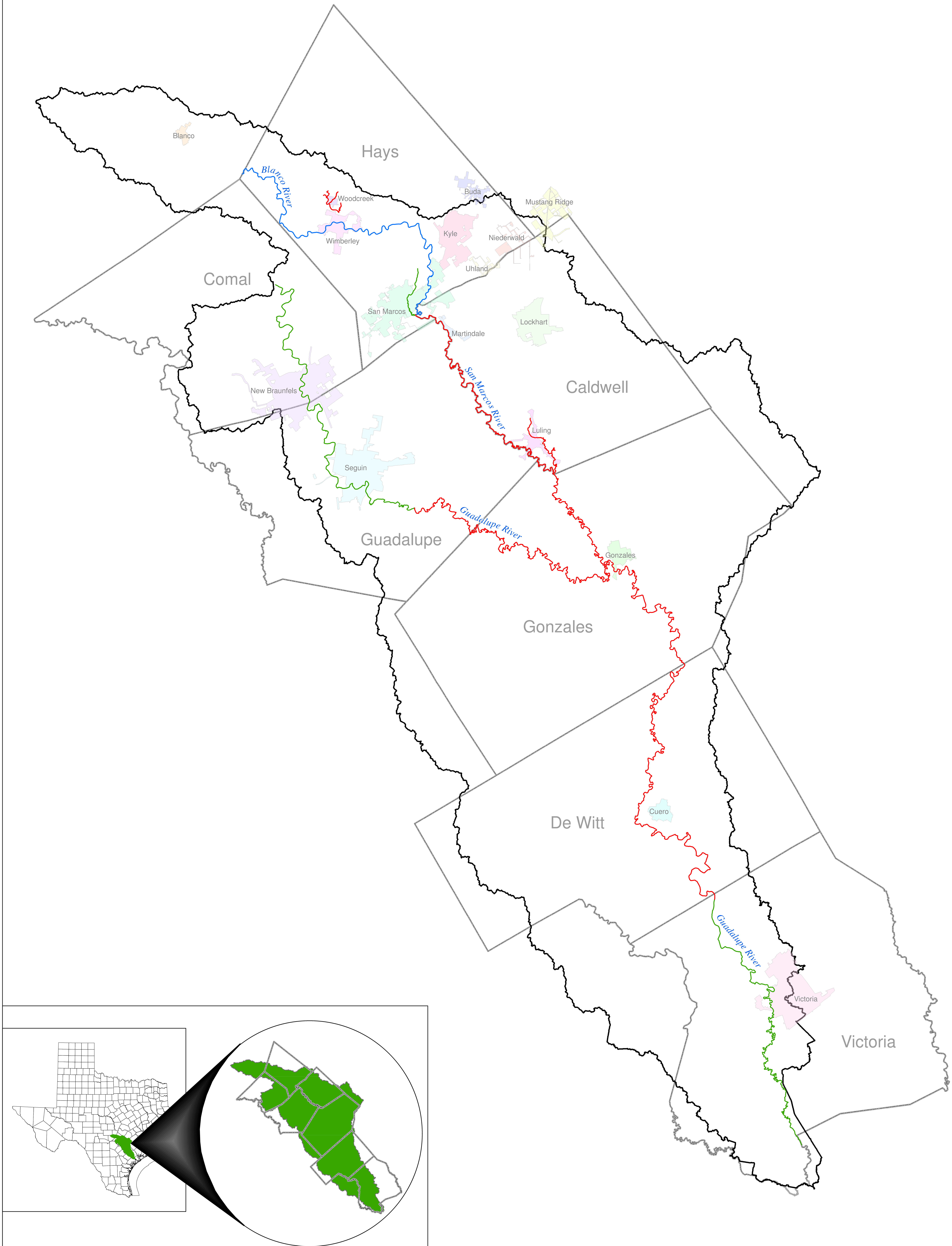
Data Evaluation QA/QC

It was assumed that the LiDAR datasets obtained from the different sources had been previously evaluated for quality control by the contractor that collected the data. Any issues discovered after the LiDAR data was compiled in to a terrain dataset were reported to the respective source and addressed appropriately.

RESULTS

DEMs were created from the compiled terrain dataset for both hydrologic and hydraulic studies. A basin-wide 30-ft by 30-ft DEM was created for delineated hydrologic sub-basins and a 3-ft by 3-ft DEM along the river corridors was created for cutting hydraulic cross-sections and floodplain mapping. The 30-ft by 30-ft basin-wide DEM dataset is included on the DVD in Appendix A.2. Figure 3 shows the final basin-wide 30-ft by 30 DEM as an example of the topographic data derived from the compiled terrain dataset.

Figures



Key to Features

- New Detailed Study
- New Limited Detail Study
- Incorporated Study
- Lower Guadalupe River Basin
- County Boundary

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GBRA Interim Feasibility Study - Phase 1

Figure 1. Project Study Area

N W E S

0 10 20 Miles

1 inch = 5 miles

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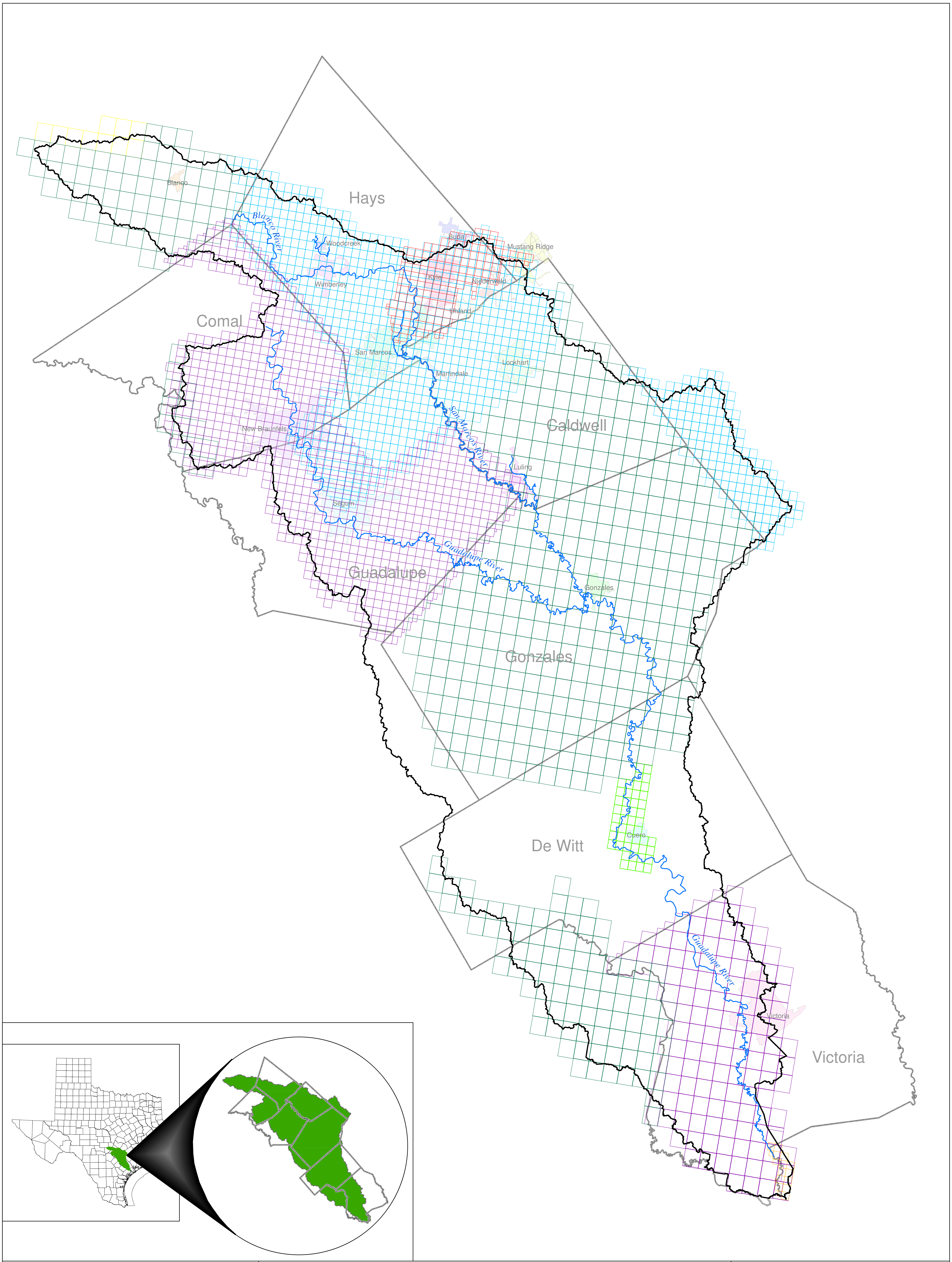

Key to Features

- Study Streams
- Lower Guadalupe River Basin

LiDAR Tiles by Source

- CAPCOG
- City of Austin
- FEMA
- LCRA
- TNRIS
- USGS
- USACE

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GBRA Interim Feasibility Study - Phase 1

Figure 2.
LiDAR Data Coverage

0 10 20 Miles

1 inch = 5 miles

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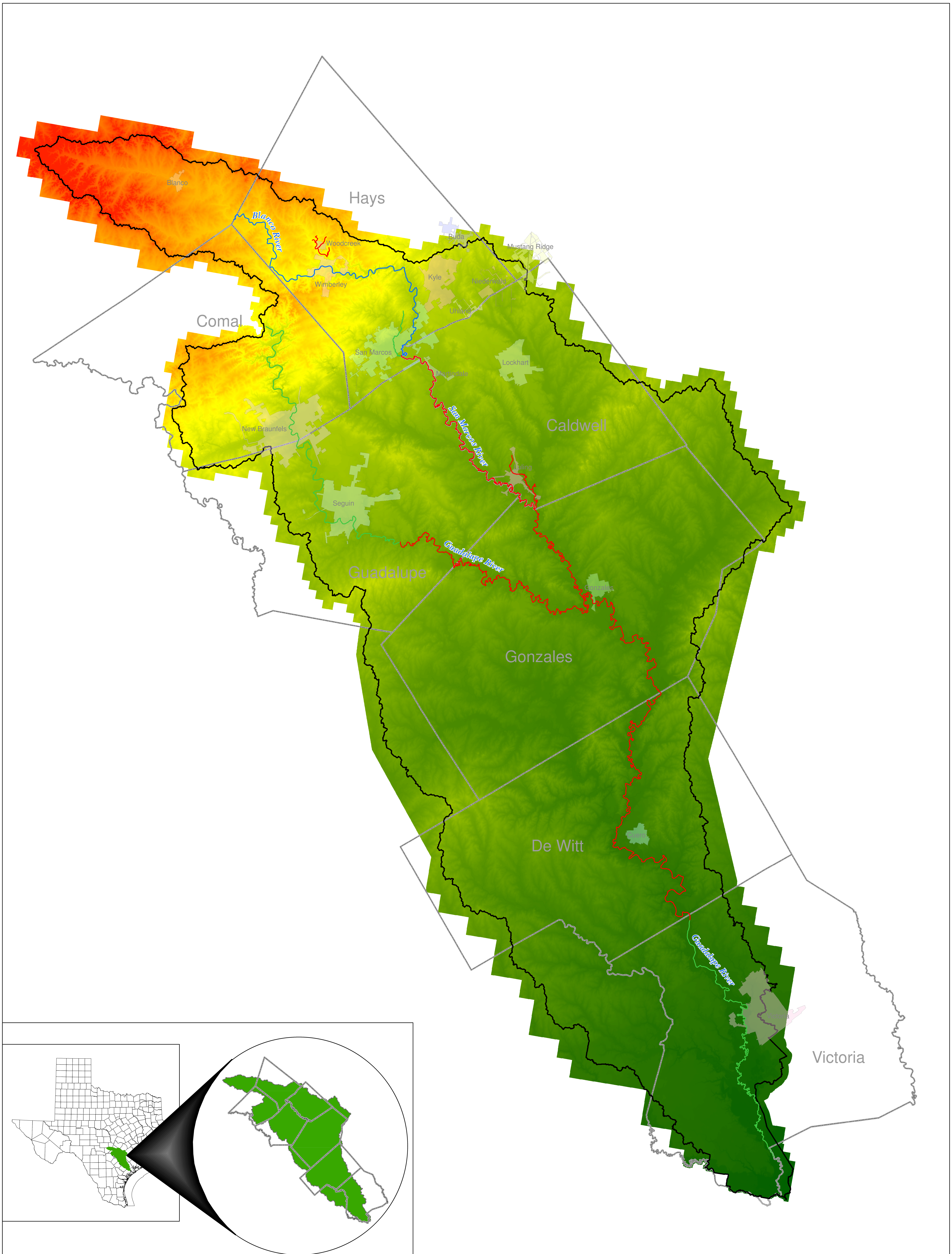

Key to Features

- New Detailed Study
- Blanco River
- Guad Incorp
- Lower Guadalupe River Basin

30 ft. DEM

High : 3000

Low : -785.827

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Interim Feasibility Study - Phase 1

Figure 3.
30 ft. X 30 ft.
Basin-wide DEM

N W E S

0 10 20 Miles

1 inch = 5 miles

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Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study – Phase 1
Technical Report Notebook (TRN)
Appendix B.1
Engineering Analysis – Hydrology

Lower Guadalupe, Blanco, and San Marcos River Watersheds

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HYDROLOGY
TECHNICAL REPORT NOTEBOOK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX B.1.1: COMPUTED PEAK DISCHARGE

APPENDIX B.1.2: SUPPORTING DOCUMENTS

APPENDIX B.1.3: CALIBRATION RESULTS

APPENDIX B.1.4: QUALITY ASSURANCE

APPENDIX B.1.5: DIGITAL DATA - DVD

HYDROLOGY TECHNICAL REPORT NOTEBOOK INTRODUCTION

The US Army Corps of Engineers (USACE) Lower Guadalupe River Basin Interim Feasibility Study Phase 1 is located within the Guadalupe-Blanco River Authority (GBRA) jurisdictional area. The GBRA has partnered with the USACE and the Texas Water Development Board (TWDB). This study is being funded through a USACE Feasibility Cost Share Agreement, a TWDB Flood Protection Planning Grant, and local funds.

Phase 1 consists of the development of existing hydrology, floodplain hydraulics, plan formulation, environmental constraints, and economics for the Lower Guadalupe, Blanco, and San Marcos Rivers as well as selected streams in Luling and Woodcreek, Texas. Hydrologic modeling for Luling and Woodcreek streams will be covered in separate technical report notebooks. The basin-wide hydrologic analysis will consist of a new calibrated hydrology model for the Lower Guadalupe River basin and frequency flows developed from a USACE basin-wide gage analysis. Hydraulic analyses on the Guadalupe, Blanco, and San Marcos Rivers were developed for approximately 420 miles of stream including about 132 miles of new detailed study that will require field surveys to be incorporated into the hydraulic model.

The Lower Guadalupe River basin has a drainage area of approximately 4,530 square miles between Canyon Dam and the confluence of the Guadalupe and San Antonio Rivers. Approximately 18 operational United States Geological Survey (USGS) discharge gages and 11 National Weather Service (NWS) forecast points are located within the Lower Guadalupe River basin. See Figure 1 for a general location map of the Lower Guadalupe River Basin with NWS forecast points and USGS gages.

TASK SUMMARY

Activities included in this hydrology TRN submittal are described in the Lower Guadalupe River Basin GBRA Interim Feasibility Study Phase 1 base contract scope of services for hydrology (W1928G-09-D-0044).

22P00 – Engineering and Design/Cost Estimating

Model development will occur in both the Base contract for the mainstem channels and flood plain and Option 1 for the tributary reaches studied in detail. The following is a summary of general guidance for the hydrologic model development:

- Discharges shall be computed for 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500 year recurrence intervals for both existing and future without project conditions.
- Point rainfall source shall be discussed with the COE and GBRA prior to use in the hydrologic analysis. It is not to be assumed that the current USGS point rainfall is the appropriate source of data.
- Figure 15 of NWS Technical Paper 40 will be used for aerial reduction.
- Snyder's Unit Hydrograph method will be used with lag times determined with consideration of the Fort Worth District's methodology.

- The routing methodology will be discussed and agreed to prior to model development.
- Block and Uniform loss rates will be used.
- Sub-basins should be sized as large as possible to support an accurate analysis for both the main stems and tributary streams studied up to the 1.5 square mile drainage area limit.
- Coordinate with the COE for results of the frequency analysis at gage sites based on systematic and historical records where applicable.
- Calibrate the hydrologic model to the frequency analysis results performed by the COE and storm reproductions where applicable.

Base Contract

4. Collection of baseline Information – This phase will identify flood-prone areas based on citizen input and city and county records. The team will acquire, assemble, and review available GIS datasets, LIDAR topography, digital ortho-photography, cross-section data, currently effective FEMA models, and previous drainage and engineering studies. Extensive coordination with participating entities will also ensure that resources are directed in the most efficient manner.
5. Hydrologic Model Development – A basin-wide HEC-HMS hydrologic model will be developed using HEC Geo-HMS. This will allow inclusion of existing city and county GIS data, and potentially reduce the time and effort needed to develop hydrologic modeling parameters. The model will include both existing and estimated future land use conditions, and will utilize existing city and county GIS data, CAPCOG, AACOG, GCRPC data and STATSGO or SSURGO soil information to generate hydrologic modeling parameters. Detailed stream network routing will be developed.
6. For the main stem, a single hydrologic model of the Guadalupe and San Marcos-Blanco Rivers will be developed using sub-basin delineations appropriate for the scale of the watershed model. Sub-basin size will be discussed and agreed to prior to execution of Geo-HMS. Rainfall will be discussed and agreed to prior to use in the HEC-HMS model. These models will be developed using methods appropriate for the study area. A calibration analysis based on historical record of rainfall and discharge will be performed. These frequencies will be compared to current USGS regression equations and the effective FEMA discharges where available. Prior to initiation of model development discussions will be held with the technical COE team members to determine the modeling assumptions and details.

METHODOLOGY

The hydrologic methods used for this study are in accordance with the Guidelines and Specifications of Flood Hazard Mapping Partners dated April 2003. The following is a summary of data sources, assumptions, and procedures used to create the Lower Guadalupe River basin-wide hydrologic analysis for the GBRA Interim Feasibility Study Phase 1.

The flood event category nomenclature in this report uses the percent annual chance exceedance (ACE) terminology and is related to the classic annual recurrence interval terminology as shown in the Table 1 below.

Table 1. Flood Event Category Nomenclature

Classic Terminology	Percent Annual Chance Exceedance
2-Year Flood	50 % ACE
5-Year Flood	20 % ACE
10-Year Flood	10 % ACE
25-Year Flood	4 % ACE
50-Year Flood	2 % ACE
100-Year Flood	1 % ACE
250-Year Flood	0.4 % ACE
500-Year Flood	0.2 % ACE

Rainfall-Runoff Method

Lower Guadalupe River basin-wide hydrologic model was developed using HEC-HMS version 3.5. The model uses the Block and Uniform loss rate method. Snyder's Unit Hydrograph was selected with lag times determined using the USACE Fort Worth District Urbanization Curve method.

Drainage Basin Area Delineation

Topographic Data
The primary source of topographic data used in this study was developed from the 2007-2008 CAPCOG and TNRIS LiDAR data. LAS files are the standard open format for storing LiDAR point records. The LAS file format (binary file format) is an alternative to proprietary systems or a generic ASCII file interchange system used by many companies that obtain LiDAR. Halff Associates generated a GBRA wide bare earth terrain dataset using the LiDAR described in Table 2. No LiDAR data was available for a substantial portion of DeWitt County. USGS topographic data was used to fill in DeWitt County area that had no LiDAR Data. Halff Associates used the terrain dataset to generate 30 ft. by 30 ft. digital elevation models (DEMs) for the hydrologic study and 3 ft. by 3 ft. digital DEMs for hydraulic studies.

Table 2: LiDAR Data Source

County	Age	Horizontal Accuracy	Source & Contact	Approximate Footprint (sq mi)
Bastrop	2008	0.70m	CAPCOG	65
Caldwell	2007	1.40m	CAPCOG	750
	2008	0.70m	CAPCOG	150
Comal	2011	0.61m	FEMA	600
DeWitt	2012	0.51m	USACE	50
Fayette	2008	0.70m	CAPCOG	120
Guadalupe	2008	1.40m	CAPCOG	10
	2007	1.40m	CAPCOG	90
	2011	0.61m	FEMA	600
Gonzales	2009	1.00m	TNRIS	1200
Hays	2008	0.70m	CAPCOG	750
	2003	1.70m	COA	130
	2011	0.61m	FEMA	25
Victoria	2006	1.40m	FEMA	650

Coordinate Systems

The standard coordinate system used for the GBRA area is NAD 83 (1993) State Plane Coordinates, Texas South Central (Zone 4204) presented in US Survey Feet with a Vertical Datum of North American Vertical Datum of 1988.

Sub-basin Delineation

The sub-basin delineation for the Lower Guadalupe River basin was developed using HEC-GeoHMS version 5.0. Sub-basins were checked and merged or split to maintain a consistent sub-basin size and to ensure adequate resolution for the headwaters of the study streams. The Lower Guadalupe River basin was divided into 50 sub-basins ranging in size from 17 to 175 square miles. The smaller sub-basins were created to accommodate important confluences and USGS gages. The larger sub-basins were created in areas not affecting hydraulic study reaches. The sub-basin delineation displayed in Figure 2 has been previously approved by Corps staff.

Hydrologic Parameter Estimation

Precipitation Data

Point precipitation was not calculated for the Lower Guadalupe basin-wide hydrologic analysis. Frequency flows for use in the final hydraulic models were derived from a USACE gage analysis (Appendix B.1.2.e). National Weather Service (NWS) gridded precipitation data was used for calibration of the hydrologic model to the October 1998, July 2002, and November 2004 events. The precipitation data consists of hourly rainfall grids for the period before, during, and after each storm event. All gridded precipitation is included with the hydrology model on the DVD in Appendix B.1.5.

Loss Rate Parameters

Runoff losses were computed using the Block and Uniform loss rate method. As part of the Fort Worth District USACE methodology, the percent sand parameter is a primary indicator for projecting both rainfall losses and unit hydrograph lag times. On a sub-basin scale, the percent sand parameter generally ranges from zero to one hundred (percent) with zero representing areas with highly impermeable clayey soils and one hundred representing areas with highly permeable sandy soils. Figure 3 illustrates the percent sand values for the soils in the Lower Guadalupe River basin.

The percent sand value is a representation of permeability rather than the actual grain size content of a soil. Soils with permeability ranging between 2 and 6 inches per hour are assigned a 133 percent sand value, those few with permeability ranging between 6 and 20 inches per hour are assigned a 167 percent sand value, and those with permeability in excess of 20 inches per hour are assigned a 200 percent sand value. The percent sand values can be in excess of 100 percent for highly permeable soils. The general relationship of permeability to percent sand is summarized in Table 3 (Determination of Percent Sand in Watersheds, USACE, 1986).

Table 3. Percent Sand and Permeability Rates

Permeability (Inches/Hour)	Percent Sand
< 0.06	0 %
0.06 – 0.2	33 %
0.2 – 0.6	66 %
0.6 – 2.0	100 %
2.0 – 6.0	133 %
6.0 - 20	166 %
> 20	200 %

Area-weighted Percent Sand values were developed for each sub-basin. In any instances where the weighted values exceeded 100, the percent sand value was then truncated at 100. The % clay values are the complement of the % sand values for each sub-basin.

The Lower Guadalupe River basin loss rates were calculated using the area weighted percent sand and percent clay values to assign Block and Uniform loss rates for each sub-basin. The default loss rates vary in relation to runoff frequency based on the historic tendency for infrequent flood events to be temporally associated with wet periods having had antecedent events capable of significantly saturating the upper soil profile. The default loss rates for 100% clay and 100% sand are shown in Table 4 (NUDALLAS Documentation, USACE, 1986). Percent impervious values were derived from the land use data and were assigned according to the relationship shown in Table 5. Impervious % for all developed low, medium, and high density land uses was increased to 47%, 70%, and 100% respectively to better represent the impact of developed areas, the effects of which tend to be dampened in large scale hydrology models. Figure 4 illustrates the distribution of land use types within the Lower Guadalupe River basin. Both calculated and calibrated Block and Uniform loss rate parameters for each basin can be seen in Appendix B.1.2.a.

Table 4. Loss Rates for Clay and Sand Soils

Annual Chance Exceedence	Clay		Sand	
	Block (in)	Uniform (in/hr)	Block (in)	Uniform (in/hr)
50%	1.5	0.2	2.1	0.26
20%	1.3	0.16	1.8	0.21
10%	1.12	0.14	1.5	0.18
4%	0.95	0.12	1.3	0.15
2%	0.84	0.10	1.1	0.13
1%	0.75	0.07	0.9	0.10
0.4%	0.61	0.06	0.73	0.09
0.2%	0.5	0.05	0.6	0.08

Table 5. Percent Impervious Values Based on Land Use

Land Use	Assumed Percent Impervious (%)
Barren Land (Rock/Sand/Clay)	0
Woody Wetlands	0
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Emergent Herbaceous Wetlands	0
Pasture/Hay	0
Shrub/Scrub	0
Grassland/Herbaceous	0
Cultivated Crops	3
Developed, Open Space, Impervious < 20%	6
Developed, Low Intensity, Impervious 20-49%	25
Developed, Medium Intensity, Impervious 50-79%	47
Developed, High Intensity, Impervious 80-100%	70
Open Water	100

<u>Snyder's Unit Hydrograph</u>

The Snyder Unit Hydrograph method is the primary method utilized by the Corps of Engineers Fort Worth District for the majority of hydrologic studies in the region; therefore, under the direction of the Corps, the Snyder Unit Hydrograph method was utilized for this study. The Snyder method requires two parameters, the Snyder standard lag and the Snyder peaking coefficient (Cp).

Snyder’s lag time or time to peak (Tp) is defined as the time from the center of mass of the excess rainfall to the peak discharge. Initial estimates of Snyder’s lag values were determined utilizing the Corps of Engineers Fort Worth District Urbanization Curves. The length of longest flowpath, corresponding weighted slope, and length to centroid flow were calculated utilizing HEC-GeoHMS for computation of Tp values.

As part of the USACE methodology, the Percent Urbanization parameter is a primary indicator for projecting unit hydrograph lag times. It typically reflects the percentage of a sub-basin which has been developed and improved with channelization and/or a stormwater collection network. The percent urbanization for each sub-basin was determined by estimating an area weighted percent urbanization for each sub-basin. Land use types and corresponding percent urbanization values are shown in Table 6 below.

Table 6. Percent Urbanization Based on Land Use

Land Use	Assumed Percent Urbanization (%)
Barren Land (Rock/Sand/Clay)	0
Woody Wetlands	0
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Emergent Herbaceous Wetlands	0
Pasture/Hay	0
Shrub/Scrub	0
Grassland/Herbaceous	0
Cultivated Crops	5
Developed, Open Space, Impervious < 20%	10
Developed, Low Intensity, Impervious 20-49%	30
Developed, Medium Intensity, Impervious 50-79%	90
Developed, High Intensity, Impervious 80-100%	95
Open Water	100

All Snyder lag times were computed using the USACE Fort Worth District Urbanization Curves. The Fort Worth District Urbanization curves were originally developed for both the Blackland Prairie Clay and the Cross Timbers Sandy Loam prevalent watersheds. When presented in graphical form, each set of curves is represented by linear relationships in logarithmic scale. For user convenience, these functions have been provided in mathematical form. The Snyder's lag time (Tp) values were computed using the following equation:

$$\log(Tp) = 0.3833\log(L*L_{ca}/(S_{st})\text{^}.5))+(Sand*(\log(Ip_{sand})-\log(Ip_{clay}))+\log(Ip_{clay}))-(BW*\%Urb)$$

Where:

- Tp = Lag time in hours
- L = River mileage from drainage area outlet to the upstream limits of the drainage area. This is the same as the longest flowpath of the sub-basin
- L_{ca} = River mileage along the longest flow path to a point nearest to the center of gravity of the drainage area
- S_{st} = Weighted slope (ft/mi) from 85% to 10% along the longest flowpath

Sand	=	Percent sand of the sub-basin as a decimal
Ip_{sand}	=	Calibration point for sand *
Ip_{clay}	=	Calibration point for clay *
BW	=	Bandwidth *
%Urb	=	Percent urbanization as a decimal

*Note: The Fort Worth District Urbanization Curves have Ip values of 0.92 for clay and 1.81 for sand and the bandwidth is 0.266 for clay and sand. These curves have been applied throughout the Fort Worth District region including Central and South Central Texas. These curves relate the runoff characteristics to surface soil, cover, land use, and drainage network characteristics, and are thus equally valid for similarly sized, shaped, and sloped sub-basins, regardless of their physical location.

The length of the longest flowpath, weighted slope and length to centroid were determined with GIS. The computed lag times range from 3.74 to 14.57 hours, with an average of 8.06 hours, according to the Fort Worth District urbanization curves.

Initially a value of 0.75 was used for the peaking coefficient, which is typical for land uses in the Dallas-Fort Worth area. The Lower Guadalupe basin is largely rural in nature and is not represented well by a Cp of 0.75. Therefore, initial Cp values were derived based on landuse and basin slope utilizing Table 2.1.6-1 in the 2006 iSWM manual. The Cp values were then adjusted during the calibration to observed gage data. The computed lag time (Tp) and calibrated peaking coefficient (Cp) for each sub-basin are listed in Appendix B.1.2.b.

Channel Routing

Initially, the Modified Puls method was selected to route the hydrographs for the channels with a hydraulic study in the Lower Guadalupe River basin. During calibration it was determined that the Modified Puls routing was inadequate to represent the amount of attenuation occurring within the study reaches when compared to observed data. Table 19 of the HEC-HMS Technical Reference Manual summarizes recommendations for usage of the various routing methods. For channels with slopes less than 0.0004 ft./ft., the Muskingum-Cunge method is the only method recommended. Channel slopes along the San Marcos and Guadalupe mainstems are very low with most near or below 0.0004 ft./ft. Therefore, it was decided to use Muskingum-Cunge routing for all reaches, which resulted in much better attenuation when compared to observed data. Reach lengths for the Muskingum-Cunge method were adjusted to more closely match the direct path of a flood wave rather than the highly sinuous channel providing a better match to observed attenuation. Input parameters and 8-point cross-sections are located in Appendix B.1.2.c.

Frequency Flow Calculation

As part of the GBRA Interim Feasibility Study, Corps of Engineers, Fort Worth District, performed a gage analysis for all discharge gages within the Lower Guadalupe River basin. The Corps produced a draft report of the gage analysis in September 2012. Halff met with the Corps on October 1, 2012 to discuss the draft analysis and began preparation of a memorandum documenting the process to be used to extract a set of frequency flows from the gage analysis. This memo was sent to the Corps in February 2013 and was followed by a meeting at which the gage analysis results from each gage were agreed upon. On March 28, 2012, the Corps delivered a revised draft gage analysis report documenting the previously agreed upon results. The most recent Corps draft gage analysis and the original Halff memorandum are included in Appendix B.1.2.e. The procedure for extracting frequency flows from the gage analysis has been revised from that presented in the original Halff memo and is presented below.

<u>Guadalupe River</u>
The six gages listed in Table 6 were used to develop frequency flows for the Guadalupe River. The "Guadalupe at FM 1117 near Seguin" gage was not analyzed by the Corps since it is a relatively new gage and the systematic record was too short. The "Guadalupe at Sattler" gage is highly affected by Canyon Dam outflows and did not produce very good gage analysis results. Therefore, a set of Canyon Dam outflows for the different frequencies was agreed upon with Corps. Table 7 contains the Guadalupe River gage analysis results used to interpolate the set of frequency flows to be used in the final hydraulic modeling.

Table 7. Guadalupe River Gage Analysis Results with Canyon Dam Outflows

Summary of Gage Analysis Results								
Location	**Frequency Flows (CFS)**							
	50% ACE	**20% ACE**	**10% ACE**	**4% ACE**	**2% ACE**	**1% ACE**	**0.4% ACE**	**0.2% ACE**
Canyon Dam Outflows	1770	4510	5000	5000	5000	15300	101325	130000
Guadalupe Above Comal River at New Braunfels (ACD)	4150	12300	21800	40100	59500	85000	130000	175000
Guadalupe River at New Braunfels	6040	16300	27900	50400	74400	106000	164000	222000
Guadalupe River at Gonzales	16500	43000	71700	124000	178000	247000	365000	480000
Guadalupe River at Cuero	16900	42500	70100	121000	174000	242000	362000	481000
Guadalupe River below Cuero	17800	45000	72300	119000	165000	219000	308000	389000
Guadalupe River at Victoria - Full Systematic Record	18000	41900	65700	105000	145000	192000	259000	347000

Gage analysis results were normalized by their respective drainage areas and plotted against drainage area for each frequency. Guadalupe frequency flows were interpolated from the gage analysis flows using a power function between the "Above Comal", New Braunfels and Gonzales gages and a linear function between the Gonzales, both Cuero gages and Victoria gage. Curves for the 1% ACE flows are shown in Figure 5. Frequency flows downstream of the Victoria gage were extrapolated based on the attenuation of peak flows (normalized by drainage area) from the basin-wide hydrology model, which provided a more conservative result than the previously mentioned linear interpolation. A complete set of Guadalupe River frequency flows corresponding to junctions in the basin-wide hydrology model is provided in Appendix B.1.1.

<u>Blanco and San Marcos River</u>
Three gages listed in Table 7 were used to develop frequency flows for the Blanco and San Marcos Rivers. The San Marcos at Ottine gage only recorded from 1916 to 1943 and does not reflect the effects of the many NRCS dams constructed within Blanco/San Marcos basin. The gage analysis results at the Ottine gage for lower frequency flows therefore appeared to be much higher than expected when compared to flows at

upstream gages and flows downstream on the Guadalupe as well. For this reason, the results for the Ottine gage were not use to extract frequency flows. Table 8 contains the Blanco/San Marcos River gage analysis results used to interpolate the set of frequency flows to be used in the final hydraulic modeling.

Table 8. Blanco/San Marcos River Gage Analysis Results

Summary of Gage Analysis Results								
Location	Frequency Flows (CFS)							
	50% ACE	20% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.4% ACE	0.2% ACE
Blanco River at Wimberley	8200	26000	44100	73000	98300	126000	166000	198000
Blanco River Near Kyle	9920	35900	64300	112000	155000	203000	272000	329000
San Marcos River at Luling	9830	26600	43500	72000	98400	130000	178000	221000

The Wimberley and Kyle gages are separated by only 57 square miles of drainage area, but produce significantly different gage analysis results. The Kyle gage has a shorter period of record which tends to produce higher gage analysis results, especially for rare events. On May 20, 2013, the Corps supplied revised gage analysis results for the Kyle gage based on a synthetic extension of the Kyle gage record based on the existing Wimberley gage record. Explanation of the revision is supplied in the email from the Corps in Appendix B.1.2.e. Gage results were normalized by both drainage area and cumulative channel storage to provide a reasonable interpolation of flows between gages. Cumulative channel storage was calculated using storage-outflow data from preliminary hydraulic models to represent the relative difference in channel storage at interpolation points.

Blanco/San Marcos frequency flows were interpolated from the gage analysis results using an exponential function between the Wimberley, Kyle and Luling gages on a plot of cumulative storage versus normalized discharge. The curve for the 1% ACE flows is shown in Figure 6. Frequency flows downstream of the Luling gage were extrapolated based on the attenuation of 1% ACE peak flows (normalized by drainage area only) from the basin-wide hydrology model, which reflects inflow from the Plum Creek watershed just downstream of the Luling gage. Similarly, frequency flows upstream of the Wimberley gage were also determined based on the trend from the basin-wide hydrology model. A complete set of Blanco/San Marcos River frequency flows corresponding to junctions in the basin-wide hydrology model is provided in Appendix B.1.1.

RESULTS / VALIDATION

Results

A summary of peak discharges for the 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, and 0.2% ACE frequency events derived from Corps gage analysis results are displayed in Appendix B.1.1. The hydrology model was calibrated to the 1998, 2002, and 2004 flood events and optimal parameters were developed for use of the hydrology model for flood forecasting purposes. Preliminary results for the 1% ACE event from the calibrated hydrology model are also included in Appendix B.1.1 and were used in the comparison to the Corps gage analysis and FIS results to further validate the hydrology model.

Calibration to Historical Events

Calibration Data

Observed hydrographs for the three calibration events were obtained from the USGS National Water Information System (NWIS). The hydrographs contained 15-minute interval, instantaneous discharge data. For some gages and events the observed data was either largely incomplete or missing altogether. Table 9 shows which gages to be used in the calibration effort failed to provide observed data for certain events. It appears four out of the nine gages did not report complete datasets during the October 1998 event.

Table 9. Observed Data Inventory

Gage	Oct 98	Jul 02	Nov 04
Guad Above Comal	Y	Y	Y
Guad at Gonzales	N	Y	Y
Guad at Cuero	Y	Y	Y
Guad at Victoria	N	Y	Y
Blanco at Wimberley	Y	Y	Y
Blanco near Kyle	N	Y	N
San Marcos at Luling	Y	Y	Y
Plum at Lockhart	Y	Y	Y
Plum at Luling	N	Y	N

As previously described, NWS rainfall data was collect for the October 1998, July 2002, and November 2004 rainfall events. Each of the three events represents a unique combination of rainfall pattern and antecedent runoff condition. The 1998 event was an extreme flooding event that concentrated almost of the rainfall below Canyon dam. The 2002 event was concentrated in the upper Guadalupe and Blanco basins with an unprecedented release from Canyon dam. The 2004 event was a more moderate flood event with more widespread rainfall. Comparisons of year-to-date total rainfall to average rainfall at Canyon Dam for the three events shows that the 1998 event had average antecedent, 2002 was preceded by a very dry period, and the 2004 event occurred after a fairly wet year. Table 10 shows the comparisons to average total rainfall preceding each event at Canyon Dam.

Table 10. Preceding Rainfall Totals at Canyon Dam

Date	Year-to-Date Total (in.)	Year-to-Date Average (in.)
6-Oct-98	27.26	28.38
28-Jun-02	8.54	18.76
5-Nov-04	44.45	32.56

Calibration Procedure

The calibration of the basin-wide hydrology model was accomplished according to the following procedure. First, the model sub-basins were split into groups according to the location of the gages in Table 8. The resulting sub-basin groups are illustrated in Figure 7. The hydrology model was then run for an initial comparison at each gage for each flood event. Then for each event, starting at the upstream most gages and working downstream, hydrologic parameters were adjusted to calibrate to the observed hydrographs. Adjustments were in the form of multipliers and were made primarily to initial losses, constant losses, and peaking coefficient. A multiplier of 1 indicates no change was made in the parameter, whereas a multiplier greater or less than one indicates a respective increase or decrease in the parameter. Snyder's lag times were not adjusted for most of the sub-basins since changes to lag time did not produce significant differences in timing, peak flows, and volumes. However, Snyder's lag time was adjusted for sub-basins in the Upper Blanco and Upper Plum Creek watersheds so that lag time to longest flowpath length ratios for these basins were made more consistent with ratios for the rest of the sub-basins. Parameters were adjusted uniformly for all sub-basins within a sub-basin group. Channel losses were added only to reaches that intersect the Edward's Aquifer contributing and recharge zones to represent potential percolation losses.

As the calibration proceeded downstream, adjustments to sub-basin groups associated with upstream gages were unchanged and parameters for only un-calibrated sub-basin groups were adjusted. Reasonable calibrations were made to the 1998 and 2004 events. Calibration to the 2002 event was affected by the large volume of runoff produced by the model from the Blanco sub-basins. Despite large increases in initial losses and channel losses, there was still a large amount of runoff volume from the Blanco/San Marcos watershed. There could also be potential issues with the rainfall amounts and distribution for this event as well as uncertainty associated with the amount of percolation loss to the Edwards Aquifer. The overall affect is that the 2002 computed hydrographs had several relatively high and earlier peaks rather than one large peak as seen in the observed data. Because of the issues with the 2002 calibration, the event calibration results were not used in the weighted average parameter calculation to determine the final calibration parameters.

The resulting calibrated parameters for the 1998 and 2004 events were compared to determine a set of parameter adjustments that provided the best calibration to both events. Weighted averages of parameter adjustment multipliers were calculated giving the 1998 event multiplier twice the weight of the 2004 event multiplier since the 1998 event represents average antecedent runoff conditions within the basin. Calibration results for the 2002 event were only included in the weighted averages for the Plum Creek gages. Charts comparing event calibration hydrographs to observed data at each gage as well as comparisons of parameter adjustments and results for each event calibration are included in Appendix B.1.3. Final calibrated parameter adjustments and results for each sub-basin group are presented in Tables 11 through 13. Final calibrated hydrographs are included in the charts in Appendix B.1.3 as well.

Table 11. Final Calibrated Parameter Adjustments

Final Calibrated Model Parameters												
Basin	Initial Loss			Constant Loss			Peaking Coefficient			Lag Time		
	Orig.	Final	Mult.	Original	Final	Mult.	Original	Final	Mult.	Orig.l	Final	Multi.
BLNC_010	0.78	0.94	1.20	0.08	0.13	1.67	0.58	0.69	1.19	9.18	10.58	1.15
BLNC_020	0.77	0.92	1.20	0.07	0.12	1.67	0.58	0.69	1.19	5.10	6.38	1.25
BLNC_030	0.77	0.92	1.20	0.07	0.12	1.67	0.58	0.80	1.38	5.31	6.90	1.30
BLNC_040	0.77	0.92	1.20	0.07	0.12	1.67	0.58	0.80	1.38	3.74	4.86	1.30
BLNC_050	0.76	1.32	1.74	0.07	0.09	1.31	0.58	0.72	1.25	4.56	4.56	1.00
BLNC_060	0.80	1.39	1.73	0.08	0.10	1.25	0.60	0.71	1.18	4.70	4.70	1.00
GUAD_010	0.76	0.79	1.04	0.07	0.09	1.33	0.59	0.77	1.31	6.13	6.13	1.00
GUAD_020	0.76	0.79	1.04	0.07	0.09	1.33	0.59	0.77	1.31	7.36	7.36	1.00
GUAD_030	0.76	1.87	2.46	0.07	0.09	1.33	0.62	0.62	1.00	6.55	6.55	1.00
GUAD_040	0.79	1.95	2.47	0.08	0.11	1.33	0.62	0.62	1.00	6.77	6.77	1.00
GUAD_050	0.86	2.12	2.46	0.09	0.12	1.33	0.60	0.60	1.00	5.74	5.74	1.00
GUAD_060	0.84	2.07	2.47	0.09	0.12	1.33	0.59	0.59	1.00	8.24	8.24	1.00
GUAD_070	0.86	2.12	2.46	0.09	0.12	1.33	0.59	0.59	1.00	10.75	10.75	1.00
GUAD_080	0.89	2.32	2.60	0.10	0.13	1.33	0.58	0.57	0.99	8.69	8.69	1.00
GUAD_090	0.82	2.02	2.47	0.08	0.11	1.33	0.60	0.60	1.00	11.40	11.40	1.00
GUAD_100	0.81	2.10	2.60	0.08	0.11	1.33	0.59	0.58	0.98	12.03	12.03	1.00
GUAD_110	0.90	2.34	2.60	0.10	0.13	1.33	0.58	0.57	0.99	11.19	11.19	1.00
GUAD_120	0.83	2.16	2.60	0.09	0.12	1.33	0.59	0.58	0.98	8.57	8.57	1.00
GUAD_130	0.78	2.03	2.60	0.08	0.11	1.33	0.59	0.58	0.98	7.61	7.61	1.00
GUAD_140	0.82	2.13	2.60	0.08	0.11	1.33	0.59	0.58	0.98	8.83	8.83	1.00
GUAD_150	0.79	2.06	2.60	0.08	0.11	1.33	0.59	0.58	0.98	7.94	7.94	1.00
GUAD_160	0.81	2.10	2.60	0.08	0.11	1.33	0.60	0.59	0.98	10.75	10.75	1.00
GUAD_170	0.83	2.16	2.60	0.09	0.12	1.33	0.59	0.58	0.98	7.71	7.71	1.00
GUAD_180	0.79	2.06	2.60	0.08	0.11	1.33	0.59	0.58	0.98	9.64	9.64	1.00
GUAD_190	0.84	2.19	2.60	0.09	0.12	1.33	0.59	0.58	0.98	6.13	6.13	1.00
GUAD_200	0.81	2.10	2.60	0.08	0.11	1.33	0.59	0.58	0.98	10.56	10.56	1.00
GUAD_210	0.83	2.16	2.60	0.09	0.12	1.33	0.59	0.58	0.98	14.57	14.57	1.00
GUAD_220	0.84	2.19	2.60	0.09	0.12	1.33	0.59	0.58	0.98	12.34	12.34	1.00
GUAD_230	0.83	2.16	2.60	0.09	0.12	1.33	0.59	0.54	0.92	7.48	7.48	1.00
GUAD_240	0.85	2.21	2.60	0.09	0.12	1.33	0.59	0.54	0.92	9.86	9.86	1.00
GUAD_250	0.85	2.21	2.60	0.09	0.12	1.33	0.59	0.54	0.92	10.32	10.32	1.00
GUAD_260	0.83	2.16	2.60	0.09	0.12	1.33	0.59	0.54	0.92	7.24	7.24	1.00
GUAD_270	0.80	2.08	2.60	0.08	0.11	1.33	0.60	0.55	0.92	8.58	8.58	1.00

Final Calibrated Model Parameters												
Basin	Initial Loss			Constant Loss			Peaking Coefficient			Lag Time		
	Orig.	Final	Mult.	Original	Final	Mult.	Original	Final	Mult.	Orig.l	Final	Multi.
GUAD_280	0.87	2.26	2.60	0.09	0.12	1.33	0.58	0.53	0.92	11.85	11.85	1.00
GUAD_290	0.85	2.21	2.60	0.09	0.12	1.33	0.59	0.54	0.92	7.94	7.94	1.00
GUAD_300	0.82	2.13	2.60	0.08	0.11	1.33	0.59	0.54	0.92	7.16	7.16	1.00
GUAD_310	0.80	2.08	2.60	0.08	0.11	1.33	0.61	0.56	0.92	5.80	5.80	1.00
GUAD_320	0.78	2.03	2.60	0.08	0.11	1.33	0.59	0.54	0.92	8.86	8.86	1.00
SMAR_010	0.76	1.32	1.74	0.07	0.09	1.31	0.59	0.70	1.19	5.28	5.28	1.00
SMAR_020	0.75	1.39	1.85	0.07	0.06	0.83	0.60	0.72	1.19	6.68	6.68	1.00
SMAR_030	0.80	1.30	1.63	0.08	0.07	0.83	0.61	0.71	1.17	8.64	8.64	1.00
SMAR_040	0.78	1.92	2.46	0.08	0.11	1.42	0.61	0.63	1.03	6.80	6.80	1.00
SMAR_050	0.77	1.90	2.46	0.07	0.13	1.81	0.60	0.60	1.00	4.82	5.30	1.10
SMAR_060	0.75	1.80	2.40	0.07	0.07	1.00	0.59	0.71	1.20	4.00	5.20	1.30
SMAR_070	0.78	1.92	2.46	0.08	0.11	1.33	0.59	0.61	1.03	5.14	5.14	1.00
SMAR_080	0.90	2.22	2.47	0.10	0.13	1.33	0.59	0.61	1.03	12.07	12.07	1.00
SMAR_090	0.82	1.42	1.73	0.08	0.07	0.83	0.59	0.70	1.19	10.48	10.48	1.00
SMAR_100	0.83	2.05	2.47	0.09	0.11	1.26	0.59	0.61	1.03	5.11	5.11	1.00
SMAR_110	0.83	2.05	2.47	0.09	0.11	1.19	0.58	0.60	1.03	5.68	5.68	1.00
SMAR_120	0.83	2.05	2.47	0.09	0.12	1.33	0.59	0.61	1.03	11.28	11.28	1.00

Table12. Final Calibrated Model Results – October 1998 Event

Gauge Location	October 1998 - Average Parameters								
	Obs Flow (cfs)	Obs Vol (AF)	Obs Time (hr)	Calib Flow (cfs)	Calib Vol (AF)	Calib Time (hr)	% Diff Flow	% Diff Vol	Time Diff (hr)
Wimberley	88500	65918	10/17/98 14:15	68315	104878	10/17/98 14:05	-23	59	0.2
Kyle									
Above Comal	90000	89805	10/17/98 17:45	82279	84185	10/17/98 16:20	-9	-6	1.4
Lockhart	47200	78869	10/18/98 3:30	50271	66045	10/17/98 16:40	7	-16	10.8
Luling_PM									
Luling_SM	206000	281272	10/18/98 6:15	221314	387850	10/18/98 3:30	7	38	2.8
Gonzales									
Cuero	473000	1563813	10/20/98 0:30	449000	1522392	10/19/98 11:30	-5.1	-3	13.0
Victoria									

Table 13. Final Calibrated Model Results – November 2004 Event

Gauge Location	November 2004- Average Parameters								
	Obs Flow (cfs)	Obs Vol (AF)	Obs Time (hr)	Calib Flow (cfs)	Calib Vol (AF)	Calib Time (hr)	% Diff Flow	% Diff Vol	Time Diff (hr)
Wimberley	9540	12843	11/22/04 16:00	6848	10818	11/22/04 15:30	-28	-16	0.5
Kyle									
Above Comal	16250	23015	11/22/04 13:30	19553	30183	11/22/04 14:55	20	31	1.4
Lockhart	6032	14088	11/22/04 18:30	6585	8766	11/22/04 15:20	9	-38	3.2
Luling_PM									
Luling_SM	81700	144379	11/22/04 22:15	57304	104260	11/23/04 0:55	-30	-28	2.7
Gonzales	92300	278082	11/23/04 11:00	102300	265045	11/23/04 17:55	11	-5	6.9
Cuero	95000	318564	11/24/04 21:30	106030	404986	11/24/04 21:50	12	27	0.3
Victoria	93900	687347	11/26/04 1:30	86224	456024	11/26/04 10:05	-8	-34	8.6

Gage Analysis/FIS Comparison

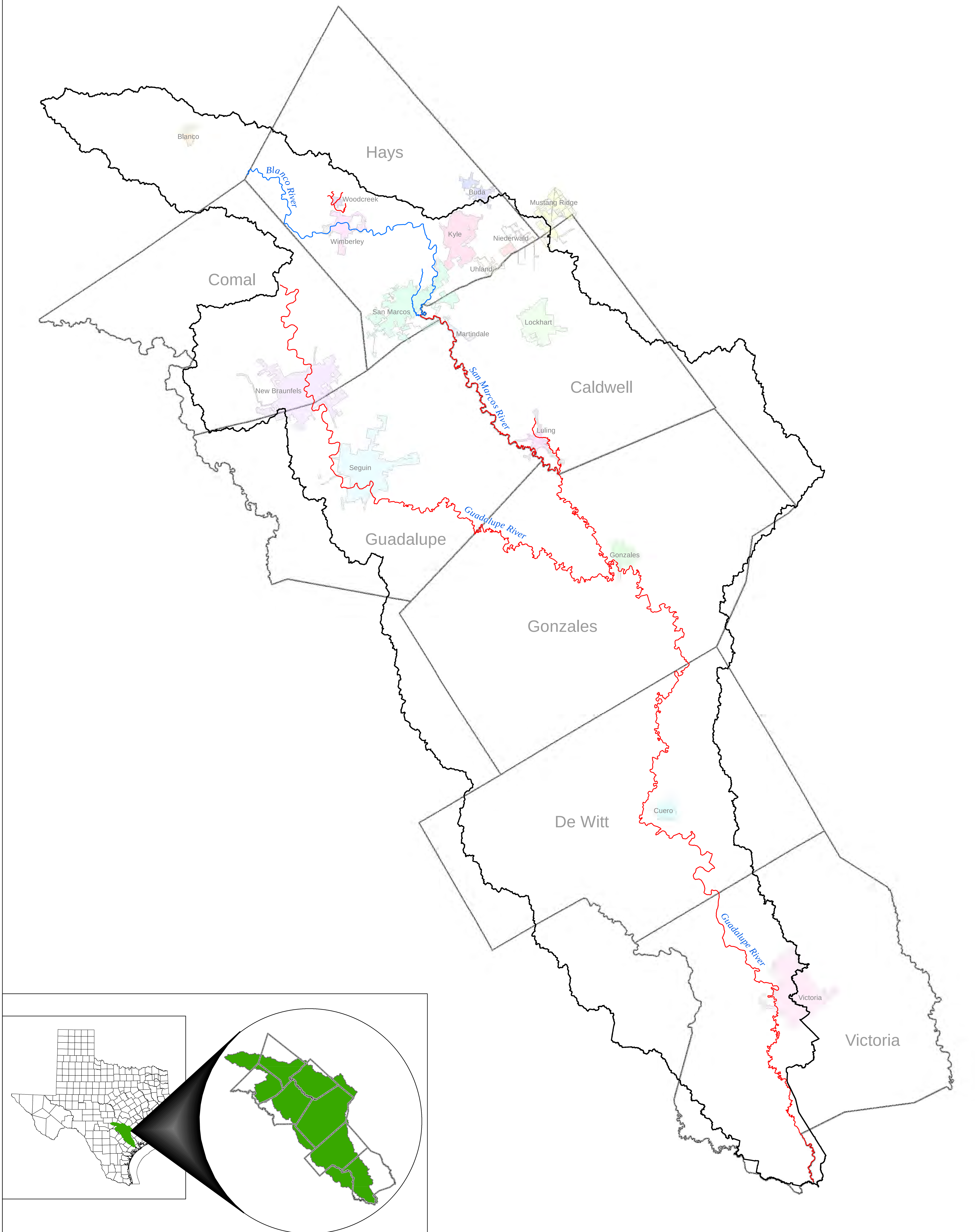
The preliminary peak discharge per drainage area results for the 1% ACE event on the Guadalupe and Blanco/San Marcos mainstems were compared to corresponding peak flows from the Corps gage analysis and effective FEMA FIS studies. The 1% ACE model run did not involve storm centering, but merely used the balanced frequency storm method applied to each sub-basin. The comparison figures for both the Guadalupe and San Marcos River preliminary results is included in Appendix B.1.2.f and Table 14 shows the results in tabular format. The Guadalupe results are mostly within 20% of FIS and gage. The hydrology model tends to underestimate the peak flows upstream of the San Marcos River confluence and closely match peak flows downstream of the confluence. The comparisons for the Blanco/San Marcos results show peak flows within 20% at the Luling gage. Upstream of the confluence of the Blanco and San Marcos River the hydrology model is consistently lower than both the FIS and gage analysis results. However, the FIS results are a closer match than the gage analysis results.

Table 14. Preliminary 1% ACE Peak Flow Comparison to FIS and Gage Analysis Results

Location	1% Calibrated Model	Current Effective FIS	Calibrated /FIS Difference (%)	USACE Gage Analysis (cfs)	Calibrated/ USACE Gage Difference (%)
Blanco River at Wimberley	82170	111000	25.97%	126000	34.79%
Blanco River near Kyle	75410	122000	38.19%	158000	52.27%
San Marcos River at Luling	124760	150100	16.88%	130000	4.03%
Guadalupe River Above Comal	43840	85458	48.70%	85000	48.42%
Guadalupe River at Gonzales	216260	287000	24.65%	247000	12.45%
Guadalupe River at Cuero	238440	N/A	N/A	242000	1.47%
Guadalupe River at Victoria	204470	192000*	-6.49%	187000	-9.34%

* Preliminary FIS value

Figures



Key to Features

Lower Guadalupe River Basin

Surveyed Streams

Non-Surveyed Streams

County Boundary

GBRA
Interim Feasibility Study - Phase 1

Figure 1.
Project Study Area

N W E S

0 10 20 Miles

1 inch = 5 miles

Key to Features

- Lower Guadalupe River Basin
- Lower Guadalupe Sub-Basins
- Surveyed Streams
- Non-Surveyed Streams
- Highways
- County Boundary

GBRA
Interim Feasibility Study - Phase 1

Figure 2.
Drainage Area Map

N W E S

0 9 18 Miles

1 inch = 4.5 miles

Key to Features

Lower Guadalupe River Basin
Lower Guadalupe Sub-Basins
Study Streams
County Boundary

% Sand

0-10
10-48
48-67
67-80
80-93
93-108
108-139
139-200

GBRA Interim Feasibility Study - Phase 1

Figure 3.
Percent Sand Soils Map

N
W E
S

0 9 18 Miles

1 inch = 4.5 miles

GBRA
Interim Feasibility Study - Phase 1

Figure 4.
Land Use Map

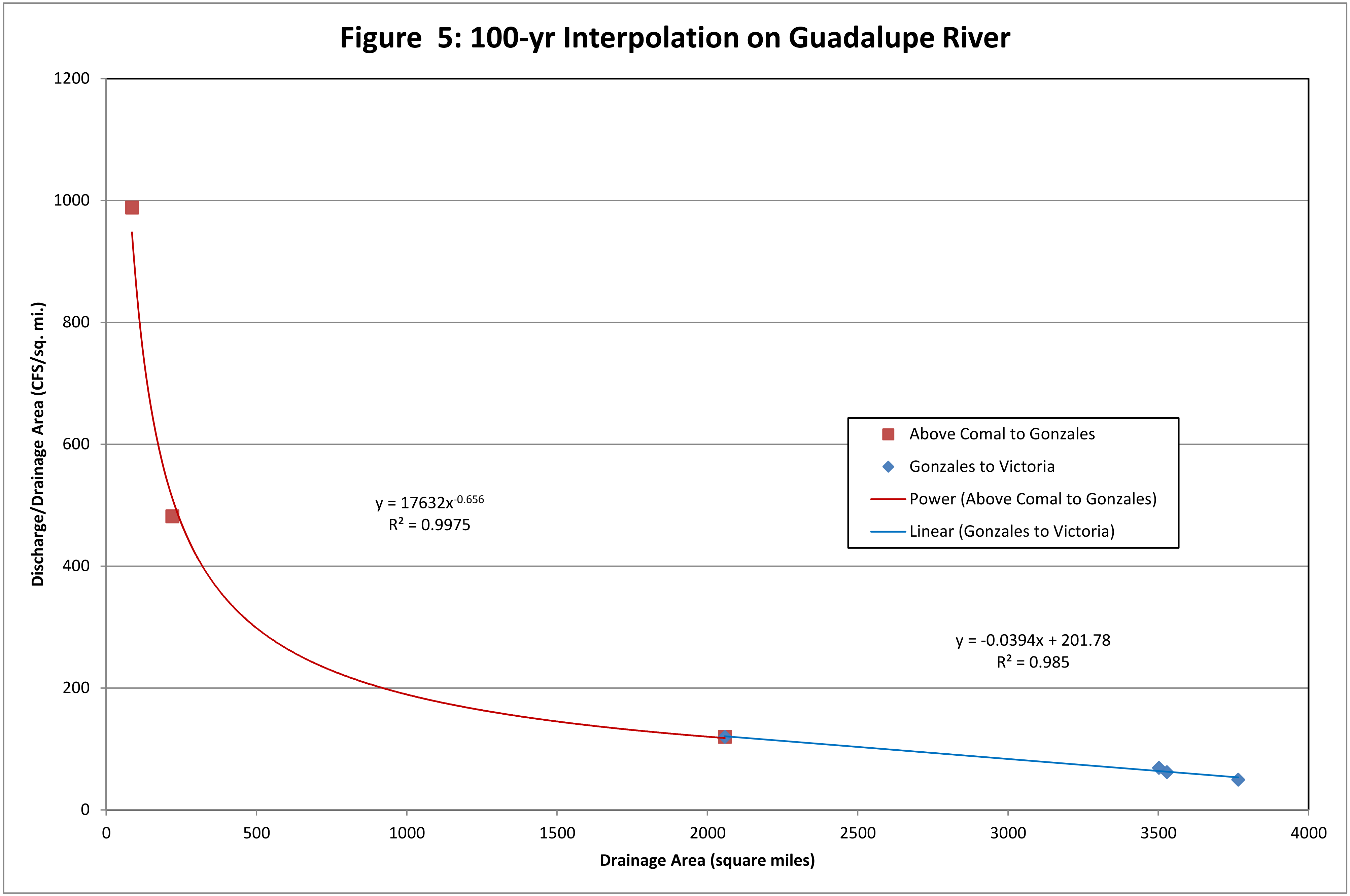


Figure 5: 100-yr Interpolation on Guadalupe River
Discharge/Drainage Area (CFS/sq. mi.)
1200
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
3500
4000
Drainage Area (square miles)
y = 17632x^-0.656
R² = 0.9975
y = -0.0394x + 201.78
R² = 0.985
Above Comal to Gonzales
Gonzales to Victoria
Power (Above Comal to Gonzales)
Linear (Gonzales to Victoria)

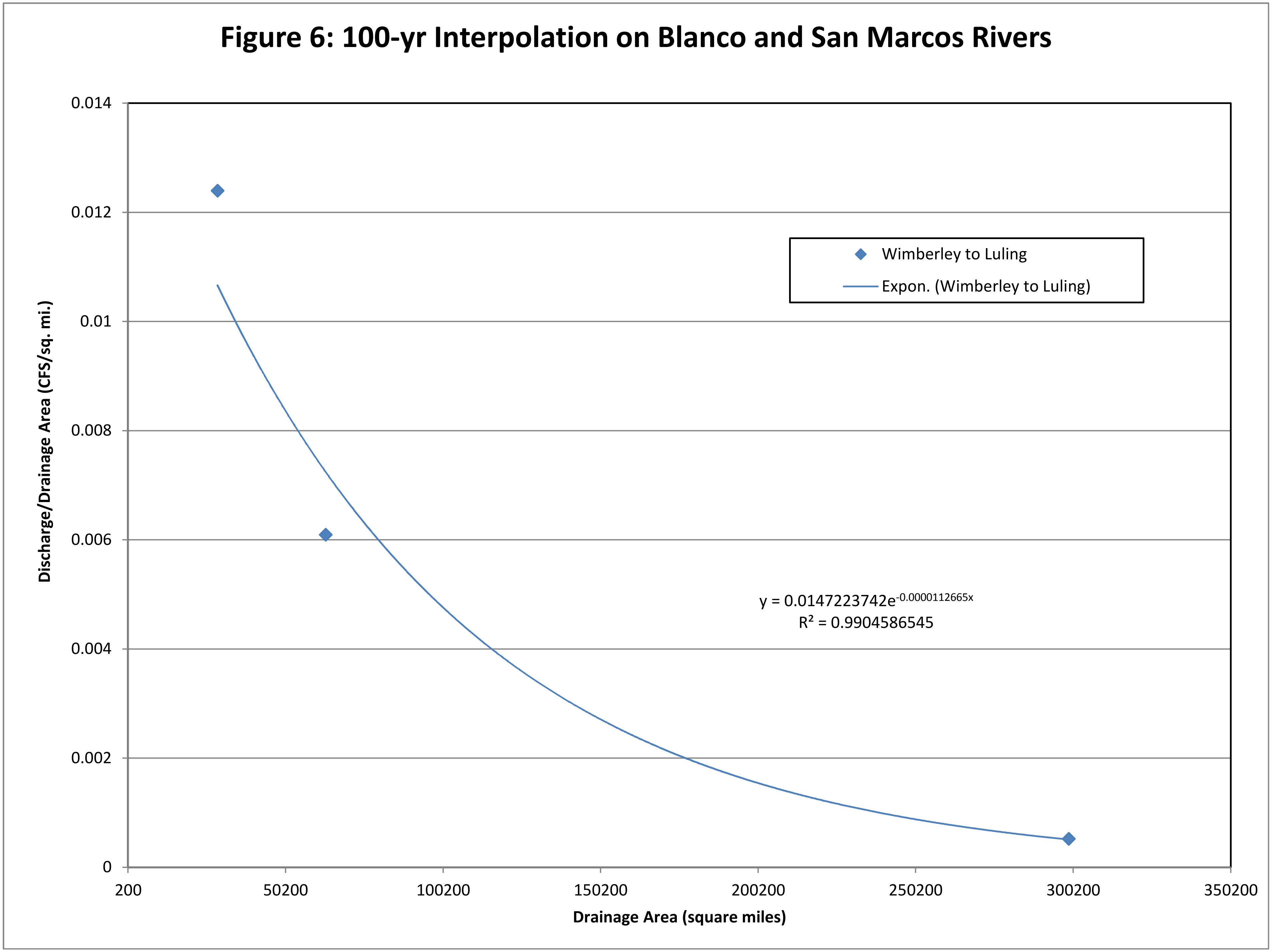
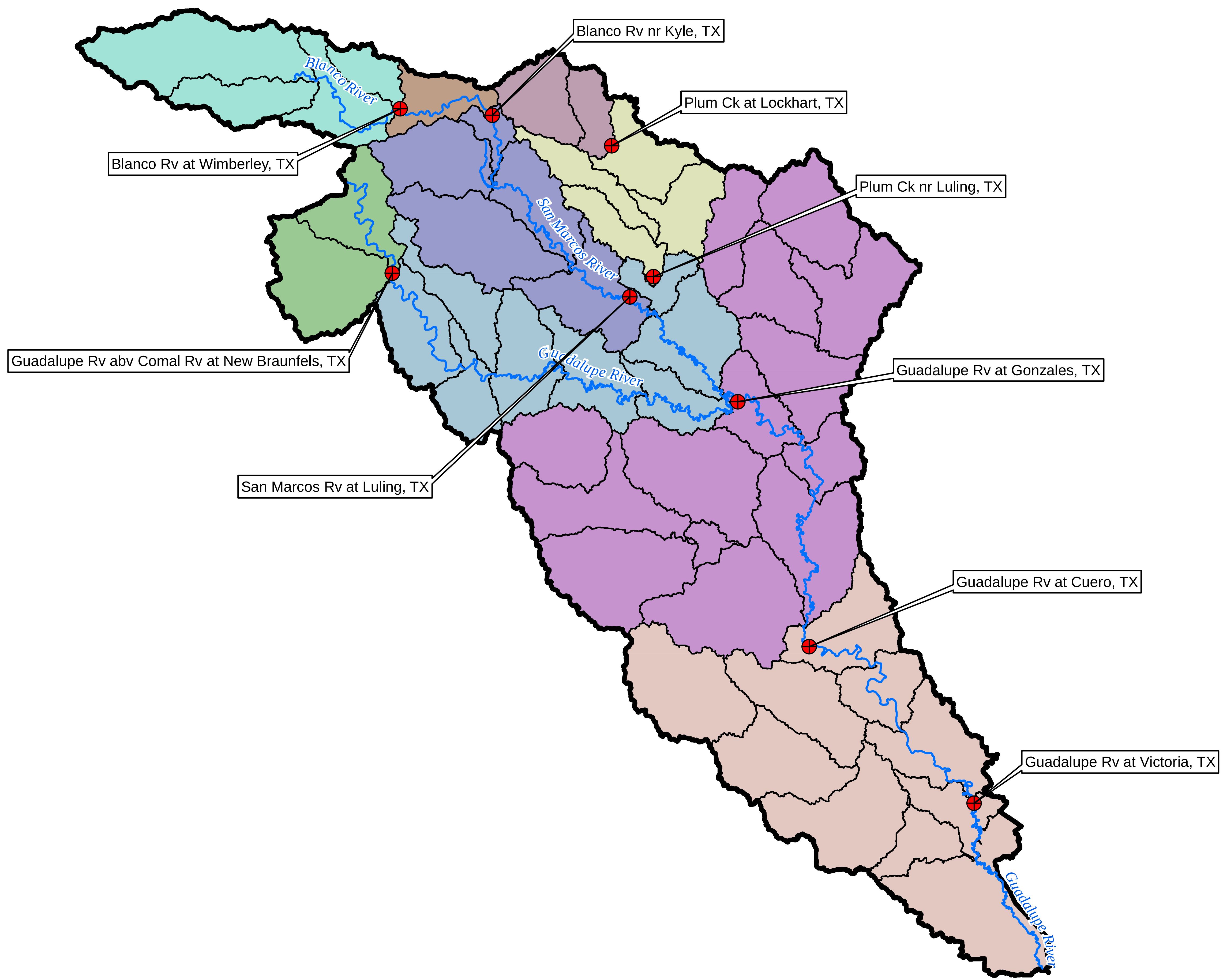


Figure 6: 100-yr Interpolation on Blanco and San Marcos Rivers
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Discharge/Drainage Area (CFS/sq. mi.)
Wimberley to Luling
Expon. (Wimberley to Luling)
y = 0.0147223742e-0.0000112665x
R² = 0.9904586545
200
50200
100200
150200
200200
250200
300200
350200
Drainage Area (square miles)



GBRA
Interim Feasibility Study - Phase I

Key to Features

Calibration Gages
Study Streams
Guadalupe River Basin
Guadalupe Sub-Basins

Subbsain_Groups

Above Comal
Cuero
Gonzales
Kyle
Lockhart
Luling_PL
Luling_SM
Victoria
Wimberley

Figure 7.
Basin-Wide Model Calibration Sub-Basin Groups

N
W E
S

0 5 10 20 Miles

1 inch = 12 miles

Appendix B.1.1

Computed Peak Discharge

HALFF

Appendix B.1.1.a
GBRA Sub-basin Peak Discharges

Hydrologic Element		Drainage Area (mi2)	Preliminary Peak Discharge (cfs) 1 % Annual Exceedance
GBRA Basins			
	BLNC_010	169.17	42,687
	BLNC_020	68.58	28,952
	BLNC_030	79.01	35,812
	BLNC_040	38.20	24,643
	BLNC_050	56.69	34,283
	BLNC_060	23.52	14,471
	GUAD_010	87.83	43,740
	GUAD_020	130.15	54,519
	GUAD_030	69.62	25,620
	GUAD_040	91.83	31,679
	GUAD_050	59.40	22,718
	GUAD_060	88.75	23,364
	GUAD_070	87.81	18,098
	GUAD_080	96.15	22,063
	GUAD_090	56.92	12,004
	GUAD_100	116.16	21,140
	GUAD_110	69.56	12,915
	GUAD_120	102.41	25,004
	GUAD_130	116.80	32,320
	GUAD_140	86.50	21,155
	GUAD_150	107.61	28,767
	GUAD_160	69.33	14,926
	GUAD_170	55.12	15,487
	GUAD_180	158.99	34,908
	GUAD_190	17.69	6,500
	GUAD_200	153.15	31,008
	GUAD_210	146.23	21,567
	GUAD_220	169.09	28,721
	GUAD_230	100.89	26,031
	GUAD_240	138.17	26,977
	GUAD_250	107.89	20,438
	GUAD_260	64.19	17,548
	GUAD_270	103.92	24,973
	GUAD_280	109.82	17,831
	GUAD_290	136.12	32,556
	GUAD_300	46.73	13,424
	GUAD_310	49.26	18,145
	GUAD_320	174.61	38,529
	SMAR_010	96.25	48,374

Hydrologic Element		Drainage Area (mi2)	Preliminary Peak Discharge (cfs)
			1 % Annual Exceedance
	SMAR_020	141.93	60,383
	SMAR_030	82.50	28,693
	SMAR_040	52.20	18,784
	SMAR_050	70.66	28,952
	SMAR_060	41.78	22,581
	SMAR_070	71.80	31,099
	SMAR_080	51.30	9,930
	SMAR_090	107.09	30,309
	SMAR_100	33.36	15,116
	SMAR_110	65.96	25,443
	SMAR_120	107.62	21,969

Appendix B.1.1.b
GBRA Stream Peak Discharges

Hydrologic Element		Drainage Area (mi^2)	Preliminary Peak Discharge (cfs) 1% Annual Chance Exceedance
Guadalupe River			
	JGUAD_010	1520	43,840
	JGUAD_010_020	1650	93,805
	JGUAD_030_050	1871	110,415
	JGUAD_040	1742	95,283
	JGUAD_050	1801	100,617
	JGUAD_060	1960	113,133
	JGUAD_070	2047	100,294
	JGUAD_080	96	22,063
	JGUAD_090	2104	71,541
	JGUAD_100	212	26,602
	JGUAD_100_200	365	50,375
	JGUAD_110	70	12,915
	JGUAD_120	102	25,004
	JGUAD_130	219	32,600
	JGUAD_130_140	375	50,531
	JGUAD_140	156	20,409
	JGUAD_150	483	57,202
	JGUAD_150_160	4014	235,548
	JGUAD_160	3531	206,620
	JGUAD_170	4069	227,053
	JGUAD_180_190	542	75,975
	JGUAD_190	383	49,957
	JGUAD_210	4215	217,306
	JGUAD_210_220	4927	238,443
	JGUAD_220	711	85,374
	JGUAD_230	5028	222,194
	JGUAD_240	138	26,977
	JGUAD_250_280	356	50,052
	JGUAD_260	5092	212,132
	JGUAD_270	5196	204,468
	JGUAD_280	248	34,099
	JGUAD_290	492	60,340
	JGUAD_300	539	62,802
	JGUAD_300_310	5784	199,053
	JGUAD_310	5245	197,494
Blanco River			
	JBLNC_010_020	238	61,718
	JBLNC_030	317	73,623
	JBLNC_040	355	82,168

Hydrologic Element		Drainage Area (mi^2)	Preliminary Peak Discharge (cfs) 1% Annual Chance Exceedance
	JBLNC_050	412	75,409
	JBLNC_060	435	63,296
	JBLNC_060_SMAR_010	531	79,170
San Marcos River			
	JSMAR_020	614	87,921
	JSMAR_020_030	756	117,296
	JSMAR_040_110	302	68,080
	JSMAR_050	71	28,952
	JSMAR_060	112	46,571
	JSMAR_070	184	54,746
	JSMAR_080	354	75,383
	JSMAR_090	863	124,759
	JSMAR_100	1250	193,913
	JSMAR_090_100	387	77,443
	JSMAR_110	250	59,599
	JSMAR_120	1358	171,216
	JSMAR_120_GUAD_090	2030	216,259

Appendix B.1.1.c
GBRA Frequency Flow
Gage Analysis

Hydrologic Element	Location Description	Upstream Drainage Area (mi2)	Gage Analysis Peak Discharge (CFS) Annual Chance Exceedance							
			50%	20%	10%	4%	2%	1%	0.4%	0.2%
Guadalupe River Junctions										
N/A	D/S Canyon Dam	1436	1800	4500	5000	5000	5000	15300	101300	130000
JGUAD_010	Upstream of Comal Conf.	1518	4200	12300	21800	40100	59500	85000	130000	175000
JGUAD_010_020	@ I-35	1652	6000	16300	27900	50400	74400	106000	164000	222000
JGUAD_040		1742	7100	19700	34100	61000	89300	126800	192300	258000
JGUAD_050	Upstream of Geronimo Cr.	1801	7700	21200	36500	65000	95000	134700	203700	273000
JGUAD_030_050	Conf. with Geronimo Cr.	1871	8300	22700	39000	69200	101000	143000	215800	288800
JGUAD_060		1960	9000	24400	41800	74000	107800	152300	229300	306500
JGUAD_070		2047	9600	26000	44400	78300	113800	160600	241300	322100
JGUAD_090		2104	10000	26900	45900	80800	117400	165600	248500	331400
JSMAR_120_GUAD_090	Conf. with San Marcos	3462	16300	41900	70200	120900	173400	243600	359300	473600
JGUAD_160		3531	16600	43400	72300	125000	180000	249900	370600	487100
JGUAD_150_160		4014	17900	46200	76200	130600	187500	259200	381800	502900
JGUAD_170	Conf. with Peach Cr.	4069	18000	46300	76300	130700	187600	259100	381300	502500
JGUAD_210	Conf. with Sandies Cr.	4215	18200	46500	76400	130400	186900	257700	378300	498900
JGUAD_210_220	Cuero Gage	4934	16900	42500	70100	121000	174000	242000	362000	481000
JGUAD_230		5028	17600	43200	68900	114100	162000	219900	315200	419000
JGUAD_260		5092	17500	42600	67800	111800	158500	214700	306900	408400
JGUAD_270	Victoria Gage	5198	18000	41900	65700	105000	145000	192000	259000	347000
JGUAD_300	Above Coleto Cr.	5245	17400	40500	63500	101400	140100	185500	250200	335200
JGUAD_300_310	Conf. with Coleto Cr.	5784	19800	46200	72400	115700	159800	211700	285500	382500
Outlet 1	Calhoun County Boundary	5959	18100	42200	66100	105700	146000	193300	260700	349300
Blanco/San Marcos River Junctions										
JBLNC_010_020	Hays County Line	238	5700	18000	30600	50700	68200	87500	115200	137400
JBLNC_030	Above Cypress	317	7500	23900	40500	67000	90300	115700	152400	181800
JBLNC_040	Wimberley Gage	355	8200	26000	44100	73000	98300	126000	166000	198000
JBLNC_050	Kyle Gage	412	8500	28200	49500	85800	119000	158000	216000	266000
JBLNC_060	Above San Marcos	435	12300	37400	63400	106500	145500	190700	257700	314900
JBLNC_060_SMAR_010	San Marcos Conf	531	15000	45700	77400	130000	177700	232900	314700	384600
JSMAR_030	Above York	614	11400	32600	54300	90700	124100	163500	222800	274900
JSMAR_020_030	York Conf	756	12900	37000	61600	102800	140600	185300	252500	311600
JSMAR_090	Luling Gage	838	9800	26600	43500	72000	98400	130000	178000	221000
JSMAR_090_100	Plum Conf	1250	15200	41100	67200	111100	151900	200700	274800	341200
JSMAR_120	Above Guad	1358	13400	36200	59200	97900	133800	176800	242100	300500

Appendix B.1.2

Supporting Documents

HALFF

Appendix B.1.2.a
Block and Uniform Loss Computations

GBRA Runoff Loss Rates

				Weighted Basin Initial Block Values (in)								Weighted Basin Uniform Loss Values (in/hr)							
Basin	%Clay	%Sand	% Impervious	50% ACE	20% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.4% ACE	0.2% ACE	50% ACE	20% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.4% ACE	0.2% ACE
GUAD_210	47.18%	52.82%	1.23%	1.82	1.56	1.32	1.13	0.98	0.83	0.67	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_170	45.31%	54.69%	1.14%	1.83	1.57	1.33	1.14	0.98	0.83	0.68	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_090	54.55%	45.45%	2.46%	1.77	1.53	1.29	1.11	0.96	0.82	0.66	0.55	0.23	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_070	26.92%	73.08%	1.48%	1.94	1.67	1.40	1.21	1.03	0.86	0.70	0.57	0.24	0.20	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_060	41.49%	58.51%	1.39%	1.85	1.59	1.34	1.15	0.99	0.84	0.68	0.56	0.24	0.19	0.16	0.14	0.12	0.09	0.08	0.07
SMAR_060	97.93%	2.07%	1.76%	1.51	1.31	1.13	0.96	0.85	0.75	0.61	0.50	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_050	86.99%	13.01%	3.57%	1.58	1.37	1.17	1.00	0.87	0.77	0.63	0.51	0.21	0.17	0.15	0.12	0.10	0.07	0.06	0.05
BLNC_060	67.81%	32.19%	5.78%	1.69	1.46	1.24	1.06	0.92	0.80	0.65	0.53	0.22	0.18	0.15	0.13	0.11	0.08	0.07	0.06
BLNC_050	91.76%	8.24%	1.00%	1.55	1.34	1.15	0.98	0.86	0.76	0.62	0.51	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
BLNC_040	88.04%	11.96%	0.97%	1.57	1.36	1.17	0.99	0.87	0.77	0.62	0.51	0.21	0.17	0.14	0.12	0.10	0.07	0.06	0.05
BLNC_030	89.58%	10.42%	0.81%	1.56	1.35	1.16	0.99	0.87	0.77	0.62	0.51	0.21	0.17	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_110	46.22%	53.78%	0.60%	1.82	1.57	1.32	1.14	0.98	0.83	0.67	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
SMAR_070	79.08%	20.92%	2.64%	1.63	1.40	1.20	1.02	0.89	0.78	0.64	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_130	78.33%	21.67%	1.19%	1.63	1.41	1.20	1.03	0.90	0.78	0.64	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_120	43.65%	56.35%	0.72%	1.84	1.58	1.33	1.15	0.99	0.83	0.68	0.56	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_140	55.10%	44.90%	1.08%	1.77	1.52	1.29	1.11	0.96	0.82	0.66	0.54	0.23	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_110	0.00%	100.00%	0.41%	2.10	1.80	1.50	1.30	1.10	0.90	0.73	0.60	0.26	0.21	0.18	0.15	0.13	0.10	0.09	0.08
SMAR_100	49.24%	50.76%	1.39%	1.80	1.55	1.31	1.13	0.97	0.83	0.67	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
SMAR_080	0.00%	100.00%	0.65%	2.10	1.80	1.50	1.30	1.10	0.90	0.73	0.60	0.26	0.21	0.18	0.15	0.13	0.10	0.09	0.08
GUAD_050	29.62%	70.38%	4.74%	1.92	1.65	1.39	1.20	1.02	0.86	0.69	0.57	0.24	0.20	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_040	75.84%	24.16%	8.65%	1.64	1.42	1.21	1.03	0.90	0.79	0.64	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_260	46.97%	53.03%	1.23%	1.82	1.57	1.32	1.14	0.98	0.83	0.67	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_270	66.27%	33.73%	6.23%	1.70	1.47	1.25	1.07	0.93	0.80	0.65	0.53	0.22	0.18	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_100	58.80%	41.20%	0.91%	1.75	1.51	1.28	1.09	0.95	0.81	0.66	0.54	0.22	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_080	4.54%	95.46%	0.52%	2.07	1.78	1.48	1.28	1.09	0.89	0.72	0.60	0.26	0.21	0.18	0.15	0.13	0.10	0.09	0.08
GUAD_300	54.39%	45.61%	2.33%	1.77	1.53	1.29	1.11	0.96	0.82	0.66	0.55	0.23	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_320	79.45%	20.55%	1.76%	1.62	1.40	1.20	1.02	0.89	0.78	0.63	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_310	64.76%	35.24%	10.00%	1.71	1.48	1.25	1.07	0.93	0.80	0.65	0.54	0.22	0.18	0.15	0.13	0.11	0.08	0.07	0.06
BLNC_010	82.42%	17.58%	0.56%	1.61	1.39	1.19	1.01	0.89	0.78	0.63	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
BLNC_020	83.62%	16.38%	0.31%	1.60	1.38	1.18	1.01	0.88	0.77	0.63	0.52	0.21	0.17	0.15	0.12	0.10	0.07	0.06	0.05
SMAR_010	94.47%	5.53%	4.63%	1.53	1.33	1.14	0.97	0.85	0.76	0.62	0.51	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_030	68.52%	31.48%	2.25%	1.69	1.46	1.24	1.06	0.92	0.80	0.65	0.53	0.22	0.18	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_010	90.63%	9.37%	2.55%	1.56	1.35	1.16	0.98	0.86	0.76	0.62	0.51	0.21	0.16	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_040	80.62%	19.38%	2.57%	1.62	1.40	1.19	1.02	0.89	0.78	0.63	0.52	0.21	0.17	0.15	0.13	0.11	0.08	0.07	0.06
SMAR_020	96.94%	3.06%	2.24%	1.52	1.32	1.13	0.96	0.85	0.75	0.61	0.50	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_090	55.55%	44.45%	0.93%	1.77	1.52	1.29	1.11	0.96	0.82	0.66	0.54	0.23	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_020	92.16%	7.84%	4.66%	1.55	1.34	1.15	0.98	0.86	0.76	0.62	0.51	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
SMAR_120	47.89%	52.11%	1.02%	1.81	1.56	1.32	1.13	0.98	0.83	0.67	0.55	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_030	92.41%	7.59%	4.45%	1.55	1.34	1.15	0.98	0.86	0.76	0.62	0.51	0.20	0.16	0.14	0.12	0.10	0.07	0.06	0.05
GUAD_150	70.09%	29.91%	0.74%	1.68	1.45	1.23	1.05	0.92	0.79	0.65	0.53	0.22	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_160	62.39%	37.61%	4.72%	1.73	1.49	1.26	1.08	0.94	0.81	0.66	0.54	0.22	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_180	73.18%	26.82%	0.59%	1.66	1.43	1.22	1.04	0.91	0.79	0.64	0.53	0.22	0.17	0.15	0.13	0.11	0.08	0.07	0.06
GUAD_190	37.50%	62.50%	0.67%	1.87	1.61	1.36	1.17	1.00	0.84	0.68	0.56	0.24	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_200	60.91%	39.09%	1.09%	1.73	1.50	1.27	1.09	0.94	0.81	0.66	0.54	0.22	0.18	0.16	0.13	0.11	0.08	0.07	0.06
GUAD_220	37.17%	62.83%	0.50%	1.88	1.61	1.36	1.17	1.00	0.84	0.69	0.56	0.24	0.19	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_230	44.50%	55.50%	2.77%	1.83	1.58	1.33	1.14	0.98	0.83	0.68	0.56	0.23	0.19	0.16	0.14	0.12	0.09	0.08	0.07
GUAD_240	30.27%	69.73%	1.23%	1.92	1.65	1.38	1.19	1.02	0.85	0.69	0.57	0.24	0.19	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_250	30.89%	69.11%	0.47%	1.91	1.65	1.38	1.19	1.02	0.85	0.69	0.57	0.24	0.19	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_290	33.29%	66.71%	3.69%	1.90	1.63	1.37	1.18	1.01	0.85	0.69	0.57	0.24	0.19	0.17	0.14	0.12	0.09	0.08	0.07
GUAD_280	18.61%	81.39%	0.31%	1.99	1.71	1.43	1.23	1.05	0.87	0.71	0.58	0.25	0.20	0.17	0.14	0.12	0.09	0.08	0.07

Appendix B.1.2.b
Snyder's Lag Time Computations

Dallas-Fort Worth Area Parameters

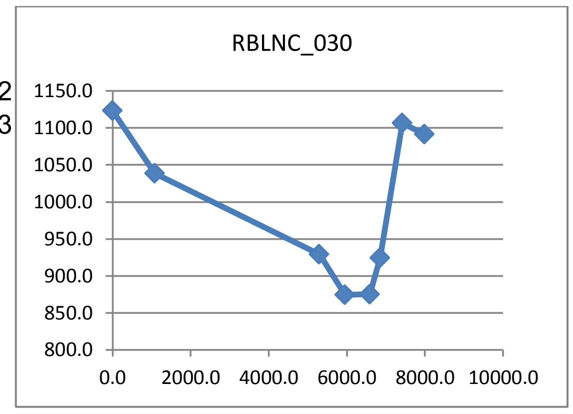
BW = 0.266
Ip_{clay} = 0.92
Ip_{sand} = 1.81

GBRA Lag Time Calculations - Existing Conditions										
Basin	Basin Area	L (mi)	L_{ca} (mi)	S_{st} (ft/mi)	LLca/Sst^.5	%Urb (%)	%Sand	$t_{p\ Computed}$ (hr)	$t_{p\ Calibrated}$ (hr)	$C_{p\ Calibrated}$
BLNC_010	169.20	46.42	25.23	15.36	298.81	11.75	0.18	**9.18**	**10.58**	**0.69**
BLNC_020	68.60	24.53	13.49	25.44	65.63	15.81	0.16	**5.10**	**6.38**	**0.69**
BLNC_030	79.00	27.22	12.81	18.21	81.72	6.49	0.10	**5.31**	**6.9**	**0.8**
BLNC_040	38.20	18.27	9.36	28.81	31.84	5.77	0.12	**3.74**	**4.86**	**0.8**
BLNC_050	56.70	22.35	12.45	23.57	57.34	8.38	0.08	**4.56**	**4.56**	**0.72**
BLNC_060	23.50	17.59	9.80	15.21	44.19	11.43	0.32	**4.70**	**4.7**	**0.71**
GUAD_010	87.80	27.88	16.06	12.99	124.20	9.50	0.09	**6.13**	**6.13**	**0.77**
GUAD_020	130.10	39.18	22.11	16.16	215.50	13.99	0.08	**7.36**	**7.36**	**0.77**
GUAD_030	69.60	32.17	15.44	9.77	158.94	10.37	0.08	**6.55**	**6.55**	**0.62**
GUAD_040	91.80	26.25	11.12	4.53	137.21	5.22	0.24	**6.77**	**6.77**	**0.62**
GUAD_050	59.40	15.96	7.13	9.57	36.79	13.56	0.70	**5.74**	**5.74**	**0.6**
GUAD_060	88.70	26.94	12.26	8.80	111.33	5.19	0.59	**8.24**	**8.24**	**0.59**
GUAD_070	87.80	30.90	15.66	7.84	172.77	5.02	0.73	**10.75**	**10.75**	**0.59**
GUAD_080	96.20	21.66	10.96	13.07	65.64	8.51	0.95	**8.69**	**8.69**	**0.57**
GUAD_090	56.90	33.12	20.06	3.95	334.36	9.58	0.45	**11.40**	**11.4**	**0.6**
GUAD_100	116.20	41.51	22.68	5.49	401.80	5.99	0.41	**12.03**	**12.03**	**0.58**
GUAD_110	69.60	25.38	13.15	8.16	116.86	10.97	1.00	**11.19**	**11.19**	**0.57**
GUAD_120	102.40	26.19	12.87	7.09	126.56	8.39	0.56	**8.57**	**8.57**	**0.58**
GUAD_130	116.80	28.07	13.18	4.58	172.86	5.34	0.22	**7.61**	**7.61**	**0.58**
GUAD_140	86.50	28.28	15.58	6.82	168.77	7.88	0.45	**8.83**	**8.83**	**0.58**
GUAD_150	107.60	29.56	13.96	6.19	165.85	6.31	0.30	**7.94**	**7.94**	**0.58**
GUAD_160	69.30	33.49	16.75	2.75	338.25	15.17	0.38	**10.75**	**10.75**	**0.59**
GUAD_170	55.10	20.96	13.17	7.65	99.81	5.41	0.55	**7.71**	**7.71**	**0.58**
GUAD_180	159.00	38.05	16.00	4.41	289.75	12.75	0.27	**9.64**	**9.64**	**0.58**
GUAD_190	17.70	14.20	8.94	7.20	47.31	9.86	0.62	**6.13**	**6.13**	**0.58**
GUAD_200	153.10	34.01	20.15	5.32	297.21	11.14	0.39	**10.56**	**10.56**	**0.58**
GUAD_210	146.20	40.44	20.65	2.37	542.89	7.43	0.53	**14.57**	**14.57**	**0.58**
GUAD_220	169.10	39.35	18.60	6.30	291.62	5.00	0.63	**12.34**	**12.34**	**0.58**
GUAD_230	100.90	23.29	8.16	4.19	92.86	10.32	0.56	**7.48**	**7.48**	**0.54**
GUAD_240	138.20	28.71	14.72	8.46	145.33	6.29	0.70	**9.86**	**9.86**	**0.54**
GUAD_250	107.90	29.47	14.90	7.19	163.84	12.16	0.69	**10.32**	**10.32**	**0.54**
GUAD_260	64.20	19.24	10.01	4.88	87.11	5.67	0.53	**7.24**	**7.24**	**0.54**
GUAD_270	103.90	27.12	15.36	4.09	206.03	5.00	0.34	**8.58**	**8.58**	**0.55**
GUAD_280	109.80	28.44	16.84	6.47	188.20	6.18	0.81	**11.85**	**11.85**	**0.53**
GUAD_290	136.10	23.92	9.68	6.53	90.63	12.30	0.67	**7.94**	**7.94**	**0.54**
GUAD_300	46.70	21.84	10.47	5.45	97.97	5.90	0.46	**7.16**	**7.16**	**0.54**
GUAD_310	49.30	20.80	9.44	6.78	75.40	7.90	0.35	**5.80**	**5.8**	**0.56**
GUAD_320	174.60	33.97	15.40	4.00	261.51	7.32	0.21	**8.86**	**8.86**	**0.54**
SMAR_010	96.30	26.06	16.92	22.31	93.32	13.65	0.06	**5.28**	**5.28**	**0.7**
SMAR_020	141.90	35.74	17.87	13.40	174.53	9.20	0.03	**6.68**	**6.68**	**0.72**
SMAR_030	82.50	30.89	18.20	7.34	207.40	11.71	0.31	**8.64**	**8.64**	**0.71**
SMAR_040	52.20	29.25	15.97	11.39	138.38	10.81	0.19	**6.80**	**6.8**	**0.63**
SMAR_050	70.70	19.69	12.25	14.32	63.70	6.27	0.13	**4.82**	**5.3**	**0.6**
SMAR_060	41.80	19.34	8.21	11.81	46.20	8.37	0.02	**4.00**	**5.2**	**0.71**
SMAR_070	71.80	22.21	8.73	9.20	63.95	7.04	0.21	**5.14**	**5.14**	**0.61**
SMAR_080	51.30	27.69	14.69	8.07	143.14	6.56	1.00	**12.07**	**12.07**	**0.61**
SMAR_090	107.10	37.27	18.34	6.65	265.06	6.05	0.44	**10.48**	**10.48**	**0.7**
SMAR_100	33.40	15.11	7.66	9.90	36.80	10.58	0.51	**5.11**	**5.11**	**0.61**
SMAR_110	66.00	18.04	7.84	9.77	45.26	6.11	0.54	**5.68**	**5.68**	**0.6**
SMAR_120	107.60	33.17	18.73	4.87	281.48	5.93	0.52	**11.28**	**11.28**	**0.61**

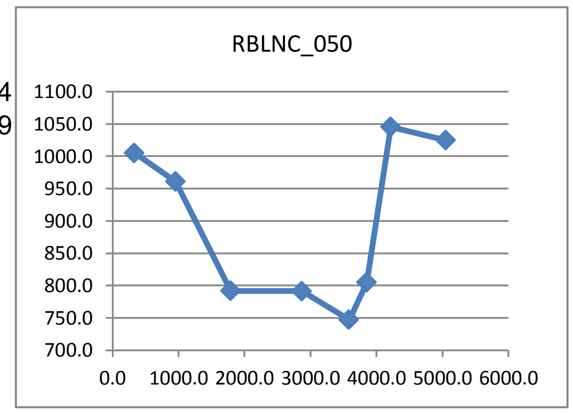
Appendix B.1.2.c
Muskingum-Cunge Routing Data

HALFF

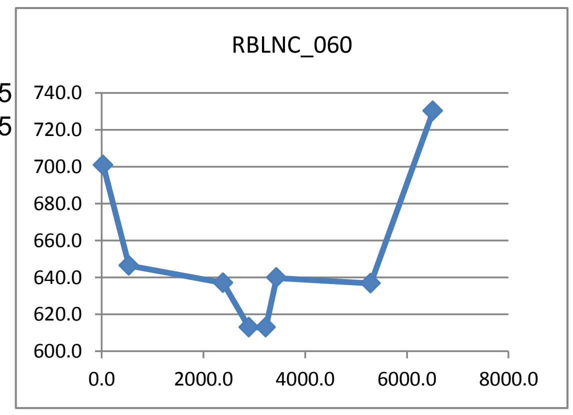
Reach	RBLNC_030		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	1123.3	0.090	0.060	0.080	XS	7991.5	248.72
2	1077.5	1038.8				Channel	1556.4	54.593
3	5297.7	929.2						
4	5956.2	874.6						
5	6584.7	875.3						
6	6854.1	924.3						
7	7422.8	1106.8						
8	7991.5	1091.4						



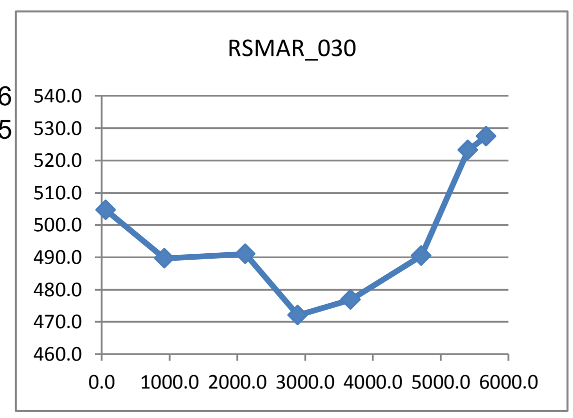
Reach	RBLNC_050		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	328.7	1005.4	0.090	0.060	0.095	XS	4722	298.4
2	956.4	960.9				Channel	2062.1	57.989
3	1793.2	791.7						
4	2869.1	791.3						
5	3586.3	746.9						
6	3855.3	804.9						
7	4213.9	1045.3						
8	5050.7	1025.0						



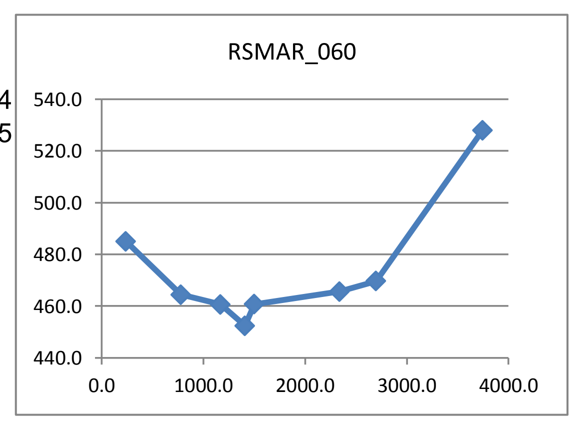
Reach	RBLNC_060		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	29.9	700.7	0.080	0.065	0.085	XS	6485.4	117.15
2	538.0	646.4				Channel	1046	26.865
3	2390.9	636.9						
4	2899.0	612.9						
5	3227.8	612.9						
6	3437.0	639.8						
7	5289.9	636.8						
8	6515.3	730.0						



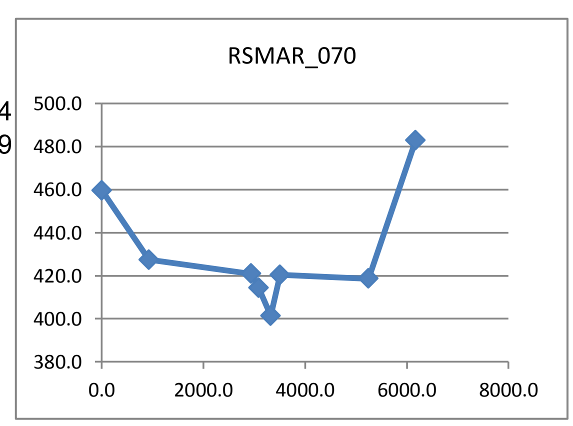
Reach	RSMAR_030		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	59.7	504.7	0.080	0.060	0.080	XS	5611.6	55.436
2	925.3	489.6				Channel	2596.9	18.975
3	2119.3	491.0						
4	2895.4	472.0						
5	3671.4	476.9						
6	4716.2	490.4						
7	5402.7	523.3						
8	5671.3	527.4						



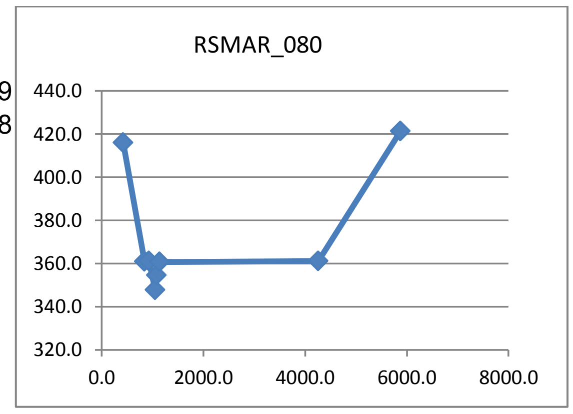
Reach	RSMAR_060		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	239.8	484.9	0.065	0.070	0.060	XS	3507.5	75.644
2	779.5	464.4				Channel	1169.2	13.275
3	1169.2	460.6						
4	1409.0	452.4						
5	1498.9	460.8						
6	2338.4	465.6						
7	2698.1	469.6						
8	3747.4	528.0						



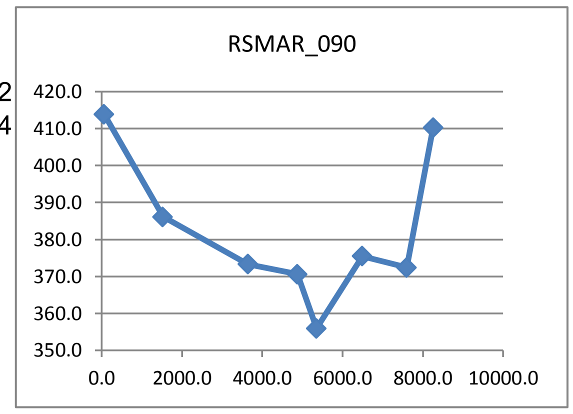
Reach	RSMAR_070		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	459.6	0.060	0.070	0.065	XS	6172.1	81.514
2	928.8	427.4				Channel	569.27	19.499
3	2936.3	420.9						
4	3086.1	414.3						
5	3325.8	401.4						
6	3505.5	420.4						
7	5243.3	418.7						
8	6172.1	482.9						



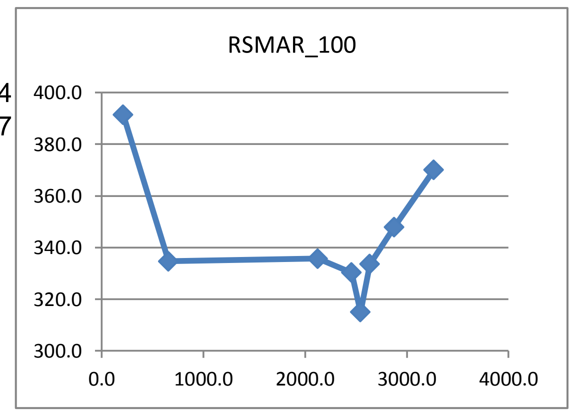
Reach	RSMAR_080		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	419.6	416.0	0.085	0.070	0.065	XS	5455.2	73.659
2	839.3	360.9				Channel	209.82	13.388
3	929.2	361.1						
4	1049.1	347.7						
5	1079.0	354.5						
6	1139.0	360.8						
7	4256.3	361.1						
8	5874.8	421.4						



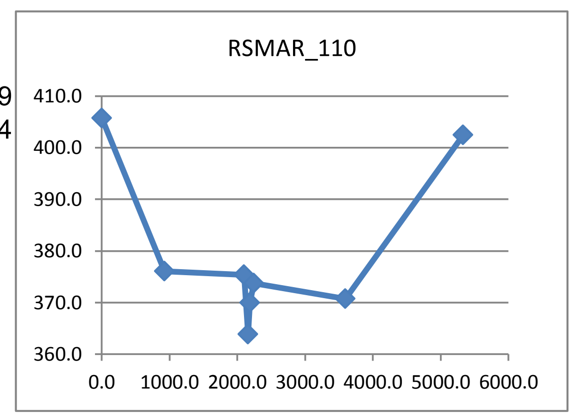
Reach	RSMAR_090		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	59.8	413.9	0.085	0.065	0.085	XS	8198.8	58.012
2	1526.0	386.1				Channel	2842.6	19.554
3	3650.5	373.3						
4	4877.4	370.6						
5	5356.1	355.9						
6	6493.2	375.4						
7	7600.3	372.4						
8	8258.6	410.2						



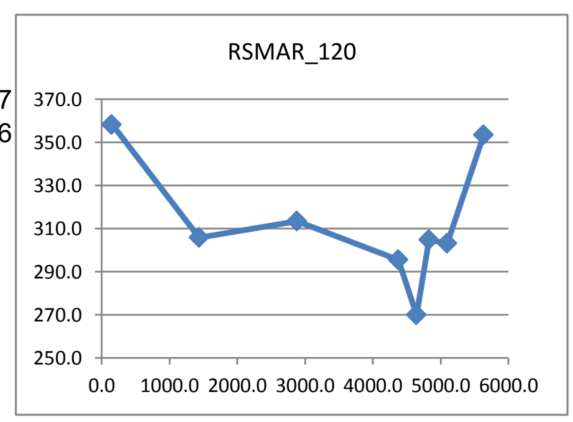
Reach	RSMAR_100		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	209.7	391.4	0.085	0.050	0.075	XS	3055.6	76.4
2	659.0	334.7				Channel	509.3	20.7
3	2126.9	335.7						
4	2456.4	330.3						
5	2546.3	315.0						
6	2636.2	333.6						
7	2875.8	347.9						
8	3265.3	370.0						



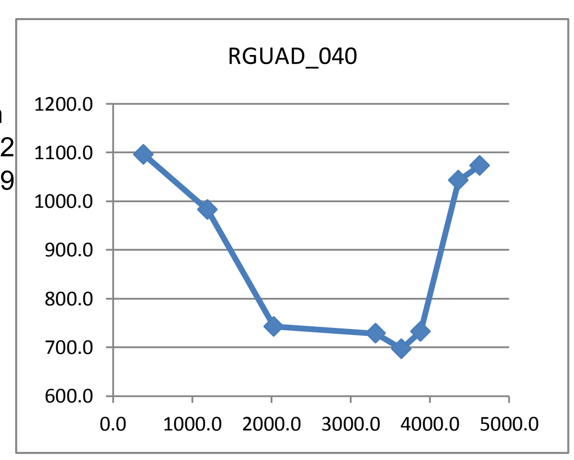
Reach	RSMAR_110		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	405.7	0.070	0.065	0.080	XS	5332.9	41.889
2	928.8	376.1				Channel	149.8	11.574
3	2097.2	375.4						
4	2157.1	363.8						
5	2187.1	370.0						
6	2247.0	373.7						
7	3595.2	370.7						
8	5332.9	402.4						



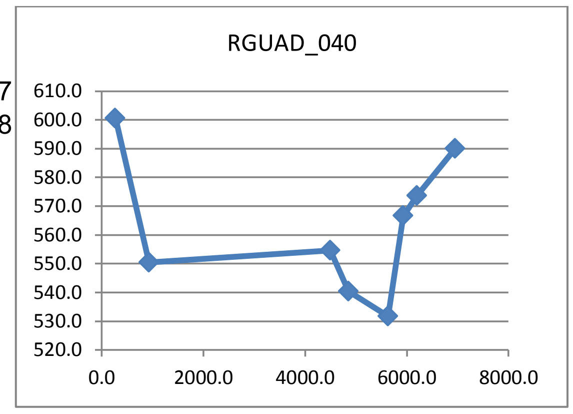
Reach	RSMAR_120		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	149.9	358.3	0.085	0.065	0.085	XS	5485.2	88.407
2	1438.7	305.9				Channel	1948.3	43.616
3	2877.5	313.5						
4	4376.2	295.4						
5	4645.9	269.9						
6	4825.8	304.8						
7	5095.5	303.0						
8	5635.1	353.4						



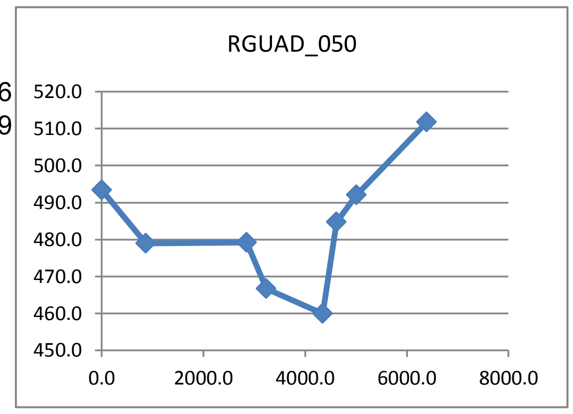
Reach	RGUAD_010		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	388.2	1095.9	0.100	$\boxed{0.05}$	0.100	XS	4239.9	399.22
2	1194.3	982.4				Channel	1851.2	45.639
3	2030.4	742.3						
4	3314.3	728.2						
5	3642.7	696.7						
6	3881.6	732.6						
7	4359.3	1042.6						
8	4628.0	1073.4						



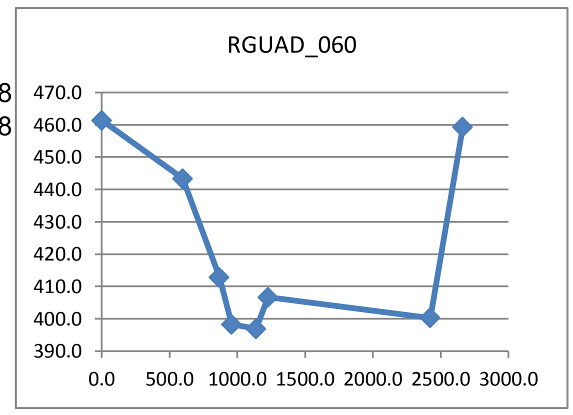
Reach	RGUAD_040		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	269.6	600.5	0.085	0.045	0.080	XS	6679.3	68.787
2	928.5	550.5				Channel	1437.7	34.888
3	4492.8	554.7						
4	4852.2	540.3						
5	5631.0	531.7						
6	5930.5	566.6						
7	6200.1	573.7						
8	6948.9	590.0						



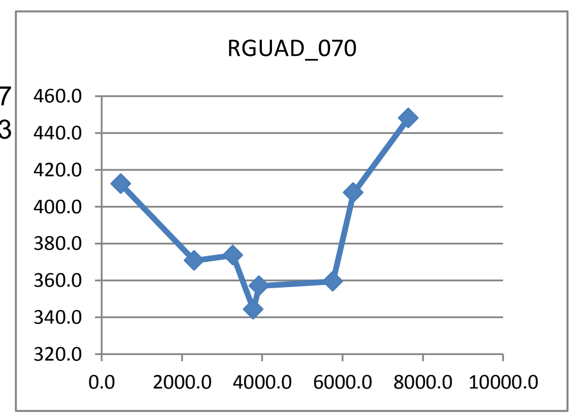
Reach	RGUAD_050		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	493.3	0.085	0.060	0.080	XS	6388.3	51.936
2	869.8	479.0				Channel	1769.5	24.789
3	2849.3	479.2						
4	3239.1	466.7						
5	4348.9	459.9						
6	4618.8	484.7						
7	5008.7	492.1						
8	6388.3	511.8						



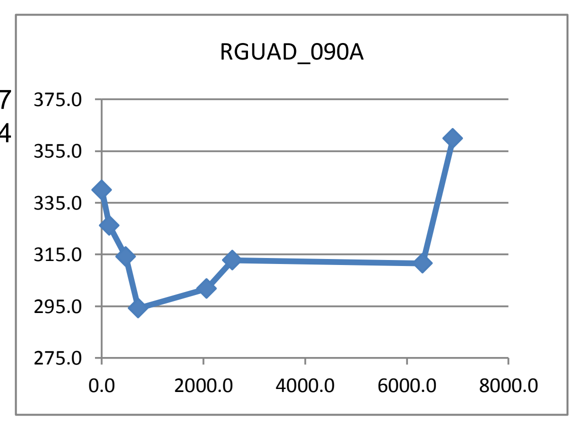
Reach	RGUAD_060		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	461.3	0.090	0.070	0.085	XS	2664.2	64.498
2	598.7	443.4				Channel	359.21	15.918
3	868.1	412.8						
4	957.9	398.2						
5	1137.5	396.8						
6	1227.3	406.7						
7	2424.7	400.3						
8	2664.2	459.3						



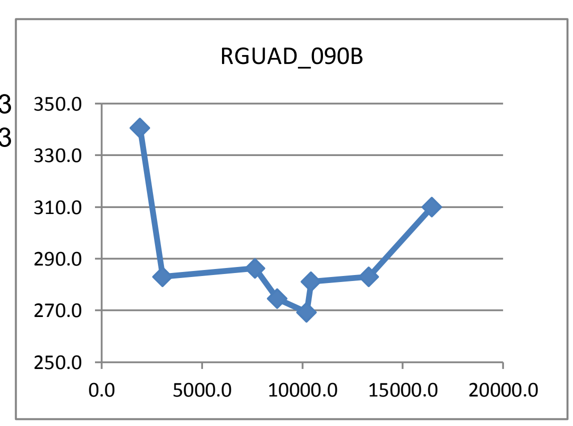
Reach	RGUAD_070		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	479.9	412.3	0.090	0.065	0.090	XS	7168.2	103.77
2	2309.4	370.7				Channel	2489.4	29.403
3	3269.2	373.6						
4	3779.0	344.2						
5	3929.0	357.0						
6	5758.5	359.5						
7	6268.4	407.4						
8	7648.0	447.9						



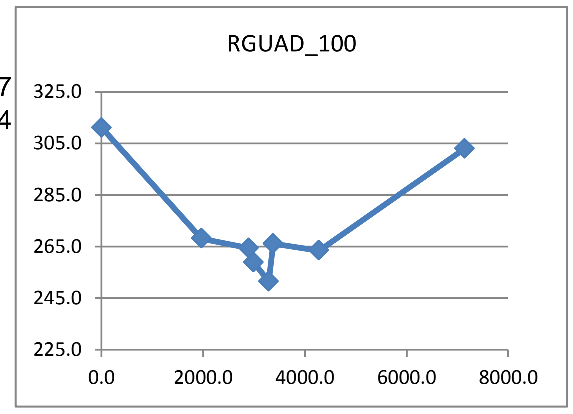
Reach	RGUAD_090A		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	340.0	0.080	0.065	0.080	XS	6912.2	65.57
2	149.6	326.2				Channel	2094.6	19.864
3	478.8	314.1						
4	718.2	294.2						
5	2064.7	301.8						
6	2573.4	312.8						
7	6313.8	311.5						
8	6912.2	359.8						



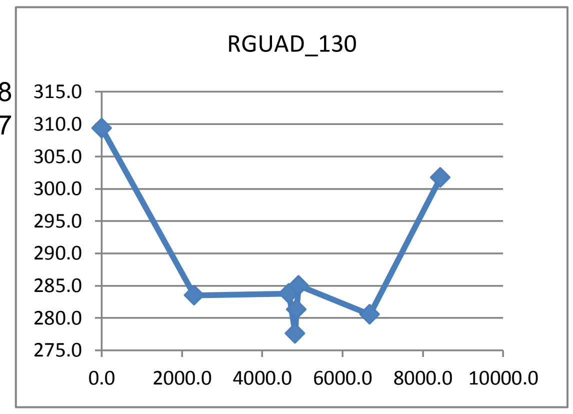
Reach	RGUAD_090B		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	1912.1	340.6	0.085	0.075	0.085	XS	14540	71.323
2	3047.3	283.0				Channel	2786.8	16.993
3	7649.6	286.3						
4	8758.4	274.5						
5	10226.6	269.3						
6	10436.4	281.1						
7	13310.3	283.0						
8	16452.1	310.0						



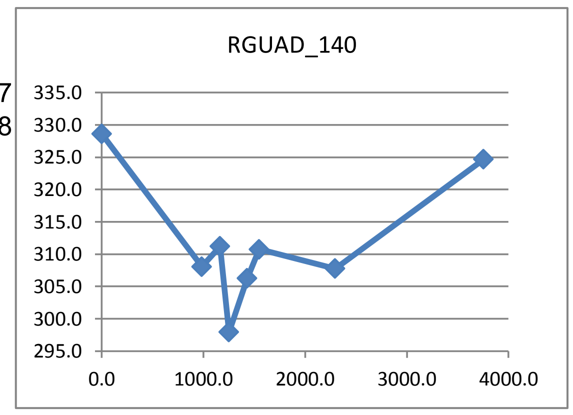
Reach	RGUAD_100		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	311.1	0.075	0.070	0.075	XS	7144.2	59.687
2	1972.9	268.1				Channel	478.27	14.654
3	2899.5	264.4						
4	2989.2	258.9						
5	3288.1	251.4						
6	3377.8	266.1						
7	4274.6	263.5						
8	7144.2	302.9						



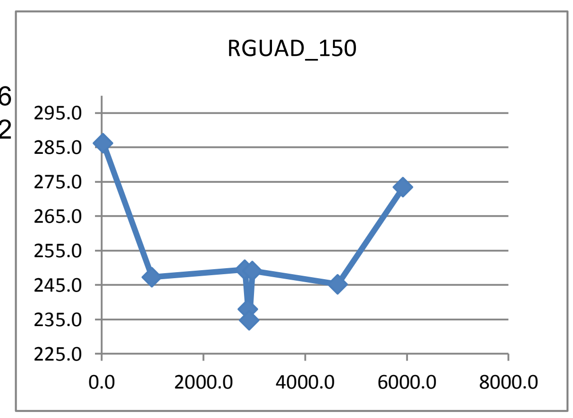
Reach	RGUAD_130		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	309.4	0.080	0.070	0.075	XS	8443	31.768
2	2305.4	283.5				Channel	239.52	7.3957
3	4670.6	283.7						
4	4820.3	277.6						
5	4850.2	281.3						
6	4910.1	285.0						
7	6676.5	280.6						
8	8443.0	301.7						



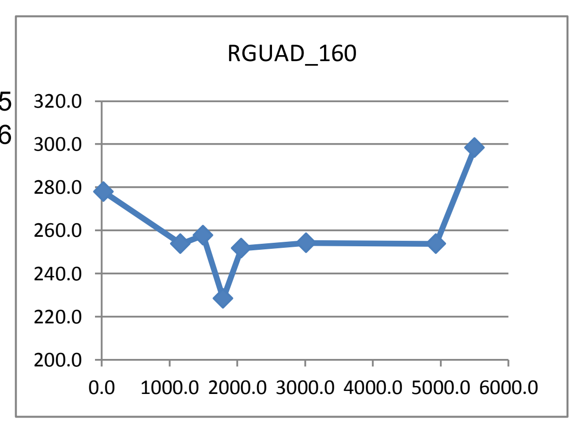
Reach	RGUAD_140		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	328.6	0.075	0.070	0.080	XS	3756.7	30.707
2	983.9	308.1				Channel	387.59	13.28
3	1162.8	311.2						
4	1252.2	297.9						
5	1431.1	306.2						
6	1550.4	310.7						
7	2295.7	307.8						
8	3756.7	324.7						



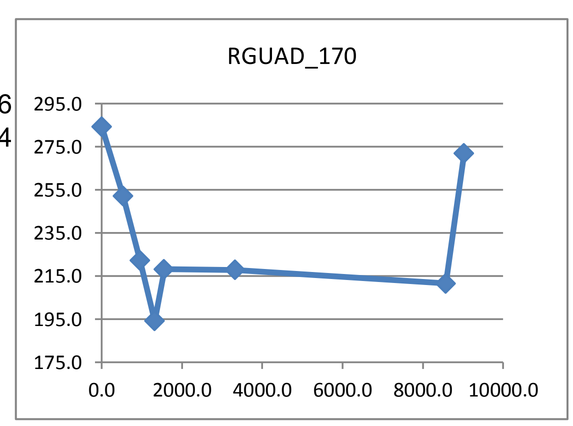
Reach	RGUAD_150		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	30.0	286.2	0.080	0.070	0.085	XS	5901.2	51.516
2	988.5	247.3				Channel	149.78	14.792
3	2815.8	249.5						
4	2875.7	237.9						
5	2905.6	234.7						
6	2965.6	249.1						
7	4643.0	245.2						
8	5931.1	273.4						



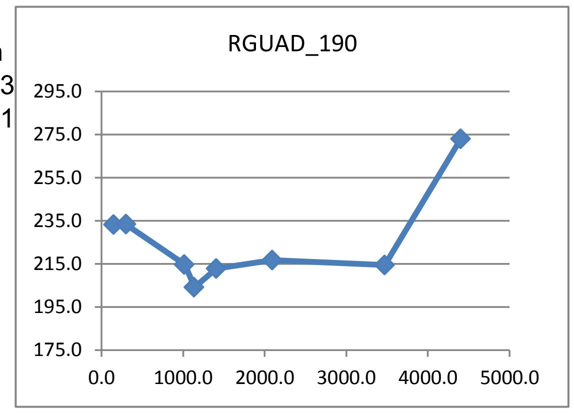
Reach	RGUAD_160		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	29.9	277.9	0.080	0.065	0.080	XS	5471.2	69.955
2	1166.0	253.7				Channel	1524.7	29.316
3	1494.9	257.6						
4	1793.8	228.3						
5	2062.9	251.8						
6	3019.6	254.2						
7	4933.0	253.7						
8	5501.1	298.3						



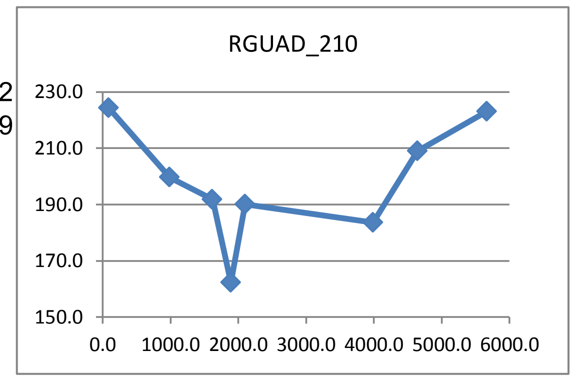
Reach	RGUAD_170		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	284.3	0.080	0.070	0.090	XS	9027.7	90.216
2	539.9	252.1				Channel	2369.4	28.094
3	959.8	222.2						
4	1319.7	194.1						
5	1559.6	218.1						
6	3329.2	217.9						
7	8577.9	211.5						
8	9027.7	271.8						



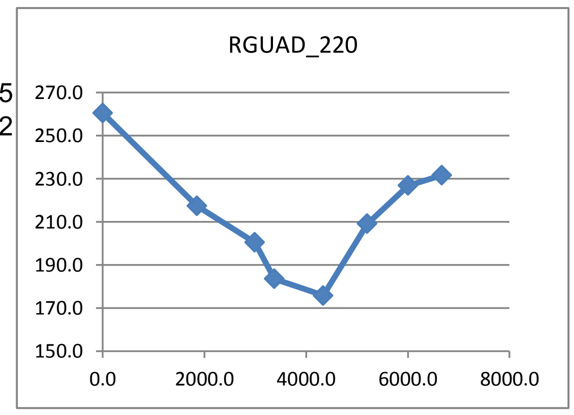
Reach	RGUAD_190		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	149.7	233.1	0.075	0.070	0.080	XS	4252	68.93
2	299.4	233.3				Channel	1078	12.571
3	1018.1	214.6						
4	1137.9	204.0						
5	1407.4	212.7						
6	2096.1	216.6						
7	3473.5	214.4						
8	4401.7	272.9						



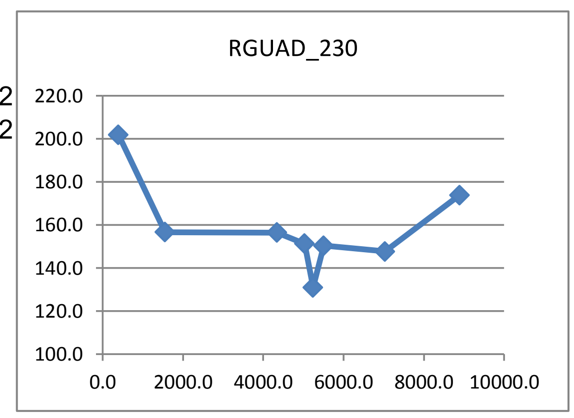
Reach	RGUAD_210		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	89.9	224.3	0.085	0.070	0.080	XS	5573.8	62.072
2	988.9	199.6				Channel	2367.4	29.509
3	1618.2	191.7						
4	1887.9	162.2						
5	2097.7	190.0						
6	3985.6	183.6						
7	4644.9	209.0						
8	5663.7	223.0						



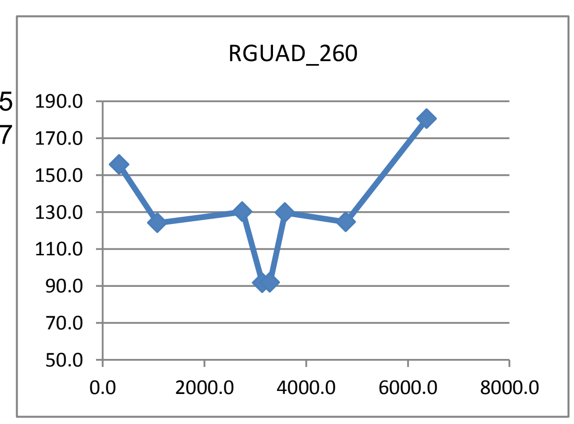
Reach	RGUAD_220		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	260.5	0.070	0.070	0.065	XS	6667.7	84.725
2	1853.8	217.3				Channel	2212.6	33.372
3	2990.0	200.4						
4	3378.7	183.6						
5	4335.5	175.8						
6	5202.6	209.2						
7	6009.9	226.8						
8	6667.7	231.6						



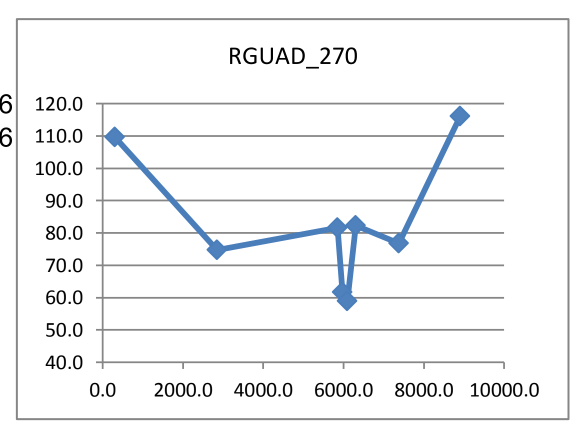
Reach	RGUAD_230		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	389.5	201.9	0.100	0.070	0.090	XS	8508.2	70.992
2	1557.8	156.6				Channel	1168.4	25.472
3	4344.0	156.4						
4	5033.0	151.3						
5	5242.7	130.9						
6	5512.4	150.3						
7	7040.2	147.7						
8	8897.7	173.9						



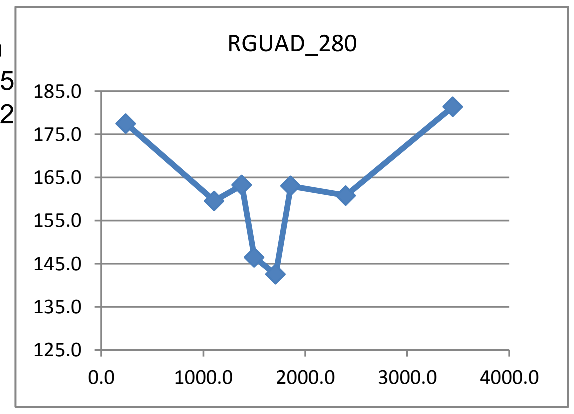
Reach	RGUAD_260		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	329.1	155.4	0.080	0.060	0.085	XS	6042.6	88.815
2	1076.9	124.1				Channel	837.59	38.547
3	2752.1	130.1						
4	3141.0	91.6						
5	3290.5	91.9						
6	3589.7	129.6						
7	4786.2	124.6						
8	6371.6	180.4						



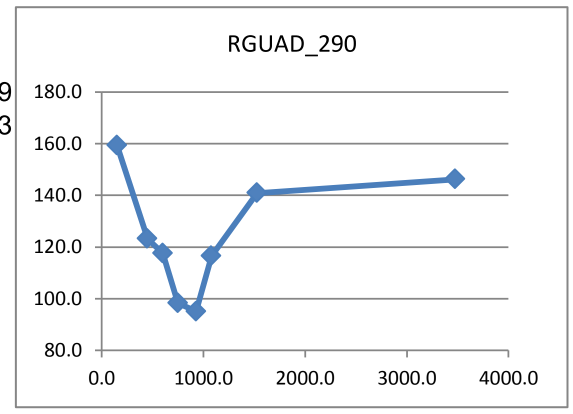
Reach	RGUAD_270		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	300.0	109.7	0.090	0.065	0.090	XS	8609	57.286
2	2849.7	74.7				Channel	449.95	23.466
3	5849.3	81.6						
4	5969.3	61.7						
5	6089.3	58.9						
6	6299.2	82.3						
7	7379.1	76.8						
8	8908.9	116.2						



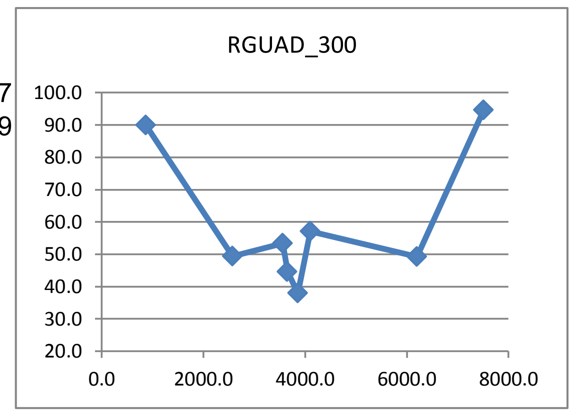
Reach	RGUAD_280		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	239.9	177.5	0.075	0.070	0.075	XS	3208.6	38.95
2	1109.5	159.5				Channel	479.79	20.72
3	1379.4	163.2						
4	1499.3	146.4						
5	1709.2	142.5						
6	1859.2	163.0						
7	2398.9	160.8						
8	3448.5	181.4						



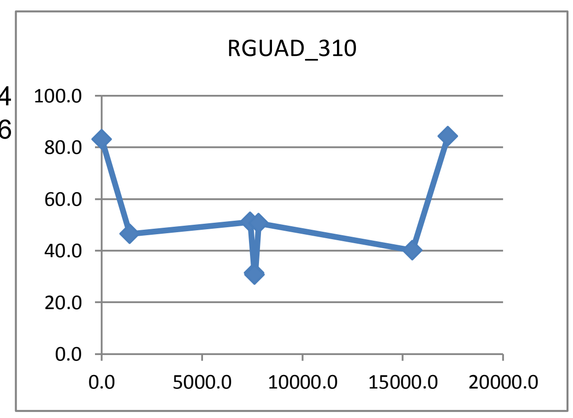
Reach	RGUAD_290		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	149.8	159.3	0.065	0.040	0.080	XS	3326.4	64.319
2	449.5	123.2				Channel	479.48	22.543
3	599.3	117.6						
4	749.2	98.3						
5	929.0	95.0						
6	1078.8	116.5						
7	1528.3	140.9						
8	3476.2	146.2						



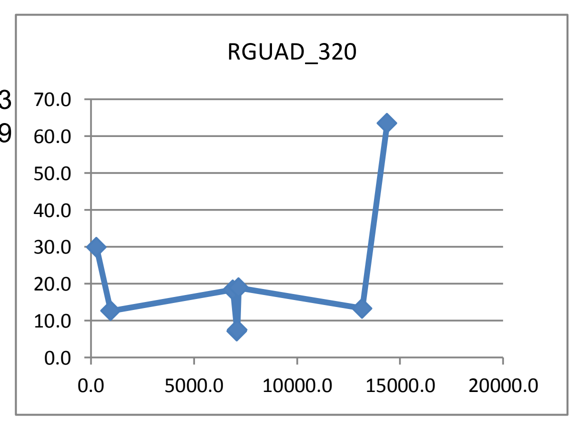
Reach	RGUAD_300		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	868.2	89.9	0.095	0.065	0.095	XS	6645.9	56.597
2	2574.5	49.4				Channel	538.86	19.119
3	3562.5	53.4						
4	3652.3	44.6						
5	3861.8	38.0						
6	4101.3	57.1						
7	6196.9	49.2						
8	7514.1	94.6						



Reach	RGUAD_310		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	0.0	83.1	0.100	0.065	0.090	XS	17251	53.764
2	1407.6	46.5				Channel	419.29	20.526
3	7397.6	51.2						
4	7607.2	31.4						
5	7637.2	30.7						
6	7816.9	50.6						
7	15484.0	40.1						
8	17251.0	84.4						



Reach	RGUAD_320		Manning's N					
Point	sta	elev	L	Ch	R		width	depth
1	270.0	29.9	0.095	0.070	0.090	XS	14098	56.333
2	959.8	12.7				Channel	269.95	11.719
3	6898.8	18.4						
4	7078.8	7.2						
5	7108.8	7.5						
6	7168.8	18.9						
7	13167.7	13.3						
8	14367.5	63.5						



Appendix B.1.2.d
Hydrologic Technical Notebook

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Project Notebook
Guadalupe Blanco River Authority Watersheds

Project: GBRA Interim Feasibility Study **AVO:** 28411

Entry # : 1

Subject : Basic Project Notes

Notes :

- USACE Ft Worth District Methodology
  - Snyder's UH
  - Urbanization Curves
  - % Sand parameters from soils data
- Coordinate System:
  - NAD_1983_StatePlane_Texas_South_Central_FIPS_4204_Feet
- GBRA Terrain
  - CapCog 2007 (1.4 m), CapCog 2008 (1.4 m), CapCog 2008 (0.7 m), COA 2003 (unknown), FEMA 2006 (1.4 m), FEMA 2011 (0.61 m), LCRA 2007 (1.4 m), TNRIS 2009 (1.0 m), TNRIS 2010 (0.5 m), TNRIS 2011 (0.5 m), USGS 2011 (1.5 m) and DeWitt_DEMclip_wFEMA_TNRIS (unknown) utilized
  - DEMs (cellsize of 30 feet) generated from LiDAR
- Channel Routing
  - Muskingum-Cunge 8pt for preliminary precipitation

Entry # : 2

Subject : Subbasin delineation

Notes :

- GeoHMS was used to develop the initial subbasin delineations
- Subbasins were then adjusted for suggested changes from a meeting with constituents from the COE, Halff, TWDB and GBRA. This took place on August 29th, 2012.

Entry # : 3

Subject : Routing Precipitation Data

Notes :

- Precipitation data was derived using the USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas (SIR 2004-5041, Asquith)) report. The USGS ddf.exe program was used to identify the point precipitation for the approximate center of the Lower GBRA study extents.

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- A 24 hour storm duration with 5 minute intensity distribution and triangular (50%) storm distribution was selected.
- The 5 minute precipitation values were estimated by visually extrapolating the trend of the 30- and 15-minute data on a log-log scale.
- The 1 hour rainfall was computed by averaging the 1 hour and 60 minute values as recommended by Asquith (SIR 2004-5041).
- The 1 day rainfall was computed by using a weighted average of the 24 hour result added to 3 times the 1 day result and then divided by 4 as recommended by Asquith (SIR 2004-5041).
- Below is a table of the routing precipitation data used in the model.

		Frequency Depth-Duration (Inches)							
Duration	**hrs**	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**250-yr**	**500-yr**
5 min	0.083333	0.7	0.94	1.09	1.33	1.56	1.83	2.18	2.53
15 min	0.25	1.07	1.41	1.66	2.02	2.33	2.69	3.23	3.71
1 hr	1	1.83	2.41	2.82	3.41	3.9	4.45	5.29	6.01
2 hr	2	2.3	3.07	3.61	4.39	5.06	5.8	6.94	7.93
3 hr	3	2.41	3.29	3.94	4.87	5.68	6.59	8	9.25
6 hr	6	2.73	3.68	4.38	5.39	6.27	7.27	8.82	10.2
12 hr	12	3.14	4.26	5.08	6.27	7.31	8.49	10.32	11.95
1 day	24	3.6	5.1	6.18	7.67	8.9	10.23	12.15	13.75

Entry # : 4

Subject : Flowpaths

Notes :

- The longest flowpaths were developed using Geo-HMS and checked manually.
- The basin centroids and centroidal flowpaths were developed using GIS tools
- The weighted slope for each flowpath was calculated over the distance from 10% of the length to 85% of the length above the outlet.

Entry # : 5

Subject : Percent Sand Parameter

Notes :

Runoff losses were computed using the Block and Uniform loss rate method.

As part of the Fort Worth District USACE methodology, the percent sand parameter is a primary indicator for projecting both rainfall losses and unit hydrograph lag times. On a subbasin scale, the percent sand parameter generally ranges from zero to one hundred (percent) with zero

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representing areas with highly impermeable clayey soils and one hundred representing areas with highly permeable sandy soils. Example soils of each type include those of the Blackland Prairie and the Cross Timbers regions, respectively.

The Blackland Prairie is nearly treeless, mostly flat grassland, with most of the unurbanized areas under cultivation. Soils typical of the Blackland Prairie are clays and clay loams, such as the Houston Black soil series. This series consists of moderately well-drained, deep, cyclic, clayey soils, which formed in alkaline, marine clay, and material weathered from shale. It has a permeability of less than 0.06 inches per hour and is the predominant series found in watersheds used to develop the Blackland Prairie Clay Urbanization Curves which are discussed later in this narrative. Soils having permeability of less than 0.06 inches per hour have thus been assigned a percent sand value of zero.

The Cross Timbers is a wooded region adjacent to the Blackland and Grand Prairies. Soils typical of the Cross Timbers are fine sandy loams, such as the Crosstell soil series. This series consists of moderately well-drained, deep, loamy soils on uplands that formed in shaley and clayey sediment containing thin strata of weakly cemented sandstone, has a permeability between 0.6 and 2 inches per hour, and is the predominant series found in the watersheds used to develop the Cross Timbers Sandy Loam Urbanization Curves which are discussed later in this narrative. Soils having permeability between 0.6 and 2 inches per hour have thus been assigned a percent sand value of 100%.

Soils with permeability ranging between 2 and 6 inches per hour are assigned a 133 percent sand value, those few with permeability ranging between 6 and 20 inches per hour are assigned a 167 percent sand value, and those even fewer with permeability in excess of 20 inches per hour are assigned a 200 percent sand value.

The percent sand value is a representation of permeability rather than the actual grain size content of a soil. The percent sand values can be in excess of 100 % for highly permeable soils. The general relationship of permeability to percent sand is summarized in Table 1 (Determination of Percent Sand in Watersheds, USACE, 1986).

Table 1. Percent Sand and Permeability Rates

Permeability (Inches/Hour)	Percent Sand
< 0.06	0 %
0.06 – 0.2	33 %
0.2 – 0.6	66 %
0.6 – 2.0	100 %
2.0 – 6.0	133 %
6.0 - 20	166 %
> 20	200 %

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When assigning specific percent sand values for given soil types, it was common to encounter soil profile layers exhibiting widely varying permeability. Examples are those cases where a shallow sandy layer overlays an extensive, heavy clay layer. Considering merely the surface layer or simply applying a depth-weighted average to determine representative (net) permeability failed to properly define the infiltration characteristics for those types of soils. In these relatively common situations, it was necessary to apply engineering judgment with regards to how the layering would impact the overall infiltration during extended rainfall-runoff events. This included consideration of the available water capacity of the shallow surface soil layer(s) in relation to the depth of precipitation leading up to the more intense period of rainfall.

Area-weighted Percent Sand values were developed for each subbasin. In any instances where the weighted values exceeded 100, the percent sand value was then truncated at 100.

The % clay values are the complement of the % sand values for each subbasin.

Entry # : 6

Subject : Percent Urbanization Parameter

Notes :

The Percent Urbanization parameter is a primary indicator for projecting unit hydrograph lag times. It typically reflects the percentage of a subbasin which has been developed and improved with channelization and/or a stormwater collection network. The percent urbanization for each subbasin was determined by estimating an area weighted percent urbanization for each subbasin. Land use data and corresponding percent urbanization values is shown in the table below.

Percent Urbanization per Land Use

Land Use	Assumed Percent Urbanization (%)
Barren Land (Rock/Sand/Clay)	0
Woody Wetlands	0
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Emergent Herbaceous Wetlands	0
Pasture/Hay	0
Shrub/Scrub	0
Grassland/Herbaceous	0
Cultivated Crops	5
Developed, Open Space, Impervious < 20%	10

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Developed, Low Intensity, Impervious 20-49%	30
Developed, Medium Intensity, Impervious 50-79%	90
Developed, High Intensity, Impervious 80-100%	95
Open Water	100

Entry # : 7

Subject : Loss Rates

Notes :

The Guadalupe River subbasin loss rates were calculated using the area weighted percent sand and percent clay values to assign Block and Uniform loss rates for each sub-basin. The default loss rates vary in relation to runoff frequency based on the historic tendency for infrequent flood events to be temporally associated with wet periods having had antecedent events capable of significantly saturating the upper soil profile. The default loss rates for 100% clay and 100% sand are shown in Table 4 (NUDALLAS Documentation, USACE, 1986).

Table 4. Loss Rates for Clay and Sand Soils

Hydrologic Loss Rates				
Annual Chance Exceedence	Clay		Sand	
	Block (in)	Uniform (in/hr)	Block (in)	Uniform (in/hr)
50%	1.5	0.2	2.1	0.26
20%	1.3	0.16	1.8	0.21
10%	1.12	0.14	1.5	0.18
4%	0.95	0.12	1.3	0.15
2%	0.84	0.10	1.1	0.13
1%	0.75	0.07	0.9	0.10
0.4%	0.61	0.06	0.73	0.09
0.2%	0.5	0.05	0.6	0.08

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Percent Impervious values were derived from the land use data and were assigned according to the relationship in the table below:

Land Use	Assumed Percent Impervious (%)
Barren Land (Rock/Sand/Clay)	0
Woody Wetlands	0
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Emergent Herbaceous Wetlands	0
Pasture/Hay	0
Shrub/Scrub	0
Grassland/Herbaceous	0
Cultivated Crops	3
Developed, Open Space, Impervious < 20%	6
Developed, Low Intensity, Impervious 20-49%	47
Developed, Medium Intensity, Impervious 50-79%	70
Developed, High Intensity, Impervious 80-100%	100
Open Water	100

Entry # : 8

Subject : Lag Times

Notes :

All Snyder lag times were computed using the USACE Fort Worth District Urbanization Curves. The Fort Worth District Urbanization curves were originally developed for both the Blackland Prairie Clay and the Cross Timbers Sandy Loam prevalent watersheds. When presented in graphical form, each set of curves is represented by linear relationships in logarithmic scale. For user convenience, these functions have been provided in mathematical form. The Snyder's lag time (Tp) values were computed using the following equation:

$$\log(Tp) = 0.3833\log(L*L_{ca}/(S_{st})\text{^}.5))+(Sand*(\log(Ip_{sand})-\log(Ip_{clay}))+\log(Ip_{clay}))-(BW*\%Urb)$$

Where:

- Tp = Lag time in hours
- L = River mileage from drainage area outlet to the upstream limits of the drainage area. This is the same as the longest flowpath of the subbasin
- L_{ca} = River mileage along the longest flow path to a point nearest to the center of gravity of the drainage area
- S_{st} = Weighted slope (ft/mi) from 85% to 10% along the longest flowpath
- Sand = Percent sand of the subbasin as a decimal

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Ip_{sand}	=	Calibration point for sand *
Ip_{clay}	=	Calibration point for clay *
BW	=	Bandwidth *
%Urb	=	Percent urbanization as a decimal

*Note: The Fort Worth District Urbanization Curves have Ip values of 0.92 for clay and 1.81 for sand and the bandwidth is 0.266 for clay and sand. These curves have been applied throughout the Fort Worth District region including Central and South Central Texas. These curves relate the runoff characteristics to surface soil, cover, land use, and drainage network characteristics, and are thus equally valid for similarly sized, shaped, and sloped subbasins, regardless of their physical location.

Entry # : 9

Subject : Preliminary Routing

Notes :

- Channel reaches were modeled using Muskingum-Cunge 8 point method
- Overbank and channel N-values correspond with the values being used in the hydraulic models.
- Reaches with hydraulic routing models will be updated to Mod Puls routing when routing models are complete

Overbank Land Use	N-Value
Bare Ground	0.06
Open Development/Roads	0.07
Shrubland	0.08
Pasture/Hay	0.06
Forested	0.1
Urban	0.12
Water	1

Channel Land Use	N-Value
Concrete	0.015
Water	0.023
Smooth Rock	0.045
Grassy	0.05
Rough Rock	.055
Trees	.06
Thick Brush/Trees	.07

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Entry # : 10

Subject : HMS Model

Notes :

Junctions were added in the model before the confluences of major rivers. This allows the flow to be generated in the program prior to the confluence.

Reaches RGUAD_210 and RGUAD_320 were computed to have a number of Modified Puls Routing Subreaches greater than 100 in the Modified Puls Routing Tables. HMS only accepts a maximum number of subreaches of 99.

Entry # : 11

Subject : Lake/Dam Discharge Data

Notes :

Both Elevation-Storage and Storage-Discharge tables for the dams at Lake Dunlap, Lake McQueeney, Lake Placid, Meadow Lake, Lake Gonzales and Wood Lake, were from data received by Freese and Nichols.

When running the preliminary HMS model for the 250 yr and 500 yr events, the Elevation-Storage and Storage-Discharge tables for Meadow Lake were exceeded. They were interpolated upward in order to run the model.

Storage-outflow and elevation-storage data were derived from previous modeling (for 2011 Dam Breach Analysis) and used to model Coleto Creek Reservoir in the HMS model

Entry # : 12

Subject : Model Calibration

Notes :

Calibration was performed to observed hydrographs for the 2004, 2002, and 1998 event. Not all gages had available data for every event. For example, the Kyle gage only had available data for the 2002 event. The sub-basins we divided into groups based on gage location and then each gage was calibrated to each storm event by adjusting initial loss and peaking coefficient for the basin group or groups that affected it. Adjustments for upstream gages were not changed when calibrated to downstream gages. Reasonable calibration results were achieved for the 1998 and 2004 events. The volume for the 2002 event was extremely high in the upper basin. Initial losses were adjusted to the maximum reasonable levels without achieving a good calibration to peak of volume. The 2002 event also had issues with timing of peaks. Therefore, the 2002 calibration was not used in the calculation the final weighted parameters. The final set of calibration parameters is based off a weighted average giving the 1998 event twice the weight of the 2004 event parameter adjustments. Results and further explanation are provided in the TRN

Entry # : 12

Subject : Modified Puls Routing steps

Notes :

Because the subbasins are large with regards to reach lengths, they were subdivided into approximately equal parts in order to accurately determine the bank full velocity. Therefore, multiple profiles could have been used to determine average velocity for the different subbasin reaches. Most subbasins were subdivided into two, three or four smaller reaches for these calculations.

The lower routing flows for Coleto Creek (5-yr, 2-yr) were extrapolated from the FIS flows in Victoria County current FIS report. These flows were used with existing RAS model (from 2011 Dam Breach analysis) to determine the bank full profile and velocity and to extract storage outflow for Mod Puls routing.

Modified Puls Routing method was not used in the final HMS model. See Entry #14 below.

Entry # : 13

Subject : Frequency Flows from COE gage analysis

Notes :

According to the scope of services for the project, frequency flows for the San Marcos and Guadalupe Rivers are to be derived from a gage analysis performed by the Corp of Engineers. Halff has met with Corps staff and agreed upon gage analysis results at each gage location. Frequency flows have been interpolated for points along the Guadalupe River corresponding to HMS model Junctions.

Determination of frequency flows for the San Marcos River has proven more difficult due to the lack of gages along the river. There is also an ongoing issue with the results of the Blanco near Kyle gage analysis. For example, the results for the 100-yr event are extremely high compared to preliminary results from the basin-wide HMS model as well as flows published in the Hays County FIS report as illustrated in the graph below. From the Kyle gage analysis results, it appears that the standard and historical period runs grossly overestimate the rarer flows. The "low outlier removed" run appears to best fit the other gage analysis results as well as FIS and preliminary HMS runs and will be used to determine frequency flows on the San Marcos.

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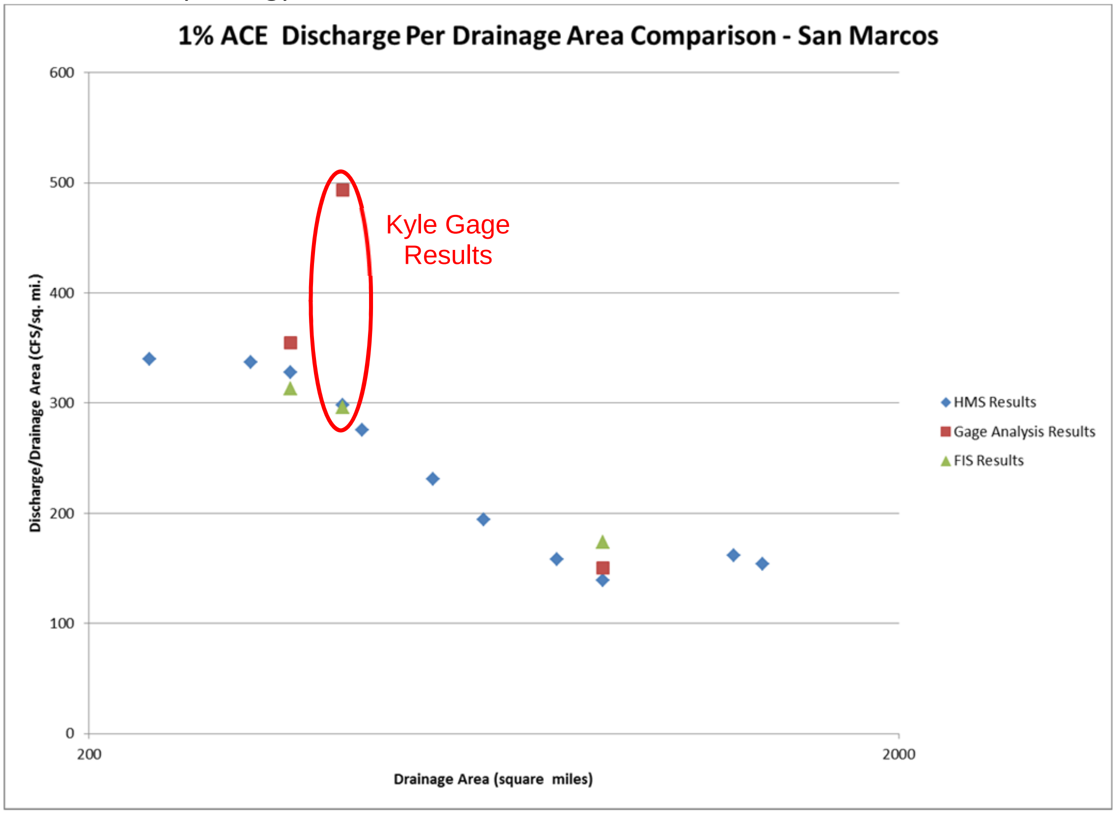
Final gage analyses flows and methodologies used to determine frequency flows are contained in the basin-wide hydrology TRN



Entry # : 14

Subject : Muskingum-Cunge Routing Reaches

Notes :

During our internal QAQC process it was found the MC routing reaches were attenuating significantly more flow than the Modified Puls reaches. These findings were based on comparisons to observed data for the 1998. 2002, and 2004 events.

After investigating, it was determined the lengths given to the reaches did not reflect the actual floodwave flow length during high flow events. This discrepancy was sometimes on the magnitude of a 50% longer reach. These greater distances also had a profound effect on the slopes.

The existing MC centerlines were smoothed using a GIS tool (reference GBRA_MC_Reaches.shp) and the subsequent changes to slope followed. These new parameter conditions were incorporated into the HMS model and resulted in more reasonable levels of attenuation in these reaches.

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Muskingum-Cunge Routing is being used for all routing reaches because it was determined that the Modified Puls method did not adequately attenuate the hydrographs. Also, channel slopes and model parameters indicate that Muskingum-Cunge is the appropriate method to use according to the HMS hydraulic reference manual.

Entry # : 15

Subject : Peaking Coefficient

Notes :

Peaking coefficients were calculated based on iSWM values by assigning each land use type a value and taking a weighted average for each basin. The middle slope was taken for each category, since it would be impractical to calculate the slope for each section of the land use shapefile. This also gave us a conservative calculation because the majority of the study area is <0.50%. This table and subsequent calculations can be found in the PeakingCoefficient_Calculations.xlsx spreadsheet. The majority of the basins came out around 0.58-0.59 due to the mostly undeveloped nature of the basin. The iSWM methodology is presented below. The calculated peaking coefficients were later adjusted during the calibration procedure.

The coefficient C_t is a regional coefficient for variations in slopes within the watershed. Typical values of C_t range from 0.4 to 2.3 and average about 1.1. The value of C_t for the East Fork Trinity River is 2.0. C_t for a watershed can be estimated if the lag time, t_p, stream length, L, and distance to the basin centroid, L_{ca}, are known. The coefficient C_p is the peaking coefficient, which typically ranges from 0.3 to 1.2 with an average value of 0.8, and is related to the flood wave and storage conditions of the watershed. The C_p value for the East Fork Trinity River is 0.69. Larger values of C_p are generally associated with smaller values of C_t. Typical values of C_p are listed in Table 1.14.

Table 1.14 Typical Values of C_p

Typical Drainage Area Characteristics	Value of C_p
Undeveloped Areas w/ Storm Drains	
Flat Basin Slope (less than 0.50%)	0.55
Moderate Basin Slope (0.50% to 0.80%)	0.58
Steep Basin Slope (greater than 0.80%)	0.61
Moderately Developed Area	
Flat Basin Slope (less than 0.50%)	0.63
Moderate Basin Slope (0.50% to 0.80%)	0.66
Steep Basin Slope (greater than 0.80%)	0.69
Highly Developed/Commercial Area	
Flat Basin Slope (less than 0.50%)	0.70
Moderate Basin Slope (0.50% to 0.80%)	0.73
Steep Basin Slope (greater than 0.80%)	0.77

Appendix B.1.2.e
USACE Draft Gage Analysis and Halff Frequency Flow Memo

Lower Guadalupe River Basin 2013 Feasibility Study

Updated Summary of Frequency Analyses at US Geological Survey (USGS) Streamflow Gauges

26 March 2013

[Detailed summaries of the modeling input data and results are provided in the companion (similarly named) MS Excel spreadsheet.]

This study is focused upon the portion of the Guadalupe River Basin downstream from Canyon Dam. However, for purposes of better assuring that a regional and holistic perspective is maintained, these frequency analyses were expanded to cover the entirety of the Guadalupe River Basin, upstream from the mouth of the San Antonio River. In practice, Canyon Dam effectively severs the frequency-related flood hydrographs' contribution from the upper basin, except for extremely rare events (in this case, those far greater than the 100-year event). Frequency-based peak discharges downstream from Canyon Dam are effectively controlled by runoff from the contributing areas downstream from the dam, except for the outlet works channel reach immediately downstream from the dam. This tendency does not apply for extremely rare events, which can produce very significant spillages over the Canyon Dam emergency spillway, such as occurred in July 2002. That particular event is projected as being on-the-scale-of a 200- to 300-year flood event at Canyon Lake.

Standard Log Pearson Type III analytical flow frequency analyses were applied in accordance with "Guidelines for Determining Flood Flow Frequency – Bulletin 17B", compiled by the Interagency Advisory Committee on Water Data in 1981-1982. US Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) software "HEC-FFA" was utilized in this regard. As the feasibility study progresses, it is anticipated that the "HEC-FFA" models may be converted to the more recent "HEC-SSP" platform. Comparison tests indicate that results between the two software versions are essentially identical, with the exception that tabulated peak discharges in the "HEC-SSP" output are not automatically rounded to three significant figures, as is the case with "HEC-FFA".

Systematic annual peak series streamflow data was initially acquired via "Hydrosphere" software, but it was subsequently extended up through Water Year 2011 and manually verified, via tabulations at the US Geological Survey (USGS) website.

Since this feasibility study has now progressed well into Water Year 2013, it would be possible to further extend the defined systematic records for many of these gauges. However, those efforts would technically be outside the current scope of study, but might be requested (or required), in response to subsequent technical reviews. In general, since the past couple of years have been free of any major storm and flood events in this study basin, it is not likely that computed results would have significantly changed in the interim. This open issue may be addressed simply through a series of test runs, aimed at determining the significance of any potential changes in the computed results. In the meantime, this summary of analysis results is to be considered "final", for this phase of the feasibility study.

The current analyses entail 51 gauging stations, 37 of which are located downstream from Canyon Dam. These stations have contributing drainage areas ranging from 0.18 square miles (115 acres) to 5,816 square miles. The contributing drainage area at Canyon Dam is 1,432 square miles. Systematic record lengths at the gauging stations vary from 1 to 88 years, with 22 of the stations having less than 20 years of systematic record. No frequency analysis was undertaken on the 17 stations having less than 10 years of systematic record.

Generalized (regional) skew coefficients were extracted from written guidance provided in December 1985, by the USACE Southwestern Division (SWD). This guidance document: includes a regional map defining generalized skew coefficients (ranging from -0.4 to 0.0); provides a procedure for adjusting this coefficient downward, whenever the standard deviation of the annual peak series data exceeds 0.5; and sets the mean-squared-error-of-generalized-skew value at 0.325. The regional skew adjustment is intended to help avoid unintentional overstatement of the rare event discharge projections, in those cases involving large standard deviations in the systematic flow record.

Peak discharges were computed and tabulated for the following standard array of flood event annual exceedance probabilities (AEPs): 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, 0.004, and 0.002. These reflect events with long-term average recurrence intervals of: 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-years.

As has been traditionally noted with annual peak series streamflow data for gauging stations in southwestern regions of the US, it is common to encounter instances where a substantial portion of the systematic record reflects very small discharges in comparison to the general trend represented by the upper half (or more) of the plotted annual peaks. This characteristic can dramatically influence the computed frequency curve, in that it typically results in a high standard deviation (steep frequency curve), which then leads to potential overstatement of discharges for the rarer flood events. This problem can be partially overcome by defining a so-called “low outlier threshold”, in such a way as to minimize the weighting applied to the smaller events in the systematic record. This tentative adjustment was applied on the subject study, wherever this problematic situation arose. Computed results have been tabulated for both the standard approach and with application of a maximum low outlier threshold. In most instances, this adjustment provides for a significantly improved appearance of “fit” between the computed frequency curve and the plotted annual peak series points. However, this adjustment should be used with caution, and generally be applied in only those cases exhibiting a well defined break in the slope of the annual peak series trend.

In order to attain better homogeneity over the applicable period-of-record, the systematic records along the mainstem of the lower Guadalupe River were adjusted to reflect solely source runoff from the contributing area downstream from Canyon Dam. This issue pertains only to the annual peaks for Water Year 2002, since that is the only year in the systematic record where emergency spills from Canyon Dam may have produced the annual peak discharge at selected downstream nodes. For all of the other years in the systematic record, gated releases from Canyon Dam were sufficiently limited as to generally ensure that peak annual discharges at the downstream nodes were fully independent from the Canyon Dam releases.

In addition, the extended historic period over which the maximum systematic record peak has not been exceeded was considered. This adjustment is meant to reasonably constrain the upper end of projected discharge frequency curve, by considering an (assumed) extended statistical period-of-record. While this approach has the advantage of better capturing the longer-term historic range in event magnitude, it fails to capture the statistical distribution during that extended (non-systematic record) period. In essence, basic statistics from the available systematic record are inherently presumed to have also prevailed during the extended (non-systematic record) period.

Besides the obviously demonstrative impact on Guadalupe River discharge-frequency relationships caused by the implementation of Canyon Dam, numerous other floodwater retarding structures and impoundment structures on tributary streams throughout the lower Guadalupe River basin have similar impacts on (at least) their immediate flooding source streams. Most of these were implemented by the US Department of Agriculture (USDA) Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS). Further complicating the matter is the fact that the systematic record was often impacted in a progressive fashion, as more and more of these dams were implemented over the course of the otherwise relatively homogenous systematic record period. At this point in the feasibility study, no attempts have been made to adjust the tentative discharge frequency curves in this regard. Computed results at each gauging station should be viewed in the context of how the site-specific data was applied.

In the near future, the pool elevation frequency relationship at Canyon Lake will be assessed, formalized, and subsequently used to define the projected discharge frequency relationship for both gated and emergency spillway releases from Canyon Dam. Those results will represent dominant (i.e. representative) peak discharges for a short stretch of the Guadalupe River, downstream from the dam. Extreme events in this array, specifically those which produce significant spills over the emergency spillway at Canyon Dam (i.e. greater than the 1 percent annual exceedance probability event), will be dominant over a much greater river distance than will the frequent-to-moderate events, which are essentially “controlled” as a result of the relatively limited gated release capacity at Canyon Dam.

A comparison of the preliminary results, by modeling assumption, and with the currently effective Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) values is provided in the companion (similarly named) MS Excel spreadsheet. Tab 3, which provides a quick reference, is simply an extraction from the more extensive tabulation shown under Tab 1.

Within this spreadsheet, the streamflow gauging stations are listed in hydrologic order, from upstream-to-downstream. Pertinent statistical data at each gauge is summarized in Columns O through X. Projected discharges for given average recurrence intervals are summarized in Columns Z through AG. Detailed listings of the annual peak series data begins on Row 254. In order to have easy access to comparative frequency curve plots for all of the gauges throughout the study area, the “HEC-FFA” modeling results were also embedded in this spreadsheet. In this regard, the annual peak series data was ranked (by magnitude), assigned probability plotting positions, and then plotted, in both “log-log” and the traditional “log-probability” scales, as shown in Columns K through AC. Regrettably, our version of MS Excel does not include capability for automatically plotting an axis in “normal probability” scale;

therefore, we added bolded vertical lines to indicate the position of the standard array of average recurrence intervals (in years).

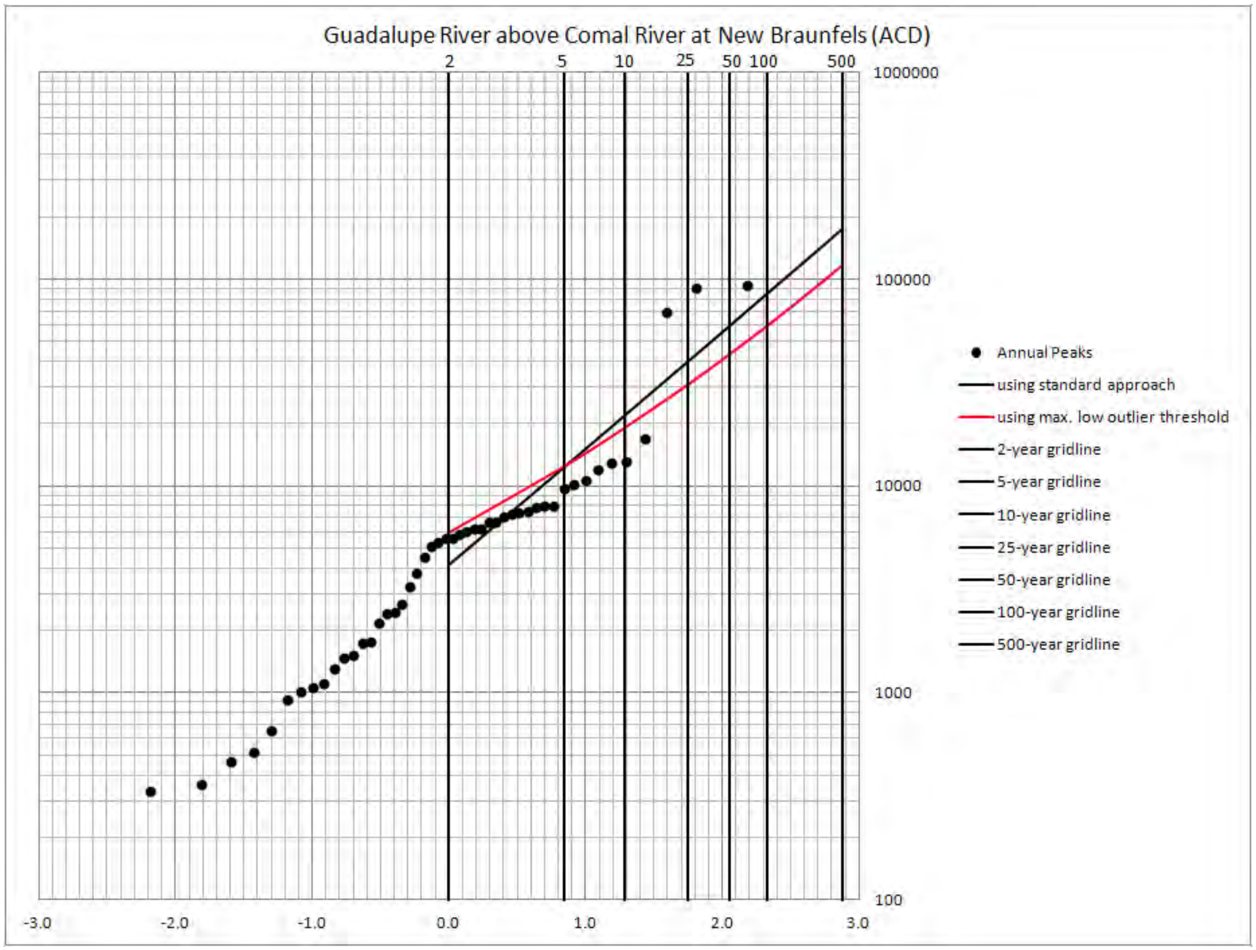
Each frequency curve graphic includes depiction of the sorted annual peaks (as black dots) and a series of statistical solutions. The black curve reflects the results using the standard Bulletin 17B approach based solely upon the systematic record data. The red curve reflects the results when the so-called “low outlier” threshold has been essentially maximized. As should be obvious at most of the gauges, this adjustment tends to provide for a much better fit to the upper half of the plotted data, but should be applied with caution, as stated previously in this narrative. The green curve reflects the results when considering the historic period over which the maximum systematic peak has not been exceeded. This adjustment would normally tend to constrain the upper part of the frequency curve, but for about half of the gauging stations in the study area, the extended historic period happens to also introduce one or more very major flood events, and this leads to an increased projection at the rare end of the discharge frequency curve.

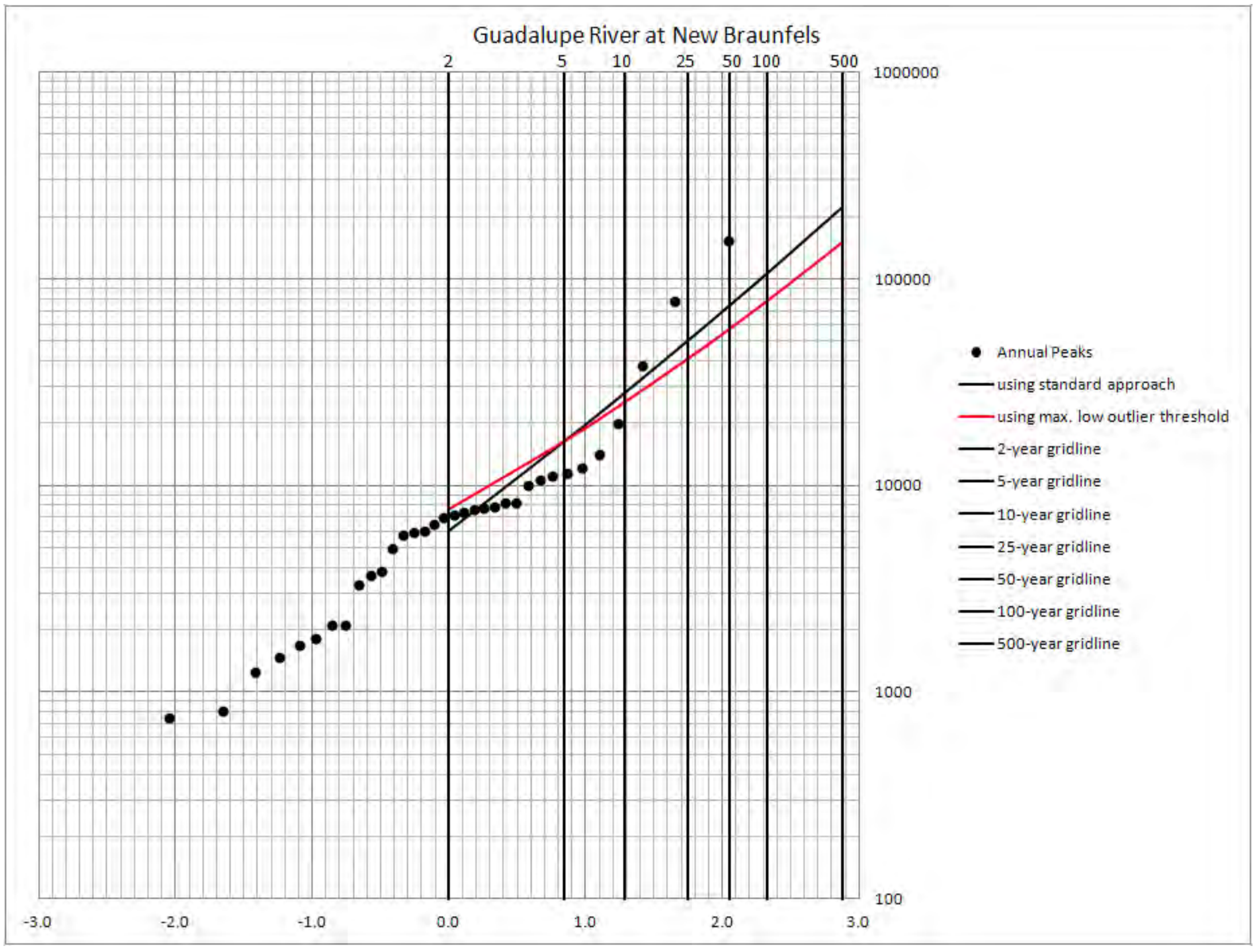
Since an earlier version of this narrative was produced in September 2012 and shared with our AE Contractor responsible for the primary components of the associated hydrologic and hydraulic analyses, Halff Associates, the Contractor has been investigating approaches for best applying (distributing) these statistically-derived discharge frequency relationships along each of the detailed study reaches of the Guadalupe, San Marcos, and Blanco Rivers systems. These matters were further discussed and debated during the in-progress review meeting held on 21 February 2013.

It was noted that the peak discharge magnitude (for a given frequency) does not always rise in relationship to the contributing drainage area, especially along reaches of the Guadalupe River downstream from the mouth of the San Marcos River. This “declining discharge in the downstream direction” tendency introduces complications with applying a standardized, contributing drainage area-based, interpolation formula for projecting peak discharges at given nodes along these river systems. It was suggested that an alternative approach would be to consider using either river stationing or cumulative river valley storage, as a better independent variable, with which to distribute the results at the streamflow gauging stations. The theory herein is that the trend in peak discharge should essentially parallel the anticipated pattern of flood hydrograph attenuation along reaches exhibiting a combination of having vast valley storage and yet having meager additional drainage area contribution. The Contractor has been researching this matter in the interim.

Also discussed at the 21 February 2013 in-progress review meeting was the issue of finalizing which particular statistically-derived frequency function (solution) should be adopted at each streamflow gauging station. To assist in this regard, we have simply highlighted (in green patterning) our proposed selection at each of the applicable gauging stations, in the affiliated spreadsheet. The highlighting has been applied to selected rows in Columns Z through AG (i.e. full range of event frequencies) within spreadsheet Tab 1 and the associated summary Columns G through J (i.e. standard array of FEMA FIS event frequencies) within spreadsheet Tab 3. Except for this newly-applied highlighting, the spreadsheet is identical to the previously-supplied September 2012 version. Brief arguments for the particular selections follow. A concise Summary of Discharges Table is provided at the end of this narrative.

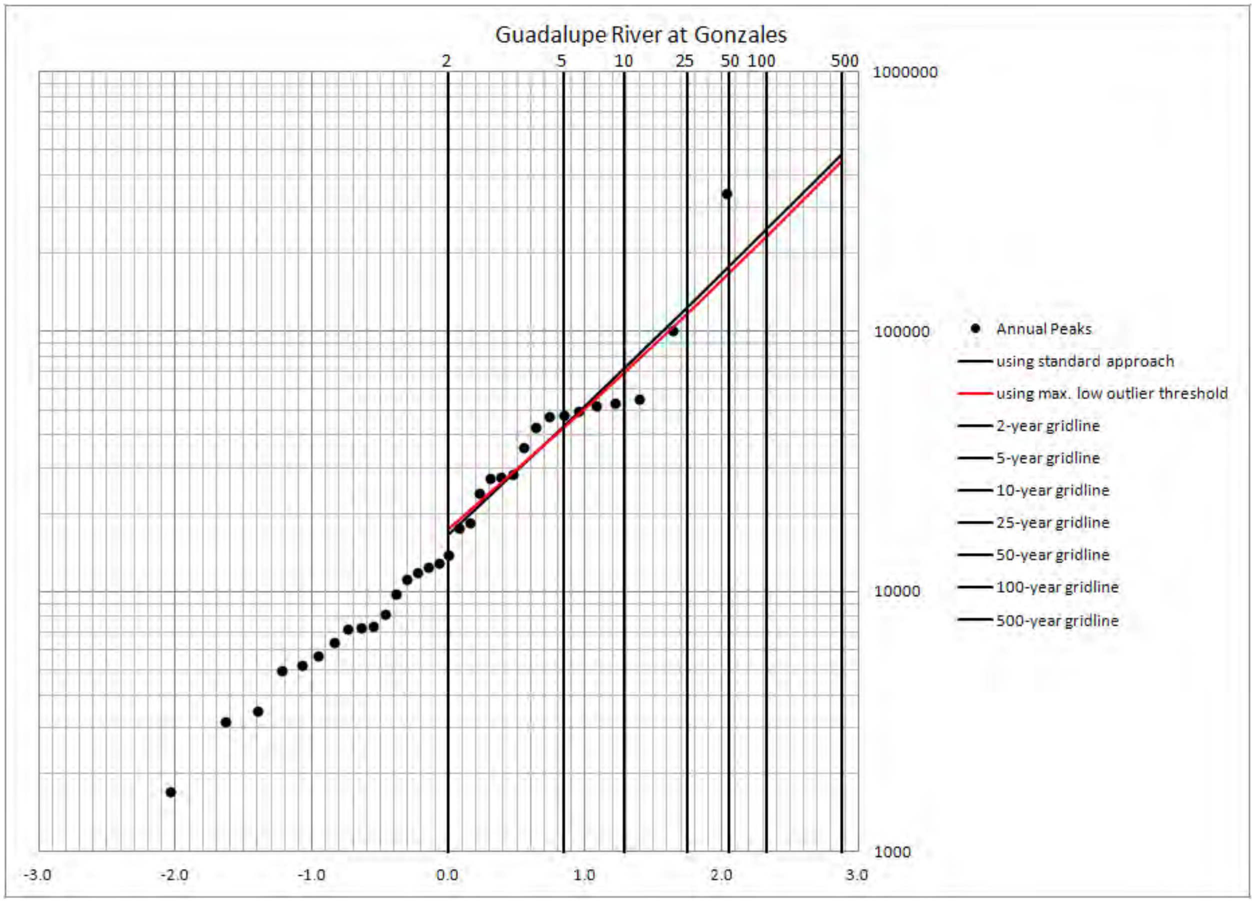
For both “Guadalupe River above Comal River” and “Guadalupe River at New Braunfels”, even though a noticeable break in the annual peak series array is evident near the 50 percent annual exceedance probability, the overall trend would not appear to strongly support application of a maximum low outlier threshold setting. Results using the standard approach would appear to be most defensible, especially since they better correlate with plotted positions of the three highest events in the systematic record.



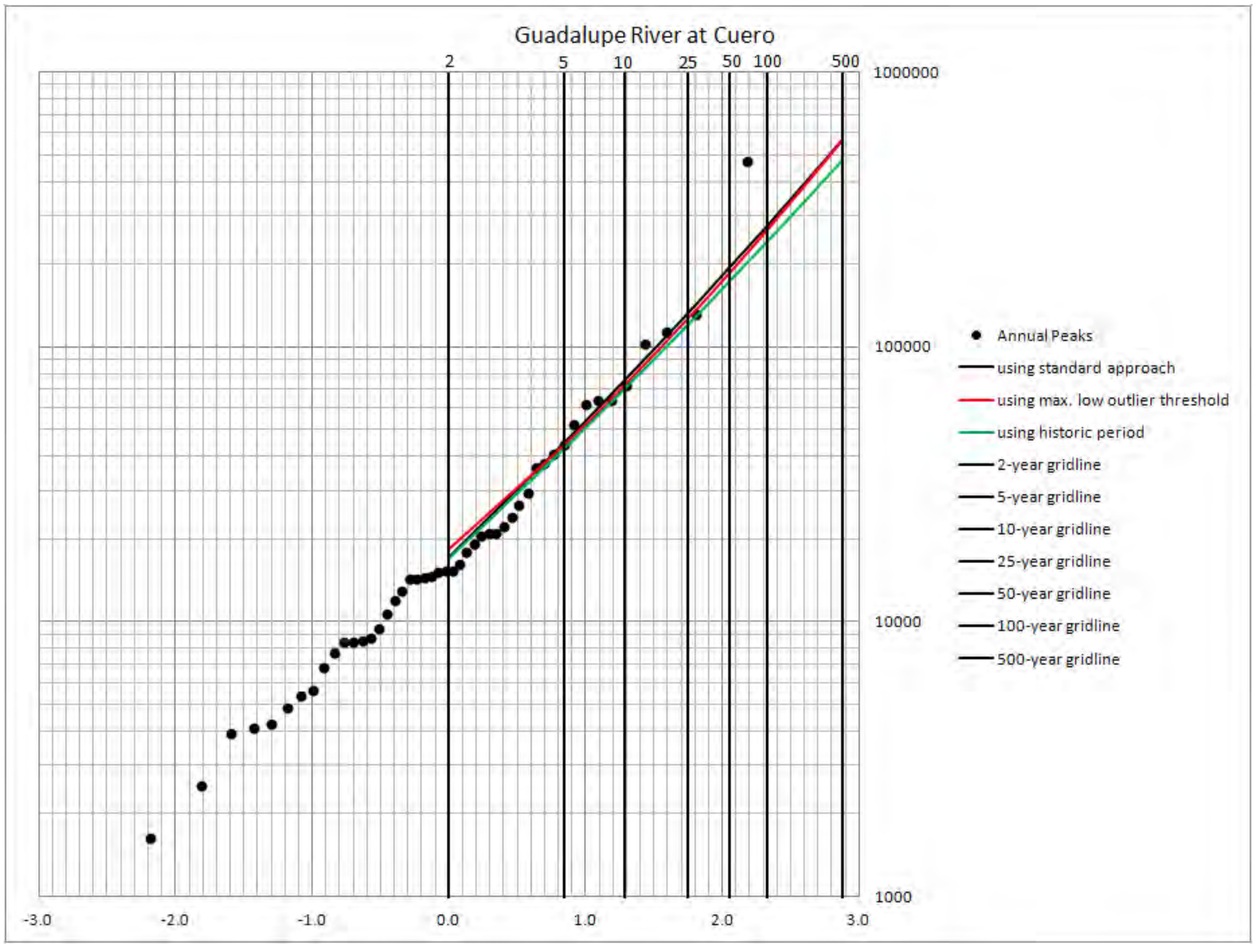


Guadalupe River at New Braunfels
2
5
10
25
50
100
500
1000000
100000
10000
1000
100
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
Annual Peaks
using standard approach
using max. low outlier threshold
2-year gridline
5-year gridline
10-year gridline
25-year gridline
50-year gridline
100-year gridline
500-year gridline

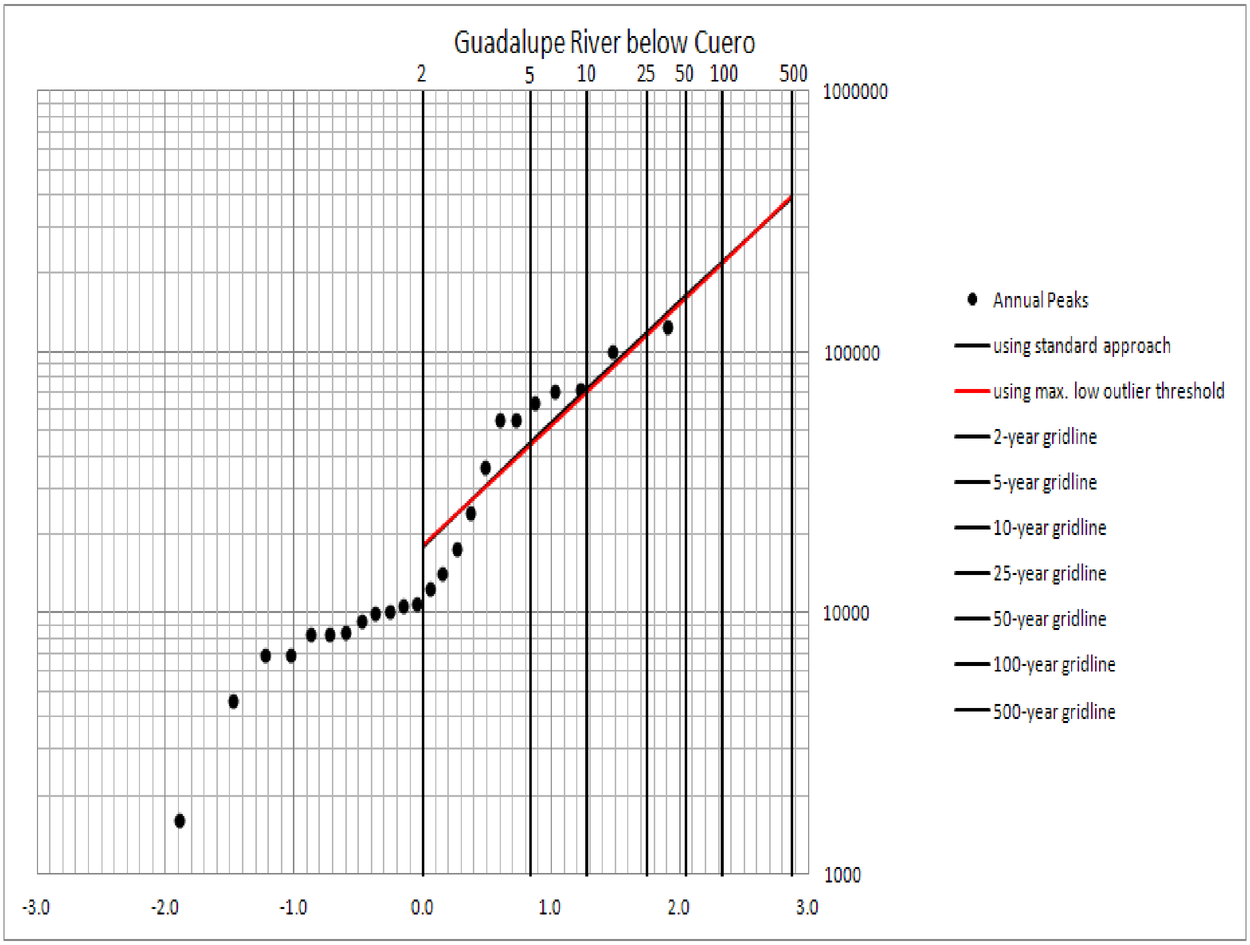
For “Guadalupe River at Gonzales”, the overall trend would not support application of a maximum low outlier threshold setting. Results using the standard approach would be most defensible.



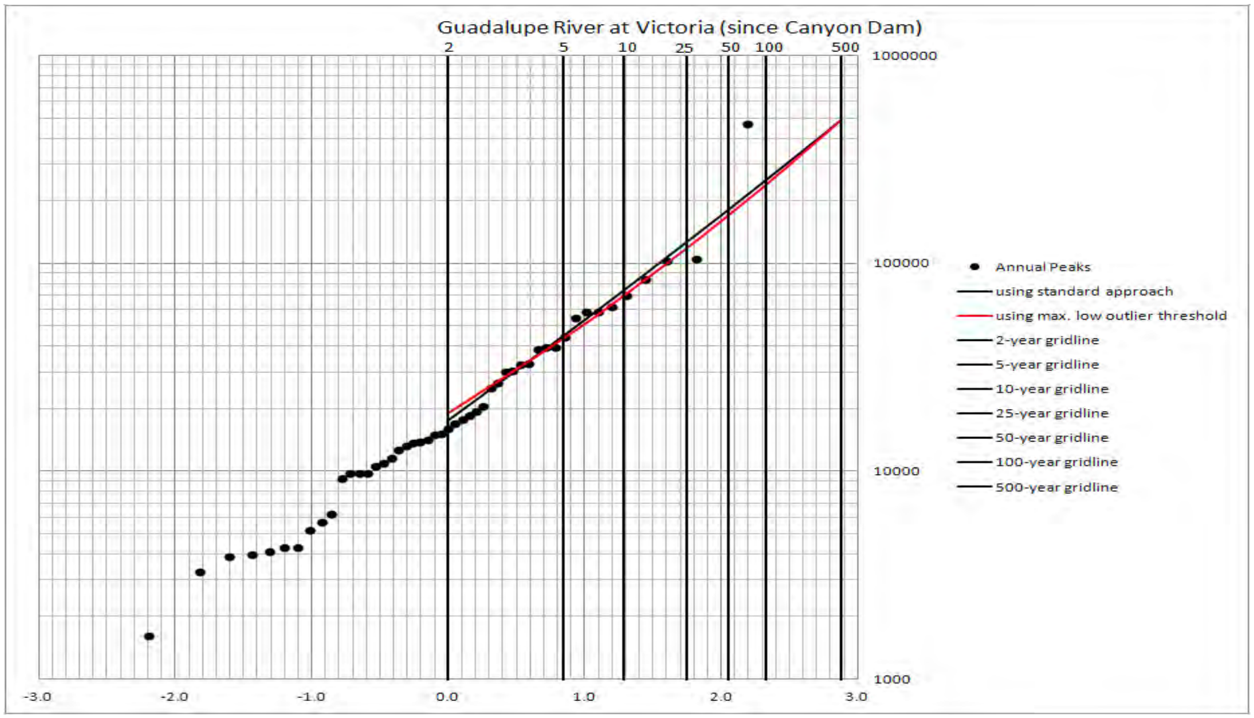
For “Guadalupe River at Cuero”, the overall trend would not support application of a maximum low outlier threshold setting. Consideration of an extended historic period fails to substantially improve the projection and would “suggest” that the October 1998 event exceeded the 0.2 percent annual exceedance probability. Results using the standard approach would appear to be more defensible.

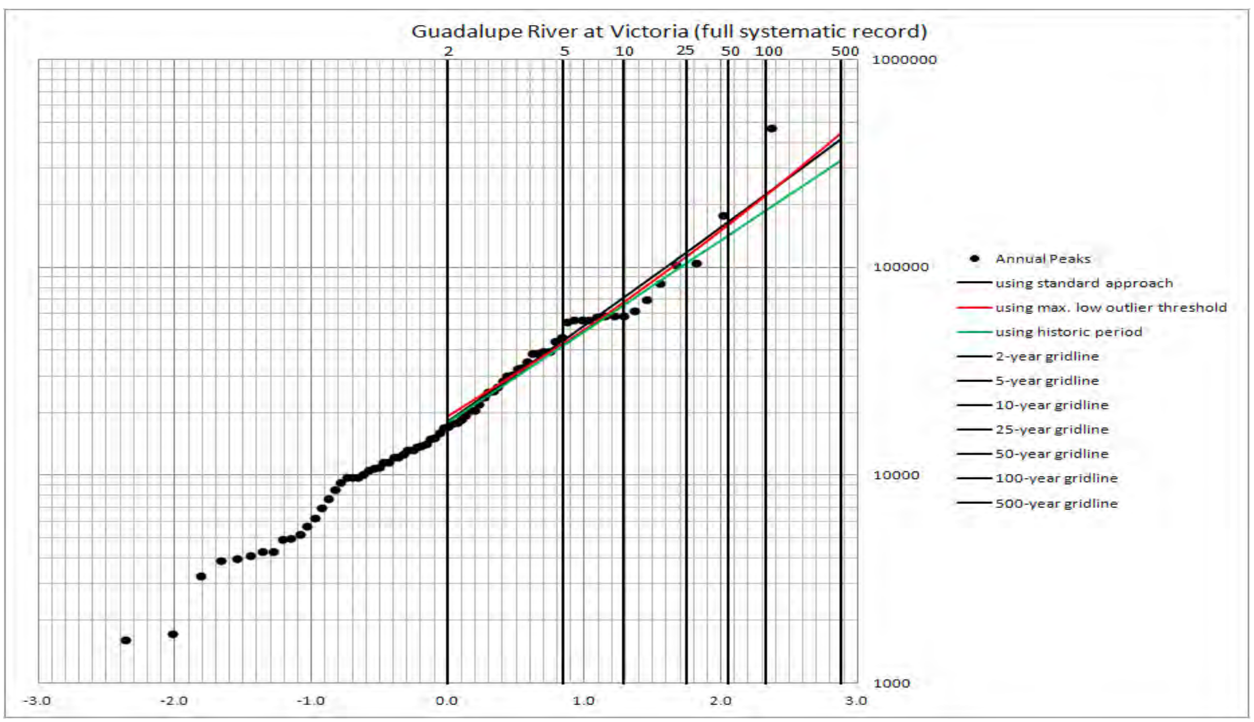


For “Guadalupe River below Cuero”, there are two noticeable breaks in the annual peak series array, but the overall trend would not appear to support application of a maximum low outlier threshold setting. At most, just the one lowest annual peak would likely be justified for treatment as a low outlier. Results using the standard approach would appear to be most defensible.

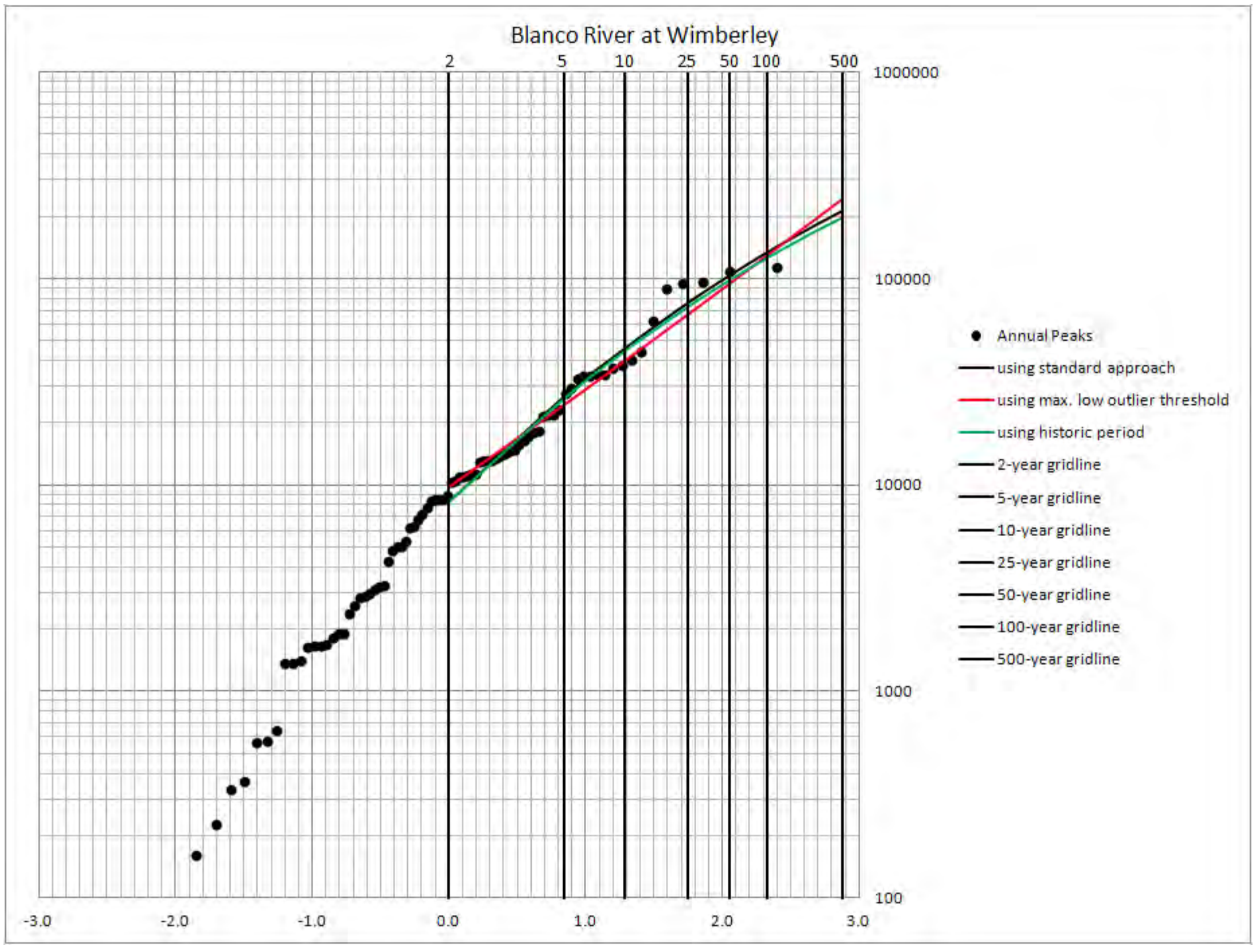


For “Guadalupe River at Victoria”, more conservatively (low) results are achieved by using the full systematic record, rather than just the portion since Canyon Dam was implemented. This supports the theory that the existence of Canyon Dam has had very minimal, if any, impact upon frequency-based flood hydrographs (especially peak discharges) at Victoria. The overall trend would not support application of a maximum low outlier threshold setting. Consideration of an extended historic period also fails to improve the projection. Results using the standard approach would be most defensible.

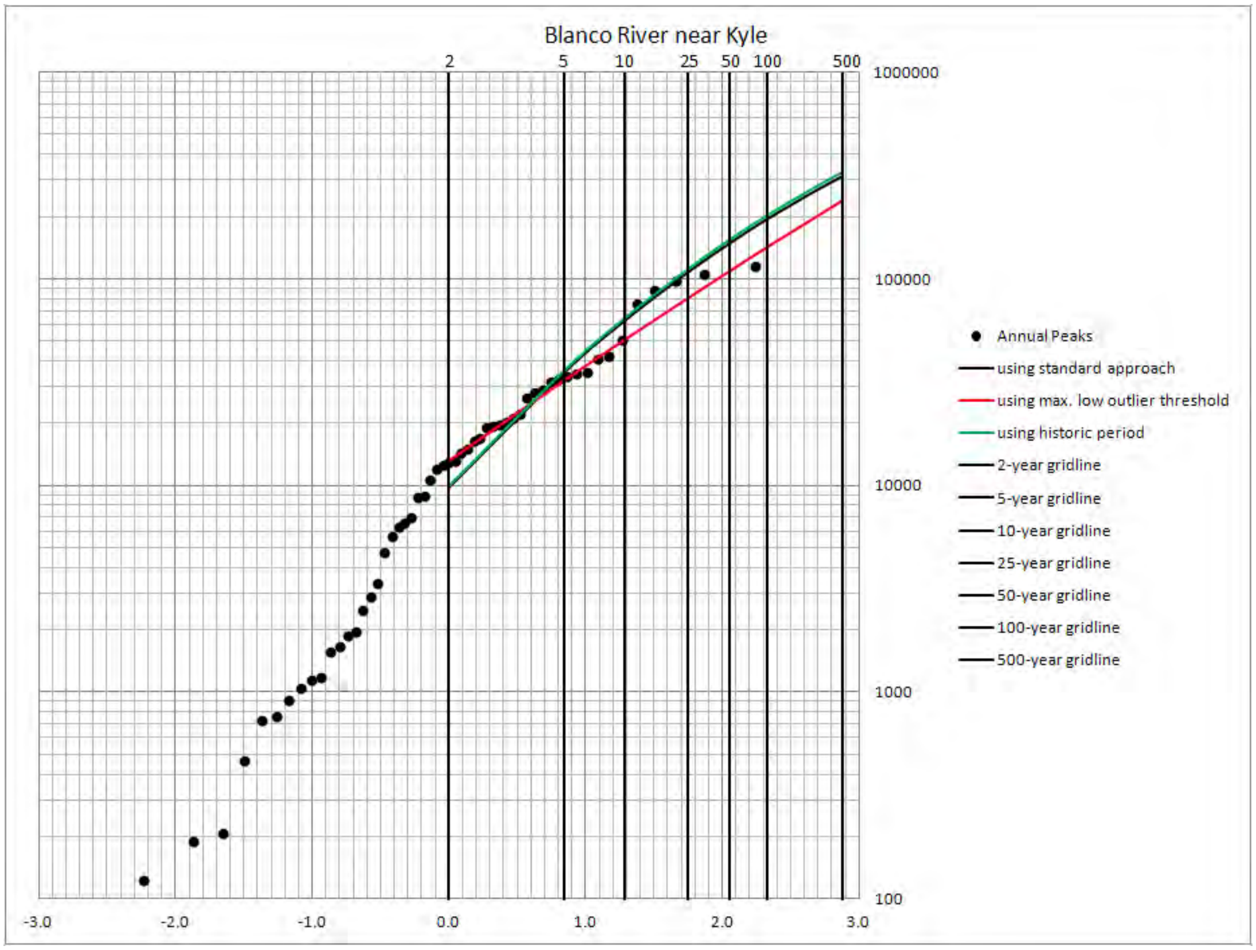




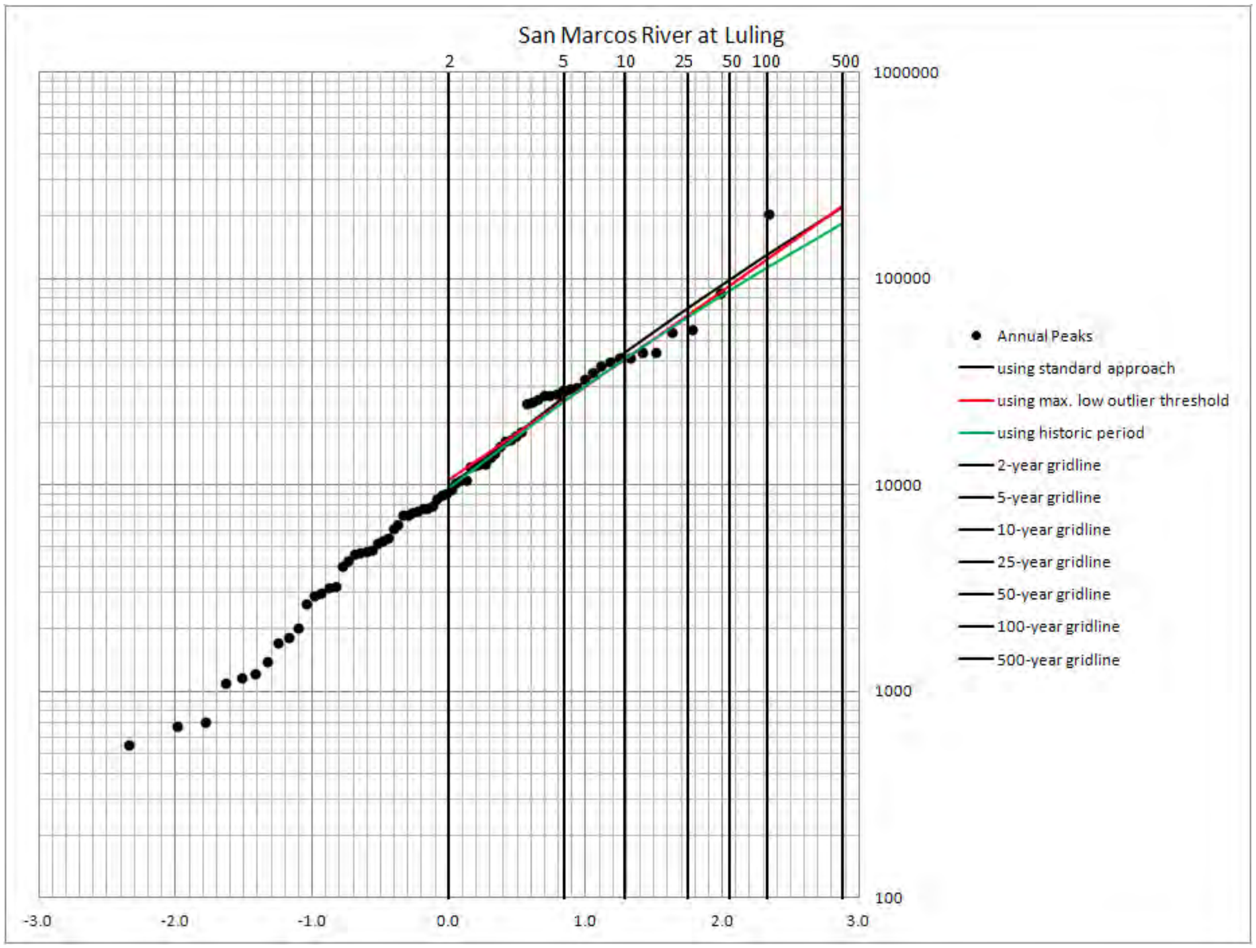
For “Blanco River at Wimberley”, even though a noticeable bend in the annual peak series array is evident near the 50 percent annual exceedance probability, the overall trend would not appear to strongly support application of a maximum low outlier threshold setting. Consideration of an (58-year) extended historic period appears to improve the projection and the defensibility somewhat, even though results are fairly similar between that and the standard approach. As a matter of fact, results for the 1 percent annual exceedance probability event agree within about three percentage points, regardless of the solution chosen.



For “Blanco River near Kyle”, even though a noticeable bend in the annual peak series array is evident near the 50 percent annual exceedance probability, the overall trend would not appear to strongly support application of a maximum low outlier threshold setting, unless it could be established that the proposed solution results are simply unreasonably conservative (high). Consideration of an (74-year) extended historic period appears to improve the projection and the defensibility somewhat, even though results are fairly similar between that and the standard approach.

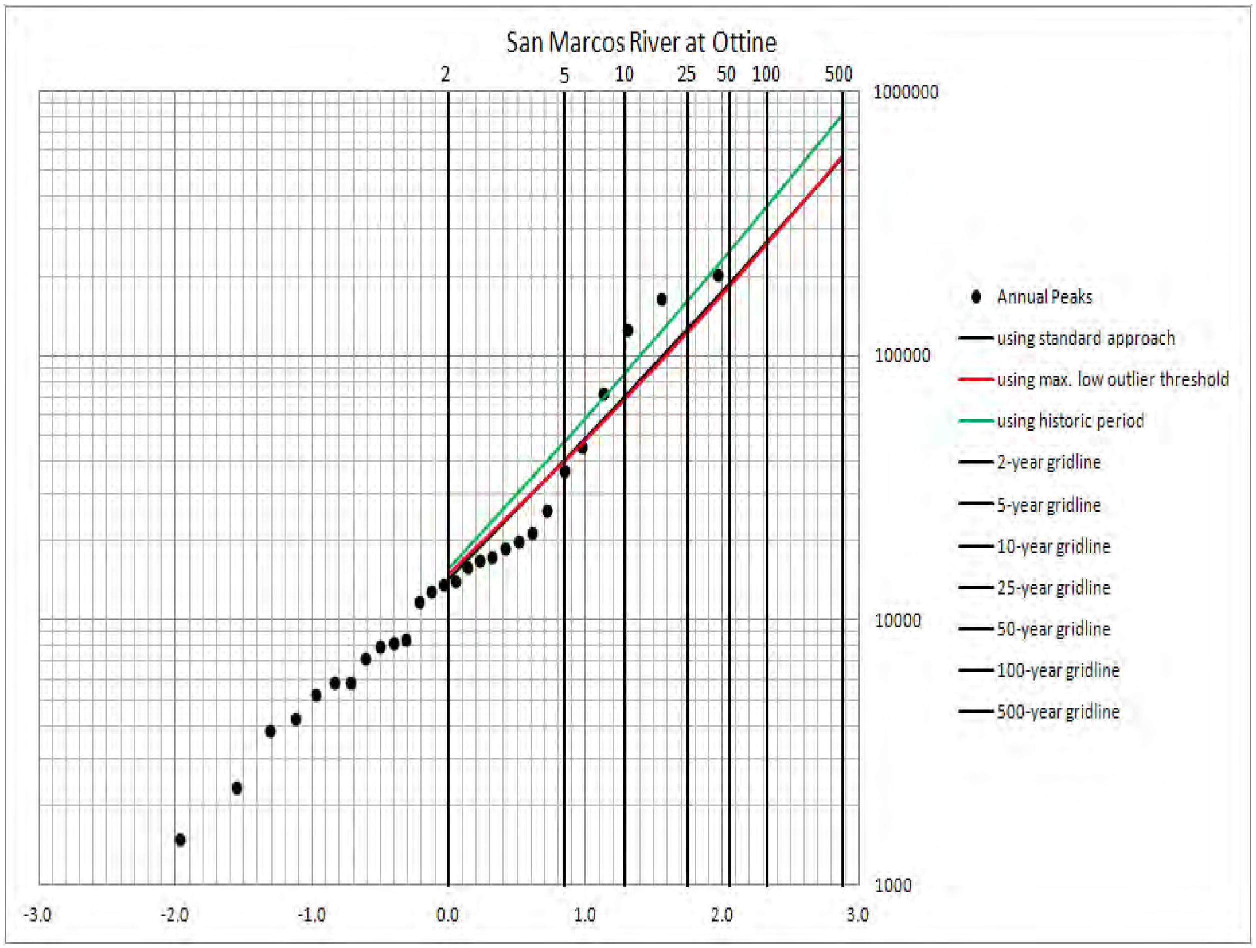


For “San Marcos River at Luling”, the overall trend would not support application of a maximum low outlier threshold setting.   It could be argued that consideration of an (80-year) extended historic period improves the projection and the defensibility somewhat, but this adjustment would “suggest” that the October 1998 exceeded a 0.2 percent annual exceedance probability.   Results using the standard approach appear to be more defensible. This selection differs from that proposed during the 21 February 2013 in-progress review meeting.



Similarly, for "San Marcos River at Ottine", the overall trend would not support application of a maximum low outlier threshold setting. Results using the standard approach appear to be reasonable, but it could be argued that consideration of even a 2-year extended historic period (from 1916 back to 1914) improves the projection and the defensibility. That specific adjustment increases the projected 1 percent annual exceedance probability estimate from 271,000 to 365,000 cfs (i.e. by 35 percent)!

This very high degree of sensitivity for the rare event peak discharge estimates at this particular streamflow gauging station should be recognized as the remainder of the feasibility study hydrologic analyses progress. Subsequent flood hydrograph reproduction (i.e. calibration) runs of the watershed runoff model may indicate that statistical application of the historic period adjustment has produced too conservative (high) peak discharge estimates.



This document is being shared with applicable members of the planning team and our AE Contractor, for their continued consideration of how to best define the discharge-frequency relationships along these subject river systems. Feedback will be used to improve the usefulness of this document and to expound upon the arguments applied therein.

Summary of Statistically-Derived Peak Discharges (cfs) at USGS Streamflow Gauges

Streamflow Gauge	Contrib. Drainage Area (sq.mi.)	Annual Exceedance Probability (percent) 2	5	10	25	50	100	250	500
		Average Recurrence Interval (years) 50	20	10	4	2	1	0.4	0.2
Guadalupe River above Comal River	1518	4150	12300	21800	40100	59500	85000	130000	175000
Guadalupe River at New Braunfels	1652	6040	16300	27900	50400	74400	106000	164000	222000
Guadalupe River at Gonzales	3490	16500	43000	71700	124000	178000	247000	365000	480000
Guadalupe River at Cuero	4934	17200	44700	75300	133000	195000	275000	420000	565000
Guadalupe River below Cuero	4961	17800	45000	72300	119000	165000	219000	308000	389000
Guadalupe River at Victoria	5198	18100	44200	70900	118000	165000	223000	320000	412000
Blanco River at Wimberley	355	8200	26000	44100	73000	98300	126000	166000	198000
Blanco River near Kyle	412	9920	35900	64300	112000	155000	203000	272000	329000
San Marcos River at Luling	838	9830	26600	43500	72000	98400	130000	178000	221000
San Marcos River at Ottine	1249	15700	47000	85000	162000	248000	365000	584000	812000

Harris, Daniel

From: Loftin, Craig H SWF <Craig.H.Loftin@usace.army.mil>
Sent: Monday, May 20, 2013 8:55 AM
To: Harris, Daniel
Cc: Vanderpool, Marie J SWF; Moya, Mike; Couche, Steven; Pilney, Stephen W SWF; Higginbotham, Bret W SWF; Prochaska, Darlene G SWF
Subject: RE: GBRA gage analysis - Kyle results
Attachments: WimberleyKyle.xlsx; SummaryBlanco.xlsx; Summary.xlsx; BLANCOWM.DAT; BLANCOWM.OUT; BLANCOKX.DAT; BLANCOKX.OUT

Hi Daniel, etal:

Late last week we extended the Blanco-Kyle annual peak series back from 1957 to 1925, using projected values from Blanco-Wimberley. It turns out that the ratio of annual peak discharges between the two stations is fairly consistent. See attached spreadsheet "WimberleyKyle.xlsx". Of the truly significant events, only May 1958 and November 2001 exhibited a starkly differing tendency. We are using a multiplier of 1.09, derived through standard "least-squares" regression, to estimate annual peak discharges at Blanco-Kyle, relative to those published at Blanco-Wimberley.

Already-published values at Blanco-Kyle, during this extended period, were retained as-is. These are for the May 1929 and the September 1952 flood events.

We have extracted the Blanco River component of the previously supplied "summary" spreadsheet and developed the second attachment ("SummaryBlanco.xlsx"). The synthetically-extended scenario produces a less steep statistical frequency curve. The "100-year" peak discharge is thus shifted downward from 203000 cfs to 158000 cfs. This adjustment also means that the projected "100-year" peak discharge ratio between Blanco-Wimberley and Blanco-Kyle is about 1.25 (i.e. 158000/126000), which reasonably reflects the tendency experienced during the significant floods of May 1929, September 1952, October 1998, and April 1957.

Please note that all of this information is currently in DRAFT status. We have received some internal review comments (none of which appear to directly impact the previously-supplied tabulations) and welcome any ideas/concerns your team would like us to consider, when we update the affiliated documentation.

We hope to be having a teleconference on these matters at 1000 hours this morning (20 May).

Chl

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MEMORANDUM

TO:	Marie Vanderpool USACE Fort Worth District	**DATE:**	2/11/2013
FROM:	Daniel Harris Halff Associates	**AVO:**	28411
EMAIL:	dharris@halff.com		

SUBJECT: Frequency flow determination from USACE Guadalupe Basin gage analysis

As part of the USACE Lower Guadalupe River Feasibility Study, the Corps performed gage analyses using HEC-FFA software on the systematic annual peak flow records of 51 gaging stations within the Guadalupe River Basin. The gage analyses were performed using Bulletin 17B Log Pearson Type III analysis. Results were produced from a standard analysis, an analysis with the 2002 peak flow removed (where applicable), an analysis with low outliers removed, and an analysis corrected for the historic record. Halff has analyzed these results and attempted to extract appropriate frequency flows for use in the final hydraulic models for the Guadalupe, Blanco, and San Marcos Rivers. The assumptions and procedures used to determine the frequency flows from the gage analyses are presented below.

<u>Guadalupe River Flows</u>

Seven gages were used to develop frequency flows for the Guadalupe River and are listed in the Table 1. The “Guadalupe at FM 1117 near Seguin” gage was not analyzed by the Corps since it is a relatively new gage and the systematic record was too short. The gages with results were examined to determine which curve – standard, low outlier removed, or historic record correction – best fit each gage record. It was determined that in most cases the “low outlier removed” results were the best fit to the recorded annual peak flow gage data. For the two gages (above Comal and Victoria) with long periods of record that included periods before and after the closure of Canyon Dam, only gage analysis results using the post-Canyon Dam record were used for frequency flow determination. These post-dam results seemed to better fit the trend of flows produced from the other gages in the analysis.

Table 1: Guadalupe Gages used to develop frequency flows

Gage Name	Drainage Area (sq mi)	Assumptions
GUADALUPE RIVER AT SATTLER	1436	Highly affected by releases from Canyon Dam. Only post-dam data available. “Max low outlier threshold” seems to be best fit curve. 500-yr taken from standard analysis which considers 2002 event.
GUADALUPE RIVER ABOVE COMAL RIVER AT NEW BRAUNFELS	1518	Since gage is close to dam, pre-dam analysis seems to overestimate flows. Post-dam analysis seems more reasonable. “Max low outlier threshold” seems to be best fit curve.
GUADALUPE RIVER AT NEW BRAUNFELS	1652	“Max low outlier threshold” seems to be best fit curve. No pre-dam data on record.

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Gage Name	Drainage Area (sq mi)	Assumptions
GUADALUPE RIVER AT GONZALES	3490	"Max low outlier threshold" seems to be best fit curve. No pre-dam data on record.
GUADALUPE RIVER AT CUERO	4934	"Historic period adjustment" seems to be best fit curve and match trend of results from surrounding gages.
GUADALUPE RIVER BELOW CUERO	4961	All data was from before Canyon Dam. The results did not match trend of surrounding gages well for lower frequencies. Used results from this gage for 2-yr, 5-yr and 10-yr analysis only.
GUADALUPE RIVER AT VICTORIA	5198	Post-dam analysis seems more reasonable and matches trend of results from surrounding gages. "Max low outlier threshold" seems to be best fit curve. Full systematic record analysis seems to underestimate lower frequency flows.

The frequency flows from each selected gage analysis were then plotted against drainage area on a log-normal scale. Figures 1 through 8 show the plots of each set of frequency flows versus drainage area. Current effective FEMA peak flows are also shown on the 10, 50, 100, and 500-yr plots. In general the FIS flows were greater than the gage analysis flows except for the Victoria gage where they were significantly lower. A summary of assumptions made for each gage is also presented in Table 1.

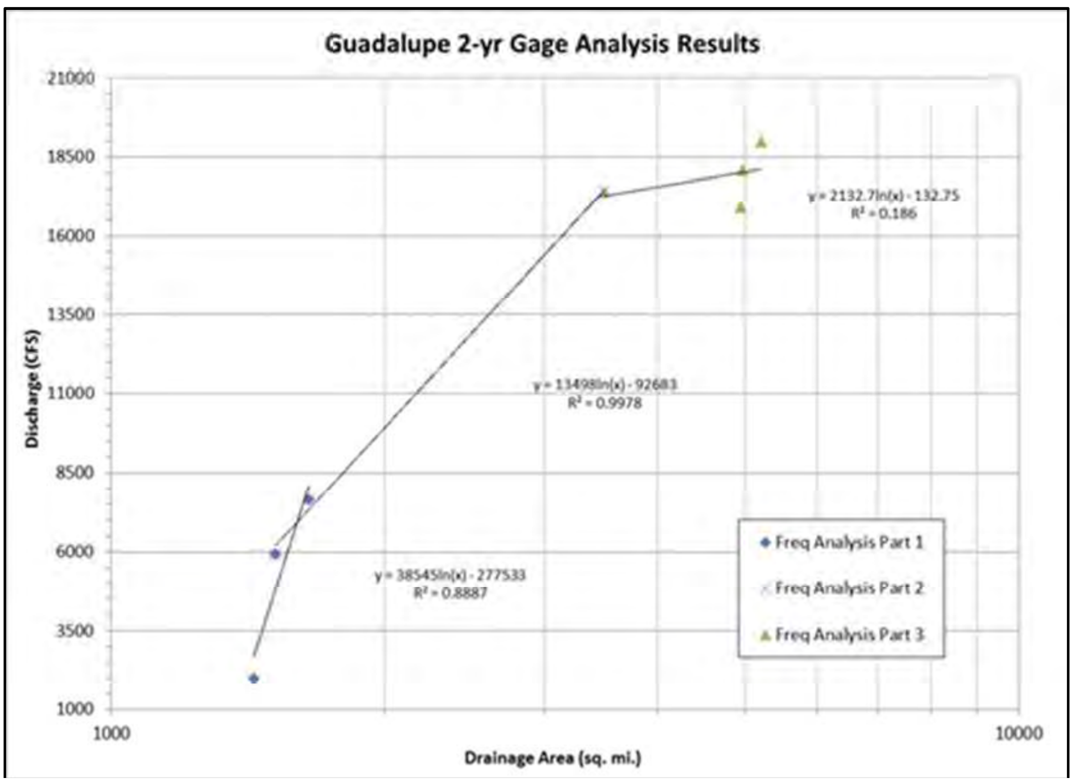

Figure 1: 2-yr Guadalupe gage analysis results

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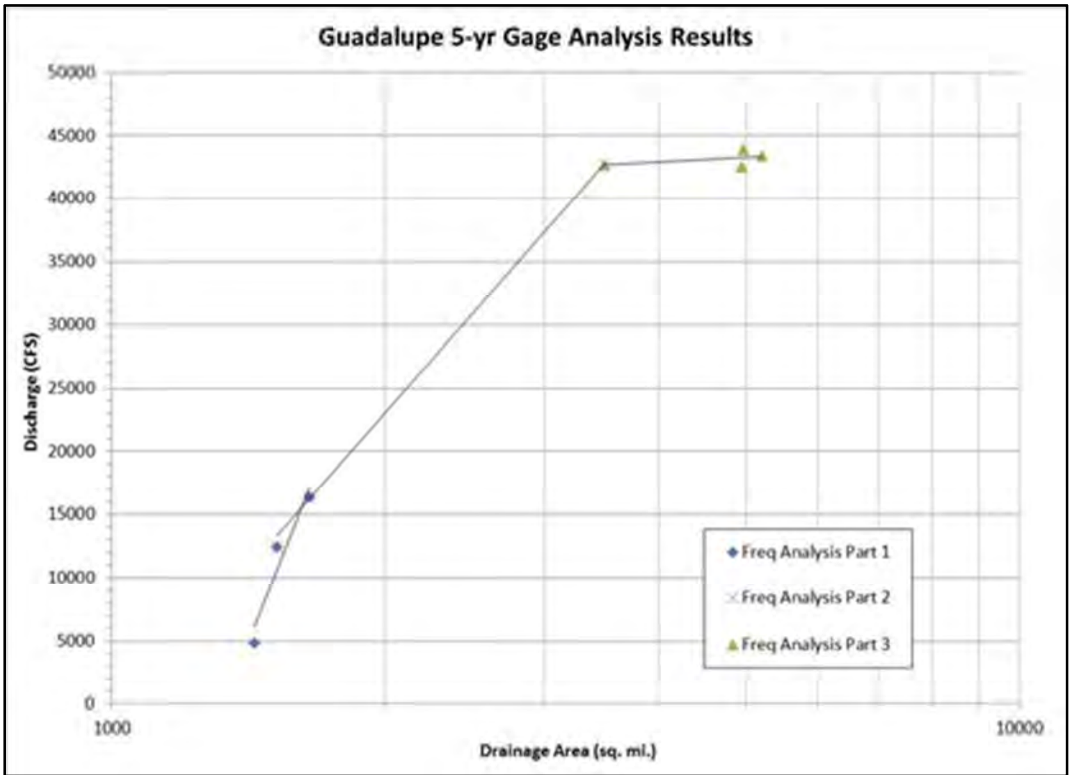

Figure 2: 5-yr Guadalupe gage analysis results

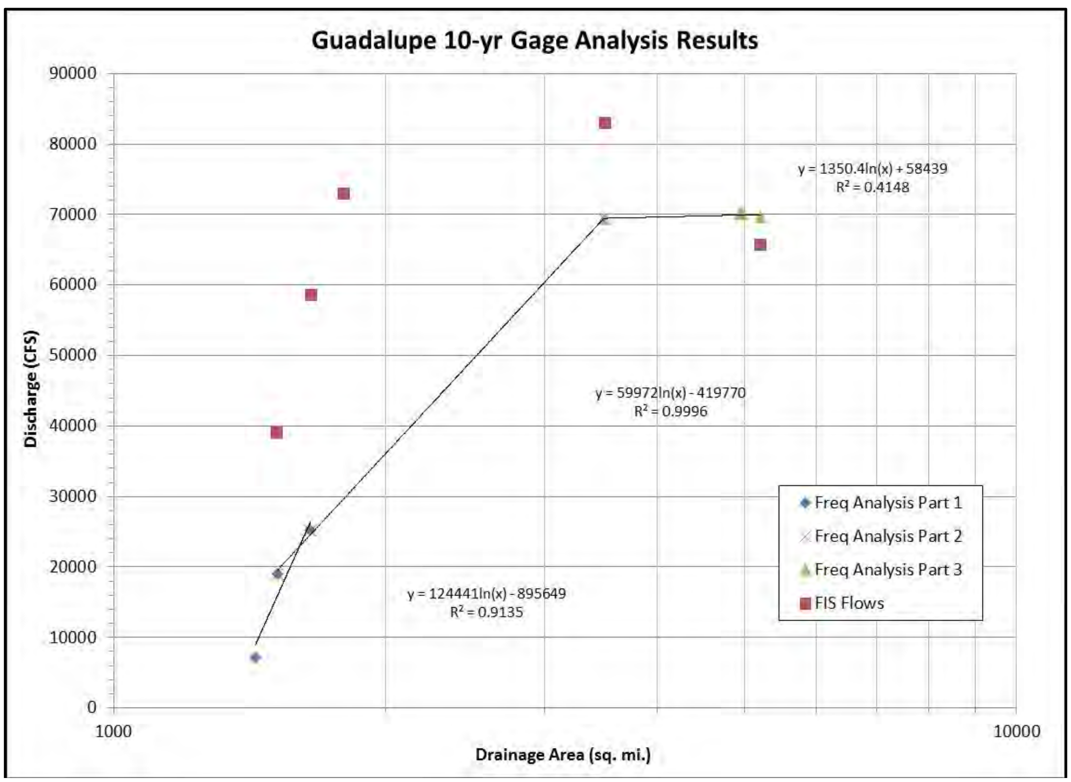

Figure 3: 10-yr Guadalupe gage analysis results

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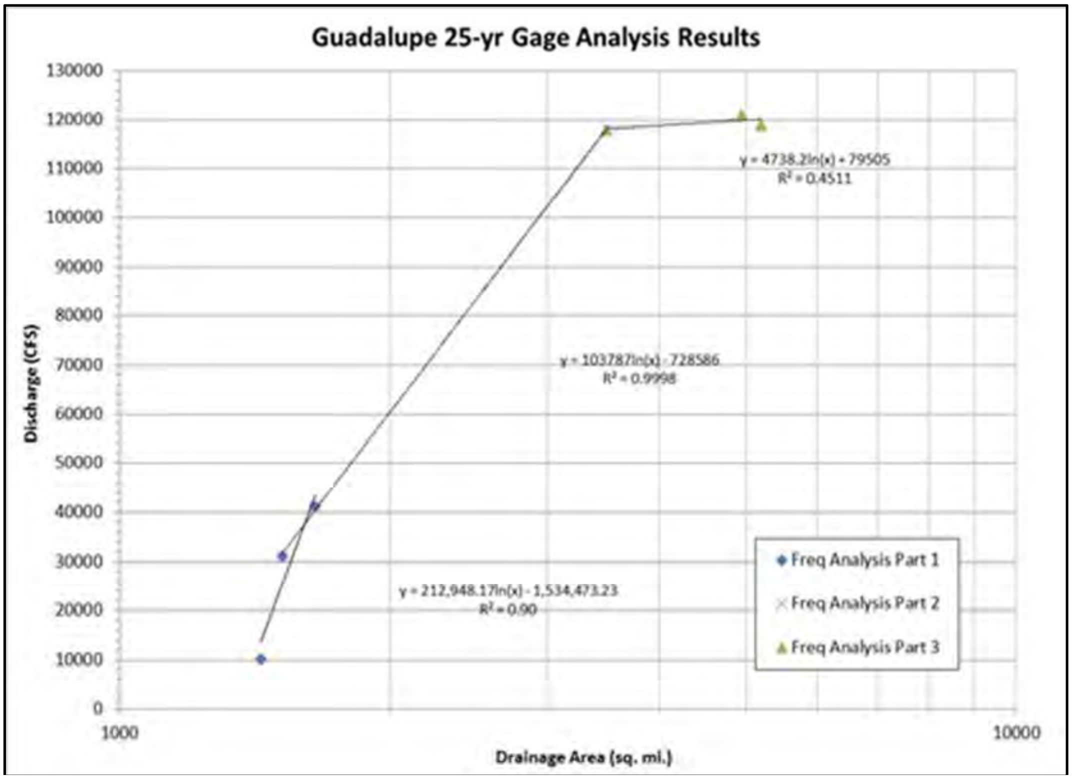

Figure 4: 25-yr Guadalupe gage analysis results

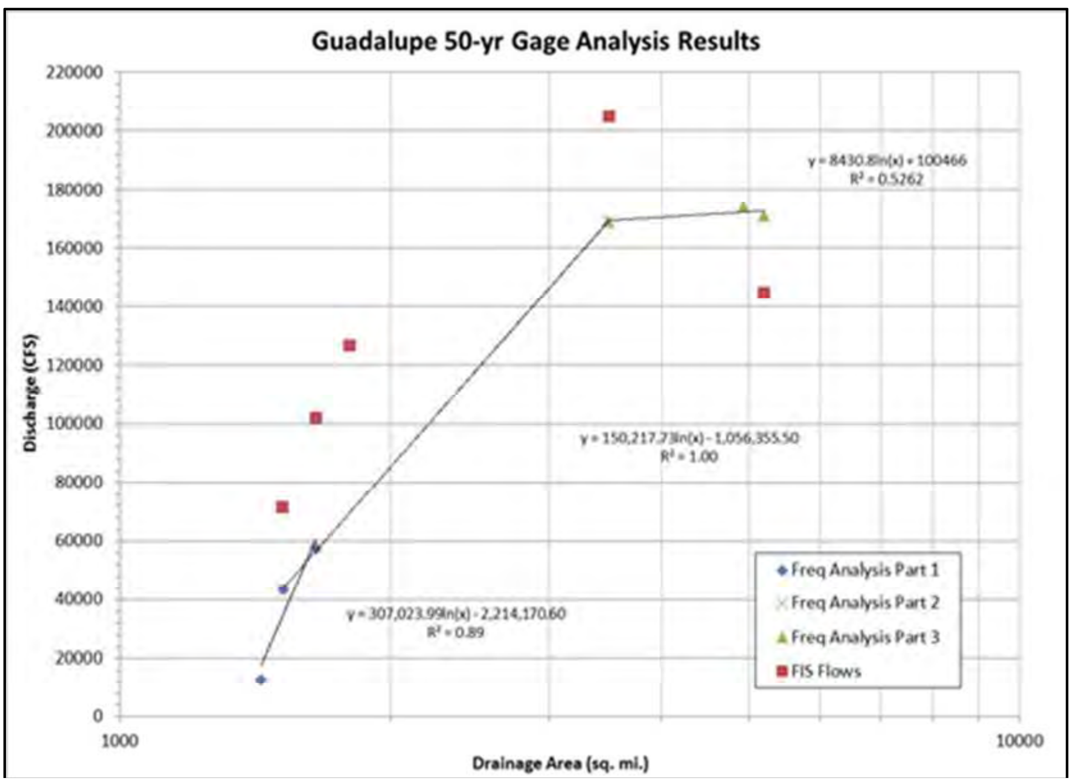

Figure 5: 50-yr Guadalupe gage analysis results

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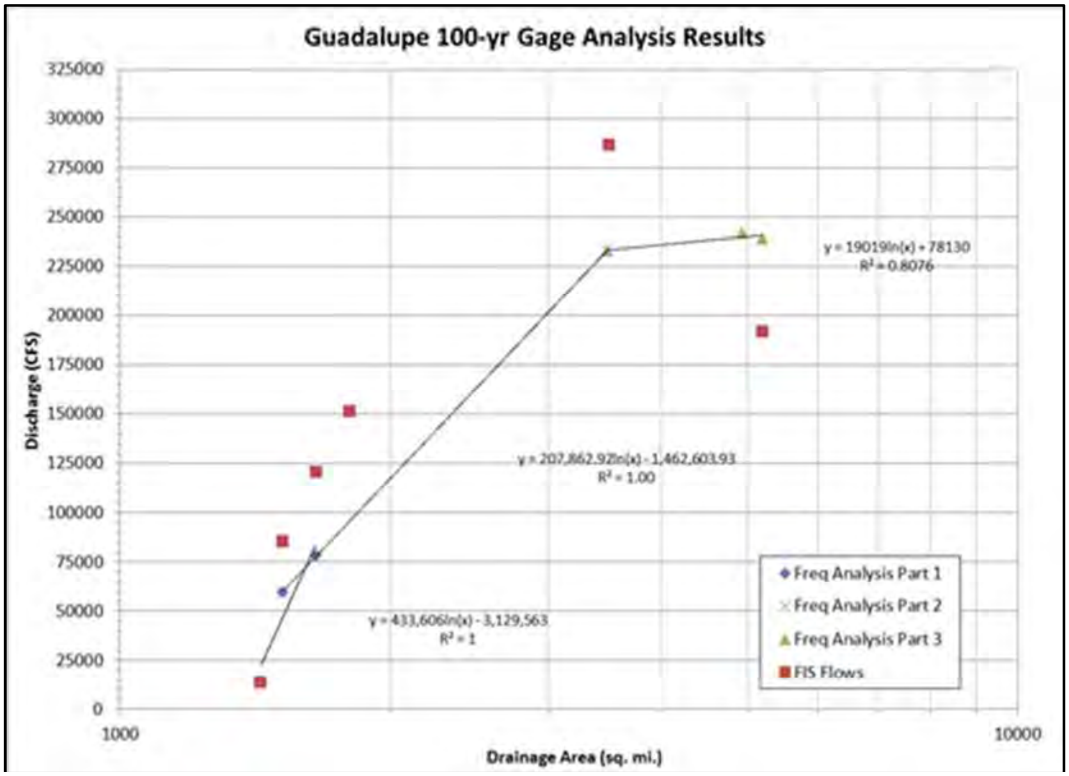

Figure 6: 100-yr Guadalupe gage analysis results

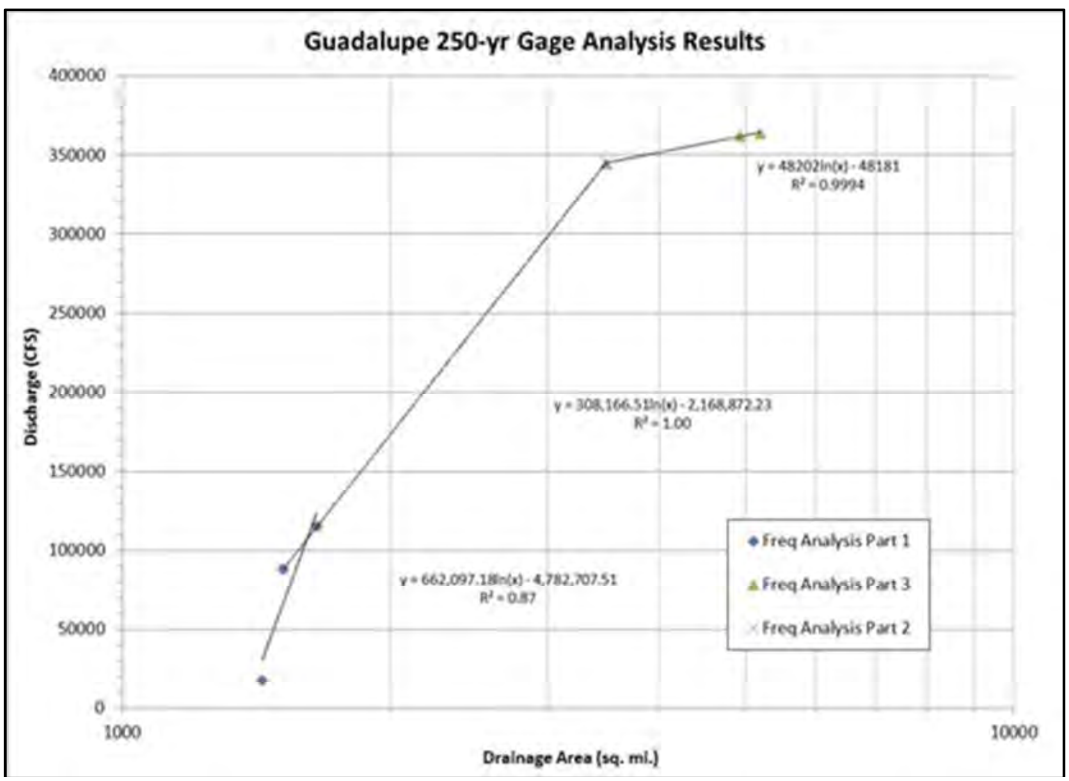

Figure 7: 250-yr Guadalupe gage analysis results

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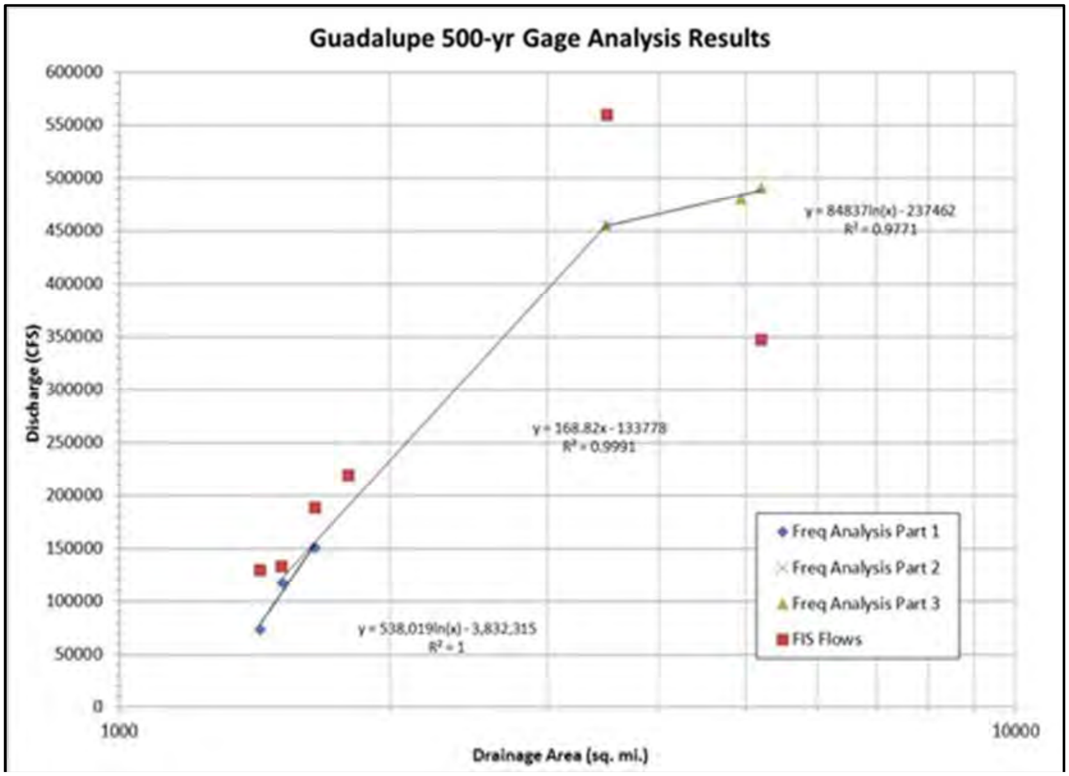

Figure 8: 500-yr Guadalupe gage analysis results

A general 3-part pattern in the frequency flow results was observed for each frequency. There appears to be a rapid increase in flows just downstream from Canyon Dam followed by a steady increase until the confluence with the San Marcos River at Gonzales. The reach from Gonzales to Victoria shows minimal increase in peak flow going downstream, which shows that the combined peak at the confluence with the San Marcos likely dominates in this section. Regression equations were developed for the three parts for each frequency event and used to calculate peak flows corresponding to hydrology model junctions along the Guadalupe River (Table 2). These computed frequency flows were compared to actual gage analysis results and FIS flows at six gage locations along the Guadalupe River. These comparisons are shown in Figures 9-14.

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Table 2: Computed Guadalupe frequency flows for hydrology model junctions

HMS Junction	U/S Area	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	250-yr	500-yr
JGUAD_010_020	1650	8000	17000	26300	43200	60400	82800	122500	153600
JGUAD_040	1742	8000	17800	25100	45900	64700	88600	130900	166800
JGUAD_030_050	1871	9000	20300	29800	53400	75400	103500	152900	196600
JGUAD_060	1960	9600	22000	32800	58200	82400	113100	167200	215900
JGUAD_070	2047	10200	23600	35600	62700	89000	122200	180700	234100
JGUAD_090	2104	10600	24600	37400	65600	93100	127900	189100	245600
JSMAR_120_GUAD_090	3462	17200	42700	69400	115200	169200	233100	344600	453900
JGUAD_160	3531	17300	42700	69500	115300	169300	233500	345600	455600
JGUAD_150	4014	17600	42900	69600	115800	170400	235900	351800	466500
JGUAD_170	4069	17600	42900	69700	115900	170500	236200	352400	467600
JGUAD_210	4215	17700	43000	69700	116000	170800	236900	354100	470600
JGUAD_220	4927	18000	43200	69900	116700	172100	239800	361700	483900
JGUAD_230	5028	18000	43300	69900	116800	172300	240200	362600	485600
JGUAD_260	5092	18100	43300	70000	116900	172400	240500	363200	486700
JGUAD_270	5196	18100	43300	70000	117000	172600	240800	364200	488400
JGUAD_300_310	5784	18300	43500	70100	117400	173500	242900	369400	497500

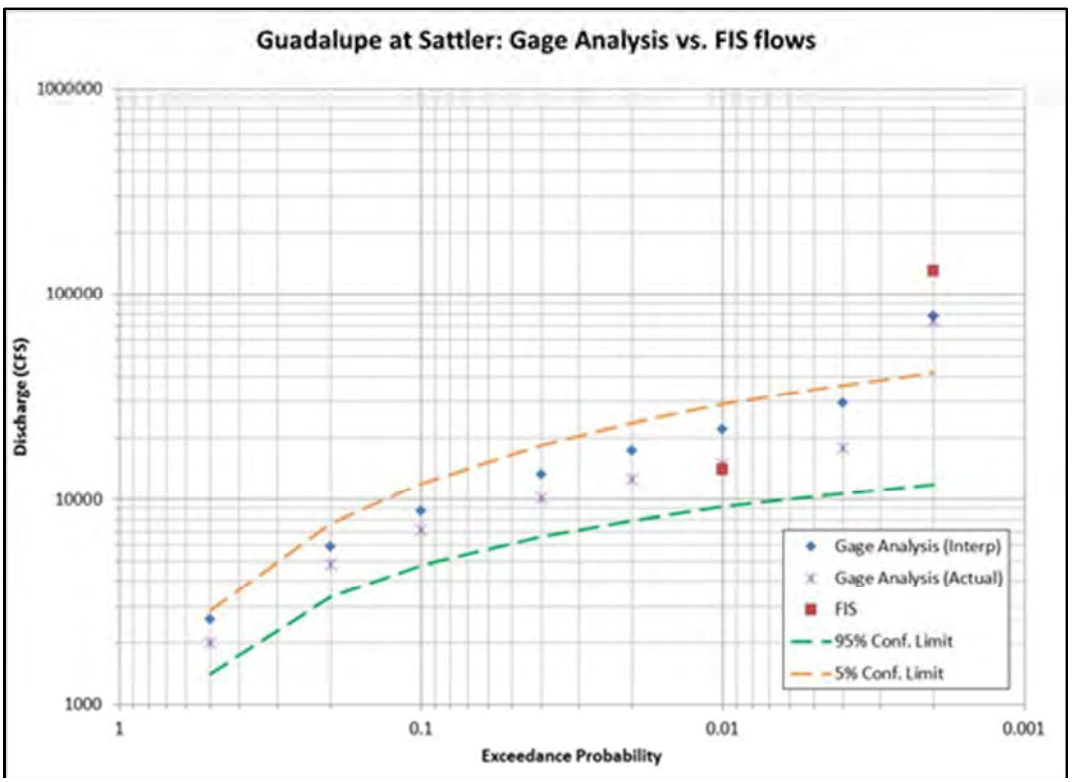

Figure 9: Guadalupe at Sattler results comparison

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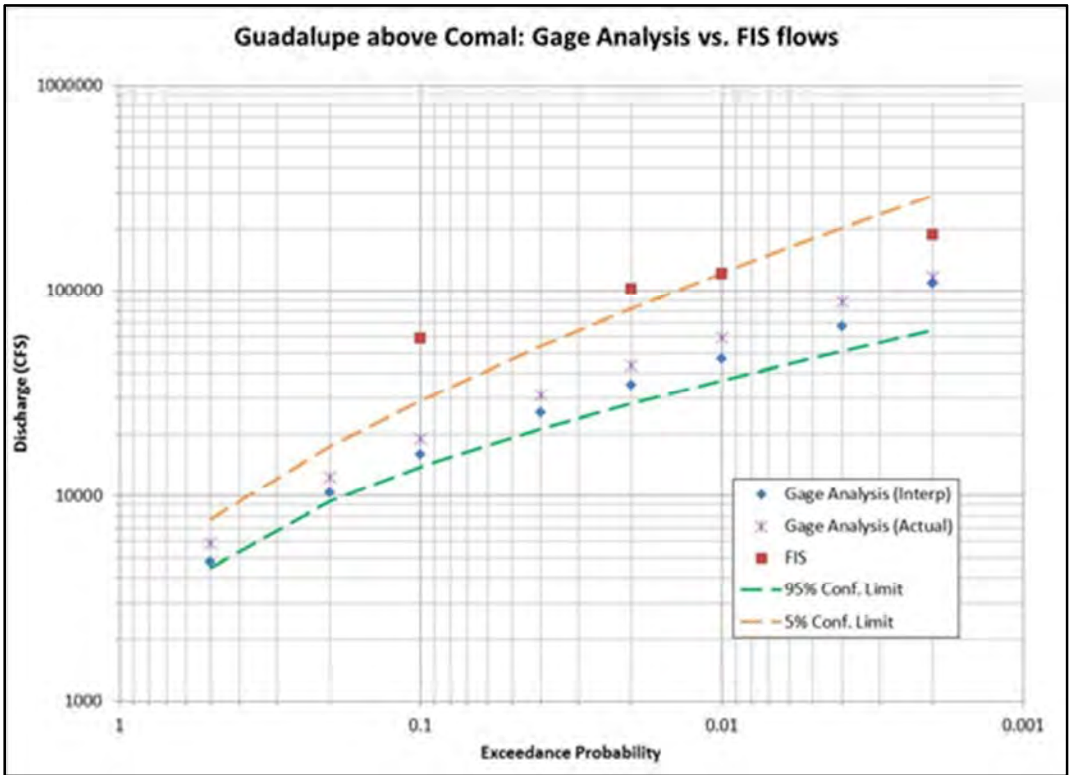

Figure 10: Guadalupe above Comal results comparison

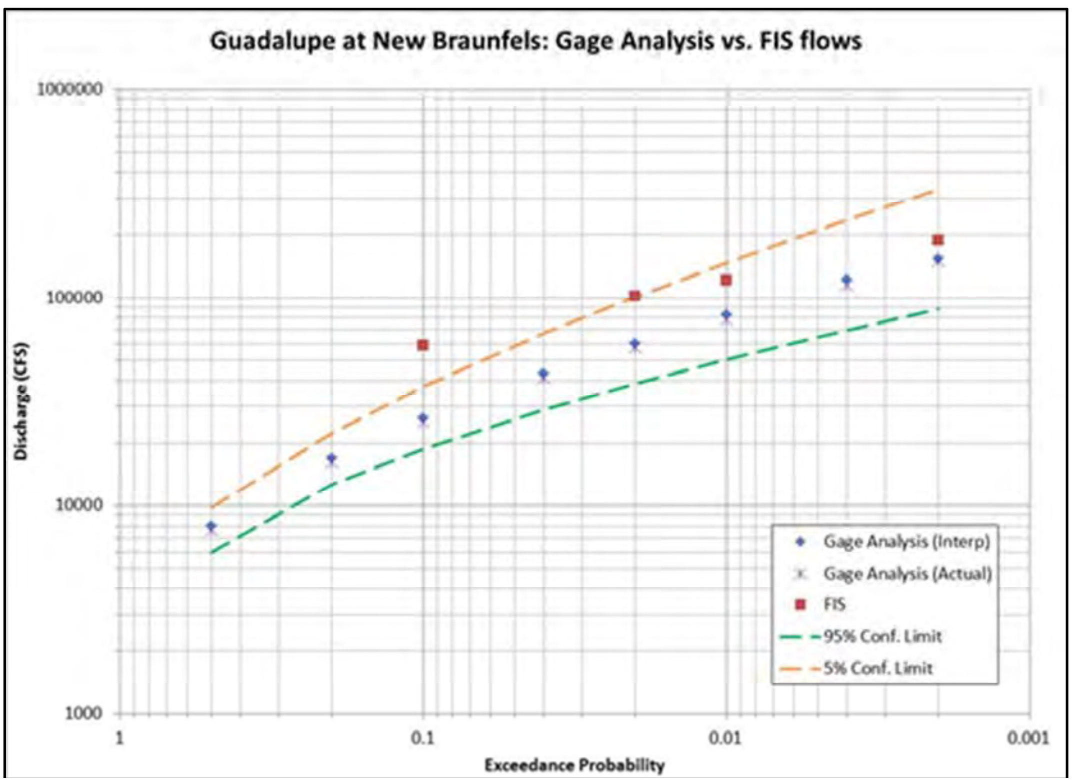

Figure 11: Guadalupe at New Braunfels results comparison

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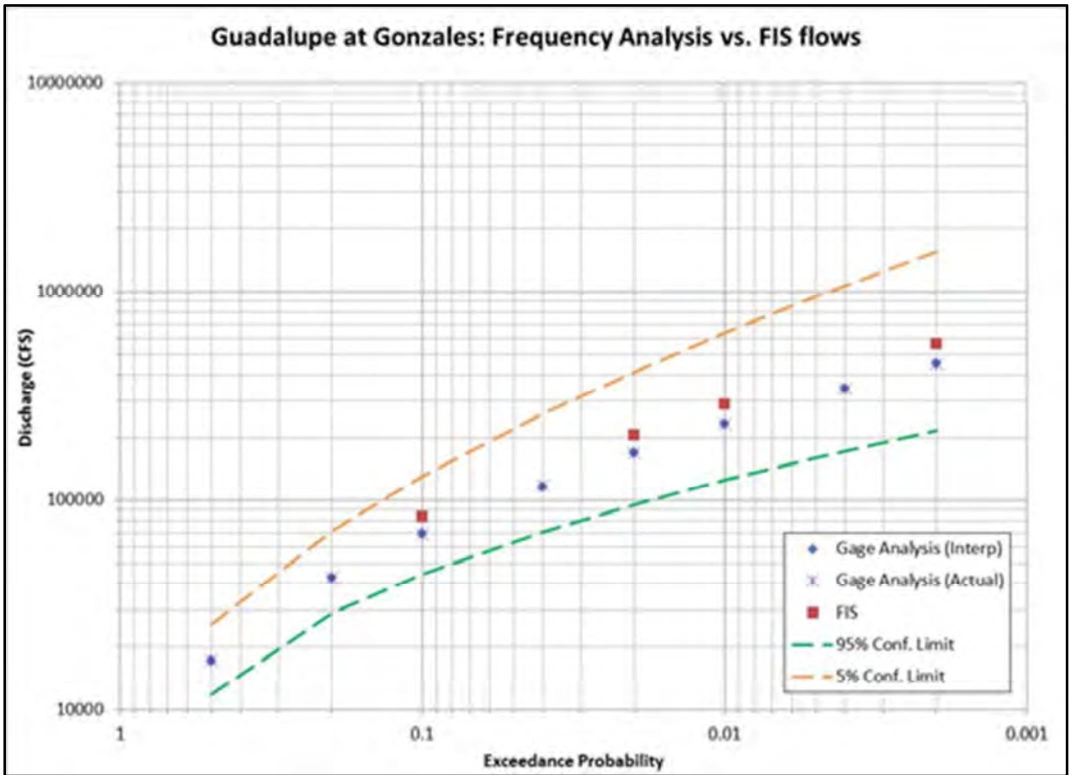

Figure 12: Guadalupe at Gonzales results comparison

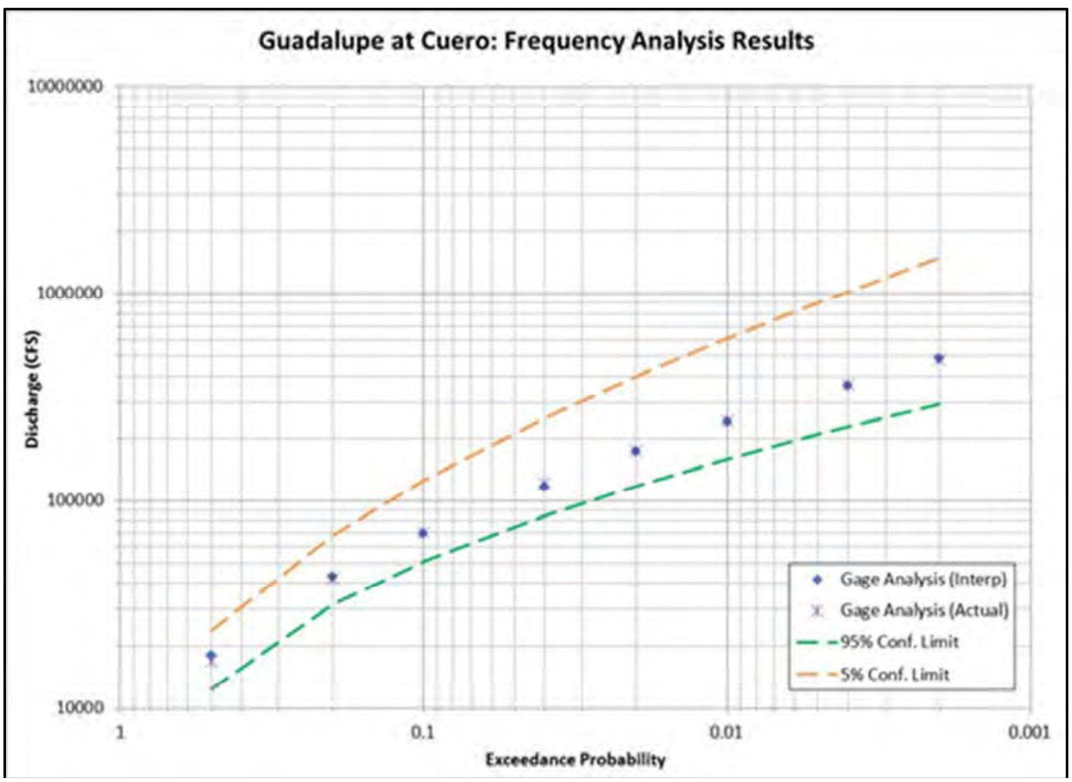

Figure 13: Guadalupe at Cuero results comparison

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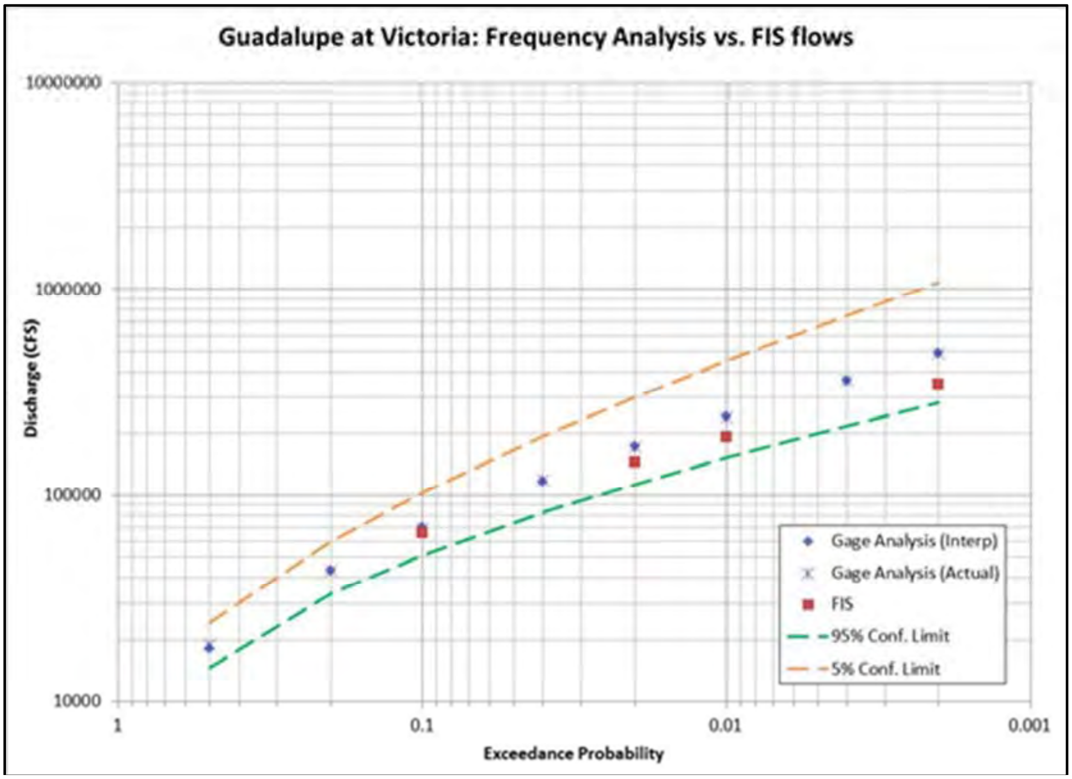

Figure 14: Guadalupe at Victoria results comparison

At most of the gages the three sets of flows compared well and were well within 95% confidence limits. For example, the FIS flows at the Gonzales gage were higher and the Victoria flows were lower than the flows from the Corps gage analysis but they were nowhere near the 95% confidence limits. However, the FIS flows at the New Braunfels and Comal gages were significantly higher than the flows from the Corps gage analysis and were very close if not above the upper confidence limit. It is unknown whether any attempts were made to calibrate the FEMA effective hydrology model to Guadalupe gage flows, and according to this comparison they don't appear to be calibrated.

Blanco/San Marcos River Flows

Four gages were used to develop frequency flows for the Blanco and San Marcos Rivers and are listed in the Table 3. The two San Marcos gages produced gage analysis results that were either much lower or much higher than expected. The San Marcos at Luling gage produced flows lower than FIS flows, which are already seem low themselves when compared to flows at the Blanco River gages. It is understood that the Luling gage flows are affected by several NRCS flood control dams in the watersheds upstream of the gage. However, the FIS flows, which were the result of a previous gage analysis, provided a more conservative estimate than the current Corps gage analysis. Therefore, a regression to the FIS flows (10, 50, 100, and 500-yr) were used to determine the 2. 5, 25, and 250-yr flows that were used for the Luling gage instead of the Corps gage analysis results. The San Marcos at Ottine gage only recorded from 1916 to 1943 and does not reflect the effects of the many NRCS dams constructed within Blanco/San Marcos basin. The gage analysis results at the Ottine gage for lower frequency

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flows therefore appeared to be much higher than expected when compared to flows at upstream gages and flows downstream on the Guadalupe as well. The FIS flows at for the Ottine gage were supposedly based off the FIS flows from the Luling gage, but the flows for the Luling gage from the DeWitt County FIS were lower than the flows reported in the Caldwell County FIS. It was concluded that the DeWitt County FIS flows were unreliable. A set of frequency flows for the Ottine gage was calculated from discharge per drainage area ratios determined from the Luling gage flows.

Table 3: Blanco/San Marcos Gages used to develop frequency flows

Gage Name	Drainage Area (sq mi)	Assumptions
BLANCO RIVER AT WIMBERLEY	355	"Max low outlier threshold" seems to be best fit curve. All FIS flows were lower than gage analysis flows
BLANCO RIVER NEAR KYLE	412	"Max low outlier threshold" seems to be best fit curve. All FIS flows were lower than gage analysis flows
SAN MARCOS RIVER AT LULING	838	All gage results were lower than FIS. FIS flows plus interpolated 2, 5, 25, 250-yr flows were used instead of gage analysis as a more conservative estimate
SAN MARCOS RIVER AT OTTINE	1249	"Max low outlier threshold" seems to be best fit curve. However, results were extremely high when compared to trend of other 3 gages as well as flows downstream on the Guadalupe. Flows at Ottine were determined from discharge per drainage area values from the Luling gage instead of gage analysis.

The frequency flows calculated for the San Marcos gages along with the gage analysis results from the Blanco gages were then plotted against drainage area on a log-normal scale. Figures 15 through 22 show the plots of each set of frequency flows versus drainage area. Current effective FEMA peak flows are also shown on the 10, 50, 100, and 500-yr plots. The plots show an increasing trend in flows in the downstream direction. However, there appears to be more scatter in the Blanco/San Marcos data than there was in the Guadalupe data. In general the FIS flows were lower than the gage analysis results at all four locations. A summary of assumptions made for each gage is also presented in Table 3.

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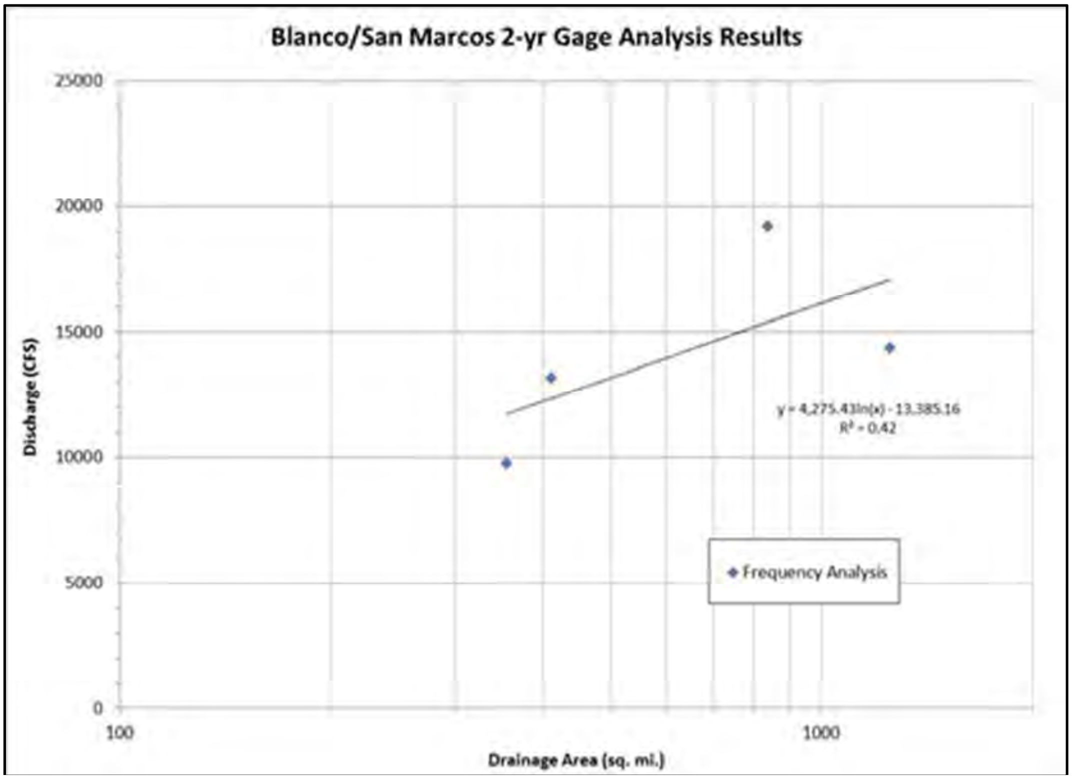

Figure 15: 2-yr Blanco/San Marcos gage analysis results

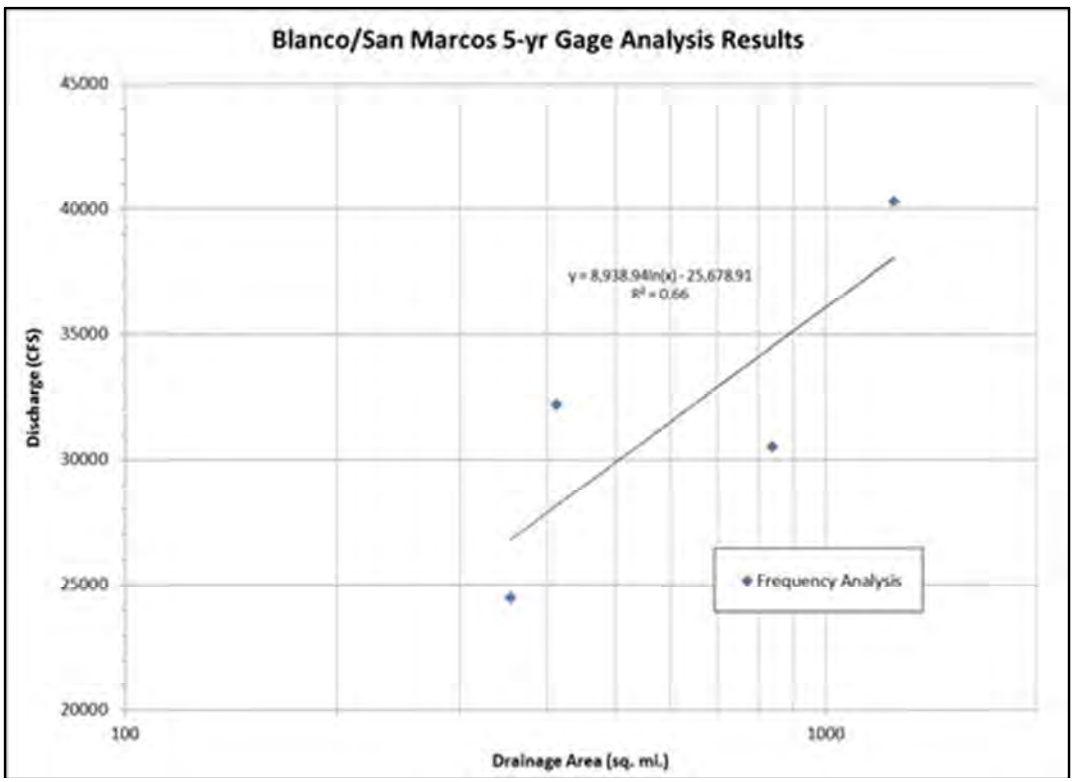

Figure 16: 5-yr Blanco/San Marcos gage analysis results

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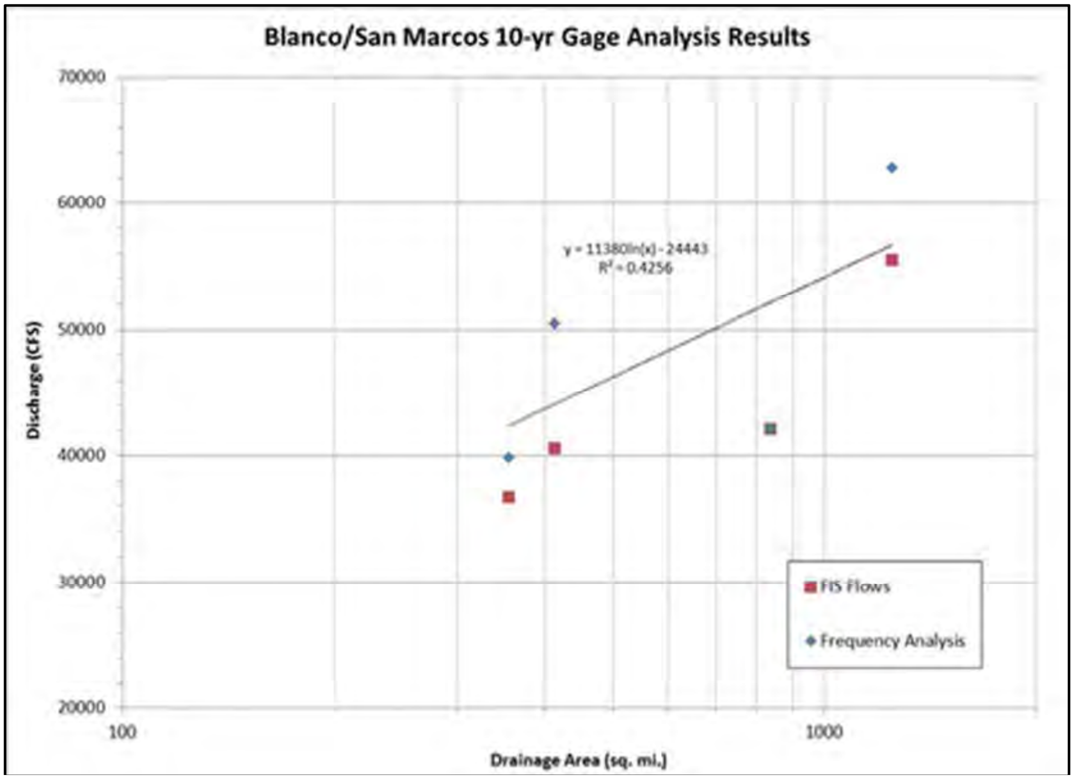

Figure 17: 10-yr Blanco/San Marcos gage analysis results

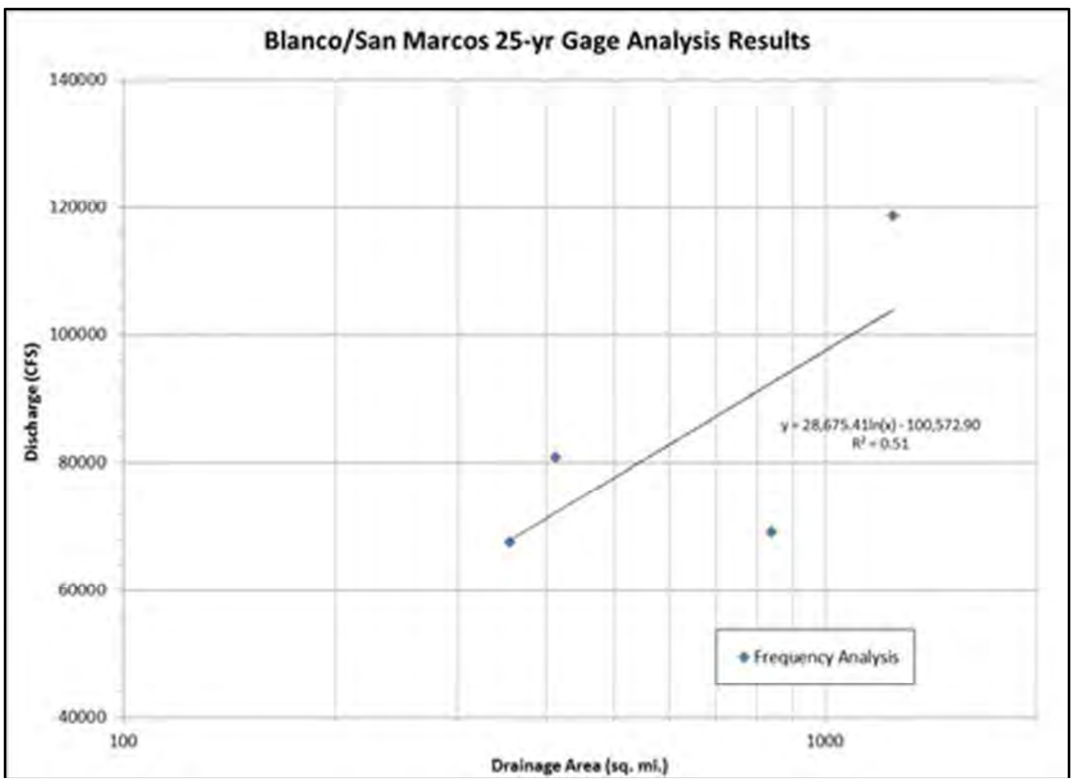

Figure 18: 25-yr Blanco/San Marcos gage analysis results

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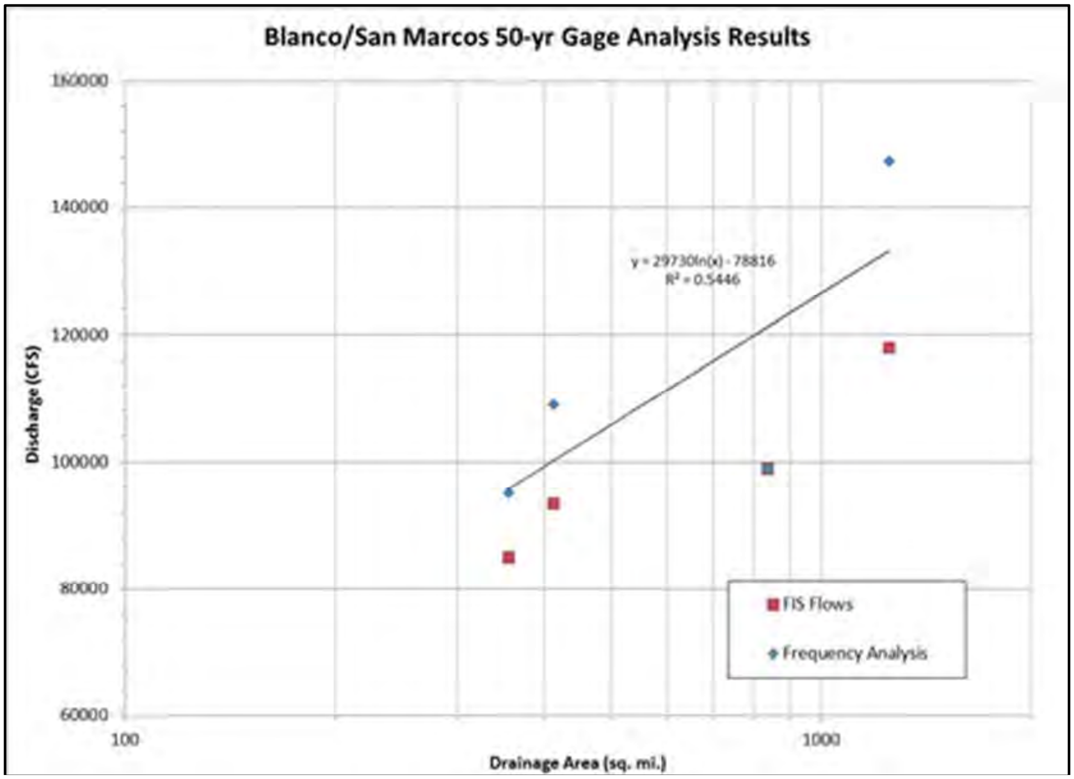

Figure 19: 50-yr Blanco/San Marcos gage analysis results

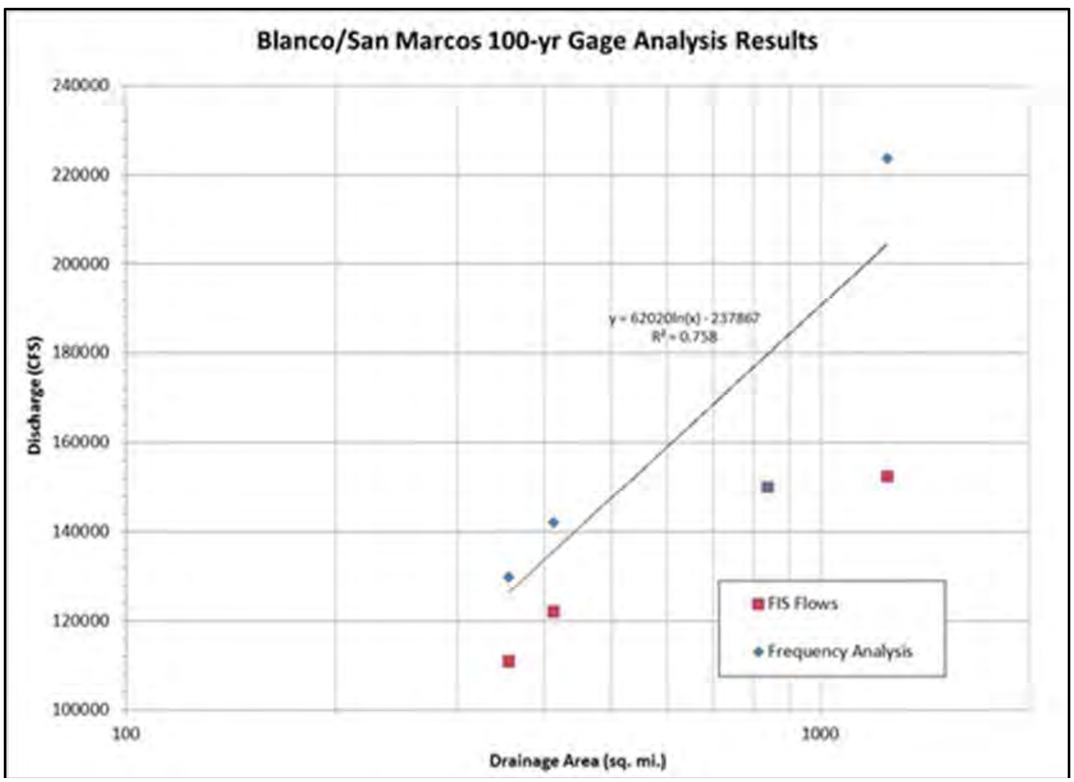

Figure 20: 100-yr Blanco/San Marcos gage analysis results

Figure 21: 250-yr Blanco/San Marcos gage analysis results

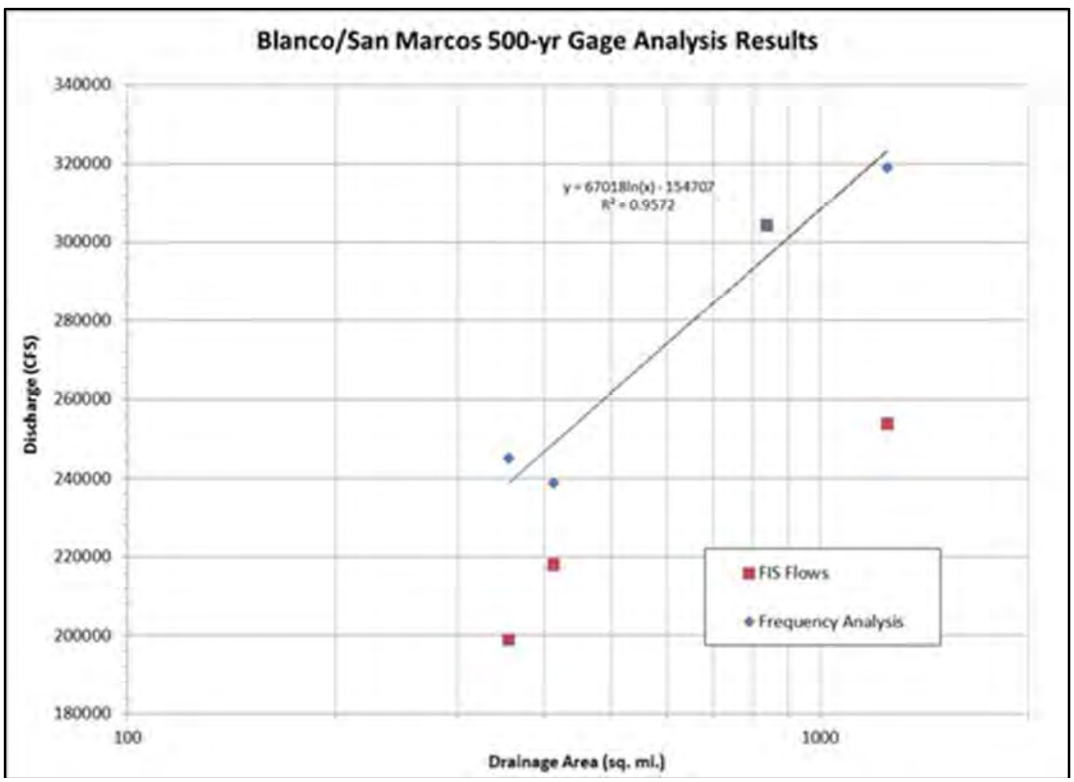

Figure 22: 500-yr Blanco/San Marcos gage analysis results

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Regression equations were developed for the each frequency event and used to calculate peak flows corresponding to hydrology model junctions along the Blanco and San Marcos Rivers (Table 4). These computed frequency flows were compared to actual gage analysis results and FIS flows at the four gage locations along the Blanco and San Marcos Rivers. These comparisons are shown in Figures 23-26.

Table 2: Computed Blanco/San Marcos frequency flows for hydrology model junctions

HMS Junction	U/S Area	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	250-yr	500-yr
JBLNC_010_020	238	10000	23200	37800	56300	83800	101500	159000	212000
JBLNC_030	317	11200	25800	41100	64500	92400	119300	176900	231200
JBLNC_040	355	11700	26800	42400	67800	95800	126300	184000	238800
JBLNC_050	412	12400	28100	44100	72100	100200	135500	193300	248800
JBLNC_060	435	12600	28600	44700	73700	101800	139000	196700	252500
JBLNC_060_SMAR_010	531	13400	30400	47000	79400	107800	151300	209200	265900
JSMAR_020_030	756	15000	33600	51000	89500	118200	173200	231200	289500
JSMAR_090	863	15500	34800	52500	93300	122200	181400	239400	298400
JSMAR_100	1250	17100	38100	56700	103900	133200	204400	262500	323200
JSMAR_120	1358	17500	38800	57600	106300	135600	209500	267700	328700

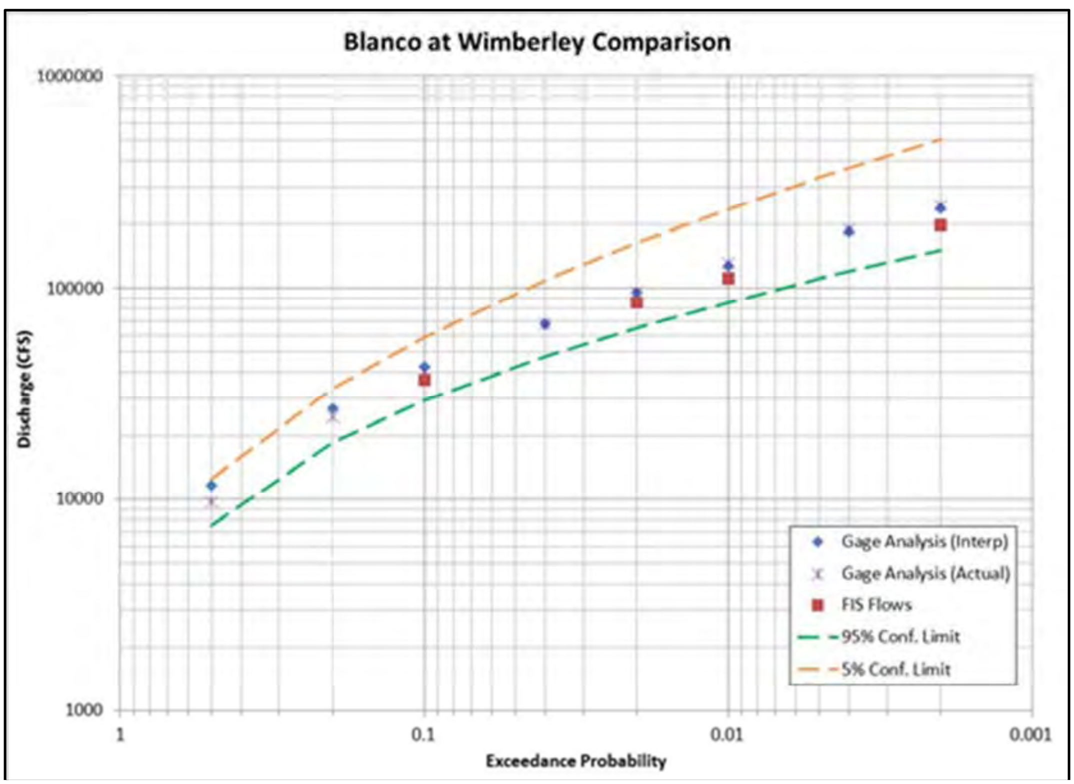

Figure 23: Blanco at Wimberley results comparison

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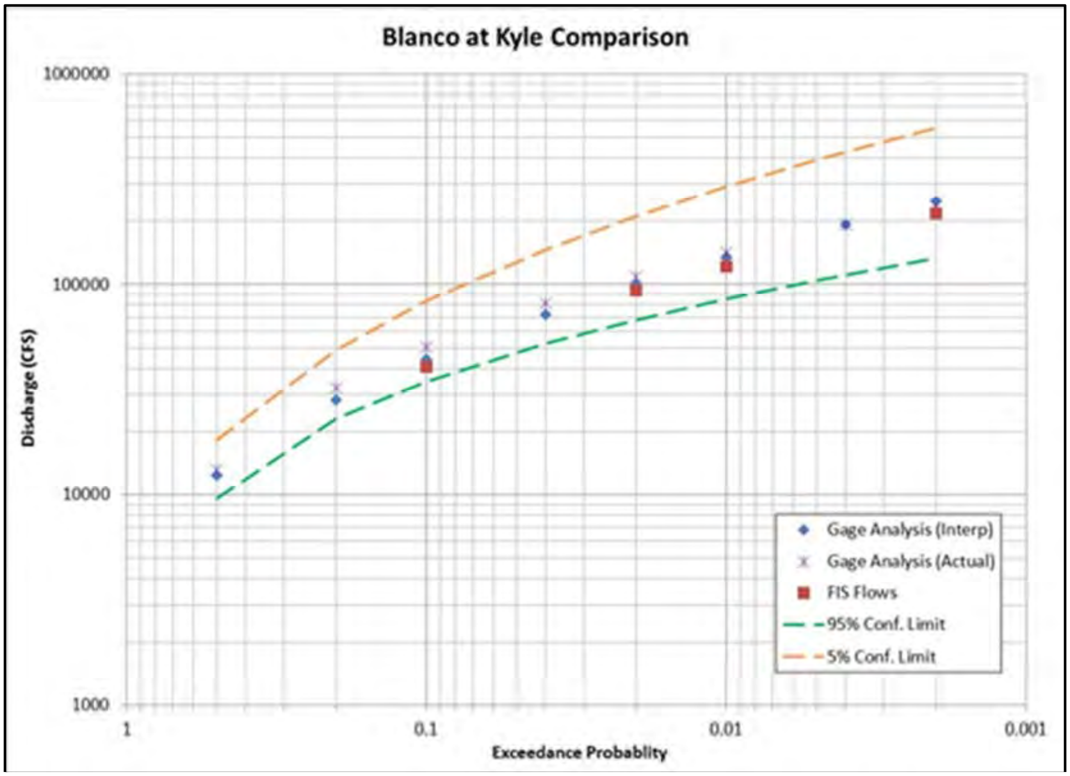

Figure 24: Blanco near Kyle results comparison

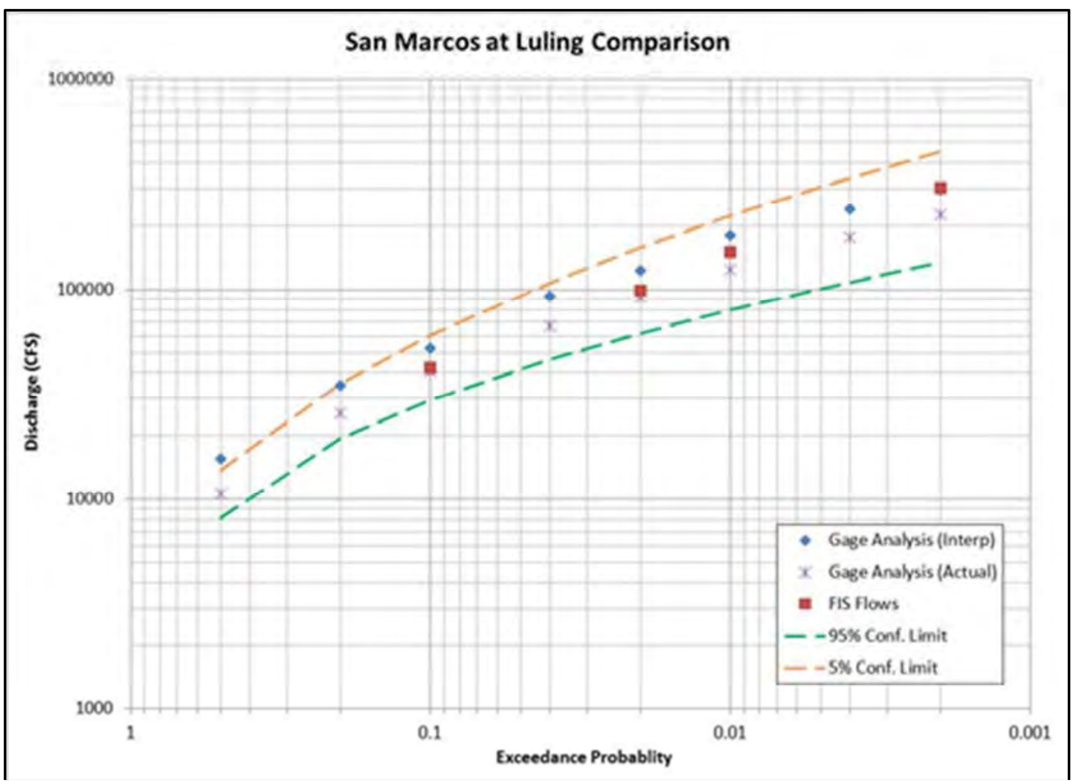

Figure 25: San Marcos at Luling results comparison

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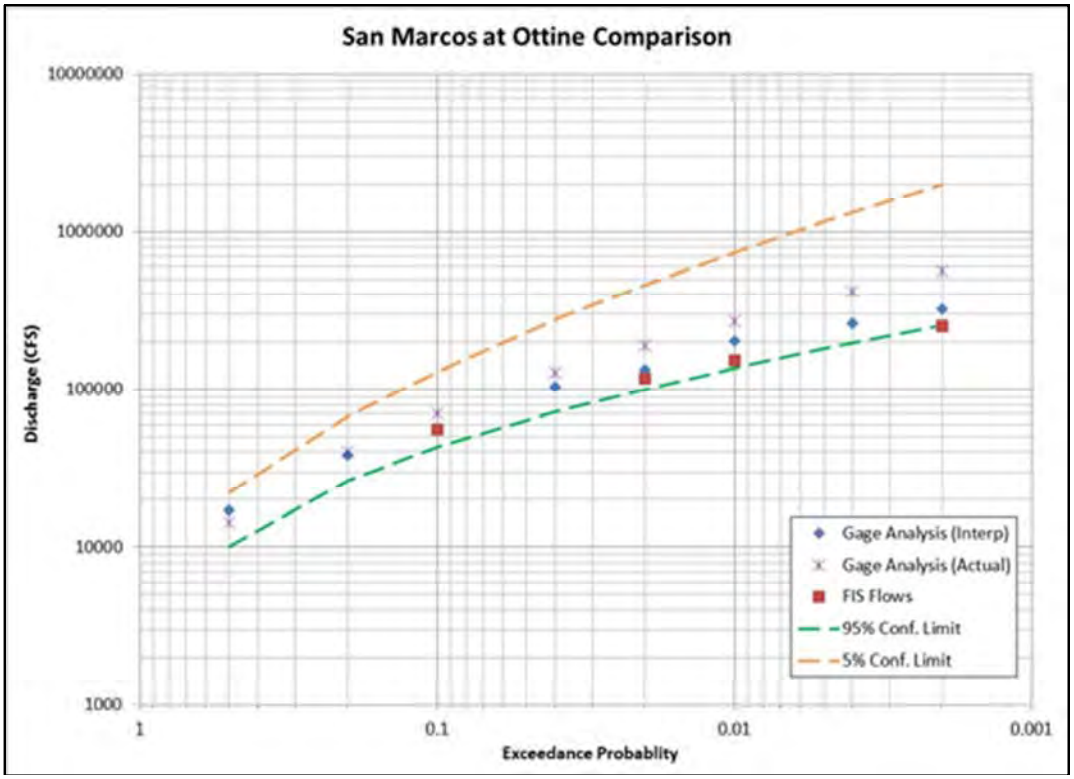
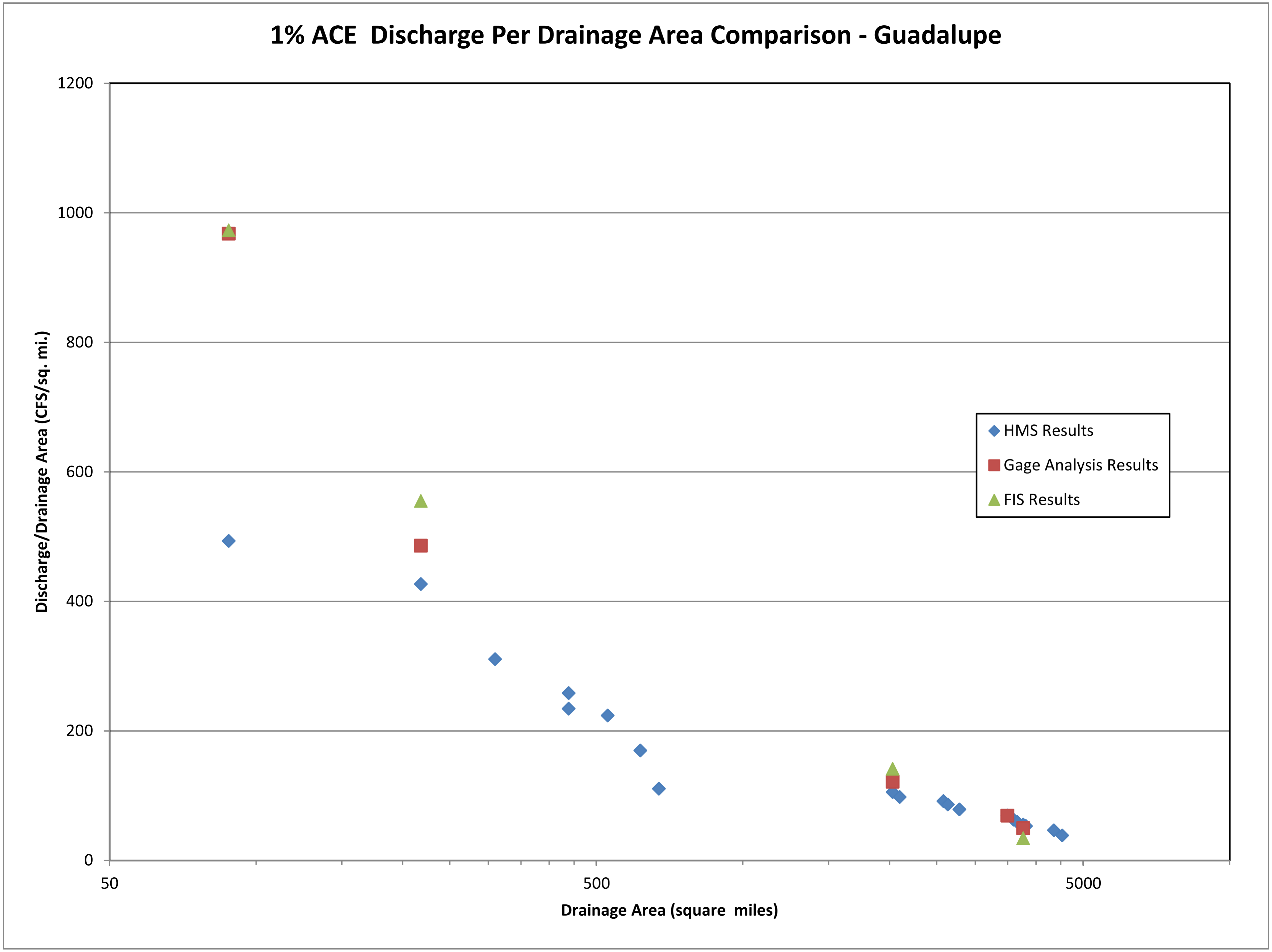
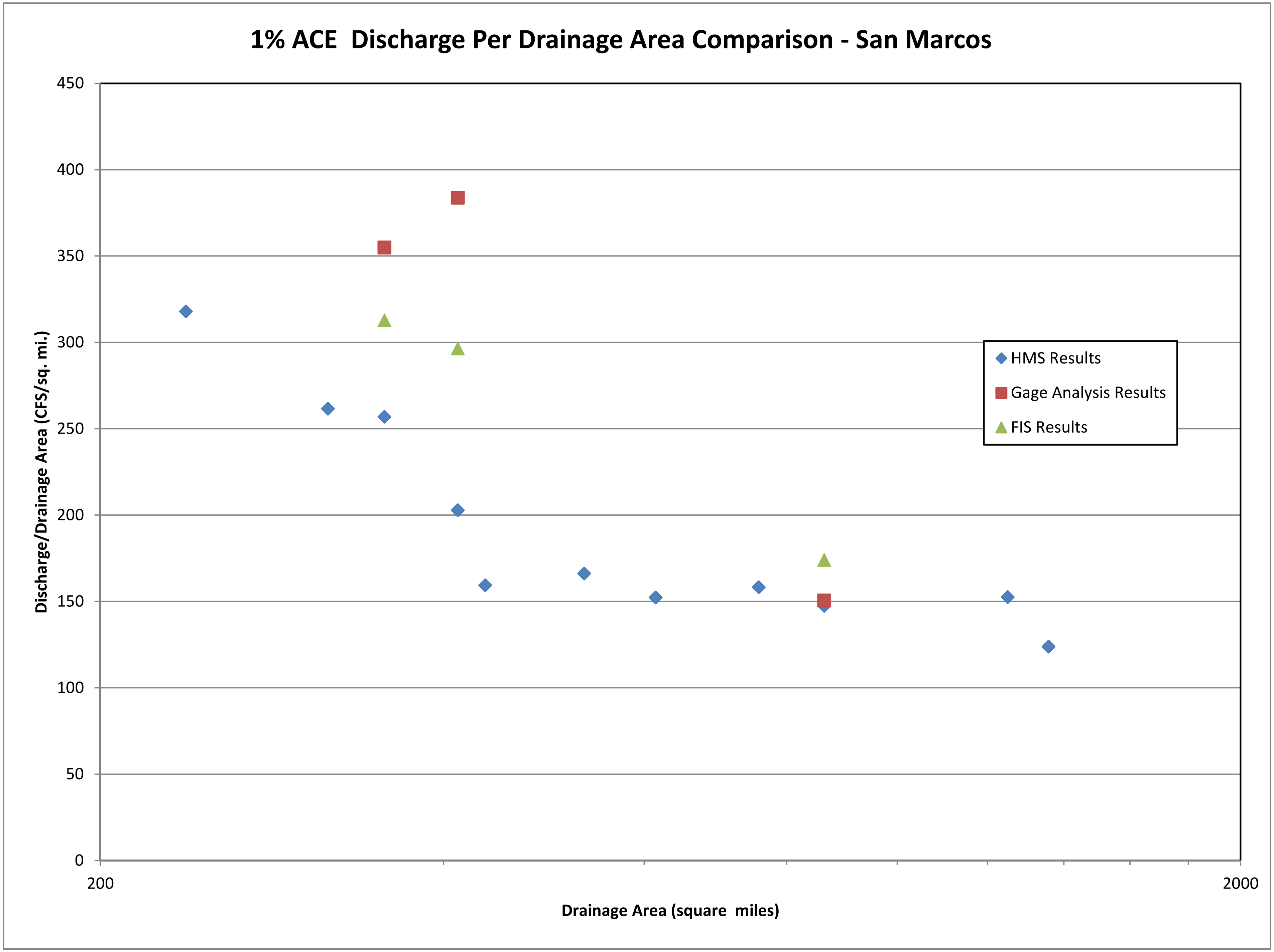


Figure 26: San Marcos at Ottine results comparison

At the Blanco River gages the flows compared well and were well within 95% confidence limits. The FIS flows for the Blanco gages were lower than the interpolated and actual gage analysis flows. For the Luling gage the interpolated flows were generally higher than the other flows and came near the 95% confidence limits for the higher frequencies. The actual gage analysis at Ottine was much higher than the interpolated or FIS flows, but all flows were with the 95% confidence limits.

Appendix B.1.2.f
Area-Discharge Comparisons


1% ACE Discharge Per Drainage Area Comparison - Guadalupe
Discharge/Drainage Area (CFS/sq. mi.)
1200
1000
800
600
400
200
0
50
500
5000
Drainage Area (square miles)
HMS Results
Gage Analysis Results
FIS Results



1% ACE Discharge Per Drainage Area Comparison - San Marcos
Discharge/Drainage Area (CFS/sq. mi.)
450
400
350
300
250
200
150
100
50
0
200
2000
Drainage Area (square miles)
HMS Results
Gage Analysis Results
FIS Results

Appendix B.1.3

Calibration Results

Calibration Summary							
Initial Loss [in]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
BLNC_010	0.78	0.78	1.00	4.68	6.00	1.25	1.60
BLNC_020	0.77	0.77	1.00	4.62	6.00	1.23	1.60
BLNC_030	0.77	0.77	1.00	4.62	6.00	1.23	1.60
BLNC_040	0.77	0.77	1.00	4.62	6.00	1.23	1.60
BLNC_050	0.76	1.98	2.61	4.56	6.00	0.00	0.00
BLNC_060	0.80	2.08	2.60	4.80	6.00	0.00	0.00
GUAD_010	0.76	0.76	1.00	1.82	2.40	0.84	1.11
GUAD_020	0.76	0.76	1.00	1.82	2.40	0.84	1.11
GUAD_030	0.76	1.82	2.39	4.56	6.00	1.98	2.60
GUAD_040	0.79	1.90	2.41	4.74	6.00	2.05	2.60
GUAD_050	0.86	2.06	2.40	5.16	6.00	2.24	2.60
GUAD_060	0.84	2.02	2.40	5.04	6.00	2.18	2.60
GUAD_070	0.86	2.06	2.40	5.16	6.00	2.24	2.60
GUAD_080	0.89	2.14	2.40	5.34	6.00	2.67	3.00
GUAD_090	0.82	1.97	2.40	4.92	6.00	2.13	2.60
GUAD_100	0.81	1.94	2.40	4.86	6.00	2.43	3.00
GUAD_110	0.90	2.16	2.40	5.40	6.00	2.70	3.00
GUAD_120	0.83	1.99	2.40	4.98	6.00	2.49	3.00
GUAD_130	0.78	1.87	2.40	4.68	6.00	2.34	3.00
GUAD_140	0.82	1.97	2.40	4.92	6.00	2.46	3.00
GUAD_150	0.79	1.90	2.41	4.74	6.00	2.37	3.00
GUAD_160	0.81	1.94	2.40	4.86	6.00	2.43	3.00
GUAD_170	0.83	1.99	2.40	4.98	6.00	2.49	3.00
GUAD_180	0.79	1.90	2.41	4.74	6.00	2.37	3.00
GUAD_190	0.84	2.02	2.40	5.04	6.00	2.52	3.00
GUAD_200	0.81	1.94	2.40	4.86	6.00	2.43	3.00
GUAD_210	0.83	1.99	2.40	4.98	6.00	2.49	3.00
GUAD_220	0.84	2.02	2.40	5.04	6.00	2.52	3.00
GUAD_230	0.83	1.99	2.40	4.98	6.00	2.49	3.00
GUAD_240	0.85	2.04	2.40	5.10	6.00	2.55	3.00
GUAD_250	0.85	2.04	2.40	5.10	6.00	2.55	3.00
GUAD_260	0.83	1.99	2.40	4.98	6.00	2.49	3.00
GUAD_270	0.80	1.92	2.40	4.80	6.00	2.40	3.00
GUAD_280	0.87	2.09	2.40	5.22	6.00	2.61	3.00
GUAD_290	0.85	2.04	2.40	5.10	6.00	2.55	3.00
GUAD_300	0.82	1.97	2.40	4.92	6.00	2.46	3.00
GUAD_310	0.80	1.92	2.40	4.80	6.00	2.40	3.00

Calibration Summary							
Initial Loss [in]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
GUAD_320	0.78	1.87	2.40	4.68	6.00	2.34	3.00
SMAR_010	0.76	1.98	2.61	4.56	6.00	0.00	0.00
SMAR_020	0.75	2.08	2.77	4.50	6.00	0.00	0.00
SMAR_030	0.80	1.95	2.44	4.80	6.00	0.00	0.00
SMAR_040	0.78	1.87	2.40	3.90	5.00	2.03	2.60
SMAR_050	0.77	2.00	2.60	4.62	6.00	1.69	2.19
SMAR_060	0.75	1.95	2.60	4.50	6.00	1.50	2.00
SMAR_070	0.78	1.87	2.40	3.90	5.00	2.03	2.60
SMAR_080	0.90	2.16	2.40	4.50	5.00	2.34	2.60
SMAR_090	0.82	2.13	2.60	4.92	6.00	0.00	0.00
SMAR_100	0.83	1.99	2.40	4.98	6.00	2.16	2.60
SMAR_110	0.83	1.99	2.40	4.15	5.00	2.16	2.60
SMAR_120	0.83	1.99	2.40	4.98	6.00	2.16	2.60

Calibration Summary							
Constant Loss [Dimensionless]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
BLNC_010	0.08	0.16	2.00	0.12	1.50	0.08	1.00
BLNC_020	0.07	0.14	2.00	0.12	1.71	0.07	1.00
BLNC_030	0.07	0.14	2.00	0.12	1.71	0.07	1.00
BLNC_040	0.07	0.14	2.00	0.12	1.71	0.07	1.00
BLNC_050	0.07	0.12	1.71	0.14	2.00	0.04	0.50
BLNC_060	0.08	0.13	1.63	0.20	2.50	0.04	0.50
GUAD_010	0.07	0.07	1.00	0.14	2.00	0.14	2.00
GUAD_020	0.07	0.07	1.00	0.14	2.00	0.14	2.00
GUAD_030	0.07	0.07	1.00	0.18	2.50	0.14	2.00
GUAD_040	0.08	0.08	1.00	0.20	2.50	0.16	2.00
GUAD_050	0.09	0.09	1.00	0.23	2.50	0.18	2.00
GUAD_060	0.09	0.09	1.00	0.23	2.50	0.18	2.00
GUAD_070	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_080	0.10	0.10	1.00	0.25	2.50	0.20	2.00
GUAD_090	0.08	0.08	1.00	0.20	2.50	0.16	2.00
GUAD_100	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_110	0.10	0.10	1.00	0.30	3.00	0.20	2.00
GUAD_120	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_130	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_140	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_150	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_160	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_170	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_180	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_190	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_200	0.08	0.08	1.00	0.24	3.00	0.16	2.00
GUAD_210	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_220	0.09	0.09	1.00	0.27	3.00	0.18	2.00
GUAD_230	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_240	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_250	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_260	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_270	0.08	0.08	1.00	0.16	2.00	0.16	2.00
GUAD_280	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_290	0.09	0.09	1.00	0.18	2.00	0.18	2.00
GUAD_300	0.08	0.08	1.00	0.16	2.00	0.16	2.00
GUAD_310	0.08	0.08	1.00	0.16	2.00	0.16	2.00

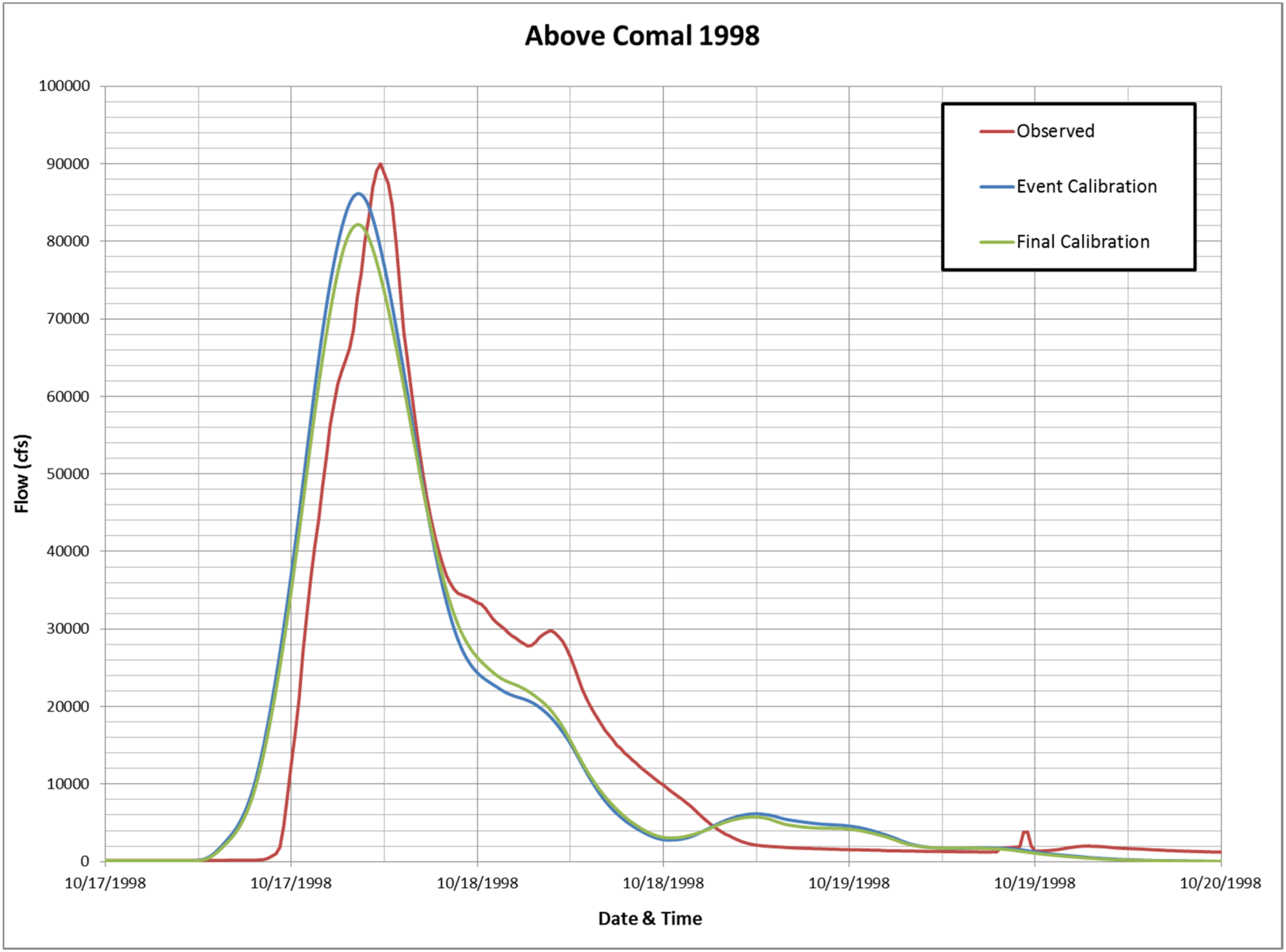
Calibration Summary							
Constant Loss [Dimensionless]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
GUAD_320	0.08	0.08	1.00	0.16	2.00	0.16	2.00
SMAR_010	0.07	0.12	1.71	0.18	2.50	0.04	0.50
SMAR_020	0.07	0.07	1.00	0.18	2.50	0.04	0.50
SMAR_030	0.08	0.08	1.00	0.20	2.50	0.04	0.50
SMAR_040	0.08	0.08	1.00	0.16	2.00	0.18	2.25
SMAR_050	0.07	0.12	1.71	0.14	2.00	0.14	2.00
SMAR_060	0.07	0.07	1.00	0.14	2.00	0.07	1.00
SMAR_070	0.08	0.08	1.00	0.16	2.00	0.16	2.00
SMAR_080	0.10	0.10	1.00	0.20	2.00	0.20	2.00
SMAR_090	0.08	0.08	1.00	0.20	2.50	0.04	0.50
SMAR_100	0.09	0.09	1.00	0.23	2.50	0.16	1.78
SMAR_110	0.09	0.09	1.00	0.18	2.00	0.14	1.56
SMAR_120	0.09	0.09	1.00	0.23	2.50	0.18	2.00

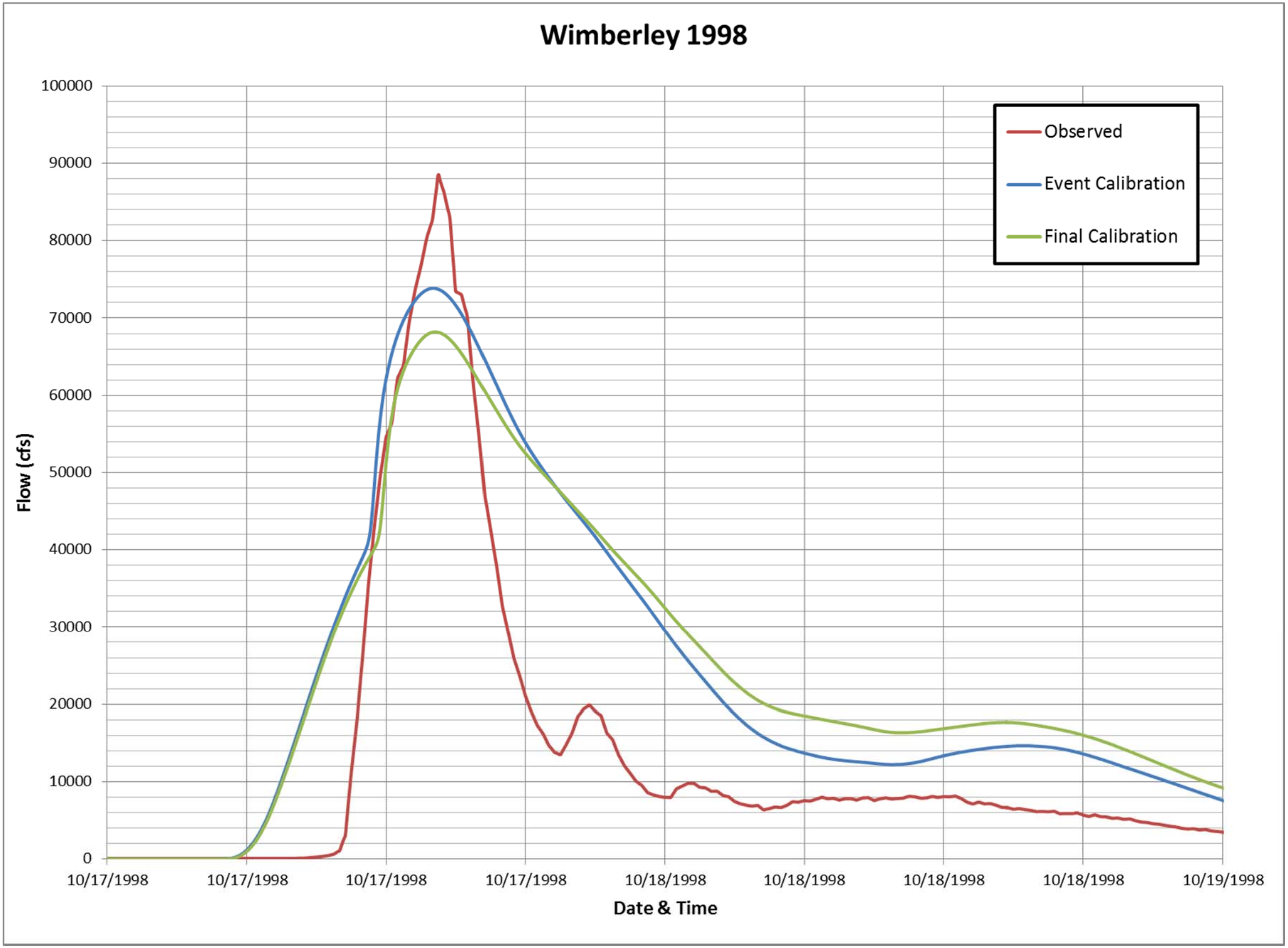
Calibration Summary							
Peaking Coefficient [Dimensionless]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
BLNC_010	0.58	0.64	1.10	0.64	1.10	0.80	1.38
BLNC_020	0.58	0.64	1.10	0.64	1.10	0.80	1.38
BLNC_030	0.58	0.80	1.38	0.80	1.38	0.80	1.38
BLNC_040	0.58	0.80	1.38	0.80	1.38	0.80	1.38
BLNC_050	0.58	0.70	1.20	0.46	0.80	0.78	1.34
BLNC_060	0.60	0.66	1.10	0.48	0.80	0.81	1.35
GUAD_010	0.59	0.80	1.36	0.53	0.90	0.71	1.20
GUAD_020	0.59	0.80	1.36	0.53	0.90	0.71	1.20
GUAD_030	0.62	0.68	1.10	0.47	0.75	0.50	0.81
GUAD_040	0.62	0.68	1.10	0.47	0.75	0.50	0.81
GUAD_050	0.60	0.66	1.10	0.45	0.75	0.48	0.80
GUAD_060	0.59	0.65	1.10	0.44	0.75	0.47	0.80
GUAD_070	0.59	0.65	1.10	0.44	0.75	0.47	0.80
GUAD_080	0.58	0.64	1.10	0.44	0.75	0.44	0.76
GUAD_090	0.60	0.66	1.10	0.45	0.75	0.48	0.80
GUAD_100	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_110	0.58	0.64	1.10	0.44	0.75	0.44	0.76
GUAD_120	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_130	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_140	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_150	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_160	0.60	0.66	1.10	0.45	0.75	0.45	0.75
GUAD_170	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_180	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_190	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_200	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_210	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_220	0.59	0.65	1.10	0.44	0.75	0.44	0.75
GUAD_230	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_240	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_250	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_260	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_270	0.60	0.66	1.00	0.45	0.75	0.45	0.75
GUAD_280	0.58	0.64	1.00	0.44	0.75	0.44	0.75
GUAD_290	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_300	0.59	0.65	1.00	0.44	0.75	0.44	0.75
GUAD_310	0.61	0.67	1.00	0.46	0.75	0.46	0.75

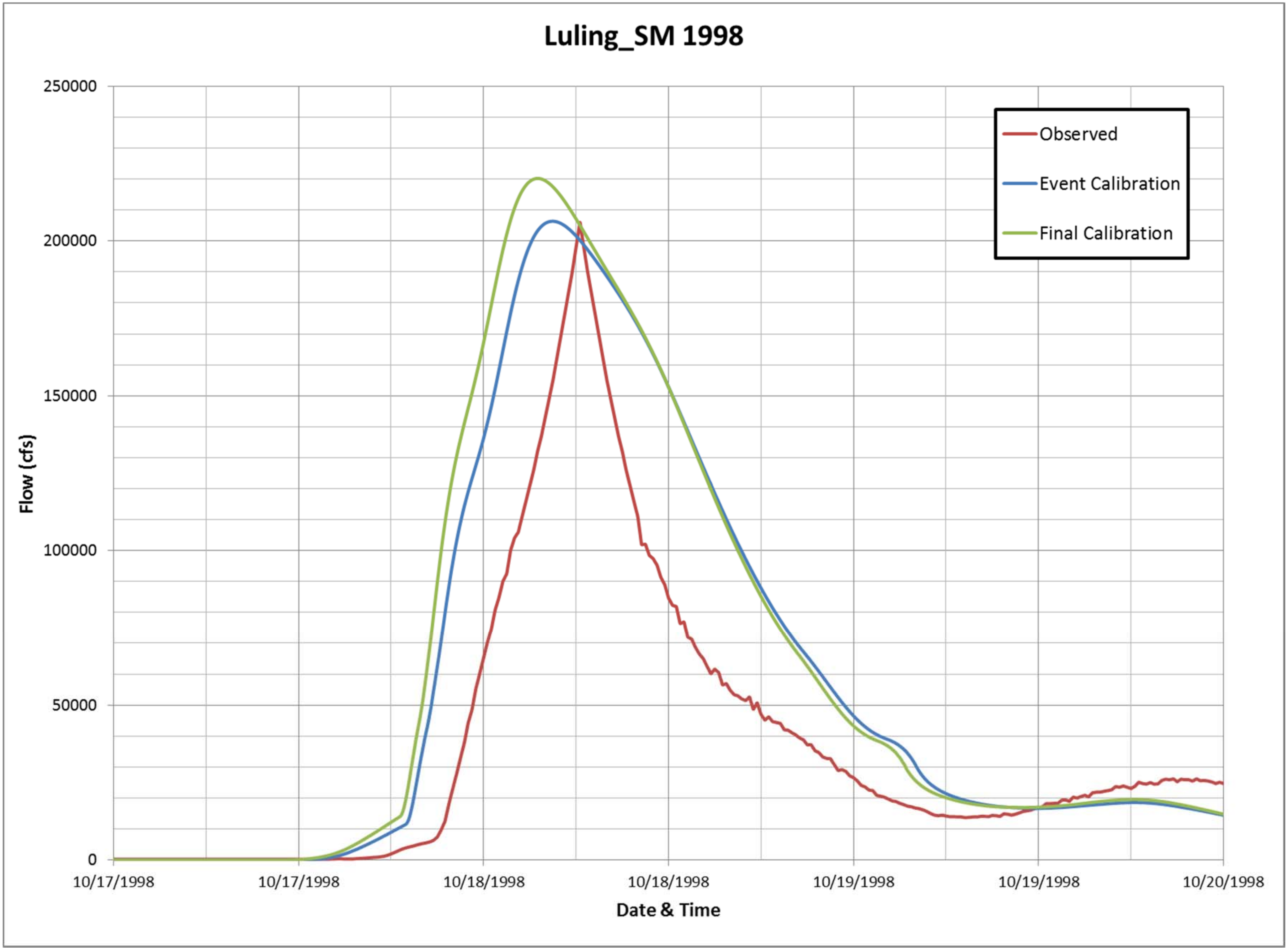
Calibration Summary							
Peaking Coefficient [Dimensionless]							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
GUAD_320	0.59	0.65	1.00	0.44	0.75	0.44	0.75
SMAR_010	0.59	0.65	1.10	0.47	0.80	0.80	1.36
SMAR_020	0.60	0.67	1.12	0.48	0.80	0.81	1.35
SMAR_030	0.61	0.66	1.08	0.49	0.80	0.82	1.34
SMAR_040	0.61	0.67	1.10	0.46	0.75	0.55	0.90
SMAR_050	0.60	0.60	1.00	0.45	0.75	0.60	1.00
SMAR_060	0.59	0.77	1.31	0.44	0.75	0.59	1.00
SMAR_070	0.59	0.65	1.10	0.44	0.75	0.53	0.90
SMAR_080	0.59	0.65	1.10	0.44	0.75	0.53	0.90
SMAR_090	0.59	0.65	1.10	0.47	0.80	0.80	1.36
SMAR_100	0.59	0.65	1.10	0.44	0.75	0.53	0.90
SMAR_110	0.58	0.64	1.10	0.44	0.75	0.52	0.90
SMAR_120	0.59	0.65	1.10	0.44	0.75	0.53	0.90

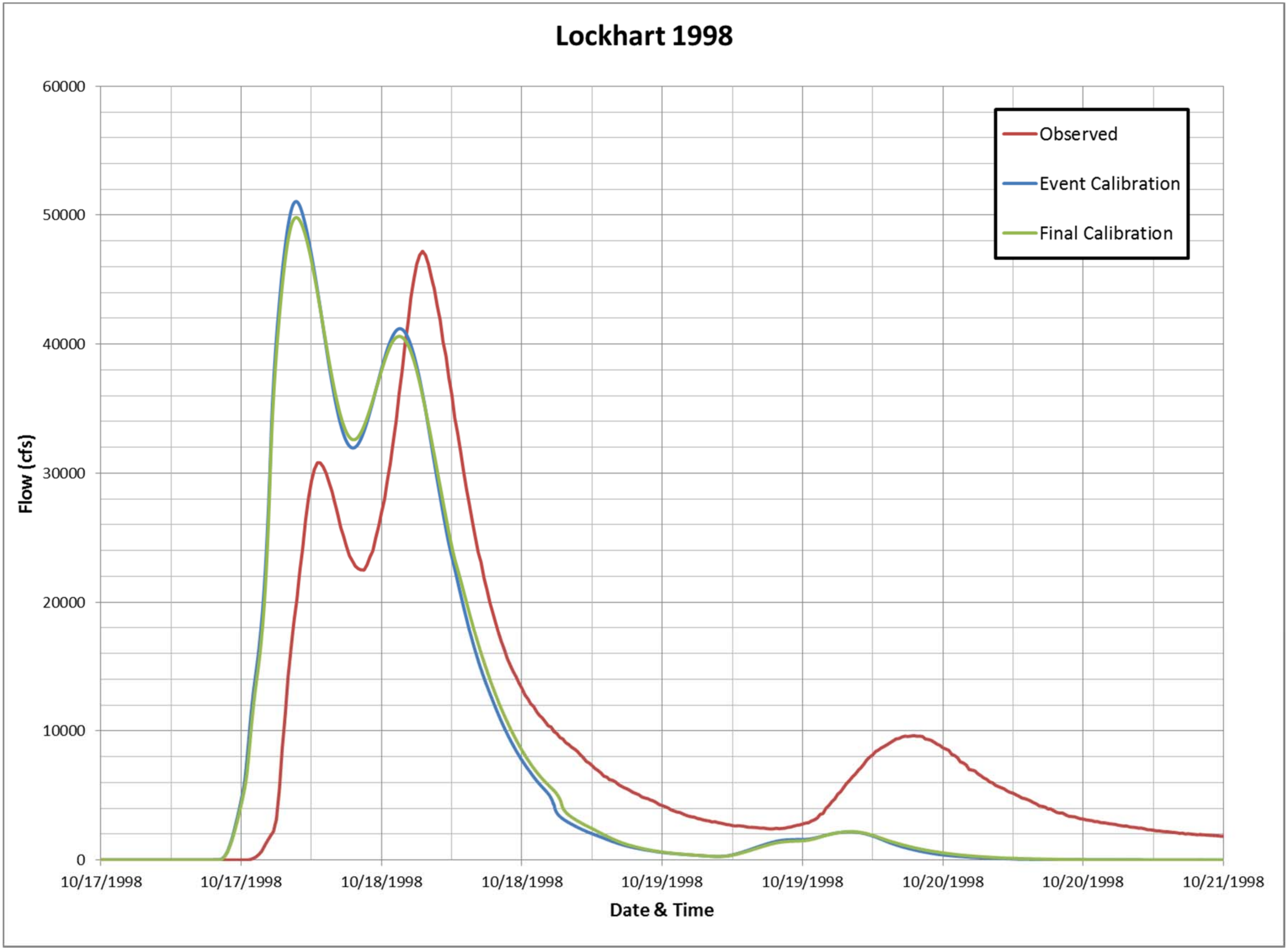
Calibration Summary							
Lag Time							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
BLNC_010	9.18	10.58	1.15	10.58	1.15	10.58	1.15
BLNC_020	5.10	6.38	1.25	6.38	1.25	6.38	1.25
BLNC_030	5.31	6.9	1.30	6.9	1.30	6.9	1.30
BLNC_040	3.74	4.86	1.30	4.86	1.30	4.86	1.30
BLNC_050	4.56	4.56	1.00	4.56	1.00	4.56	1.00
BLNC_060	4.70	4.7	1.00	4.7	1.00	4.7	1.00
GUAD_010	6.13	6.13	1.00	6.13	1.00	6.13	1.00
GUAD_020	7.36	7.36	1.00	7.36	1.00	7.36	1.00
GUAD_030	6.55	6.55	1.00	6.55	1.00	6.55	1.00
GUAD_040	6.77	6.77	1.00	6.77	1.00	6.77	1.00
GUAD_050	5.74	5.74	1.00	5.74	1.00	5.74	1.00
GUAD_060	8.24	8.24	1.00	8.24	1.00	8.24	1.00
GUAD_070	10.75	10.75	1.00	10.75	1.00	10.75	1.00
GUAD_080	8.69	8.69	1.00	8.69	1.00	8.69	1.00
GUAD_090	11.40	11.4	1.00	11.4	1.00	11.4	1.00
GUAD_100	12.03	12.03	1.00	12.03	1.00	12.03	1.00
GUAD_110	11.19	11.19	1.00	11.19	1.00	11.19	1.00
GUAD_120	8.57	8.57	1.00	8.57	1.00	8.57	1.00
GUAD_130	7.61	7.61	1.00	7.61	1.00	7.61	1.00
GUAD_140	8.83	8.83	1.00	8.83	1.00	8.83	1.00
GUAD_150	7.94	7.94	1.00	7.94	1.00	7.94	1.00
GUAD_160	10.75	10.75	1.00	10.75	1.00	10.75	1.00
GUAD_170	7.71	7.71	1.00	7.71	1.00	7.71	1.00
GUAD_180	9.64	9.64	1.00	9.64	1.00	9.64	1.00
GUAD_190	6.13	6.13	1.00	6.13	1.00	6.13	1.00
GUAD_200	10.56	10.56	1.00	10.56	1.00	10.56	1.00
GUAD_210	14.57	14.57	1.00	14.57	1.00	14.57	1.00
GUAD_220	12.34	12.34	1.00	12.34	1.00	12.34	1.00
GUAD_230	7.48	7.48	1.00	7.48	1.00	7.48	1.00
GUAD_240	9.86	9.86	1.00	9.86	1.00	9.86	1.00
GUAD_250	10.32	10.32	1.00	10.32	1.00	10.32	1.00
GUAD_260	7.24	7.24	1.00	7.24	1.00	7.24	1.00
GUAD_270	8.58	8.58	1.00	8.58	1.00	8.58	1.00
GUAD_280	11.85	11.85	1.00	11.85	1.00	11.85	1.00
GUAD_290	7.94	7.94	1.00	7.94	1.00	7.94	1.00
GUAD_300	7.16	7.16	1.00	7.16	1.00	7.16	1.00
GUAD_310	5.80	5.8	1.00	5.8	1.00	5.8	1.00

Calibration Summary							
Lag Time							
Basin	Original	1998 Event	1998 Multiplier	2002 Event	2002 Multiplier	2004 Event	2004 multiplier
GUAD_320	8.86	8.86	1.00	8.86	1.00	8.86	1.00
SMAR_010	5.28	5.28	1.00	5.28	1.00	5.28	1.00
SMAR_020	6.68	6.68	1.00	6.68	1.00	6.68	1.00
SMAR_030	8.64	8.64	1.00	8.64	1.00	8.64	1.00
SMAR_040	6.80	6.8	1.00	6.8	1.00	6.8	1.00
SMAR_050	4.82	5.3	1.10	5.3	1.10	5.3	1.10
SMAR_060	4.00	5.2	1.30	5.2	1.30	5.2	1.30
SMAR_070	5.14	5.14	1.00	5.14	1.00	5.14	1.00
SMAR_080	12.07	12.07	1.00	12.07	1.00	12.07	1.00
SMAR_090	10.48	10.48	1.00	10.48	1.00	10.48	1.00
SMAR_100	5.11	5.11	1.00	5.11	1.00	5.11	1.00
SMAR_110	5.68	5.68	1.00	5.68	1.00	5.68	1.00
SMAR_120	11.28	11.28	1.00	11.28	1.00	11.28	1.00

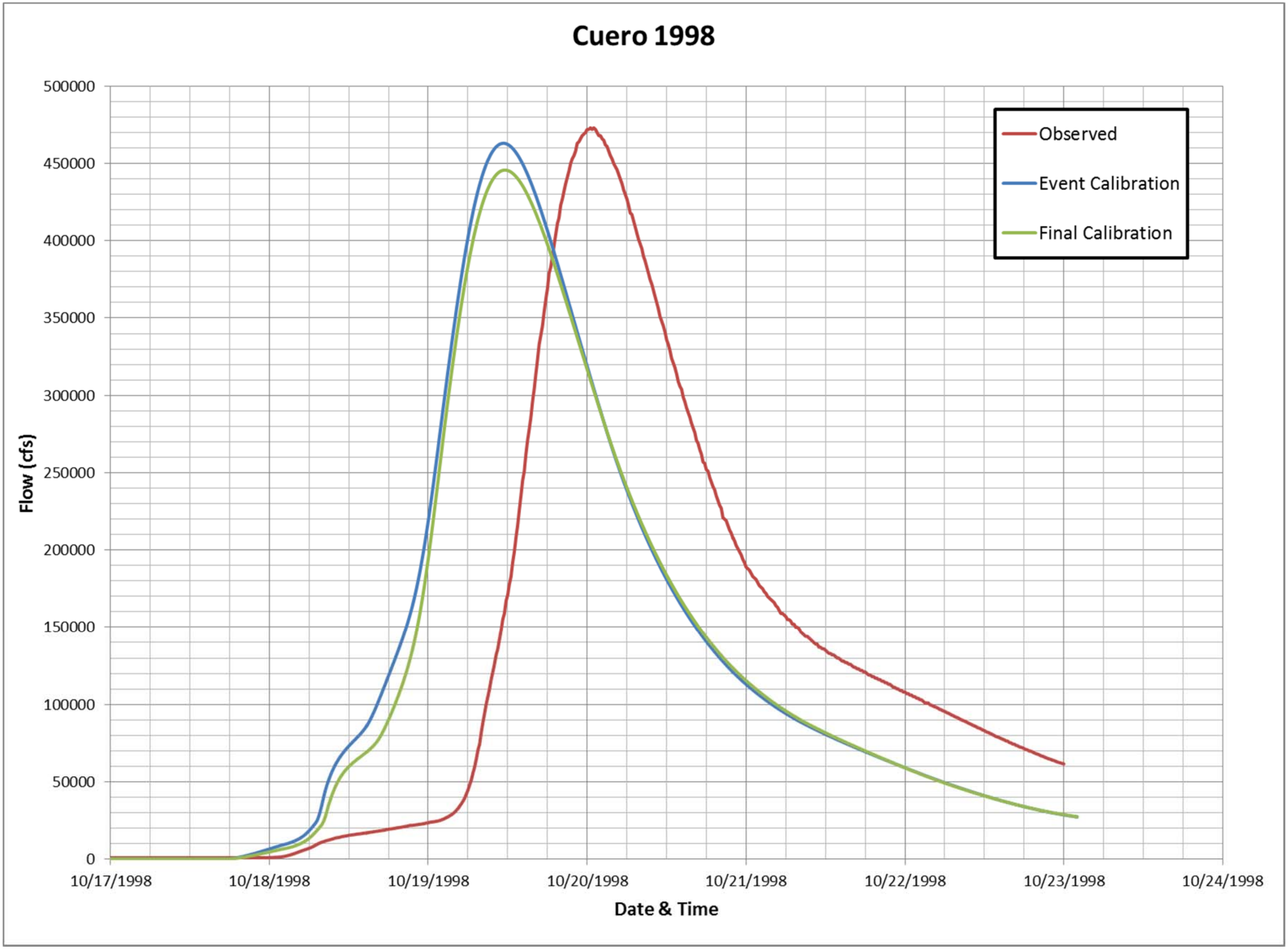

Above Comal 1998
Flow (cfs)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
10/17/1998
10/17/1998
10/18/1998
10/18/1998
10/19/1998
10/19/1998
10/20/1998
Date & Time
Observed
Event Calibration
Final Calibration

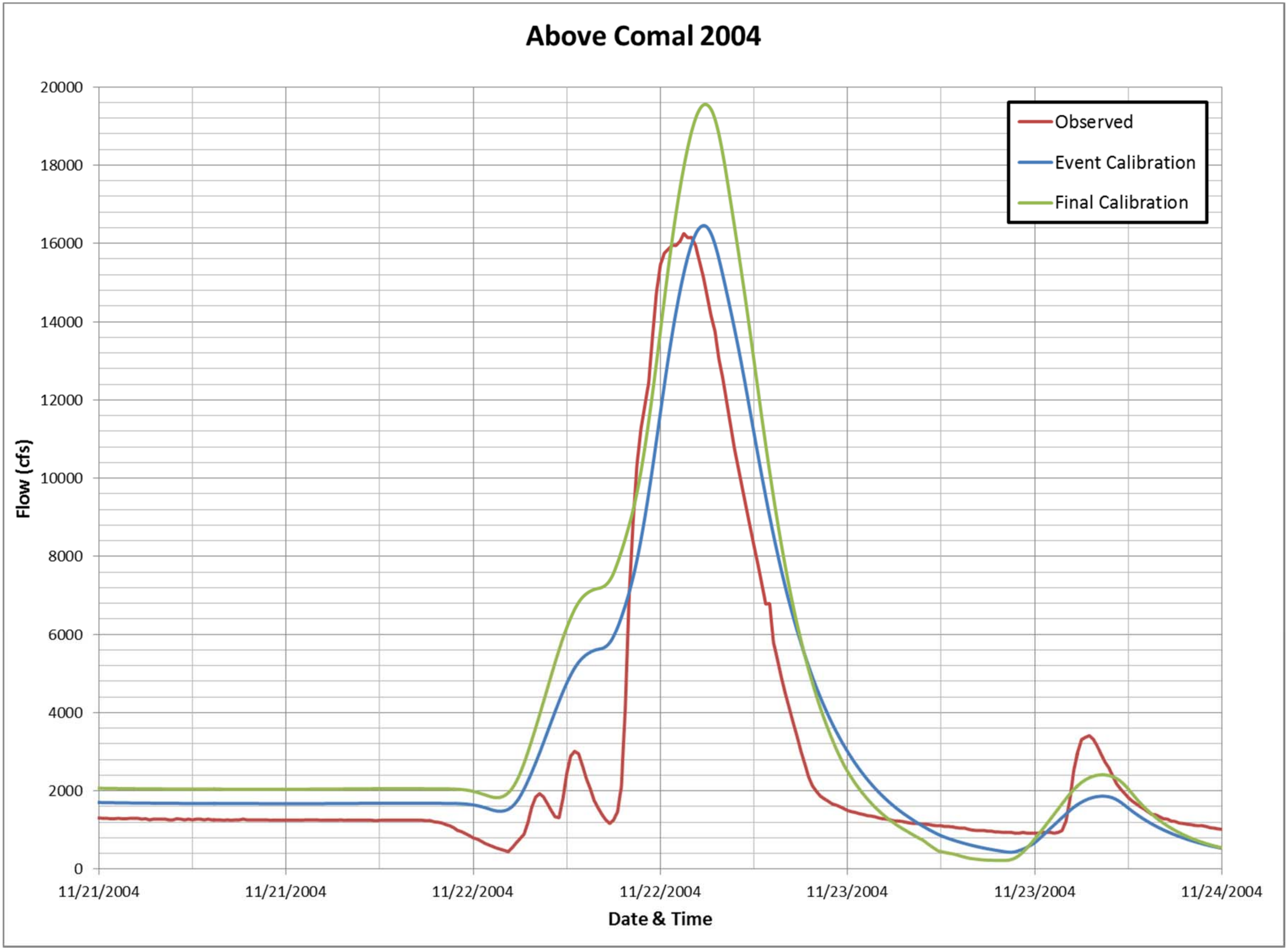

Wimberley 1998
Observed
Event Calibration
Final Calibration
Flow (cfs)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
10/17/1998
10/17/1998
10/17/1998
10/17/1998
10/18/1998
10/18/1998
10/18/1998
10/18/1998
10/19/1998
Date & Time

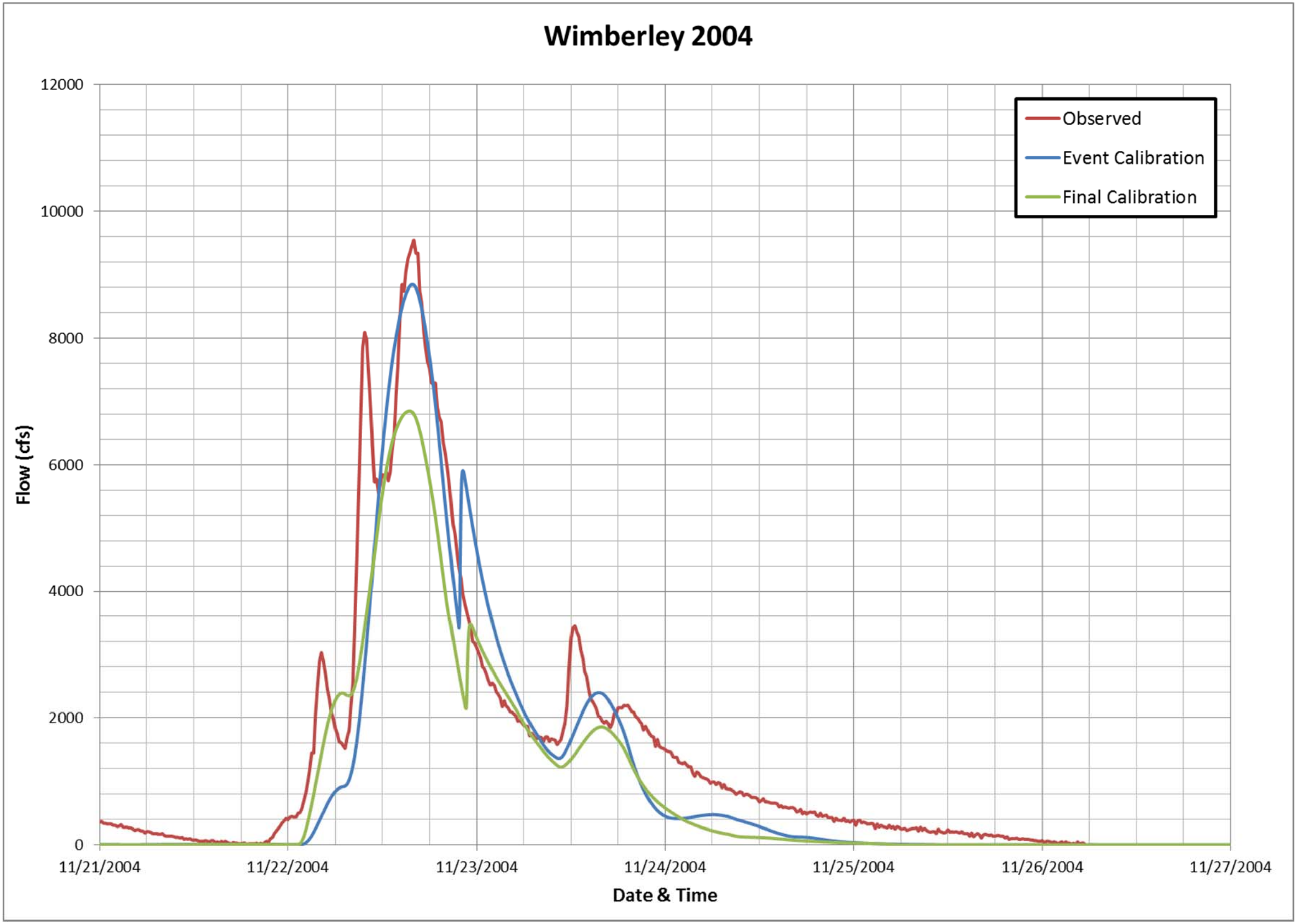

Luling_SM 1998
250000
200000
150000
100000
50000
0
Flow (cfs)
10/17/1998
10/17/1998
10/18/1998
10/18/1998
10/19/1998
10/19/1998
10/20/1998
Date & Time
Observed
Event Calibration
Final Calibration

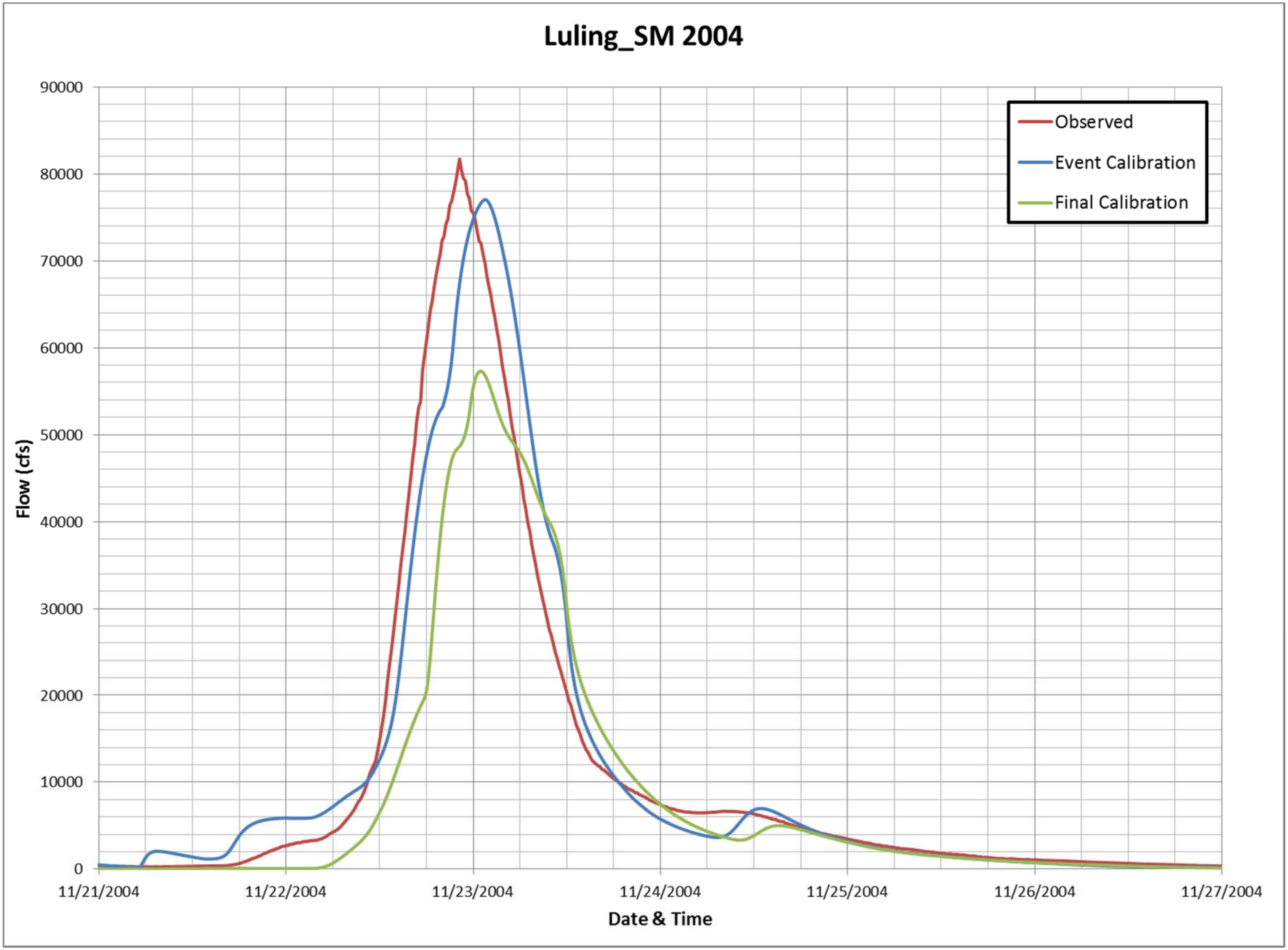


Lockhart 1998
Observed
Event Calibration
Final Calibration
60000
50000
40000
30000
20000
10000
0
Flow (cfs)
10/17/1998
10/17/1998
10/18/1998
10/18/1998
10/19/1998
10/19/1998
10/20/1998
10/20/1998
10/21/1998
Date & Time


Cuero 1998
Flow (cfs)
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
10/17/1998
10/18/1998
10/19/1998
10/20/1998
10/21/1998
10/22/1998
10/23/1998
10/24/1998
Date & Time
Observed
Event Calibration
Final Calibration


Above Comal 2004
Observed
Event Calibration
Final Calibration
Flow (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
11/21/2004
11/21/2004
11/22/2004
11/22/2004
11/23/2004
11/23/2004
11/24/2004
Date & Time


Wimberley 2004
Flow (cfs)
0
2000
4000
6000
8000
10000
12000
11/21/2004
11/22/2004
11/23/2004
11/24/2004
11/25/2004
11/26/2004
11/27/2004
Date & Time
Observed
Event Calibration
Final Calibration


Luling_SM 2004
Observed
Event Calibration
Final Calibration
Flow (cfs)
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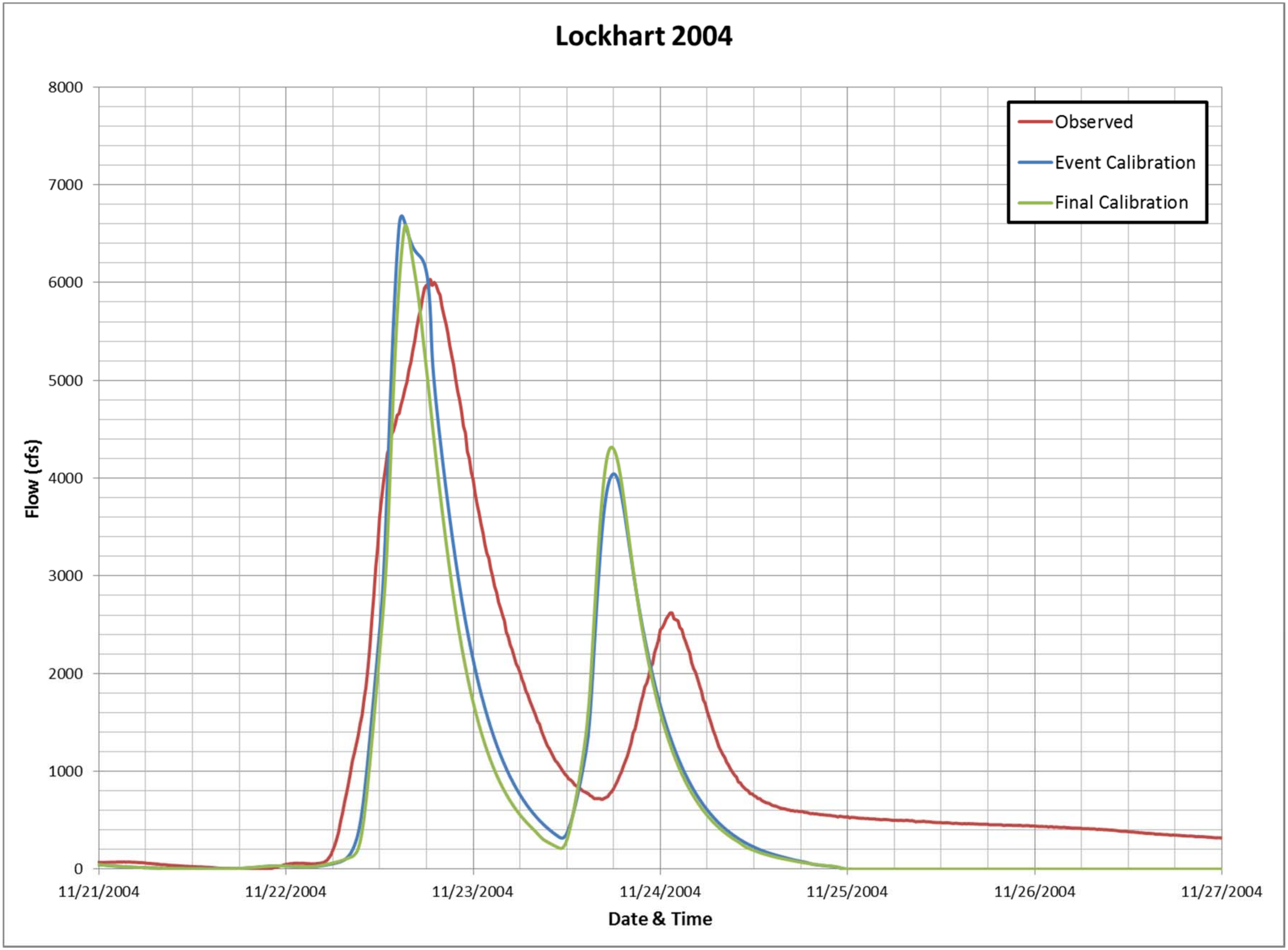
80000
70000
60000
50000
40000
30000
20000
10000
0
11/21/2004
11/22/2004
11/23/2004
11/24/2004
11/25/2004
11/26/2004
11/27/2004
Date & Time



Lockhart 2004
Observed
Event Calibration
Final Calibration
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
11/21/2004
11/22/2004
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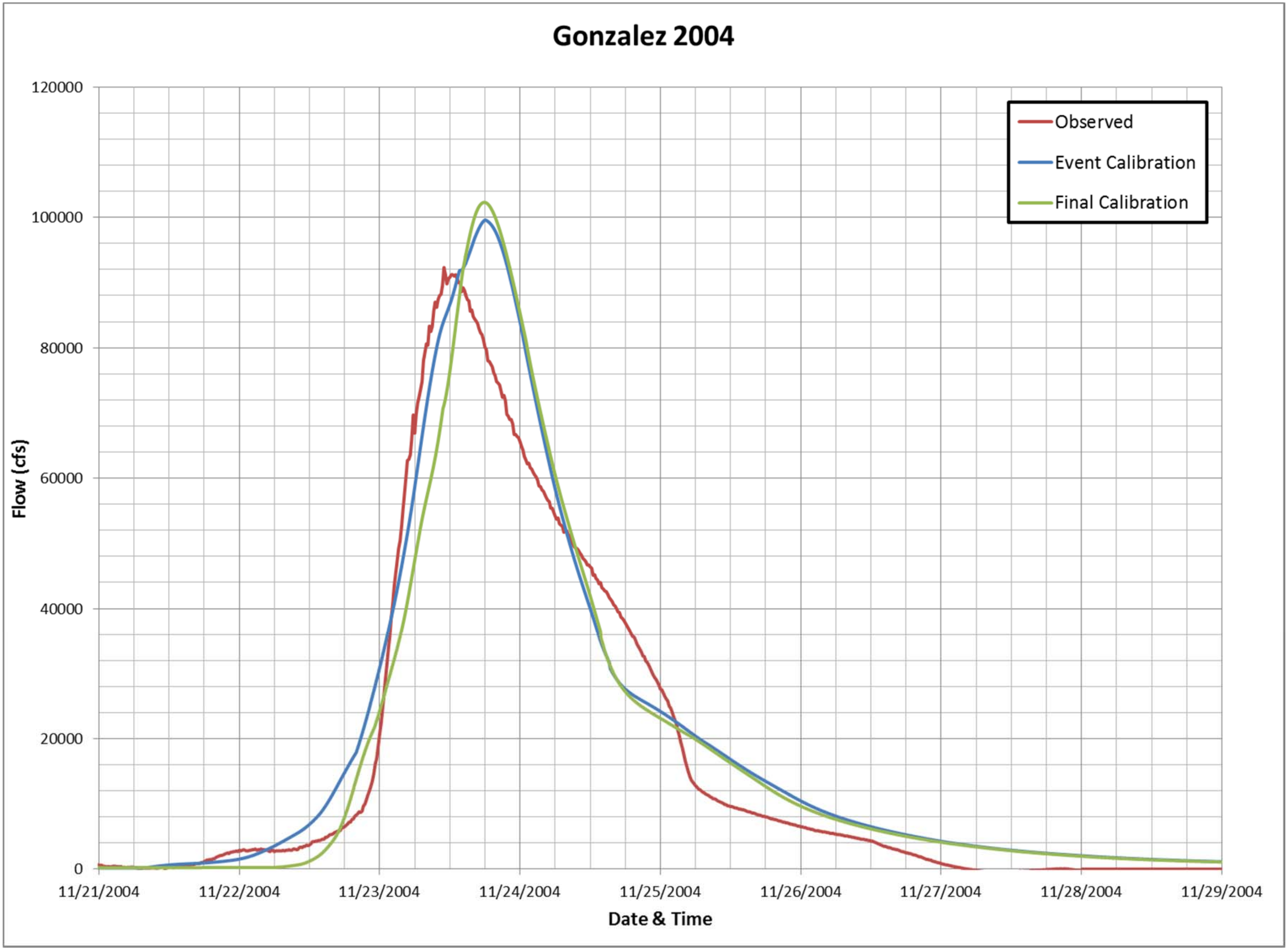
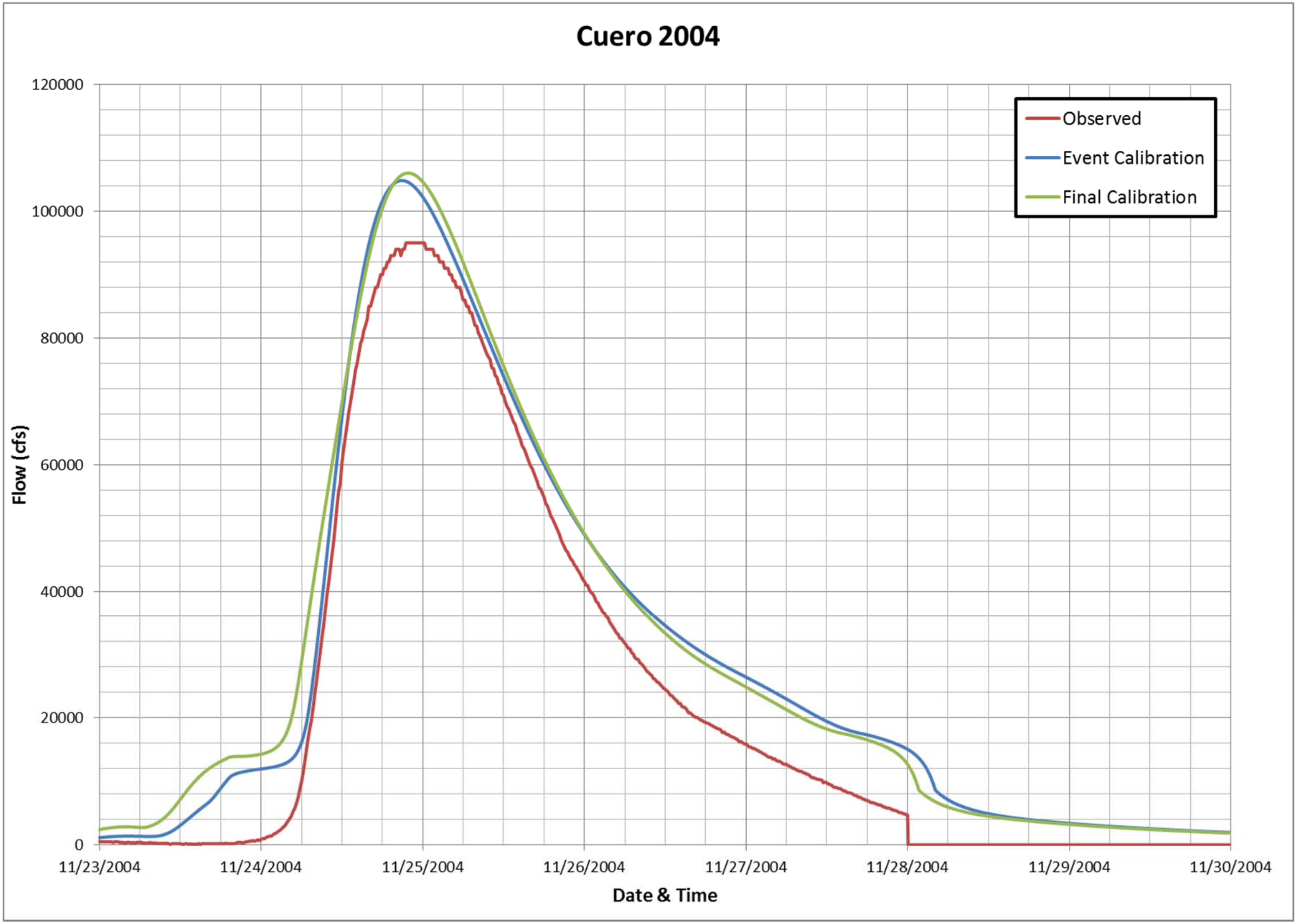
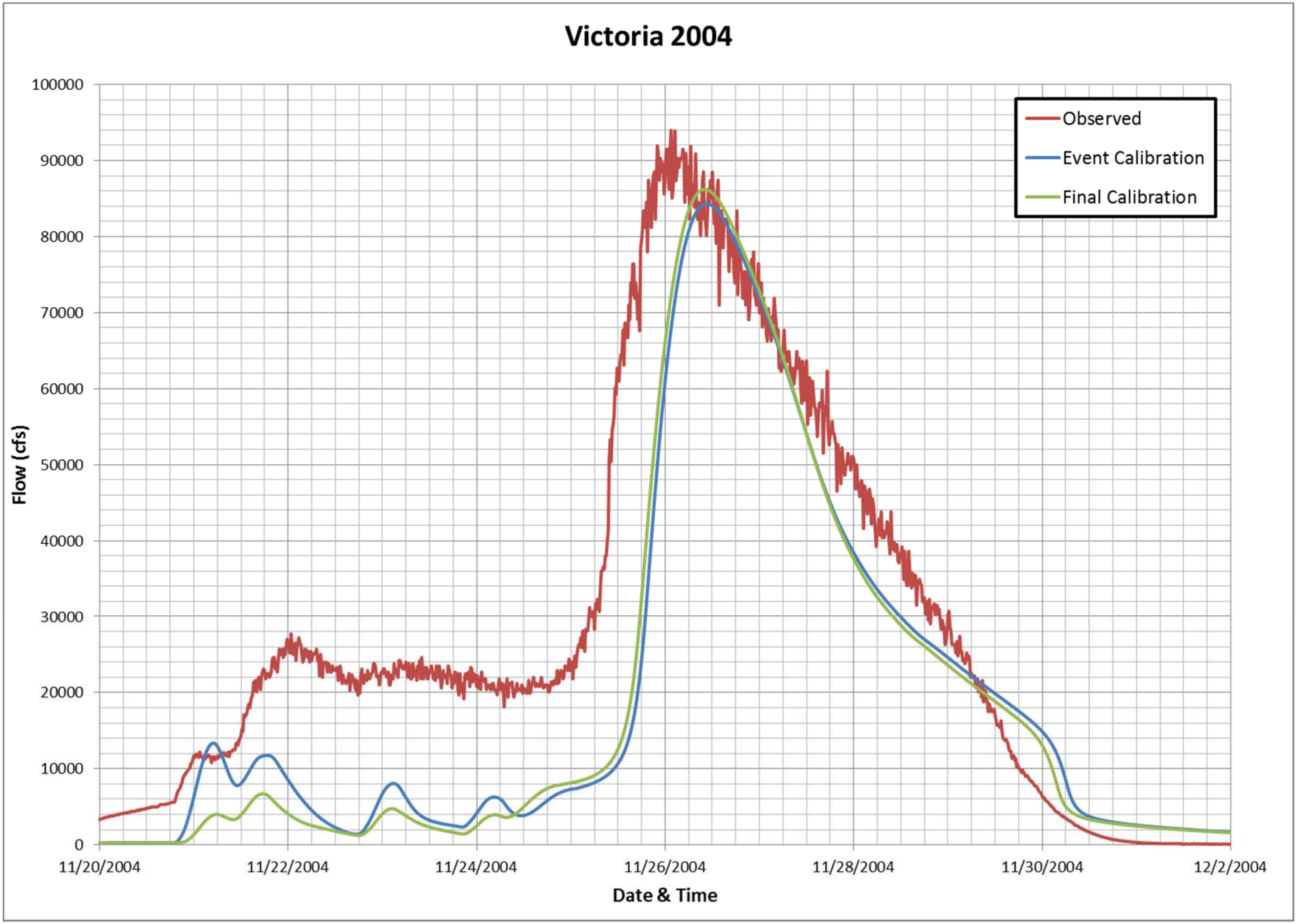
11/26/2004
11/27/2004
Date & Time



Gonzalez 2004
Observed
Event Calibration
Final Calibration
120000
100000
80000
60000
40000
20000
0
Flow (cfs)
11/21/2004
11/22/2004
11/23/2004
11/24/2004
11/25/2004
11/26/2004
11/27/2004
11/28/2004
11/29/2004
Date & Time



Cuero 2004
120000
100000
80000
60000
40000
20000
0
Flow (cfs)
11/23/2004
11/24/2004
11/25/2004
11/26/2004
11/27/2004
11/28/2004
11/29/2004
11/30/2004
Date & Time
Observed
Event Calibration
Final Calibration


Victoria 2004
Observed
Event Calibration
Final Calibration
Flow (cfs)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
11/20/2004
11/22/2004
11/24/2004
11/26/2004
11/28/2004
11/30/2004
12/2/2004
Date & Time

Appendix B.1.4

Quality Assurance

Appendix B.1.4.a
Internal QA/QC Review

Hydrology QA/QC Checklist

Watershed Name: Lower GBRA

Modeler's Name: Steven Couche/Adam Breznicky

Model Name: GBRA

Reviewer's Name: Joe Barrow/Angela Wright

WATERSHED DELINEATION:

Reviewer's Initials: JTB Date: 11/6/2012

Modeler's Initials: SKC/AMB Date: 11/5/2012

DATA FILES RECEIVED:

- ☒ ArcMap project file (watershed boundaries (name and area), study stream centerlines, topographic data, images, and etc.)
- ☒ Description of modeler's assumptions, notes, and special issues.

TECHNICAL REVIEW:

- ☒ DA breaks at headwater limits of detailed hydraulic study.
- ☒ DA breaks at pertinent locations such as confluences, detention facilities, major highways, gages, etc.
- ☒ DA breaks at location common to current effective if applicable and feasible.
- ☒ Compare DA to previous studies. Flood Forecast Model
- ☒ Is DA size reasonable for type of study?
- ☒ Do DA boundaries agree with available contours and images?

REVIEW COMMENTS:

1. DA's compare reasonably with Flood Forecast Model.

RESPONSE TO COMMENTS:

1. Subbasin delineation not modified.

ADDITIONAL REVIEW COMMENTS:

1.

II. "SKELETON" MODEL:

Reviewer's Initials: JTB Date: 11/6/2012

Modeler's Initials: SKC/AMB Date: 11/5/2012

DATA FILES RECEIVED:

- ☒ ArcMap project file with Land Use, Soils, Drainage Paths, etc. ____
- ☒ Description of modeler's assumptions, data sources. ____
- ☒ HMS model paths ____
- ☒ Loss Rate computations ____
- ☒ Time of Concentration / Lag Time computations ____

TECHNICAL REVIEW:

Total Drainage Area: 4526.322
Total No. of Subbasins: 50
Min DA sq. mi.: 17.691
Max DA sq. mi.: 174.610

Basin Models:

Unit Hydrograph Method: Snyder's

Computation Interval: 15?
Peaking Factor: 0.75
Min Tc / Lag: 0.35
Max Tc / Lag: 12.42

Loss Rate Method: Block&Uniform
Min CN: N/A
Max CN: N/A
Min Initial Loss: Varies with Frequency(100yr 0.76)
Max Initial Loss: Varies with Frequency (100 yr 0.87)
Min Uniform Loss: Varies with Frequency (100 yr 0.07)
Max Uniform Loss: Varies with Frequency (100 yr 0.11)
Rainfall Source: USGS Atlas of Depth Duration Frequency (SIR 2004-5041)
Rainfall Distribution: 24 hr 50% centered

REVIEW COMMENTS:

1. Suggest using 5 min time step (and include 5 min intensity) because of smaller basins.
2. Urbanization / Imperviousness values appear low for basins near cities (such as W630 & W5020). Please review base data.
3. Be consistent in naming components. All junctions should be J___, Stream routing R___. Don't use "User Point" label.
4. Use correct probability (all say 50%) in Meteorological component.
5. Fill in descriptions in components (basins, junctions, routing, etc.)
6. Provide complete description of models and spreadsheet tables. For example loss rate spreadsheet says City of Luling Runoff Loss Rates, is this correct?
7. Include only spreadsheets that were used in models.

RESPONSE TO COMMENTS:

1. 5 min time steps will be used for the control and meteorological events (5 min intensities added).
2. The land use file (GBRA_LandUSE.shp) was reviewed. It was then altered by hand editing near cities and neighborhoods to more accurately reflect the overall land uses. The urbanization and impervious parameters were then recalculated for each subbasin and utilized in the model. There was a minor increase in urbanization and imperviousness for some subbasins. However, it was minor because of the large subbasin areas.
3. Consistent names were given for all basins, junctions and reaches. The Blanco (BLNC), San Marcos (SMAR) and Guadalupe (GUAD) Rivers were assigned unique for letter designations to help locate/organize components.
4. The correct probabilities were assigned to the Meteorological components.
5. Descriptions were provided for each basin model.
6. The typo was corrected. Also, a "File Index" will accompany further transmissions to provide descriptions of the appropriate documents.
7. Only relevant spreadsheets will be included for future transmissions.

III. FLOOD ROUTING:

Reviewer's Initials: JTB Date: 11/6/2012

Modeler's Initials: SKC/AMB Date: 11/5/2012

Data files received:

☒ ArcMap project file with Land Use, Soils, Drainage Paths, etc. ____

☒ Description of modeler's assumptions, notes, and special issues. ____
☐ Data sources, hydraulic models, computations, record plans, etc. ____

Routing Method(s):
Channel/Floodplain Storage: Muskingum-Cunge
Detention Routing: Storage -Discharge

Review Comments:

1. Several Stream Routings show little or no change in peak flow or time.(R1600, R1550, R2700) and others show drastic change(R160, R220, R270). Please check routing characteristics. Are Mannings n values in routing characteristics consistent with HEC-RAS model?
2. Brief outline of modeling basis was provided. Bottom of page 1 mentions Barton Creek. Is this a typo? If so, please correct.
3. Reservoir routing for Lake Gonzalez and Lake Meadow indicates a 100 year flow over the top of the dam. Is this an issue?

Response to Comments:

1. The Manning's N-values were adjusted to align with the HEC-RAS models. The HMS models were re-run and the routing results showed accurate differences in peak flow and peak time for the reaches.
2. Typo corrected.
3. None of the featured dams have flood capacity control measures and are used primarily for generating hydroelectric power. Therefore, this overtopping is accurate.

IV. FINAL MODEL:

Reviewer's Initials: ALW Date: 5/6/2013

Modeler's Initials: SKC/AMB Date: 11/5/2012

Data files received:
☒ Calibration
☒ Frequency Analysis
☒ Table of Discharges
☒ Comparison of Discharges

Calibration Procedures/Results:

See Hydraulic Notebook and TRN

Frequency Analysis Procedures/Results:

Discharge differences greater than 10% of current FIS:

Review Comments:

1. Please reply to Joe's previous QAQC comments above.
2. I agree with Joe's orginal comment that percent impervious values seem low. The shapefile N:\28000s\28411\GIS\Shapefiles\GBRA_LandUSE.shp has a land use type called "Developed, High Intensity,80-100 impervious" and the calculated percent impervious was 70. These polygons are so small that I think you should use 100% instead of 70%. This applies to all developed land use types.
3. I only see the 100-year frequency event in the model. Is this correct or should there be a range of storms?
4. It might be helpful to do a quick discharge comparison to the USACE gages and FIS studies to see how the HMS models compares.
5. Prepare a drainage vs discharge divided by drainage area charge (cfs/sq mi) chart to double check the computed
6. Should there be a routing reach in basin BLNC_040?
7. Why is RSMAR_100 split into 2 reaches? Should there be a detention pond between the reaches?
8. A junction node may be needed at the junction of SMAR_090 and SMAR_100 to be consistent with the rest of the model.
9. What is the Colete XS cross section shapefile for at the bottom of the watershed in the HMS model? If it is not needed remove the shapefile from the HMS model.
10. Check the lag time calculations and assumptions for GUAD_190 and GUAD_210. The lag times don't seem to fit with the other data in the plots.
11. Please explain the Canyon Dam inflow selection of 100cfs.
12. Canyon Lake Storage-Discharge Functions has lot of storage areas with 0 cfs discharge. Remove all but the last storage area so that there is only one with 0 cfs discharge,
13. Lake Gonzales Storage –Discharge Function remove the 0,0 point. This is causing some oscillation in the unit hydrograph in the lower flows.
14. Remove 0,0 points for all lake storage-discharge tables.
15. Half of the Elevation Storage Table start at 0 and the others do not. I would remove the 0 point from the table. I think all of the flows should be high enough in the tables that HEC-HMS doesn't need to extrapolate. This may not work if you plan to run low flows through this model.
16. Manning n values are very low for some Muskingum cunge channels. I would not expect to see anything below 0.065.
17. Remove cross sections tables that are not being used to eliminate confusion later.
18. Muskingum Routing reaches RGUAD_140, RGUAD_130, RGUAD_150, RGUAD_100, seem to be storing a lot of flow compared to other reaches that were modeled with HEC-RAS.

Response to Comments:

1. Comments replied to.
2. It does appear that due to the nature of the shapefile, it would be beneficial to raise the % Impervious for the developed land use types. For high density, it will be changed from 70% to 100%, for medium density 47% to 70%, and for low density 25% to 47%. The % Impervious parameter for the basins will be recalculated and updated in HMS. On the high end, a 1% - 2% difference was seen and on the low end, the change was negligible.
3. We have models for the other frequencies but will be calibrating with the parameters for a 1% ACE event. Changes described for the 1% model will be carried through all necessary models.
4. We will calibrate the models after this phase of QAQC is complete.
5. A chart was prepared between the computed HMS discharges, FIS flows and Historical Gage Analyses. The results show we are reasonable and will be further evaluated post-calibration.
6. RBLNC_040 was originally used in the model, but it was removed due to the reach being a short distance.
7. The Plum Creek RAS model does not span the length of the basin, so the reach was split so both Muskingum Cunge (RSMAR_100A) and Modified Puls (RSMAR_100B) could be utilized.
8. Agreed. JSMAR_090_100B added.
9. It was used to determine where the Coleto routing should be implemented but is no longer needed. Shapefile removed from the model.
10. The two main factors driving the lag time for GUAD_210 are length and slope, both of which were verified. The longest flowpath hits a major trib (lower elevation) quickly, therefore taking the elevation difference out of the Sst parameter. For GUAD_190, when compared to other small area basins, it has a unique combination of high percent sand (62%) and low slope.
11. The 100 cfs was an arbitrary number for pre-calibration QAQC. During calibration, Canyon Dam discharge data will be incorporated for each event.
12. All 0 discharge points removed except for one.
13. Point removed.
14. The models need the (0,0) points within the S-D tables because of the E-S tables. HMS was having trouble finding initial storages for the lakes without these data points.
15. As noted above, HMS needed these low points to calculate the initial storages for the lakes. I also do not believe it negatively affects any calculations due to the model linearly interpolated to (0,0) when it does not have sufficient chart coverage.
16. Agreed. The MC sections used for the calibration models were reviewed and changed as necessary. In general, the channel n-value's were raised to app. 0.065 – 0.085.
17. Additional Muskingum Cunge data not being used was removed from model.

18. Agreed. This issue was looked into and it was found the Muskingum Cunge centerlines being used were showing a far greater length than was actually occurring for the floodwave at high at flows. After discussion, the MC centerlines were modified to show a straighter flow path over the reach. In addition to decreasing length, it also increased slope, leading to less attenuation. This process was detailed in the Hydrology Notebook.

Internal QAQC Comments: Basin-wide calibration and Draft TRN

1. % Impervious values in Table 4 still do not make sense. If you are going to list the percent impervious in the description then I still think that you should use a conservative value on the higher end of the description. At the very least you have to be within the range shown in the description. The last QAQC says that these were adjusted but this table doesn't seem like anything changed.

Table 4. Percent Impervious Values Based on Land Use

Land Use	Assumed Percent Impervious (%)
Barren Land (Rock/Sand/Clay)	0
Woody Wetlands	0
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Emergent Herbaceous Wetlands	0
Pasture/Hay	0
Shrub/Scrub	0
Grassland/Herbaceous	0
Cultivated Crops	3
Developed, Open Space, Impervious < 20%	6
Developed, Low Intensity, Impervious 20-49%	25
Developed, Medium Intensity, Impervious 50-79%	47
Developed, High Intensity, Impervious 80-100%	70
Open Water	100

The changes were not shown in the above table. As described in the previous QAQC document, the low intensity was changed to 47%, medium intensity to 70% and high intensity to 100%. The table in the TRN will be updated.

2. Peaking Coefficient (Cp) –Can you send me the source you used that says 0.75 is based on DFW land use? I copied the NCTCOG iSWM info on CP below but it did not reference the value to DFW specifically.

The coefficient C_t is a regional coefficient for variations in slopes within the watershed. Typical values of C_t range from 0.4 to 2.3 and average about 1.1. The value of C_t for the East Fork Trinity River is 2.0. C_t for a watershed can be estimated if the lag time, t_p, stream length, L, and distance to the basin centroid, L_{ca}, are known. The coefficient C_p is the peaking coefficient, which typically ranges from 0.3 to 1.2 with an average value of 0.8, and is related to the flood wave and storage conditions of the watershed. The C_p value for the East Fork Trinity River is 0.69. Larger values of C_p are generally associated with smaller values of C_t. Typical values of C_p are listed in Table 1.14.

Table 1.14 Typical Values of C_p

Typical Drainage Area Characteristics	Value of C_p
Undeveloped Areas w/ Storm Drains	
Flat Basin Slope (less than 0.50%)	0.55
Moderate Basin Slope (0.50% to 0.80%)	0.58
Steep Basin Slope (greater than 0.80%)	0.61
Moderately Developed Area	
Flat Basin Slope (less than 0.50%)	0.63
Moderate Basin Slope (0.50% to 0.80%)	0.66
Steep Basin Slope (greater than 0.80%)	0.69
Highly Developed/Commercial Area	
Flat Basin Slope (less than 0.50%)	0.70
Moderate Basin Slope (0.50% to 0.80%)	0.73
Steep Basin Slope (greater than 0.80%)	0.77

0.75 is a calibrated value from the Onion Creek Study. The initial, pre-calibration peaking coefficient calculations were calculated according to iSWM. The necessary tables and descriptions will be added to the modeling notebook.

3. Areal Reduction – HMS is giving a warning that the areal reduction may not be valid beyond 400 sq. miles. Table 15 in TP-40 stops at 400 sq. mi also. Is it valid to use this method beyond 400 sq. miles for the frequency events? The line levels off so maybe it is as reduced as it gets at 400 sq. mi?
   a. Does this sentence from your report refer to areal reduction? "The 1% ACE model run did not involve storm centering, but merely used the balance frequency storm method applied to each sub-basin."

A storm area was in advertently set in the meteorology models. The storm area was reset to zero and an areal reduction analysis run to determine areally reduced 100-yr flows.

a) No, the storm centering is a completely different topic.

4. I think that you need to have a table that shows the % difference between the current USGS regression equations and the effective FEMA discharges. This is part of Task 6 listed in the Task

Summary. We also put this comparison in all hydrology reports in FW and it is a good tool to know if your model is within the ballpark of past studies.

a. Your report says “Overall, the Guadalupe results are in the range of the gage and FIS results”. I am not really sure what that means. A percent difference would give the exact range.

A table was created to compare the GBRA final calibrated model with a 1% ACE event, current effective FIS flows and the USACE gage analysis data. It will be included within the modeling notebook and TRN.

a) The wording will be updated to be more descriptive of the comparison

5. When you submit the model you may need to remove paths names from the run files. I had to repath the results files for all the runs.

This will be corrected for the COE submittal

6. Double check nodes in all frequencies. I think some are named differently or are missing. I just copied the Global summary for the 500yr, 250yr, 100yr, and 50yr and they don’t match. The difference is somewhere around JSMAR_100 or JSMAR_100B

Discrepancies between the models were found and changed as necessary.

7. Edwards Aquifer recharge zone – I am not sure that you can use this to make your calibration better. Onion Creek sits in the recharge zone and so does Barton Creek. We did not account for aquifer recharge for either basin. Maybe if you explain it to me some more or show me a map of what basins you are using it on and how you applied the zones. The recharge zone does not seem cover the entire basin but the report sounds like you used the recharge zone over the entire watershed.

The Edwards Aquifer Recharge Zone only covers the basins in Comal and Hays Counties. Channel losses to represent recharge were only applied to reaches affected by the recharge zone.

8. I see adjustments to initial loss. Did you also try to adjust the constant rate? Both parameters vary by frequency. I think the frequency of the storm events varied as the storms moved through the basin.

a. You may also want to rename initial abstraction in your tables in the report to initial loss to match HMS.

The constant rate was only adjusted for the sub-basins in the Blanco watershed. “Abstraction” was changed to “loss” within the tables and the modeling notebook.

9. I don’t agree with your sentence in the report that says “Snyder’s lag times were not adjusted as they are calculated from sub-basin physical characteristics.” I think the lag time could be used for calibration to adjust the location of the peaks. I would remove this sentence from your report.

The decision to not adjust lag times was because of the lack of impact they had on the peak flows/volumes. The models were responding better to the initial loss and peaking coefficient adjustments, so they became the primary calibration parameters. The TRN was updated to reflect this explanation

10. Before you changed from the modified puls routing did you adjust the reach length to represent the flood wave and not the windy channel like you did for Muskingum Cunge? Did you also try adjusting the routing steps with the new length or just doing an overall adjustment for each watershed group?

Because the routing models were used within HMS as .dss files and not manual inputs, the length of the model was unable to be changed. However, a quick sensitivity analysis was conducted on the number of subreaches. It was found that multiplying the original calculated subreaches by 0.4 and re-running the model resulted in a minimal change in attenuation for the modified-puls reaches.

11. I think you need a summary table of all the frequency storm event results in the appendix. Not just the 100-year discharges.

Frequency models other than the 1% ACE will not be included with the submittal because the HMS model is not being used to produce frequency flows for the study. A single, calibrated model will be provided. It will be run with the 1% ACE event solely for comparison purposes.

12. Add time to peak to table 11 for the observed and computed data.

Time of peak was added to the requested tables. The final results were removed for the 2002 event since the calibration was abandoned.

13. Not sure that I understand the calculation of parameters for the final calibrated model. The report says "Weighted averages of parameter adjustments were calculated giving the 1998 event twice the weight of the 2002 event since it represents average antecedent runoff conditions within the basin." I think you just need to simplify the sentence or remove it.

Wording in report was updated to more clearly describe calibration adjustments and determineation of final parameters.

14. Hydrograph charts – What is the difference between Event Calibration and Final Calibration?

Event calibrations were performed separately for the 1998, 2002 and 2004 events. The final calibration is the term given to the final set of basin parameters, which were calculated using the calibrated event parameters. This will be more clearly noted in the modeling notebook and TRN.

15. Table 10 – What does multiplier mean? Is it the Original number multiplied by the multiplier to get the final result?

Yes. The multiplier times the original calculated parameter will result in the calibrated parameter. This will be further clarified in the TRN.

16. Table 11 – Why does the 2002 table only have 2 comparisons in the TRN? The gage data shows a lot more available gage data. You also have a typo on Page 12 in the last paragraph. You say that you weighted the parameters for the 1998 and 2002 events but the paragraph above that says that the 2002 calibration did not work.

There were large discrepancies between the 2002 event and our model results. Calibration for all the gages was attempted, but the results were unreasonable except for the Lockhart and Luling_PL gages. I agree that the 2002 final calibration should be removed from the main report, but we will leave information in the appendix to show the results of our calibration attempt. The typo will be corrected.

17. I noticed that the Onion Creek model validation on the same storms used a different initial loss for the 2002 storm to get the peaks closer into the ballpark for the other parameters. This was just used to validate the previous calibration and not for a new calibration.

We adjusted the losses for the 2002 event to the reasonable limits without being able to match volume at the gages. The 2002 event also had major timing issues when compared to the observed hydrographs

Appendix B.1.4.b
USACE
QA/QC Review

Comment Report: All Comments
Project: Lower Guadalupe-Feas with GBRA_326395
Review: Hydrology Review - GBRA Luling Woodcreek
Displaying 28 comments for the criteria specified in this report.

Id	Discipline	DocType	Spec	Sheet	Detail
5105920	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

On 21 March 2013, it was noted that numerous "Lca" measurements were obviously in error specifically on the Guadalupe Basin HEC-HMS modeling inputs. The Contractor (Halff) was notified by phone and they provided a corrected version on the afternoon of 22 March 2013.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
No further comment

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

Id	Discipline	DocType	Spec	Sheet	Detail
5105921	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Woodcreek Hydrology Notebook.docx Word file, entry # 7, Loss Rates, page 4, first sentence, Barton Creek should be changed to City of Woodcreek.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Woodcreek hydrology notebook updated.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105925	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Wood_Snyders_Lag_Loss_EX_20809.xls, under losses tab, title says Barton Creek Runoff Loss Rates – Existing Conditions. Title should be changed to City of Woodcreek Runoff Loss Rates – Existing Conditions.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

Title updated in spreadsheet

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105927	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Wood_Snyders_Lag_Loss_EX_20809.xls, data for Barton Creek is under tab Sheet1 and Sheet2.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

Sheet1 and Sheet2 tabs were removed from spreadsheet

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105930	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Wood_Snyders_Lag_Loss_EX_20809.xls, under plots tab, in the Longest Flowpath vs. Lag Time plot, there is a point plotted at 1.81, 0.16 . This corresponds to average L of 1.81 and minimum Tp of 0.16. Was this point intended to be on plot?

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
The point was not intended to be on the plot and was removed.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good1

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105933	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Wood_Snyders_Lag_Loss_EX_20809.xls, under plots tab, Slope vs. Lag Time plot is labeled Longest Flowpath vs. Lag Time. Please re-label plot.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Plot relabeled correctly as Slope vs. Lag Time.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105941	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Wood_Snyders_Lag_Loss_EX_20809.xls, under plots tab, in the Slope vs. Lag Time plot, there is a point plotted at 379.23, 0.16. This point corresponds to average slope, of 379.23 and minimum Tp of 0.16. Was this point intended to be on plot?

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
The point was not intended to be on the plot and was removed

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105942 Hydrology Feasibility Study n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Woodcreek_Muskingum_Cunge_Routing.xls, the channel length and slope data is missing. Under Table tab, reach characteristics are for the Guadalupe River HEC-HMS model. Provide reach characteristics for Woodcreek.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
The Woodcreek_Muskingum_Cunge_Routing.xls spreadsheet was updated with the correct information.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105943 Hydrology Feasibility Study n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

In the Woodcreek HEC-HMS model, provide subbasin, junction and routing descriptions.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Descriptions for junctions, basins and reaches added

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105944 Hydrology Feasibility Study n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

In the Woodcreek HEC-HMS model, for Muskingum-Cunge routing method, the Manning's n for channel, left bank and right bank does not match the values in the Excel spreadsheet Woodcreek_Muskingum_Cunge_Routing.xls. Is the Manning's n for channel, left bank and right bank in the HEC-HMS model correct and the Excel spreadsheet needs to be updated?

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

The model is correct and the spreadsheet has been updated.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105945	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Woodcreek HEC-HMS model, in the meteorlogic models, the storm area field needs to be left blank. Currently, the storm area is set at 9.579 square miles, which is the total area of the three separate streams.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

Storm area has been left blank as suggested.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105947	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling Hydrology Notebook.docx Word file, entry # 3, Routing Precipitation Data, the precipitation values in the Frequency Depth-Duration table does not match the precipitation values in the Frequency Depth-Duration table in the Excel spreadsheet Luling_USGS_Precipitation_Routing.xls, especially for the 1 day duration.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

This table has been updated in the Luling Hydrology Notebook.docx to match the values shown in the Luling_USGS_Precipitation_Routing.xls Excel spreadsheet, which are the correct values.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105948	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, in the meteorlogic models, the precipitation values do not match the values in the Excel spreadsheet Luling_USGS_Precipitation_Routing.xls. Also, the 5-minute precipitation value is missing for all frequencies in the meteorlogic models in the HEC-HMS model. The 5-minute precipitation values needs to be entered since a 2-minute computation time interval is being used.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
These values have been entered for all storms, and the intensity duration has been changed from 15 minutes to 5 minutes in order to make this change. Flow values are therefore slightly higher than before.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105950	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Luling_Muskingum_Cunge_Routing.xls, the channel length and slope data is missing. Under Table tab, reach characteristics are for the Guadalupe River HEC-HMS model. Provide reach characteristics for Luling.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
The reach characteristics for Luling are shown under the "Characteristics" tab. These values are for Luling and not for the Guadalupe River HEC-HMS model. The Luling_Muskingum_Cunge_Routing.xls spreadsheet does not have a "Table" tab. Routing is also being updated to Modified Puls.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105951	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls, under plots tab, Slope vs. Lag Time plot is labeled Longest Flowpath vs. Lag Time. Please re-label plot.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Plot has been relabeled correctly

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105952	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, provide subbasin, junction and routing descriptions.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Descriptions have been added to HMS model

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105954	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, the drainage areas do not match the values in the Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

The values in the model are correct, and the values in the Luling_Snyders_Lag_Loss_EX_20121108.xls Excel spreadsheet were incorrect. The spreadsheet has been updated to reflect the correct values, and checked to make sure all other values are correct.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good1

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105955	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, the drainage areas do not match the values in the Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

This comment is a repeat of 5104954. See previous response

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

OK

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105956	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, the drainage areas do not match the values in the Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

This comment is a repeat of 5104954. See previous response

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
OK

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105957	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, the initial and constant loss rates for all except the 100-year frequency do not match the data in the Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
This has been fixed for all frequencies

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105958	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, the cross-section data for XS_SLT_30 is incorrect. This cross-section data is the same as XS_SMT_03.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
This has been fixed.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105959	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the Luling HEC-HMS model, for subbasin SLT_100, for the Snyder Transform, Fort Worth method, the percent urbanization value does not match value in the Excel spreadsheet Luling_Snyders_Lag_Loss_EX_20121108.xls.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
This has been fixed for all frequencies.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105961	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the GBRA Hydrology Notebook.docx Word file, entry # 7, Loss Rates, page 5, first sentence, Barton Creek should be changed to Guadalupe River.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
"Barton Creek" changed to "Guadalupe River"

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105962	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet GBRA_Snyders_Lag_Loss_EX.xls, under plots tab, Slope vs. Lag Time plot is labeled Longest Flowpath vs. Lag Time. Also, the centroidal longest flowpath vs. lag time is labeled Longest Flowpath vs. Lag Time. Please re-label plots.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
plots re-labeled appropriately

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105963	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In Excel spreadsheet GBRA_Snyders_Lag_Loss_EX.xls, under the Tlag tab, title of table says City of GBRA Lag Time Calculations – Existing Conditions. The title should say Lower GBRA.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
"City of GBRA" changed to "Lower GBRA"

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105964	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the GBRA HEC-HMS model, provide subbasin, junction and routing descriptions.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**
Descriptions for junction, basins and reaches added

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**
Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013
Current Comment Status: **Comment Closed**

5105965	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the GBRA HEC-HMS model, the computation time interval is 5-minutes. Please consider a minimum computation time interval of 15-minute.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

The computation interval will be finalized when during routing calculations and will likely be 15 minutes.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

5105967	Hydrology	Feasibility Study	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

In the updated GeoHMS layers provided on 22 Mar 2013, the subbasin shapefile, Subbasin133.shp, has the default W names for subbasins instead of user defined subbasin names. Please change the W names to the user defined subbasin names.

Submitted By: Stephen Pilney (8178861610). Submitted On: Mar 27 2013

1-0 Evaluation **Concurred**

Subbasin133.shp is not the most current subbasin shapefile. The correct subbasin shapefile will contain user defined names and will be included with the next submittal.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Apr 22 2013

1-1 Backcheck Recommendation **Close Comment**

Good!

Submitted By: Stephen Pilney (8178861610) Submitted On: Apr 22 2013

Current Comment Status: **Comment Closed**

Public / SBU / FOUO

Comment Report: All Comments
Project: Lower Guadalupe
Review: H&H QA Lower Guadalupe
Displaying 10 comments for the criteria specified in this report.

Id	**Discipline**	**Section/Figure**	**Page Number**	**Line Number**
5348029	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 1, Hydrology Technical Report Notebook Introduction, second paragraph, first sentence, the word as was omitted after "San Marcos Rivers as well" .

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**
Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348032	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 1, Task Summary, 22P00-Engineering and Design/Cost Estimate, "The routing methodology will be discussed and agree", the word agree needs to be changed to agreed.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**
Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348034	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 2, Task Summary, 22P00-Engineering and Design/Cost Estimate, Base Contract, number 4, second sentence, insert a comma after the word acquire.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348036	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 4, Loss Rate Parameters, last paragraph, last sentence, Table 3 should be Table 2.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348038	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 5, second paragraph, Table 4 should be Table 3 and Table 5 should be Table 4.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348039	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 6, first paragraph, last sentence, Table 6 should be Table 5.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348040	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 5, Table 3, Loss Rates for Clay and Sand, for the 0.4% annual chance exceedance for sand, the block loss should be 0.73 inches instead of 0.7 inches. In Appendix B.1.2.d, Hydrologic Technical Notebook, page 5, Table 4, Loss Rates for Clay and Sand, the block loss is 0.73 inches for sand. Also, in Excel spreadsheet GBRA_Snyders_Lag_Loss_EX.xls, the block loss is 0.73 inches for sand.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348044	Hydrology	n/a	n/a	n/a

Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 8, Frequency Flow Calculation, second sentence, date of gage analysis September 2014 should be September 2012.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**

Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348046 Hydrology n/a n/a n/a
Comment Classification: **Public (Public)**

In the TRN_Basin-wide_Hydro.pdf file, on page 9, first paragraph, second sentence, Corp should be Corps.

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**
Correction made

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

5348048 Hydrology n/a n/a n/a
Comment Classification: **Public (Public)**

In the HEC-HMS model, under Meteorologic Models, Nov2004, gridded precipitation, the time shift was zero. The National Weather Service NEXRAD data time is usually in GMT. The USGS stream gage data is in local time, CST or CDT. Time shift is 5 hours for CDT and 6 hours for CST. The time shift was also zero in Oct1998 and Jul2002. Were you aware that there is a time shift capability for gridded precipitation in HEC-HMS under Meteorologic Models tab?

Submitted By: Stephen Pilney (8178861610). Submitted On: Sep 10 2013

1-0 Evaluation **Concurred**
Appropriate time shifts were applied to the HRAP gridded rainfall and the calibration was updated for 1998 and 1994 and updated and completed for 2002. The 2002 event was still a very different rainfall event than the 1998 and 2000 and didn't calibrate well, escpeccially in the Blanco and San Marcos watersheds. It likely that the 2002 event will not be used in the weighted average parameter calculation because its calibration results are so different.

Submitted By: Daniel Harris (512-777-4600) Submitted On: Sep 20 2013

Backcheck not conducted

Current Comment Status: **Comment Open**

Appendix B.1.5

Digital Data

US Army Corps of Engineers
Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study - Phase 1

Technical Report Notebook (TRN)
Appendix D.1
Engineering Analysis – Hydraulics

Guadalupe, Blanco, and San Marcos River Watersheds

Submitted to:

US Army Corps of Engineers®

Prepared by:

HALFF

4030 WEST BRAKER LANE, SUITE 450
AUSTIN, TEXAS 78759

AVO 28411B

March 2014

HYDRAULICS
TECHNICAL REPORT NOTEBOOK

APPENDIX D.1
TABLE OF CONTENTS

APPENDIX D.1: PEAK FLOW SUMMARY
- Summary of Frequency Peak Flow

APPENDIX D.2: WORKMAPS
- Hydraulic Work Maps
- HEC-RAS Water Surface Profiles

APPENDIX D.3: SUPPORTING DOCUMENTATION
- D.3.a – Hydraulic Notebook
- D.3.b – Survey Summary
- Field Reconnaissance

APPENDIX D.4: QUALITY ASSURANCE
- Ford Consulting QA/QC Review
- USACE Hydraulic Model Review and Responses

APPENDIX D.5: DIGITAL DATA
- PDF Version of Appendix D – Hydraulic TRN
- HEC-RAS Hydraulic Models
- Field Reconnaissance Photos
- Work Maps
- GIS Data
- Survey Data

HYDRAULICS TECHNICAL REPORT NOTEBOOK INTRODUCTION

The US Army Corps of Engineers (USACE) Lower Guadalupe River Basin Interim Feasibility Study Phase 1 is located within the Guadalupe-Blanco River Authority (GBRA) jurisdictional area. The GBRA has partnered with the USACE and the Texas Water Development Board (TWDB). This study is being funded through a USACE Feasibility Cost Share Agreement, a TWDB Flood Protection Planning Grant, and local funds.

Phase 1 consists of the development of existing hydrology, floodplain hydraulics, plan formulation, environmental constraints, and economics for the Lower Guadalupe, Blanco, and San Marcos Rivers as well selected streams in Luling and Woodcreek, Texas. Basin-wide final hydraulic analyses have been developed for approximately 420 miles of stream including about 132 miles of detailed study that required field surveys to be incorporated into the hydraulic models, 48 miles of limited detail study without surveys, and 240 miles of incorporated existing studies. Routing and final hydraulic modeling for Luling and Woodcreek streams will be covered in separate technical report notebooks.

Table 1 outlines the Lower Guadalupe River Basin Interim Feasibility Study Phase I basin-wide study streams, their hydraulic study type, and stream mileage. It should be noted that the stream mileages in Table 1 have been slightly adjusted due to alignment of the streams to new basin-wide LiDAR. Figure 1 illustrates the overall study area including county boundaries and study stream centerlines and also illustrates the three study types included in the basin-wide hydraulic study. All figures are located under the Figures tab.

The types of hydraulic studies performed for this TRN include:

- With Survey Study – This is a new detailed study (or restudy of current effective detailed studies) on the Guadalupe and San Marcos Rivers. Final hydraulics for "with survey" studies include survey data, flood profiles of the 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, and 0.2% annual chance exceedance (ACE) events, and base flood elevations.
- Without Survey Study – This is a new limited detailed study of the Blanco River. Surveys will be added in Phase 2 of the GBRA IFS. Final hydraulics for "without survey" studies do not include survey data, but do include flood profiles of the 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, and 0.2% ACE events.
- Incorporated Study – These studies are existing detailed studies of the Guadalupe River developed during the FEMA Map Mod program in Comal, Guadalupe, and Victoria Counties

Table 1. Phase I Basin-wide Study Streams

Stream Name	Stream Length (Miles)			
	With Survey	Without Survey	Incorporated	Total Study
Guadalupe River	55.39	0	240.66	296.05
San Marcos River	76.93	0	0	76.93
Blanco River	0	47.77	0	47.77
Total Phase I	**132.32**	**47.77**	**240.66**	**420.75**

TASK SUMMARY

Activities included in this final hydraulics TRN submittal are described in the Lower Guadalupe River Basin GBRA Interim Feasibility Study Phase 1 Project Management Plan (PMP) and are reflected in the scope of work for hydraulic modeling under contract with Ford Consulting, Inc. (W9127S-10-D-0022, Work Order DY02). The tasks from the PMP pertaining to routing hydraulics are as follows:

22P.4 Hydraulics

22P.4.1 Review the existing hydraulics from the studies identified. Detailed hydraulic models with supporting workmaps and corresponding documentation will be developed for each stream studied using the current version of HEC-River Analysis System (RAS) to define existing conditions. Streams that will be studied are included in Table 1.

22P.4.2 Hydraulic models will be developed utilizing information from "as-built" design plans provided by GBRA for WIK credit, topography provided as part of Task 22P.2, and field observations. Available bridge plans will be obtained from Texas Department of Transportation (TxDOT), County, and City sources. Sufficient elevations and field measurements will be taken at all major road crossings (bridges) in the detailed study areas if they are not provided as part of Task 22P.2.

22P.4.3 The HEC-RAS model will be geo-referenced using HEC-GeoRAS, version 4.2, an extension in ArcView.

22P.4.4 Input for the models will include assigning channel bank stations, reach lengths, Manning's roughness values, coefficients (including expansion and contraction coefficients), ineffective flow areas, bridge modeling techniques, reach boundary condition assumptions, and the number and location of cross-sections. Develop Manning's roughness values based on land use maps, aerial photography, and site visits.

22P.4.5 Develop storages for use in hydrologic modeling.

22P.4.6 Storm and high water mark data will be obtained through coordination with the local sponsor for use in calibration of the models. The models will be reasonable calibrated to USGS gage rating curves and recorded gage heights for historic flood events and any established high water marks. A list of gages and events used will be provided.

22P.4.7 Water surface profiles will be delineated for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year hypothetical storm events for both existing and future without project conditions. All bridges should be identified in the profiles.

22P.4.8 Develop floodplain delineations for the 100- and 500-year events. The 100-year floodplain delineation will NOT include Base Flood Elevations (BFE's) lines or lettered cross-sections, nor does the scope include any encroachment analyses.

22.4.9 The backwater modeling (HEC-RAS) output will be converted to a format necessary for importation into the HEC-FDA (version 1.2.4) model, including careful fine-tuning if those outputs to eliminate any occasional, minor “dips” in water surface elevation or hydraulic rating curves. This process will culminate with support of the Economics Section in preparation of the risk and uncertainty analyses modeling (in HEC-FDA), including importation of water surface profile data and confirmation/enhancement of exceedance probability functions and hydraulic rating curves applicable for each damage reach.

22.4.10 Write a technical appendix documenting the detailed hydraulic analysis procedures, assumptions, methodologies, and results. The appendix will include a brief description of each of the streams modeled in detail and a table with the range of Manning’s roughness coefficients used for each stream. Provide all digital models and supporting GIS information. Work maps and other graphics should be in color and include stream centerlines, cross-sections, and the appropriate 100-yr floodplain delineation. Pages should be 8.5”x11” or 11”x17” fold outs.

METHODOLOGY

Hydraulic Modeling

Hydraulic methods used for this study are in accordance with the national, state and local standards. The River Analysis System HEC-RAS Version 4.1.0., dated January 2010, was used to estimate water surface profiles for the study streams on this project. Hydraulic models were created for the Blanco River, San Marcos River, and six connected reaches along the Guadalupe River, which include incorporated models. Four of the six Guadalupe River reaches are incorporated existing hydraulic models created during the recent FEMA Map Mod effort in Comal, Guadalupe, and Victoria Counties. All HEC-RAS models are included in Appendix D.1.5. The following is a summary of data sources, assumptions, and procedures used to incorporate existing or create new HEC-RAS models for the study area.

Incorporated Models

Four of the six Guadalupe River reaches are incorporated existing hydraulic models created during the recent FEMA Map Mod effort in Comal, Guadalupe, and Victoria Counties. Technical modeling details for the incorporated reaches can be found in the Comal County Effective Flood Insurance Study (FIS) (2009), Guadalupe County Effective FIS (2007), and Victoria County Preliminary FIS (upcoming).

Minimal changes were made to the incorporated model geometries since they have already been reviewed and accepted by FEMA. The main update of note to the incorporated models was to use frequency discharges derived from the Corps gage analysis rather than those from the existing hydrologic studies. Details of the Corps gage analysis and interpolation of frequency discharges is presented in Appendix B.1 – Basin-wide Hydrology TRN.

Collected Data and Parameter Estimation for New Models

Topography
The primary source of topographic data used in this study was developed from the 2007-2008 CAPCOG and TNRIS LiDAR data. LAS files are the standard open format for storing LiDAR point records. The LAS file format (binary file format) is an alternative to proprietary systems or a generic ASCII file interchange system used by many companies that obtain LiDAR. Halff Associates generated a GBRA wide bare earth terrain dataset using the LiDAR described in Table 2. No LiDAR data was available for a substantial portion of DeWitt County. USGS topographic data was used to fill in DeWitt County area that had no LiDAR Data. Halff Associates used the terrain dataset to generate 30 ft. by 30 ft. digital elevation models (DEMs) for the hydrologic study and 3 ft. by 3 ft. digital DEMs for hydraulic studies.

Table 2: LiDAR Data Source

County	Age	Horizontal Accuracy	Source & Contact	Approx. Area (sq mi)
Bastrop	2008	0.70m	CAPCOG	65
Caldwell	2007	1.40m	CAPCOG	750
	2008	0.70m	CAPCOG	150
Comal	2011	0.61m	FEMA	600
DeWitt	2012	0.51m	USACE	50
Fayette	2008	0.70m	CAPCOG	120
Guadalupe	2008	1.40m	CAPCOG	10
	2007	1.40m	CAPCOG	90
	2011	0.61m	FEMA	600
Gonzales	2009	1.00m	TNRIS	1200
Hays	2008	0.70m	CAPCOG	750
	2003	1.70m	COA	130
	2011	0.61m	FEMA	25
Victoria	2006	1.40m	FEMA	650

Surveys
Field surveys of open channel sections and bridges/culverts along the detailed study reaches of the Guadalupe and San Marcos Rivers were conducted April 2013 through July 2013. Access was denied to some open channel section locations by land owners. In these cases, surveys were obtained at alternative locations upstream or downstream of the originally designated survey location. Some channel section surveys were collected using boat-mounted sonar equipment where the water was too deep for standard survey methods. The survey data was collected using surveying standards set by FEMA as specified in the current version of Guidelines and Specifications for Flood Hazard Mapping Partners. Electronic files including data text files, photographs, and field notes are included on the DVD in Appendix D.1.5. A summary of survey locations is included in Appendix D.1.3.b.

Field Reconnaissance
Field reconnaissance of the major roadway crossings in the Phase I study area were conducted from October 2012 through November 2012. All accessible roadway crossings on the Blanco, San Marcos and Guadalupe Rivers were documented with photos and field notes. Field measurements were taken for the Blanco River structures included in the limited detail study. Field reconnaissance sheets for visited structures are located in Appendix D.1.3.c, and photos are included in Appendix D.1.5. Photo locations are referenced in the field notes by file name.

Manning's "N" Value
Manning’s “n” values were assigned by a combination of visual inspection and analysis of aerial photos and land use data. Manning’s roughness coefficients for the channels ranged from 0.018-0.12 and overbank roughness coefficients ranged from 0.023-0.15 through the study area. Table 3 provides the range of Manning’s “n” values used in each model reach for this study. Initial overbank n-values were extracted from the Texas Commission on Environmental Quality’s 2003 Edwards Aquifer existing conditions land use/land cover shapefile as shown in Table 4. These initial n-values were checked and adjusted, if necessary, based on the field reconnaissance and 2009 aerial photos using the composite roughness coefficient calculation guidance for natural channels (Chow, V.T. Open Channel Hydraulics, 1959).

Table 3. Manning's Roughness Coefficients

Stream Name	Channel "n" values	Overbank "n" values
Guadalupe River		
1-Victoria	0.065	0.05-0.15
2-Dewitt	0.065	0.055-0.12
3-Gonzalez	0.065	0.05-0.12
4-Lower Guadalupe	0.018-0.05	0.026-0.12
5-23248	0.015-0.07	0.04-0.1
6-Upper Guadalupe	0.035-0.04	0.04-0.14
San Marcos River	0.023	0.06-0.1
Blanco River	0.03-0.1	0.035-0.12

Table 4. Existing Land Use Classifications and Corresponding Initial N-Values

Land Use Code LUCODE	Major Group	TR-55 Cover Type	N-Value
111000	Stream/River	n/a	1.00
114000	Reservoir	n/a	1.00
211000	Single-family Residential	Residential District - 1/4 acre	0.09
212000	Multi-family Residential	Residential District - 1/8 acre	0.12
221000	Commercial/Light Industry	Urban District - Industrial	0.09
222000	Heavy Industry	Urban District - Industrial	0.12
223000	Communications and Utilities	Urban District - Industrial	0.12
224000	Institutional	Urban District - Commercial and Business	0.12
225000	Agricultural Business	Farmsteads	0.10
226000	Transportation	Streets and Roads, Paved	0.06
227000	Entertainment and Recreational	Open Space - Fair Condition	0.07
230000	Mixed Urban	Urban District - Commercial and Business	0.12
300000	BARE	Fallow - Bare Soil	0.06
310000	Transitional Bare	Fallow - Bare Soil	0.06
320000	Quarries/Strip Mines/Gravel Pits	n/a	1.00
330000	Bare Rock/Sand	Fallow - Bare Soil	0.06
411000	Forested	Woods - Fair Condition	0.10
412000	Shrub land	Brush - Fair Condition	0.08
413000	Planted/Cultivated Woody (Orchards/Vineyards/Groves)	Woods - Grass Combination	0.06
414000	Mixed Forest/Shrub	Woods, Brush Combination	0.09
421000	Natural Herbaceous	Pasture, Grassland, or Range	0.06
422000	Planted/Cultivated Herbaceous	Row Crops - Straight Row + Crop Residue Cover	0.06
431000	Woody Wetland	n/a	0.10
432000	Emergent Herbaceous Wetlands	n/a	0.06
Note: All areas with a n-value of 1.00 will be modeled as ineffective area or blocked obstructions.			

Channel Cross-Section Point Filtering
Extracting cross-sections using GeoRAS and the 3’x3’ hydraulic DEM resulted in many cross-sections containing more than the maximum 500 points allowed for HEC-RAS modeling. The cross-section filtering approach selected for the Phase I study was the ”Near and Collinear” filtering option available in HEC-RAS. The tolerances used for this filtering approach were as follows:

- Horizontal Filter Tolerance : 0.25
- Vertical Filter Tolerance: 0.25
- Collinear Vertical Filter Tolerance: 0.25
- Collinear Minimum Change Slope: 0.005.

If there were still too many points after using the ”Near and Collinear” method, the “Minimize Area Change” method was selected and the number of points was further reduced.

General Modeling Considerations for New Models

HEC-RAS Model Computation Settings
Hydraulic routing models for the various routing flows for the study streams were computed using HEC-RAS, version 4.1.0. Default hydraulic modeling computation settings were used during this analysis. All studies were computed using steady flow analysis with a subcritical flow regime. Calculation tolerances were not modified from the default tolerances and all final modeling was performed using the default root search method (parabolic method or single-root) of computing critical depth.

Boundary Conditions
Boundary conditions varied depending on the reach being modeled. The Blanco and San Marcos River models used known water surfaces based on the immediate downstream model results. The most downstream reach on the Guadalupe River used normal depth based on average invert slope at that location. The remaining Guadalupe reaches used known water surface based either off of the immediate downstream reach or, in one instance, on the known frequency elevations upstream of a dam control structure.

Geometry Data
Cross-sections were derived from the hydraulic DEMs generated using the GBRA basin-wide LiDAR dataset. Some channel sections were modified to match field measurements, as built drawings and survey data. These revisions to the cross-sections, if any, are noted in the model.

Cross-sections were evaluated for natural grade breaks for bank station placement. Bank stations were placed as near as possible to the natural grade breaks so that the streams maintained a smooth channel depth that may slightly increase as they move downstream along the profile.

Available bridges/culverts for all streams were modeled using field measurements, "as-built" plans, or bridge/culvert data from the current effective USACE models. Where available, survey data was incorporated in the final hydraulic models as well. The method used to model the bridges/culverts is noted in the model. Blanco River structures were modeled using field measurements and USACE model data only. The San Marcos River model used mostly survey data with some TxDOT as-built data (confirmed by spot shot surveys). The Guadalupe River structures were modeled using TxDOT as-built data confirmed and/or adjusted by spot shot survey data.

Ineffective areas and blocked obstructions were set following the standard practice as outlined in the HEC-RAS Hydraulic Reference Manual. Typically, ineffective area expansion and contraction ratios for bridges or culverts were specified as 1:1 upstream or 2:1 downstream, unless otherwise modeled based on the engineer's assessment of physical conditions. Cross-section expansion and contraction coefficients were typically left at the default values of 0.1 and 0.3, unless the expansion/contraction physical conditions significantly impacted flow.

Pilot Channels
One of the limitations to using LiDAR elevation data is that the airplane-mounted lasers used to collect the data do not penetrate water. Therefore, cross-sections cut from LiDAR terrain data reflect a top-of-water channel invert. The channel inverts at these LiDAR cross-sections were adjusted with pilot channels based on upstream and downstream channel survey data. The pilot channel invert was determined using the slope between the surveyed cross-sections. Once the invert was determined, two different methods were used to approximate the channel below the water surface. In the San Marcos model, the average side-slopes of the channel were projected down to the invert elevation to form a trapezoidal approximation of the channel below the water surface. In the new Guadalupe model reaches, intermediate cross-sections were interpolated between survey locations. Channel sections from interpolated cross-sections with stations corresponding to existing cross-sections were used to approximate the existing cross-section channel below the water surface.

Flow Data
The hydraulic model incorporated the standard eight annual chance events (50%, 20%, 10%, 4%, 2%, 1%, 0.4%, 0.2%) based on discharges interpolated from a basin-wide USACE gage analysis as reported in Appendix B.1 Basin-wide Hydrology TRN. Interpolation results were compared to existing hydrology models along the Guadalupe River and adjusted to better match the existing hydrology for rare events (i.e. 250 and 500-yr events). These flows were adjusted because it appears that the gage analysis and interpolation overestimated the very rare discharges when compared to the existing hydrology studies. Peak discharges at key locations along the study streams were placed approximately one-half to one-third upstream of the reach between the flow break locations as well as at all headwaters. A summary of peak flows is included in Appendix D.1.1.

WORK MAPS AND RESULTS

Hydraulic Floodplain Delineation and Work Maps

The 0.2% and 1% ACE Floodplains were delineated using HEC-RAS output data and GIS tools. The HEC-RAS water surface elevation results for the 0.20% and 1% frequencies were converted to water surface DEMs. These water surface DEMs were intersected with the ground surface DEM and the resulting floodplain delineation was plotted on hydraulic work maps at a scale of 1" = 4000' with additional GIS data including LiDAR contours and aerial photos. A work map index is located in Figure 2.

Results

Resulting water surface elevations from the hydraulic analysis are depicted on the work maps and profiles provided in Appendix D.2. Below is a description of each studied stream:

Guadalupe River
Guadalupe River was studied for 296.1 miles with surveyed sections and structures from Canyon Dam downstream to the Victoria/Calhoun County Boundary near the Town of Tivoli. The study was broken up into six models: (1) Victoria, (2) Dewitt, (3) Gonzalez, (4) Lower Guadalupe, (5) 23248, and (6) Upper Guadalupe. Sections 1, 4, 5 and 6 are incorporated existing studies and sections 2 and 3 are new studies. Modeled channel slopes average 0.2%. The calculated depth of flow for the baseline conditions 1% ACE flood event averages about 38.6 feet with estimated average channel velocity of 6.2 fps.

San Marcos River
San Marcos River was studied for 76.9 miles with surveyed sections and structures from its confluence with the Blanco River near the City of San Marcos downstream to its confluence with the Guadalupe River near the City of Gonzales. Modeled channel slopes average 0.3 %. The calculated depth of flow for the baseline conditions 1% ACE flood event averages about 41.2 feet with estimated average channel velocity of 14.7 fps.

Blanco River
Blanco River was studied in limited detail for 47.8 miles without surveyed sections and structures from the Blanco/Hays County line to its confluence with the San Marcos River near the City of San Marcos. Modeled channel slopes average 0.3%. The calculated depth of flow for the baseline conditions 1% ACE flood event averages about 36.3 feet with estimated average channel velocity of 12.8 fps.

Comparison to High Water Marks:
Existing high water mark elevations are available on the Guadalupe, San Marcos and Blanco Rivers for the 1998 event. Flows for the 1998 event were taken from the calibrated basin-wide hydrology model described in the Basin-Wide Hydrology TRN – Appendix B.1. The calibrated flows were entered into the final hydraulic model and resulting flood elevations were compared to the known high water marks. Profiles of the 1998 event at selected locations showing comparisons to high water marks can be seen at the end of Appendix D.1.2.b. A list of 1998 high water marks is provided in Table 5.

Table 5. 1998 Flood Event High Water Marks

River	Location	Elev	Datum	Source
Blanco	IH 35	607.60	NAVD88	USACE
Blanco	SH 80	587.30	NAVD88	USACE
Guadalupe	Gruene Rd	635.10	NAVD88	USACE
Guadalupe	Loop 337	629.00	NAVD88	USACE
Guadalupe	1140 River Crest Dr, NB	623.50	NAVD88	USACE
Guadalupe	Zipp and Lulliwood	589.20	NAVD88	USACE
Guadalupe	Common St, NB	622.10	NAVD88	USACE
Guadalupe	I-35, NB	609.60	NAVD88	USACE
Guadalupe	Corner of Glenn cove and Fox Run, Seguin	488.95	NAVD88	USACE
Guadalupe	I-10	518.55	NAVD88	USACE
Guadalupe	Pecan Grove Estates, Lake Placid	514.05	NAVD88	USACE
Guadalupe	Royal George Cir., Lake McQueeny	541.25	NAVD88	USACE
Guadalupe	1126 Happy Over Rd., Lake McQueeny	550.25	NAVD88	USACE
Guadalupe	Rio Grande and Chapparal, Seguin	495.75	NAVD88	USACE
Guadalupe	FM 447, Victoria Co.	115.92	NAVD88	TXDOT
Guadalupe	Loop 463, Victoria Co.	86.88	NAVD88	TXDOT
Guadalupe	US 59, Victoria Co.	53.71	NAVD88	TXDOT
Guadalupe	Water Mark on Moody Street	64.33	NAVD88	City of Victoria
Guadalupe	Water Mark on Fence At Murray and Glass	64.01	NAVD88	City of Victoria
Guadalupe	Mark on Old Victoria Co Health Dept	63.25	NAVD88	City of Victoria
Guadalupe	Mark on House at Wheeler and Third	61.41	NAVD88	City of Victoria
San Marcos	FM 1979	514.32	NAVD88	USACE
San Marcos	FM 1977	480.87	NAVD88	USACE
San Marcos	CR 272	447.43	NAVD88	USACE
San Marcos	US 90E	379.46	NAVD88	USACE

Results show a reasonable comparison at most locations with calculated elevations within 2 feet of observed elevations. However, the incorporated model within Guadalupe County (Guadalupe River model segment 4) showed observed data consistently 4-6 feet lower than the calculated profile. This consistent difference may be related to the quality of topographic data used in the original modeling or differences in roughness values. Observed data on the lower Blanco River was consistently 3.5-4.5 feet higher than the calculated profile. This difference may be caused by the complexity of the hydraulic modeling on the Blanco near San Marcos.

Affected Structures:
A preliminary inventory of structures located in the 1% ACE floodplain is summarized in Table 6 below and shown in the Figure 3. These structures were identified using recent aerial photos. This dataset does not specify the type of structure or make an assumption of the first floor elevation compared to the water surface elevation. A shapefile of these structure locations is included in Appendix D.5.

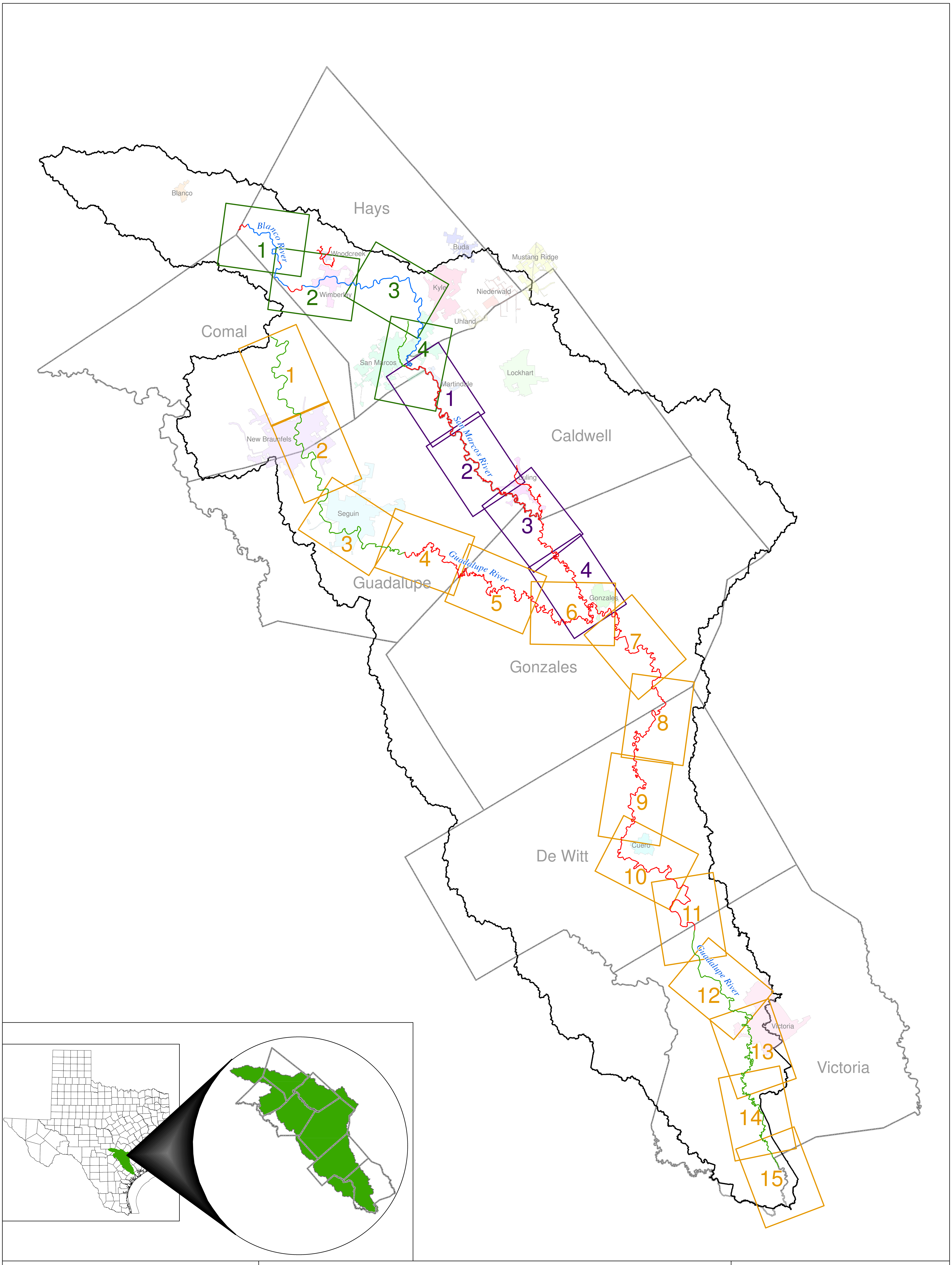
Table 6. Preliminary Inventory of Affected Structures (1% ACE)

Stream	Number of Structures
Guadalupe River	3020
San Marcos River	555
Blanco River	453
Total	**4,028**

Figures

GBRA Interim Feasibility Study - Phase 1

Figure 1.
Project Study Area



Key to Features

- New Detailed Study
- New Limited Detail Study
- Incorporated Study
- Lower Guadalupe River Basin
- County Boundary
- Blanco River Workmaps
- Guadalupe River Workmaps
- San Marcos River Workmaps

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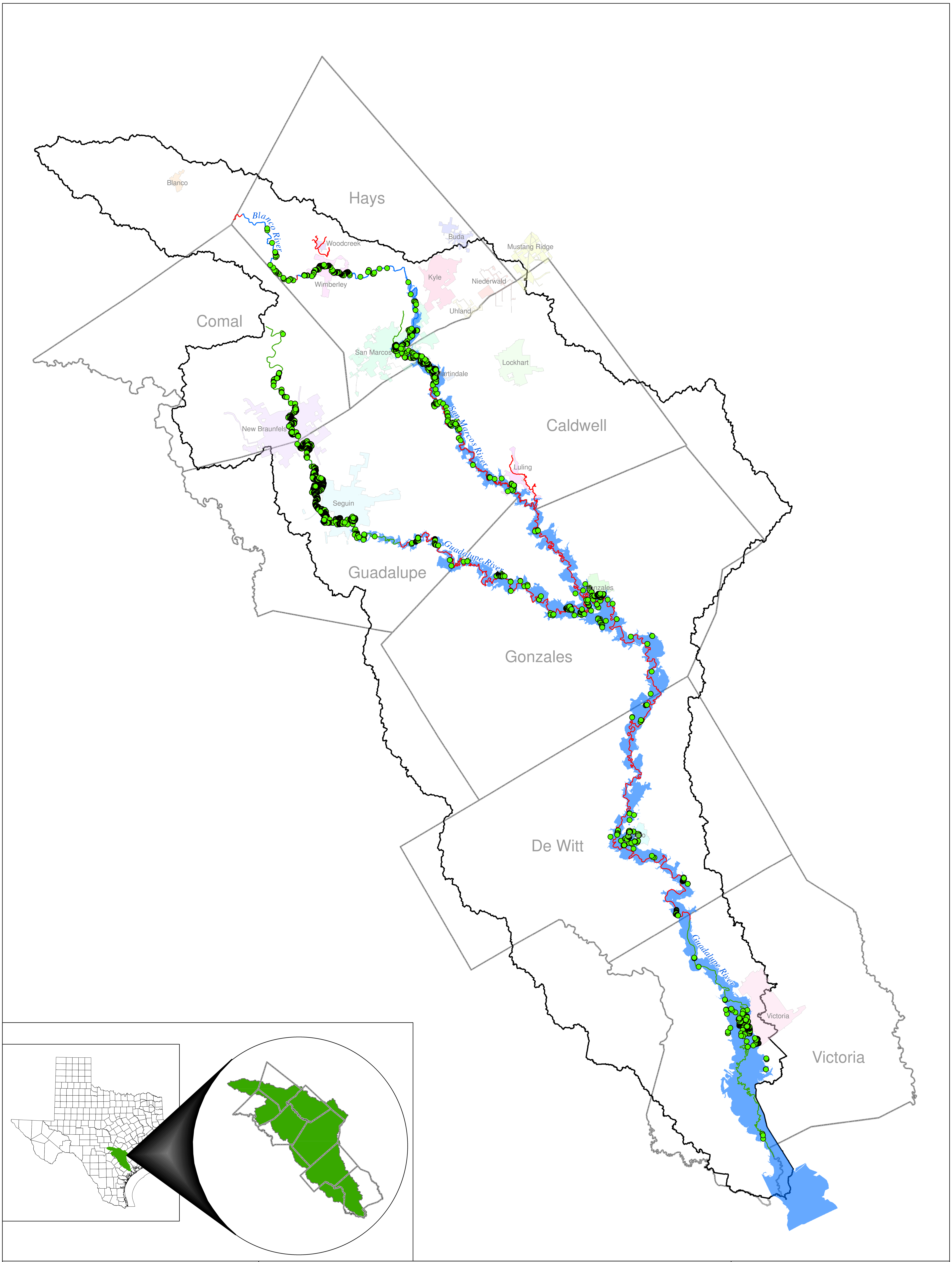
Figure 2.
Work Map Index

N W E S

0 10 20 Miles

1 inch = 5 miles

HALFF



Key to Features

- Affected Structures
- New Detailed Study
- New Limited Detail Study
- Incorporated Study
- 100-yr Floodplain
- Lower Guadalupe River Basin
- County Boundary

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Figure 3. Affected Structure Locations

N W E S

0 10 20 Miles

1 inch = 5 miles

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Appendix D.1.1

Peak Flow Summary

Hydrologic Element	Location Description	HEC-RAS Cross-Section Station	Upstream Drainage Area (mi2)	Gage Analysis Peak Discharge (CFS) Annual Chance Exceedance 50%	20%	10%	4%	2%	1%	0.4%	0.2%
Guadalupe River											
N/A	D/S Canyon Dam	1543582	1436	1800	4500	5000	5000	5000	15300	101300	130000
JGUAD_010	Upstream of Comal Conf.	1470344	1518	4200	12300	21800	40100	59500	85000	112400	132900
JGUAD_010_020	@ I-35	1420964	1652	6000	16300	27900	50400	74400	106000	159100	188300
JGUAD_040		1341919	1742	7100	19700	34100	61000	89300	126800	180700	220800
JGUAD_050	Upstream of Geronimo Cr.	1281422	1801	7700	21200	36500	65000	95000	134700	192800	237100
JGUAD_030_050	Conf. with Geronimo Cr.	1253887	1871	8300	22700	39000	69200	101000	143000	205600	254400
JGUAD_060		1210478	1960	9000	24400	41800	74000	107800	152300	220200	274200
JGUAD_070		1103587	2047	9600	26000	44400	78300	113800	160600	233100	292000
JGUAD_090		960490	2104	10000	26900	45900	80800	117400	165600	240900	302700
JSMAR_120_GUAD_090	Conf. with San Marcos	883191	3462	16300	41900	70200	120900	173400	243600	363000	474500
JGUAD_160		804436	3531	16600	43100	72300	125100	179900	250000	369800	485800
JGUAD_150_160		749694	4014	17900	45800	76300	130800	187000	258300	379800	498800
JGUAD_170	Conf. with Peach Cr.	715919	4069	18000	45900	76500	130900	187000	258100	379200	497900
JGUAD_210	Conf. with Sandies Cr.	621206	4215	18200	46100	76600	130600	186200	256400	375700	493300
JGUAD_210_220	Cuero Gage	518448	4934	16900	42500	70100	121000	174000	242000	362000	481000
JGUAD_230		465183	5028	17600	42600	69500	114700	160200	216100	309500	405900
JGUAD_260		390263	5092	17500	42000	68300	112400	156600	210700	300900	394500
JGUAD_270	Victoria Gage	314224	5198	18000	41900	65700	105000	142000	187000	259000	347000
JGUAD_310	Above Coleto Cr.	212473	5245	17400	40500	63500	101400	137200	180600	250200	335200
JGUAD_300_310	Conf. with Coleto Cr.	155706	5784	19800	46200	72400	115700	156500	206100	285500	382500
Outlet 1	Calhoun County Boundary	67943	5959	18100	42200	66100	105700	142900	188200	260700	349300
Blanco River											
JBLNC_010_020	Hays County Line	247798.5	238	5700	18000	30600	50700	68200	87500	115200	137400
JBLNC_030	Above Cypress	194521.4	317	7500	23900	40500	67000	90300	115700	152400	181800
JBLNC_040	Wimberley Gage	155898.6	355	8200	26000	44100	73000	98300	126000	166000	198000
JBLNC_050	Kyle Gage	103846.7	412	8500	28200	49500	85800	119000	158000	216000	266000
JBLNC_060	Above San Marcos	42921.67	435	12300	37400	63400	106500	145500	190700	257700	314900
San Marcos River											
JBLNC_060_SMAR_010	San Marcos Conf	403769	531	15000	45700	77400	130000	177700	232900	314700	384600
JSMAR_020	Above York	356498	614	11400	32600	54300	90700	124100	163500	222800	274900
JSMAR_020_030	York Conf	272222	756	12900	37000	61600	102800	140600	185300	252500	311600
JSMAR_090	Luling Gage	196464	838	9800	26600	43500	72000	98400	130000	178000	221000
JSMAR_090_100	Plum Conf	138828	1250	15200	41100	67200	111100	151900	200700	274800	341200
JSMAR_120	Above Guad	55586	1358	13400	36200	59200	97900	133800	176800	242100	300500

Appendix D.1.2

Work Maps

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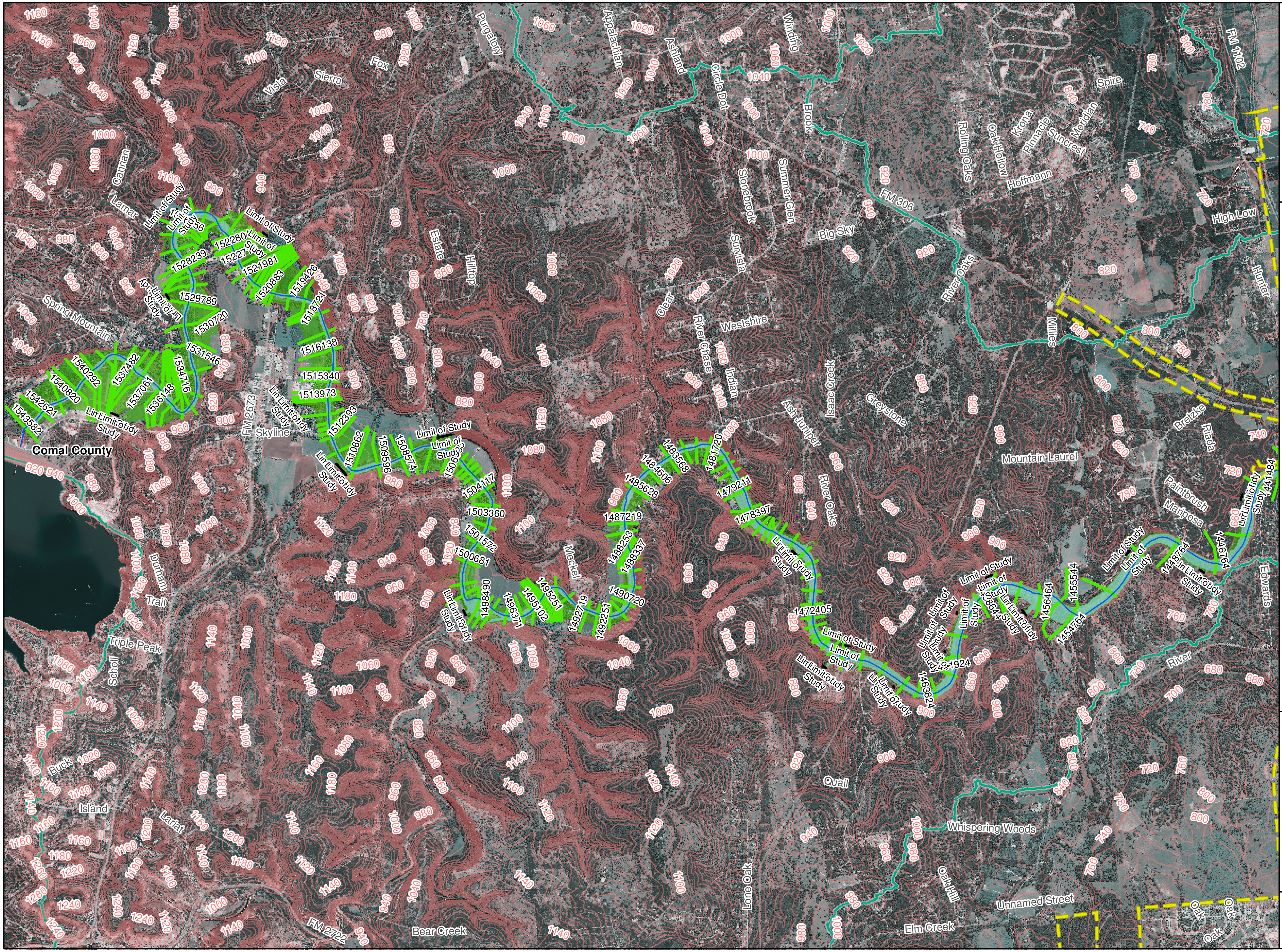
Appendix D.1.2.a
Hydraulic Work Maps



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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- New Braunfels

Phase I Hydraulic Work Map

Guadalupe River

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Feet

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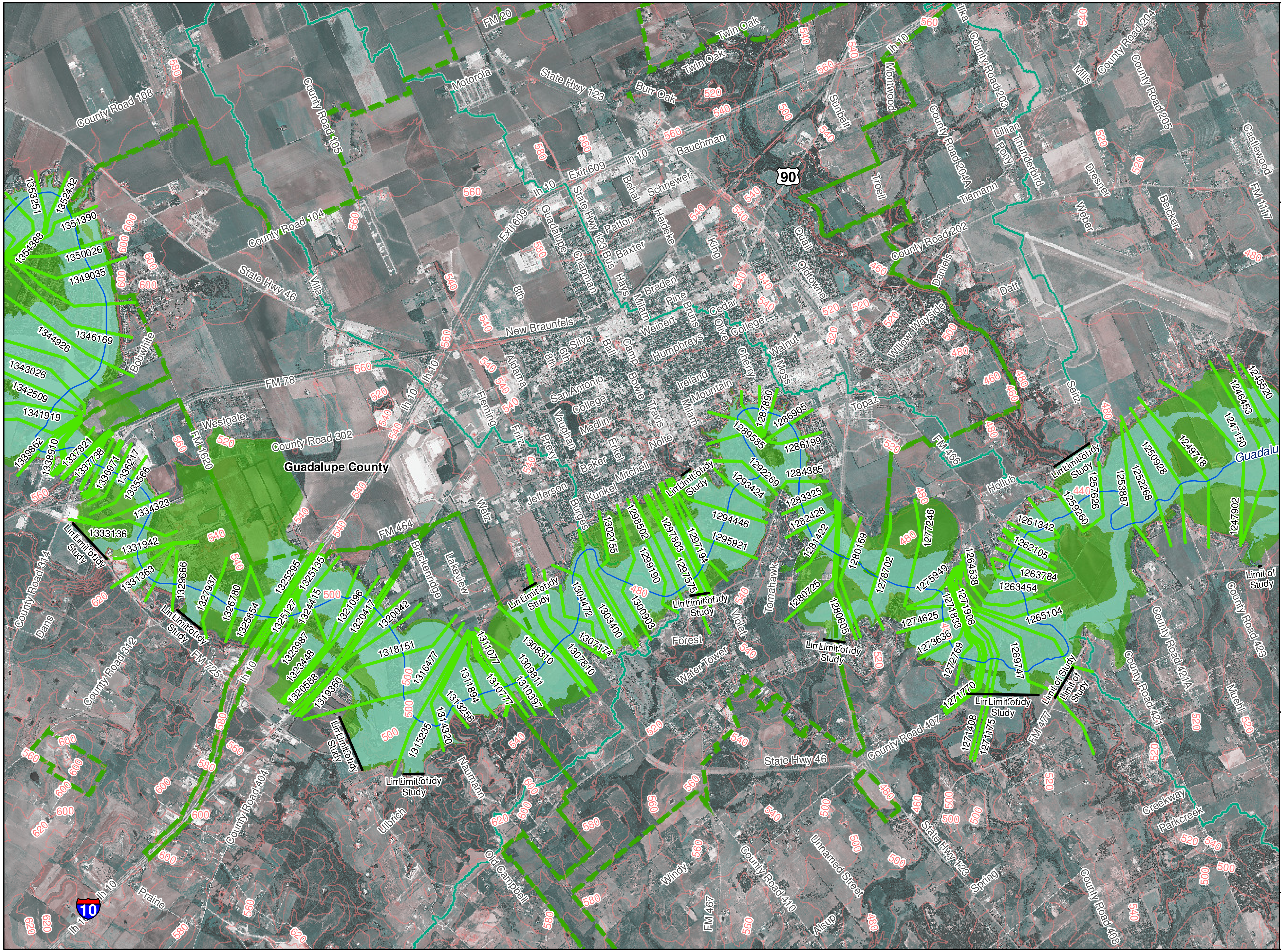

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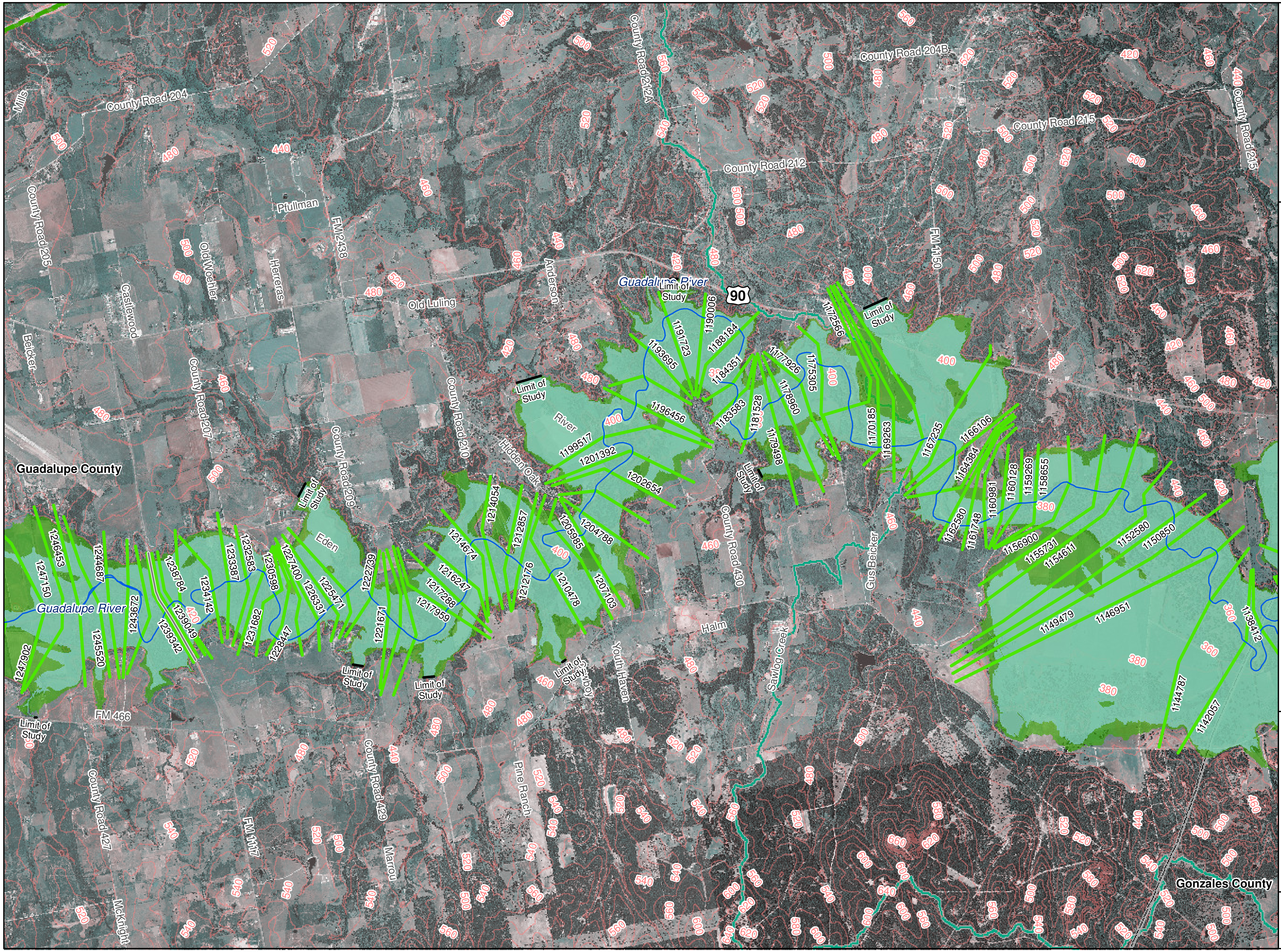

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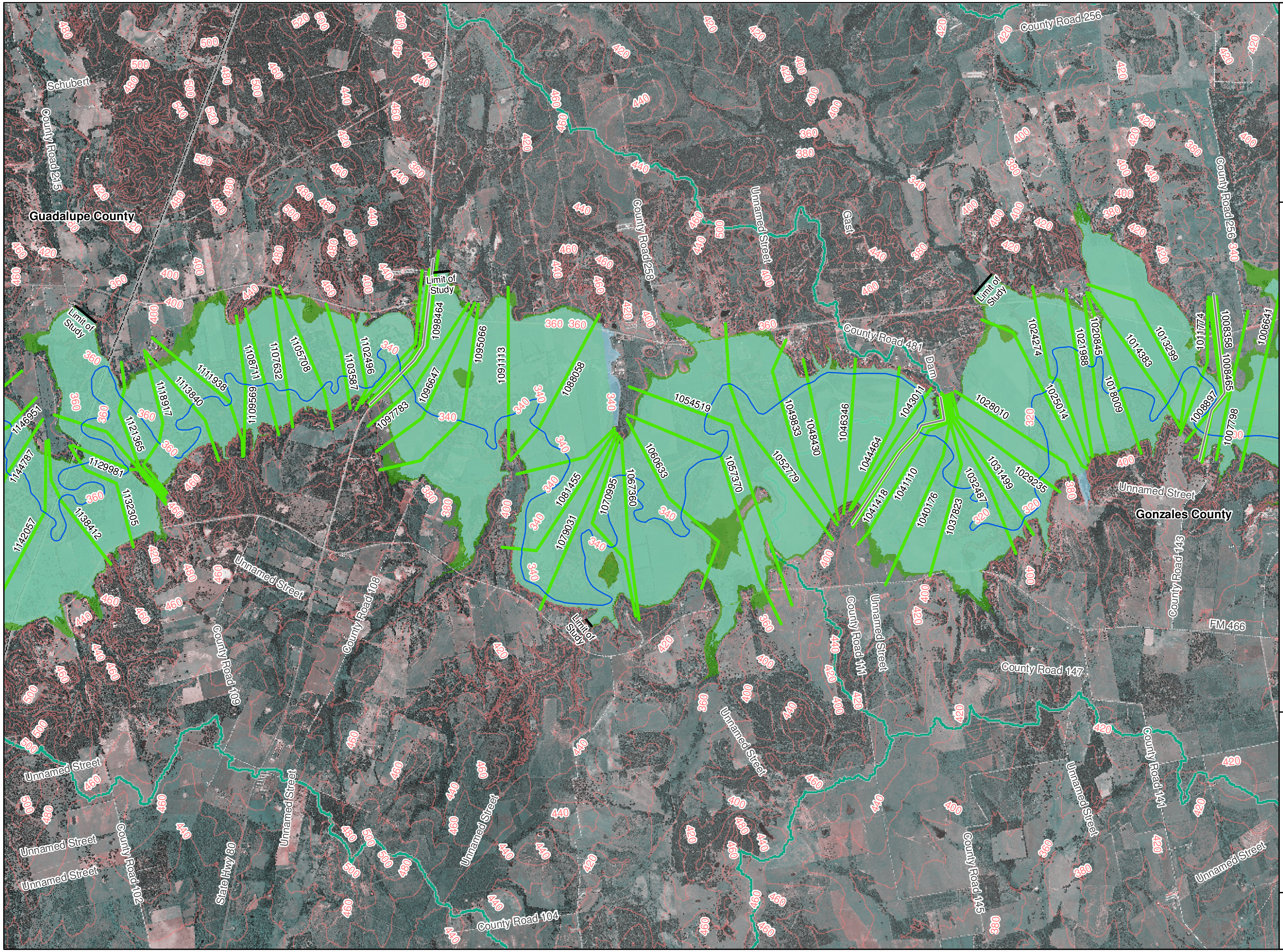

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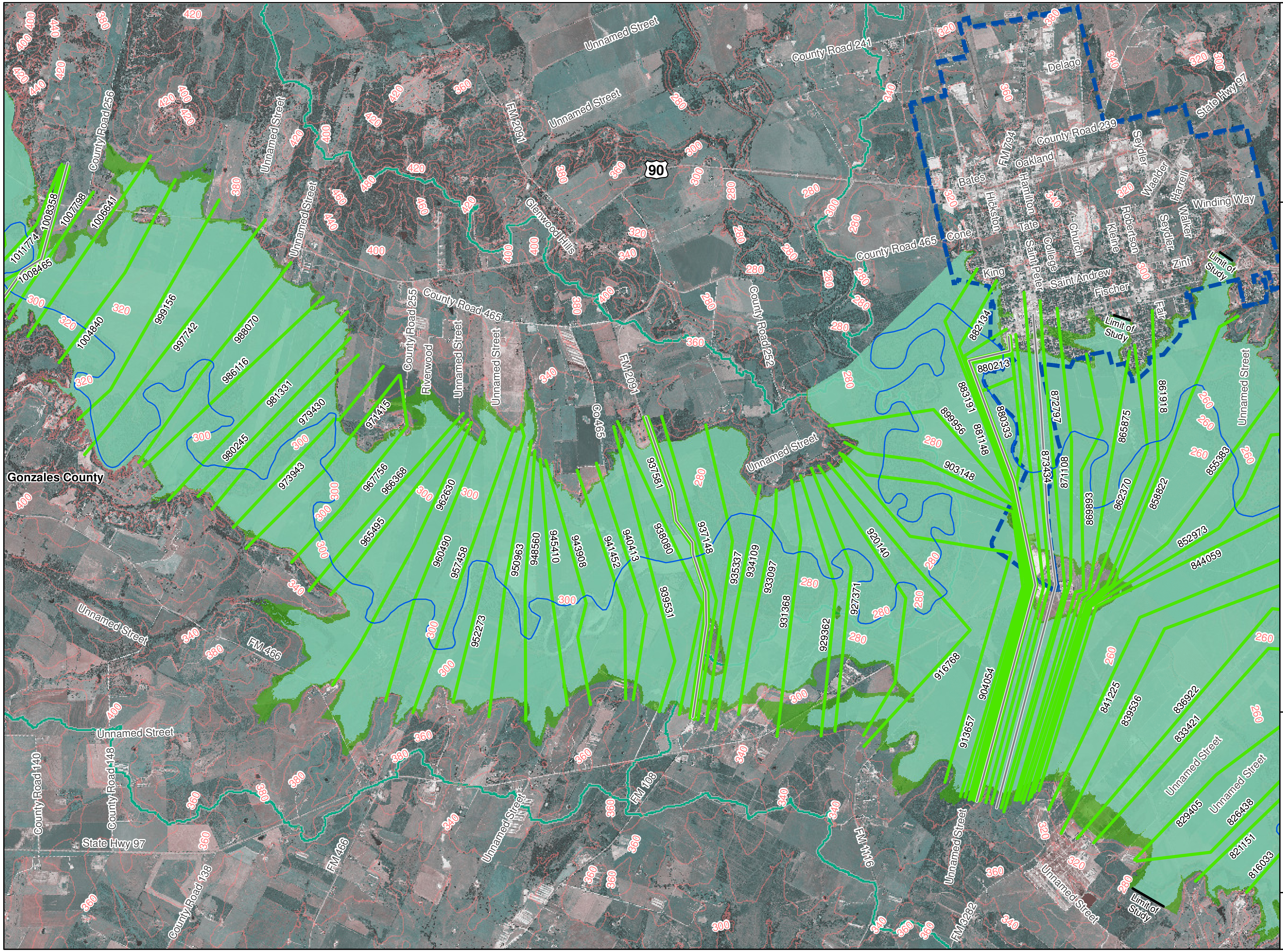

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Jurisdiction

- Gonzales

Phase I Hydraulic Work Map

Guadalupe River

N W E S

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Feet

Page 6 of 16

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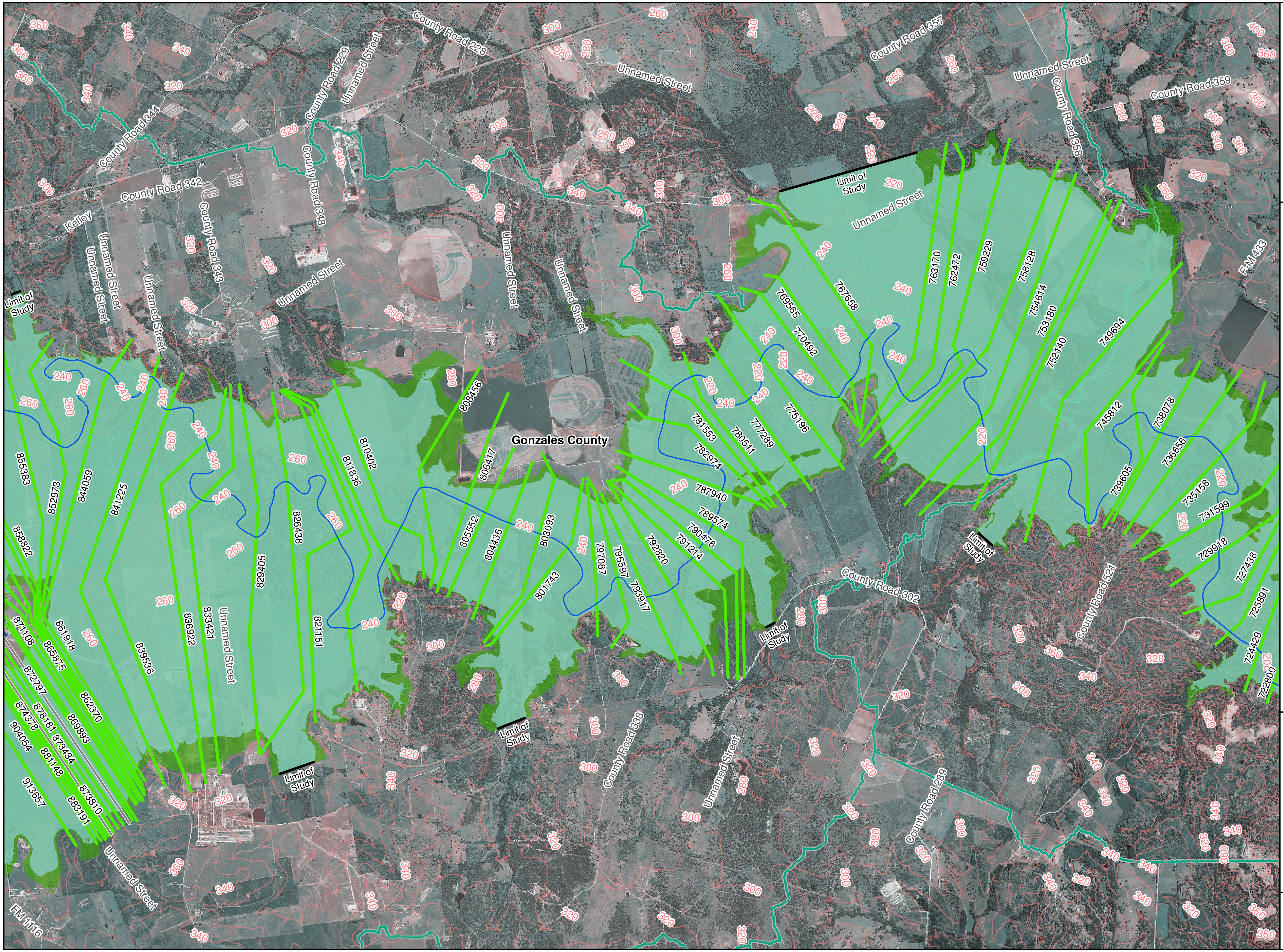

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Phase I Hydraulic Work Map

Guadalupe River

N E S W

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Feet

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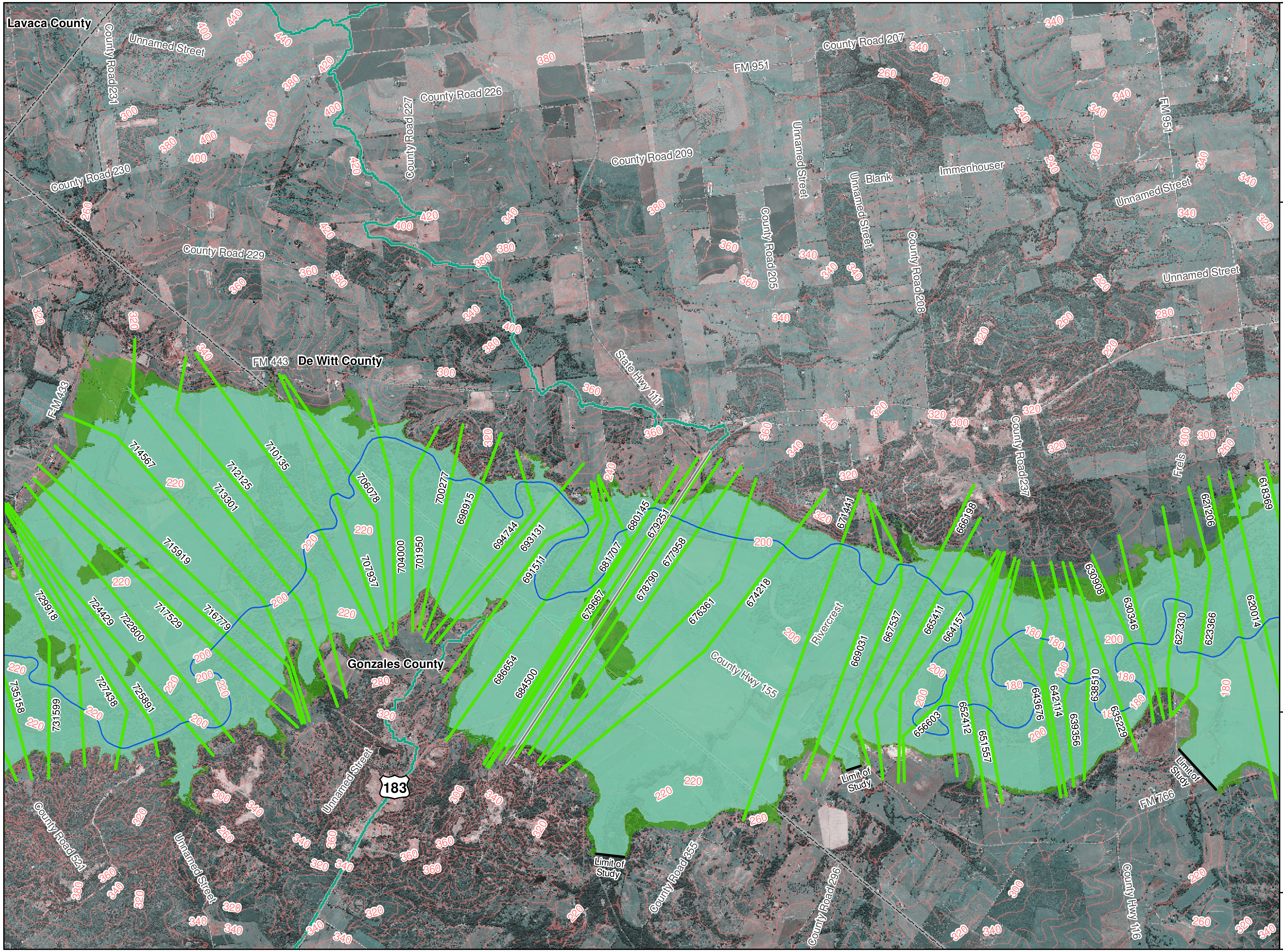

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Feet

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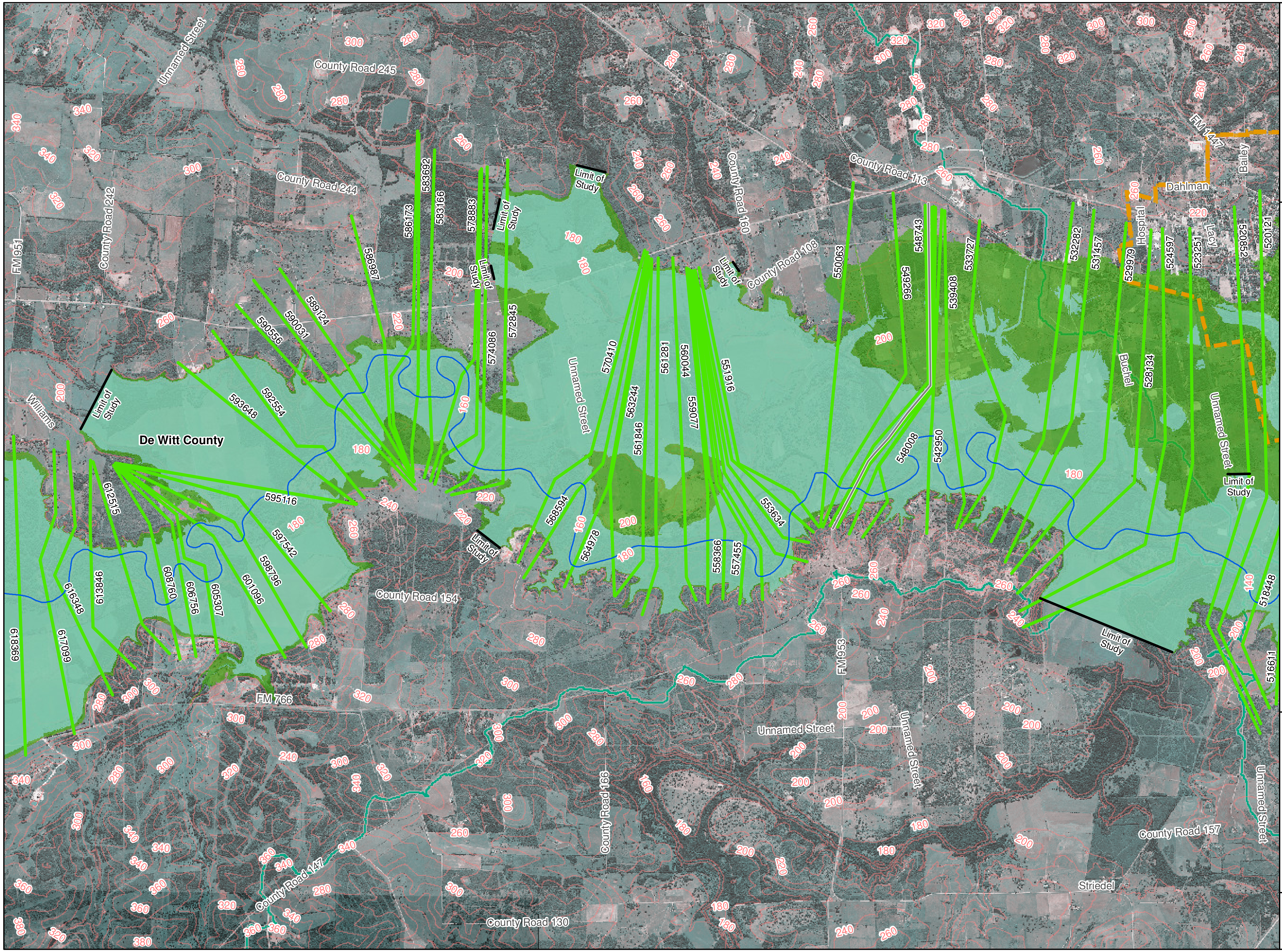

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Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- Cuero

Phase I Hydraulic Work Map

Guadalupe River

N E S W

0 2,000 4,000
Feet

HALFF

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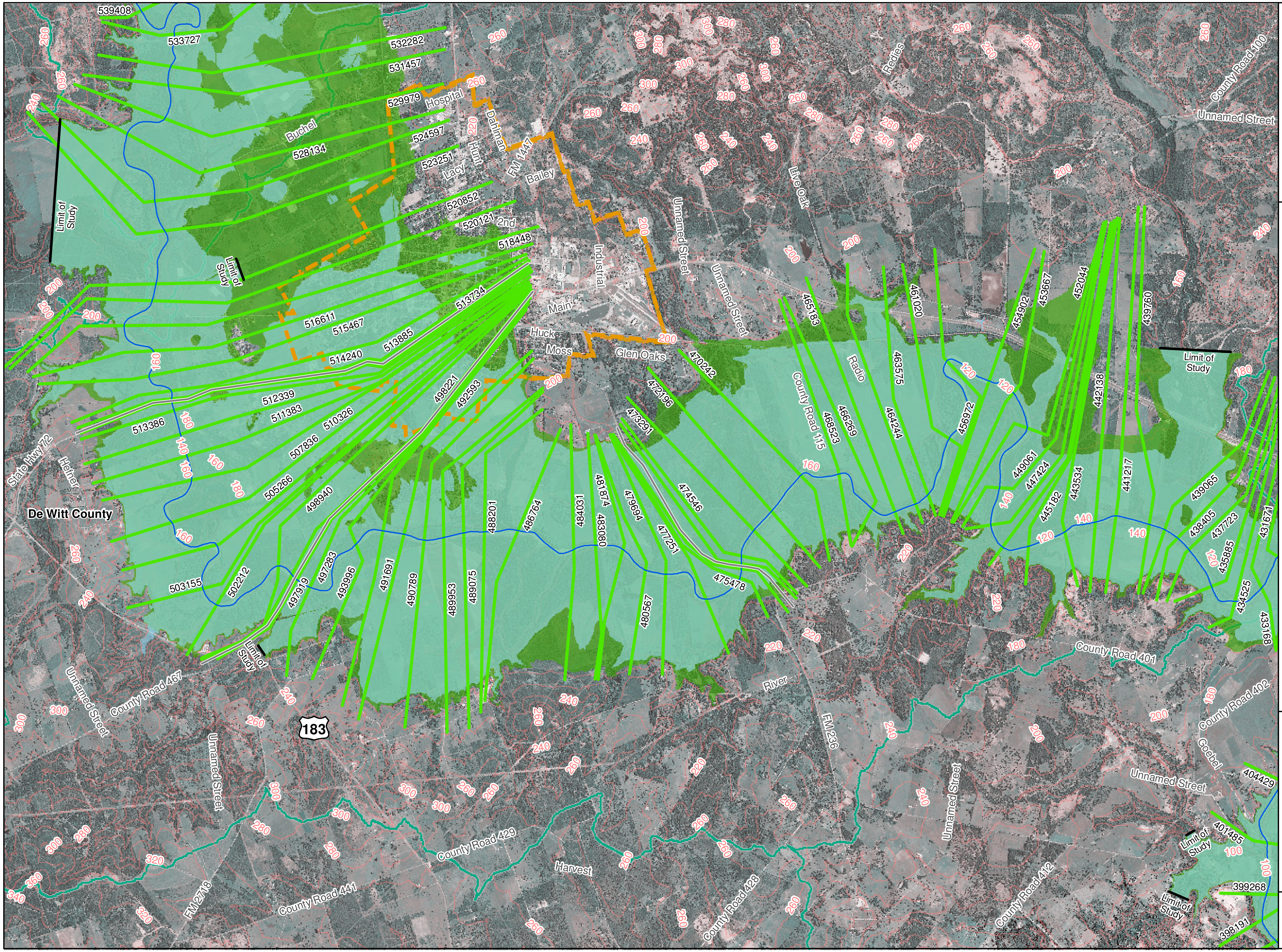

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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- Cuero

Phase I Hydraulic Work Map

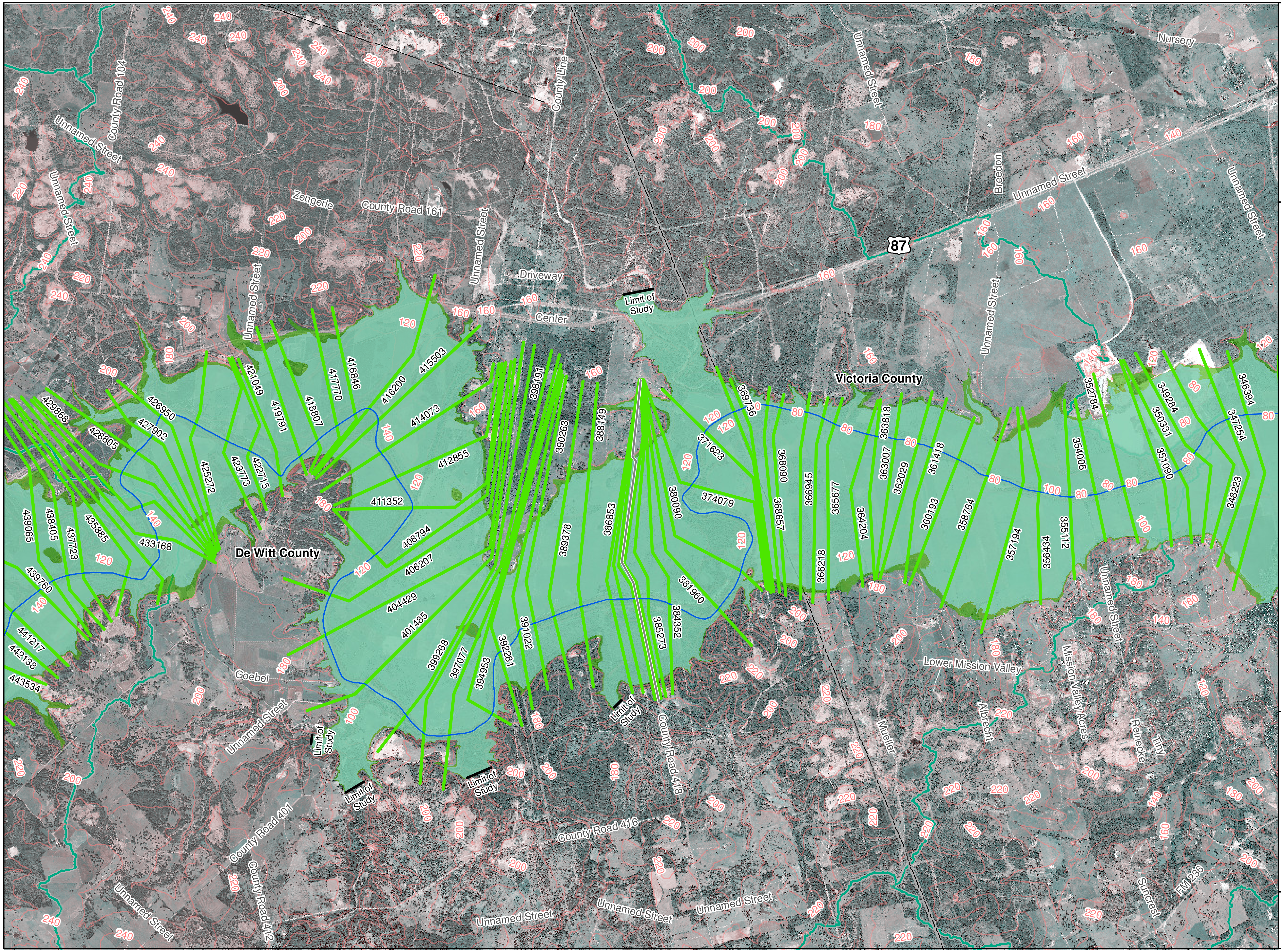
Guadalupe River

N E S W

0 2,000 4,000

Feet

HALFF



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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
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Phase I Hydraulic Work Map

Guadalupe River

0 2,000 4,000
Feet

HALFF®

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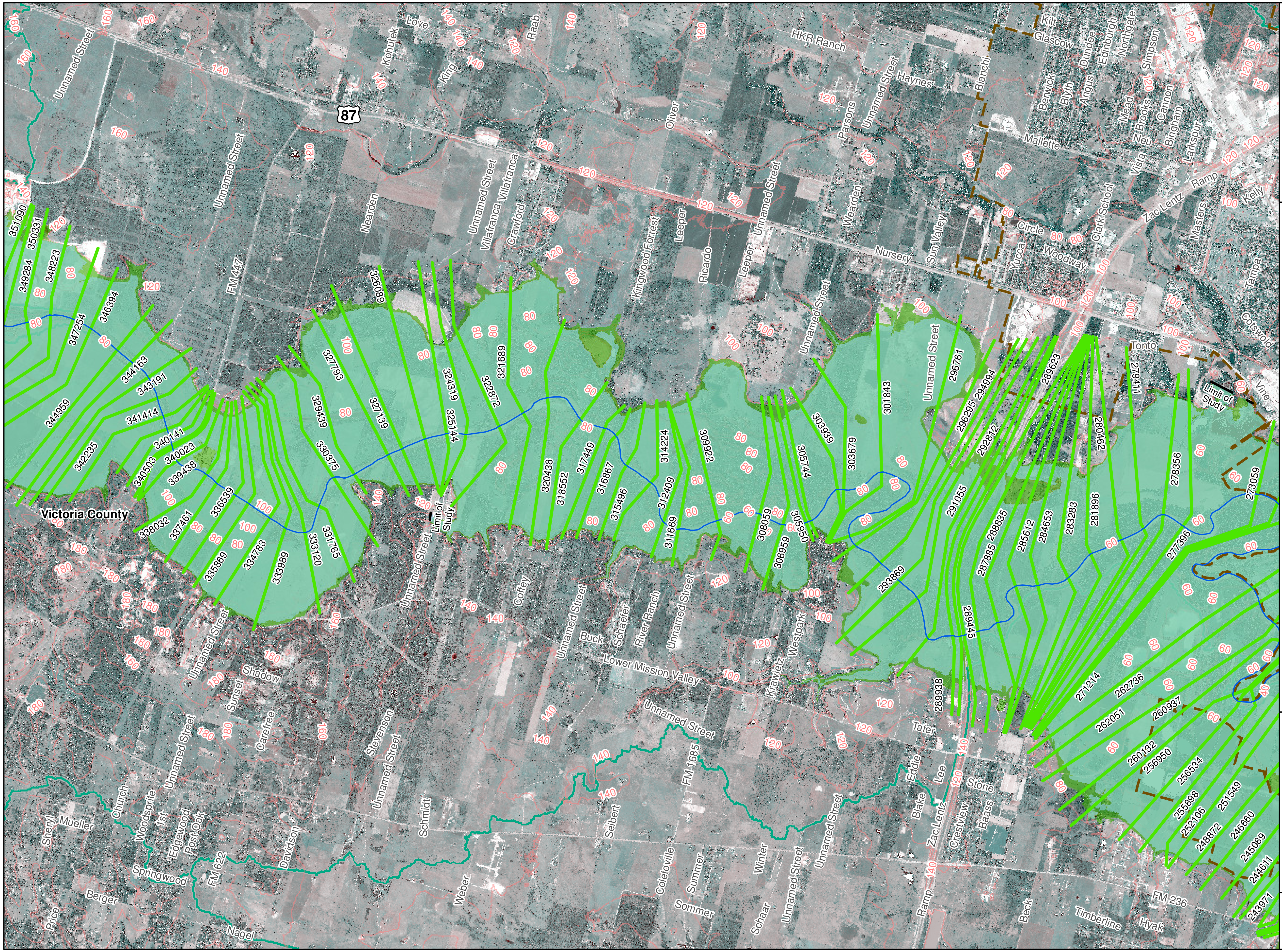

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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalupe River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- Victoria

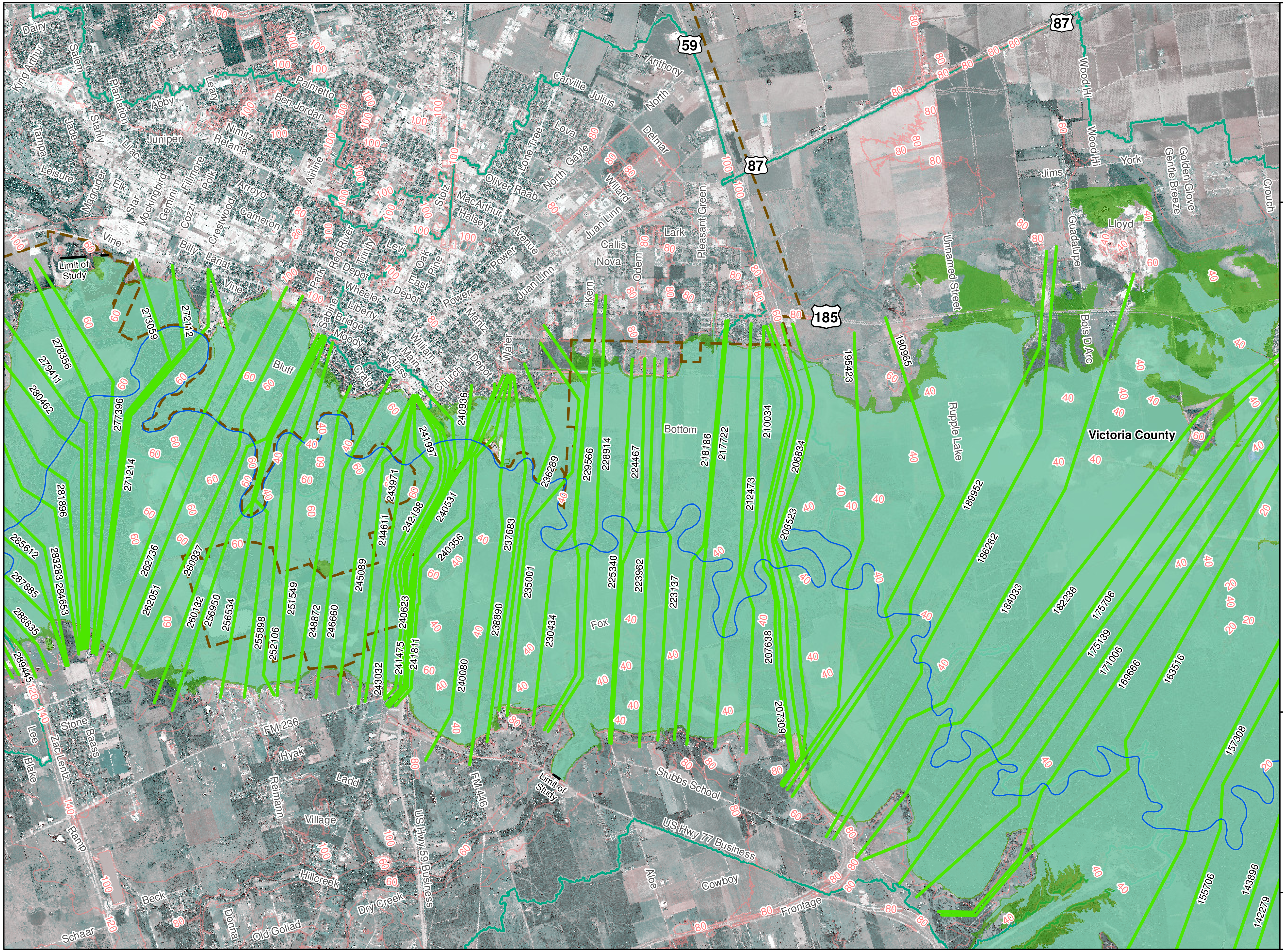
Phase I Hydraulic Work Map

Guadalupe River

N E S W

0 2,000 4,000
Feet

HALFF



Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- Victoria

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GBRA Interim Feasibility Study - Phase I

Phase I Hydraulic Work Map

Guadalupe River

0 2,000 4,000 Feet

HALFF

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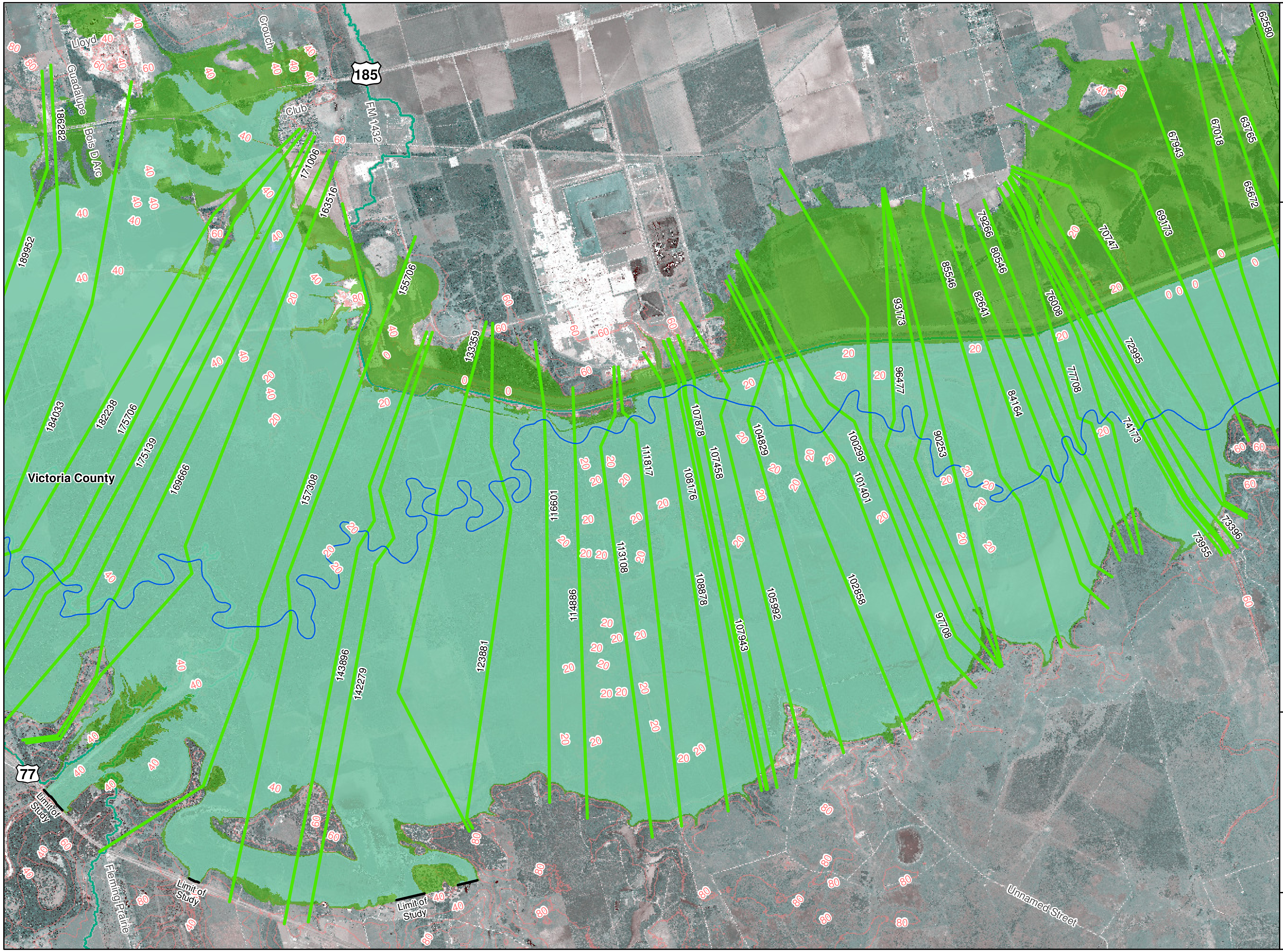

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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Phase I Hydraulic Work Map

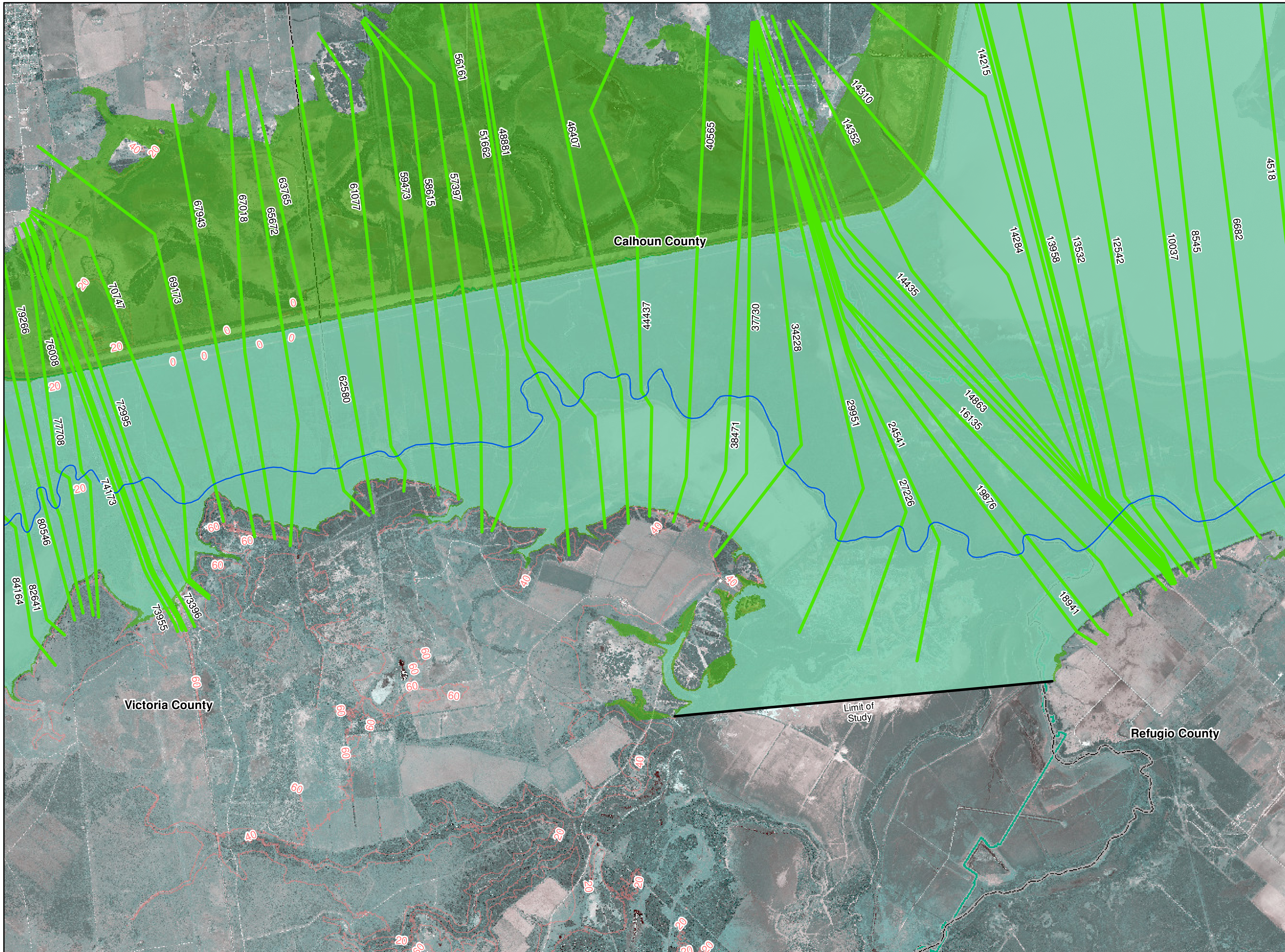
Guadalupe River

N E S W

0 2,000 4,000
Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\Guad_FigureX_HydraulicWorkmap.mxd



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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Phase I Hydraulic Work Map

Guadalupe River

0 2,000 4,000
Feet

HALFF®

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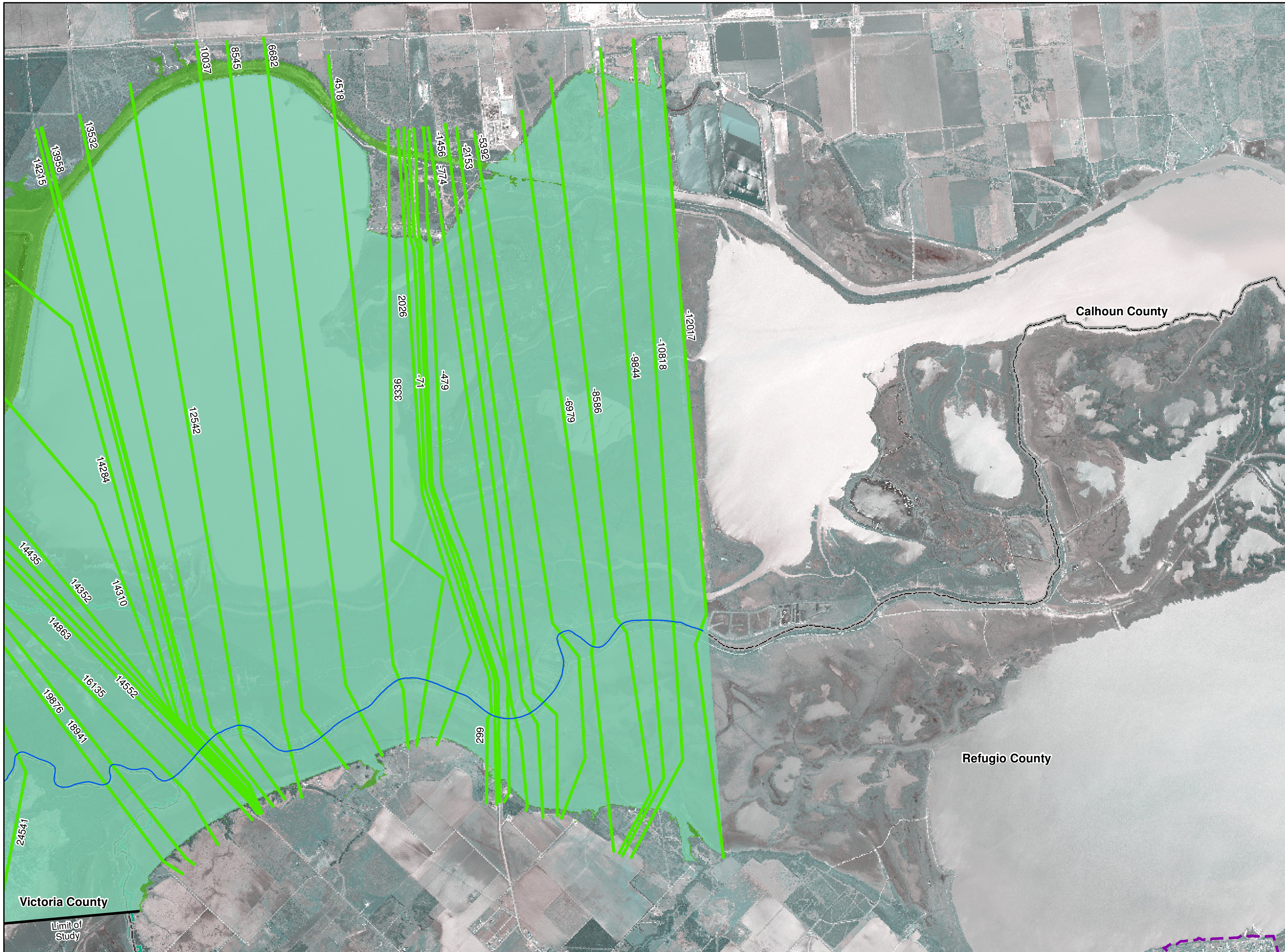

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GBRA Interim Feasibility Study - Phase I

Key to Features

- RAS Structures
- Guadalope River Center Line
- Guadalupe XS
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdiction

- Austwell

Phase I Hydraulic Work Map

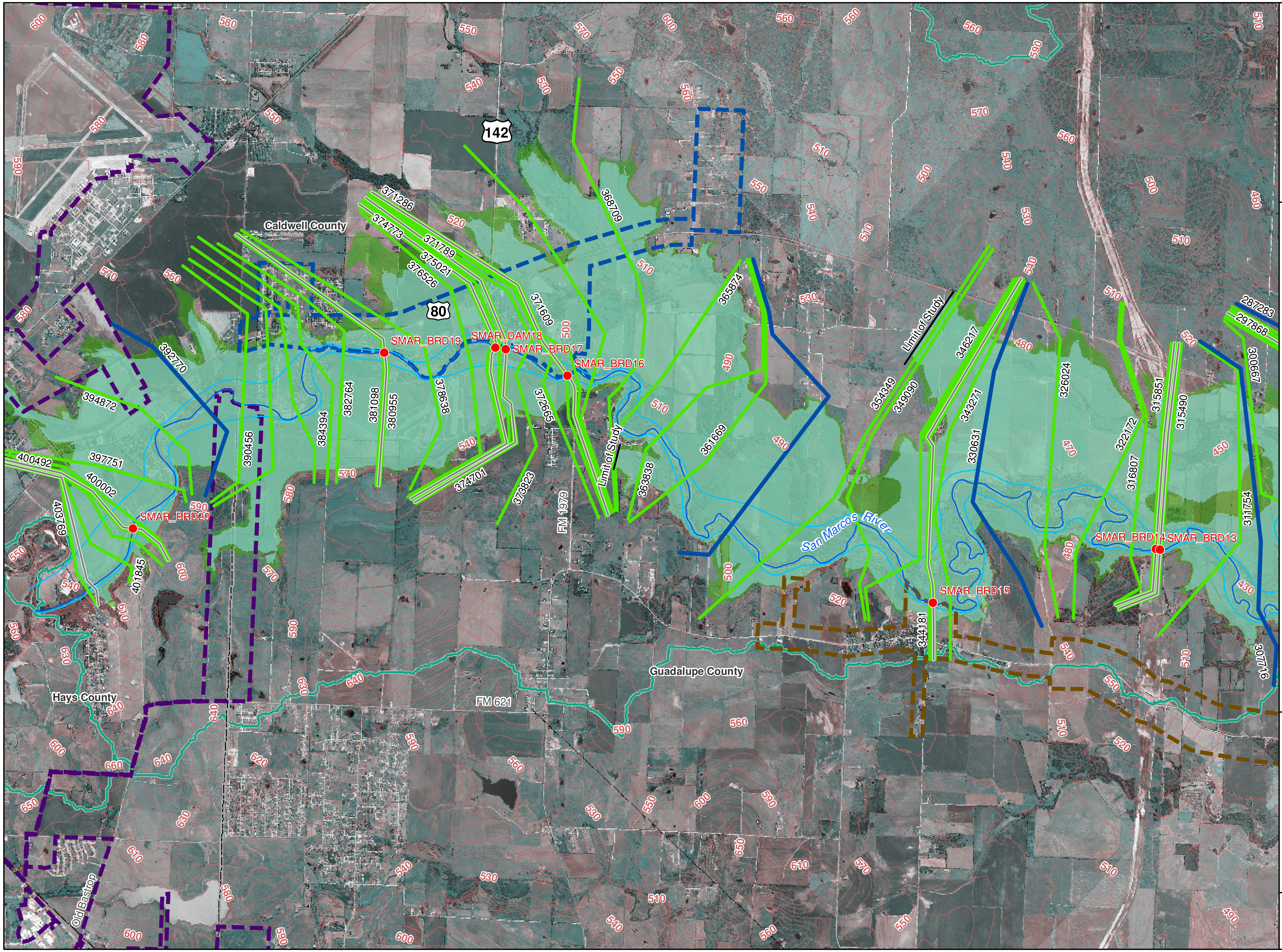
Guadalupe River

N E S W

0 2,000 4,000 Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\Guad_FigureX_HydraulicWorkmap.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

GBRA Structures

- Survey
- RAS Structures
- San Marcos Center Line
- San Marcos Flowpaths
- San Marcos Cross Sections
- San Marcos Surveyed XS
- Watershed Subbasins
- 10 ft Contours
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Martindale
- San Marcos
- Staples

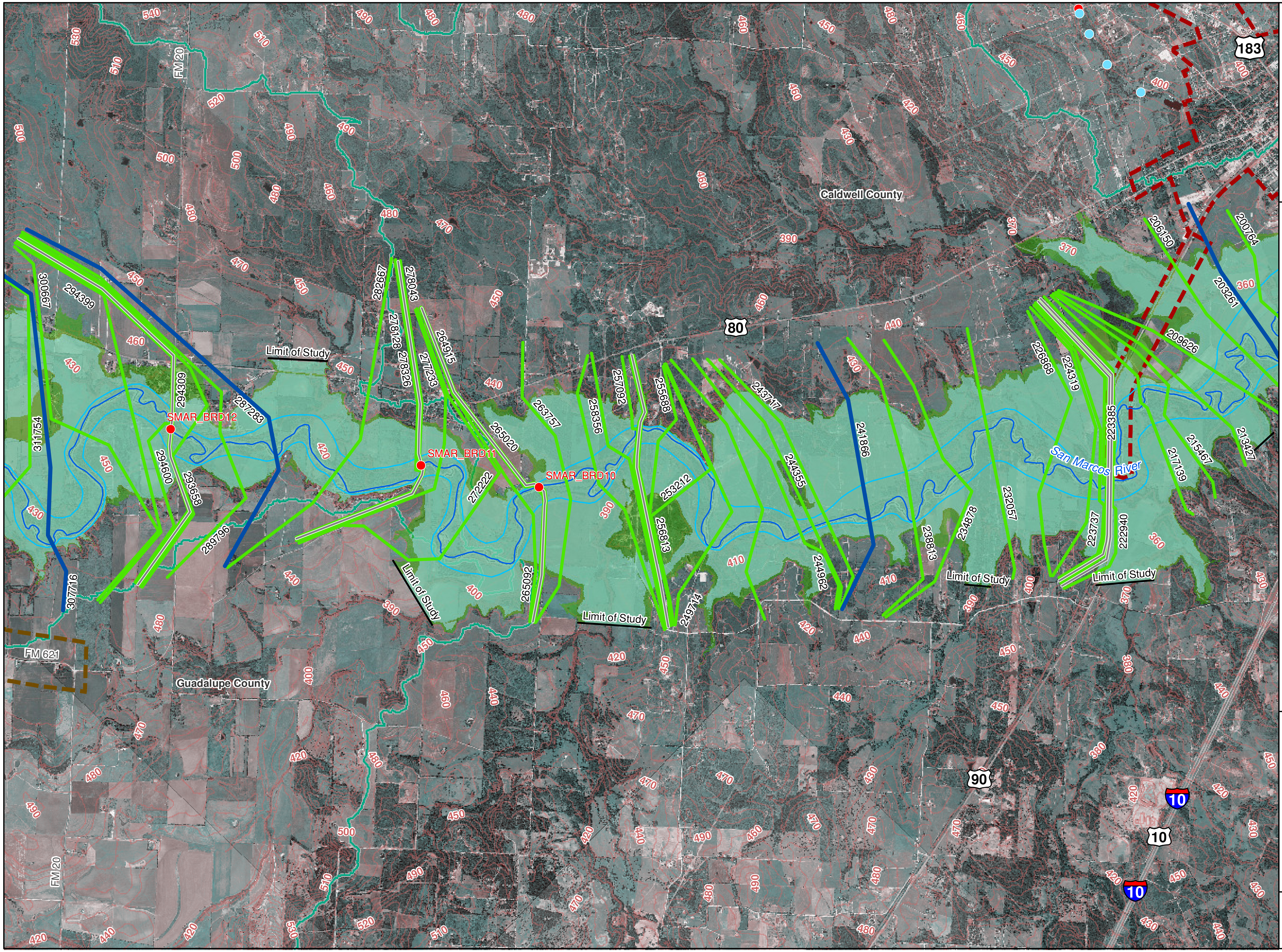
Phase I Hydraulic Work Map

San Marcos River

0 2,000 4,000
Feet

Page 1 of 4

HALFF



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GBRA Interim Feasibility Study - Phase I

Legend

GBRA Structures

- Survey
- XS+SS
- RAS Structures
- San Marcos Center Line
- San Marcos Flowpaths
- San Marcos Cross Sections
- San Marcos Surveyed XS
- Watershed Subbasins
- 10 ft Contours
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Luling
- Staples

Phase I Hydraulic Work Map

San Marcos River

0 2,000 4,000 Feet

HALFF

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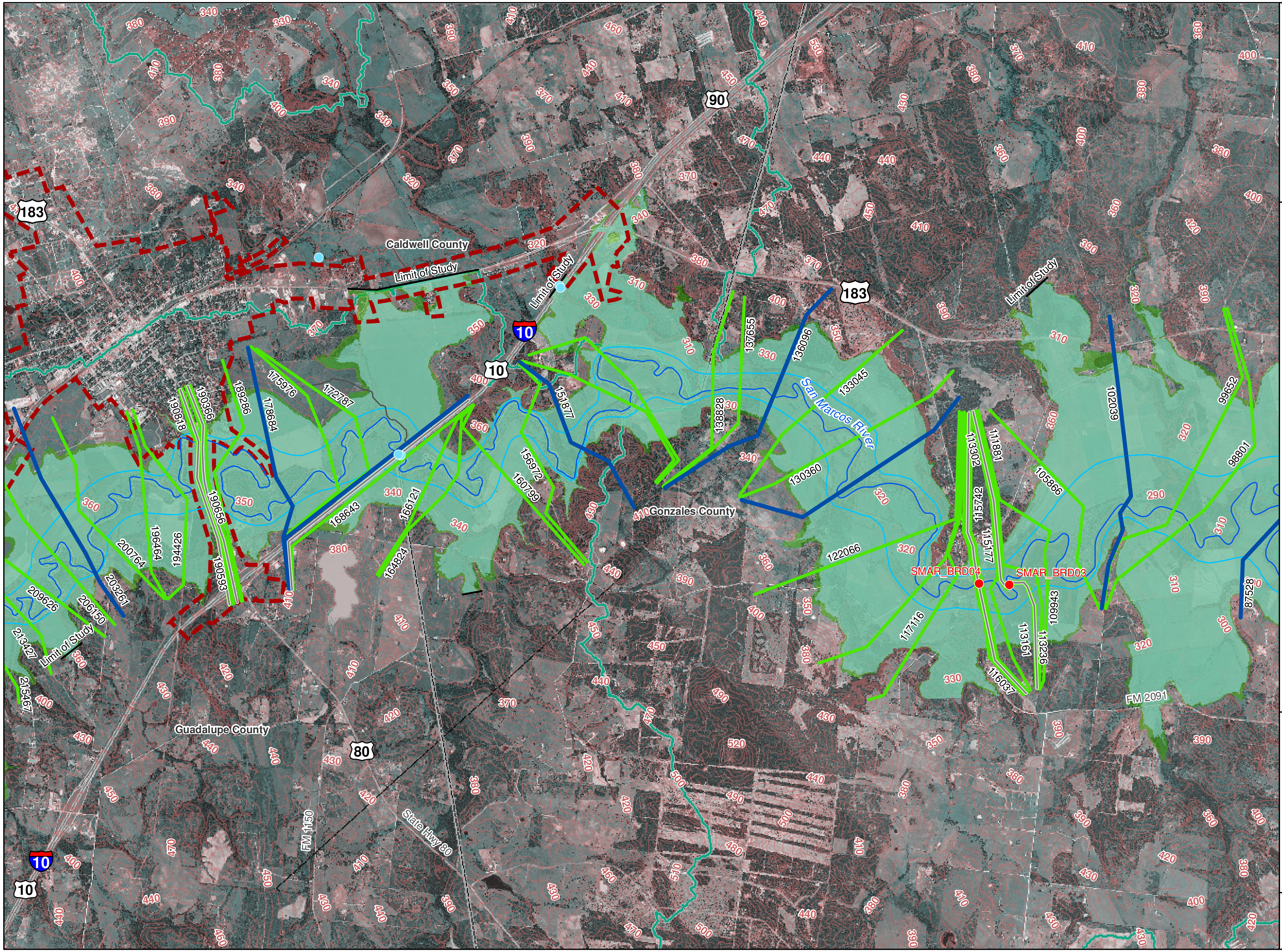

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GBRA Interim Feasibility Study - Phase I

Legend

GBRA Structures

- Survey
- XS+SS
- RAS Structures
- San Marcos Center Line
- San Marcos Flowpaths
- San Marcos Cross Sections
- San Marcos Surveyed XS
- Watershed Subbasins
- 10 ft Contours
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Luling

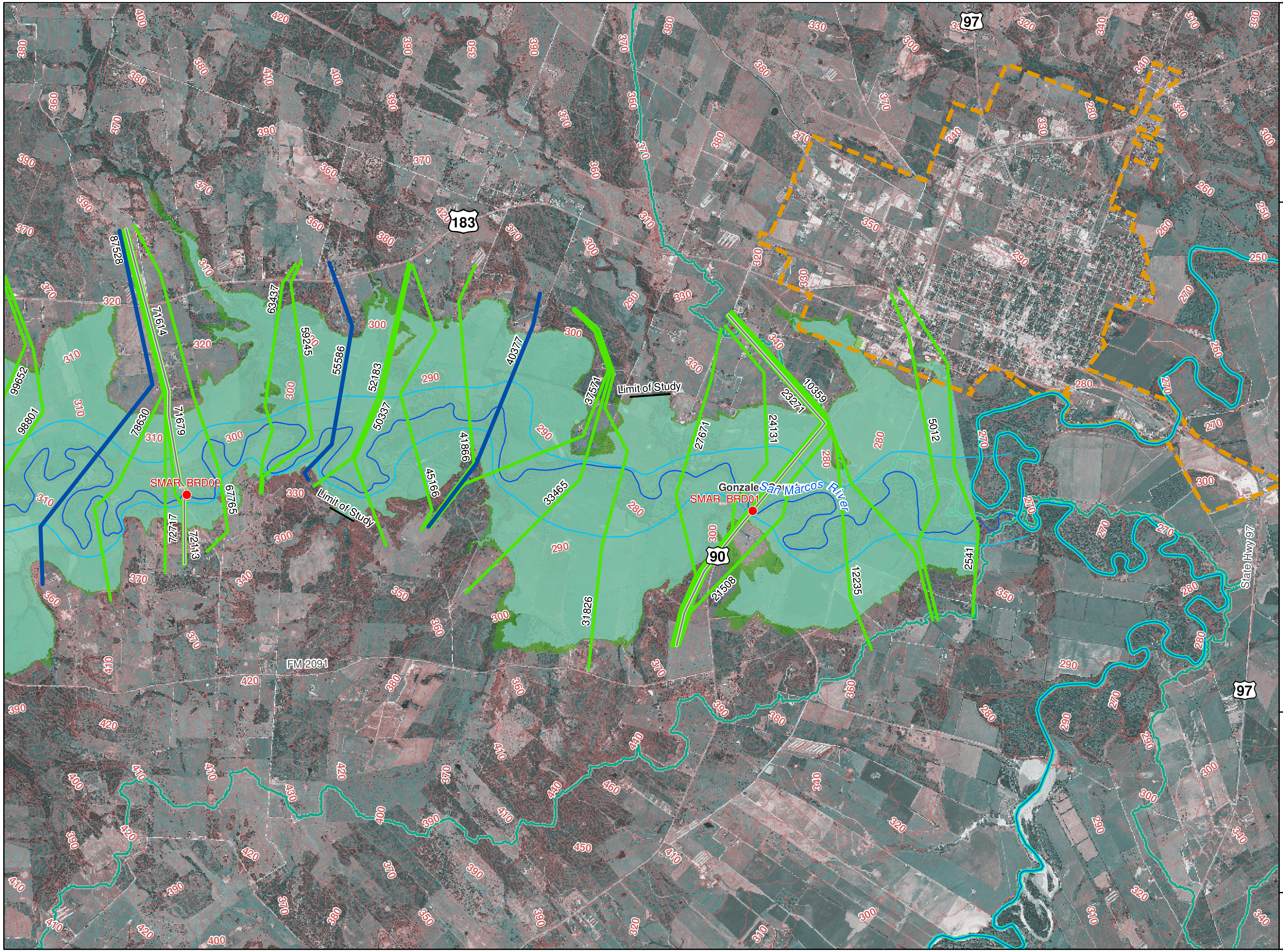
Phase I Hydraulic Work Map

San Marcos River

0 2,000 4,000
Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\SM_FigureX_HydraulicWorkmap2.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

GBRA Structures

- Survey
- RAS Structures
- San Marcos Center Line
- San Marcos Flowpaths
- San Marcos Cross Sections
- San Marcos Surveyed XS
- Watershed Subbasins
- 10 ft Contours
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Gonzales

Phase I Hydraulic Work Map

San Marcos River

0 2,000 4,000

Feet

Page 4 of 4

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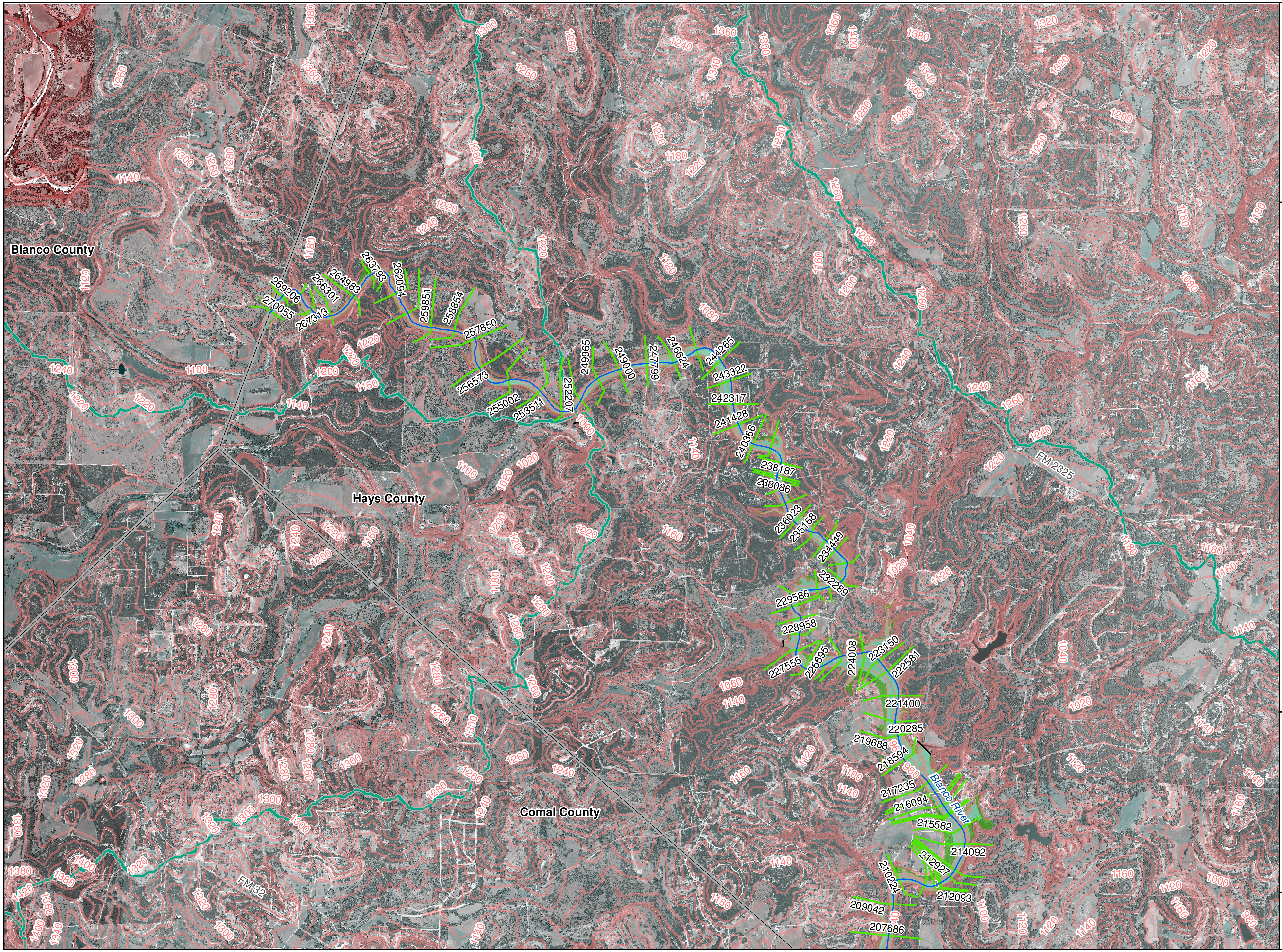
N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\SM_FigureX_HydraulicWorkmap2.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

- RAS Structures
- Blanco Cross Sections
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Phase I Hydraulic Work Map

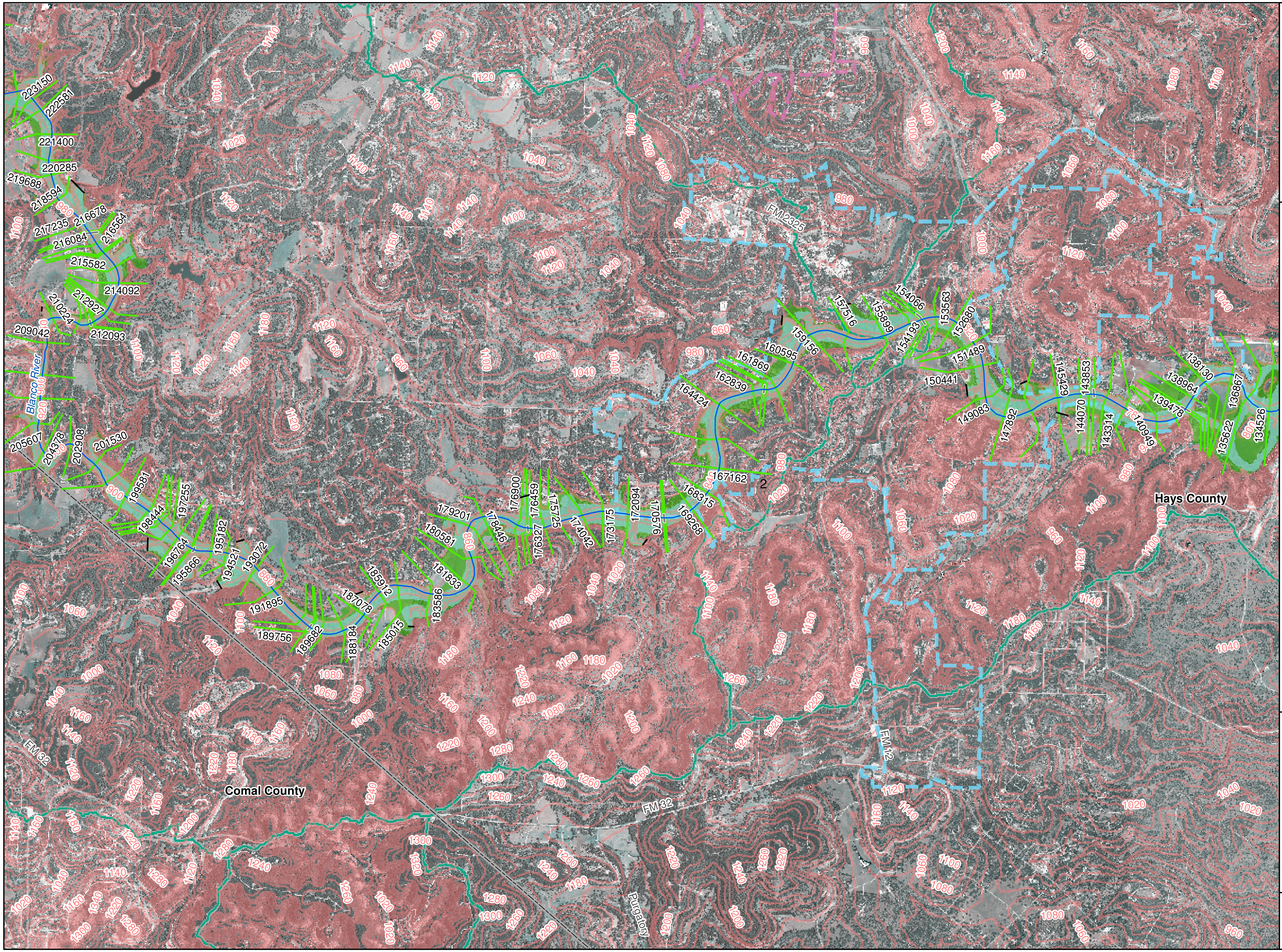
Blanco River

N
W E
S

0 2,000 4,000
Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\Blanco_FigureX_HydraulicWorkmap.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

- RAS Structures
- Blanco Cross Sections
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Wimberley
- Woodcreek

Phase I Hydraulic Work Map

Blanco River

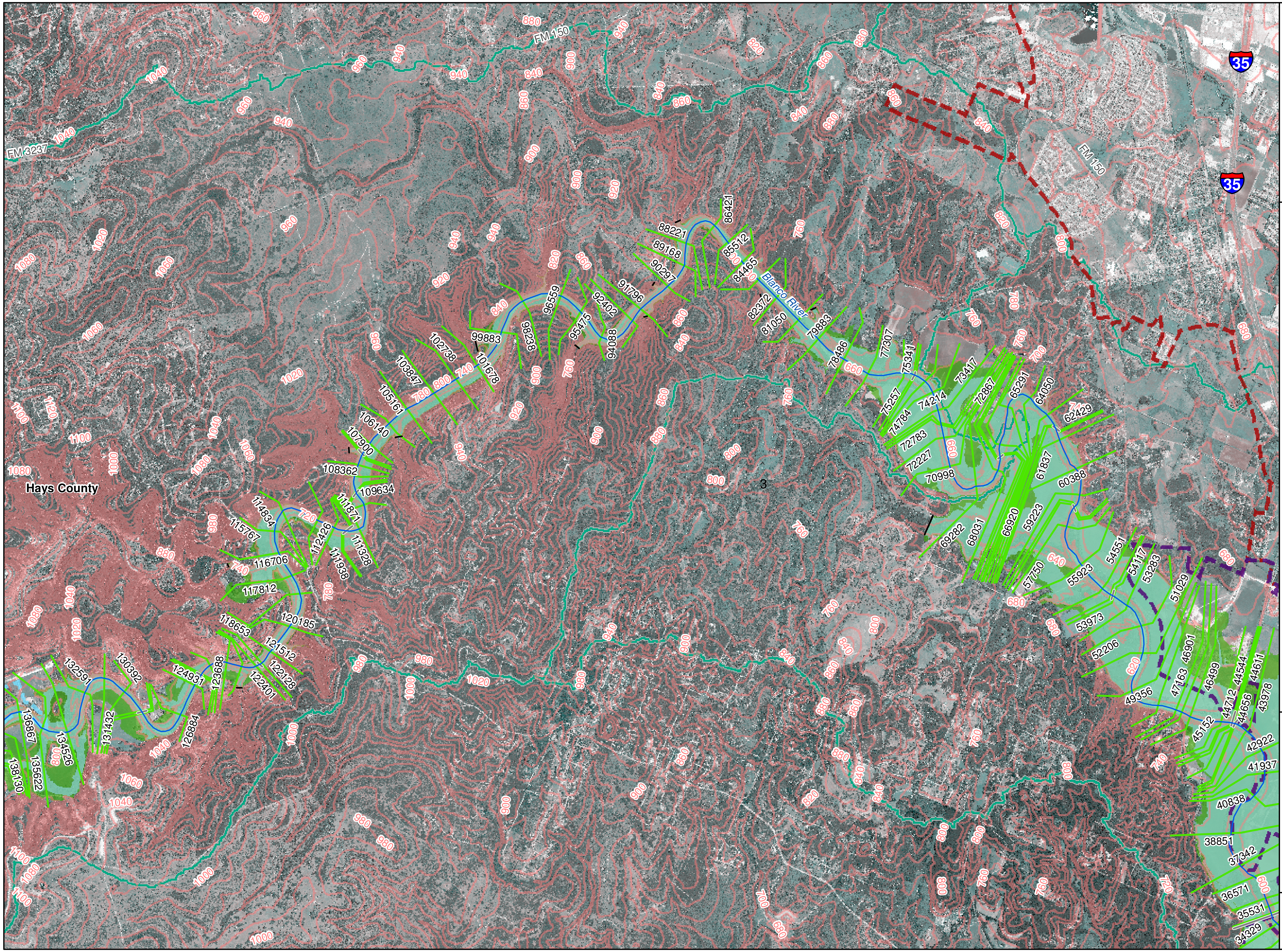
N W E S

0 2,000 4,000

Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\Blanco_FigureX_HydraulicWorkmap.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

- RAS Structures
- Blanco Cross Sections
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Kyle
- San Marcos
- Wimberley

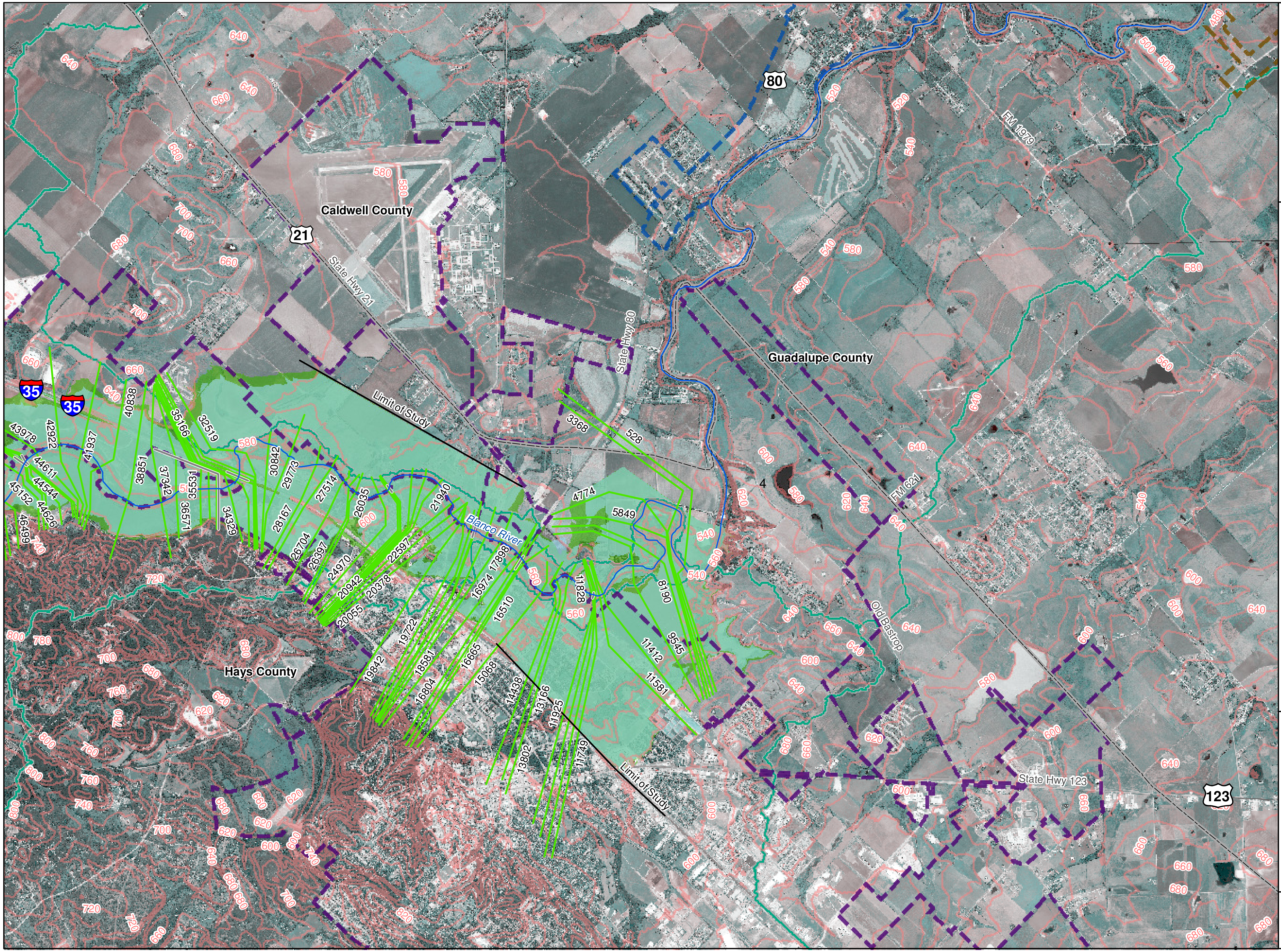
Phase I Hydraulic Work Map

Blanco River

0 2,000 4,000
Feet

HALFF

N:\28000s\28411\GIS\MXDs\Exhibits\WorkMaps_Index\Blanco_FigureX_HydraulicWorkmap.mxd



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GBRA Interim Feasibility Study - Phase I

Legend

- RAS Structures
- Blanco Cross Sections
- County
- Watershed Subbasins
- 20ft Contour
- 1% Floodplain
- 0.2% Floodplain

Jurisdictions

- Martindale
- San Marcos
- Staples

Phase I Hydraulic Work Map

Blanco River

0 2,000 4,000
Feet

HALFF

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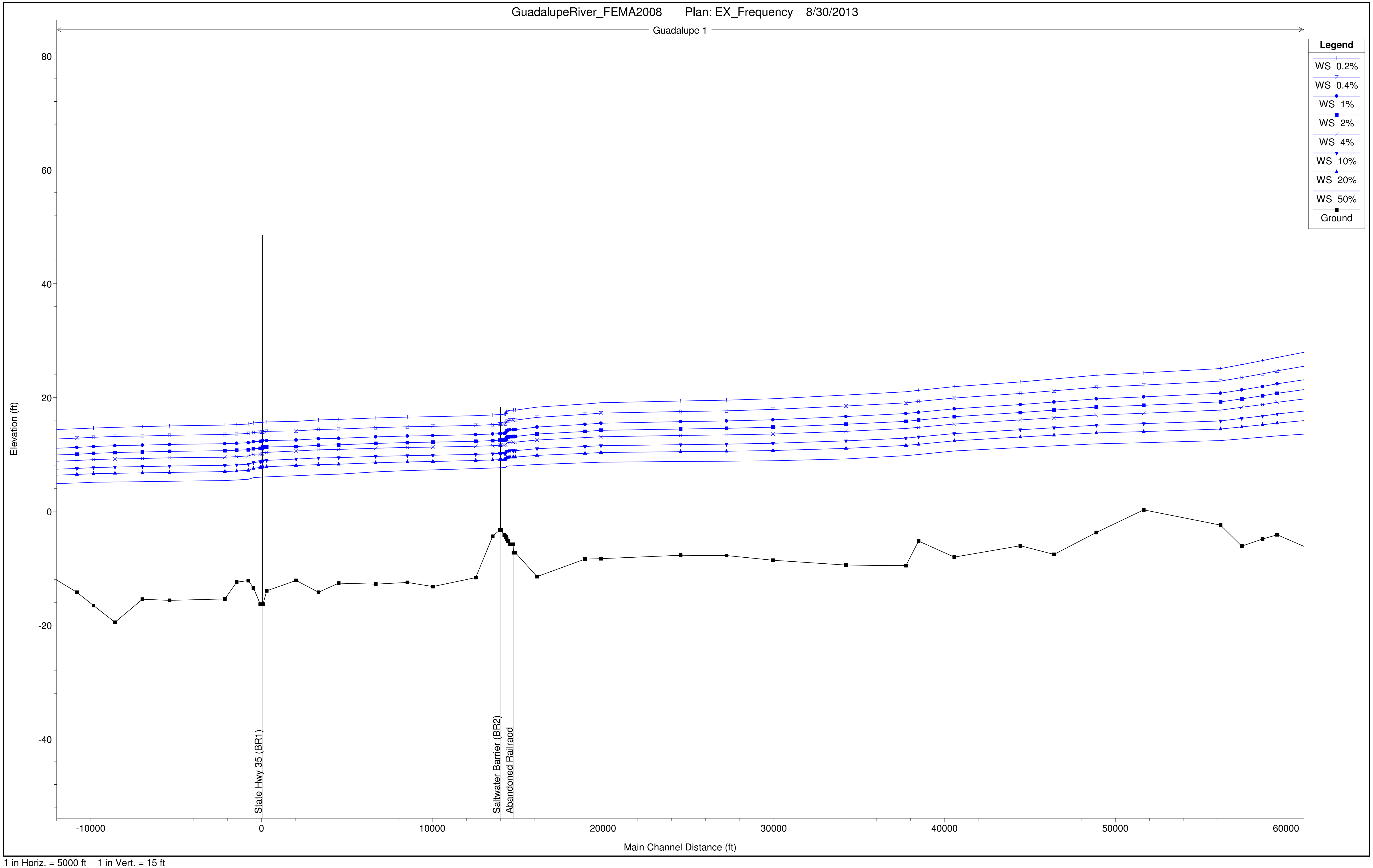
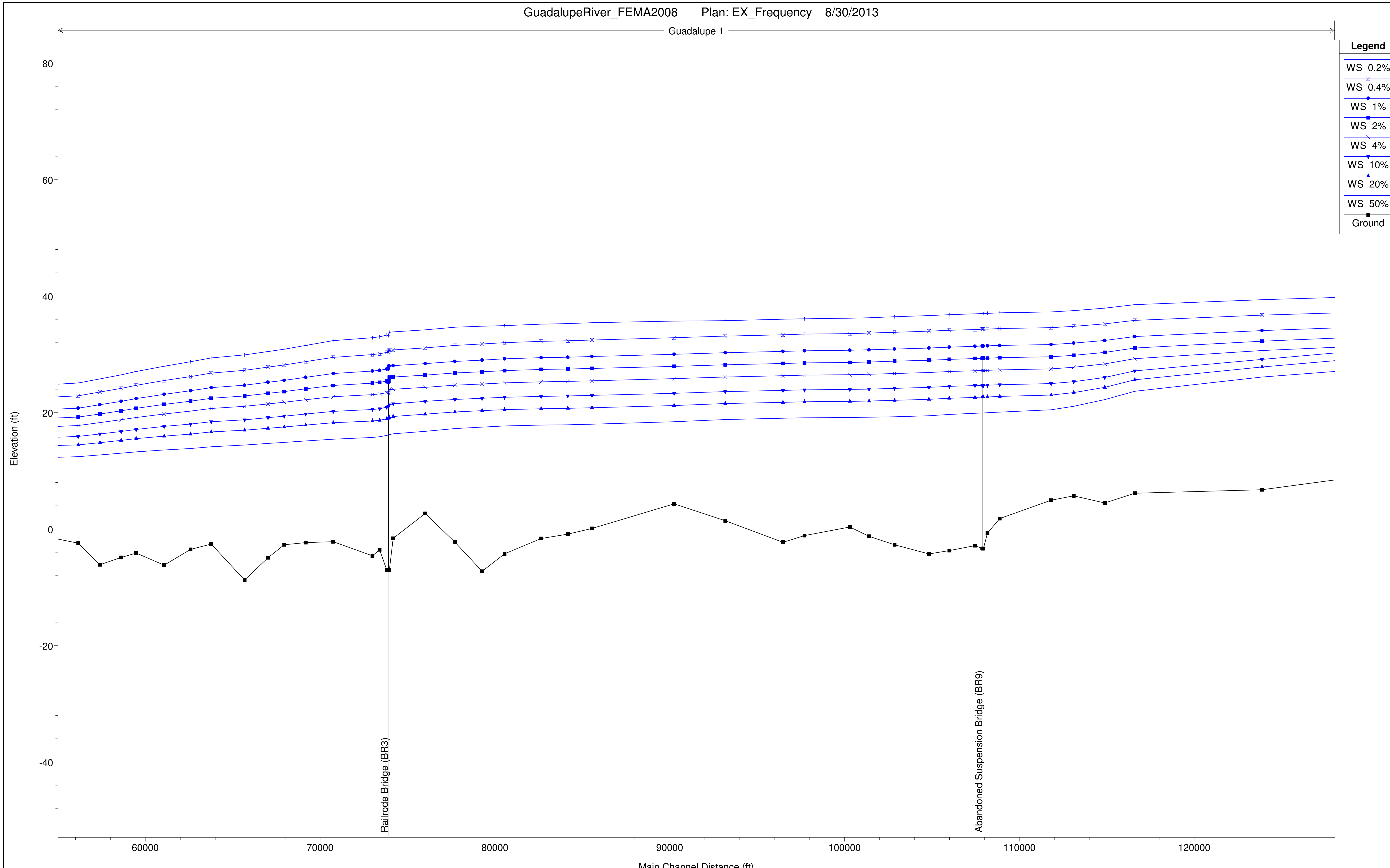
Appendix D.1.2.b
HEC-RAS Water Surface Profiles

Guadalupe River
HEC-RAS Water Surface Profiles

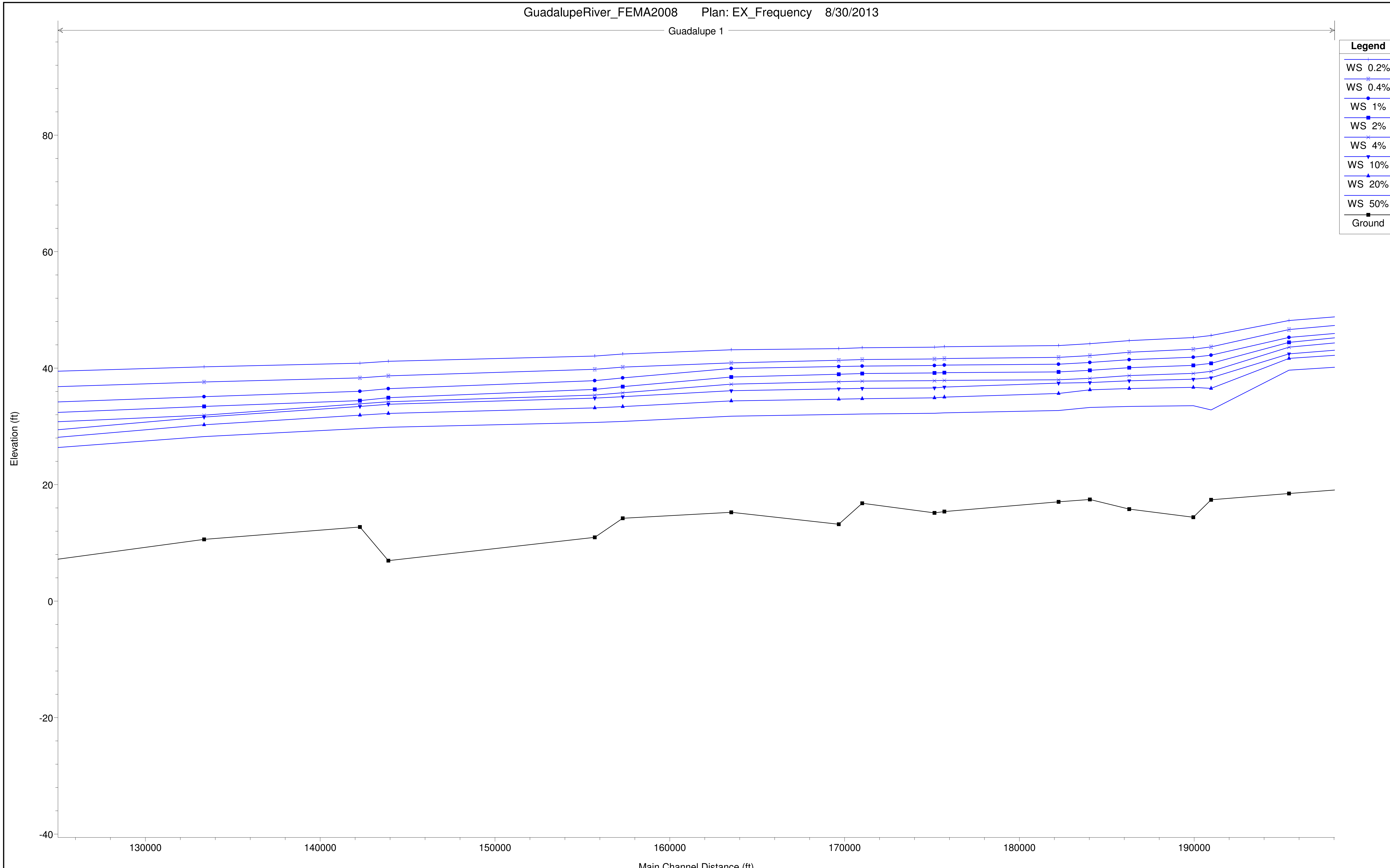
HALFF



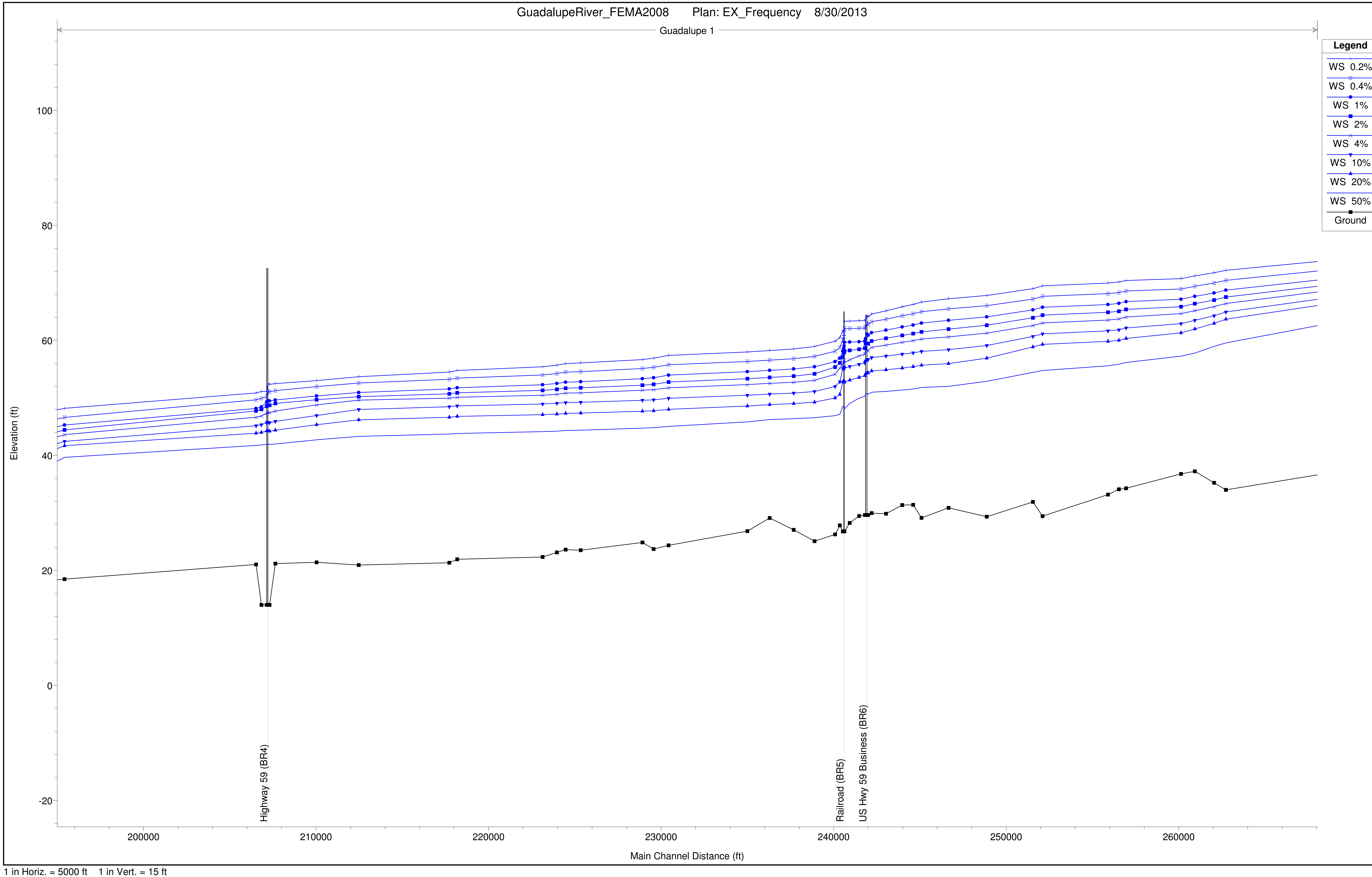
GuadalupeRiver_FEMA2008 Plan: EX_Frequency 8/30/2013
Guadalupe 1
Legend
WS 0.2%
WS 0.4%
WS 1%
WS 2%
WS 4%
WS 10%
WS 20%
WS 50%
Ground
Elevation (ft)
80
60
40
20
0
-20
-40
State Hwy 35 (BR1)
Saltwater Barrier (BR2)
Abandoned Railraod
-10000
0
10000
20000
30000
40000
50000
60000
Main Channel Distance (ft)
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

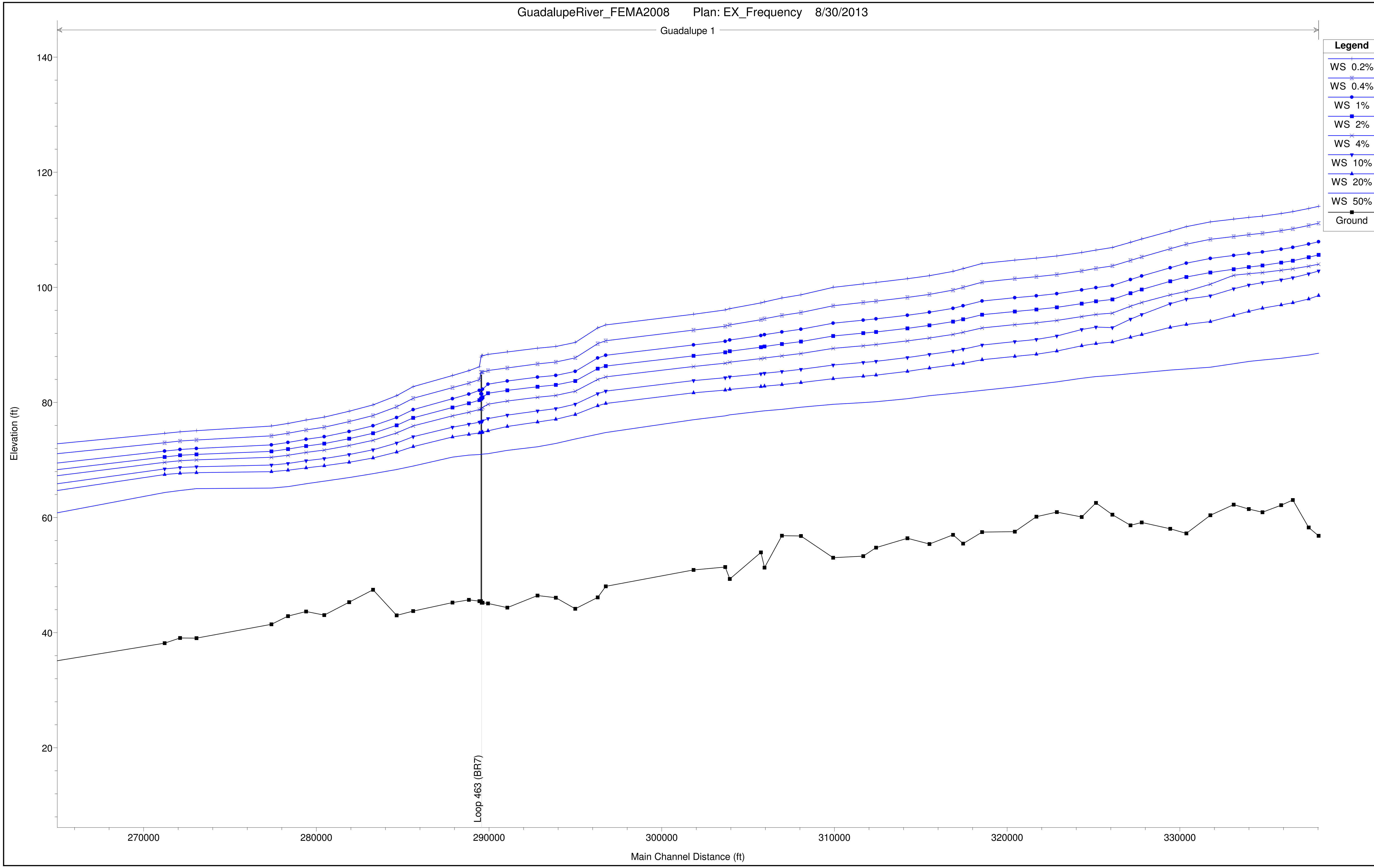


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

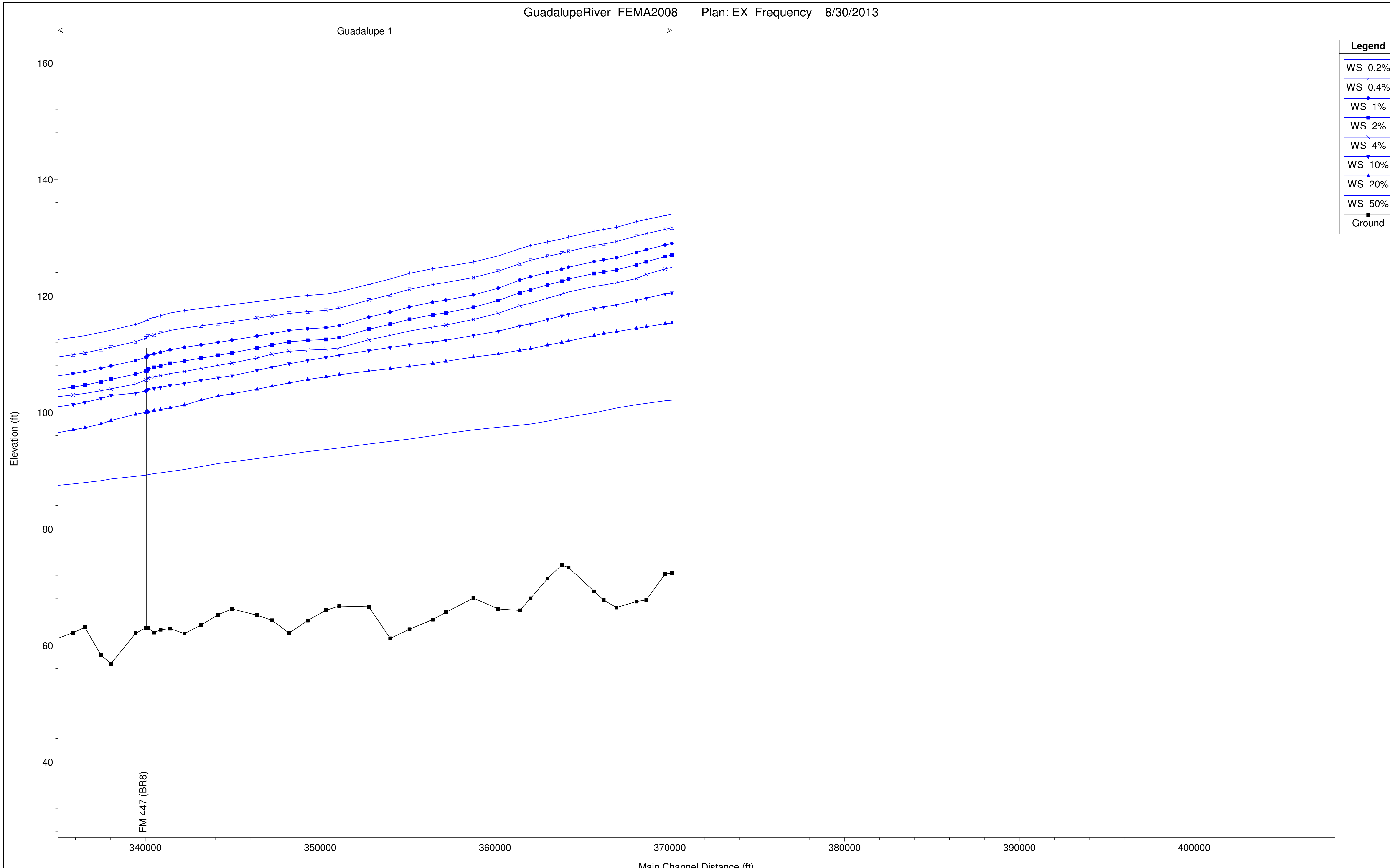


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

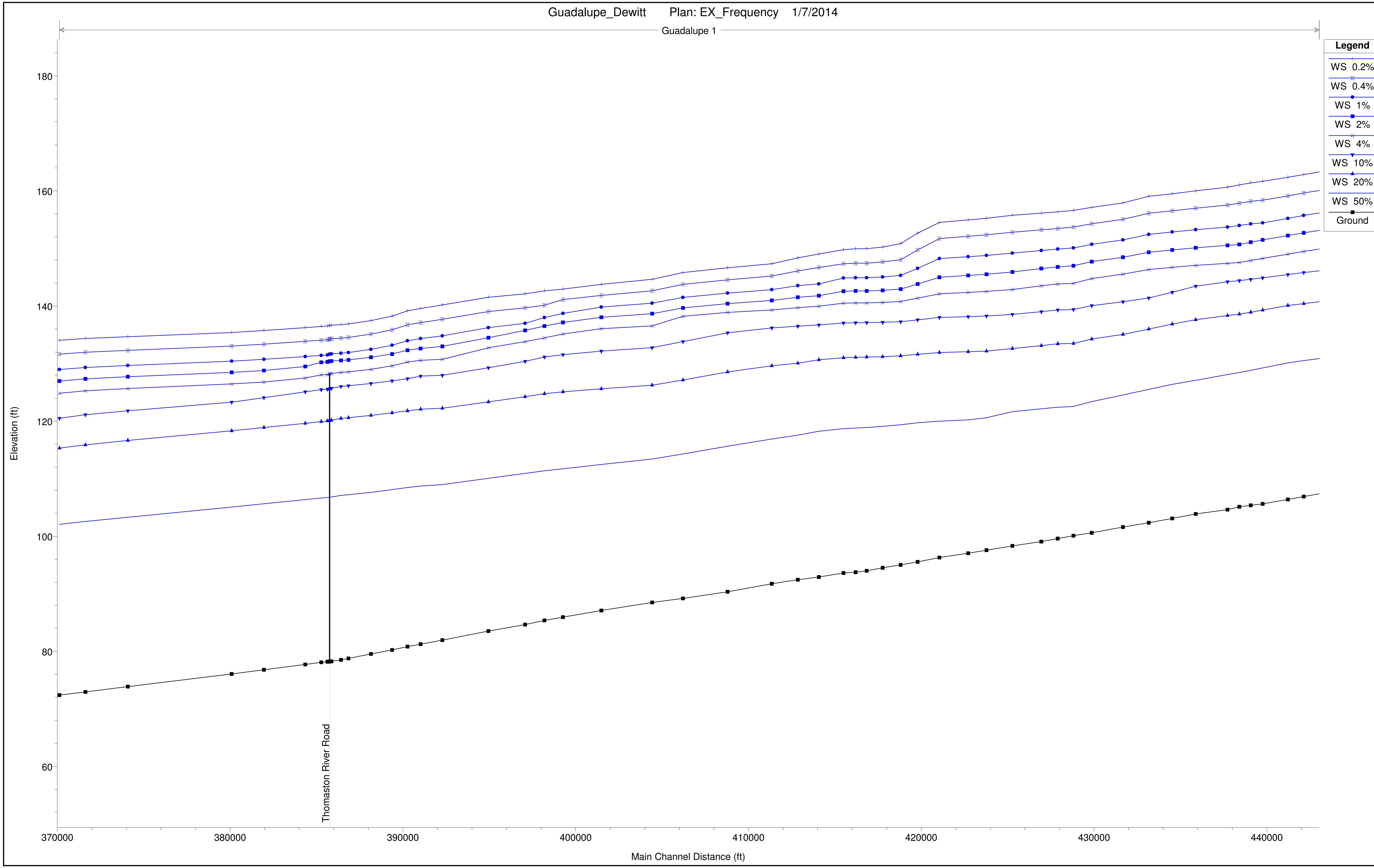

GuadalupeRiver_FEMA2008 Plan: EX_Frequency 8/30/2013
Guadalupe 1
Legend
WS 0.2%
WS 0.4%
WS 1%
WS 2%
WS 4%
WS 10%
WS 20%
WS 50%
Ground
Elevation (ft)
100
80
60
40
20
0
-20
Highway 59 (BR4)
Railroad (BR5)
US Hwy 59 Business (BR6)
200000
210000
220000
230000
240000
250000
260000
Main Channel Distance (ft)
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



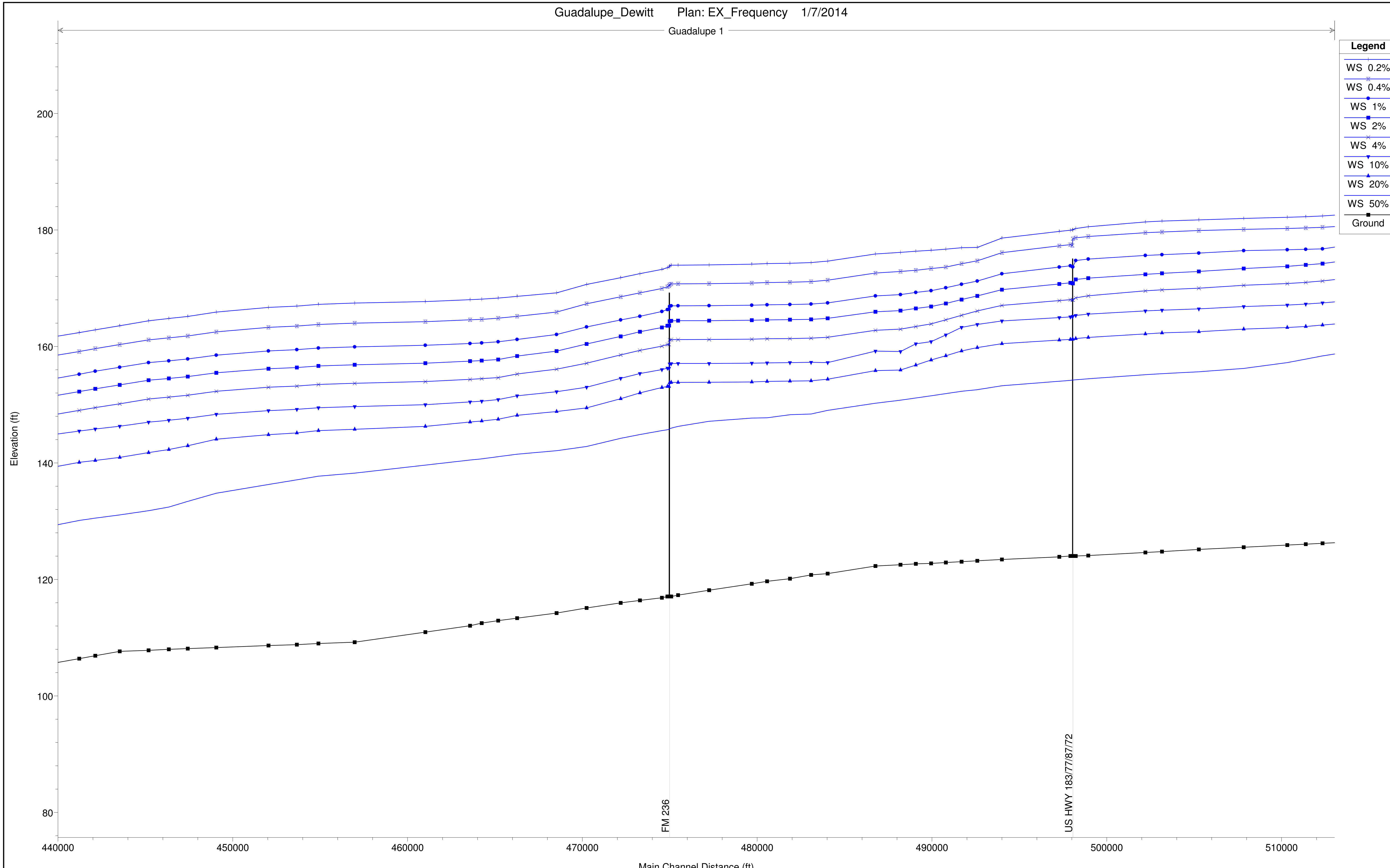
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



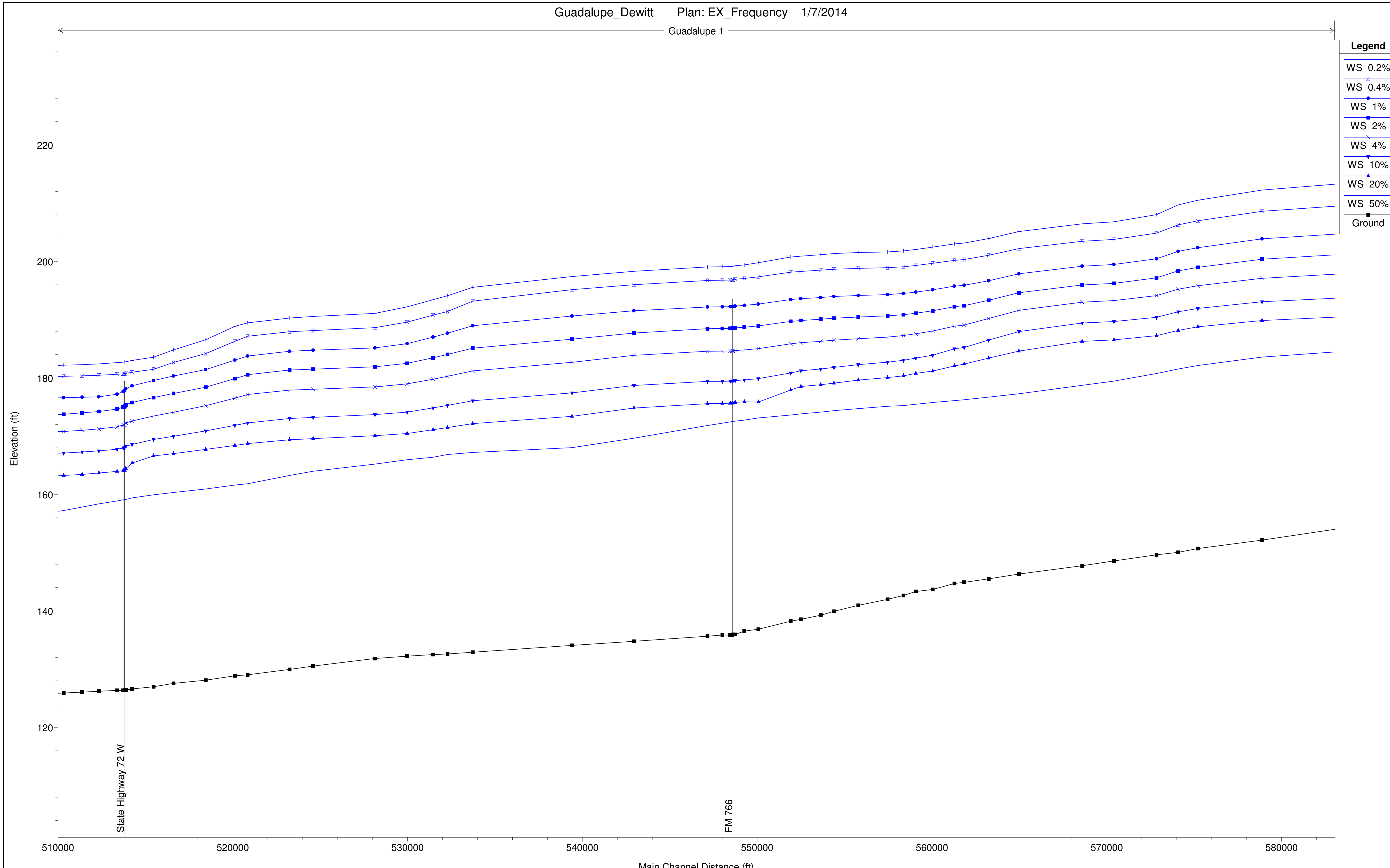
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



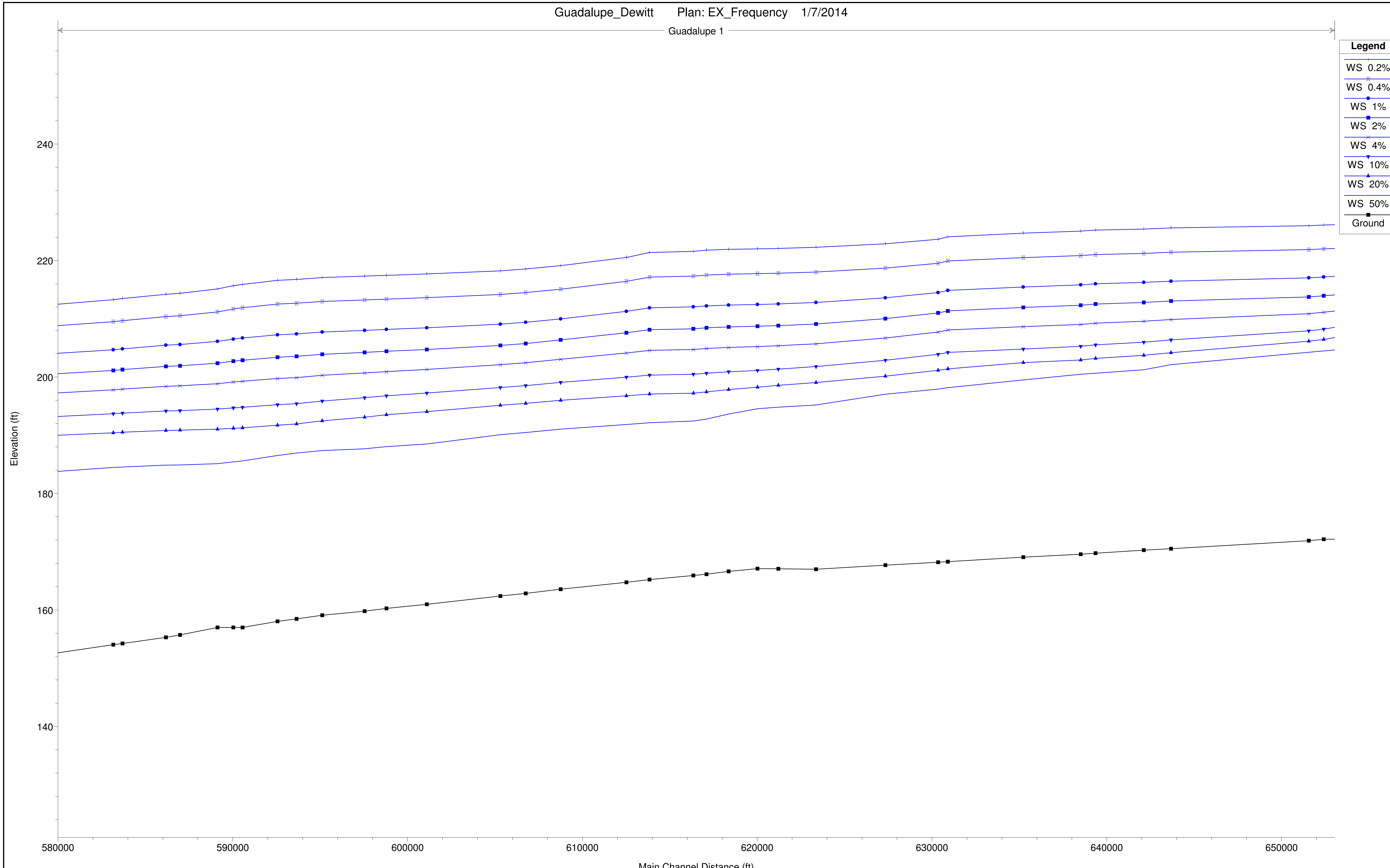
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



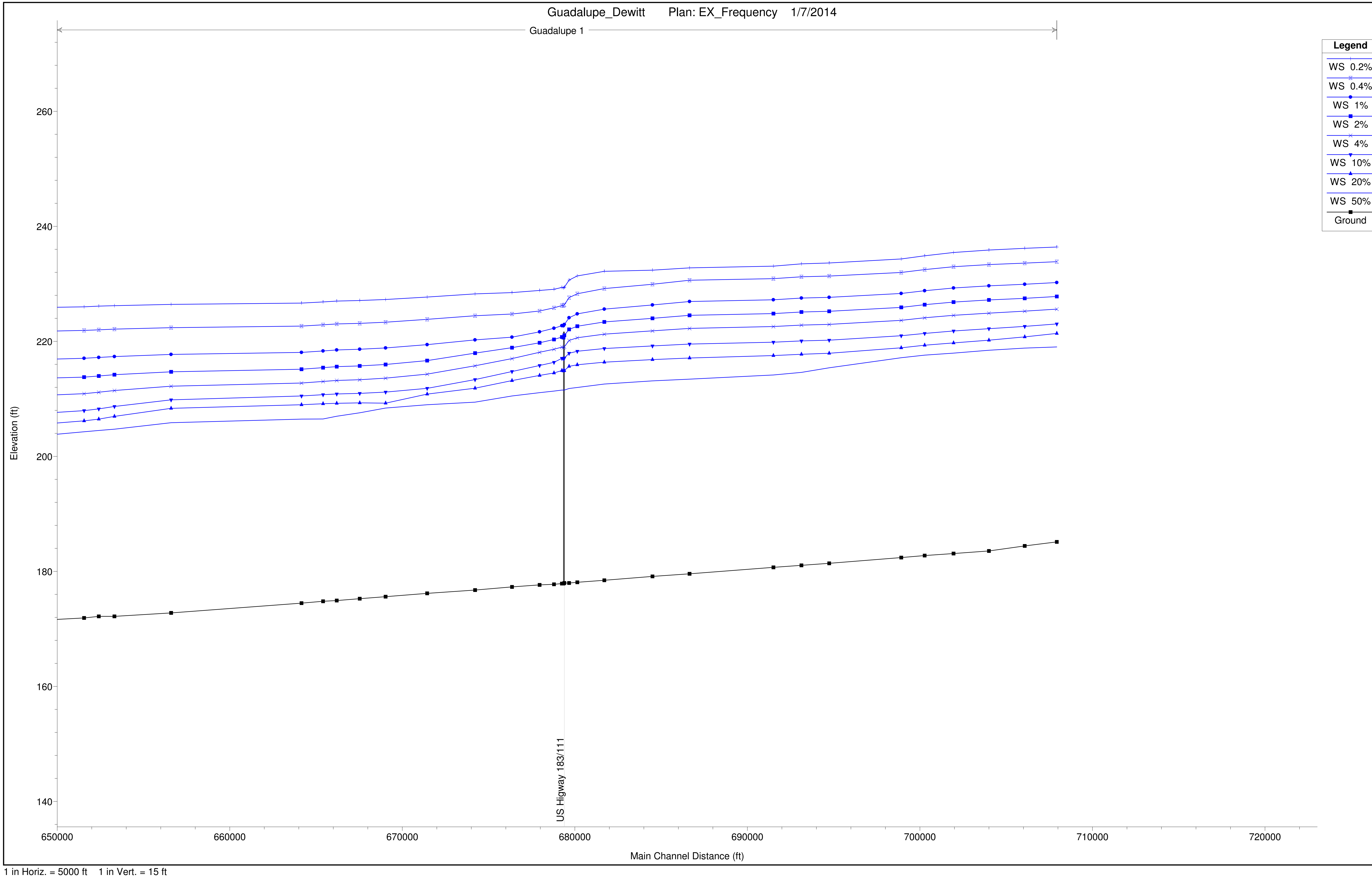
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

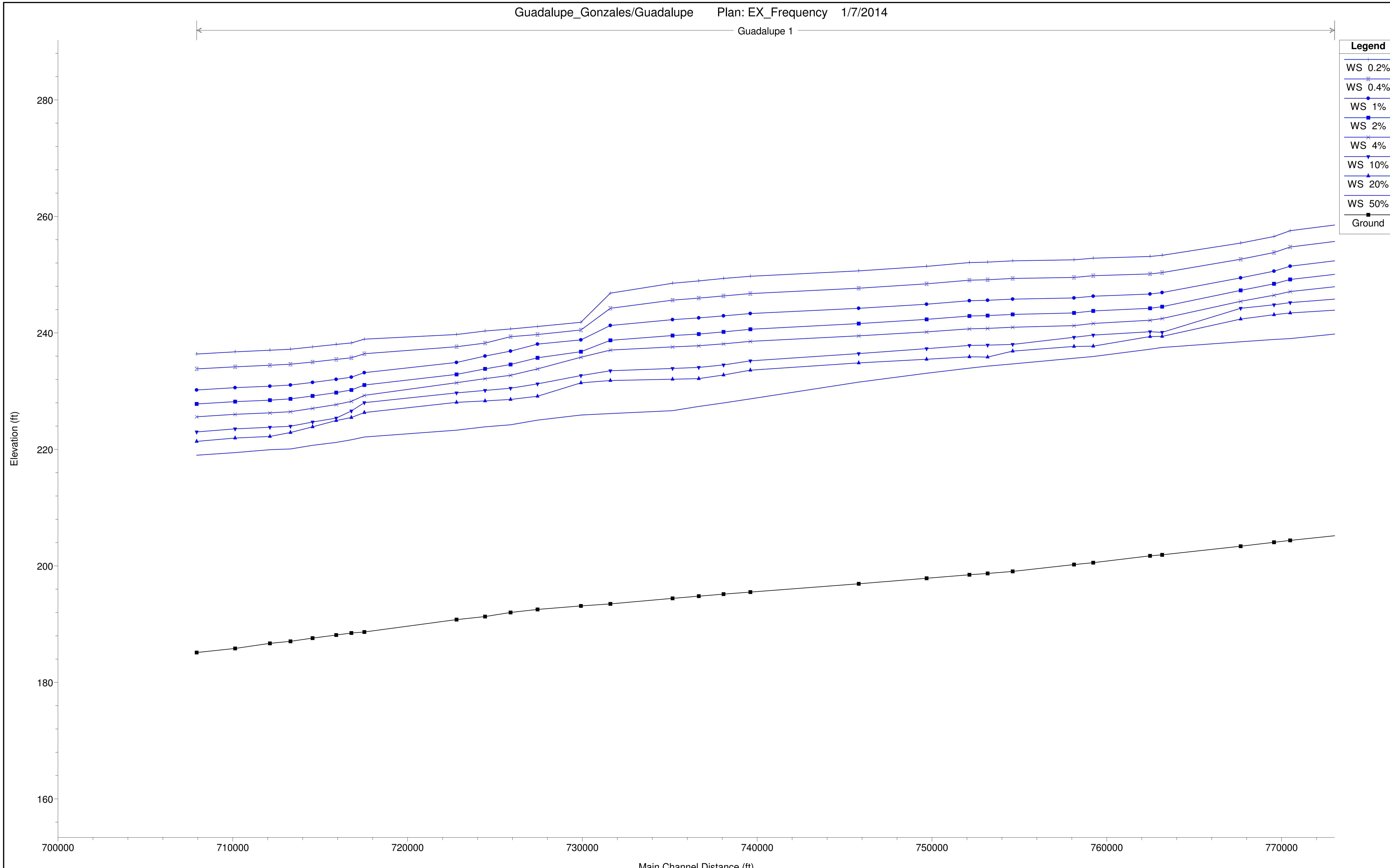


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

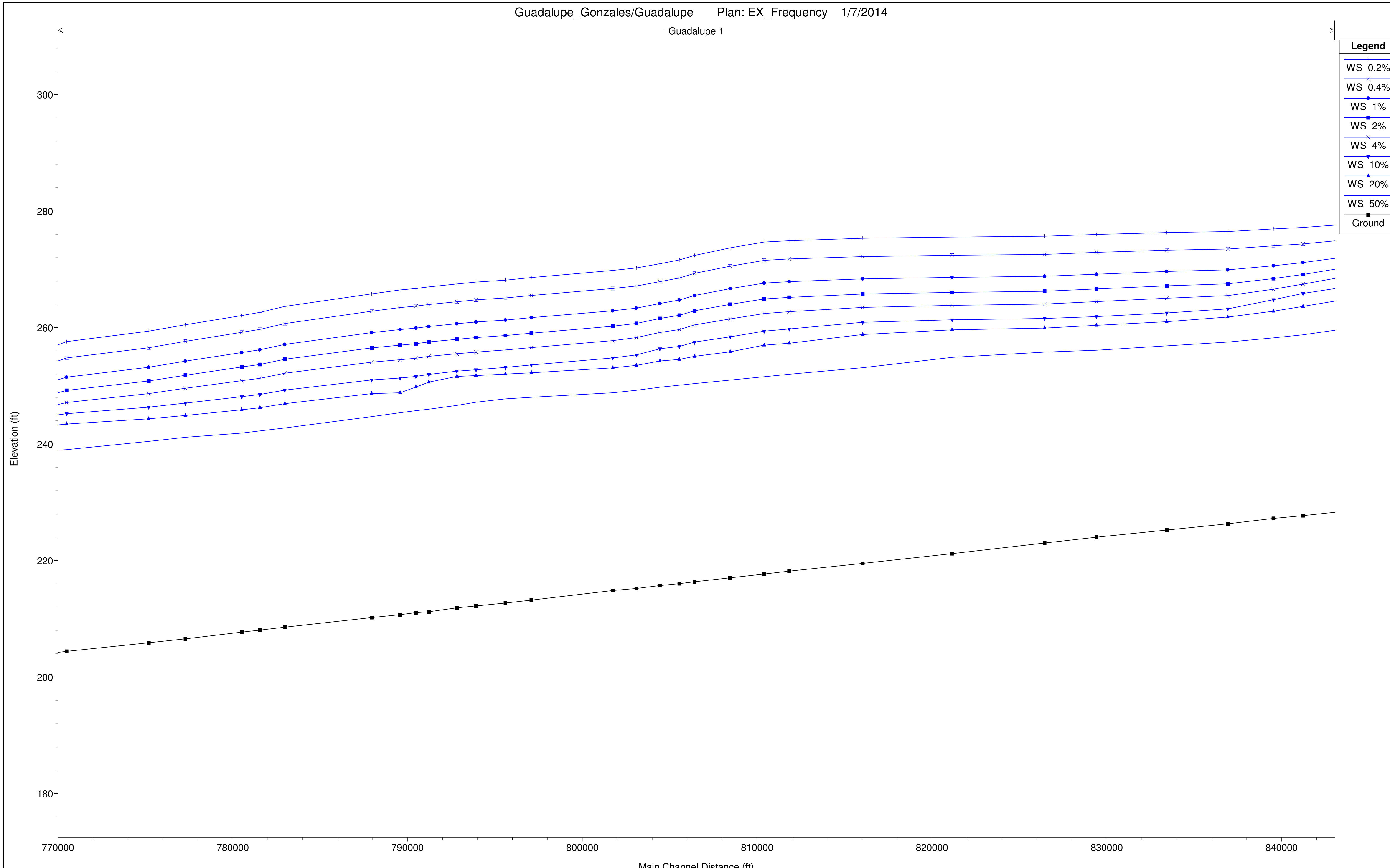


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

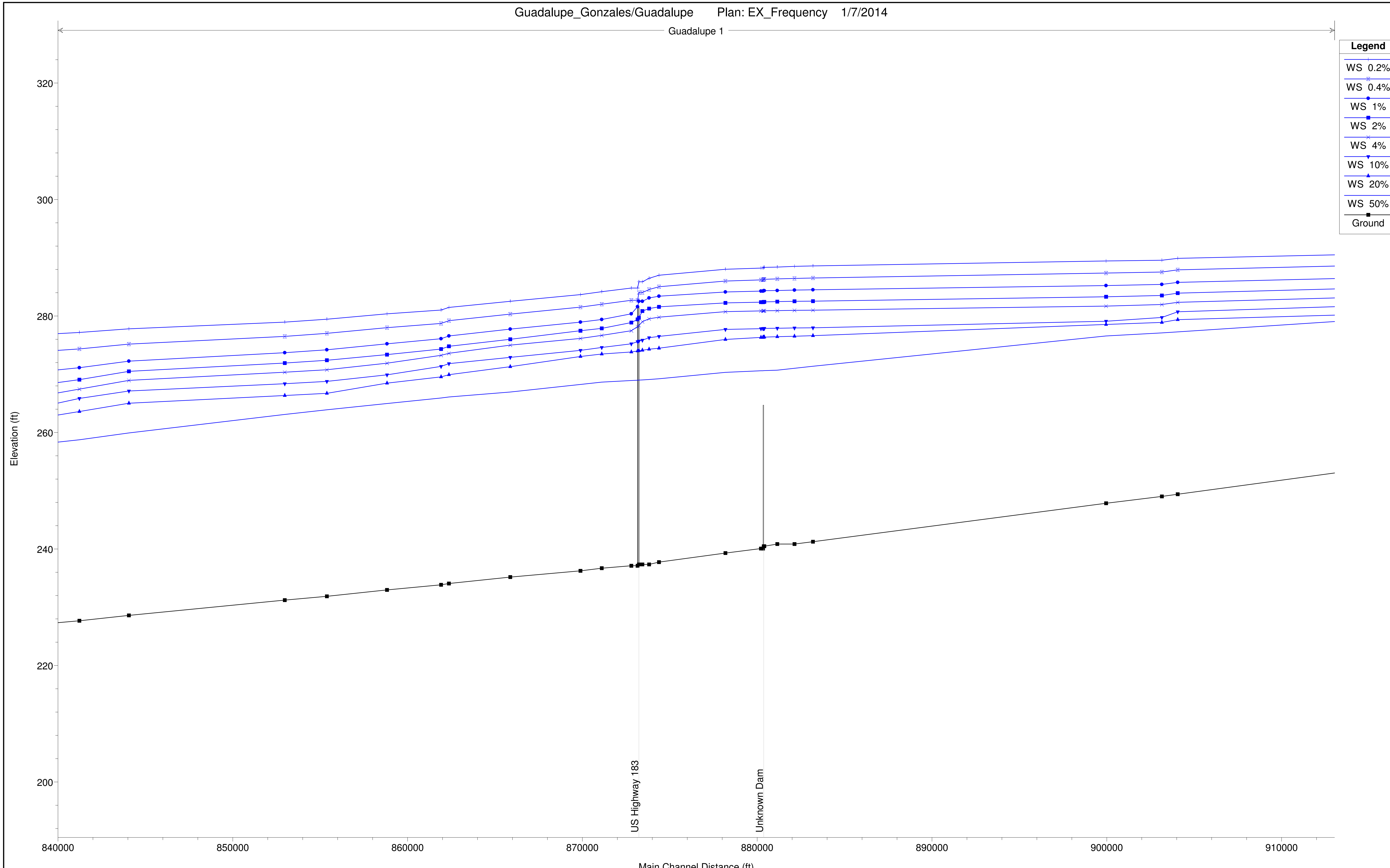

Guadalupe_Dewitt Plan: EX_Frequency 1/7/2014
Guadalupe 1
Legend
WS 0.2%
WS 0.4%
WS 1%
WS 2%
WS 4%
WS 10%
WS 20%
WS 50%
Ground
Elevation (ft)
260
240
220
200
180
160
140
US Higway 183/111
650000
660000
670000
680000
690000
700000
710000
720000
Main Channel Distance (ft)
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



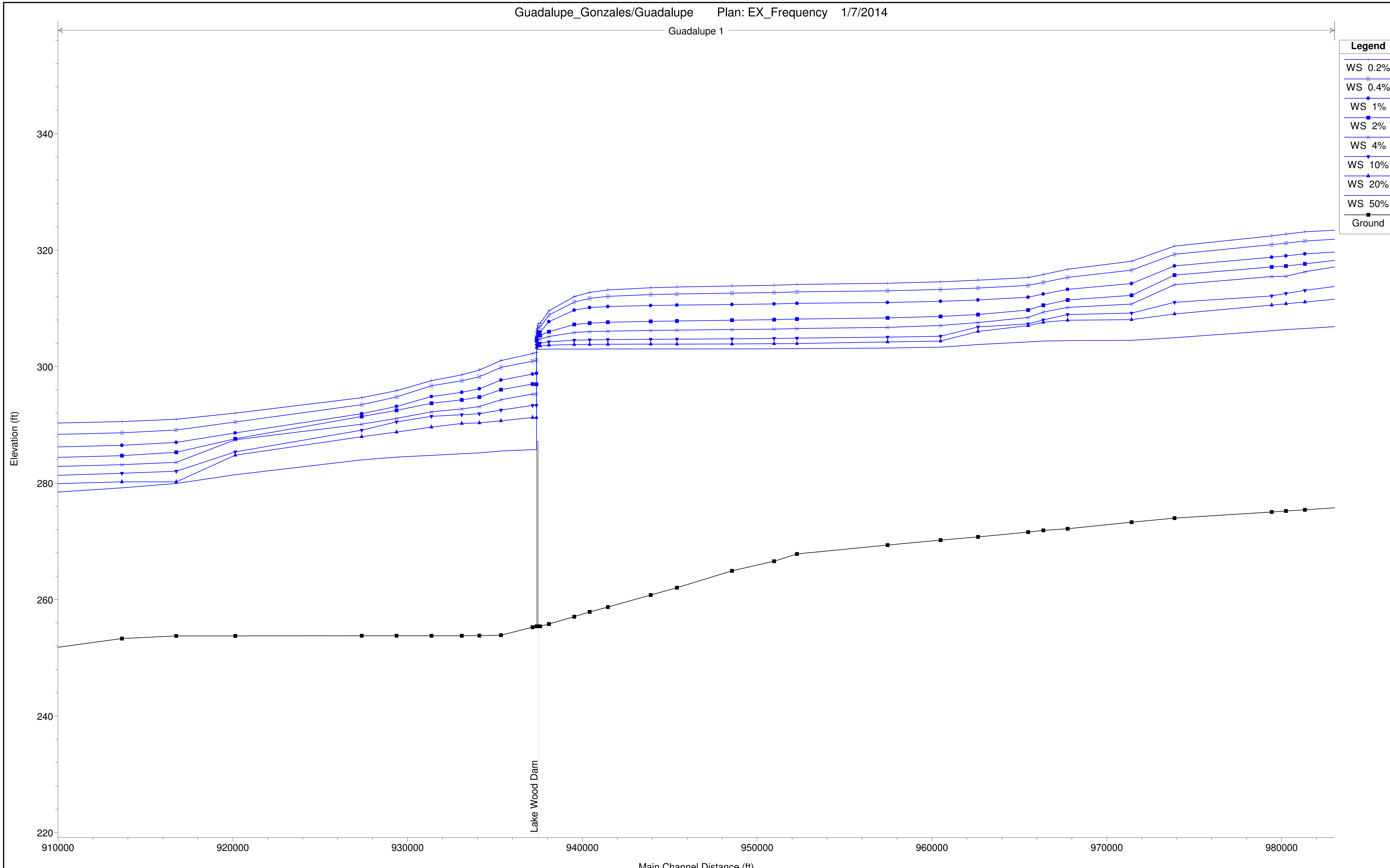
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



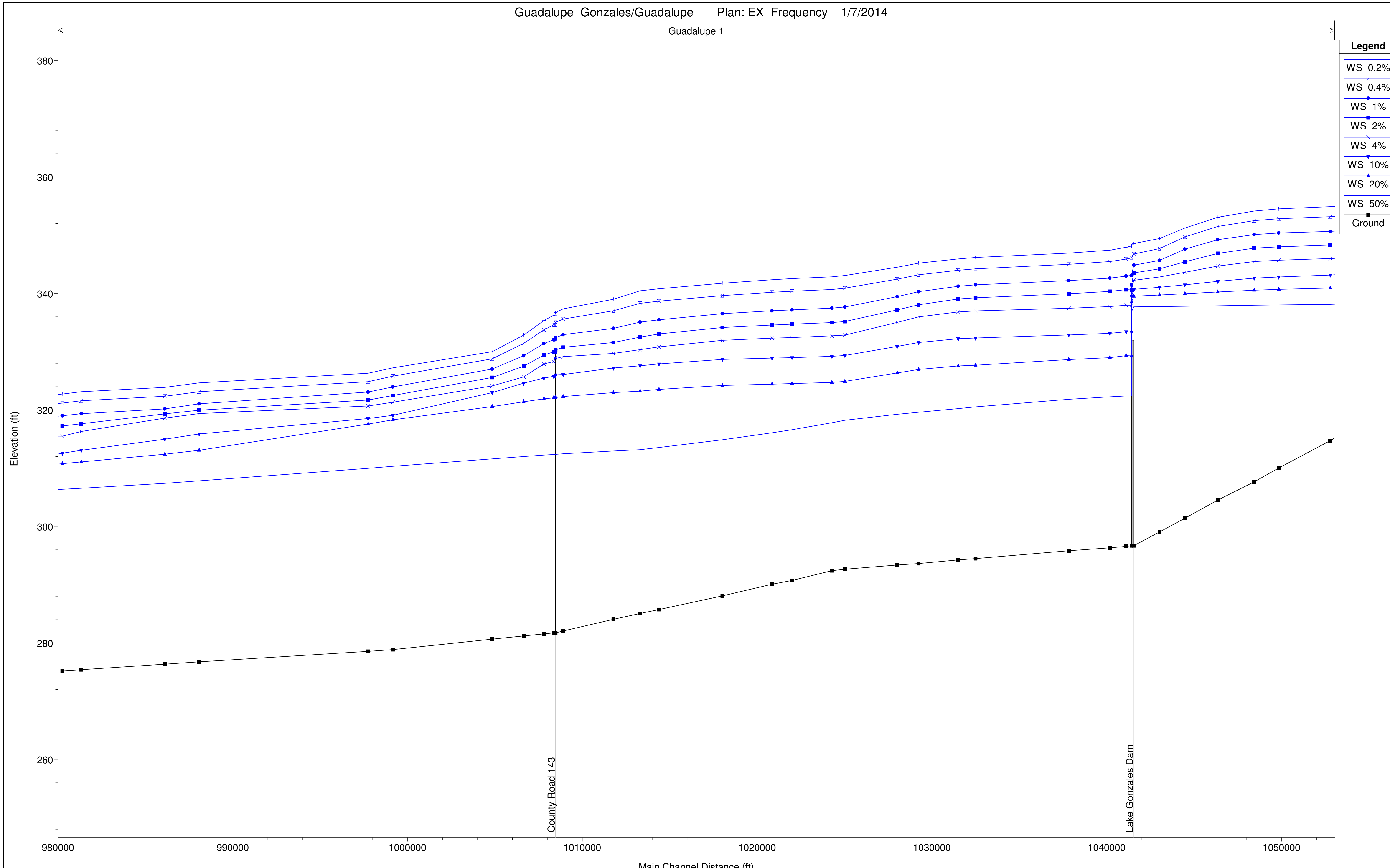
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

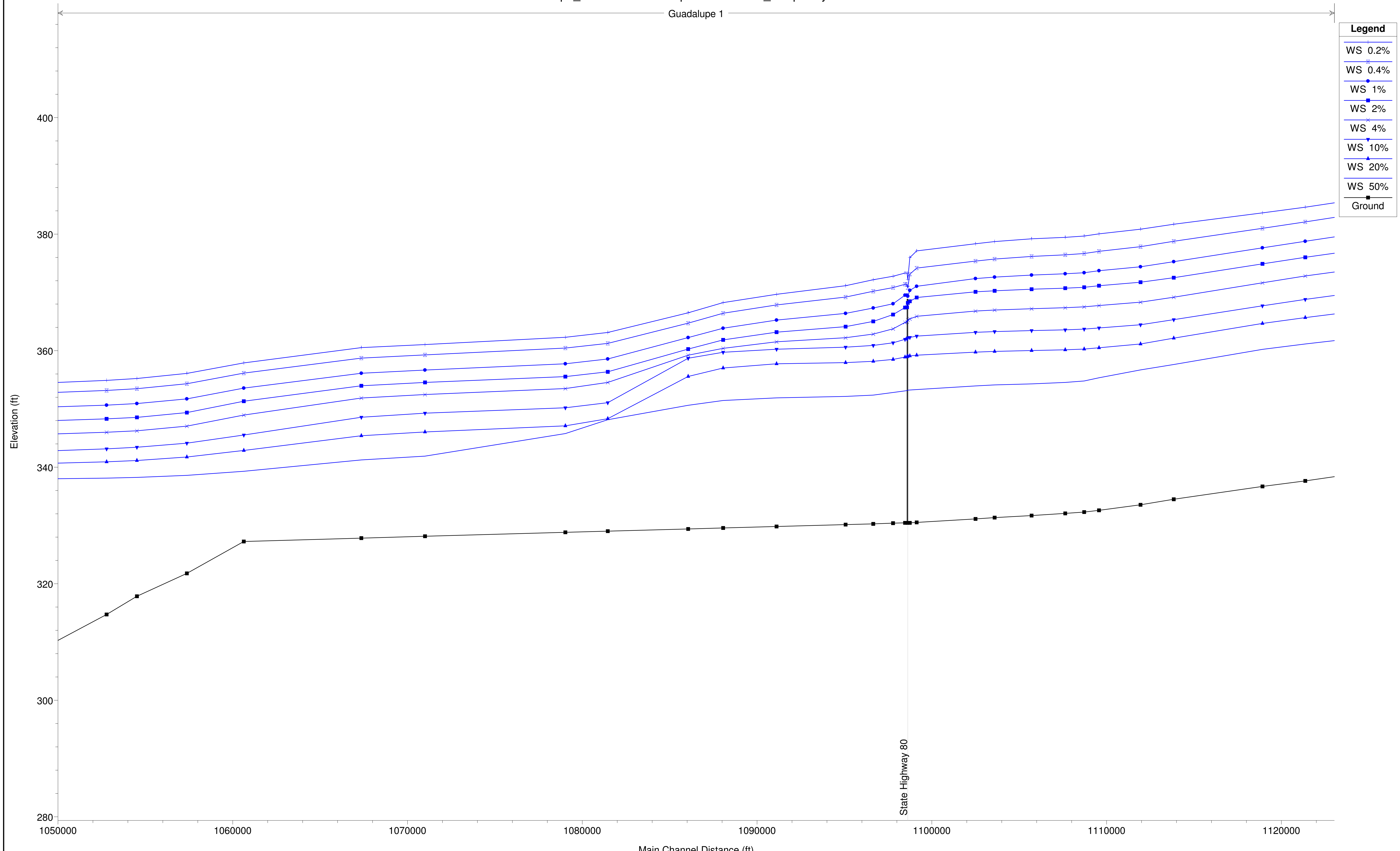


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

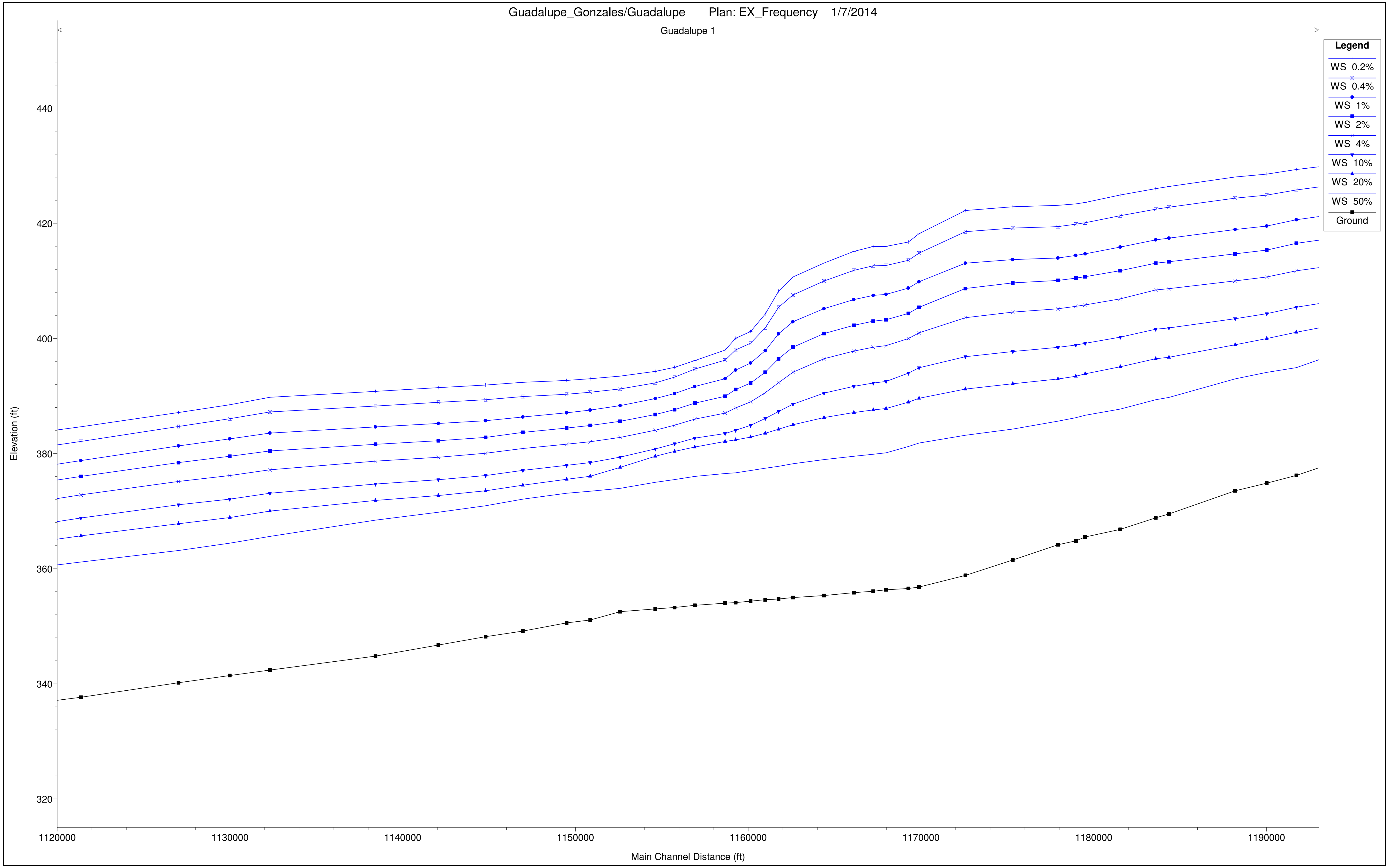


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

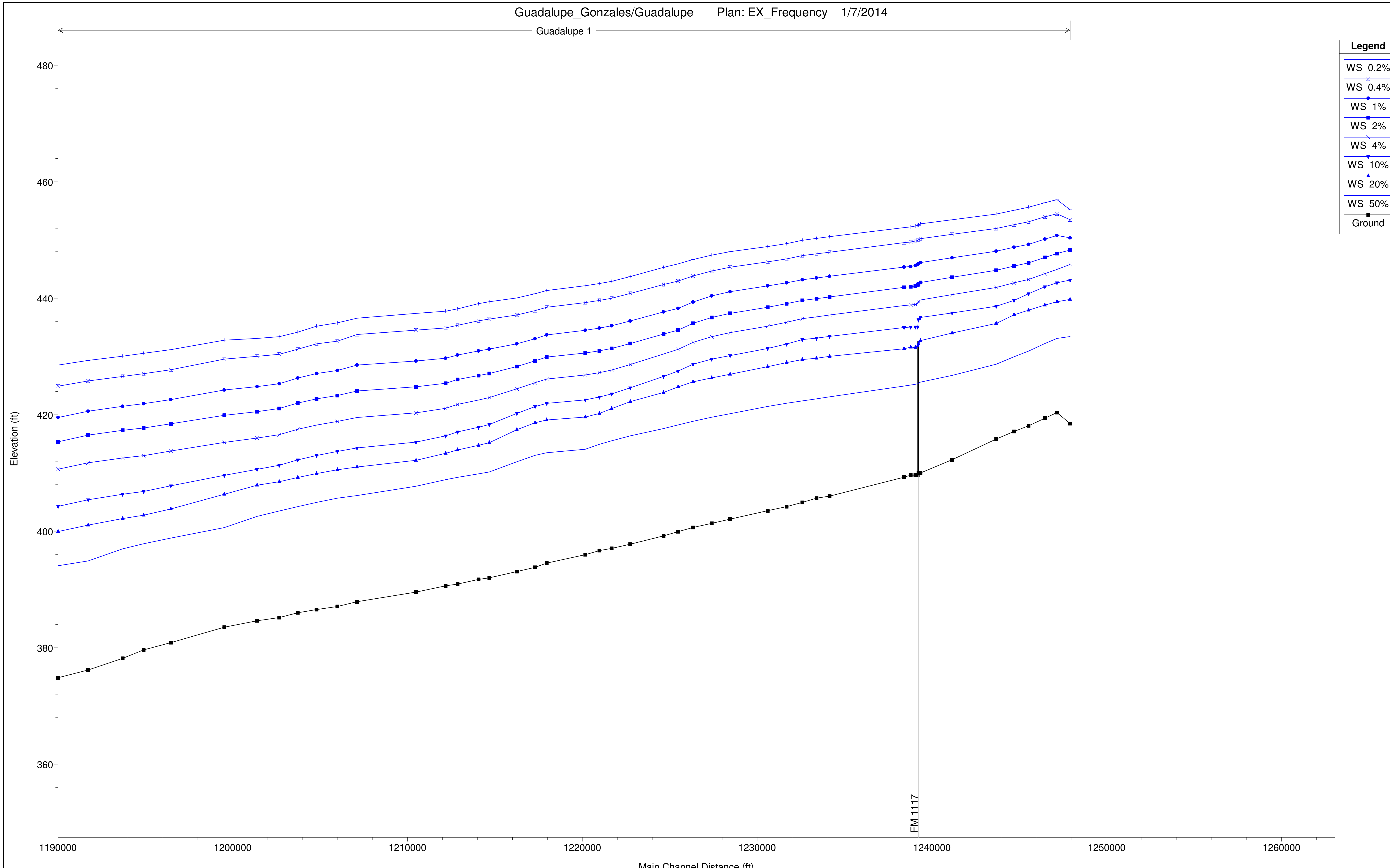
Guadalupe_Gonzales/Guadalupe Plan: EX_Frequency 1/7/2014



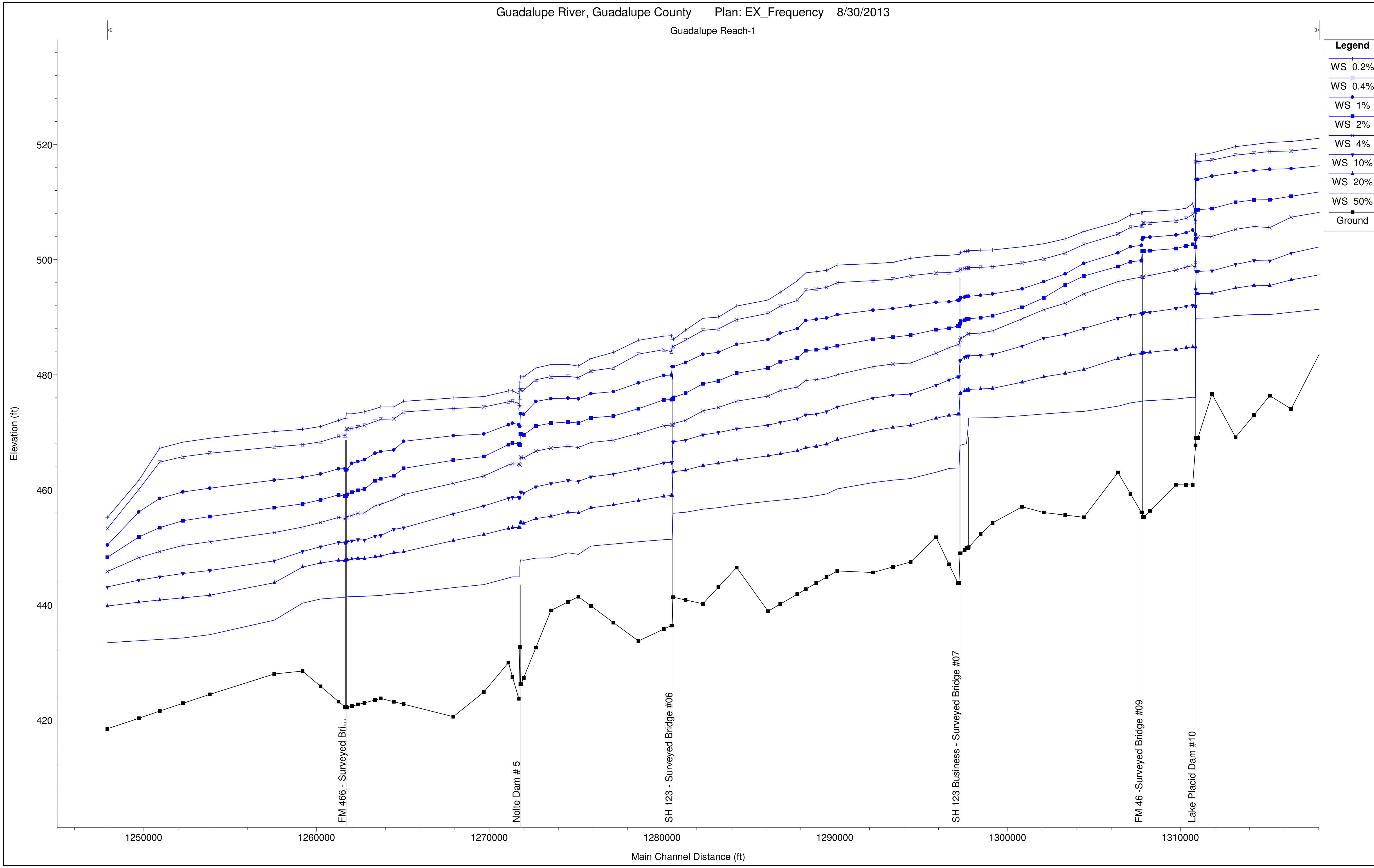
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



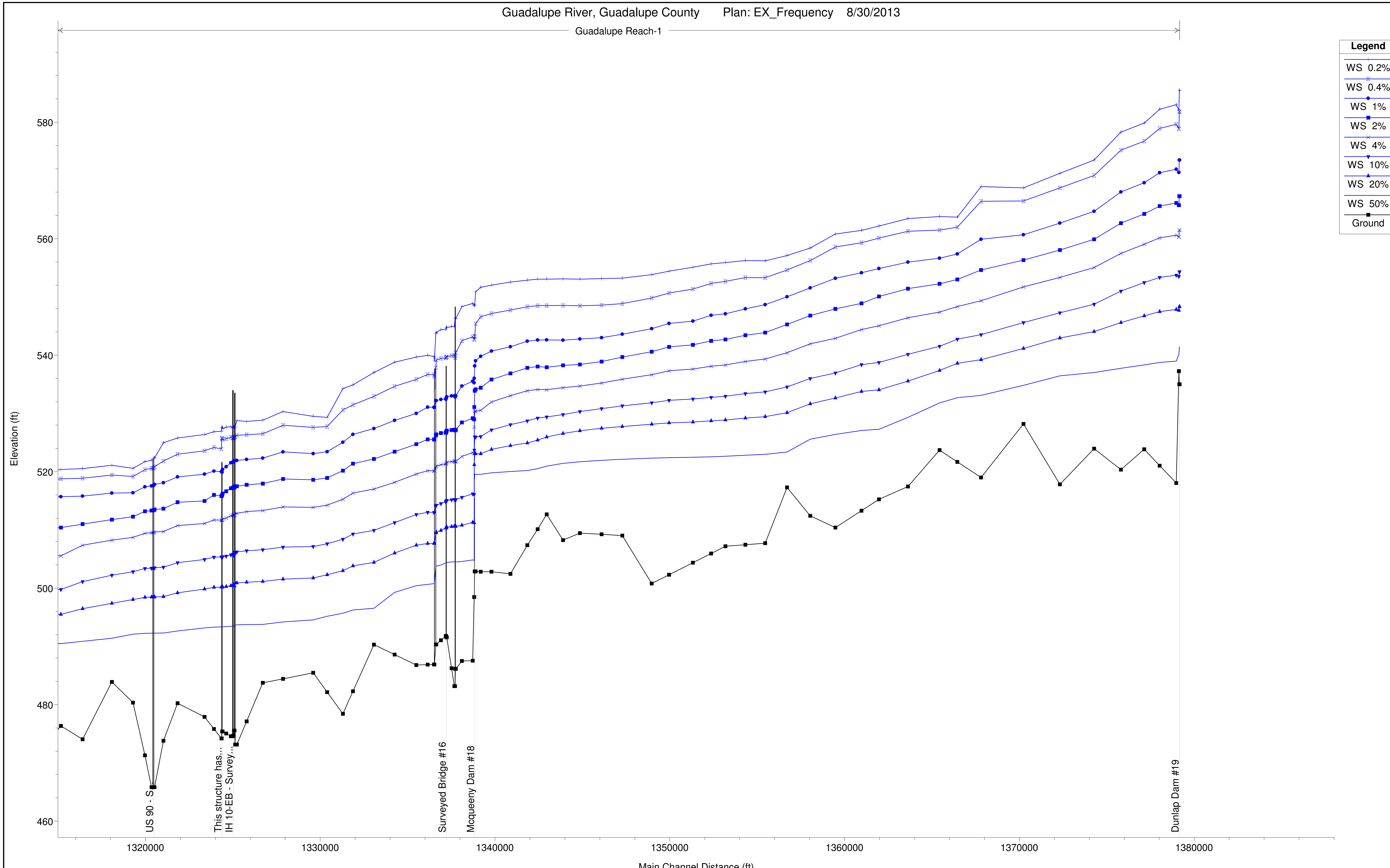
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



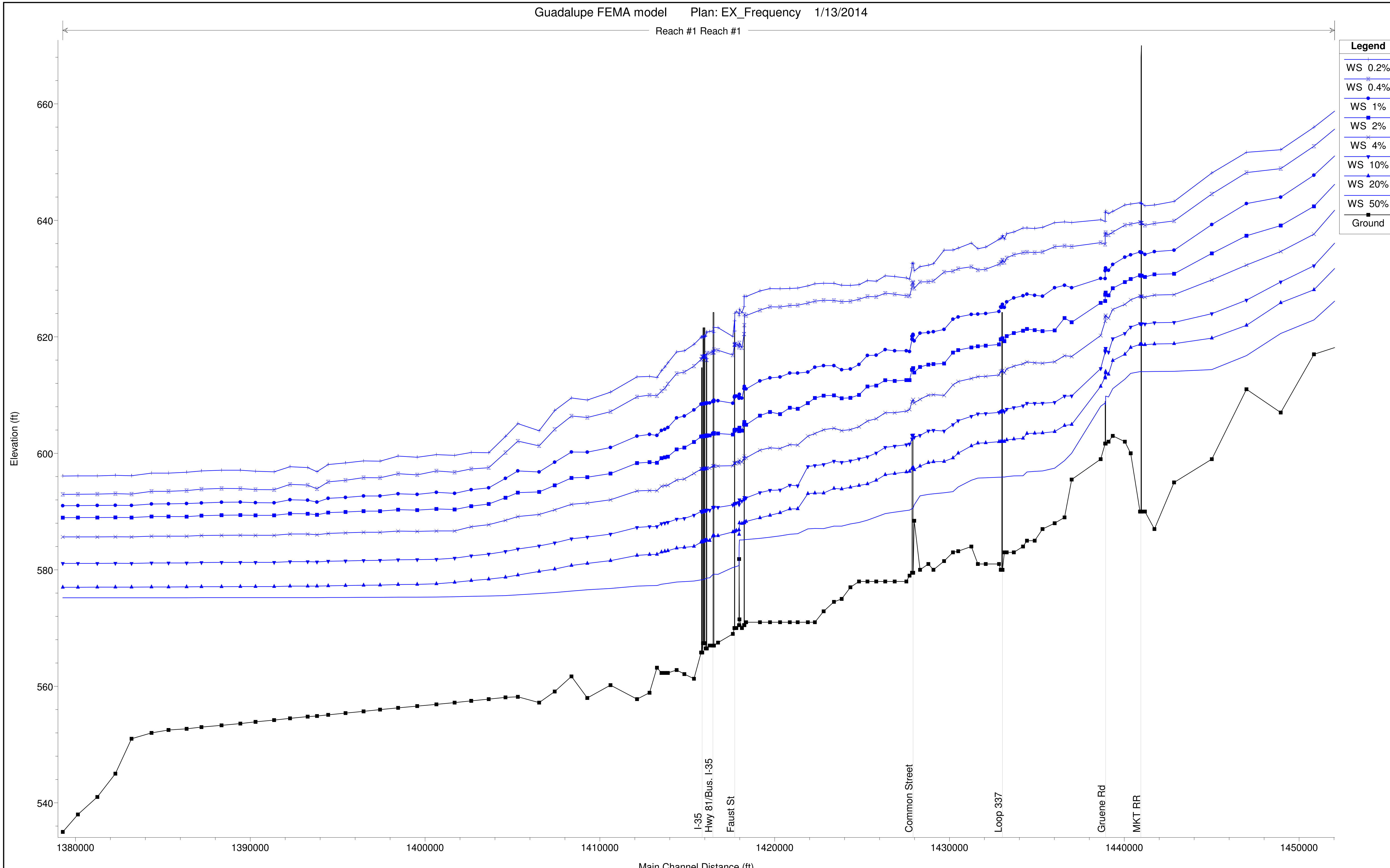
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



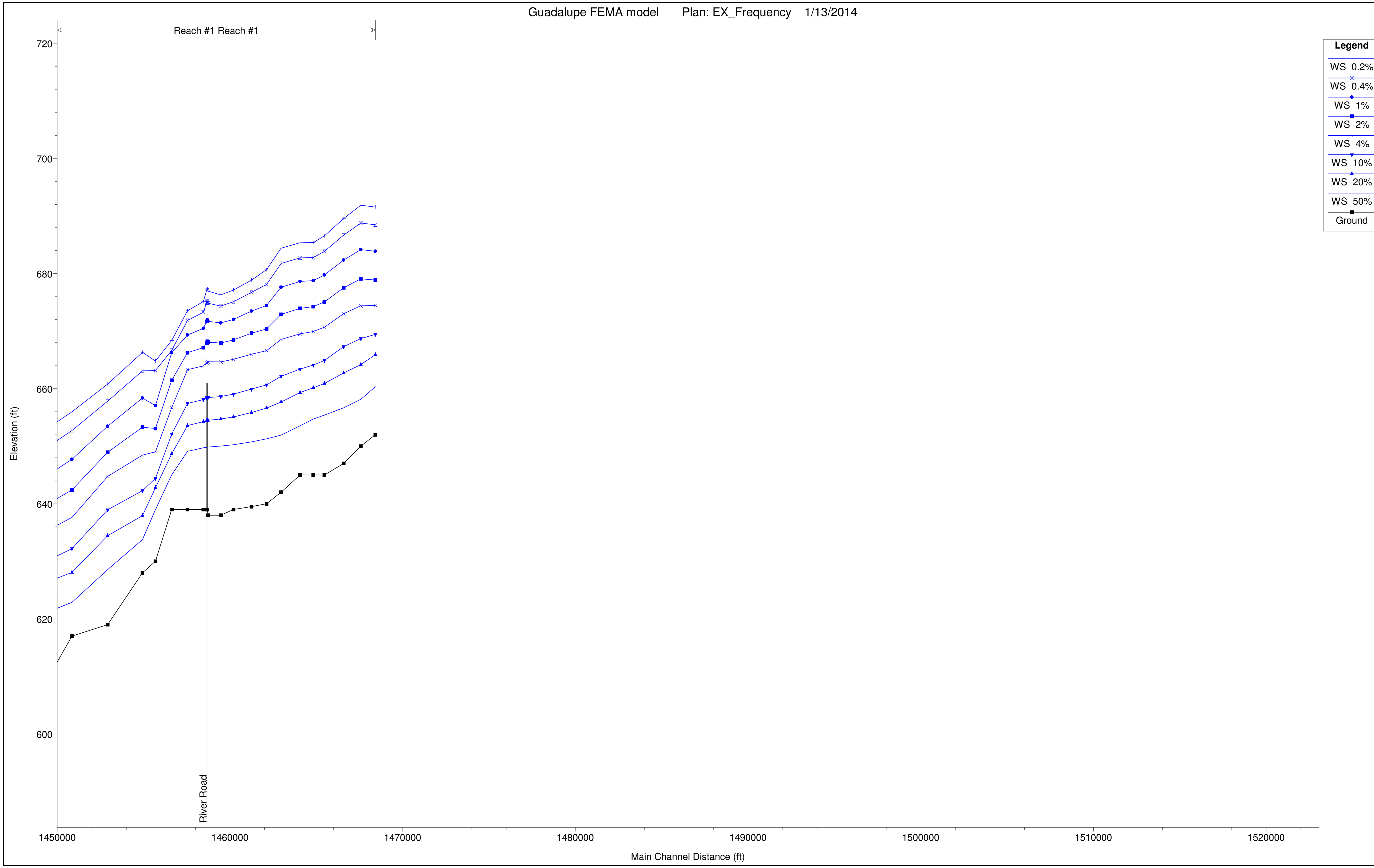
1 in Horiz. = 5000 ft   1 in Vert. = 15 ft



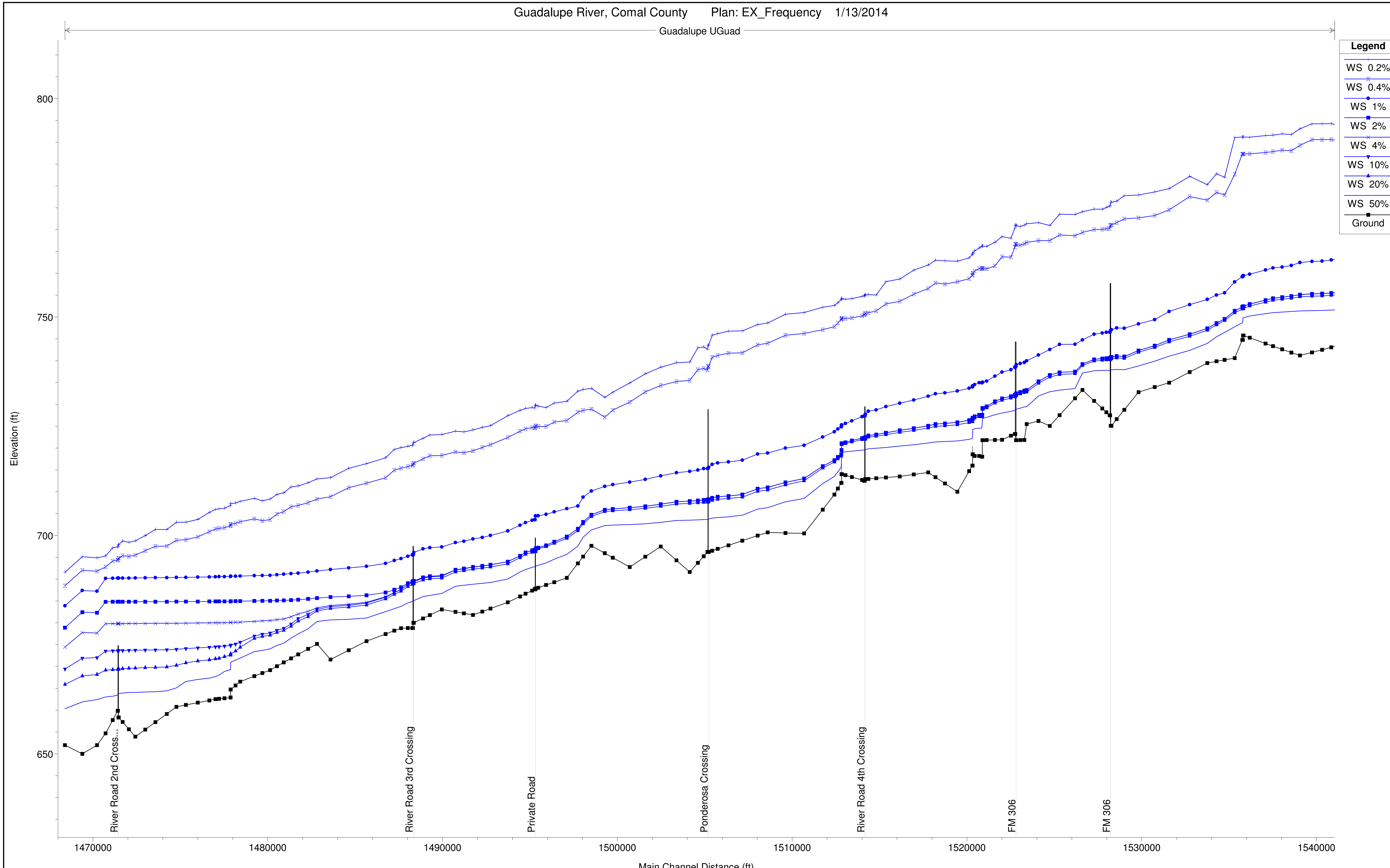
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



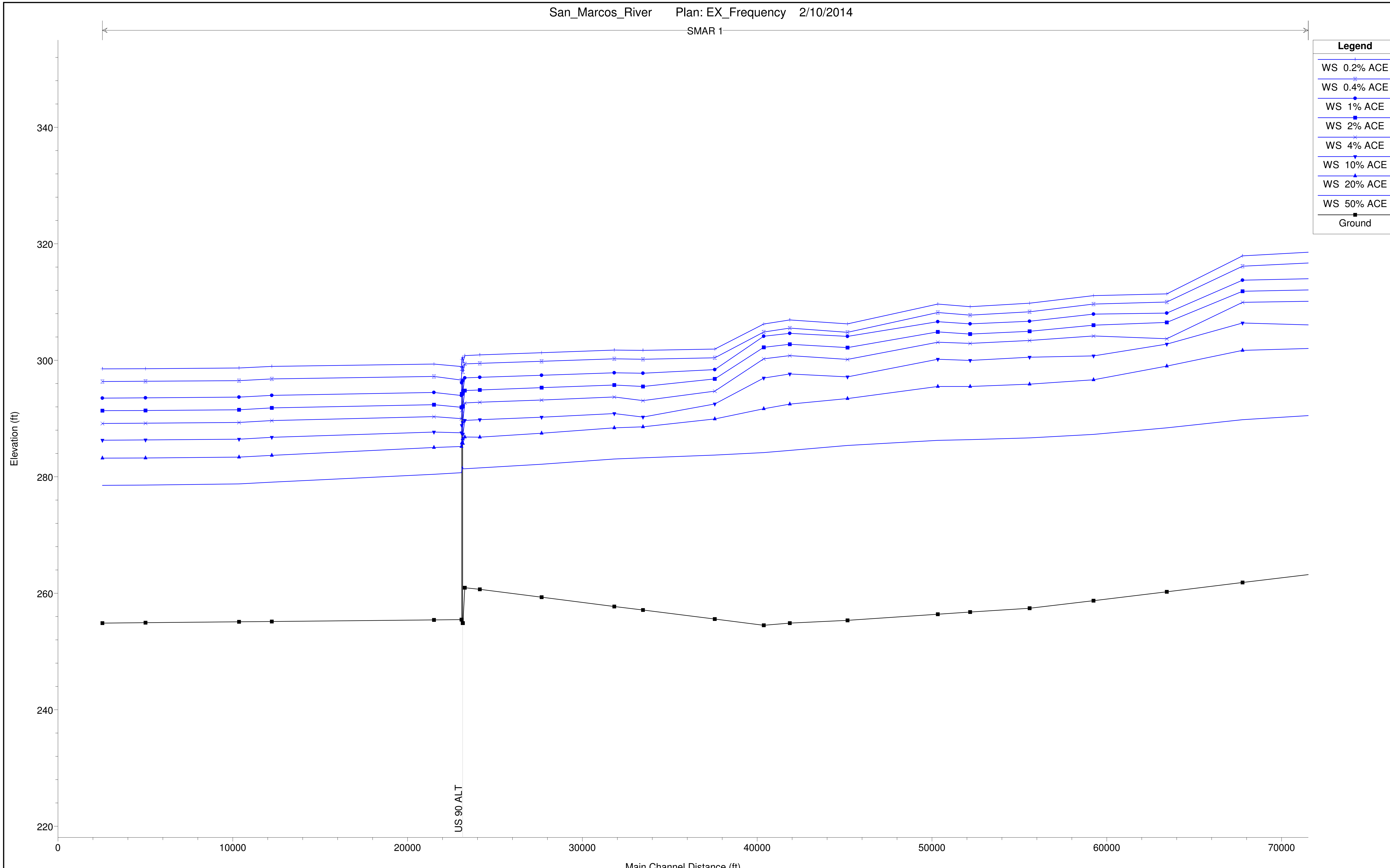
1 in Horiz. = 5000 ft 1 in Vert. = 15 ft



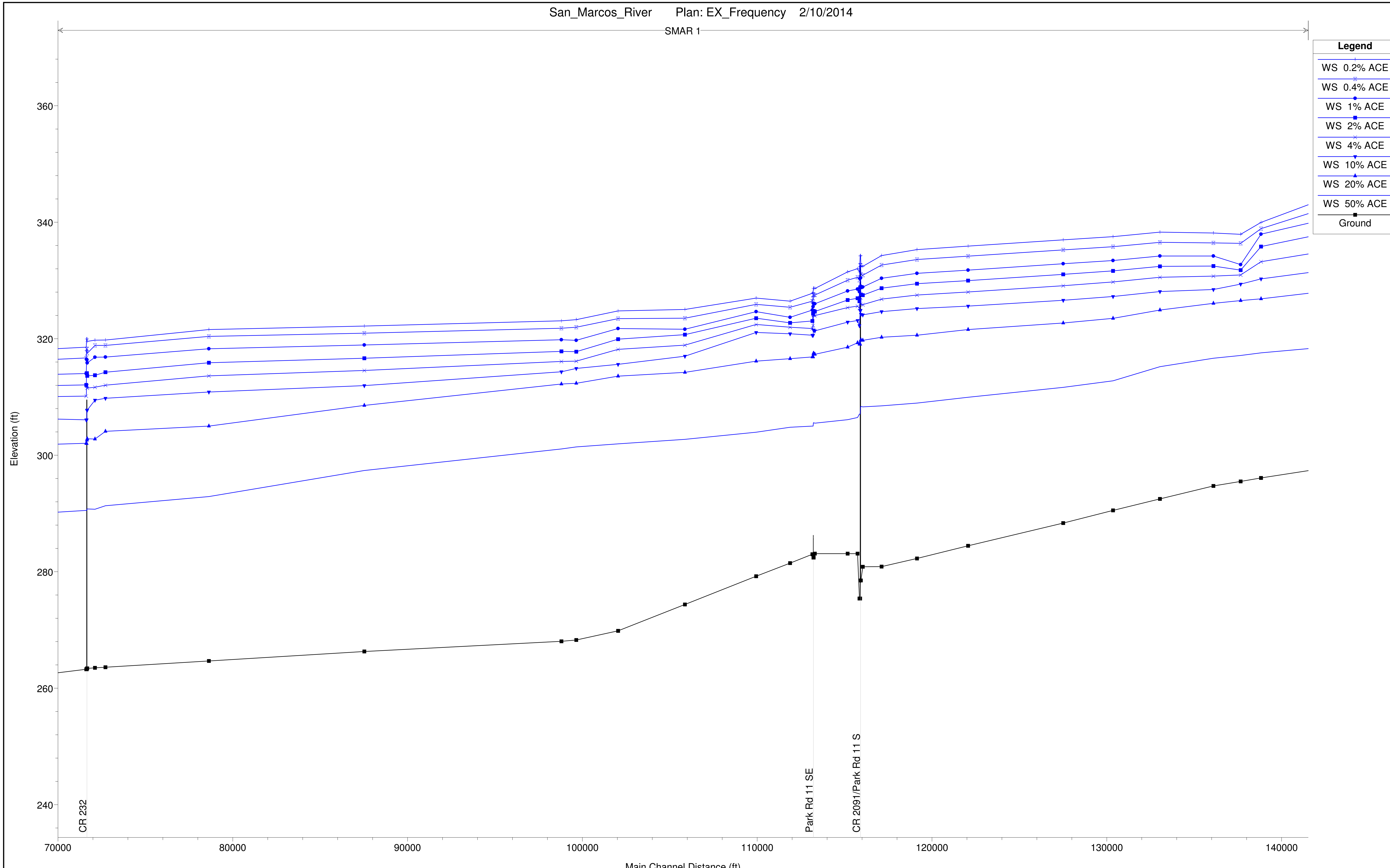
1 in Horiz. = 5000 ft 1 in Vert. = 20 ft

San Marcos River
HEC-RAS Water Surface Profiles

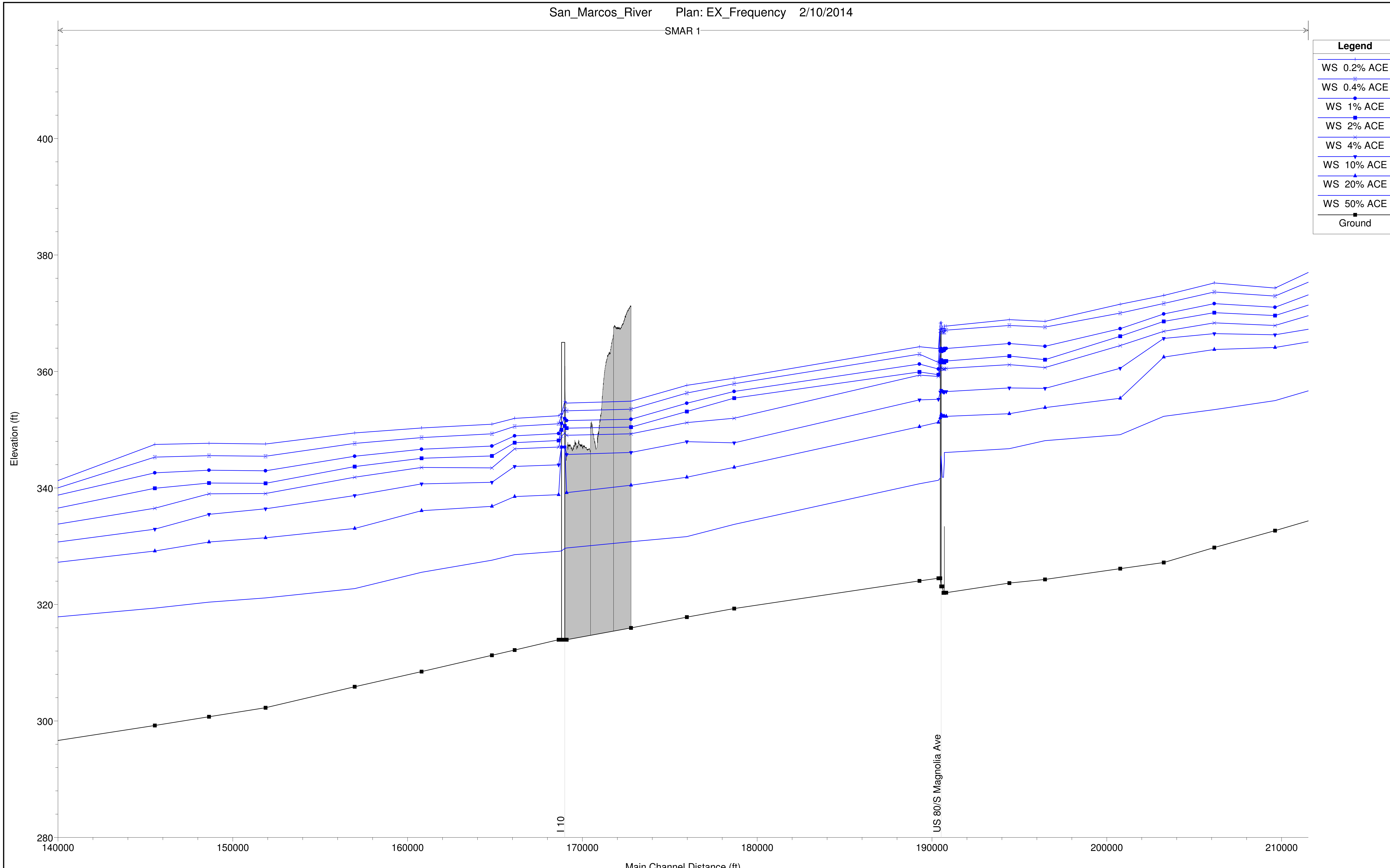
HALFF

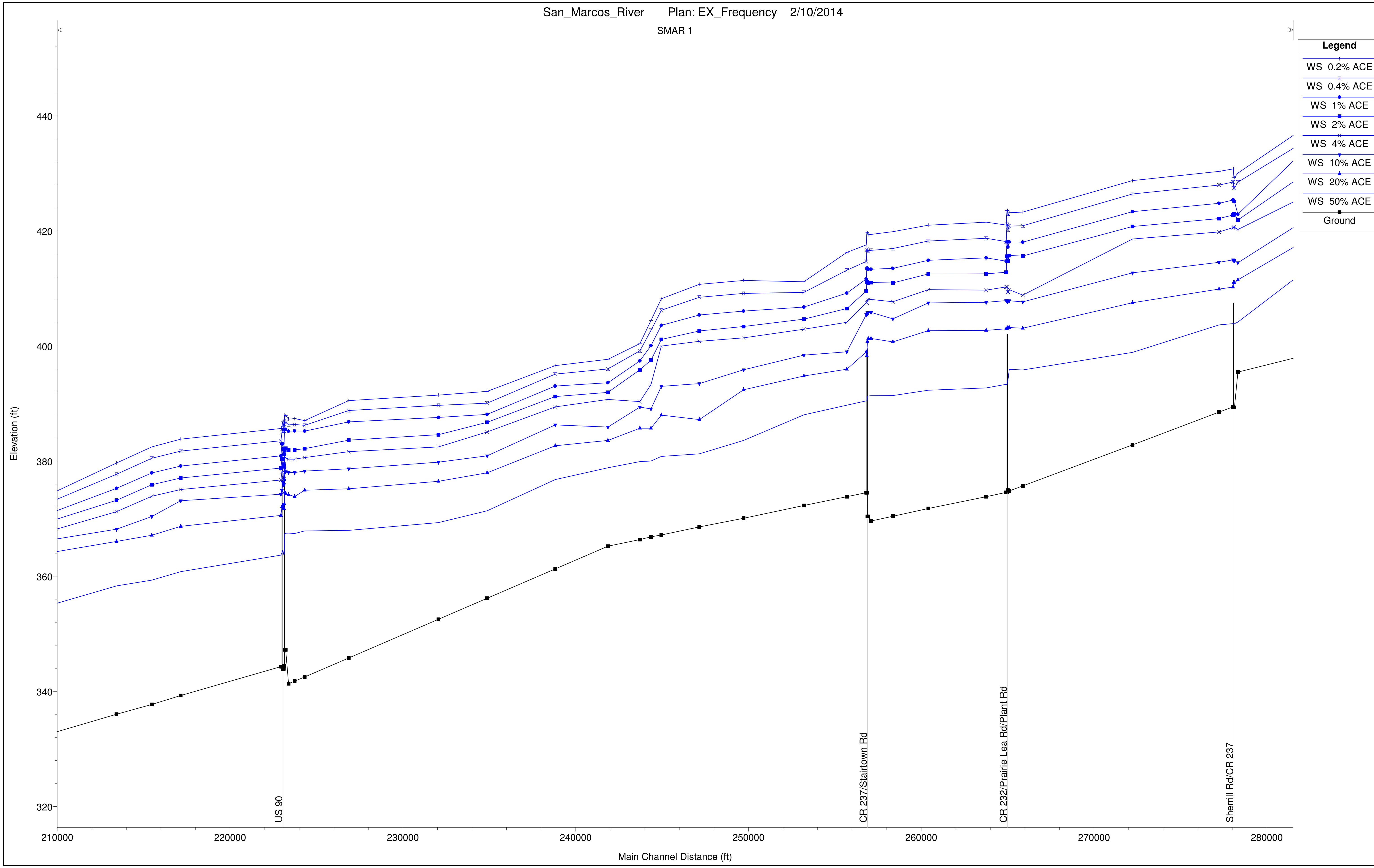


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

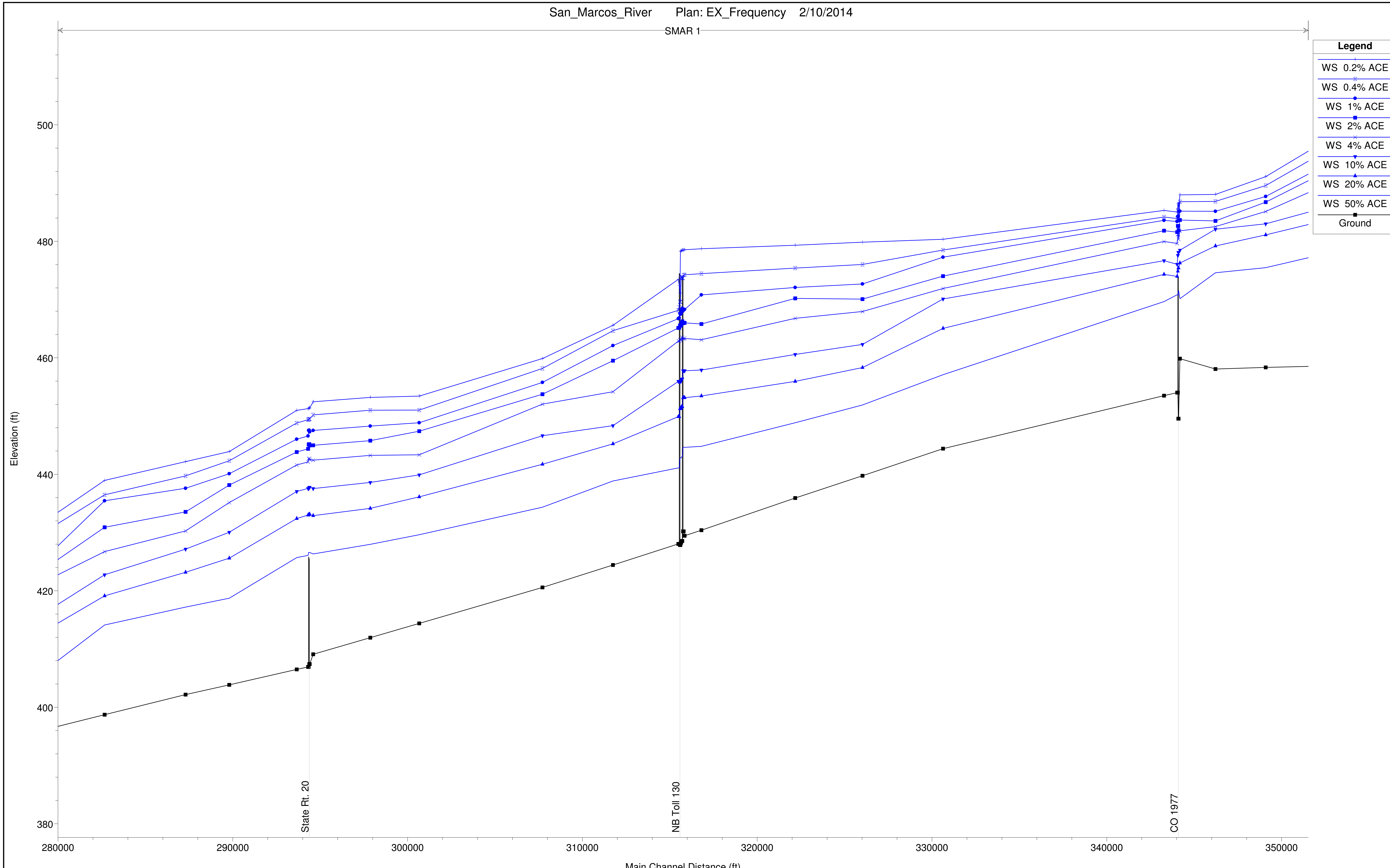


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

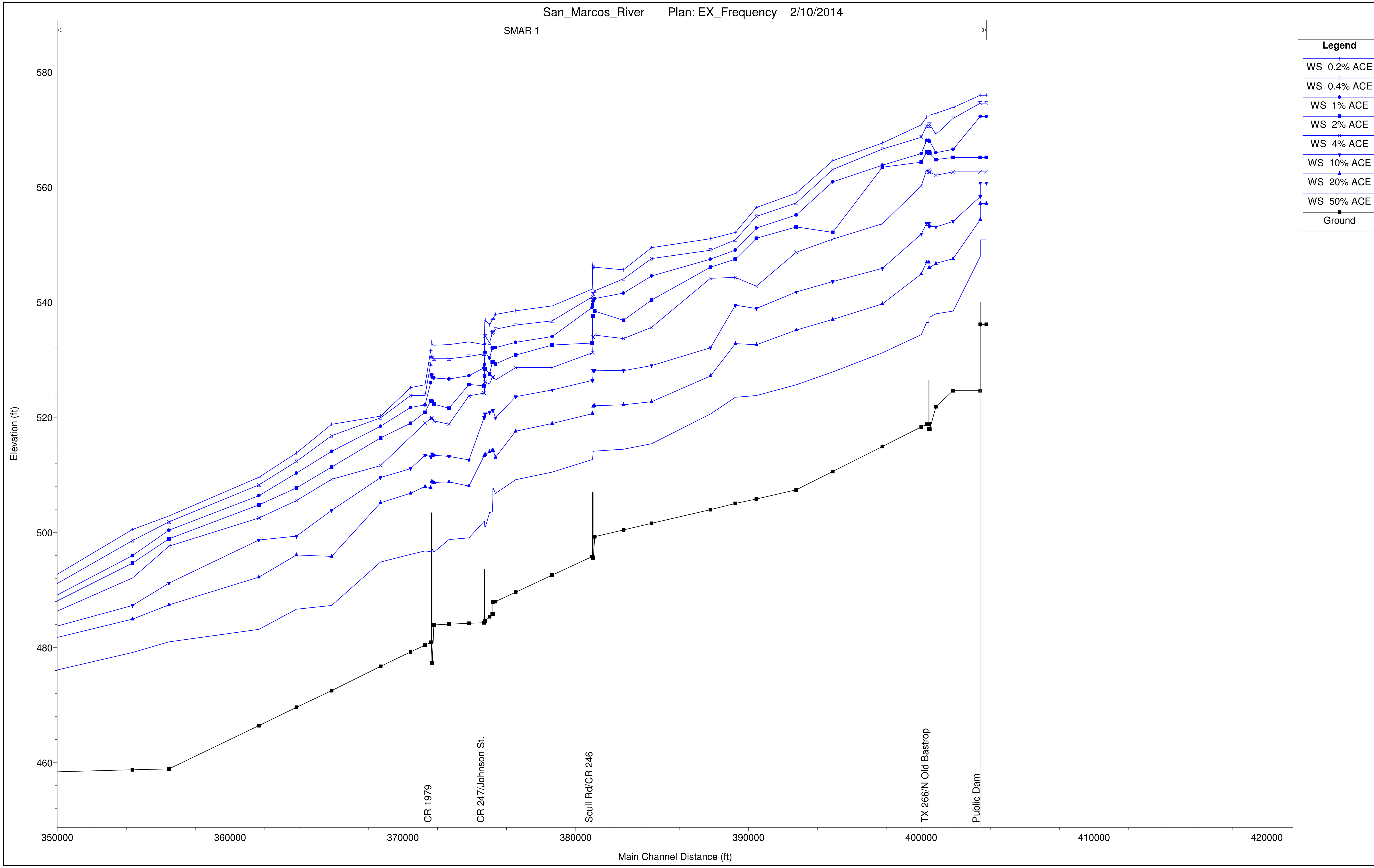

San_Marcos_River Plan: EX_Frequency 2/10/2014
SMAR 1
Legend
WS 0.2% ACE
WS 0.4% ACE
WS 1% ACE
WS 2% ACE
WS 4% ACE
WS 10% ACE
WS 20% ACE
WS 50% ACE
Ground
Elevation (ft)
400
380
360
340
320
300
280
140000
150000
160000
170000
180000
190000
200000
210000
Main Channel Distance (ft)
I 10
US 80/S Magnolia Ave



1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

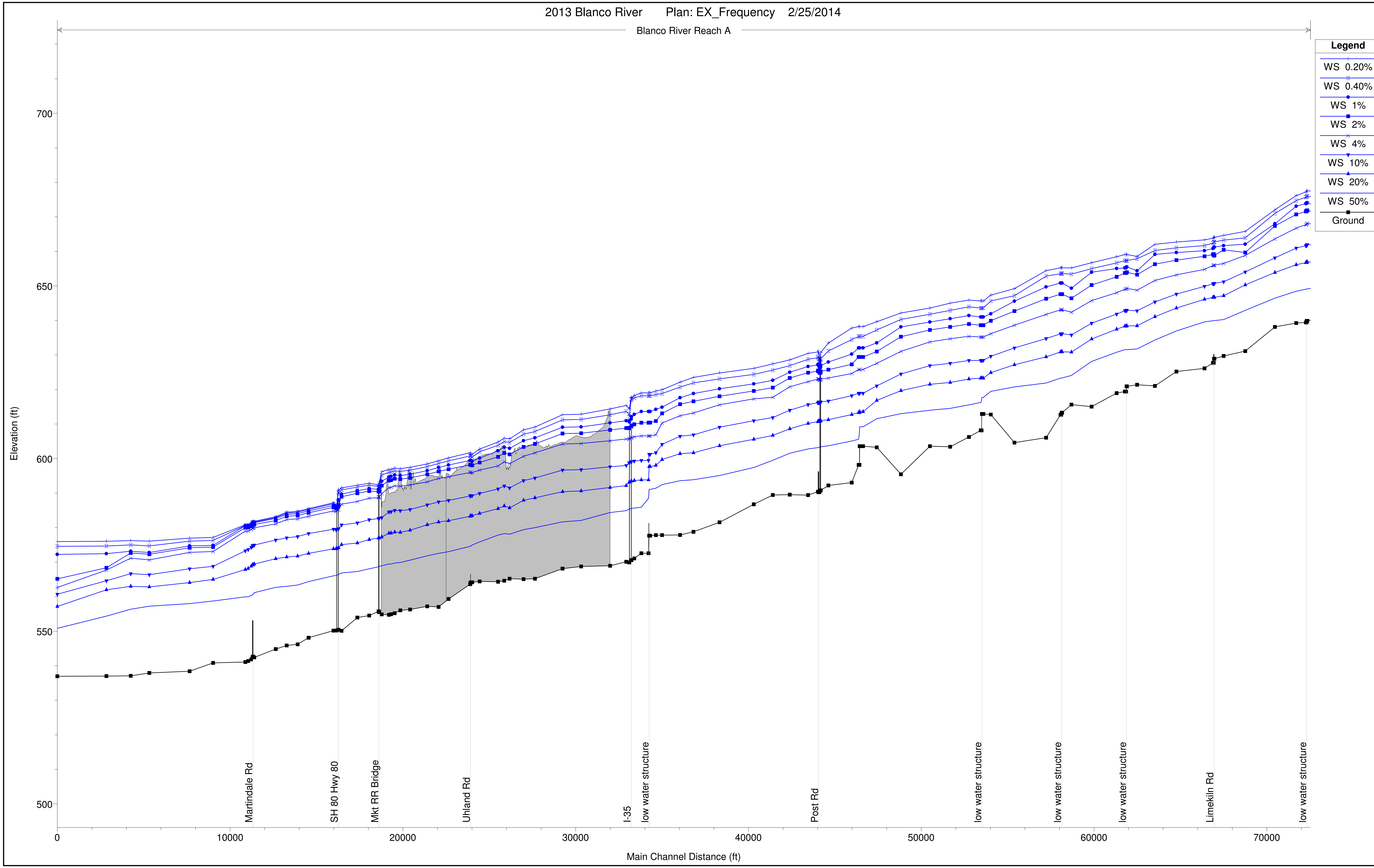


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

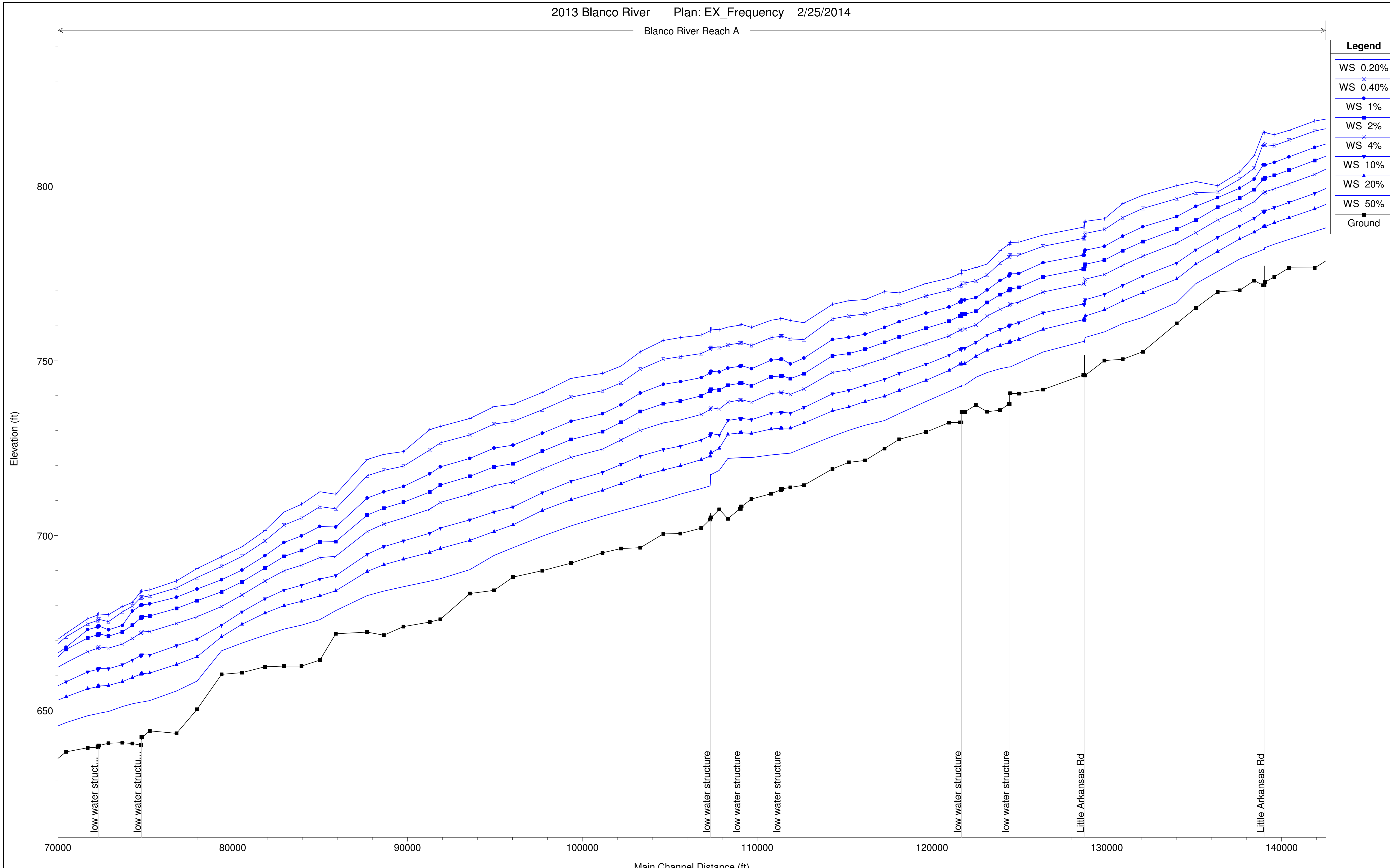


1 in Horiz. = 5000 ft 1 in Vert. = 15 ft

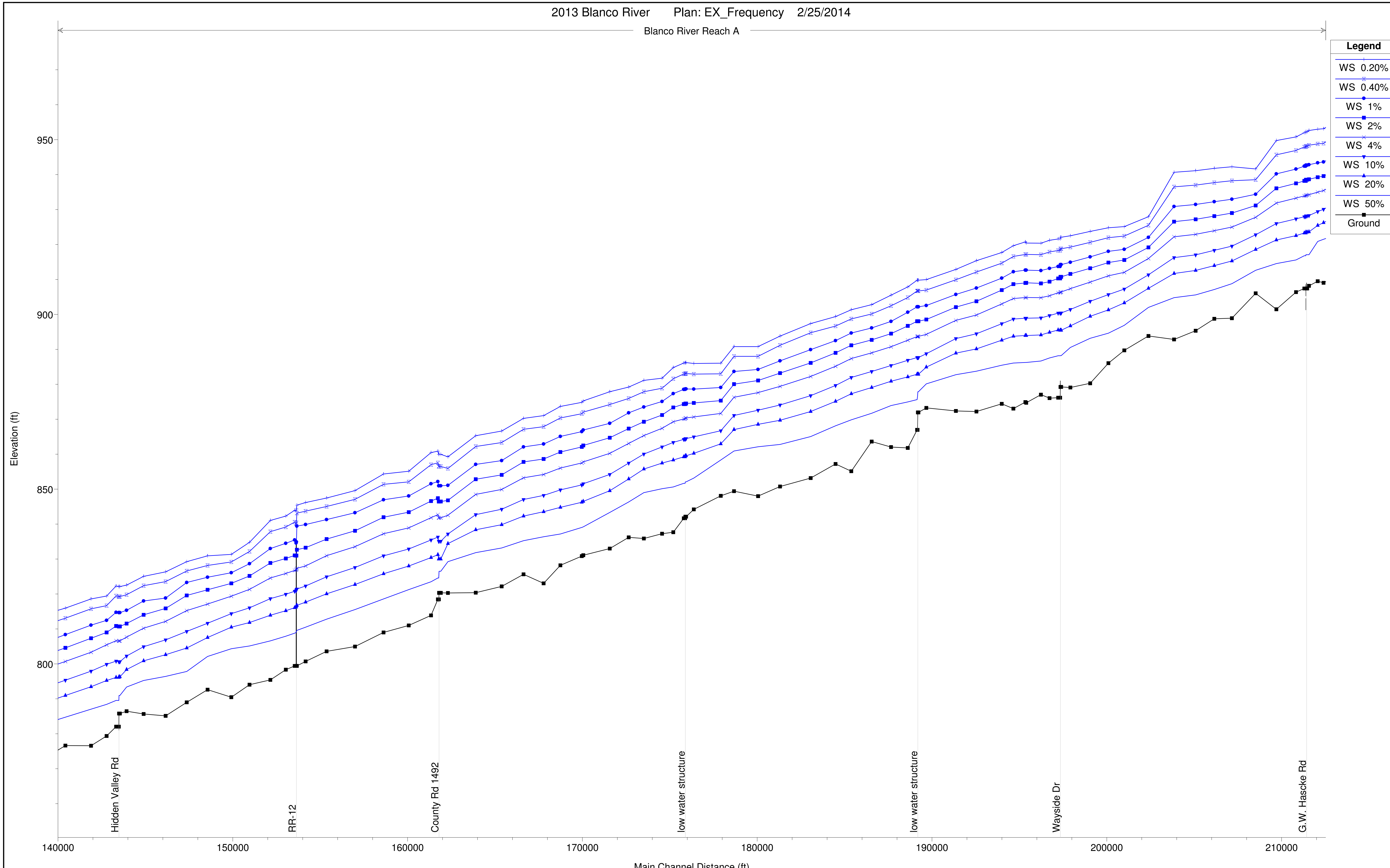
Blanco River
HEC-RAS Water Surface Profiles



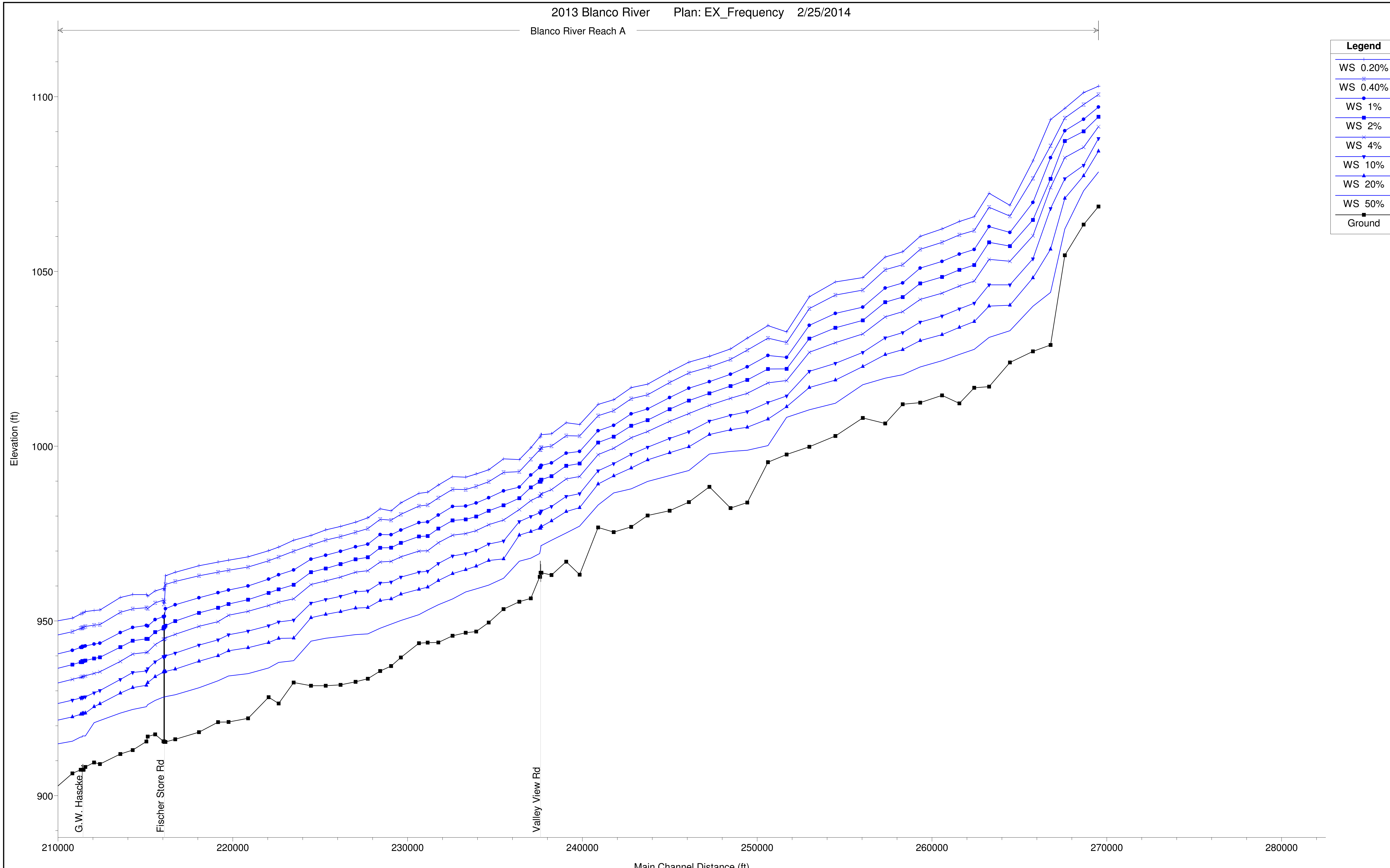
1 in Horiz. = 5000 ft 1 in Vert. = 25 ft



1 in Horiz. = 5000 ft 1 in Vert. = 25 ft



1 in Horiz. = 5000 ft 1 in Vert. = 25 ft



1 in Horiz. = 5000 ft 1 in Vert. = 25 ft

1998 Event
HEC-RAS Water Surface Profile

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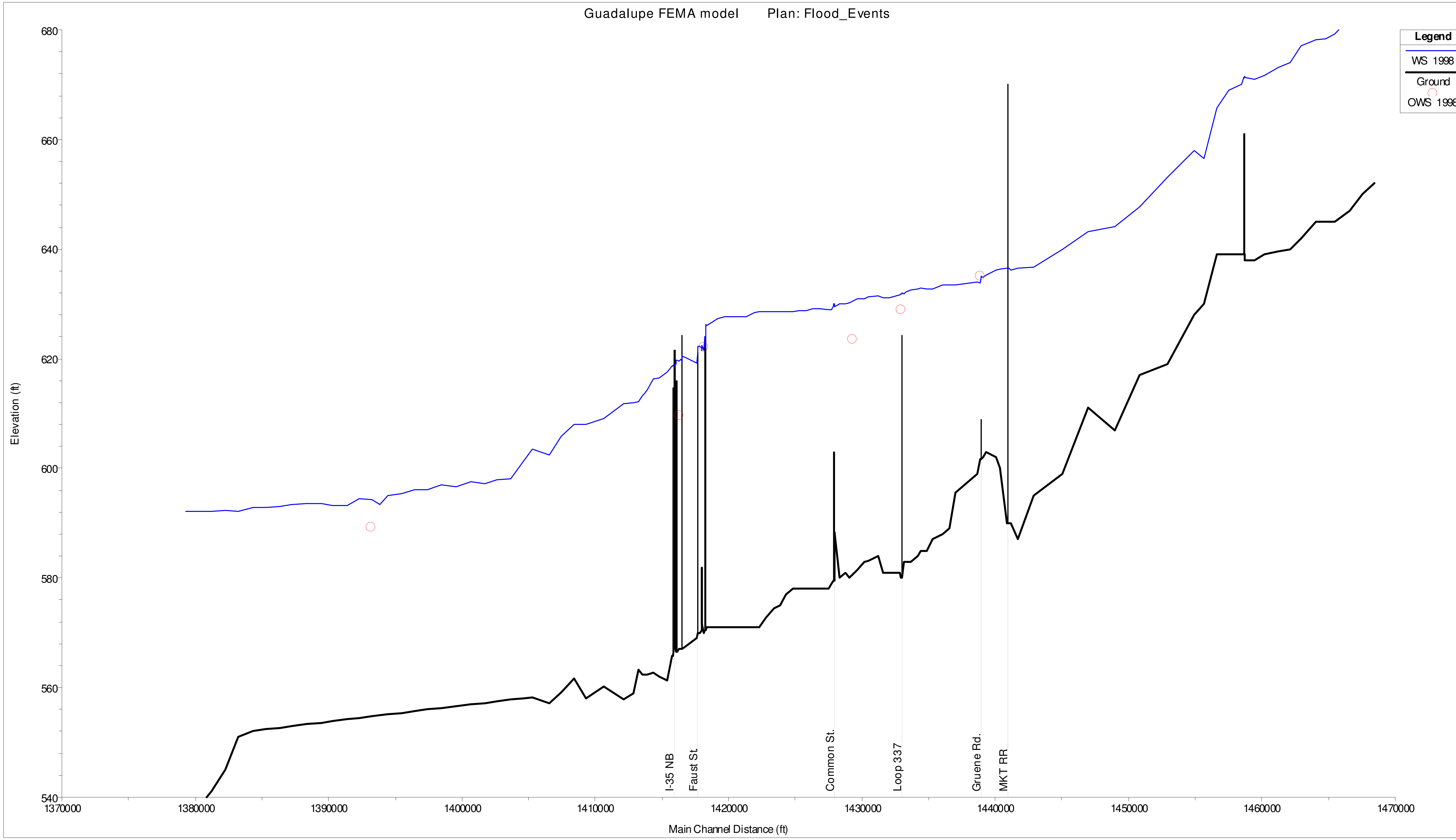
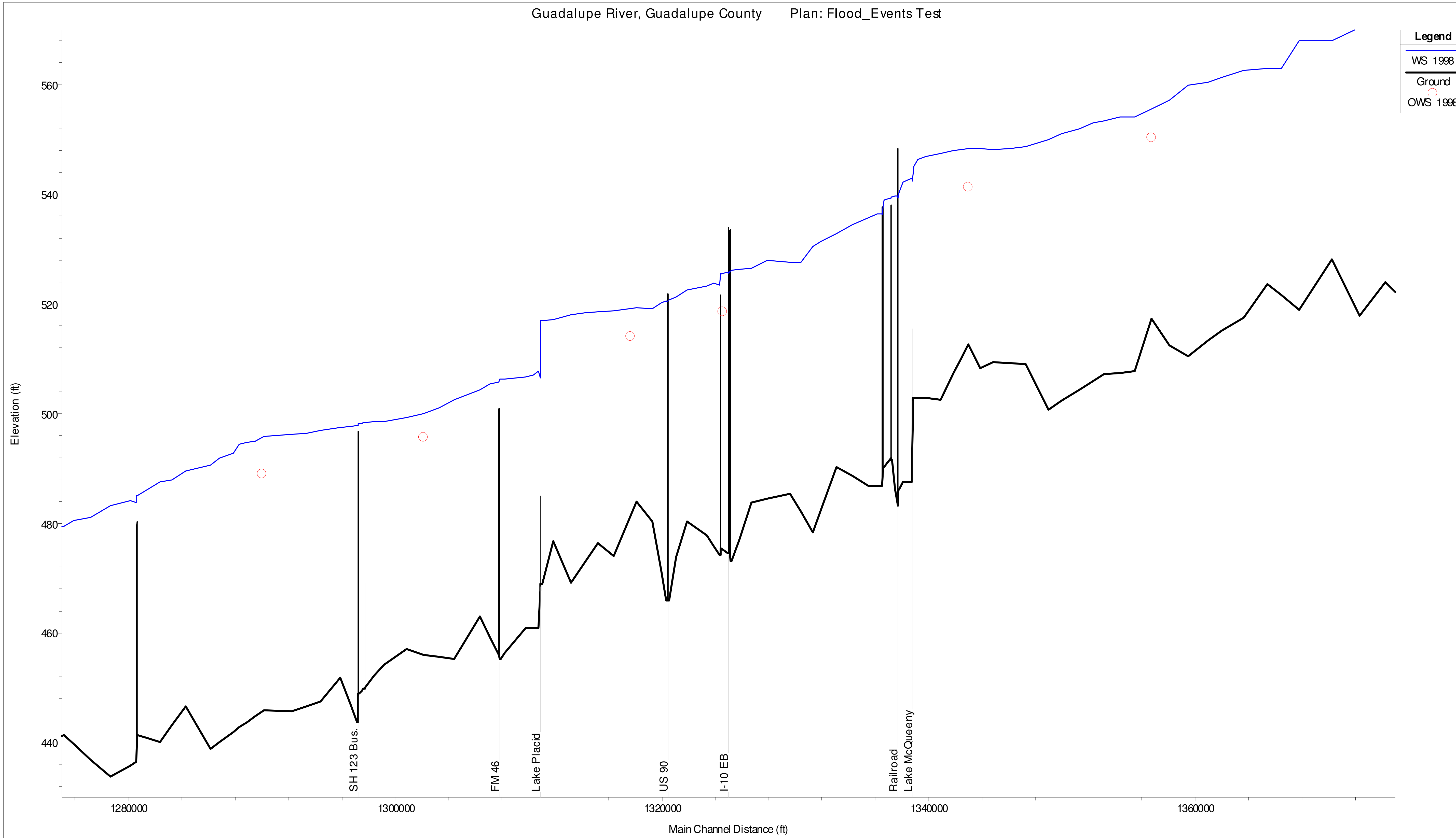
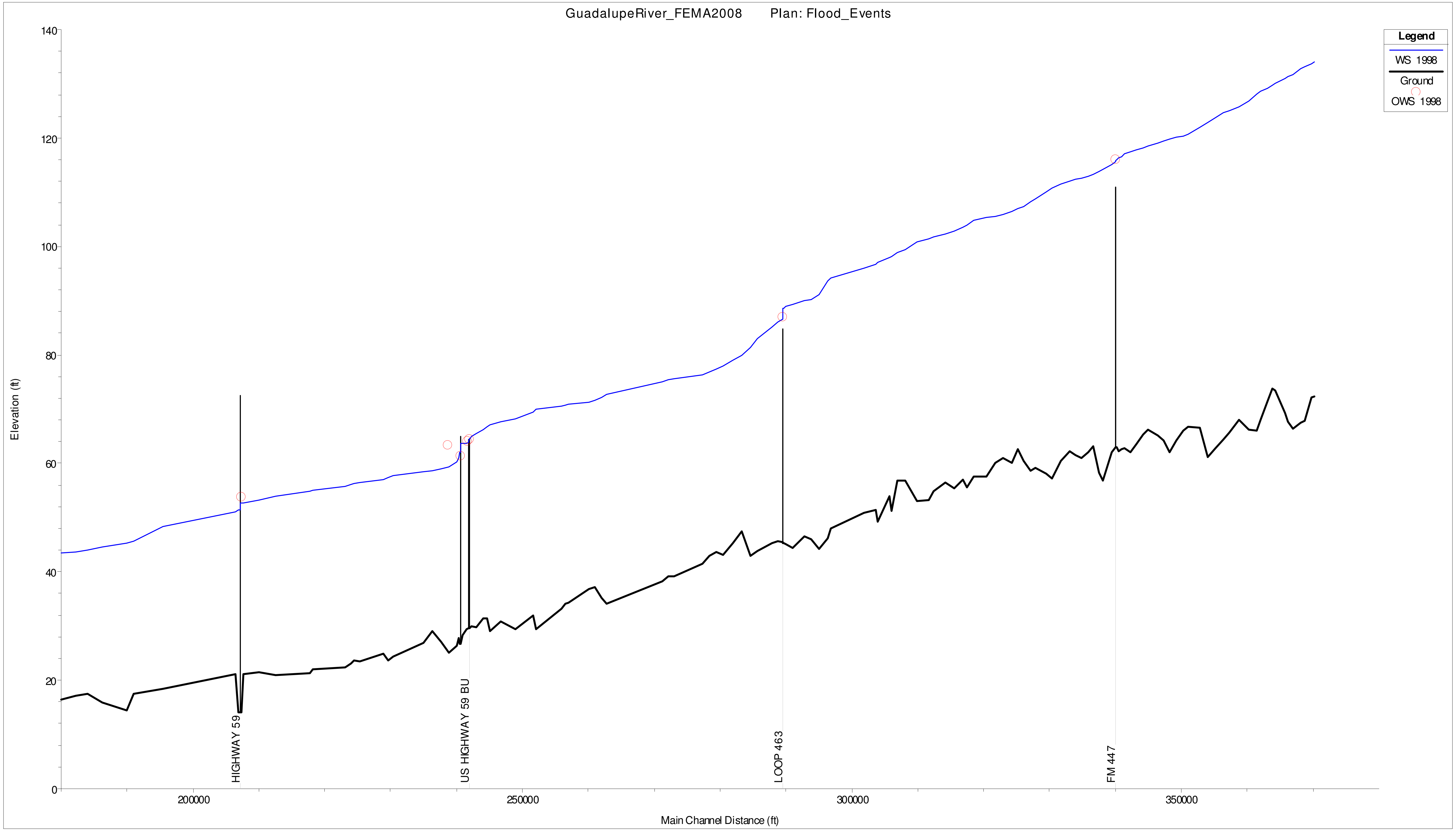


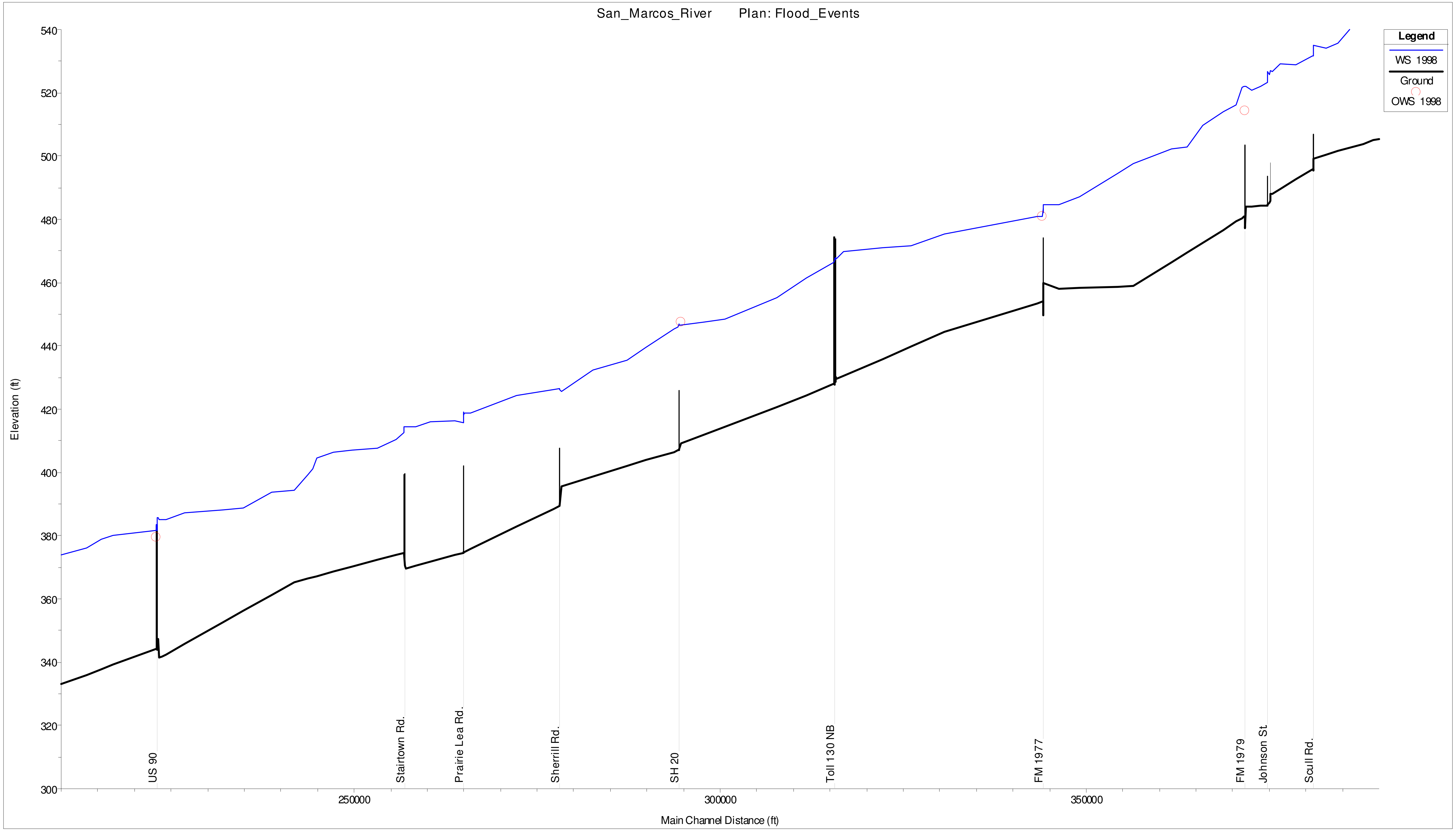
Guadalupe FEMA model Plan: Flood_Events
Legend
WS 1998
Ground
OWS 1998
Elevation (ft)
680
660
640
620
600
580
560
540
1370000
1380000
1390000
1400000
1410000
1420000
1430000
1440000
1450000
1460000
1470000
Main Channel Distance (ft)
I-35 NB
Faust St
Common St.
Loop 337
Gruene Rd.
MKT RR



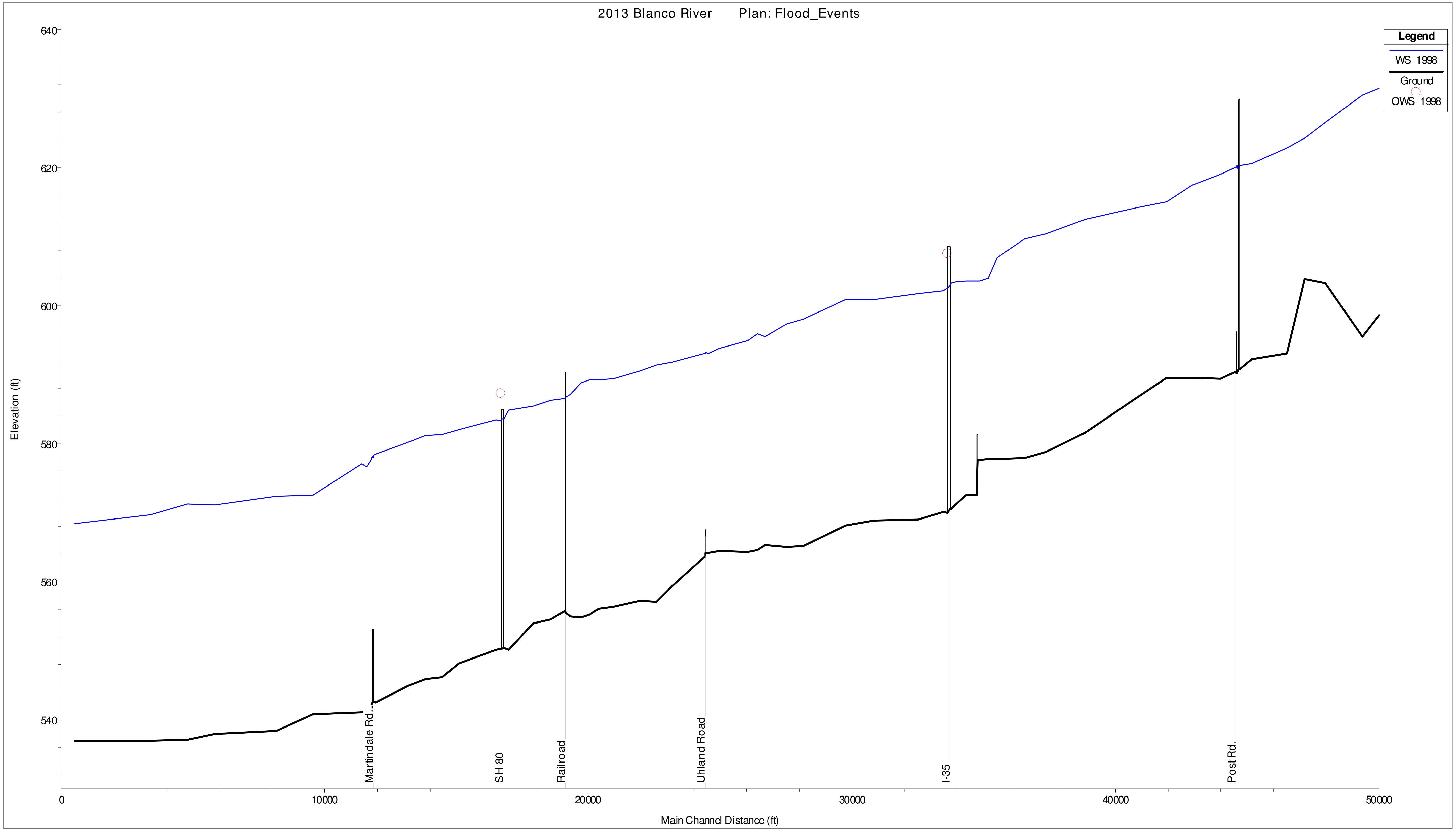
Guadalupe River, Guadalupe County Plan: Flood_Events Test
Legend
WS 1998
Ground
OWS 1998
Elevation (ft)
560
540
520
500
480
460
440
SH 123 Bus.
FM 46
Lake Placid
US 90
I-10 EB
Railroad
Lake McQueeny
1280000
1300000
1320000
1340000
1360000
Main Channel Distance (ft)



GuadalupeRiver_FEMA2008 Plan: Flood_Events
Legend
WS 1998
Ground
OWS 1998
Elevation (ft)
140
120
100
80
60
40
20
0
HIGHWAY 59
US HIGHWAY 59 BU
LOOP 463
FM 447
200000
250000
300000
350000
Main Channel Distance (ft)



San_Marcos_River Plan: Flood_Events
Legend
WS 1998
Ground
OWS 1998
Elevation (ft)
540
520
500
480
460
440
420
400
380
360
340
320
300
US 90
Stairtown Rd.
Prairie Lea Rd.
Sherrill Rd.
SH 20
Toll 130 NB
FM 1977
FM 1979
Johnson St.
Scull Rd.
250000
300000
350000
Main Channel Distance (ft)


2013 Blanco River Plan: Flood_Events
Legend
WS 1998
Ground
OWS 1998
Elevation (ft)
640
620
600
580
560
540
Martindale Rd...
SH 80
Railroad
Uhland Road
I-35
Post Rd.
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)

Appendix D.1.3

Supporting Documents

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Appendix D.1.3.a
Hydraulic Modeling Notebook

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Hydraulic Project Notebook
Guadalupe Blanco River Authority Watersheds

Project: GBRA Interim Feasibility Study **AVO:** 28411

Entry # : 1

Subject : Basic Project Notes

Notes :

- USACE Standards
  -
- Coordinate System:
  - NAD_1983_StatePlane_Texas_South_Central_FIPS_4204_Feet
- GBRA Terrain
  - CapCog 2007 (1.4 m), CapCog 2008 (1.4 m), CapCog 2008 (0.7 m), COA 2003 (unknown), FEMA 2006 (1.4 m), FEMA 2011 (0.61 m), LCRA 2007 (1.4 m), TNRIS 2009 (1.0 m), TNRIS 2010 (0.5 m), TNRIS 2011 (0.5 m), USGS 2011 (1.5 m) and DeWitt_DEMclip_wFEMA_TNRIS (unknown) utilized
  - DEMs (cellsize of 30 feet) generated from LiDAR
- Hydraulics
  - Survey locations for Detailed Streams
    - All Bridges, culverts, and critical stream XS
    - Maximum Distance between Surveyed XS ~ 2500-3000 ft.
    - Low Water Crossings
      - Field measurements taken and incorporated into RAS model
  - Field measurements for Limited Detailed Streams
    - Supplement LiDAR with field measurements to estimate the bridge/culvert crossing dimensions.
  - XS Layout
    - FEMA guidelines – place where appropriate to catch all differences in geometry.
    - Cut a XS near the subbasin boundary for routing purposes.
    - Cut a XS near the 1/3 to ½ upstream from subbasin boundary for flow break locations.
  - Manning's N Values
    - Channel Manning's N values will be based on field observations and aerial photos.
    - Overbank Manning's N limit – 0.04-0.15
    - Natural Channel Manning's N limit – 0.045-0.08
    - Other Channel Manning's N values
      - Concrete – 0.013
      - Ponded water – 0.023
    - Landuse Shapefile
      - 2003 TCEQ – Edwards Aquifer LULC
      - Clip with a buffer around your hydraulic model. Then hand edit per stream for better n-values. Please keep a copy of this hand edited landuse in the corresponding geo-RAS geodatabase.

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Land Use Code LUCODE	Major Group	TR-55 Cover Type	N-Value
111000	Stream/River	n/a	1.00
113000	Lake/pond	n/a	1.00
114000	Reservoir	n/a	1.00
210000	Residential	Residential District - 1/2 acre	0.08
211000	Single-family Residential	Residential District - 1/4 acre	0.09
212000	Multi-family Residential	Residential District - 1/8 acre	0.12
221000	Commercial/Light Industry	Urban District - Industrial	0.09
222000	Heavy Industry	Urban District - Industrial	0.12
223000	Communications and Utilities	Urban District - Industrial	0.12
224000	Institutional	Urban District - Commercial and Business	0.12
225000	Agricultural Business	Farmsteads	0.10
226000	Transportation	Streets and Roads, Paved	0.06
227000	Entertainment and Recreational	Open Space - Fair Condition	0.07
227200	Urban Parks	Open Space - Fair Condition	0.07
230000	Mixed Urban	Urban District - Commercial and Business	0.12
300000	BARE	Fallow - Bare Soil	0.06
310000	Transitional Bare	Fallow - Bare Soil	0.06
320000	Quarries/Strip Mines/Gravel Pits	n/a	1.00
330000	Bare Rock/Sand	Fallow - Bare Soil	0.06
411000	Forested	Woods - Fair Condition	0.10
412000	Shrub land	Brush - Fair Condition	0.08
413000	Planted/Cultivated Woody (Orchards/Vineyards/Groves)	Woods - Grass Combination	0.06
414000	Mixed Forest/Shrub	Woods, Brush Combination	0.09
421000	Natural Herbaceous	Pasture, Grassland, or Range	0.06
422000	Planted/Cultivated Herbaceous	Row Crops - Straight Row + Crop Residue Cover	0.06
431000	Woody Wetland	n/a	0.10
432000	Emergent Herbaceous Wetlands	n/a	0.06
Note: All areas with n-value of 1.00 will be modeled as ineffective area or blocked obstructions.			

- Blocked Obstructions/Ineffective Flows on XS
  - Urban Areas
    - We prefer to model these areas with a n-value based on land use over the use of blocked obstructions.
    - If large building or row of homes blocking flow on multiple cross-sections, include as blocked obstruction.
- Cross-Section Filter Method
  - RAS XS Point Filter
    - Near and Collinear filtering option
      - Horizontal Filter Tolerance : 0.25;
      - Vertical Filter Tolerance : 0.25;
      - Collinear Vertical Filter Tolerance : 0.25; and
      - Collinear Minimum Change Slope : 0.005

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- Expansion/Contraction Coefficients
  - Expansion/Contraction Coefficients - when bridge/culvert contraction and expansion is significantly different from "normal', the expansion/contraction coefficients must be modified to reflect the field conditions, otherwise the default values of 0.1 and 0.3 should be used.
- Flow Break Locations
  - Basin Centroid to 1/3 upstream from the subbasin outlet
- Diversions or Confluence
  - In special cases where cross-sections span multiple channels near confluences or diversions, peak discharge from the downstream confluence of these channels was placed at the most upstream cross-section that spans multiple channels.
- Routing Tables
  - Set 12 Routing Flows per Modified-Puls routing reach. Routing flows will be based on the frequency flows reported in the current effective FIS. See Entry 4 for details.

Entry # : 2

Subject : GeoRAS Development

Notes :

- The new detailed study of the main stem Guadalupe River was split into two models at the DeWitt/Gonzales County line.
- Stream Centerlines
  - o Stream centerlines were aligned
  - o Extend to snap to the confluence
- Cross Section Layout
  - o Typically 2500 to 3000 foot spacing (3-4 cross sections per mile)
  - o Standard 4 section layout around bridges, culverts, and inline structures
  - o Additional cross sections as necessary to accurately model bends, and channel/valley transitions and changes in channel slope.

Entry # : 3

Subject : HEC-RAS Naming Conventions

Notes :

For consistency between the models, please use the following naming conventions in your HEC-RAS models.

1. Project
   - o Description:
     - Stream Name:
     - Detailed Study 2012
     - Date:

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- Location:
- Avo: 28411
- Firm: Halff Associates, Inc.
- Client: GBRA
- HEC-RAS version 4.1.0
- Datum: NAVD 88

2. Routing Set-up – Guadalupe River
    - Plan – **Routing**
        - Short ID – Routing
        - Description - Plan used for <stream name> Routing data.
    - Geometry – **Routing_Geometry**
        - Description – <stream name> routing geometry.
    - Flows – **Routing_Flows**
        - Profiles – 2-yr / 10, 2-yr / 5, 2-yr /2, COE 2-YR, COE 5-YR, COE 10-YR, COE 25-YR, COE 50-YR, COE 100-YR, COE 250-YR, COE 500-YR, and 500-YR + 30%

3. Routing Set-Up San Marcos River
    - Plan – **Routing**
        - Short ID – ROUT
        - Description - Plan used for San Marcos Routing data.
    - Geometry – **Routing_Geometry**
        - Description – San Marcos routing geometry.
    - Flows – **Routing_Flows**
        - Profiles – 50%*0.1, 50%*0.2, 50%*0.5, 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, 0.2%, 0.2%*1.3 ACE events

4. Existing Conditions Set-up
    - Plan – **EX_Frequency**
        - Short ID – EX_FREQ
        - Description – Plan used for existing condition frequency analysis.
    - Geometry – **<stream name>**
        - Description – Final <stream name> analysis geometry. Existing conditions as of October 2012. (Fix date when complete).
    - Flows – **EX_Frequency_Flows**
        - Profiles – 2-YR, 5-YR, 10-YR, 25-YR, 50-YR, 100-YR, 250-YR, 500-YR

5. Future Conditions Set-up
    - Plan – **FUT_Frequency**
        - Short ID – FUT_FREQ
        - Description – Plan used for future condition frequency analysis.
    - Geometry – **<stream name>**
        - Description – Final Barton Creek analysis geometry. Existing conditions as of October 2012. (Fix date when complete).
    - Flows – **FUT_Frequency_Flows**
        - Profiles – 2-YR, 5-YR, 10-YR, 25-YR, 50-YR, 100-YR, 250-YR, 500-YR

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Guadalupe River Entries

Entry # : 4

Subject : Modified-Puls Routing Tables

Notes :

- Routing flows were developed using the DRAFT "Lower Guadalupe River Basin 2012 Feasibility Study" prepared by the USACE
- Guadalupe River USGS Stream Gages

Table 2. USGS Peak Streamflow Gages Located on the Guadalupe River

Usgs Gage No.	Description	Drainage Area (Sm)
08176500	Guadalupe River At Victoria	5198
08175800	Guadalupe River At Cuero	4934
08173900	Guadalupe River At Gonzales	3490
08169500	Guadalupe River At New Braunfels	1652
08168500	Guadalupe River Above Comal River At New Braunfels	1518
08167800	Guadalupe River At Sattler	1436

Guadalupe River Routing flows were developed for the following discharges

Table 3. Routing Flows

Routing Flow	Approximate Frequency
RF1	2-yr/10
RF2	2-yr/5
RF3	2-yr/2
RF4	2-yr
RF5	5-yr
RF6	10-yr
RF7	25-yr
RF8	50-yr
RF9	100-yr
RF10	250-yr
RF11	500-yr
RF12	500-yr + 30%

- Routing reaches with an existing AE zone:
  - Routing flows will be based on the current effective 100-yr and 500-yr flows.

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- The 2-yr through 50-yr and 250-yr flows will be estimated as a proportion of the 100-yr flow according to the factors shown in table 4.

Table 4

Area Range	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	250-yr	500-yr
0-1	0.26	0.49	0.60	0.74	0.86	1.00	1.21	1.39
1-3	0.22	0.45	0.57	0.72	0.85	1.00	1.23	1.41
3-6	0.18	0.33	0.53	0.68	0.83	1.00	1.26	1.49
6-10	0.18	0.26	0.53	0.68	0.83	1.00	1.25	1.49
10-20	0.13	0.23	0.45	0.63	0.80	1.00	1.31	1.58
20-30	0.13	0.22	0.43	0.61	0.79	1.00	1.31	1.58
30-40	0.13	0.22	0.43	0.61	0.78	1.00	1.33	1.60
40-50	0.12	0.22	0.43	0.61	0.77	1.00	1.34	1.63
50-90	0.12	0.22	0.43	0.61	0.77	1.00	1.35	1.65
90-150	0.12	0.22	0.43	0.61	0.77	1.00	1.40	1.72

- Routing reaches with no current effective flows
  - Estimate of the 100-yr flow was based on a regression of the stream reaches with a current effective FEMA flow using the following equation:

    $$Q100 = 1952.6*(Area)^{0.6914}$$

  - The factors in table 2 were then applied to determine the remaining routing flows.

Entry # : 5

Subject : Summary of Manning's N-Values in the New Detailed Study and Incorporated Guadalupe Hydraulic Models

Notes :

Model	Channel	Overbanks
1-Victoria FIS	0.065	0.05-0.15
2-DeWitt GBRA	0.065	0.05-0.12
3-Gonzales GBRA	0.065	0.05-0.12
4-LowerGuadalupe2	0.015-0.1	0.026-0.1
5-23428	0.015-0.07	0.04-0.1
6-UpperGuad	0.04-0.08	0.04-0.15

5

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Entry # : 6

Subject : Guadalupe Hydraulic Model Starting Boundary Conditions

Notes :

- 1-Victoria FIS Model (Incorporated)
  - Upstream and Downstream Normal Depth – n=0.0001
- 2- DeWitt GBRA Model (New Study)
  - Victoria FIS Model XS 370126-Known Water Surface
- 3-GonzalesGBRA (New Study)
  - DeWitt GBRA Model 705294-Known Water Surface
- 4-LowerGuadalupe2 (Incorporated)
  - GonzalesGBRA Model 1247728-Known Water Surface
- 5-23248 (Incorporated)
  - Known water surface elevation at the dam. WSEL was extrapolated for the 2-year/10, 2-year/5, 2-yr/2, 250-year, and 500-year + 30%
- 6-UpperGuad (Incorporated)
  - 5-23248 Model XS 88190 known water surface elevation
  - 4 decimal places were needed in the starting WSEL to match the current effective FWDT. 4 decimal places were also used in the routing model.

Entry # : 7

Subject : Guadalupe River LOMRS

Notes : As of 10/31/2012-Availble LOMRs have been requested from city officials.

- Victoria County
- DeWitt County
  - No LOMRs found on November 5, 2012
- Gonzales County
  - No LOMRs found on November 5, 2012
- Guadalupe County
  - No LOMRs found on November 5, 2012
- Comal
  - Panel 455
    - 11-06-0637P – Effective October 5, 2011

Entry # : 8

Subject : Guadalupe River Bridges

Notes : November 15, 2012

- Bridge surveys were not available for the routing model submittal
- Bridges along the Guadalupe River have been added using the following data when available:
    - TxDOT Plans, Photos, and Bridge Inspections

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  - Bing Maps
  - Top of Road was generally assumed from the terrain data

Entry # : 9

Subject : GBRA Dam Data

Notes : GBRA Dam data was provided by Freese and Nichols. As-built drawings and recent survey data prepared by Freese and Nichols for a dam breach analysis were obtained.

- 3 Dams are located within the Guadalupe River detailed study model.
  - XS 1041324 – Lake Gonzales Dam (old name H4)
  - XS 937366 – Lake Wood Dame (old name H5)
  - XS 880197 – Unknown Dam located to the east of Gonzales, TX
    - Data has been requested for this dam.
    - The dam was approximately modeled in HEC-RAS.

Entry # : 10

Subject : Hydraulic Flows

Notes :

The 250 and 500-yr flows derived from the gage analysis were much higher than results from existing hydrology models between the Guadalupe above Comal gage and the Gonzales gage. There is a long distance between these analysis points and the gage analysis may be overestimating the less frequent flows. Results from existing hydrologic studies for the Guadalupe river were used instead of gage analysis results at the gage locations. These flows were used in interpolating the flows at locations between I-35 in New Braunfels and the Gonzales gage for the 500-yr and 250-yr events.

Entry # : 11

Subject : Incorporated Models XS Containment

Notes :

There were several cross-sections in the Guadalupe (Section 5) and Upper Guadalupe (Section 6) incorporated models that did not contain the updated hydraulic flows. It was determined that these cross-sections must be extended using LiDAR in order to contain. The original cross-section geometry was maintained with exception of the far overbank that was not containing. LiDAR geometry was added on to the extent of the original geometry. This insured that the original geometry from the incorporated model was consistent.

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San Marcos River Entries

Entry # : 4

Subject : Routing Flows

Notes :

- Data used from USGS 2012 Streamflow Gauging Sites Lower Guadalupe River Basin Feasibility Study
- The 2 yr event was multiplied by 0.1, 0.2 and 0.5 to produce additional data points. The 500 yr event was multiplied by 1.3 for the same reason. The table is shown below.

Location	At San Marcos	At Luling	At Ottine
2 yr*0.1	40	980	1440
2 yr*0.2	100	2660	2880
2 yr*0.5	160	4350	7200
2 yr	410	9830	14400
5 yr	1000	26600	40300
10 yr	1640	43500	70100
25 yr	2870	72000	128000
50 yr	4200	98400	189000
100 yr	5970	130000	271000
250 yr	9230	178000	417000
500 yr	12600	221000	565000
500 yr *1.3	16380	287300	734500

Taken from USGS Gauge Analysis

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Entry # : 5

Subject : San Marcos Revised Model

Notes :

- Originally a Hec-2 model from 1998 FEMA FIS
- Revised by ESPY for 2007 San Marcos Flood Protection Plan
- Halff took the model and updated XS, bridge and inline structures to coordinate with current Lidar.
- New XS, bridge and inline structure profiles then cut off new Lidar. This model was made compatible with Hec-RAS 4.1. Shapefiles were also updated.
- N-values derived from delineated shapefile also used for Main Stem San Marcos model.
- Structure data input based on field visits and/or aerial.

Entry # : 6

Subject : Use of Survey Data

Notes :

- Some survey data for US XS was shot on the side slopes of the road. These XS's were placed immediately on the upstream and downstream sides of these side slopes in order to catch the natural terrain and capture the full capacities.
- Therefore, only channel and bank shots were taken from these surveys and projected on the upstream XS's.
    - The data utilized for the XS's can be determined from the following descriptions within the HEC-RAS model:
        - Modified for survey → All applicable shots were used
        - Channel modified for survey → Channel and bank shots were projected to the correct XS
        - Fully modified for survey → Used for bridges, indicating all openings were corrected for survey

Appendix D.1.3.b
Survey Summary

Appendix D.1.3.b

Survey Summary

HEC-RAS Stream	Survey Cross Section	HEC-RAS Cross Section	Structure or Cross Section	Date Gathered
Guadalupe River	GUA_100	1239200	Structure	11/15/2012
	GUA_200	1098592	Structure	11/16/2012
	GUA_300	1008439	Structure	11/15/2012
	GUA_400	873213	Structure	1/24/2013
	GUA_500	679364	Structure	1/11/2013
	GUA_600	548591	Structure	1/16/2013
	GUA_700	513802	Structure	1/7/2013
	GUA_800	498039	Structure	1/7/2013
	GUA_900	474973	Structure	1/8/2013
	GUA_1000	385761	Structure	1/7/2013
	GUA_1100	679364	Structure	1/17/2013
	GUA_1200	679364	Structure	1/24/2013
	GUA_1300	513802	Structure	1/7/2013
	GUA_1400	498039	Structure	4/19/2013
	GUA_1500	873213	Structure	1/24/2013
	GUAXS_100	1247150	XS	4/29/2013
	GUAXS_200	1214674	XS	5/28/2013
	GUAXS_300	1199517	XS	4/26/2013
	GUAXS_400	1170185	XS	4/24/2013
	GUAXS_500	1152580	XS	4/24/2013
	GUAXS_600	1132305	XS	6/17/2013
	GUAXS_700	1108711	XS	5/6/2013
	GUAXS_900	1060633	XS	4/26/2013
	GUAXS_1100	1024274	XS	6/4/2013
	GUAXS_1200	999156	XS	6/19/2013
	GUAXS_1300	973943	XS	7/15/2013
	GUAXS_1400	952273	XS	4/19/2013
	GUAXS_1500	935337	XS	4/19/2013
	GUAXS_1600	916768	XS	6/19/2013
	GUAXS_1700	844059	XS	4/30/2013
	GUAXS_1800	829405	XS	7/3/2013
	GUAXS_2200	754614	XS	7/31/2013
	GUAXS_2300	727438	XS	7/31/2013
	GUAXS_2400	704000	XS	5/2/2013
	GUAXS_2500E	656603	XS	8/2/2013
	GUAXS_2600H	623366	XS	8/2/2013
	GUAXS_2700	620014	XS	6/5/2013
	GUAXS_2800	595116	XS	6/6/2013
	GUAXS_2900	570410	XS	7/10/2013
	GUAXS_3000	561281	XS	7/10/2013
	GUAXS_3100	528134	XS	6/5/2013
	GUAXS_3200	486764	XS	7/8/2013
	GUAXS_3300	456972	XS	7/8/2013
	GUAXS_3400A	443534	XS	8/2/2013
	GUAXS_3500B	423773	XS	8/2/2013
	GUAXS_3600	399268	XS	7/10/2013
San Marcos River	SAN_100	400370	Structure	10/26/2012
	SAN_200	380994	Structure	10/26/2012

Appendix D.1.3.b

Survey Summary

HEC-RAS Stream	Survey Cross Section	HEC-RAS Cross Section	Structure or Cross Section	Date Gathered
San Marcos River	SAN_300	17598	Structure	1/23/2013
	SAN_400	374735	Structure	11/29/2012
	SAN_500	371652	Structure	10/29/2012
	SAN_600	344069	Structure	4/15/2013
	SAN_700	315737	Structure	10/30/2012
	SAN_800	315559	Structure	10/30/2012
	SAN_900	294362	Structure	10/31/2012
	SAN_1000	278080	Structure	10/31/2012
	SAN_1100	264972	Structure	1/23/2013
	SAN_1200	223160	Structure	10/22/2012
	SAN_1300	223026	Structure	10/22/2012
	SAN_1400	190504	Structure	10/16/2012
	SAN_1500	190714	Structure	10/17/2012
	SAN_1600	115891	Structure	5/3/2013
	SAN_1700	113209	Structure	10/18/2012
	SAN_1800	71653	Structure	12/11/2012
	SAN_1900	23126	Structure	12/11/2012
	SAN_2000	190504	Structure	11/26/2012
	SAN_2100	190504	Structure	11/26/2012
	SAN_2200	223026	Structure	1/4/2013
	SAN_2300	223160	Structure	1/4/2013
	SAN_2400	115891	Structure	12/11/2012
	SAN_2500	115891	Structure	12/11/2012
	SAN_3000	256875	Structure	2/13/2013
	SANXS_100	392770	XS	4/16/2013
	SANXS_200	356498	XS	4/25/2013
	SANXS_300	330631	XS	4/25/2013
	SANXS_400	307716	XS	7/3/2013
	SANXS_500	287283	XS	4/16/2013
	SANXS_650	241866	XS	5/29/2013
	SANXS_900	203261	XS	7/9/2013
	SANXS_1000	178684	XS	6/18/2013
	SANXS_1100	169101	XS	5/1/2013
	SANXS_1200	169101	XS	5/20/2013
	SANXS_1400	151877	XS	7/9/2013
	SANXS_1500	136096	XS	7/31/2013
	SANXS_1600	127510	XS	7/12/2013
	SANXS_1700	102039	XS	5/29/2013
	SANXS_1800	87528	XS	6/14/2013
	SANXS_1900	55586	XS	7/10/2013
	SANXS_2000	40377	XS	5/2/2013

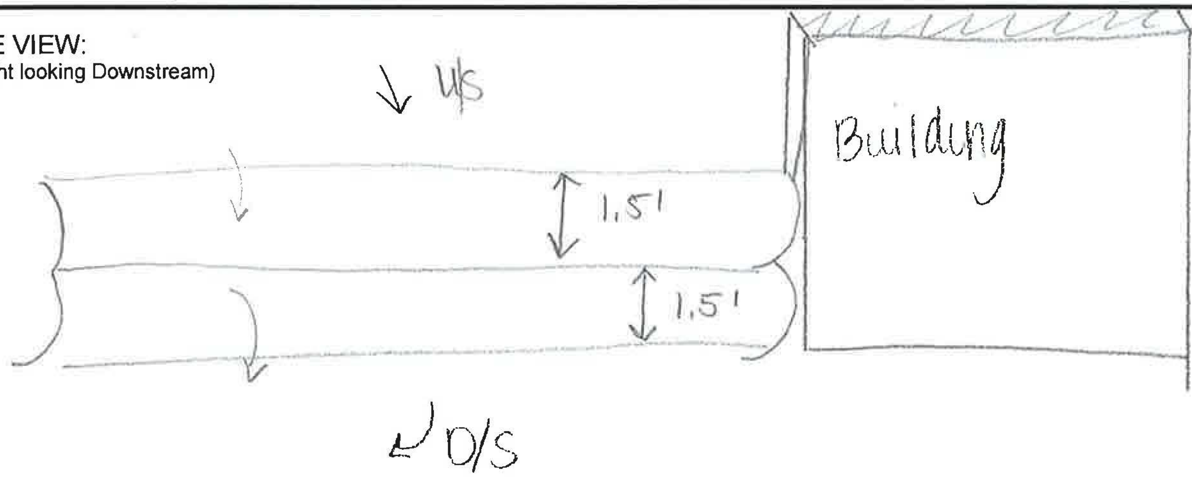
Appendix D.1.3.c
Field Reconnaissance

HALFF **Survey Field Sheet**

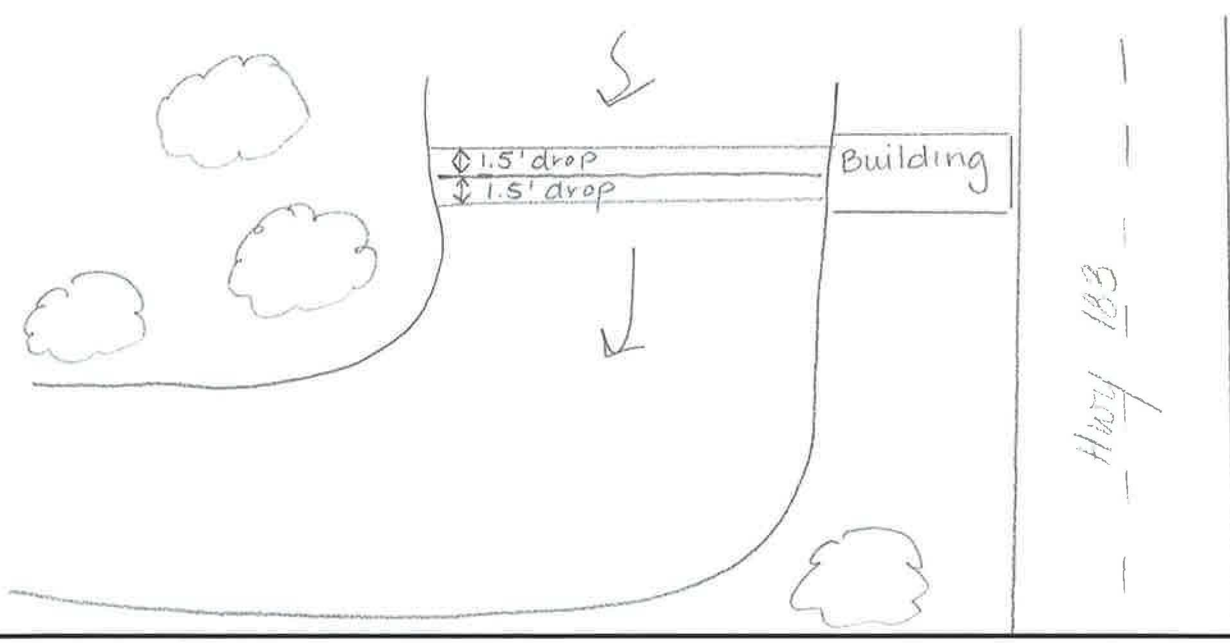
PROJECT: GBRA 28411
SURVEY NAME:
STREAM NAME: GUADALUPE
DATE: 11/27/12.
LOCATION: Dam near Gonzalez
CREW: AW + PS
TYPE: BR( ) CUL( ) DAM(✓) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):	@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:
CULVERT:	I/O Type:				Material:			Wingwall Angle		
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:
ERM Description:								Coordinate System:		
Photo Numbers:			USC:		USF:		DSF: 25,26		DSC:	
Additional Info:	Lakewood?									
File Name:										

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 GBRA ~~[illegible]~~

SURVEY NAME:

STREAM NAME: Guadalupe

DATE: 11/27/12

LOCATION: FM 1117

CREW: AW & PS

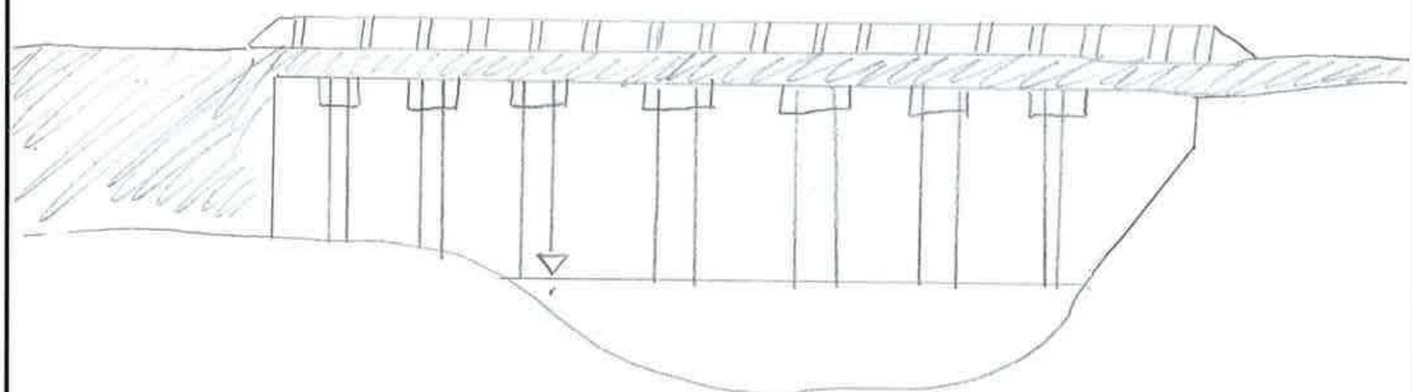
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2'	Deck:	2'	Width:	40'	Pier(s):	6	@	2.0'	Pier Shape: circular
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	10	USF:	11	DSF:	8	DSC:	9	TR 7

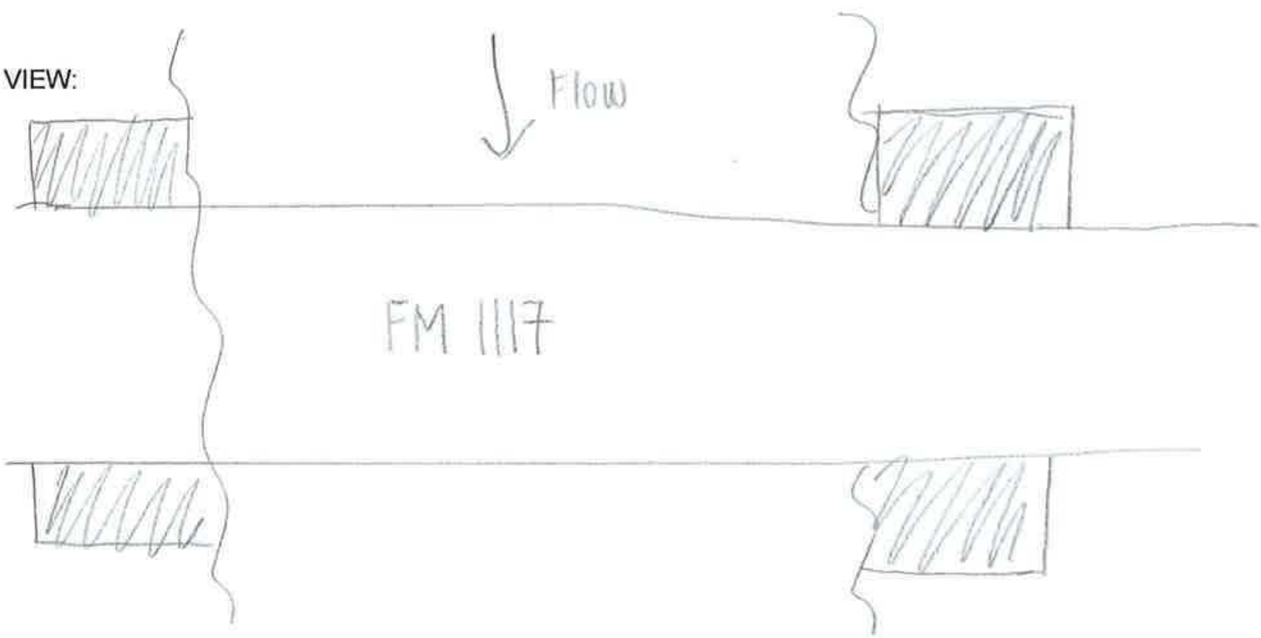
Additional Info: erosion on DS bend + 2 culverts in ROB

File Name: 2'.Ø corrugated metal 3x $\boxed{}_{4'}$ 3' concrete

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411 GBRA

SURVEY NAME:

STREAM NAME: Guadalupe

DATE: 11/27/12

LOCATION: SH 80

CREW: AW & PS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE: Rail Height: 2.25' Deck: 1.8' Width: 30' Pier(s): 4 / 13 @ 2.5' / 3.2' Pier Shape: Flat / square

CULVERT: Number: ____ Shape: ____ Length: ____ Height: ____ Width: ____ Skew: ____

CULVERT: I/O Type: ____ Material: ____ Wingwall Angle ____

DAM: Top Width: ____ Side Slope ____ Side Slope ____ US: ____ DS: ____ Outlet: ____

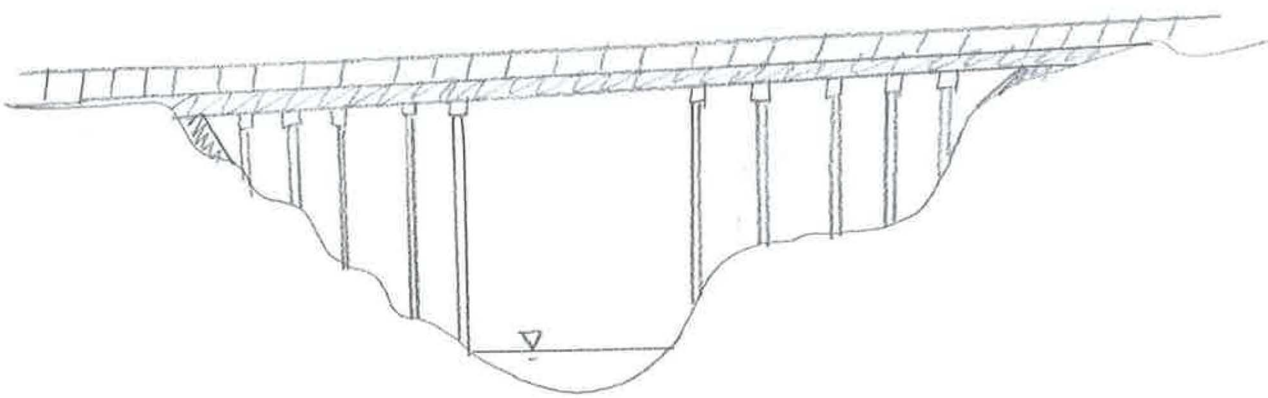
ERM Description: ____ Coordinate System: ____

Photo Numbers: USC: 16,17,18 USF: 13 DSF: 15 DSC: 14 TOR: 12

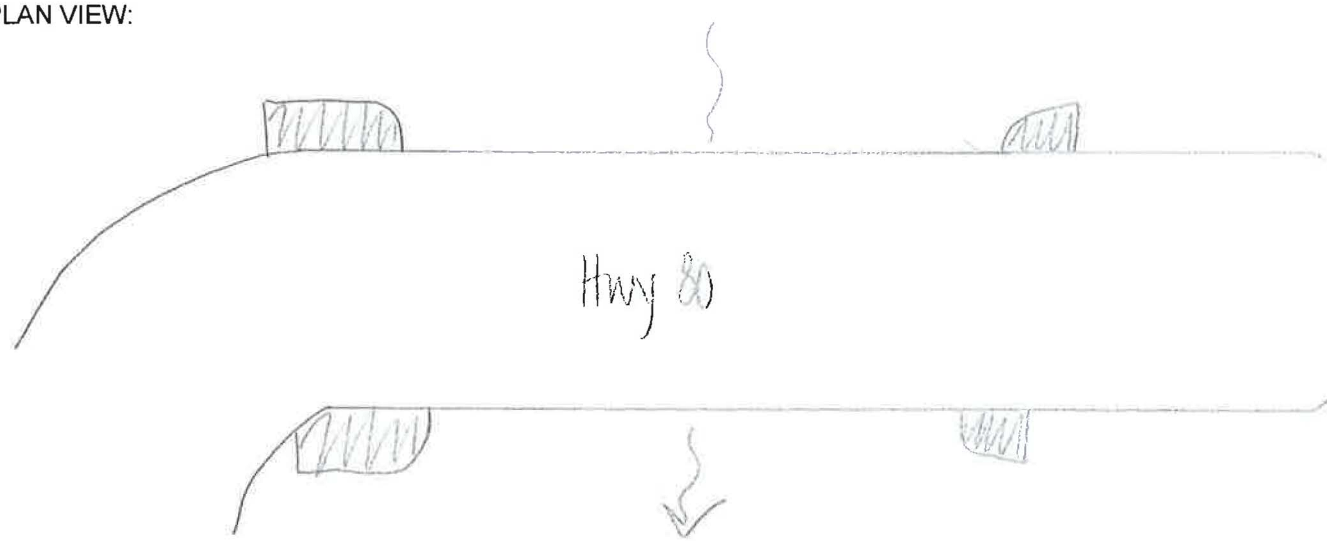
Additional Info: main bridge was not accessible

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 GBRA — SURVEY NAME:

STREAM NAME: Guadalupe — DATE: 11/27/12

LOCATION: CR 143 — CREW: AW & PS

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2.5'	Deck:	0.5'	Width:	25'	Pier(s):	2 3	@	2.0'	Pier Shape: flat circle
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:

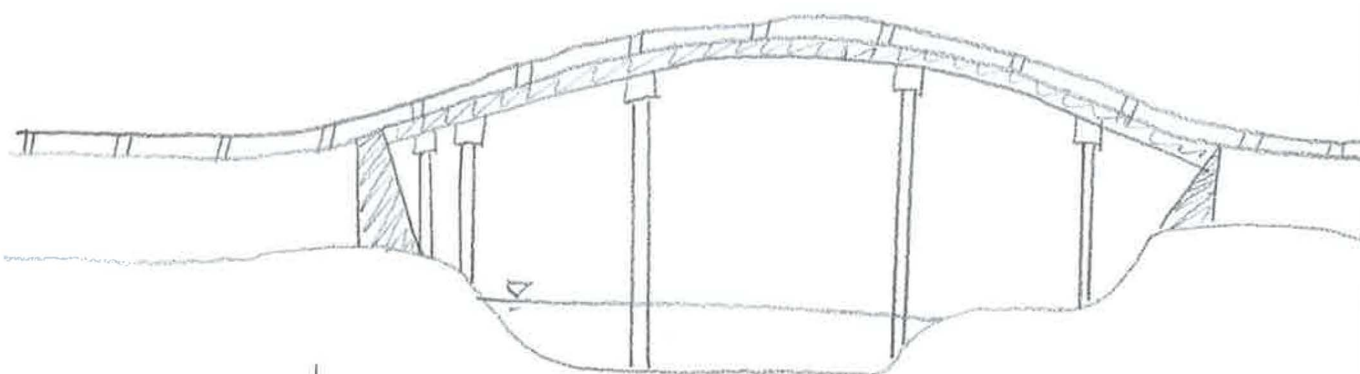
ERM Description: — Coordinate System:

Photo Numbers: USC: 19 USF: 24 DSF: 21,23 DSC: 20 TOR: 22

Additional Info: flat piers on channel edge

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:

HALFF

Survey Field Sheet

PROJECT: 28411 GBRA
SURVEY NAME:

STREAM NAME: Guadalupe
DATE: 11/27/12

LOCATION: US HWY 183 Main Bridge
CREW: AW & RS

TYPE: BR( ) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2.5' Deck: 2.0' Width: Pier(s): 40 @ 16.5" Pier Shape: sq.

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

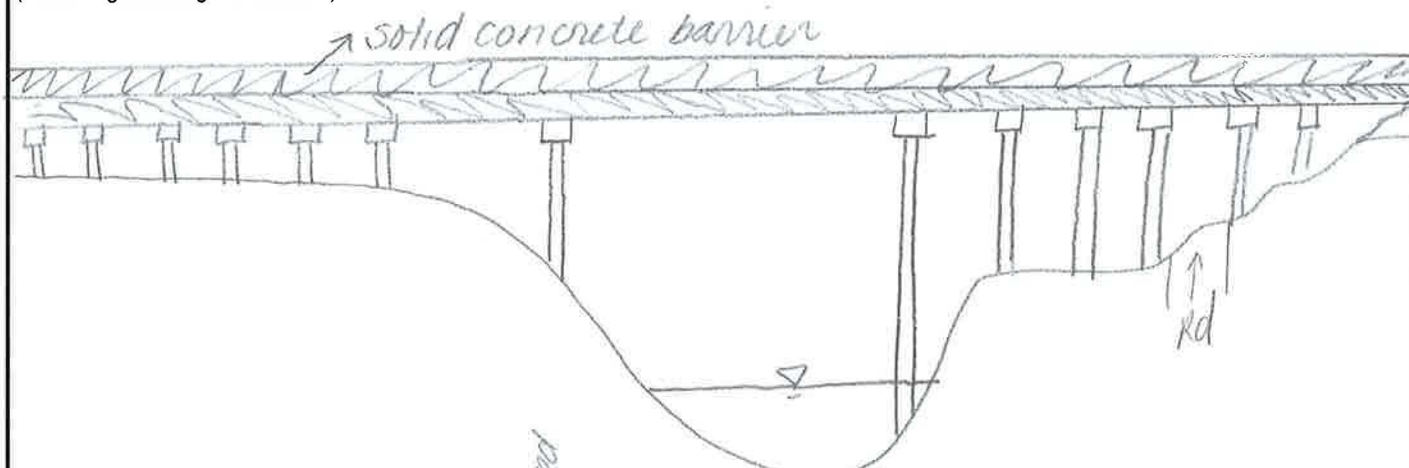
ERM Description: Coordinate System:

Photo Numbers: USC: 36 USF: 27, 28, 29, 30, 31, 32, 33, 34 DSF: 31-40 DSC: 35 TOR 41

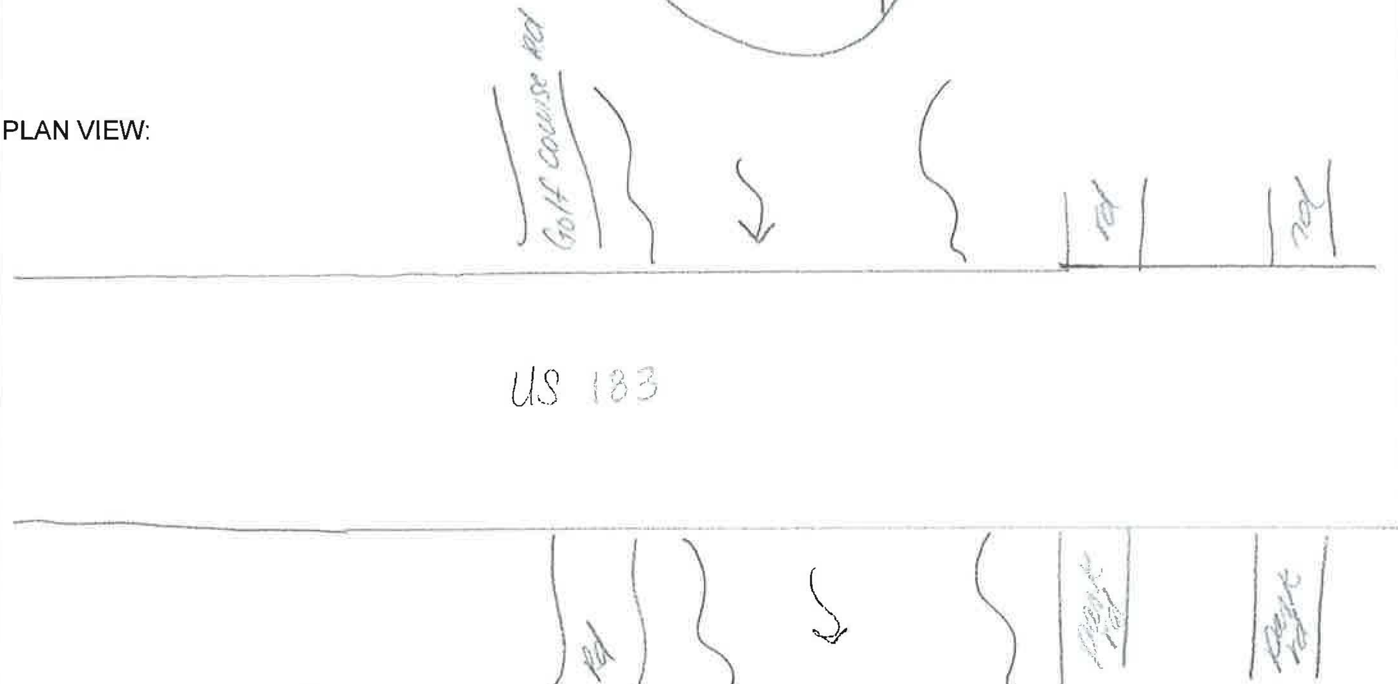
Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: GBRA 284/1

SURVEY NAME:

STREAM NAME: GUADALUPE

DATE: 11/27/12

LOCATION: US HWY 183 Relief

CREW: AW + PS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2.5' Deck: 2' Width: Pier(s): X 6 @ Pier Shape: Square

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

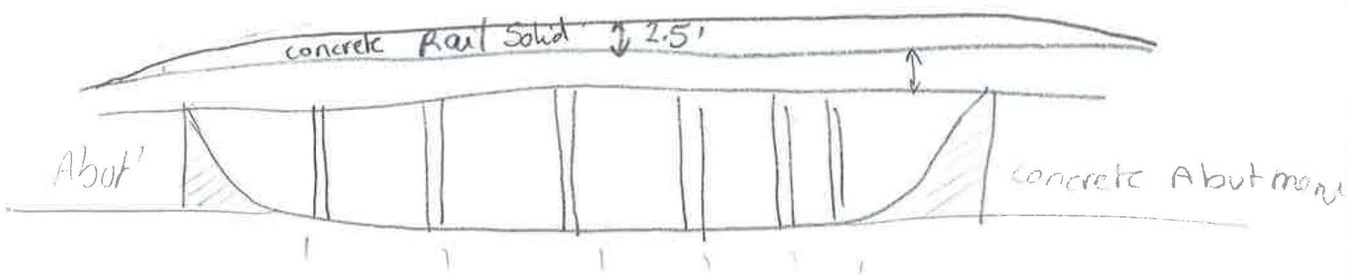
ERM Description: Coordinate System:

Photo Numbers: USC: USF: 41, 42, 43 DSF: DSC: TOR - 44

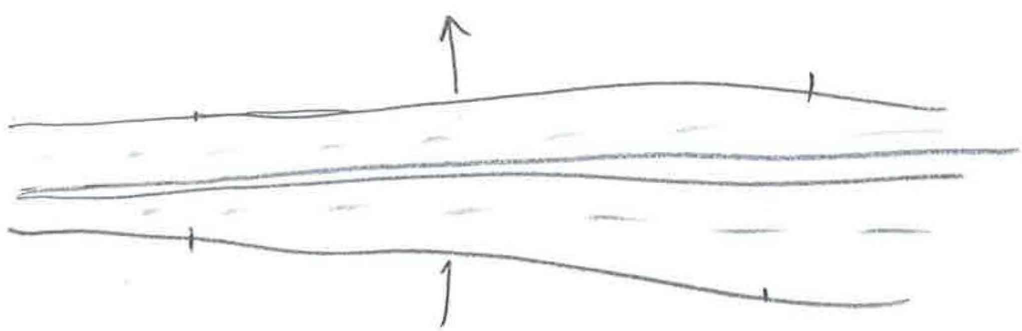
Additional Info: DS Not accessible, Concrete barrier Rail

File Name:

PROFILE VIEW: US
(Left to Right looking ~~Downstream~~)



PLAN VIEW:



No Visible Channel

GAU-500-CULV

HALFF — **Survey Field Sheet**

PROJECT: GBRA SURVEY NAME:

STREAM NAME: GUADALUPE DATE: 11/23/12.

LOCATION: HWY 183 Culvert Dewit CREW: AW & PS

TYPE: BR( ) CUL(✓) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):	@		Pier Shape:	
CULVERT:	Number:	4'	Shape:	BOX	Length:	7'	Height:	5'	Width:		Skew:	
CULVERT:	I/O Type:				Material:	Concrete.	Wingwall Angle	45°.			
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	

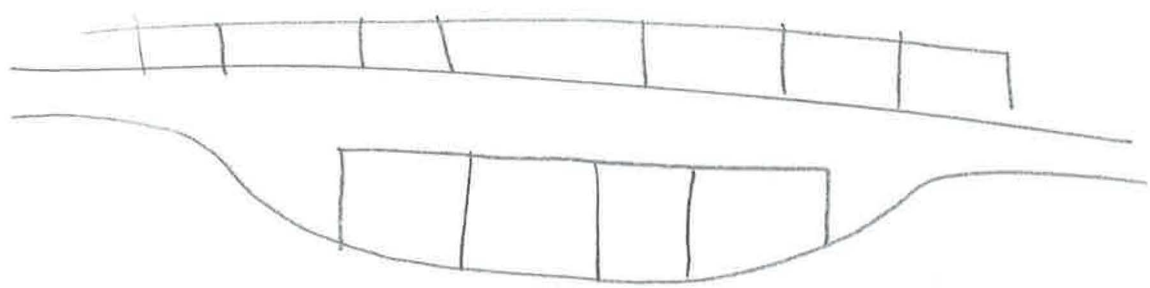
ERM Description: Coordinate System:

Photo Numbers: USC: 53 USF: 51, 52 DSF: DSC:

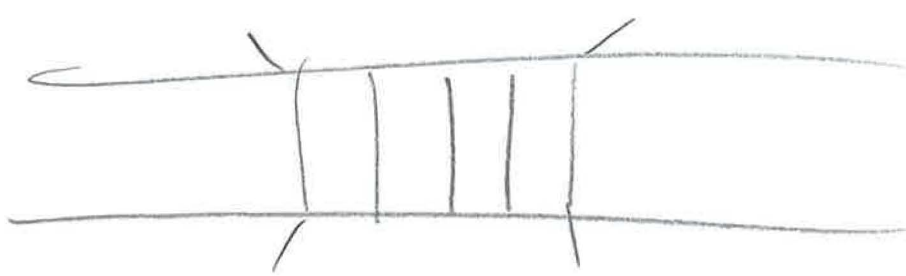
Additional Info: Guard Rail

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA.500_Main

HALFF — **Survey Field Sheet**

PROJECT: GBRA SURVEY NAME:

STREAM NAME: ~~Hwy 183 Main Dewitt~~ GUADALUPE DATE: 11/27/12

LOCATION: HWY 183 Main Dewitt. CREW: AWV PS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2.5	Deck:	3'	Width:		Pier(s):	6	@	≈3'	Pier Shape: circular.
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:

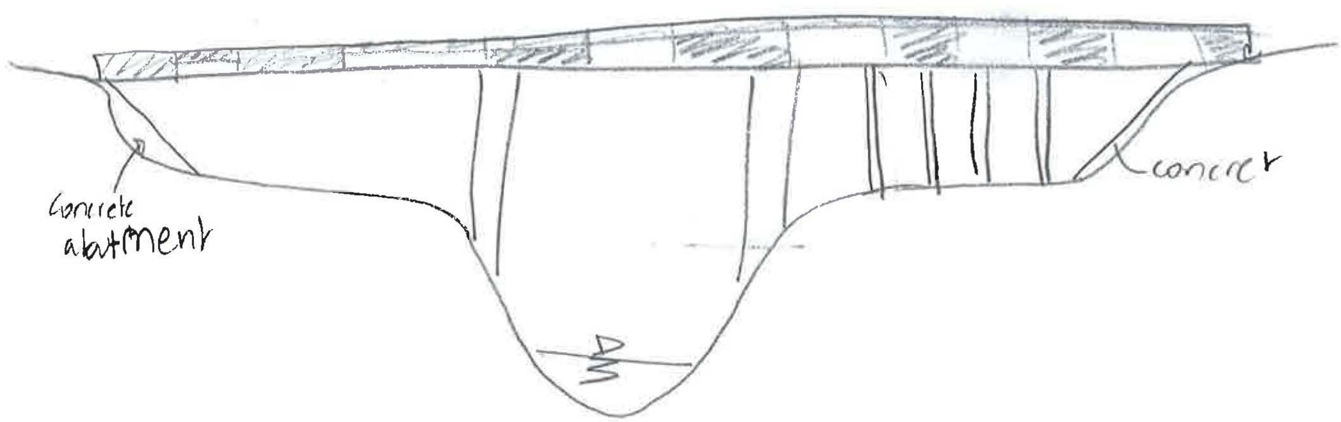
ERM Description: Coordinate System:

Photo Numbers: Under 47 USC: N/A USF: 45, 48 DSF: 46 DSC: N/A

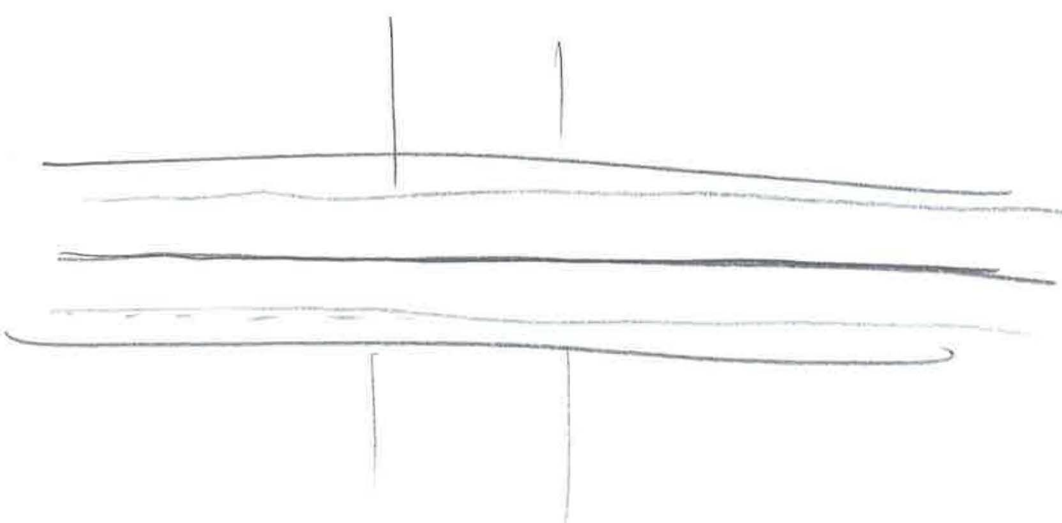
Additional Info: Channel not accessible, concrete rail

File Name:

PROFILE VIEW:
(Left to Right looking Downstream) ✓



PLAN VIEW:



GUA-500-relief

HALFF — **Survey Field Sheet**

PROJECT: GBRA

SURVEY NAME:

STREAM NAME: GUADALUPE

DATE: 11/27/12.

LOCATION: HWY 183 Releif Drawt

CREW: AW & DS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2'3"	Deck:	13" ~~13~~	Width:		Pier(s):	6	@	≃2'	Pier Shape:	Square
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	

ERM Description:

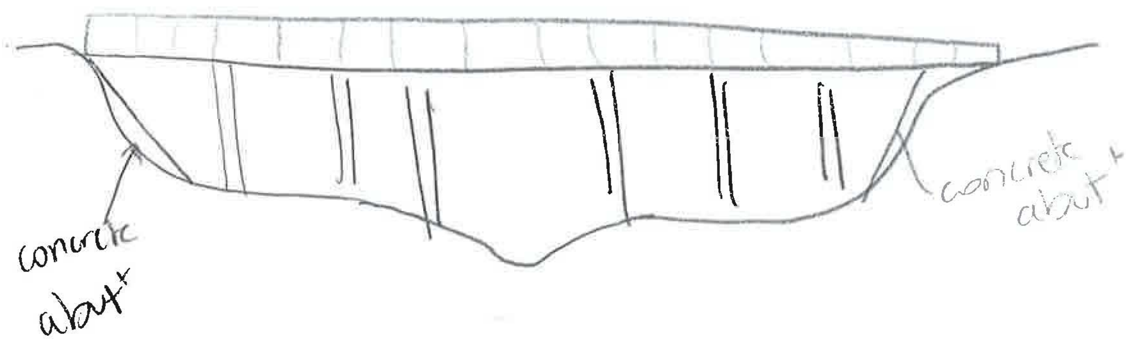
Coordinate System:

Photo Numbers: USC: 49 USF: 48 DSF: N/A DSC: N/A TOR = 50

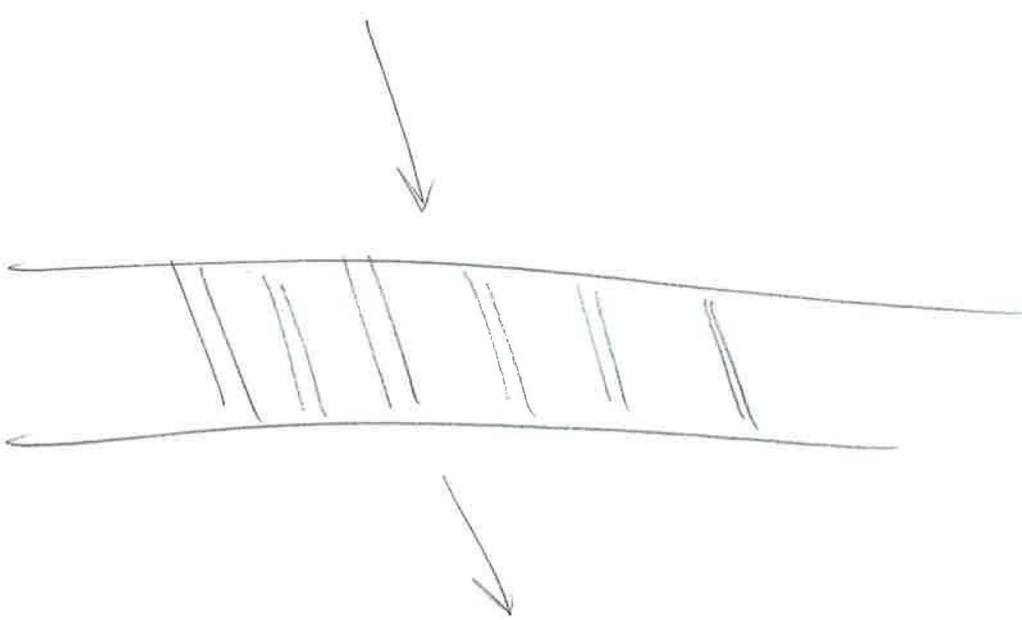
Additional Info: GUARD Rail.

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA_600

HALFF — Survey Field Sheet

PROJECT: 28411-GBRA SURVEY NAME: ~~AW & PS~~

STREAM NAME: Guadalupe River DATE: 11/28/2012

LOCATION: FM 766 CREW: AW & PS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE:	Rail Height:	1.5'	Deck:	3'	Width:		Pier(s):	10	@	~1.5'	Pier Shape: circular
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:

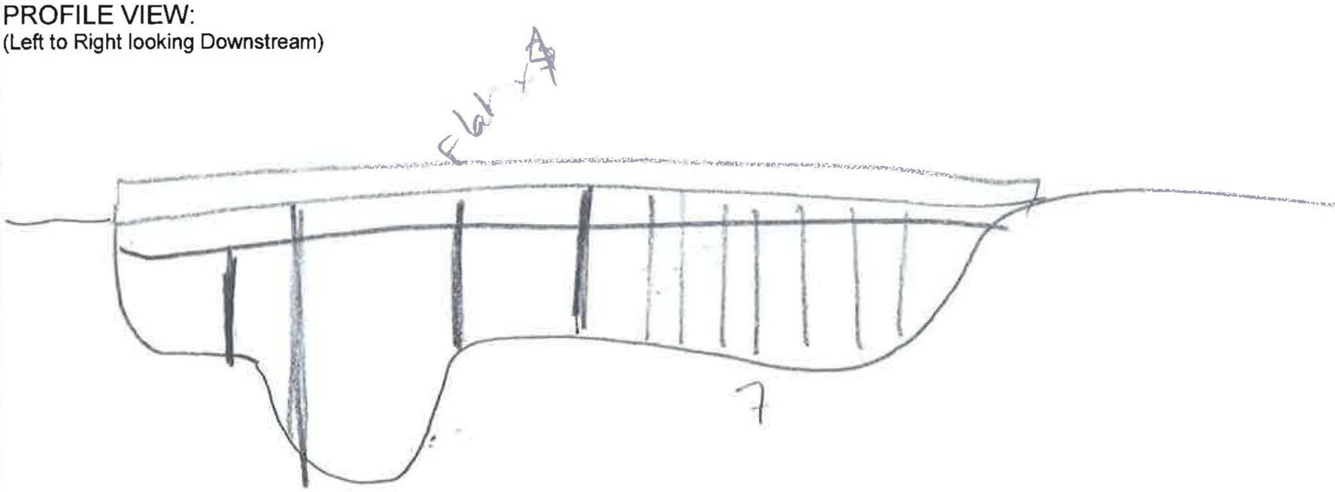
ERM Description: ______ Coordinate System: ______

Photo Numbers: USC: 124, 125 USF: 127, 128, 129 DSF: 130, DSC: 131, 132, 133 TOR = 126

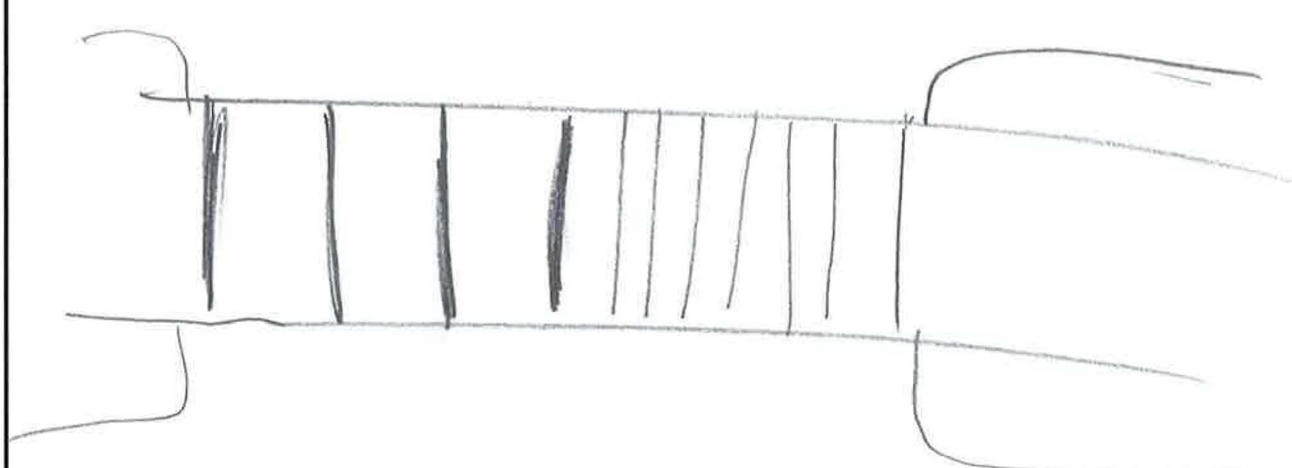
Additional Info: Guard Rail

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA-700-CULV1

HALFF — **Survey Field Sheet**

PROJECT: GBRA SURVEY NAME: ______

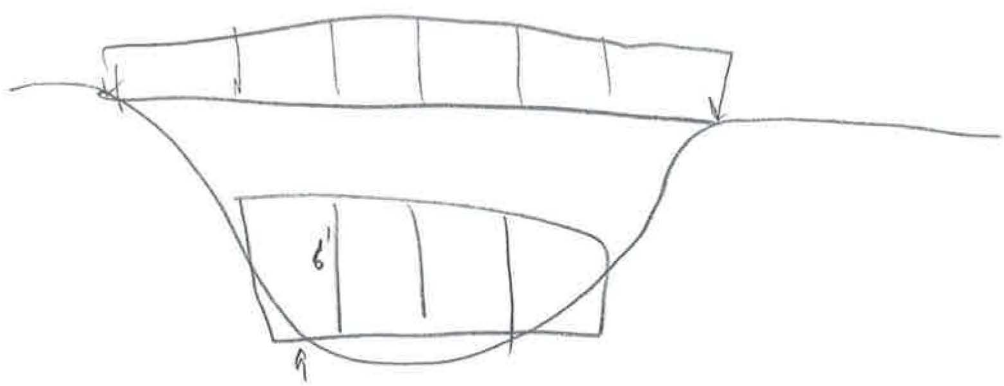
STREAM NAME: Guadalupe DATE: 11/28/12

LOCATION: HWY 72 Culverts CREW: AW & PS

TYPE: BR( ) CUL(✓) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

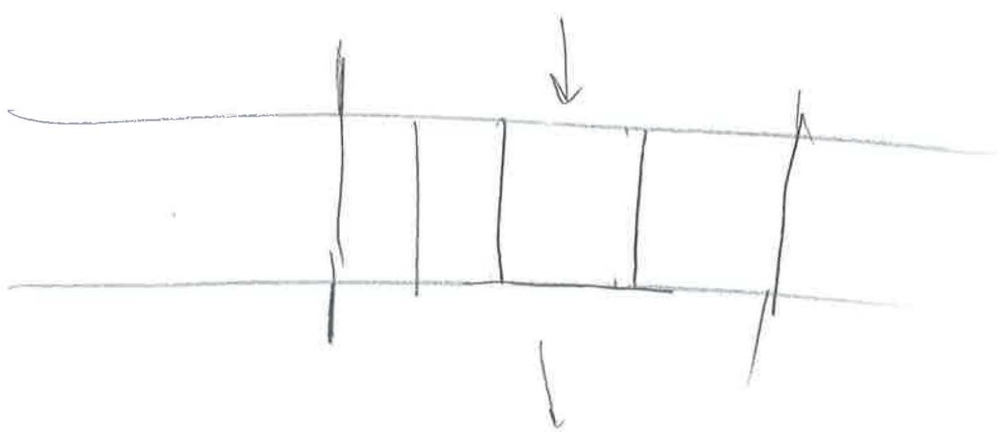
BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):	@	Pier Shape:	
CULVERT:	Number:	4	Shape:	Box	Length:	9	Height:	8	Width:	Skew: No
CULVERT:	I/O Type:				Material:		Wingwall Angle			
DAM:	Top Width:		Side Slope		Side Slope		US:	DS:	Outlet:	
ERM Description:							Coordinate System:			
Photo Numbers:			USC:	~~N/A~~	USF:		DSF: 119	DSC: 120	TOR - 117, 118	
Additional Info:	Guard Rail									
File Name:										

PROFILE VIEW: US
(Left to Right looking Downstream)



1 foot spacing.

PLAN VIEW:



GUA-700_CULV2

HALFF Survey Field Sheet

PROJECT: GBRA SURVEY NAME:

STREAM NAME: GUADALUPE DATE: 11/28/12

LOCATION: HWY 72 by Cuero CREW: AW & PS

TYPE: BR( ) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2.5 Deck: 1' Width: Pier(s): 2 @ 1' Pier Shape: Concrete Square

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

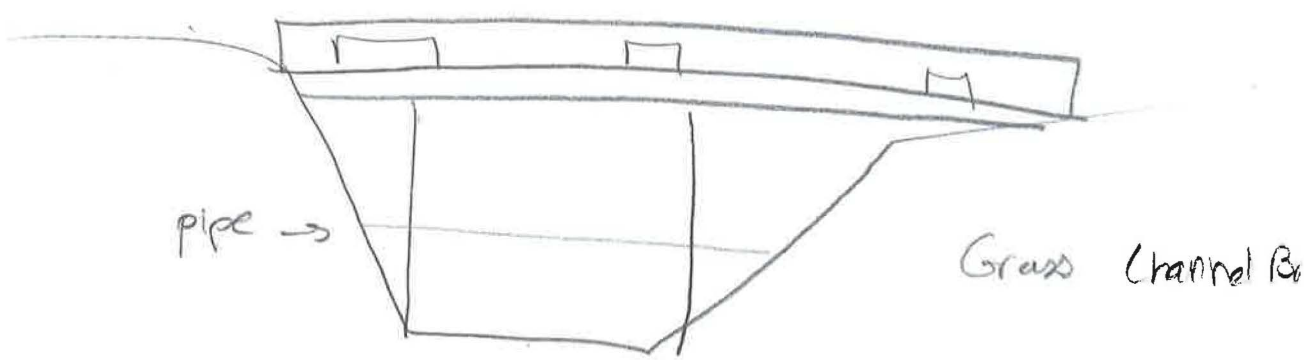
ERM Description: Coordinate System:

Photo Numbers: USC: 121 USF: 123, 122 DSF: DSC: TBR

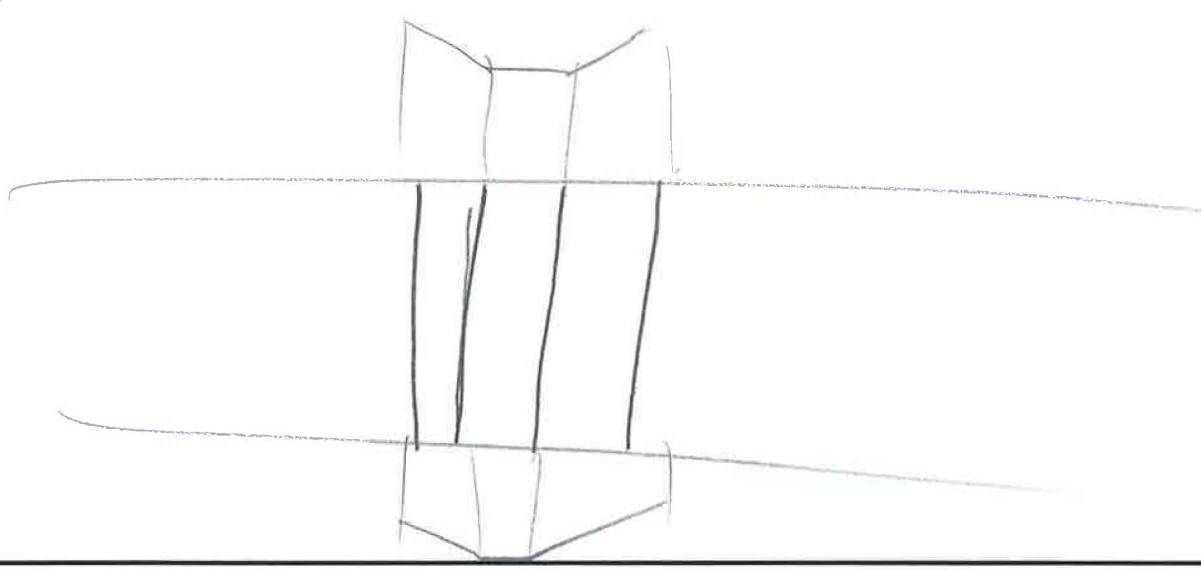
Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA.700

HALFF

Survey Field Sheet

PROJECT: GBRA

SURVEY NAME:

STREAM NAME: GUADALUPE Main

DATE: 11/26/12

LOCATION: HWY 72 Main

CREW: AW & DS

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2.5' Deck: 3' Width: Pier(s): 4 @ Pier Shape: Circular - concrete

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

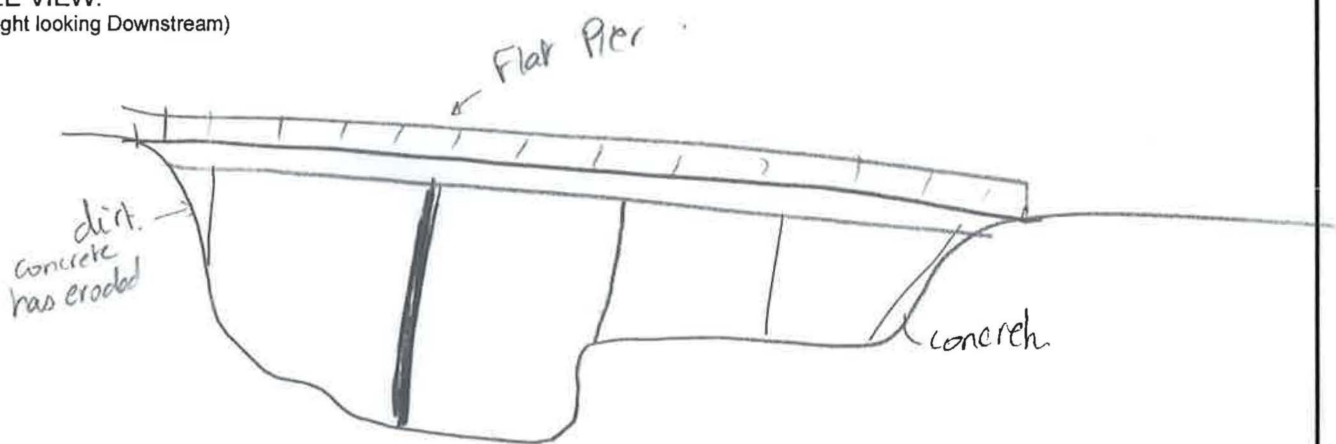
ERM Description: Coordinate System:

Photo Numbers: log Sum = 111 USC: 107 USF: 106,114 DSF: 110,109 DSC: 108 TOR.

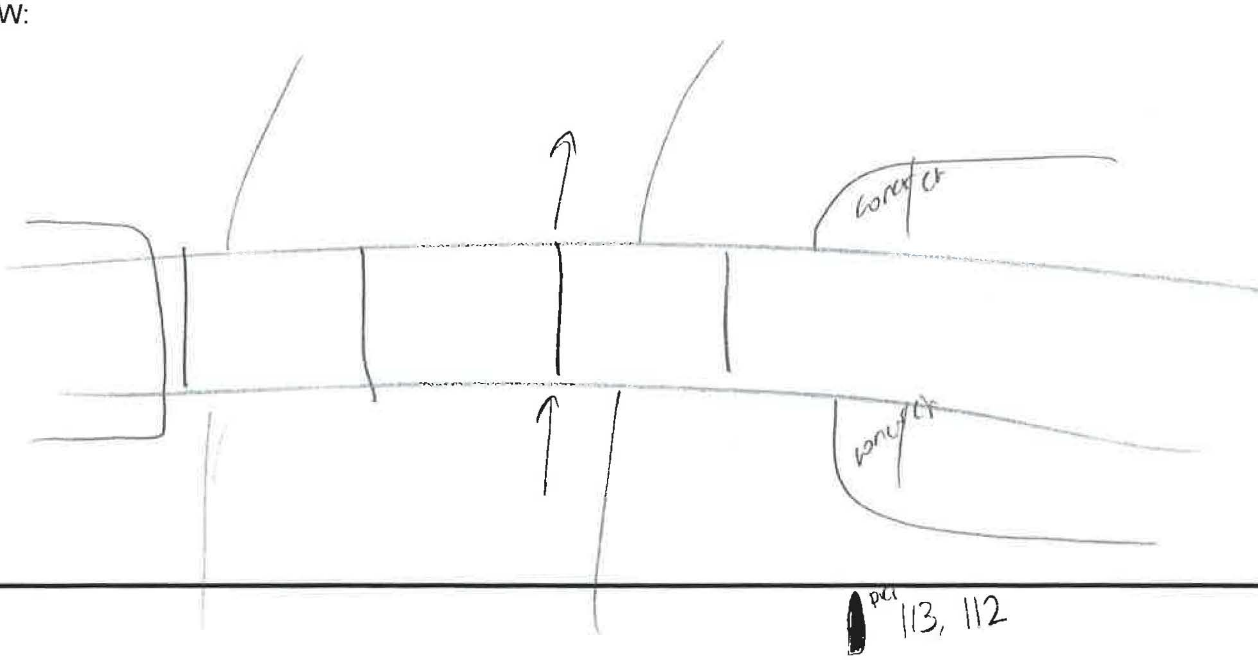
Additional Info: Concrete Rail not solid

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



pier 113, 112

GUA 800 - CULV

HALFF

Survey Field Sheet

PROJECT: GBRA

SURVEY NAME:

STREAM NAME: GUADALUPE

DATE: 11/28/12

LOCATION: HWY 183 by Cuero 187

CREW: AW & PS

TYPE: BR(√) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2' Deck: 2' Width: Pier(s): 4 @ 1' Pier Shape: □

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

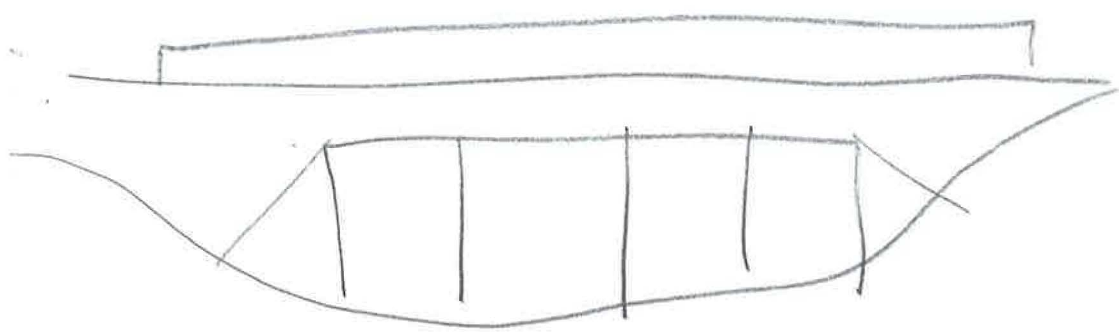
ERM Description: Coordinate System:

Photo Numbers: USC: 100 99 USF: DSF: 96, 97, DSC: 98 76

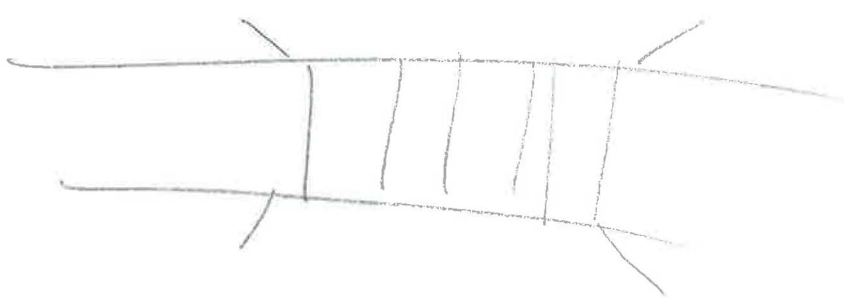
Additional Info: Concrete Rail

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



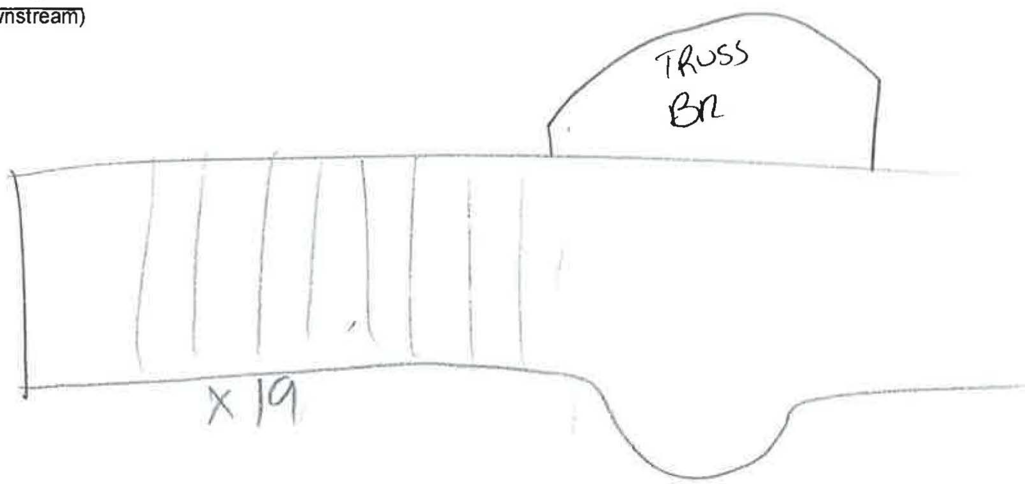
GUA.800-Main

HALFF — Survey Field Sheet

PROJECT: GBRA
SURVEY NAME:
STREAM NAME: GUADALUPE
DATE: 11/28/12
LOCATION: HWY 183/87 Main.
CREW: AW & RS
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2.5' Deck: 2 Width: Pier(s): 19 @ 1' Pier Shape: Square
CULVERT: Number: Shape: Length: Height: Width: Skew:
CULVERT: I/O Type: Material: Wingwall Angle
DAM: Top Width: Side Slope Side Slope US: DS: Outlet:
ERM Description: Coordinate System:
Photo Numbers: USC: 104,105 USF: DSF: 87,88 DSC: 90 TOP: 89,103
Additional Info: main channel was not accessible
File Name:

PROFILE VIEW: US
(Left to Right looking ~~Downstream~~)



PLAN VIEW:

GUA. 800 - Relief

HALFF | **Survey Field Sheet**

PROJECT: GBRA SURVEY NAME: ______

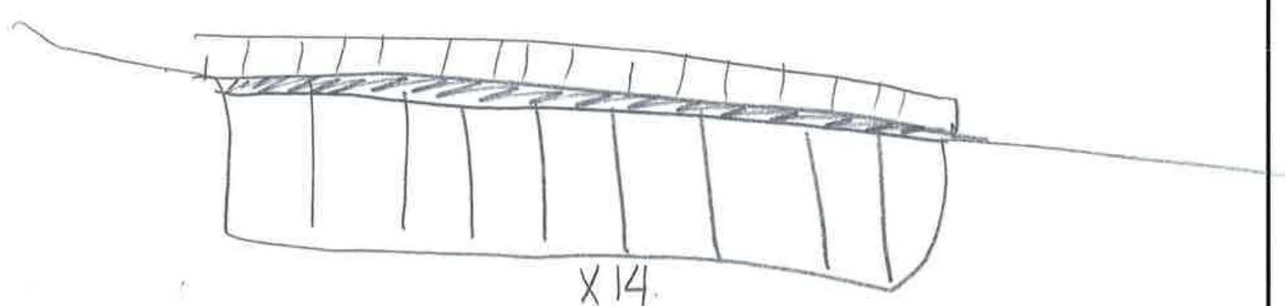
STREAM NAME: GUADALUPE DATE: 11/28/12

LOCATION: Hwy 183/87 Relief Dewitt CREW: AW & PS

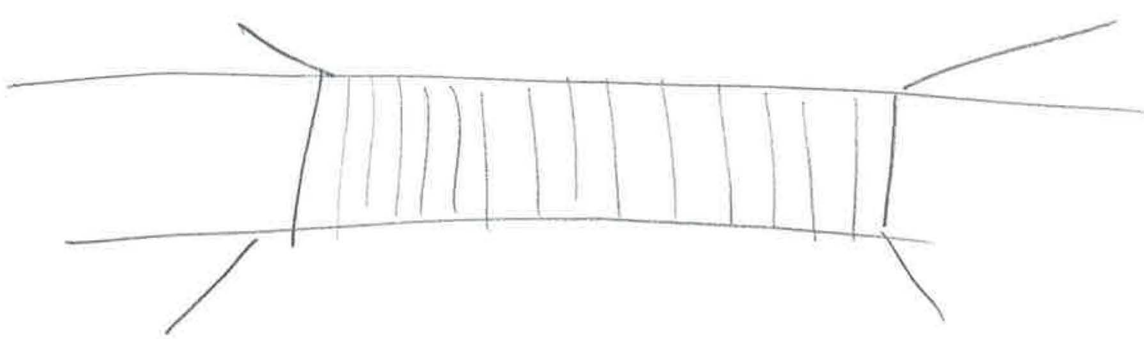
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE:	Rail Height:	2.5'	Deck:	2'	Width:		Pier(s):	14	@	1'	Pier Shape: square
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	101	USF:	92 → 95	DSF:		DSC:		TOR 102
Additional Info:	No Channel definition										
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA 900

HALFF — **Survey Field Sheet**

PROJECT: GBRA

SURVEY NAME:

STREAM NAME: GUADALUPE

DATE: 11/28/12

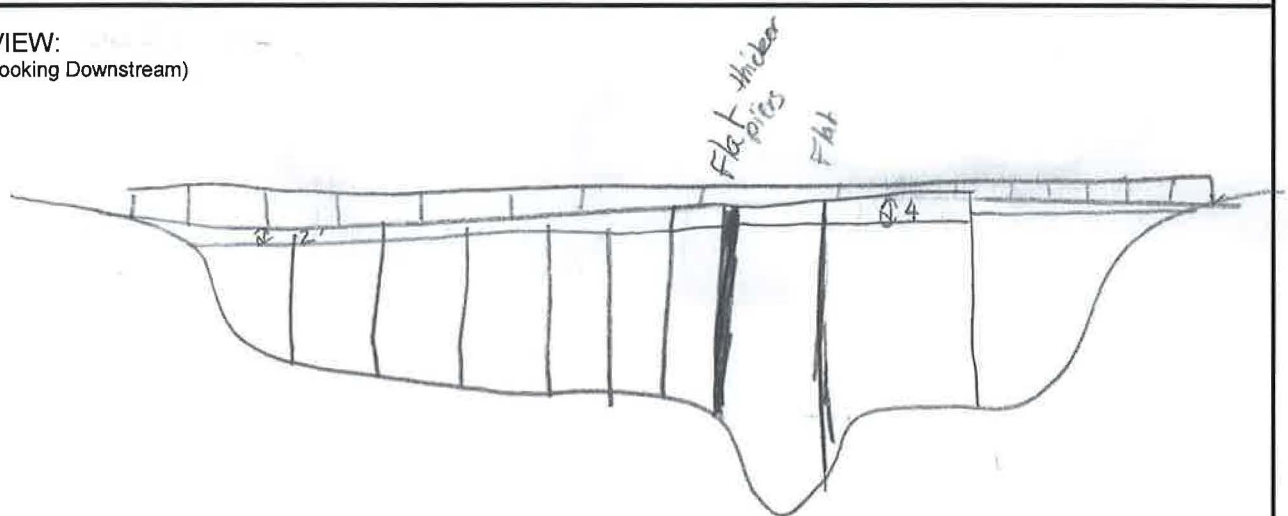
LOCATION: FM ~~236~~ 236 Main.

CREW: AW & PB

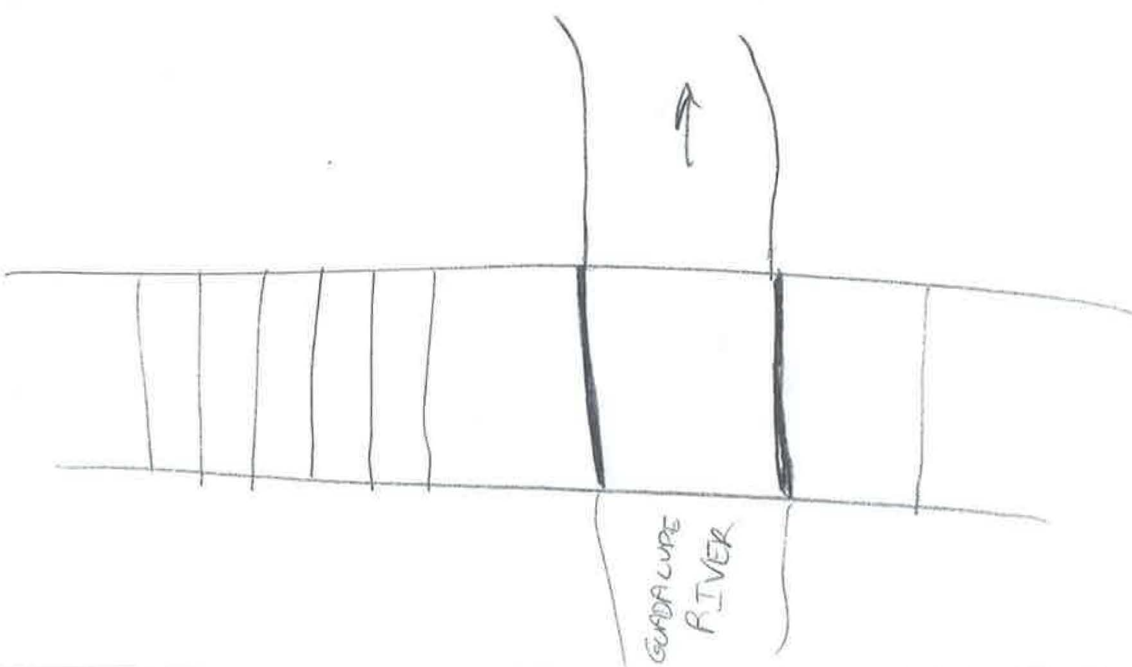
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:	2' @ OB 4' @ CH	Width:		Pier(s):	9	@		Pier Shape: Cir
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	59	USF:	60, 61	DSF:	55-58	DSC:	54	TOR 63
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: GBRA   SURVEY NAME:

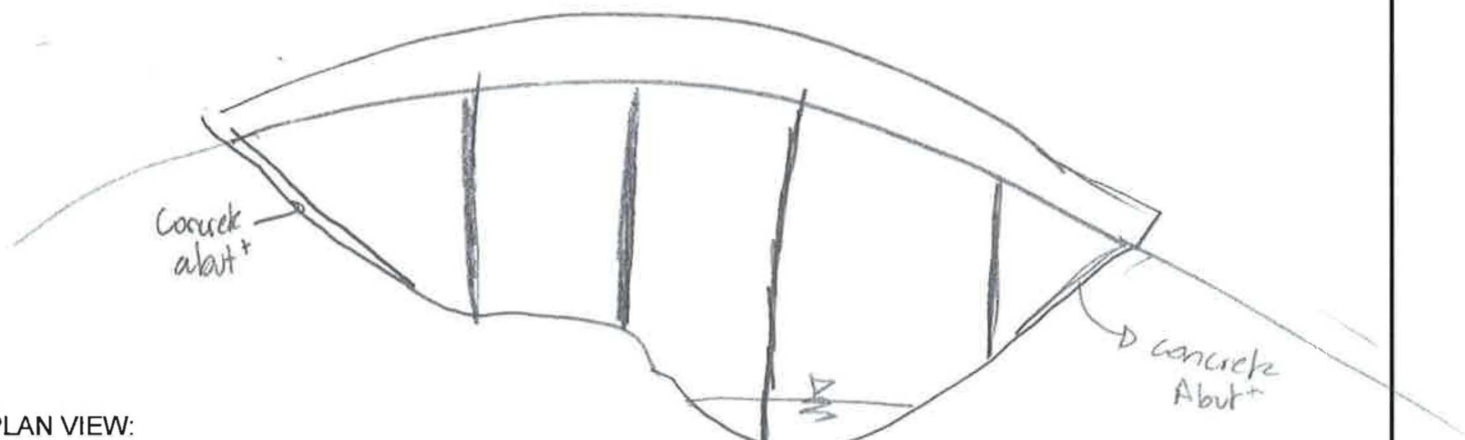
STREAM NAME: Guadalupe   DATE: 11/28/12

LOCATION: Thomaston River Road   CREW: AW & PS

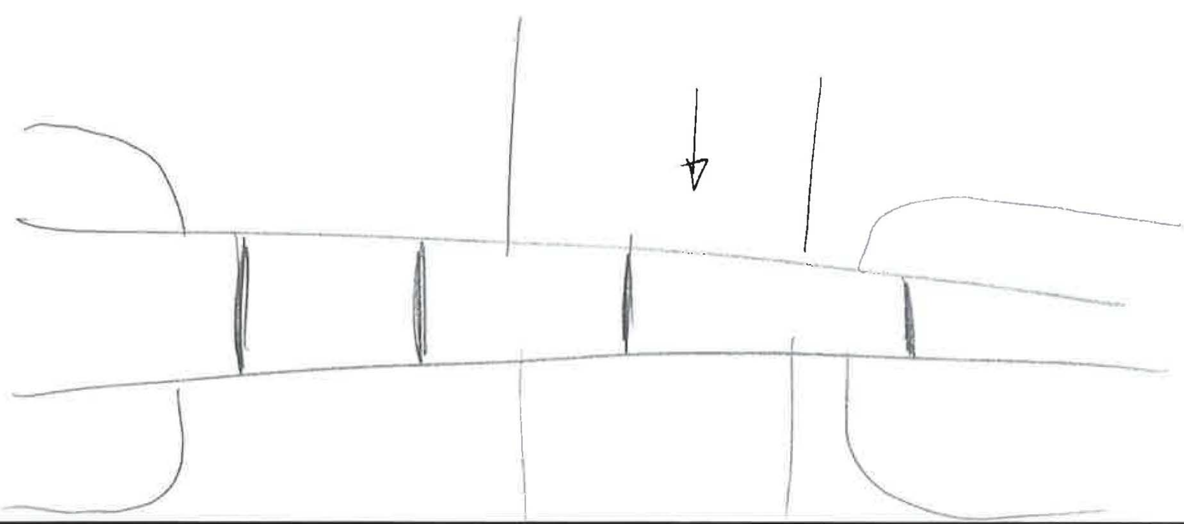
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2.5	Deck:	3	Width:		Pier(s):	4	@		Pier Shape: circular Flat
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:	log sgm = 77		USC:	79.85	USF:	81.80	DSF:	76.84	DSC:	78	TOR: 83
Additional Info:	concrete Rail. with holes										
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



GUA-1000-Relief

HALFF **Survey Field Sheet**

PROJECT: GBRA

SURVEY NAME:

STREAM NAME: GUADALUPE

DATE: 11/28/12

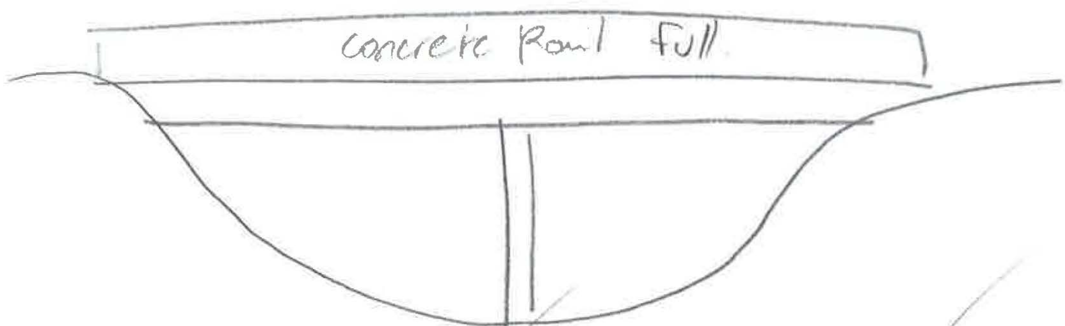
LOCATION: Thomaston Releif

CREW: AW d PS

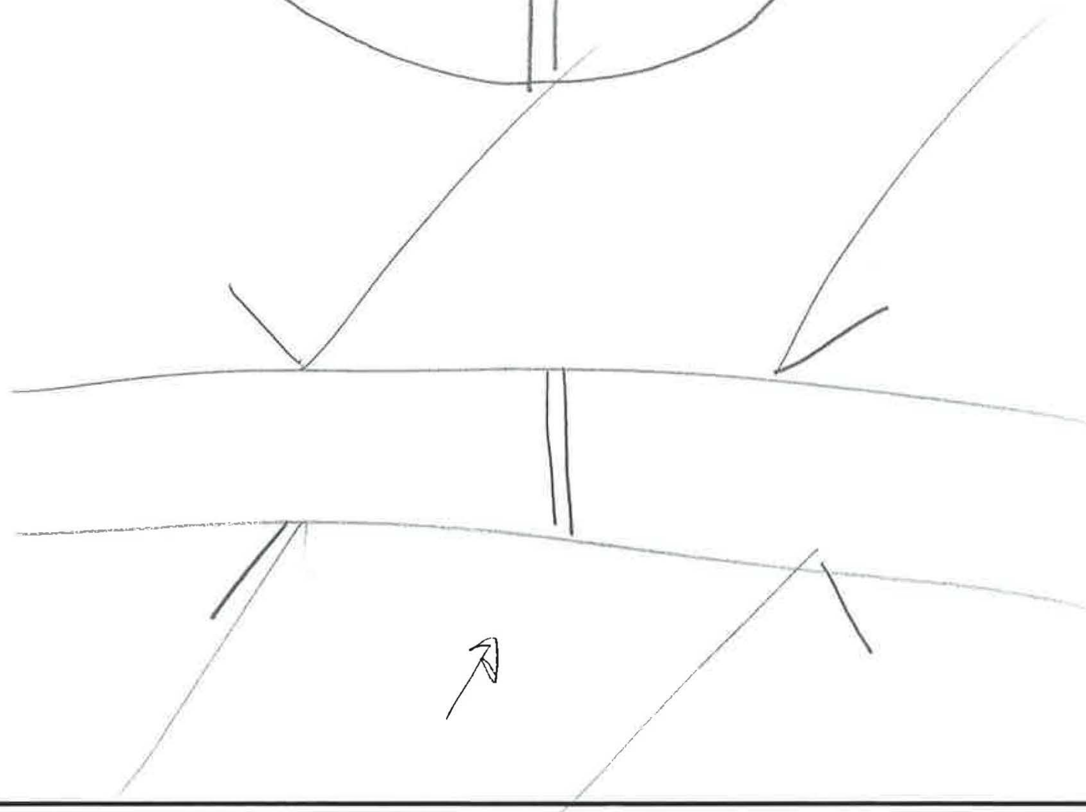
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	1	Deck:	1.5	Width:		Pier(s):	1	@	1'	Pier Shape: square
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	73	USF:	74	DSF:	71	DSC:	72	TOR = 75
Additional Info:		concrete Rail									
File Name:											

PROFILE VIEW: ✓
(Left to Right looking Downstream)



PLAN VIEW:



HALFF **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10,17,12

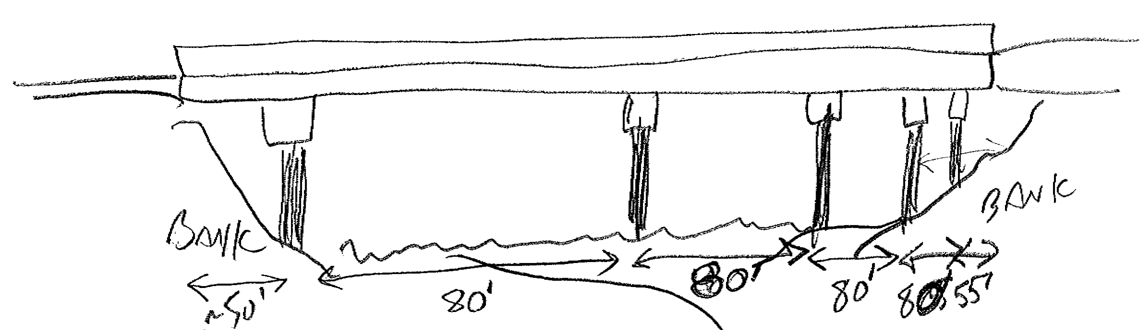
LOCATION: Staintown Rd CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2'8"	Deck:	3'10"	Width:	30'1"	Pier(s):	5 @	varies	Pier Shape:	round
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	~45°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	79	USF:	—	DSF:	81	DSC:	78	XS: 80
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

not to scale



PLAN VIEW:

HALFF — Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: San Marcos River

DATE: 10.17.12

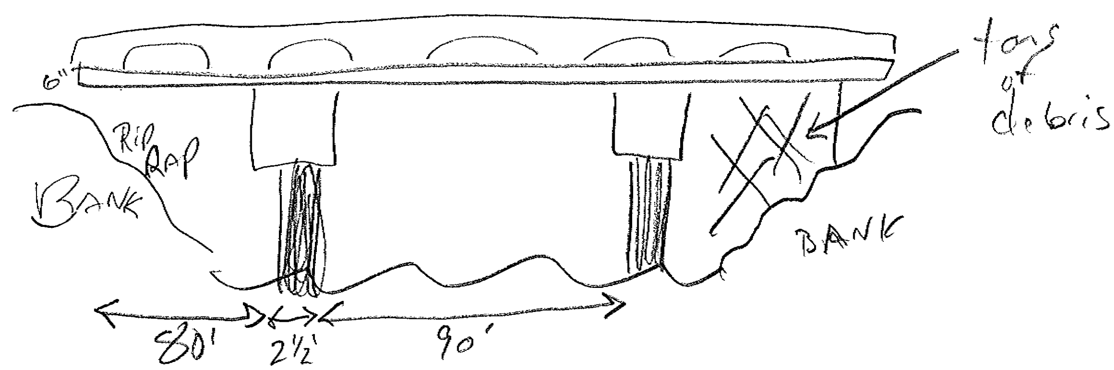
LOCATION: Plant Rd Bridge

CREW: AB SC

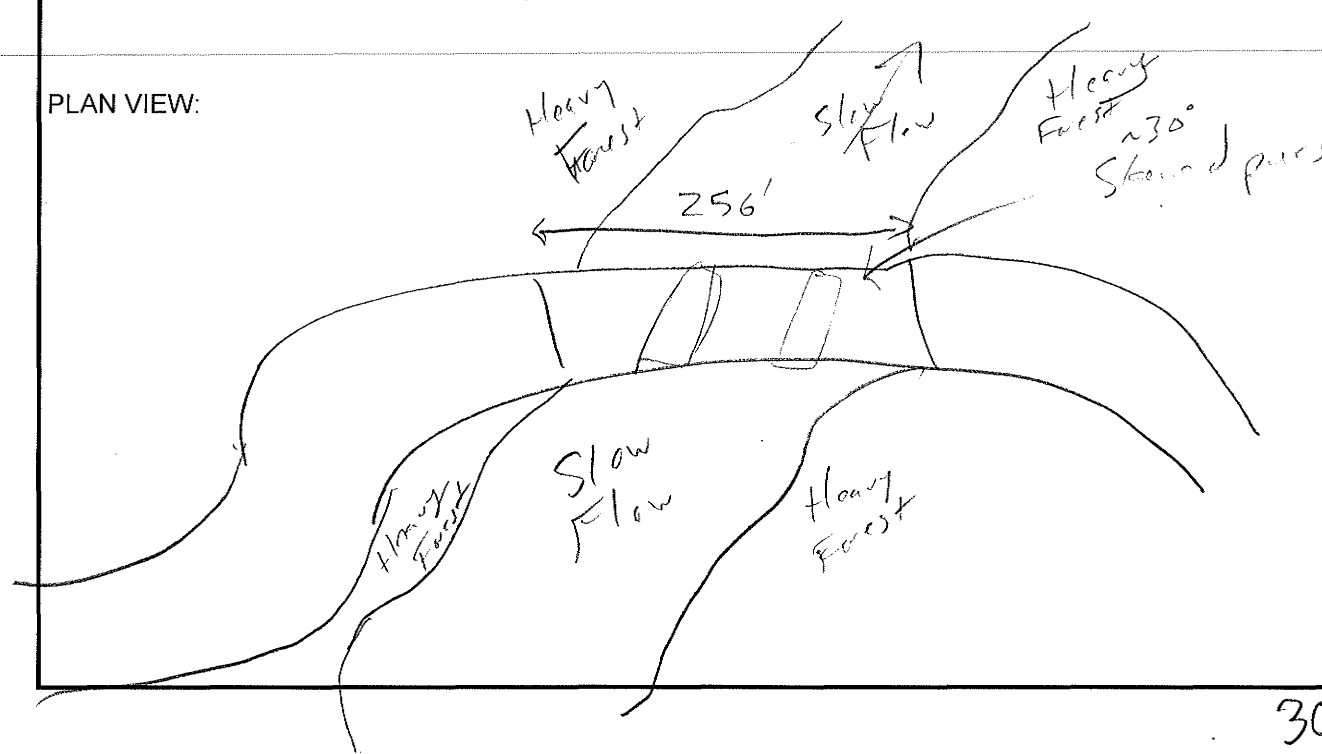
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE:	Rail Height:	2'3"	Deck:	3'9"	Width:	26'	Pier(s):	2	@	90'	Pier Shape: round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew: ~30°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	75	USF:	77	DSF:	—	DSC:	76	XS: 74
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.17.12

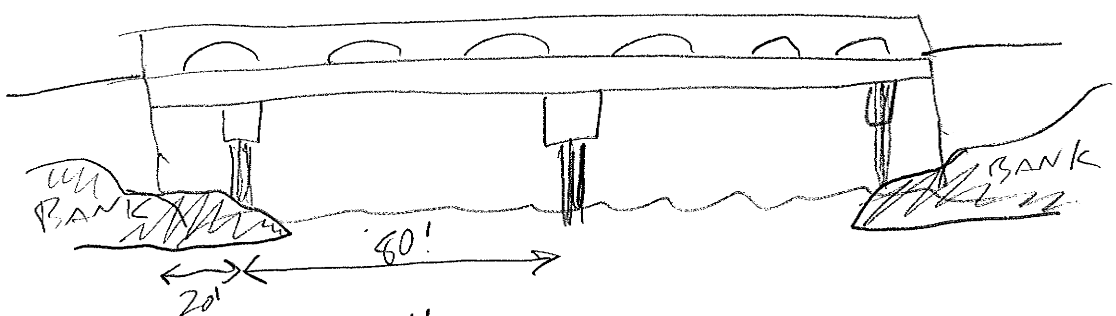
LOCATION: CR 239 Sherrill Rd Bridge CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

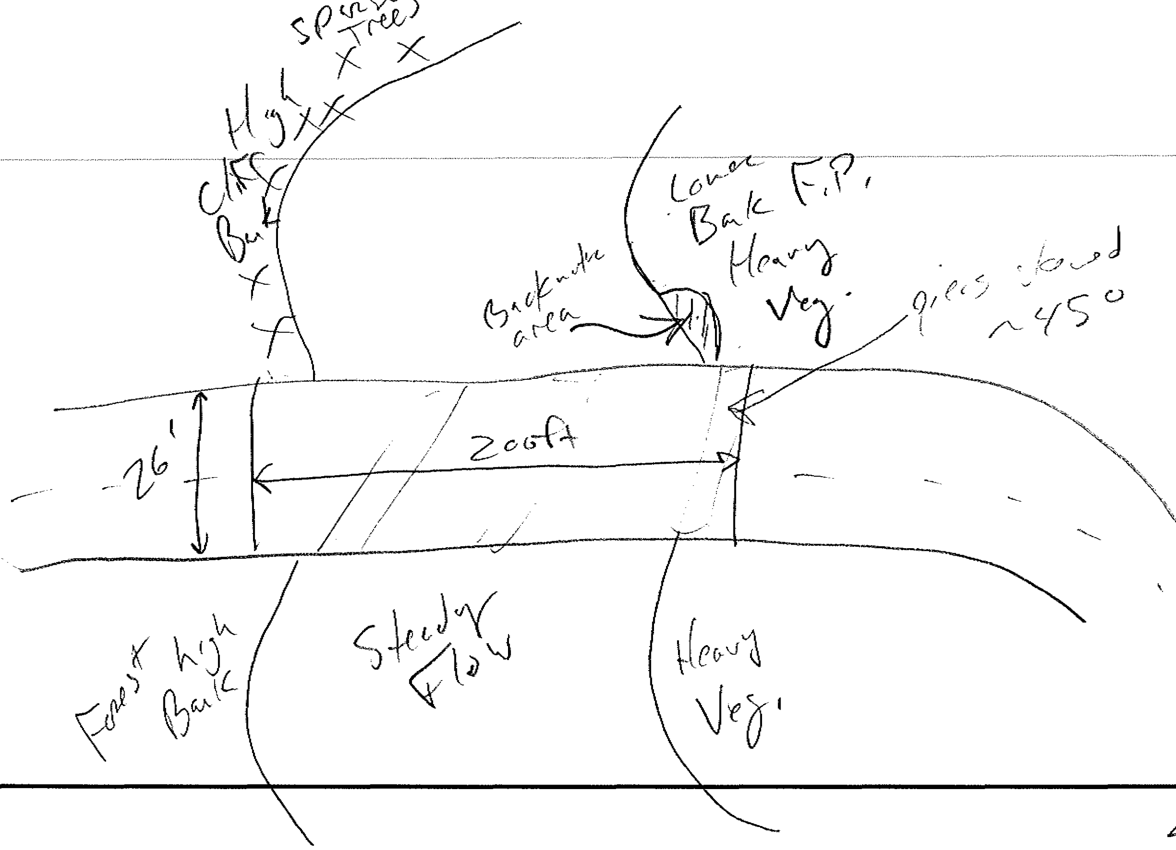
BRIDGE:	Rail Height:	2'3"	Deck:	~3'	Width:	26'	Pier(s):	3	@	80'	Pier Shape: round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew: ~45°
CULVERT:	I/O Type:		Material:		Wingwall Angle						
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:					Coordinate System:						
Photo Numbers:		USC:	71	USF:	none	DSF:	72, 73	DSC:	70	XS: 69	
Additional Info:				couldn't get to it							
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

piers maybe ~2-3ft



PLAN VIEW:



* Alternatives - Local Spoke of recurring issues

HALFF **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME: ______

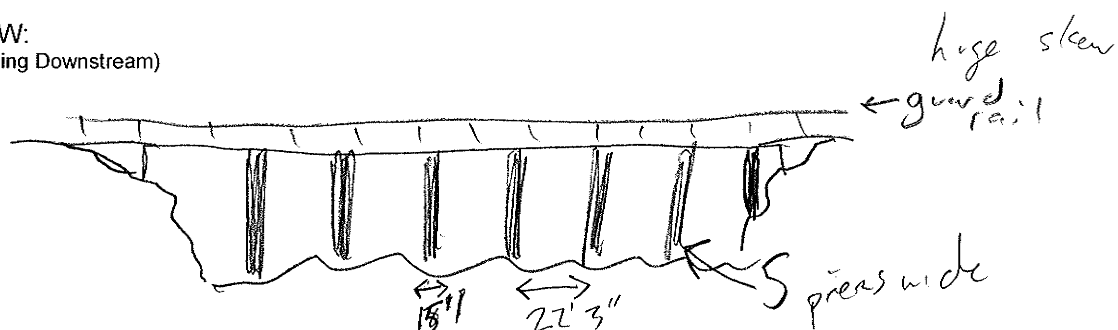
STREAM NAME: San Marcos River DATE: 10.17.12

LOCATION: Rt 20 Bridge CREW: AB SC

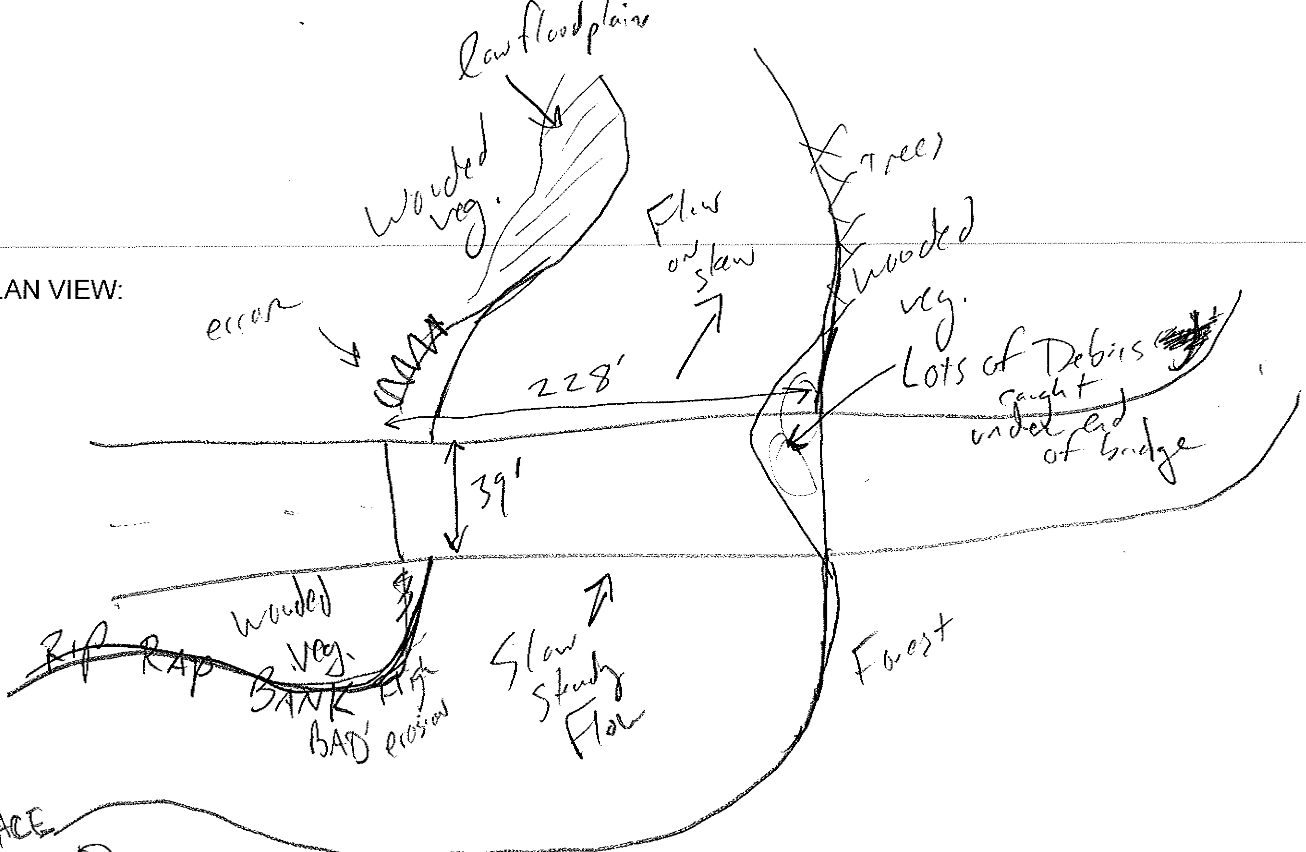
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE:	Rail Height:	2'3"	Deck:	15"	Width:	39'	Pier(s):	8 (15" wide)	@	22'3"	Pier Shape: SQUARE
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew: almost 45°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	65	USF:	68	DSF:	67	DSC:	66	~~XS~~: 64
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



USACE ISLAND SPLIT

HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

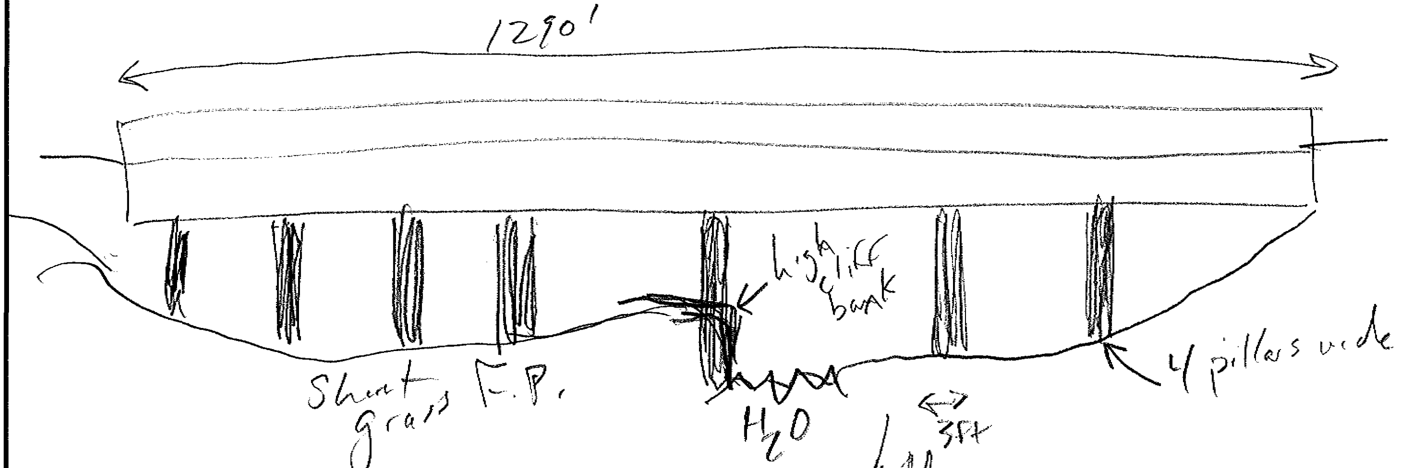
STREAM NAME: San Marcos River DATE: 10.17.12

LOCATION: TX toll Rd 130 CREW: AB SC

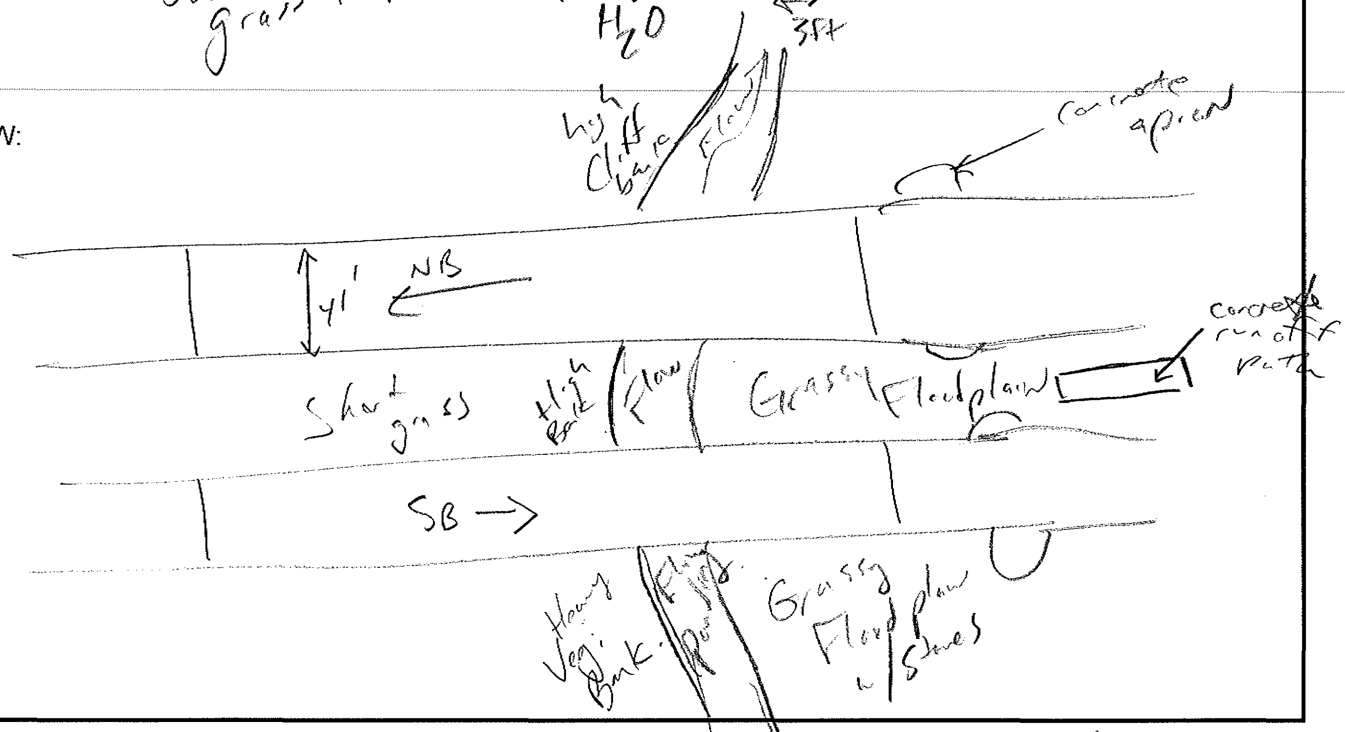
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2'9"	Deck:	5'4"	Width:	41'	Pier(s):	3 ft wide piers 7 x/2	@ 100ft	Pier Shape:	round
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	61	USF:	60	DSF:	59	DSC: 62	XS: none	
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream) L: 1290'



PLAN VIEW:



26+27

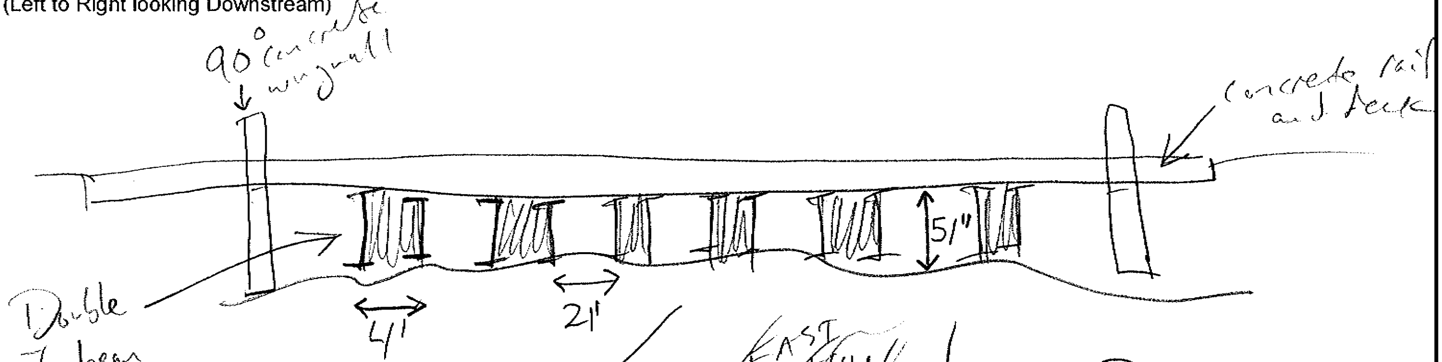
HALFF — **Survey Field Sheet**

PROJECT: 28411
SURVEY NAME:
STREAM NAME: San Marcos River
DATE: 10.17.12
LOCATION: CO 1977 bridge
CREW: AB SC

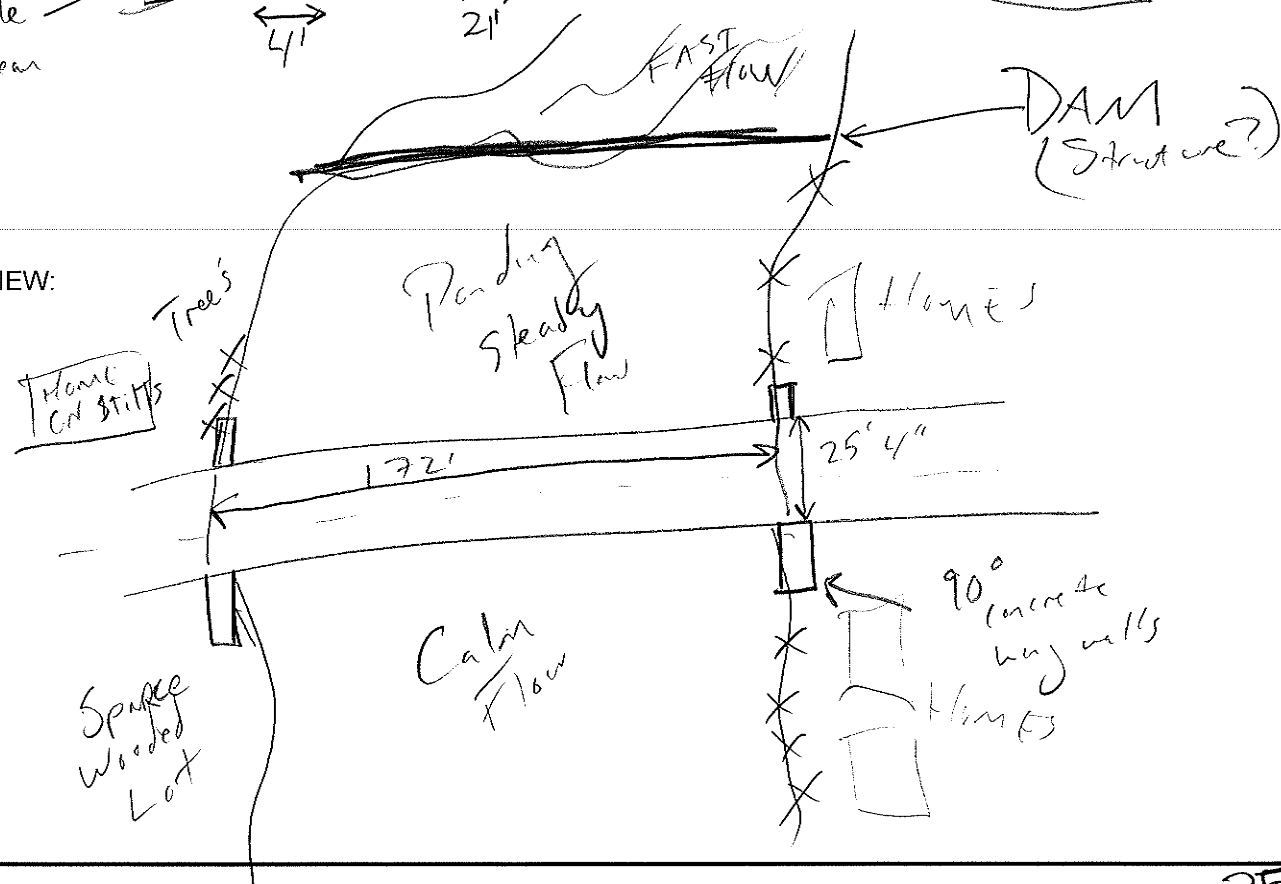
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE: Rail Height: 18" Deck: 9" Width: 25'4" Pier(s): 6 @ 25 Pier Shape: thin I beams
CULVERT: Number: ____ Shape: ____ Length: ____ Height: ____ Width: ____ Skew: ____
CULVERT: I/O Type: ____ Material: ____ Wingwall Angle 90°
DAM: Top Width: ____ Side Slope ____ Side Slope ____ US: ____ DS: ____ Outlet: ____
ERM Description: ____ Coordinate System: ____
Photo Numbers: USC: 56 USF: 55 DSF: 58 DSC: ~~56~~ 57 XS: 54
Additional Info:
File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



25

HALFF **Survey Field Sheet**

PROJECT: 18411 SURVEY NAME: ____________

STREAM NAME: San Marcos River DATE: 10.17.12

LOCATION: County Rd 1979 Bridge CREW: AB SC

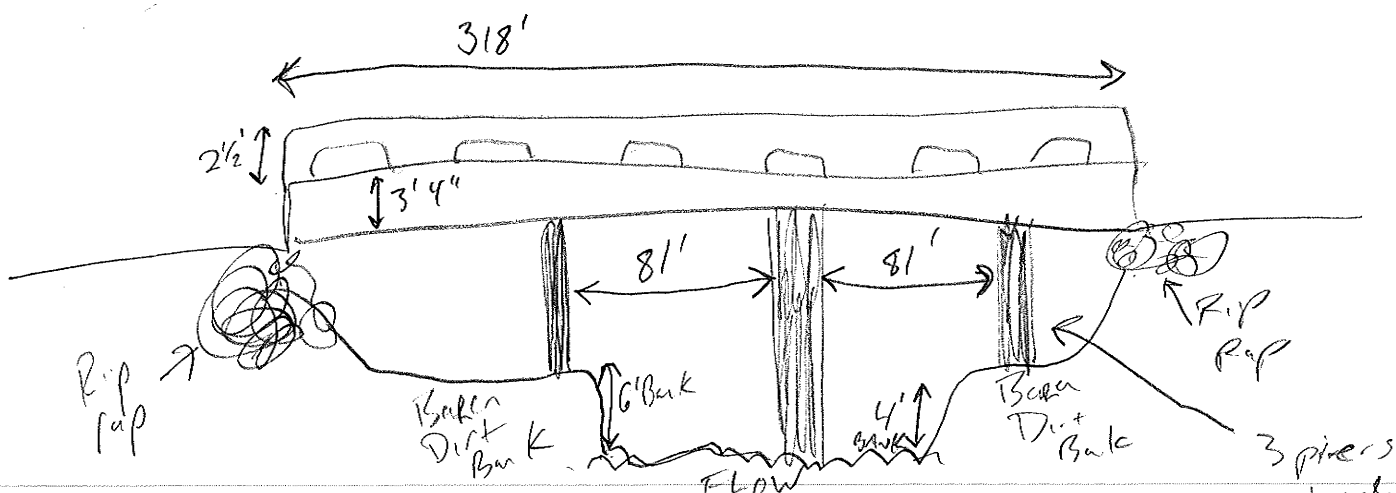
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ________ ERM ID: ________ GEOID: ________

BRIDGE:	Rail Height:	2½'	Deck:	3'4"	Width:	31'	Pier(s):	3	@	81'	Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	50	USF:	53	DSF:	52	DSC:	51	XS: 49
Additional Info:											
File Name:											

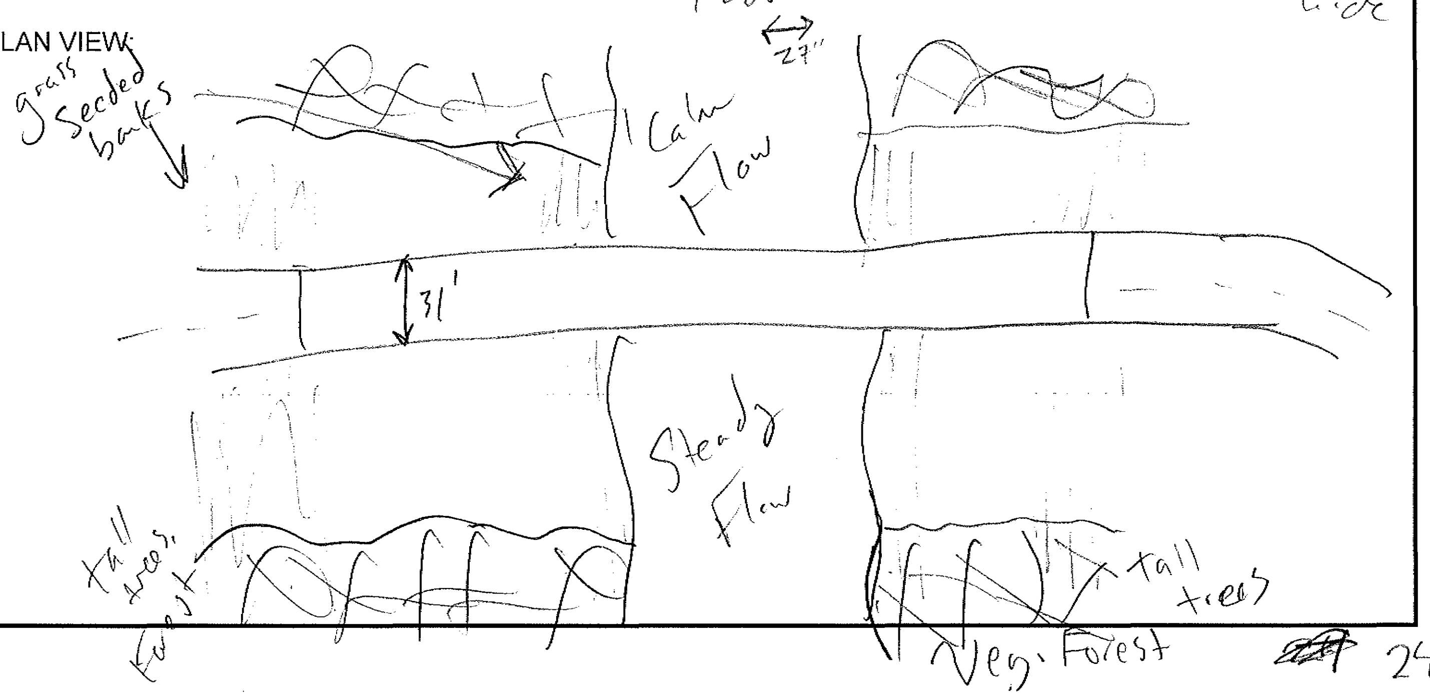
PROFILE VIEW:
(Left to Right looking Downstream)

ALL concrete

Piers 27" wide



PLAN VIEW:



24

HALFF

Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: San Marcos

DATE: 10.17.12

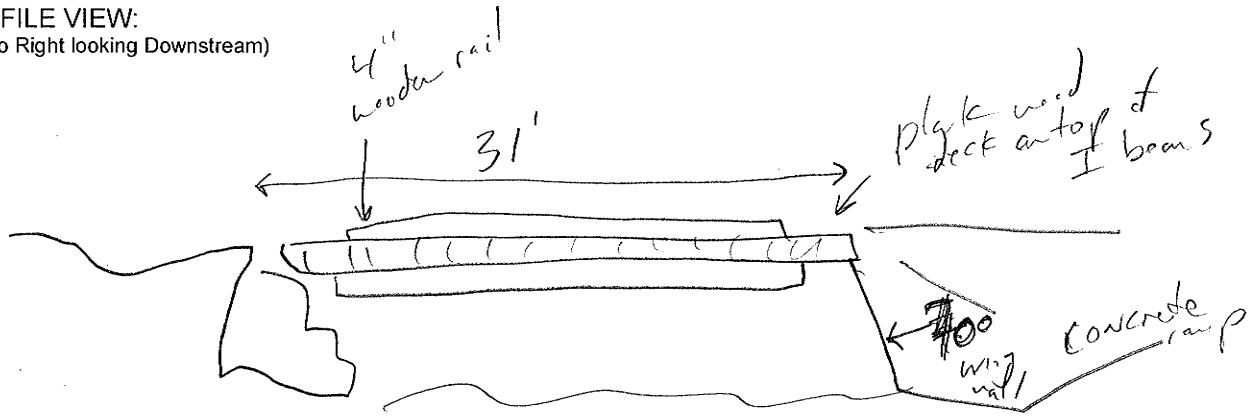
LOCATION: private rd off NW River Rd. Access from Lockhart St.

CREW: AB SC

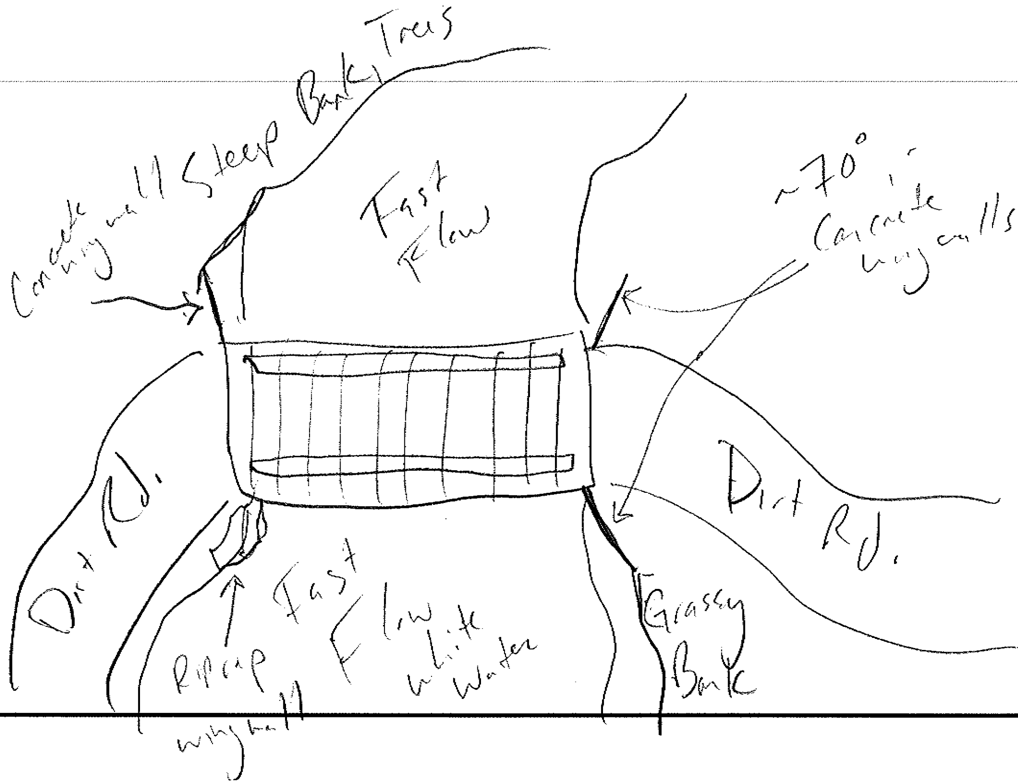
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3"	Deck:	16"	Width:	14'	Pier(s):	0	@	—	Pier Shape:	—
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle		~70°			
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:	44	USF:	43	DSF:	46	DSC:	45	XS: 42	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos DATE: 10.17.12

LOCATION: next to #97 CREW: AB SC

TYPE: BR( ) CUL( ) DAM( ) XS(X) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):		@	Pier Shape:	
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:		USF:		DSF:		DSC:		
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

#98
inline structure. Dam like
D.S.F pics 47, 48

private property

at least 6' tall

PLAN VIEW:

45° slope D.S. side
Solid Flow

Tower-like station on west bank.
Flow station?

HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcus River DATE: 10.17.12

LOCATION: NW River Rd at Quail Run Rd CREW: AB, SC.

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2'4" Deck: 2'10" Width: 29'3" Pier(s): 0 @ — Pier Shape: —

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle 45°

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

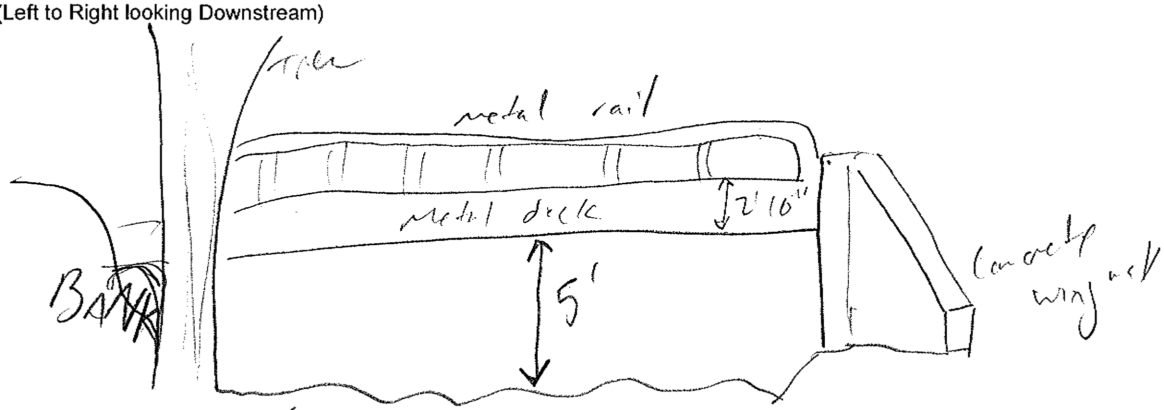
ERM Description: Coordinate System:

Photo Numbers: USC: 39 USF: 38 DSF: 41 DSC: 40 XS: 37

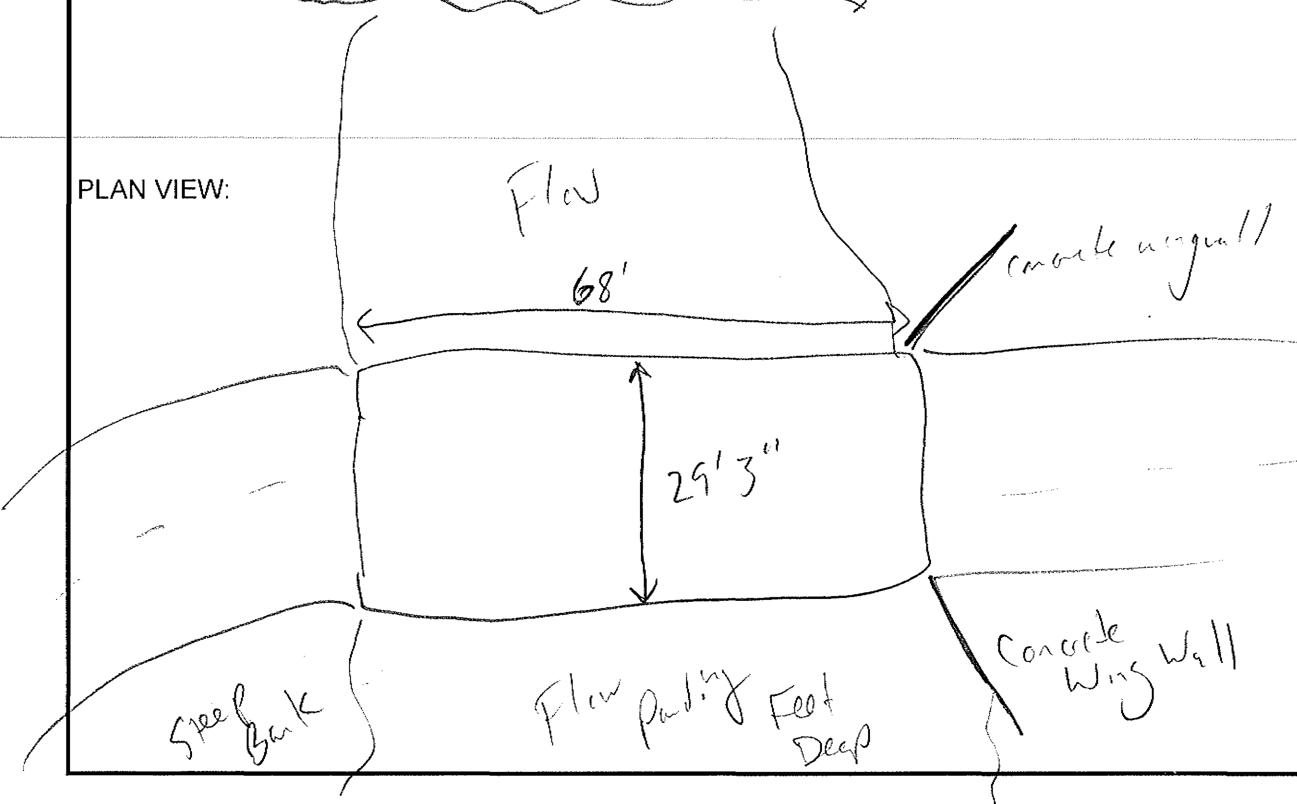
Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.17.12

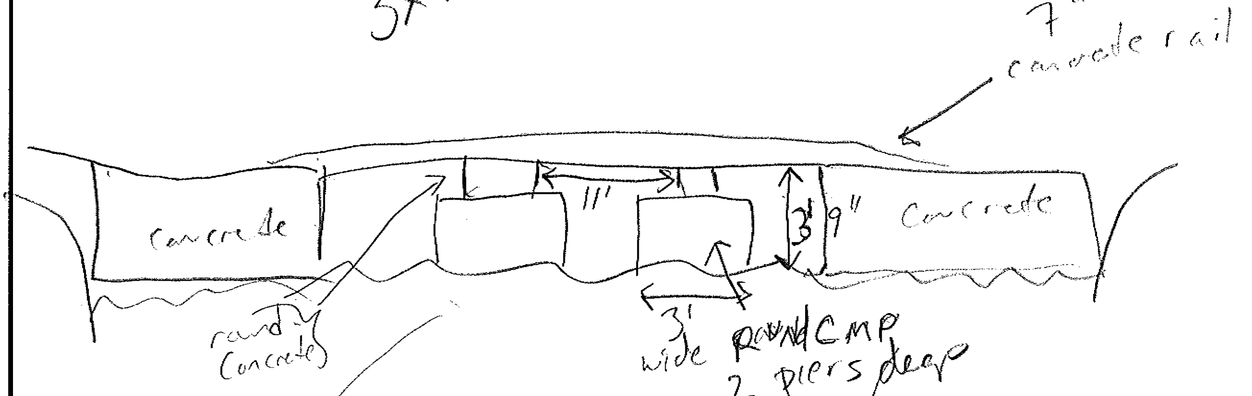
LOCATION: TX 266 N old Bastrop Co. HWY CREW: AB SC

TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

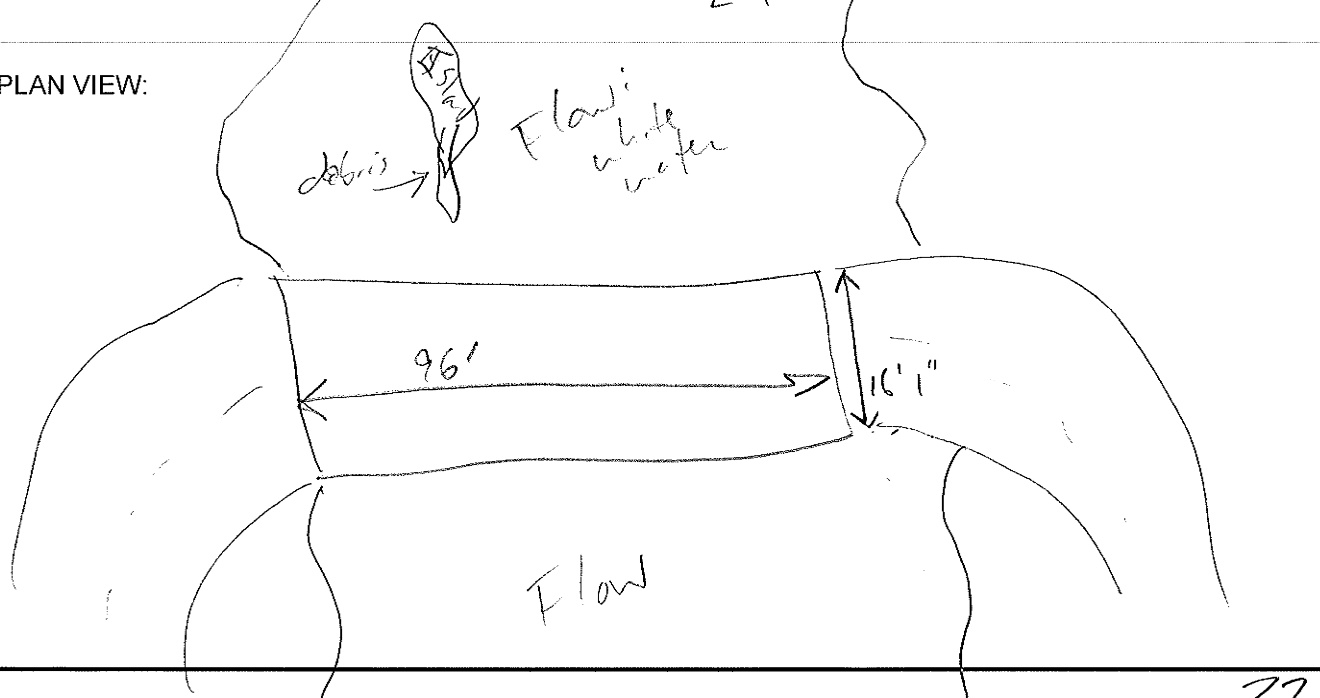
BRIDGE:	Rail Height:	7"	Deck:	10"	Width:	16'1"	Pier(s):	2	@	11'	Pier Shape: round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:	Concrete	Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	34	USF:	36	DSF:	32	DSC:	35	XS: 33
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

Model 3x11' wide culverts



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

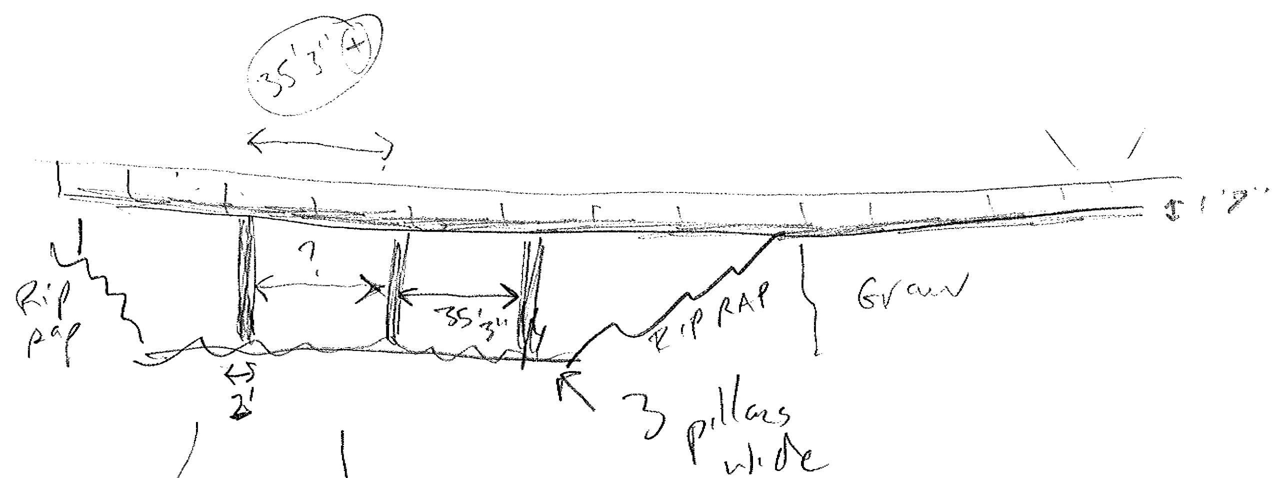
STREAM NAME: BLANCO DATE: 10.17.12

LOCATION: TX 295 OLD MARTINDALE RD Bridge CREW: AB SC

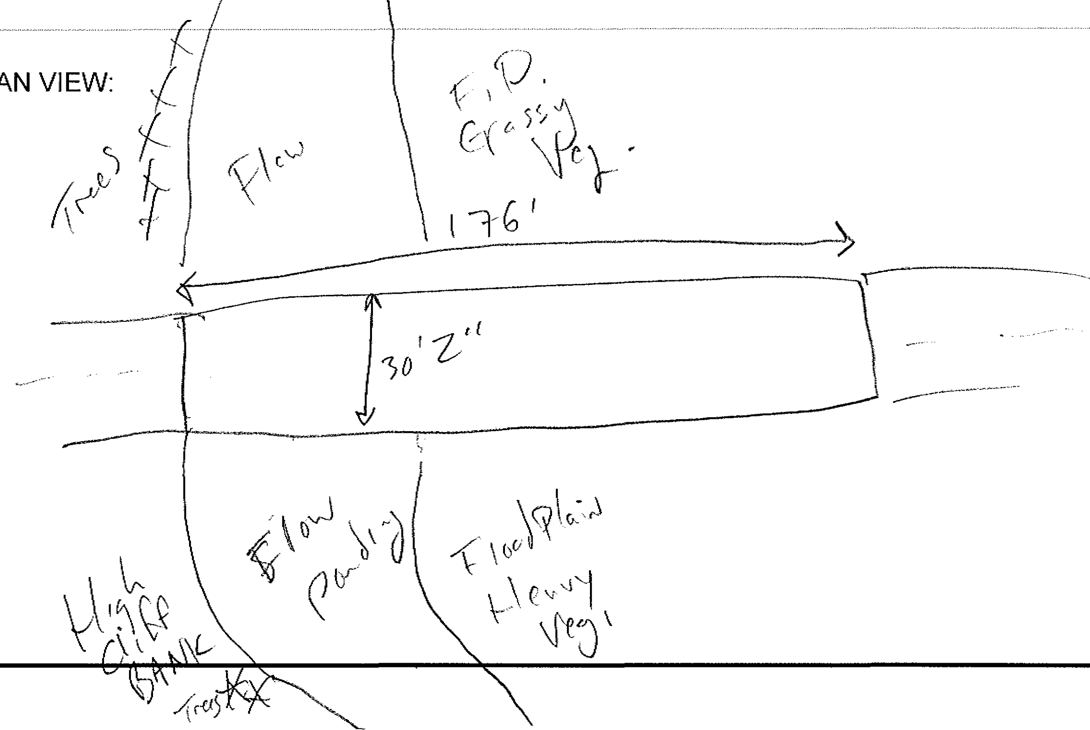
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE:	Rail Height:	2'4"	Deck:	1'8"	Width:	30'2"	Pier(s):	3	@	35'3"	Pier Shape: Round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	28	USF:	29	DSF:	30	DSC:	27	XS: 26
Additional Info:											
File Name:							31: blind salamander RV Park				

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: ~~[illegible]~~ 28411B SURVEY NAME:

STREAM NAME: Blanco DATE: 2/19/2014

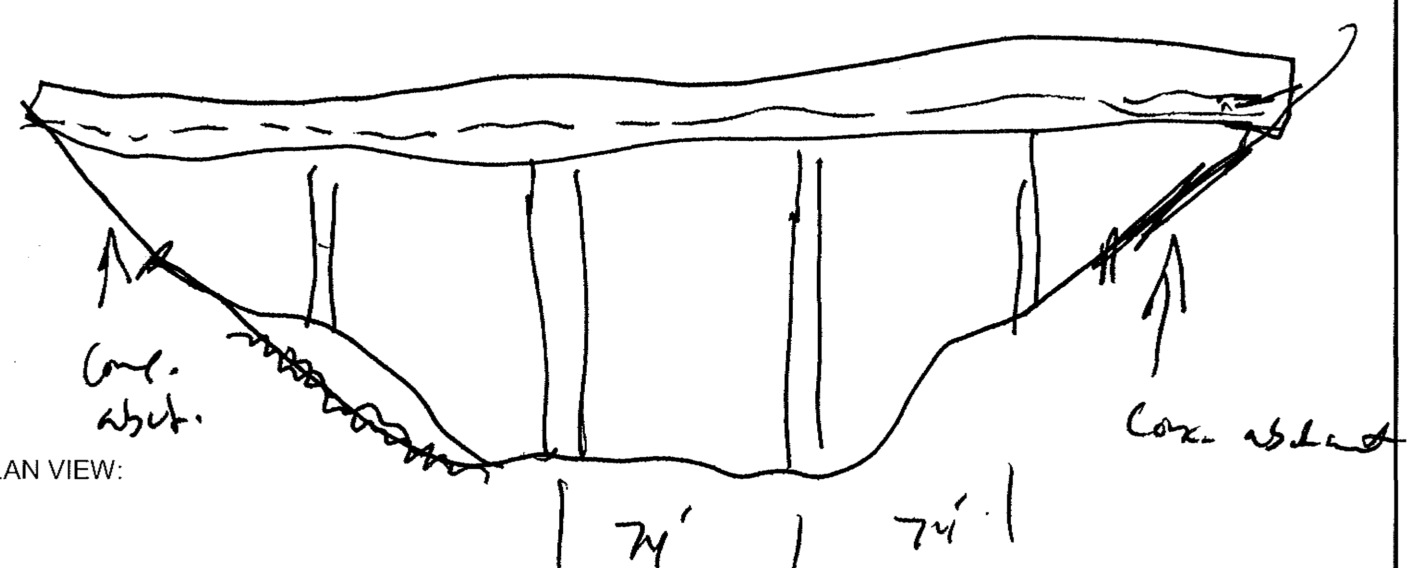
LOCATION: Fisher Store Rd. CREW: Harris/Bolin

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2ft	Deck:	4'	Width:	369'	Pier(s):	4	@ 3'w 77'/3'	Pier Shape:	round
CULVERT:	Number:		Shape:		Length:		Height:		Width: 33'	Skew:	<20°
CULVERT:	I/O Type:				Material:		Wingwall Angle		33' Hyd. width		
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:		USF:		DSF:		DSC:		
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

38.8' TO Rail to water Surface



PLAN VIEW:

Bedrock channel with some water

Channel drains on U/S LOB w/ House

Think drains in all other Overbanks

House in High ROB on D/S side

HALFF — **Survey Field Sheet**

PROJECT: 28411B SURVEY NAME: ____

STREAM NAME: Blanco River DATE: 2/19/2014

LOCATION: Valley View Dr. CREW: Harris/Blan

TYPE: BR( ) CUL(X) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE: Rail Height: 6 in bollards Deck: ____ Width: ____ Pier(s): ____ @ ____ Pier Shape: ____

CULVERT: Number: 5 Shape: Box-3 Length: 16' Height: 1 ft Width: ____ Skew: none

CULVERT: I/O Type: Pipe Arch-2 Material: Box Wingwall Angle: none

DAM: Top Width: ____ Side Slope ____ Side Slope ~23' Pipe Arch US: ____ DS: ____ Outlet: ____

ERM Description: ____ Coordinate System: ____

Photo Numbers: ____ USC: ____ USF: ____ DSF: ____ DSC: ____

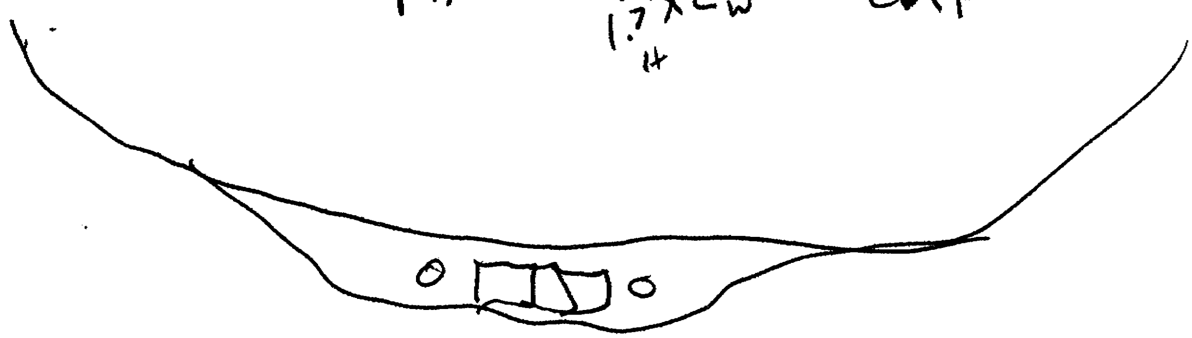
Additional Info: ____

File Name: ____

PROFILE VIEW:
(Left to Right looking Downstream)

Boxes 3 - 1.5' H X 7' w — Concrete — Bedrock bottom

Pipe arch 1.7' H X 2' w — CMP



PLAN VIEW:

Bed rock - cobbles / Boulders Channel 45 ~ D/S some tall grasses

Trees on overbanks

House on RB U/S side

Overbanks steep

Approaches to crossing likely washed out and repaired with concrete

HALFF — Survey Field Sheet

PROJECT: 2946B

SURVEY NAME:

STREAM NAME: Blanco River

DATE: 2/19/2014

LOCATION: Park old Stagecoach Blanco Vista

CREW: Harris / Bolin

TYPE: BR( ) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):		@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:	4'	Side Slope		Side Slope		US:	Vertical	DS:	1:1	Outlet: Pipes
ERM Description:							Coordinate System:				
Photo Numbers:			USC:		USF:		DSF:		DSC:		
Additional Info:											~4' Lift
File Name:											D/S Face

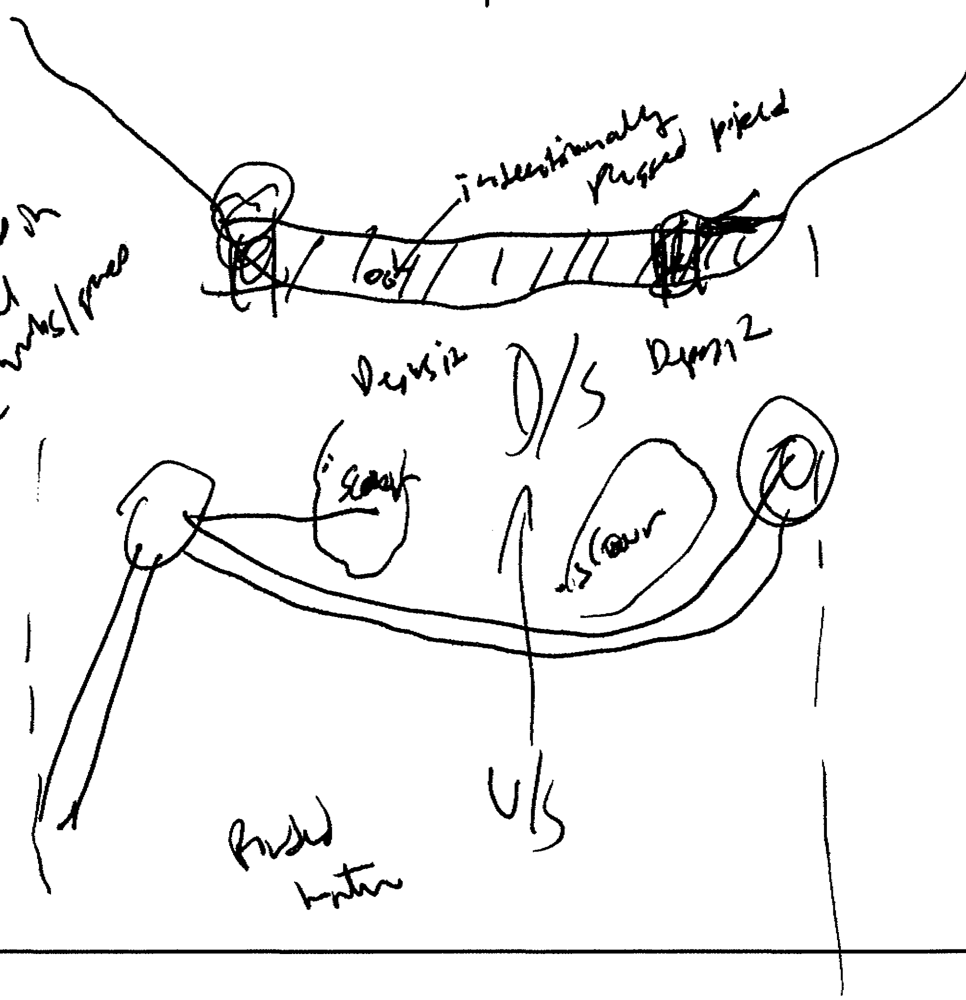
PROFILE VIEW:
(Left to Right looking Downstream)

330' total length

9+ ft leg

Flood debris in trees in channel

bedrock/cobbles in channel with shrubs/grass some



PLAN VIEW:

HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

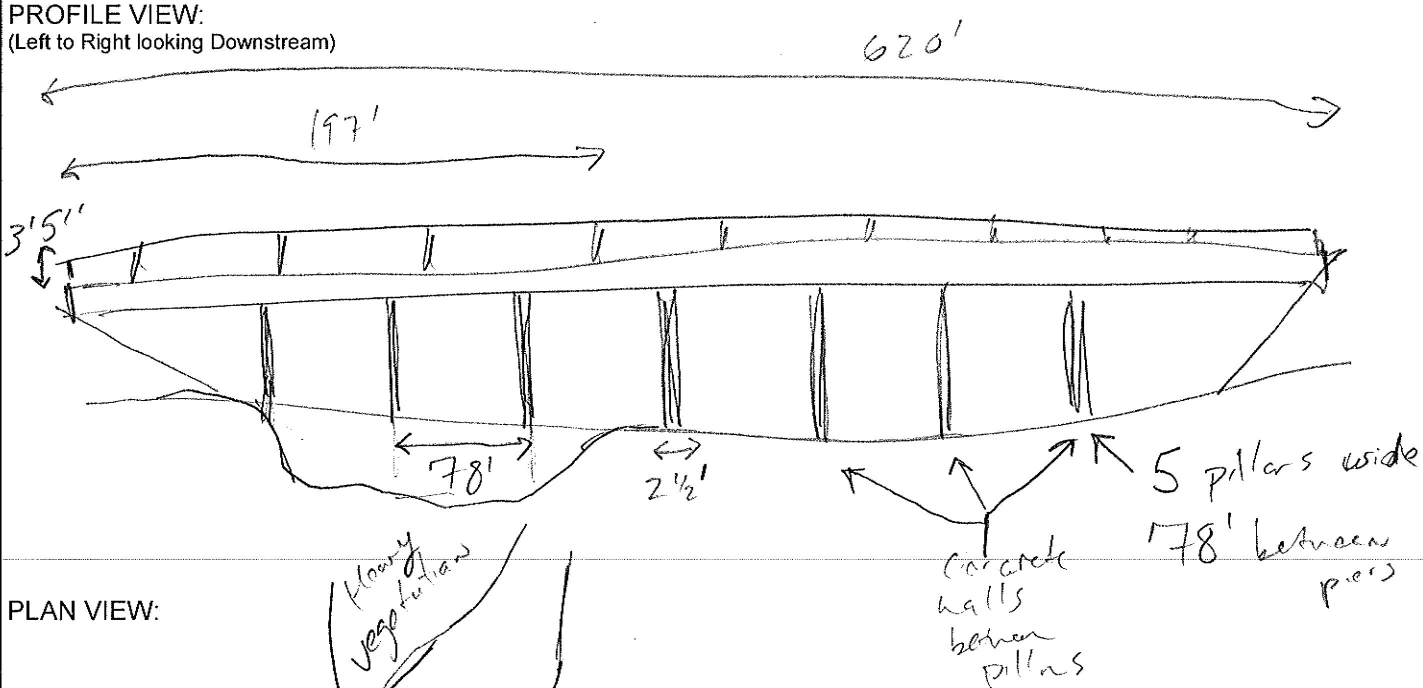
STREAM NAME: BLANCO RIVER DATE: 10.17.12

LOCATION: TX 80 Bridge CREW: AB SC

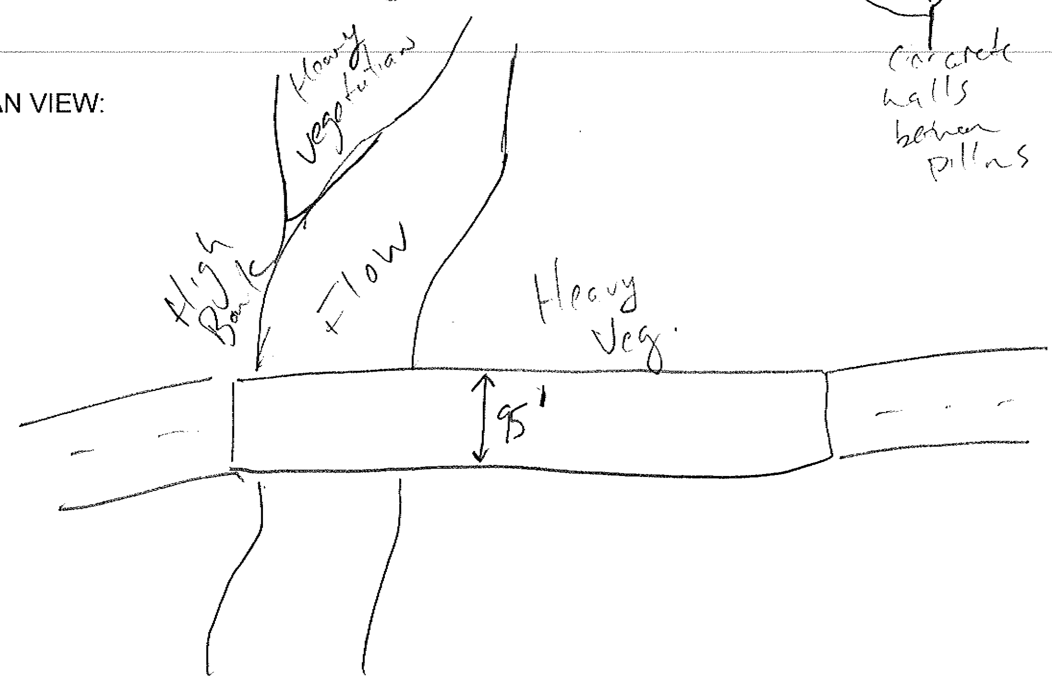
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'5"	Deck:	4'9"	Width:	95'	Pier(s):	7	@	78'	Pier Shape: round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	~~25~~ 24	USF:	~~23~~ 22	DSF:	~~25~~	DSC:	~~25~~ 23	
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: Blanco River DATE: 10.17.12

LOCATION: Uhland Rd. Bridge CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ______ ERM ID: ______ GEOID: ______

BRIDGE: Rail Height: 6" Deck: ______ Width: 20'3" Pier(s): ______ @ ______ Pier Shape: ______

CULVERT: Number: 2 Shape: Box Length: 20'3" Height: 2'4" Width: 8'8" Skew: ______

CULVERT: I/O Type: ______ Material: Concrete Wingwall Angle ______

DAM: Top Width: ______ Side Slope ______ Side Slope ______ US: ______ DS: ______ Outlet: ______

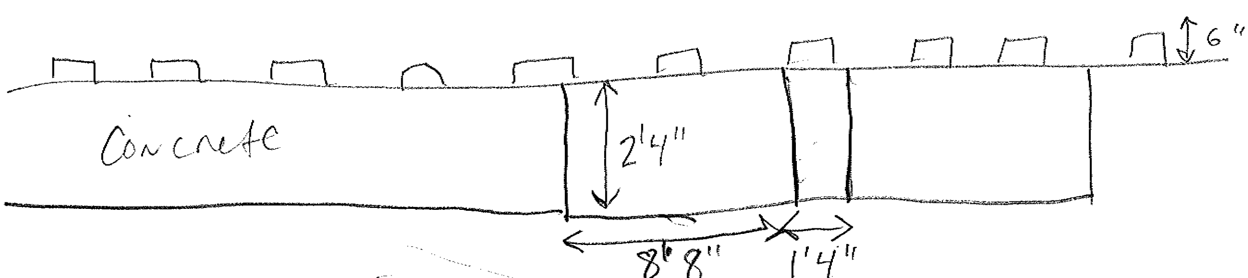
ERM Description: ______ Coordinate System: ______

Photo Numbers: USC: 18 USF: 17 DSF: 19 DSC: 20 XS: 21

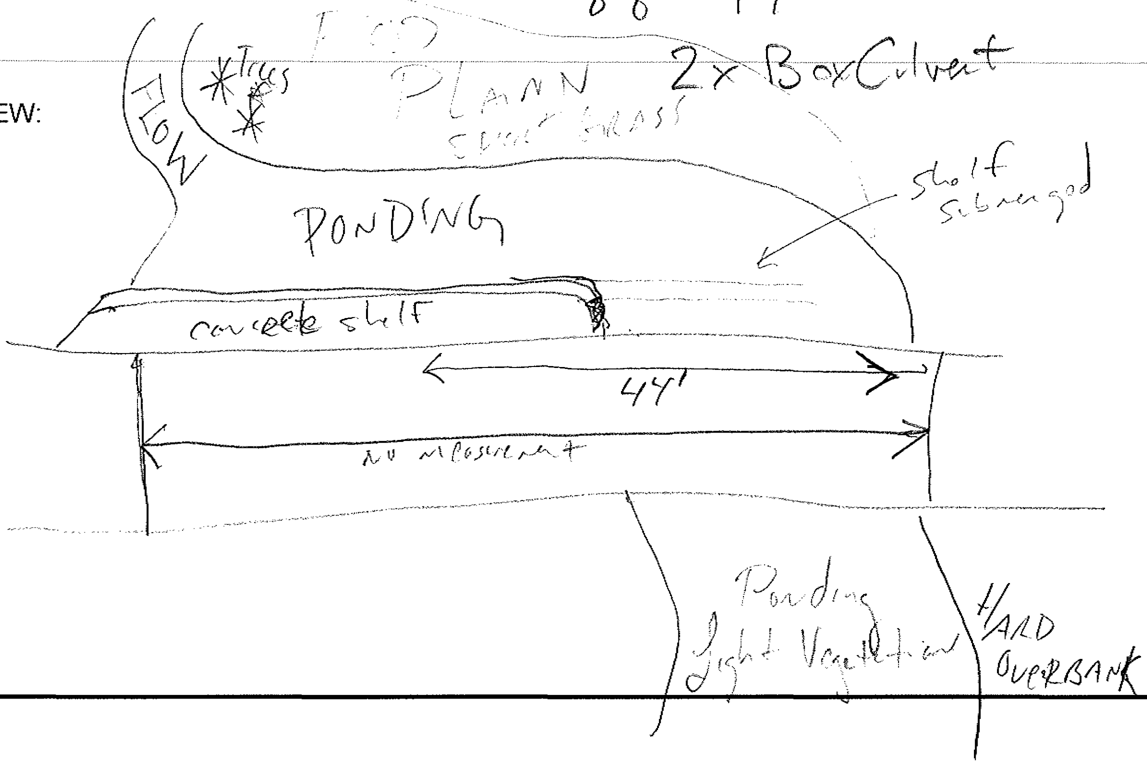
Additional Info: ______

File Name: ______

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: Blanco River

DATE: 10/17/2012

LOCATION: RR Bridge

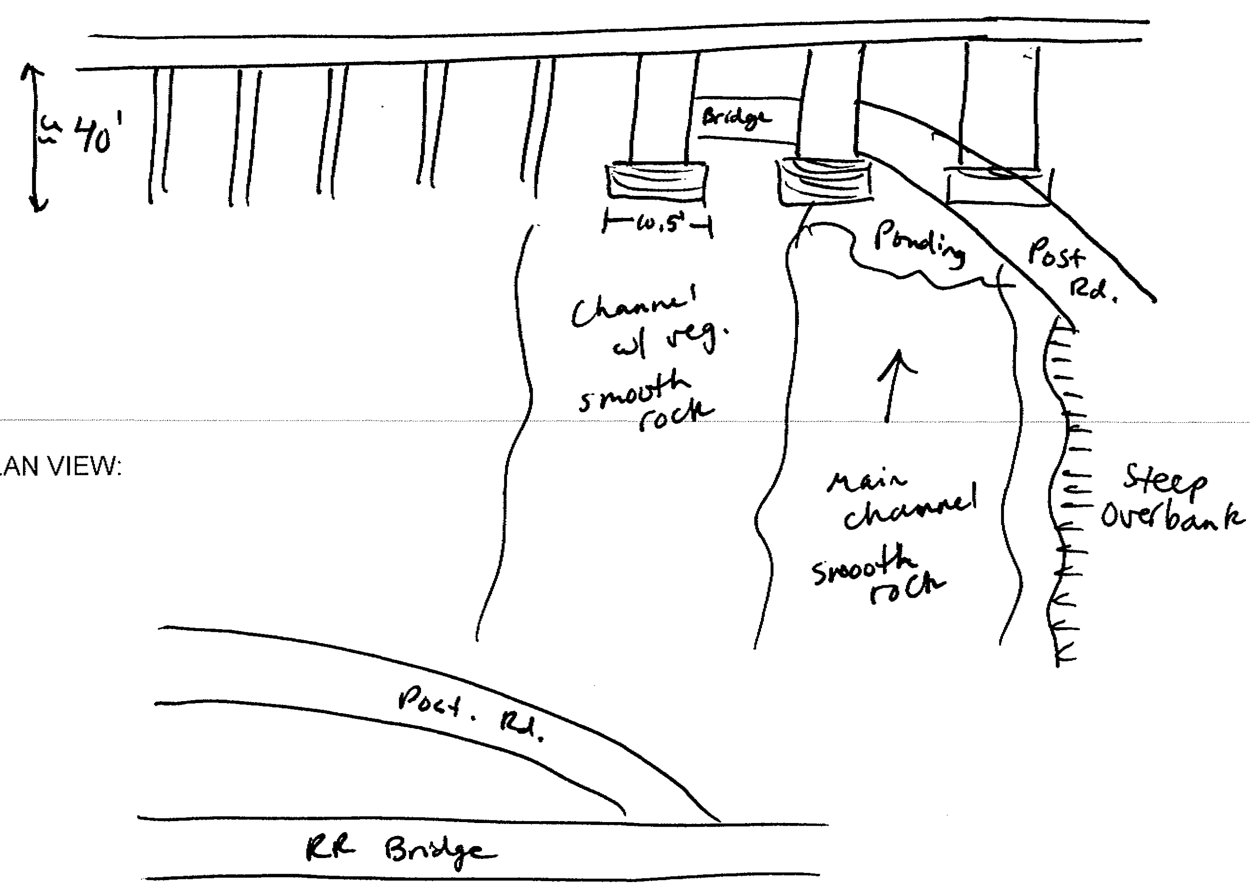
CREW: AB & SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:	Tall	Width:		Pier(s):	8	@ varies	Pier Shape:	Oval
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	1	USF:	2	DSF:		DSC:		
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: Blanco River

DATE: 10/17/2012

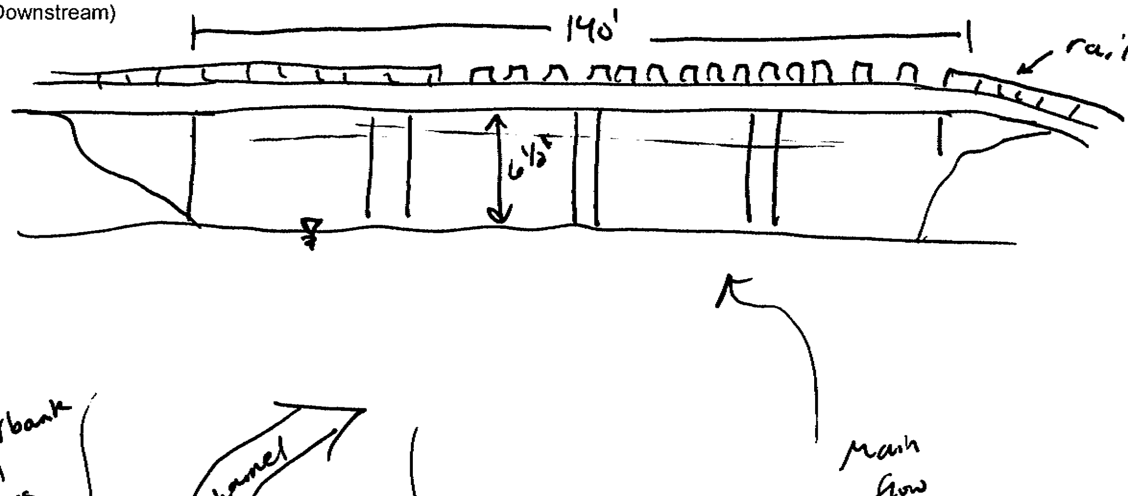
LOCATION: Post Rd.

CREW: AB & SC

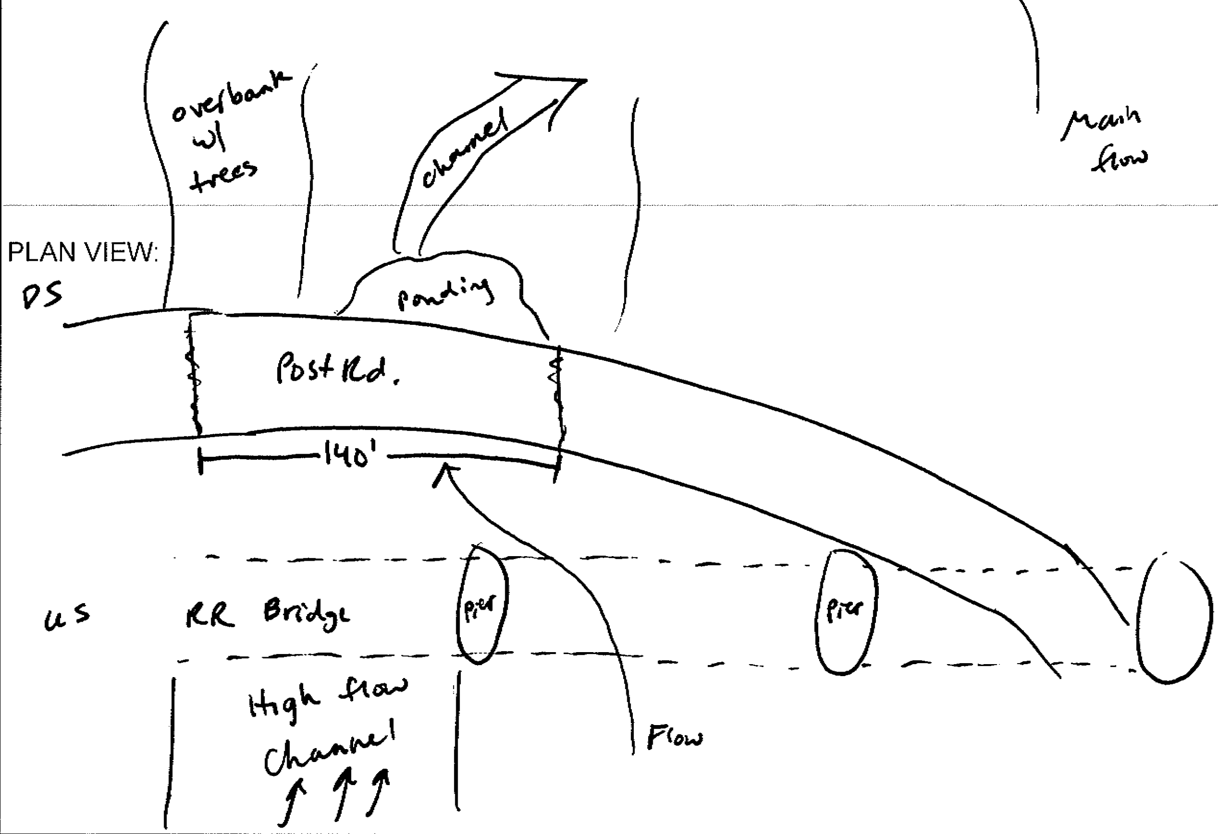
TYPE: BR( ) CUL(X) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	6"	Deck:	3'3"	Width:	26'	Pier(s):		@	Pier Shape:	
CULVERT:	Number:	4	Shape:	Box	Length:	26'	Height:	6.5'	Width:	33'3"	Skew: 30°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	4	USF:	3	DSF:	7	DSC:	6	OTXS: 5
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

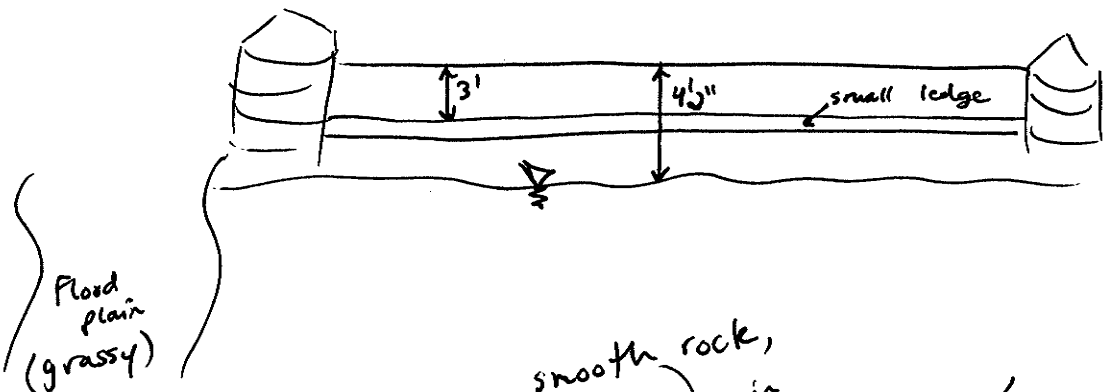
STREAM NAME: Blanco River DATE: 10/17/2012

LOCATION: Dam Near Old Stagecoach Rd. CREW: AB & SC

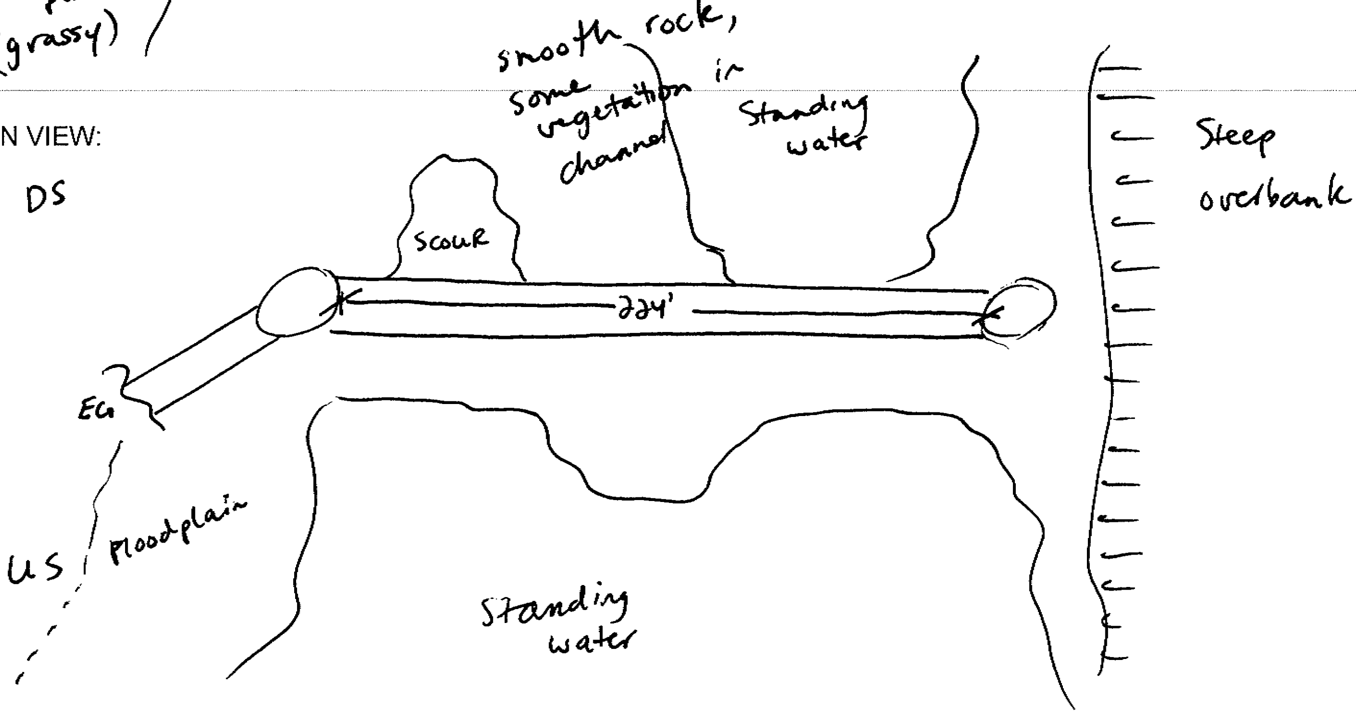
TYPE: BR( ) CUL( ) DAM(X) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):		@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:	6'6"	Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	11	USF:	8	DSF:	12	DSC:	10	OTXS: 9
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

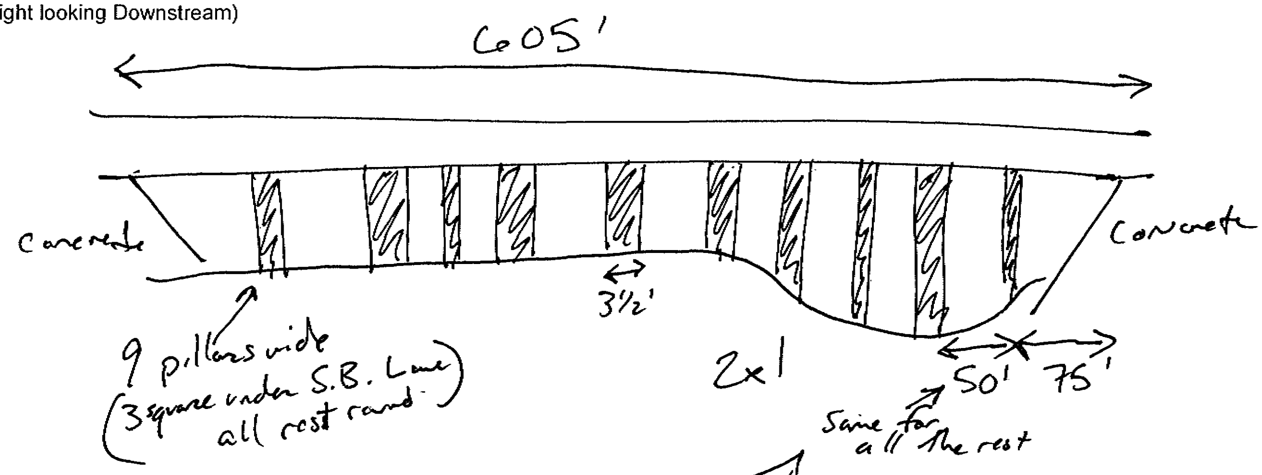
STREAM NAME: Blanco River DATE: 10/17.12

LOCATION: I 35 CREW: AB SC

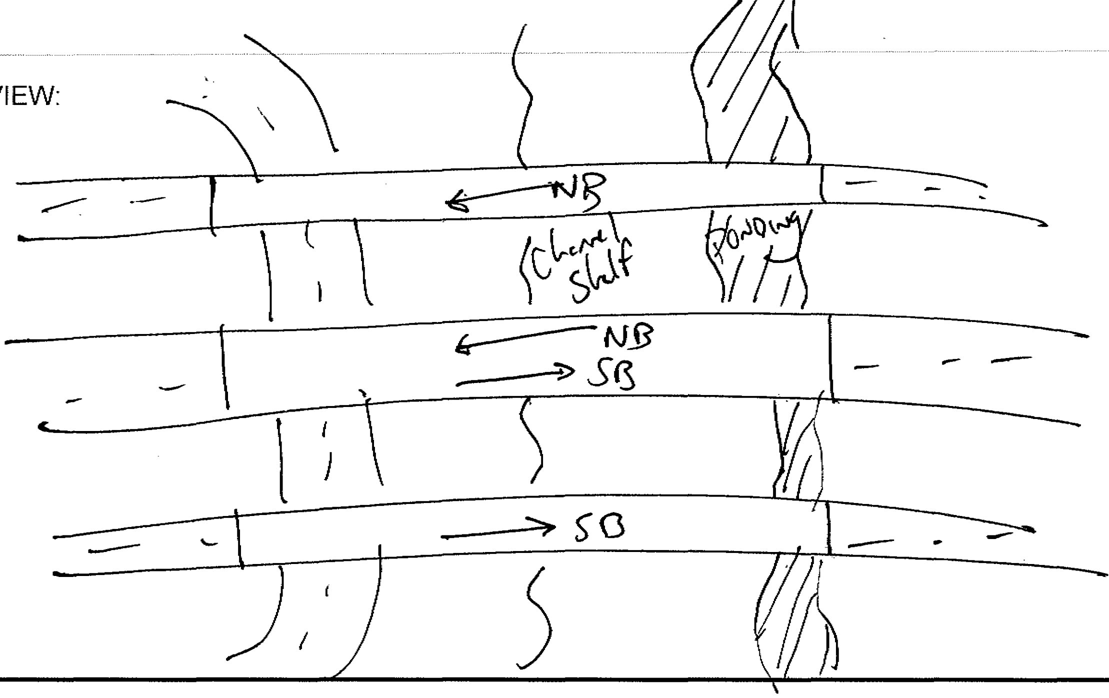
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE:	Rail Height:	2'8"	Deck:	3'9"	Width:	110'	Pier(s):	10	@	50' (except one)	Pier Shape: round except 3 square
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:		USF:		DSF:		DSC:		
Additional Info:	pictures refer to #93, 95										
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411　　SURVEY NAME:

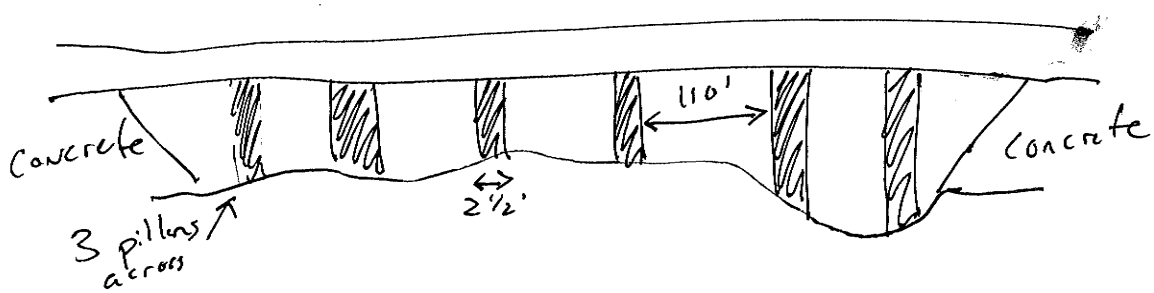
STREAM NAME: Blanco River　　DATE: 10.17.12

LOCATION: 135 Frontage　　CREW: AB SC

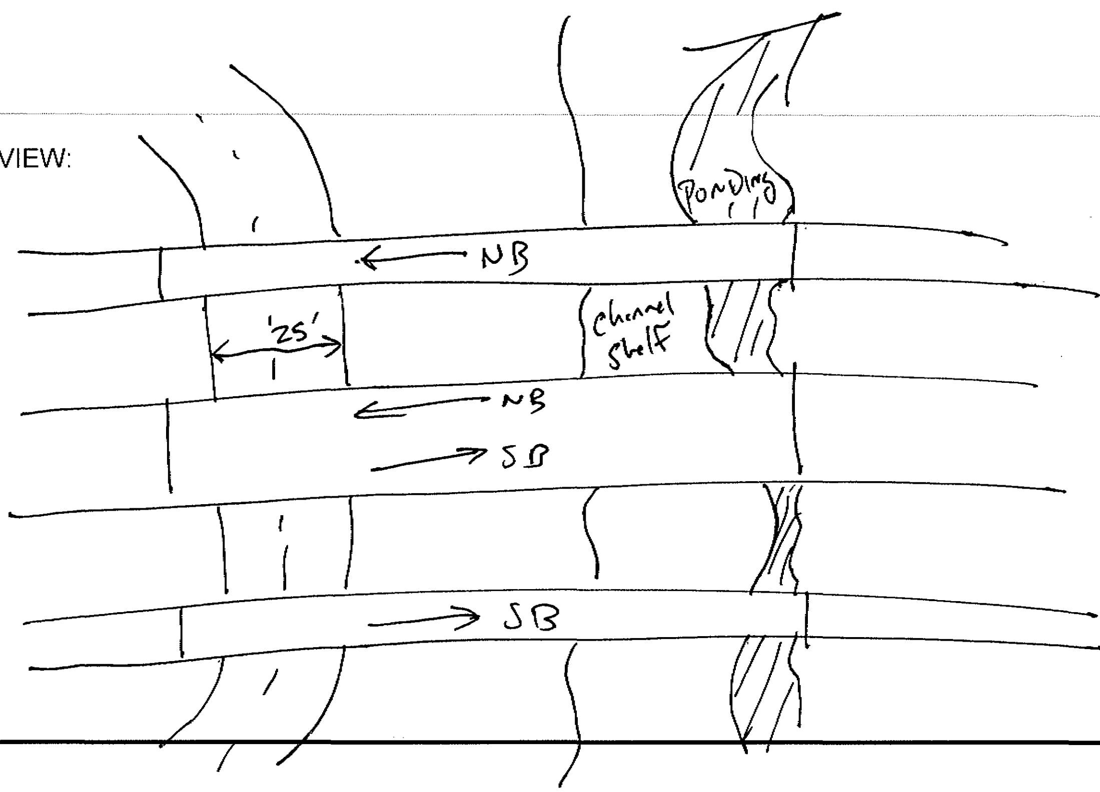
TYPE: BR(✓) CUL( ) DAM( ) XS( )　ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE:	Rail Height:	2'8"	Deck:	3'9"	Width:	35'	Pier(s):	6	@	110'	Pier Shape: Round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	14	USF:	13	DSF:	16	DSC:	15	
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



93, 95

HALFF — Survey Field Sheet

PROJECT: 28411 | SURVEY NAME:

STREAM NAME: San Marcos River | DATE: 10.31.12

LOCATION: 911 / 2091 Bridge | CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE: Rail Height: 2'8" Deck: 2' Width: 24' Pier(s): 7 @ varies Pier Shape: varies

CULVERT: Number: ____ Shape: ____ Length: ____ Height: ____ Width: ____ Skew: ____

CULVERT: I/O Type: ____ Material: ____ Wingwall Angle ____

DAM: Top Width: ____ Side Slope ____ Side Slope ____ US: ____ DS: ____ Outlet: ____

ERM Description: ____ Coordinate System: ____

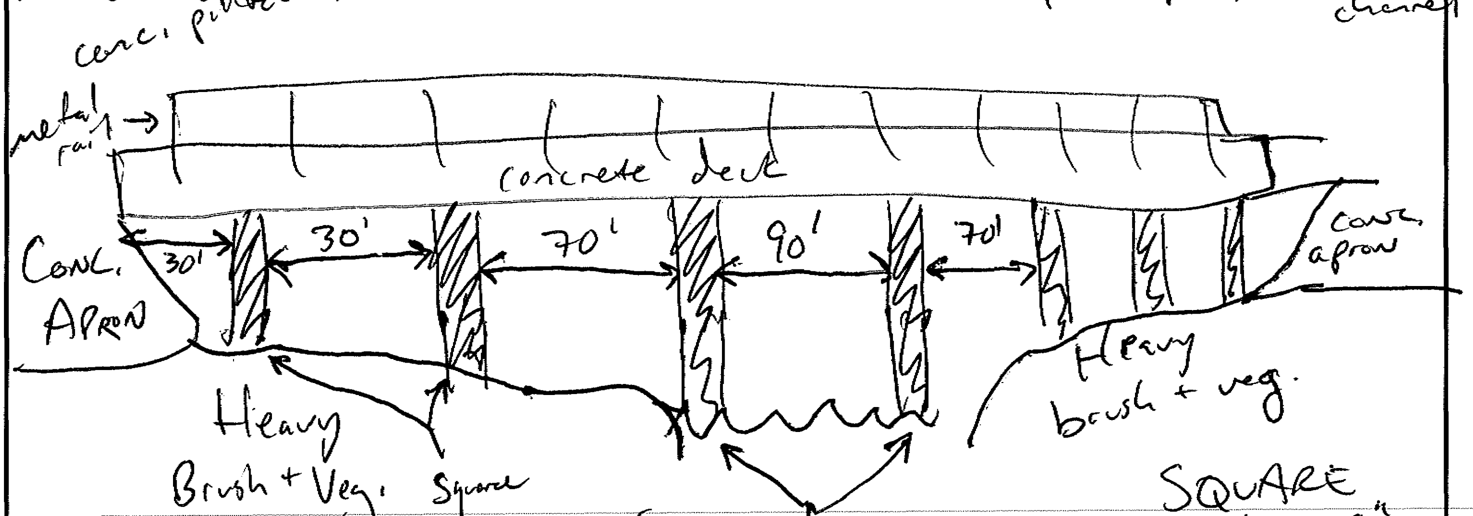
Photo Numbers: USC: 78 USF: 76 DSF: 76 DSC: 79 XS: 77

Additional Info: ____

File Name: ____

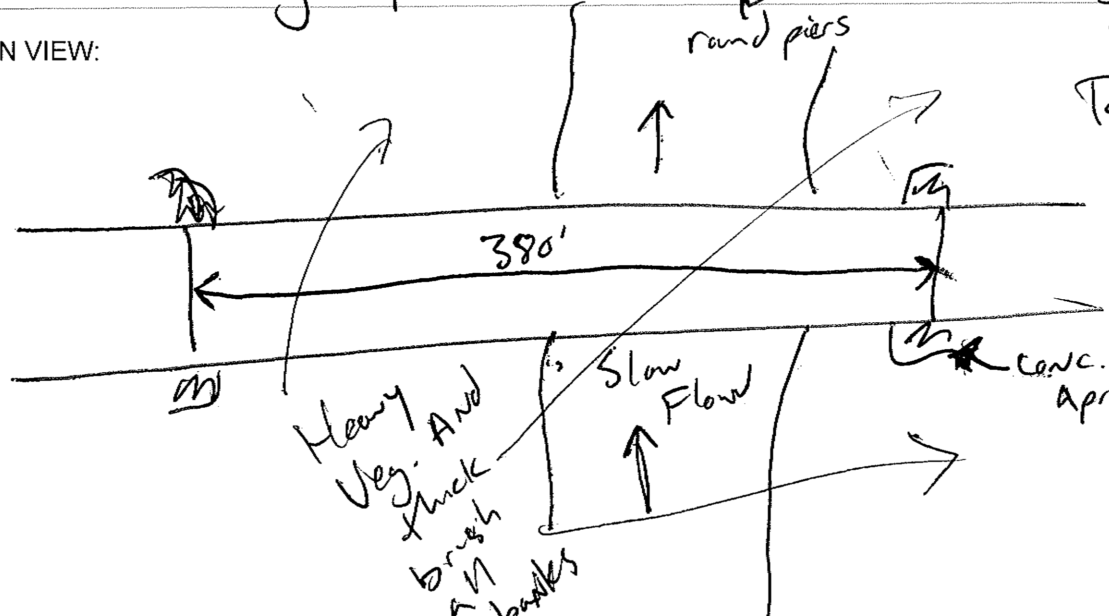
PROFILE VIEW:
(Left to Right looking Downstream)

5 piers square 2 round in channel



SQUARE pillars 15"
Round ~2.5'

PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

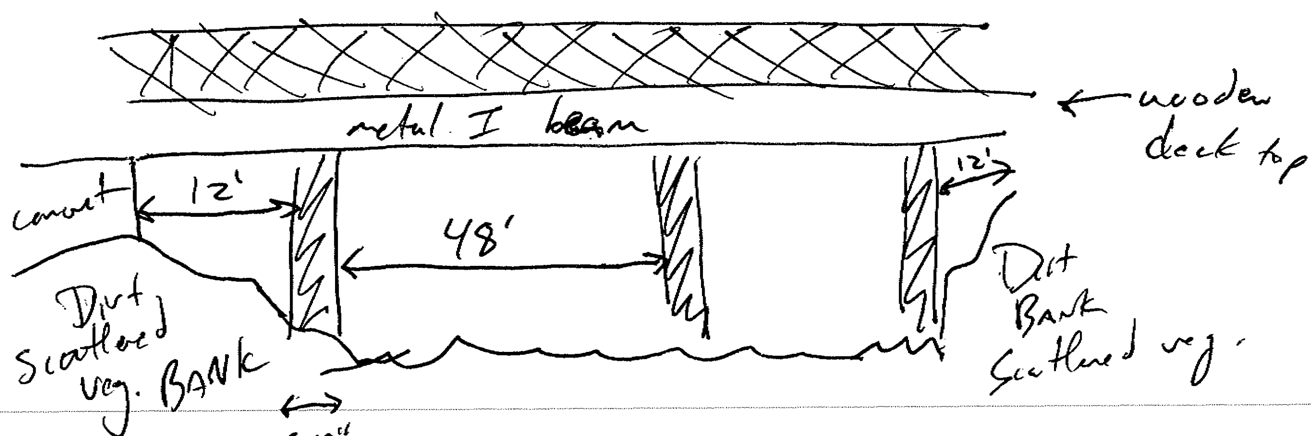
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Footbridge just North of R12 CREW: AB SC

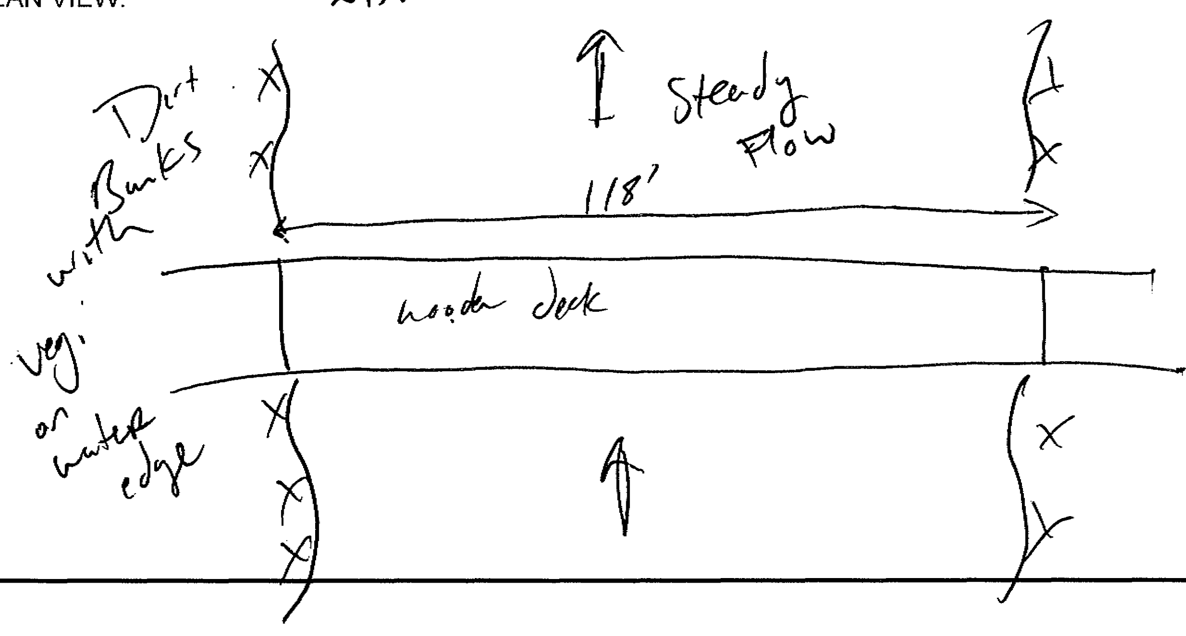
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'6"	Deck:	1'8"	Width:	8'	Pier(s):	3	@	48'	Pier Shape:	Concrete SQUARE
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:	17	USF:	18	DSF:	20	DSC:	19	XS: 16	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



B

HALFF

Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: San Marcos River

DATE: 10.31.12

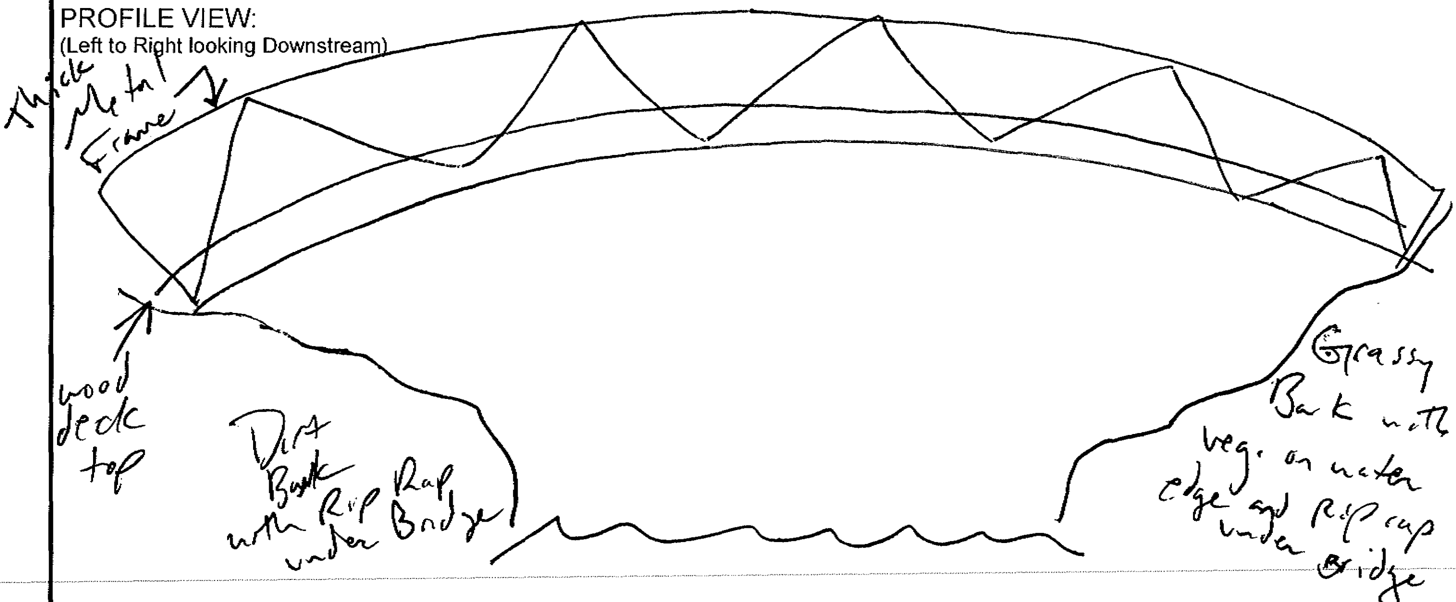
LOCATION: footbridge just north of Rte 12

CREW: AB SC

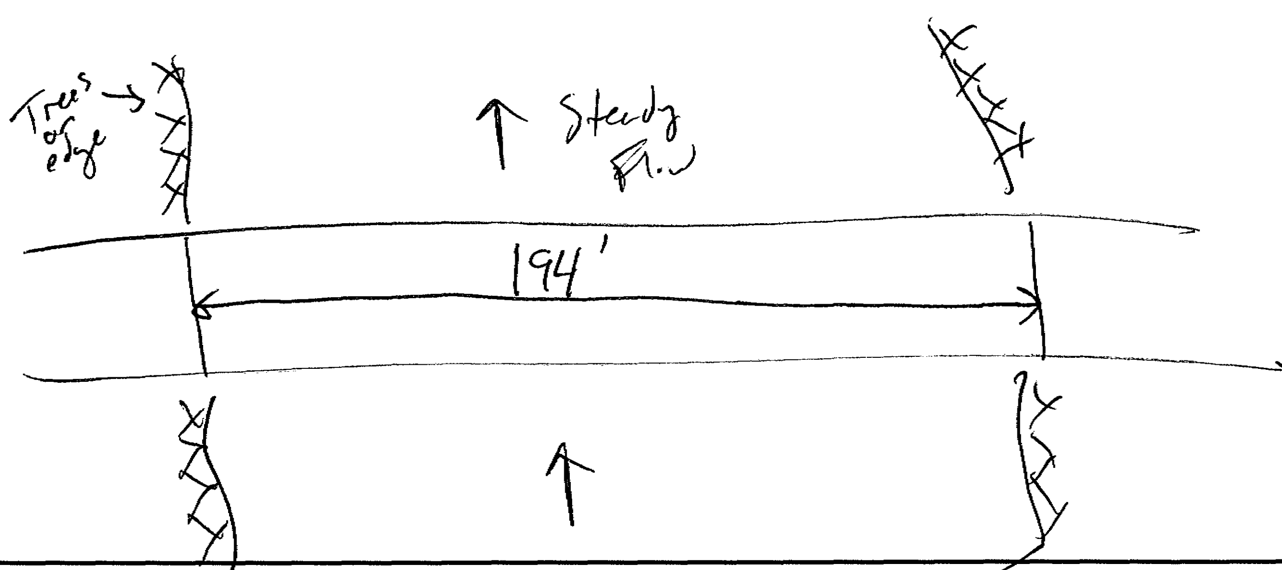
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	6'4"	Deck:	2'9"	Width:	10'	Pier(s):	0	@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	22	USF:	24	DSF:	25	DSC:	23	XS: 21
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



C

HALFF — Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

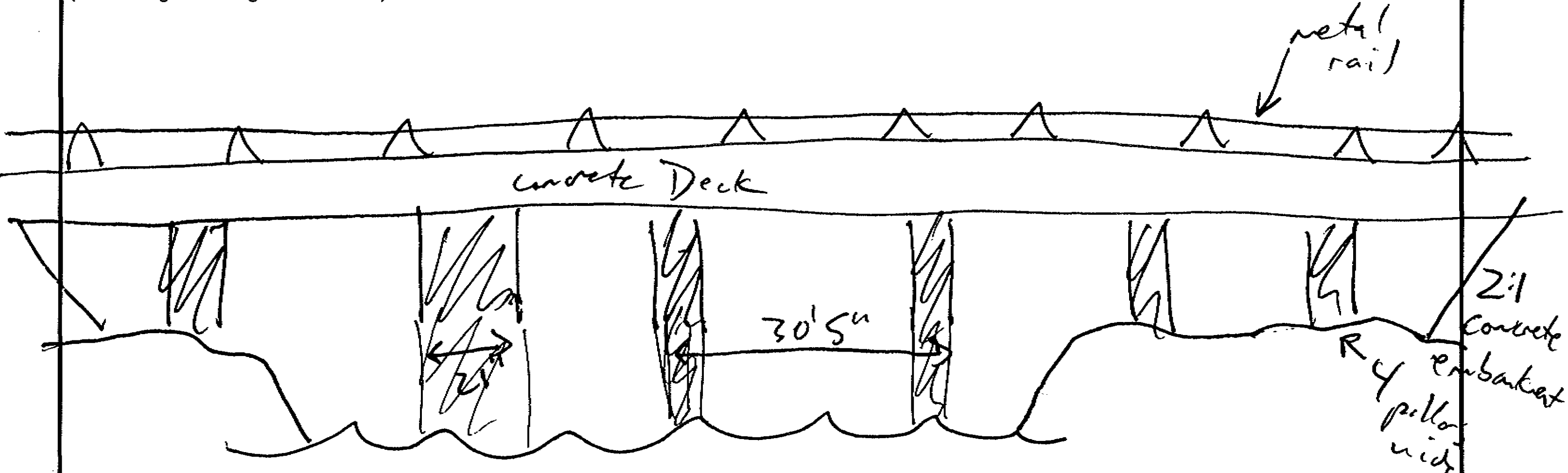
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Rt. 12 Bridge CREW: AB SC

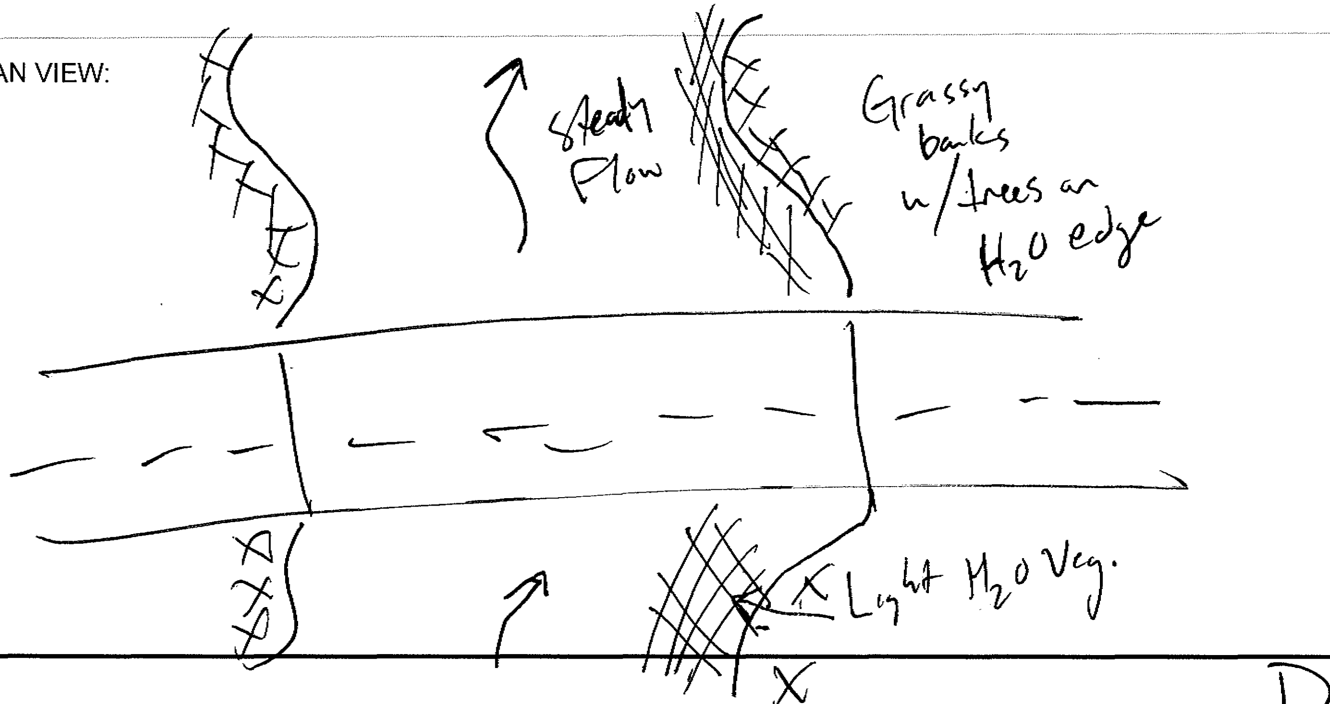
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'3"	Deck:	2'9"	Width:	60'	Pier(s):	6	@ 30'5"	Pier Shape:	round 4' wide
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	27	USF:	26	DSF:	29	DSC: 28	XS: 30	
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



D

HALFF — **Survey Field Sheet**

PROJECT: 2844 SURVEY NAME: ____

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: RR Crossing, South side of Rt. 12 CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE: Rail Height: 3' 6" Deck: 6' 4" Width: 17' Pier(s): 4 @ 30' Pier Shape: Square I beams

CULVERT: Number: ____ Shape: ____ Length: ____ Height: ____ Width: ____ Skew: ____

CULVERT: I/O Type: ____ Material: ____ Wingwall Angle ____

DAM: Top Width: ____ Side Slope Side Slope US: ____ DS: ____ Outlet: ____

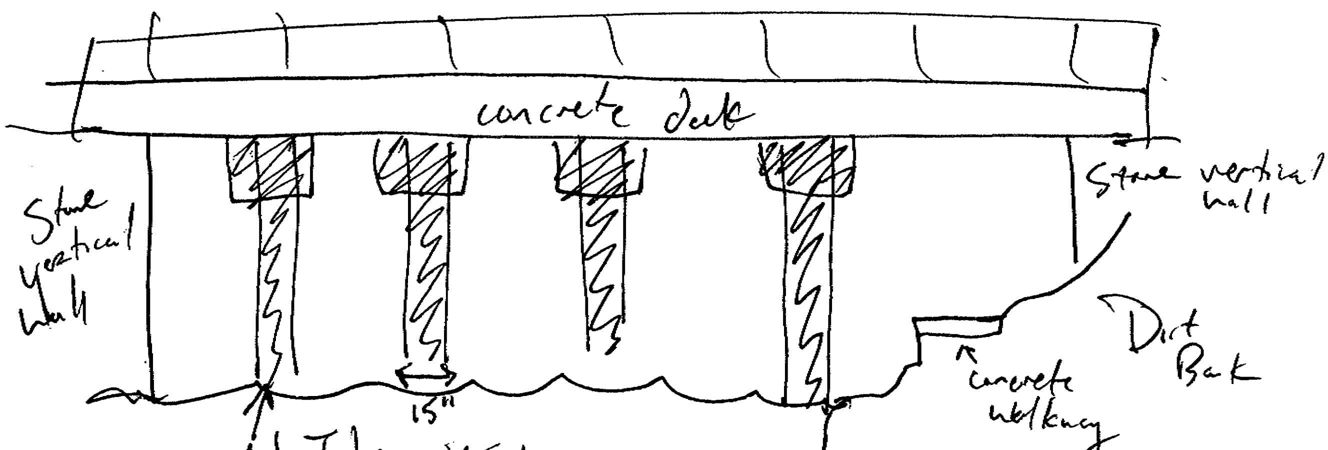
ERM Description: ____ Coordinate System: ____

Photo Numbers: USC: 32 USF: 34 DSF: 35 DSC: 33 XS: 31

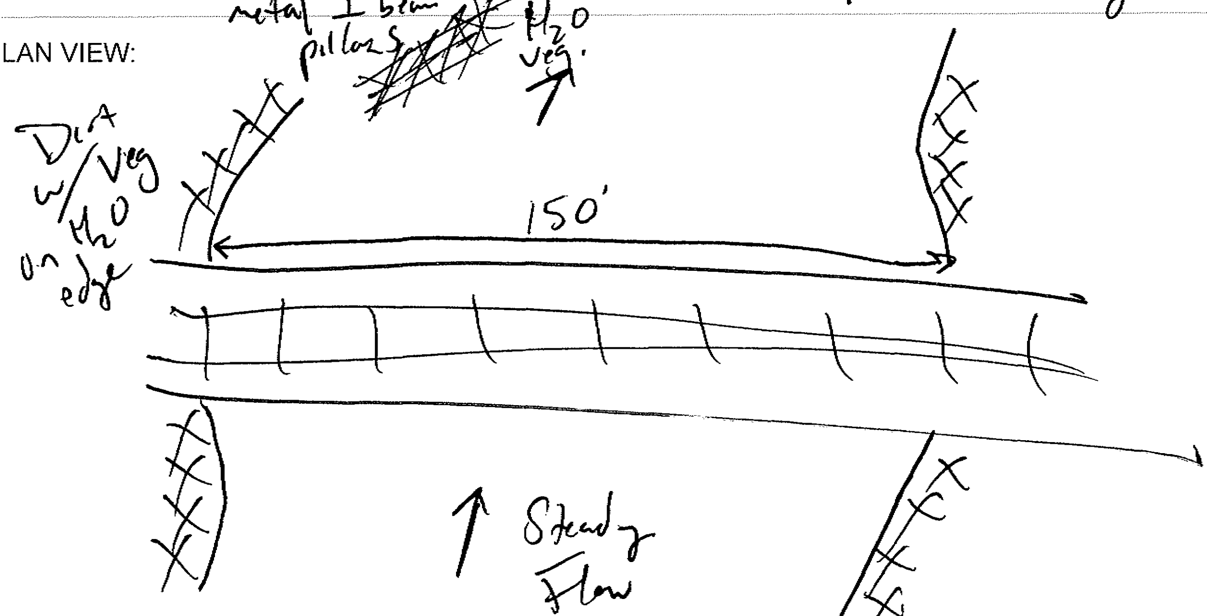
Additional Info: ____

File Name: ____

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



E

HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

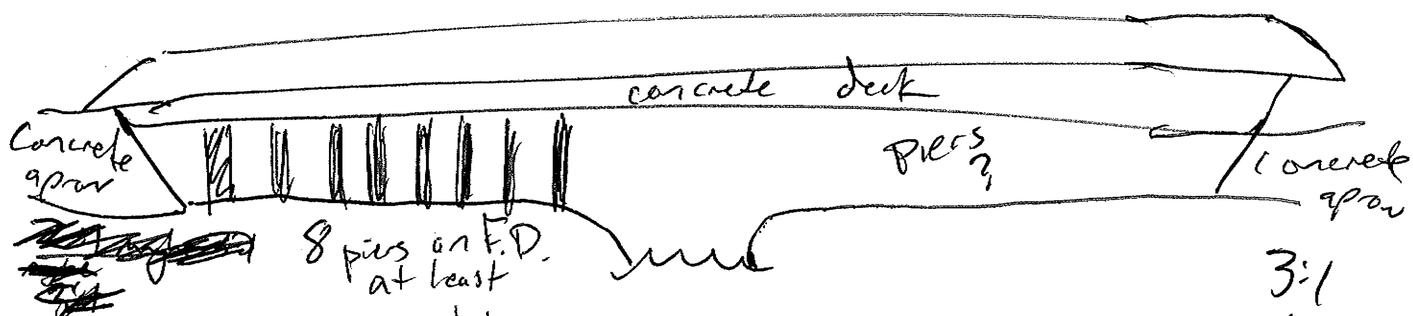
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: I10 NB and S.B. CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	2'3"	Deck:	4'	Width:	40'	Pier(s): 3' wide	~16?	@ ~50'	Pier Shape:	Round
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:		USF:		DSF:		DSC: 74	XS: 75	
Additional Info:											
File Name:											

PROFILE VIEW: ALL Concrete
(Left to Right looking Downstream)



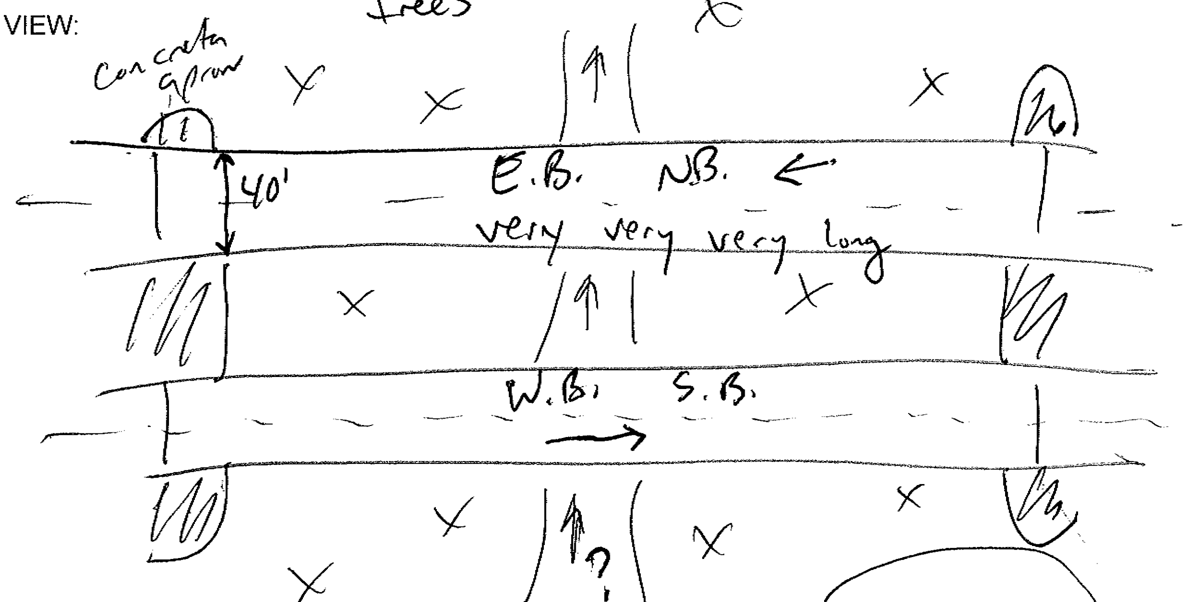
8 piers on F.D. at least

3:1 embankments

Very wide floodplains on both sides

Grassy w/scattered trees

PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: ALT Rt. 90 West of Gonzales City CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

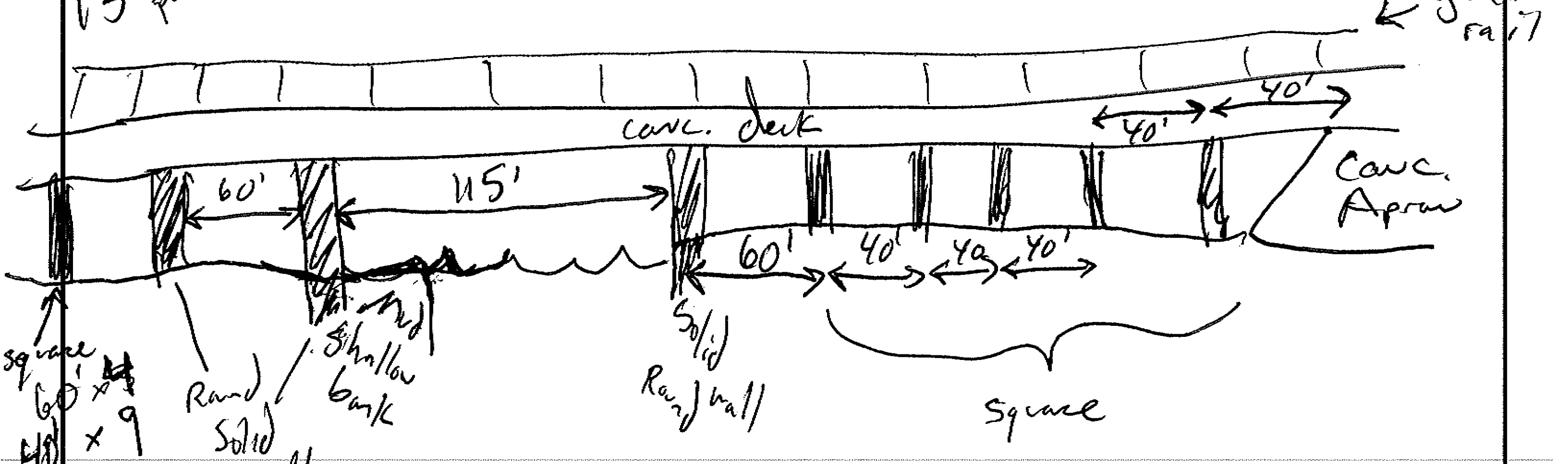
BRIDGE:	Rail Height:	2'4"	Deck:	2'10"	Width:	50'	Pier(s):	21	@ varies	Pier Shape:	Square on F.P. round in channel
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	30°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC: 91		USF: 90		DSF:		DSC: 92	XS: 89	
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

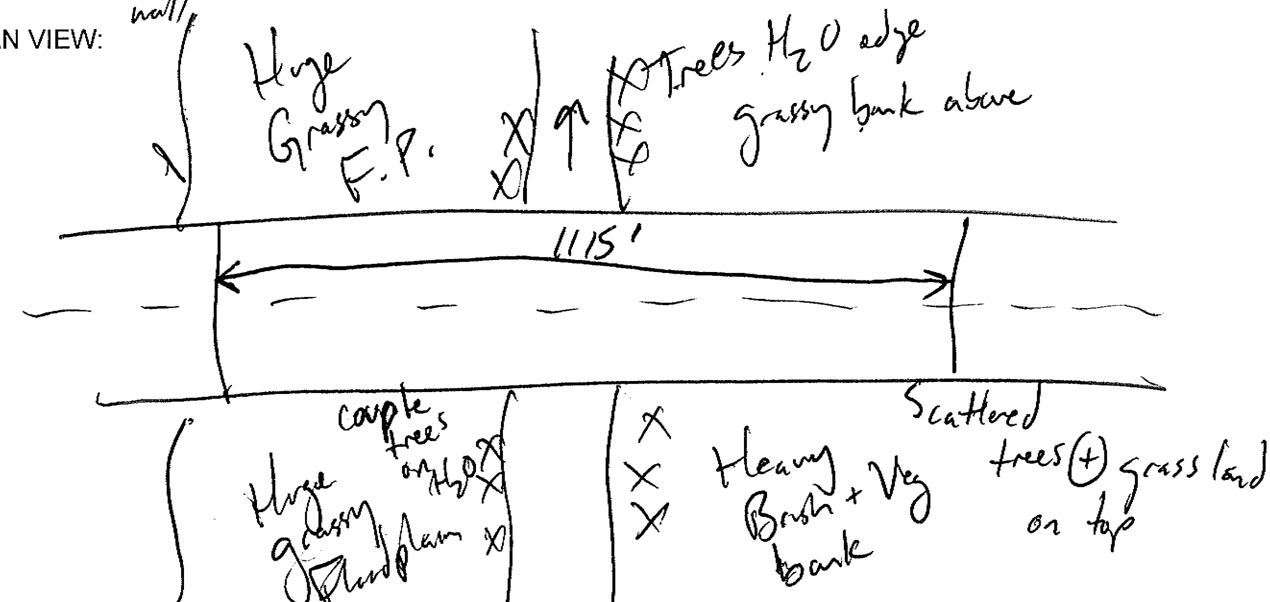
13 square piers left bank

3 round piers middle across river

5 piers 15" wide Right bank



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 2841 SURVEY NAME:

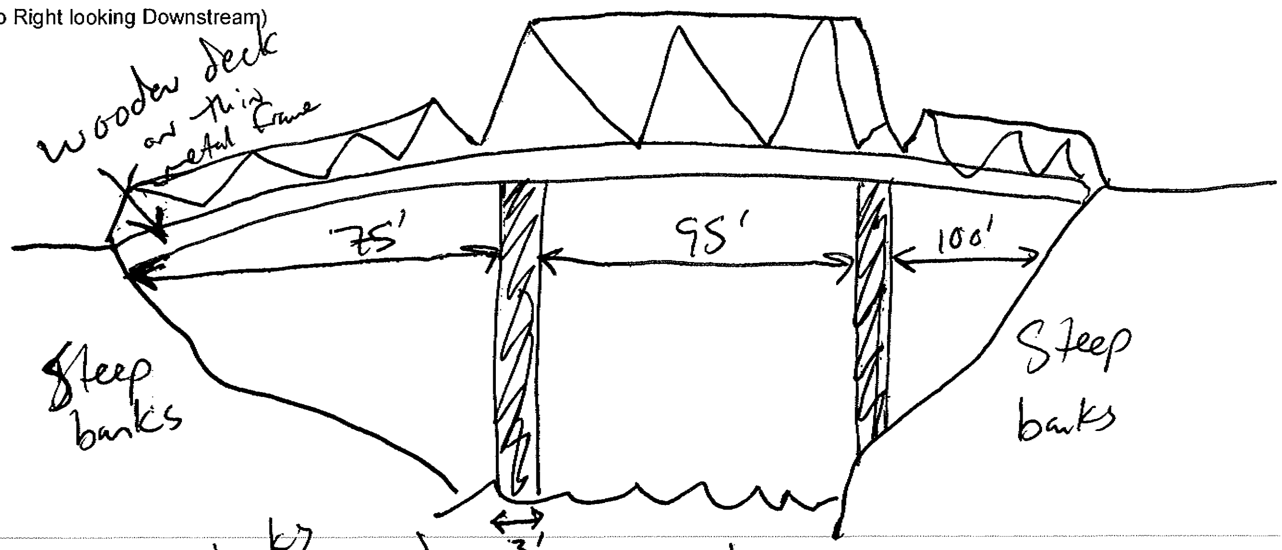
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: County Road 232 CREW: AB SC

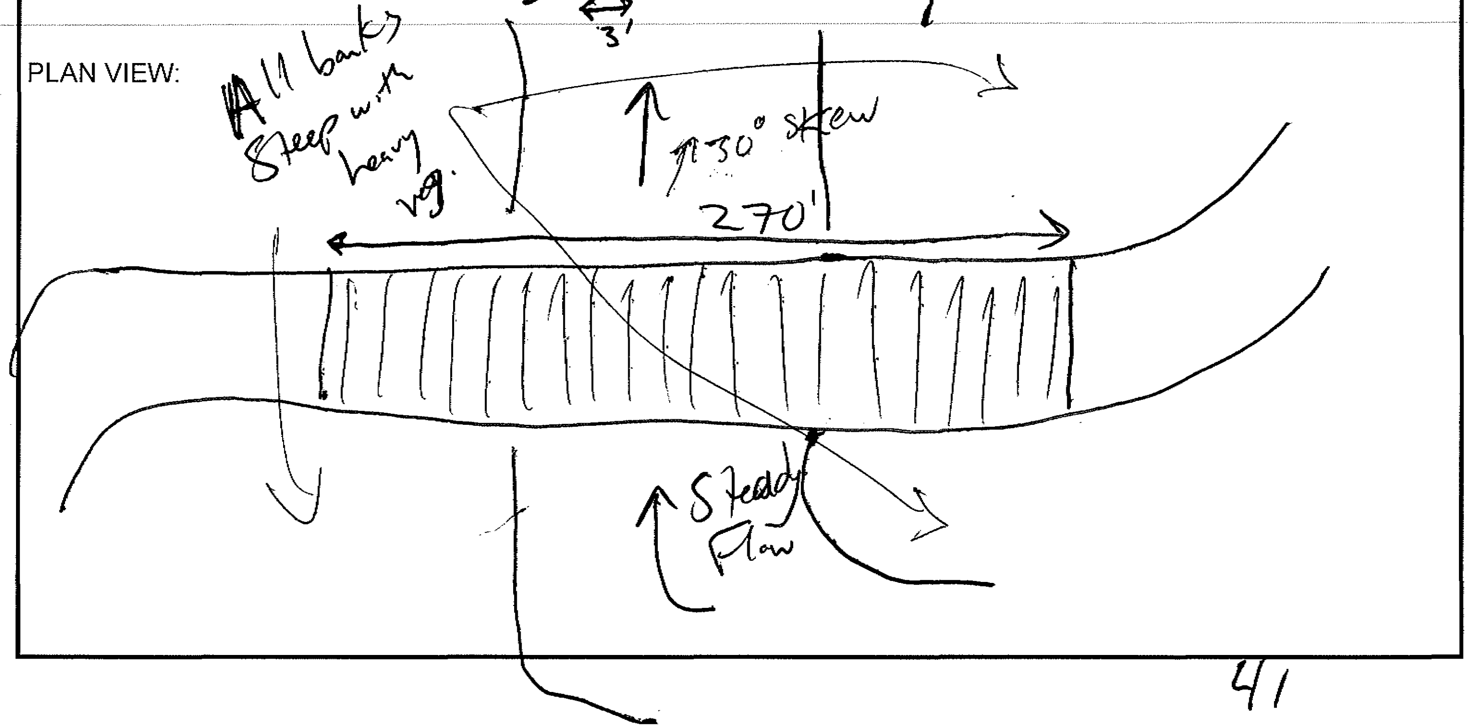
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3' 10"	Deck:	2'	Width:	16'	Pier(s):	2	@ varies	Pier Shape	ROUND
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	30°
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	87	USF:	86	DSF:	X	DSC:	88	XS: 85
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411 — SURVEY NAME:

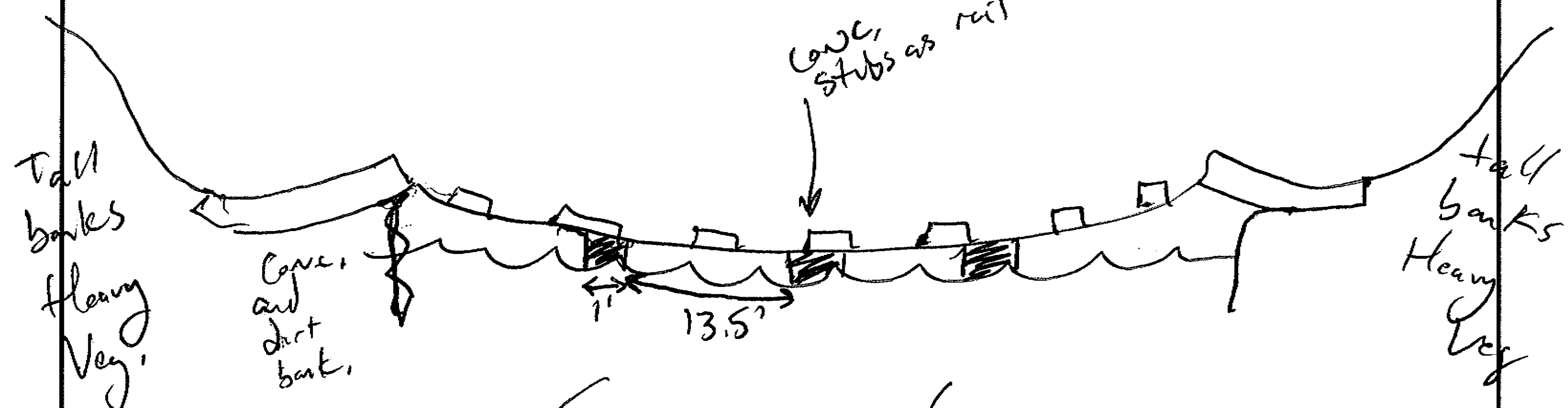
STREAM NAME: San Marcos River — DATE: 10.31.12

LOCATION: End of P11 SW Park — CREW: AB SC

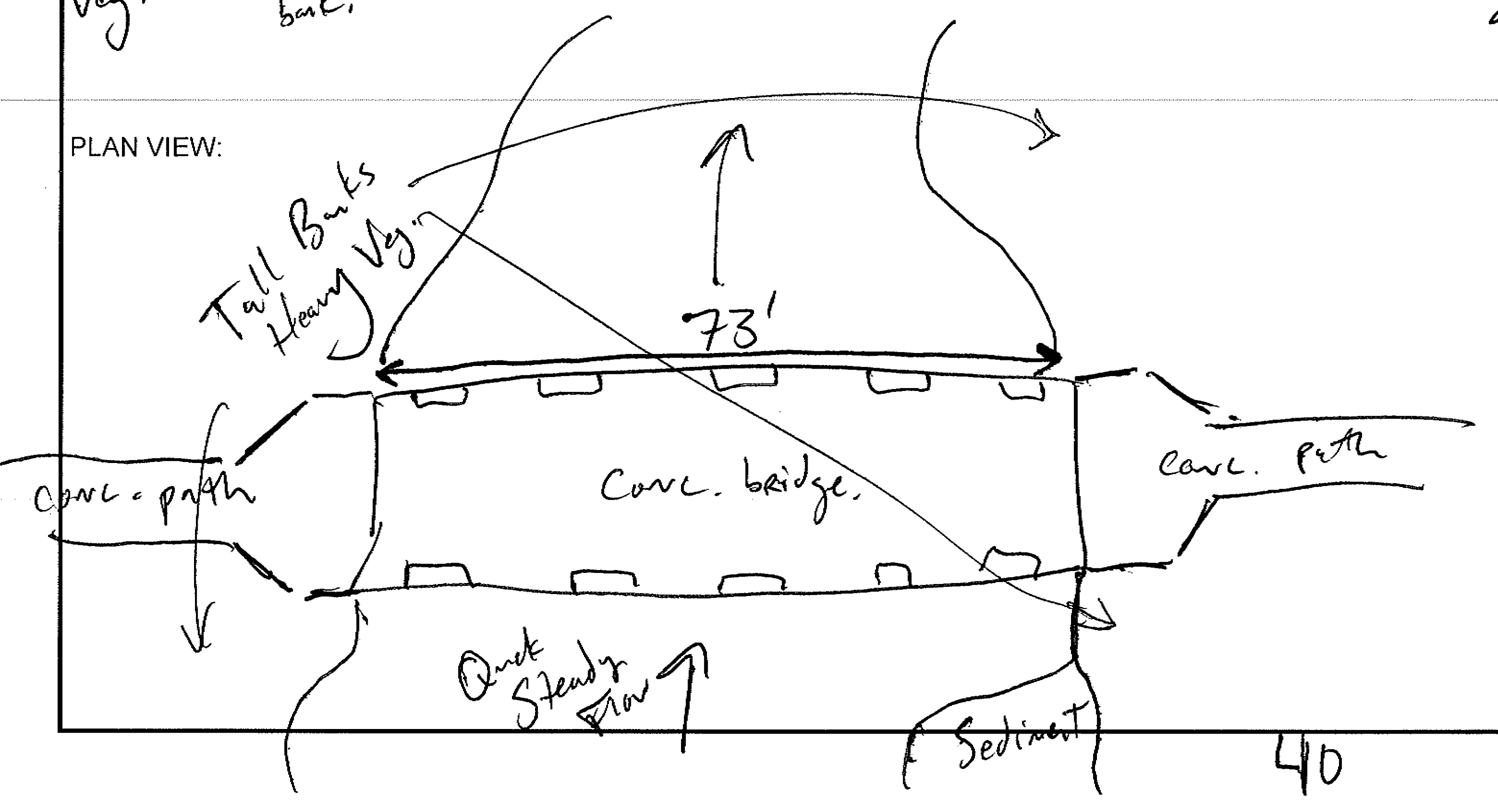
TYPE: BR(X) CUL(X) LWC DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	6"	Deck:		Width:	20'	Pier(s):	3	@	13.5'	Pier Shape:	Square
CULVERT:	Number:	4	Shape:	Box	Length:	20'	Height:	inches above H_2O	Width:	13.5'	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:	81	USF:	84	DSF:	83	DSC:	82	XS: 80	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



40

HALFF Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: 2+88 south edge of Luling CREW: AD SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2'3" Deck: 3'3" Width: 56' Pier(s): 8 @ 50' except 1 Pier Shape: Round on center piers. End ones are square.

CULVERT: Number: Shape: Length: Height: 30" Width: 1 Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

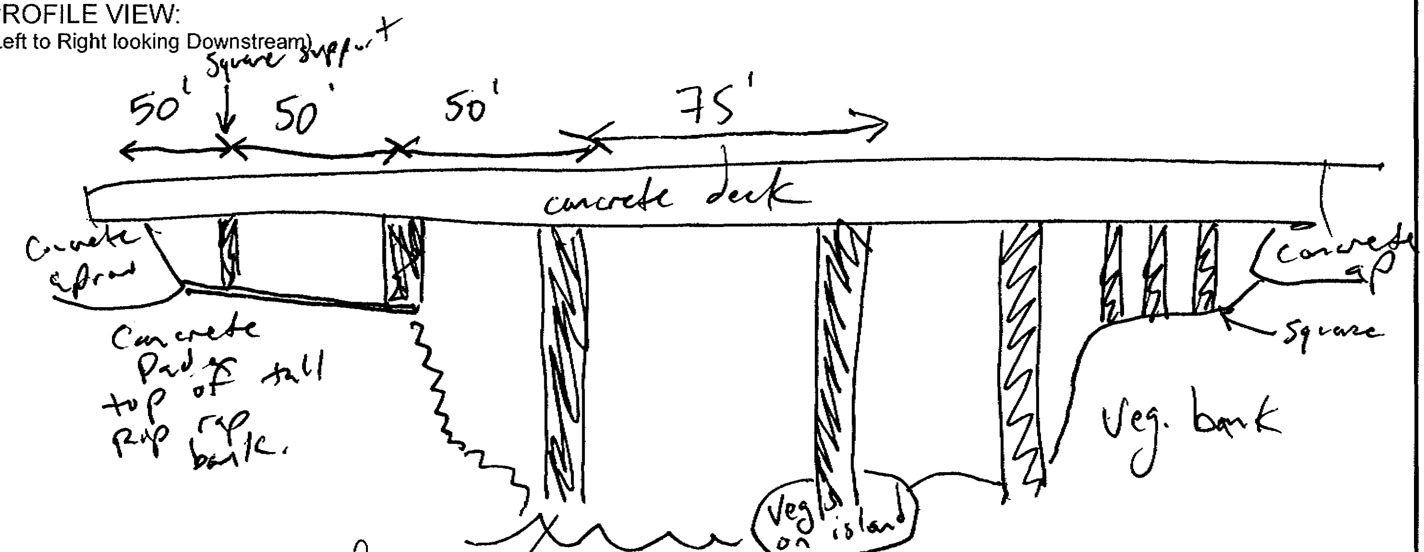
ERM Description: Coordinate System:

Photo Numbers: USC: 70 USF: 69 DSF: 71 DSC: 72 XS: 73

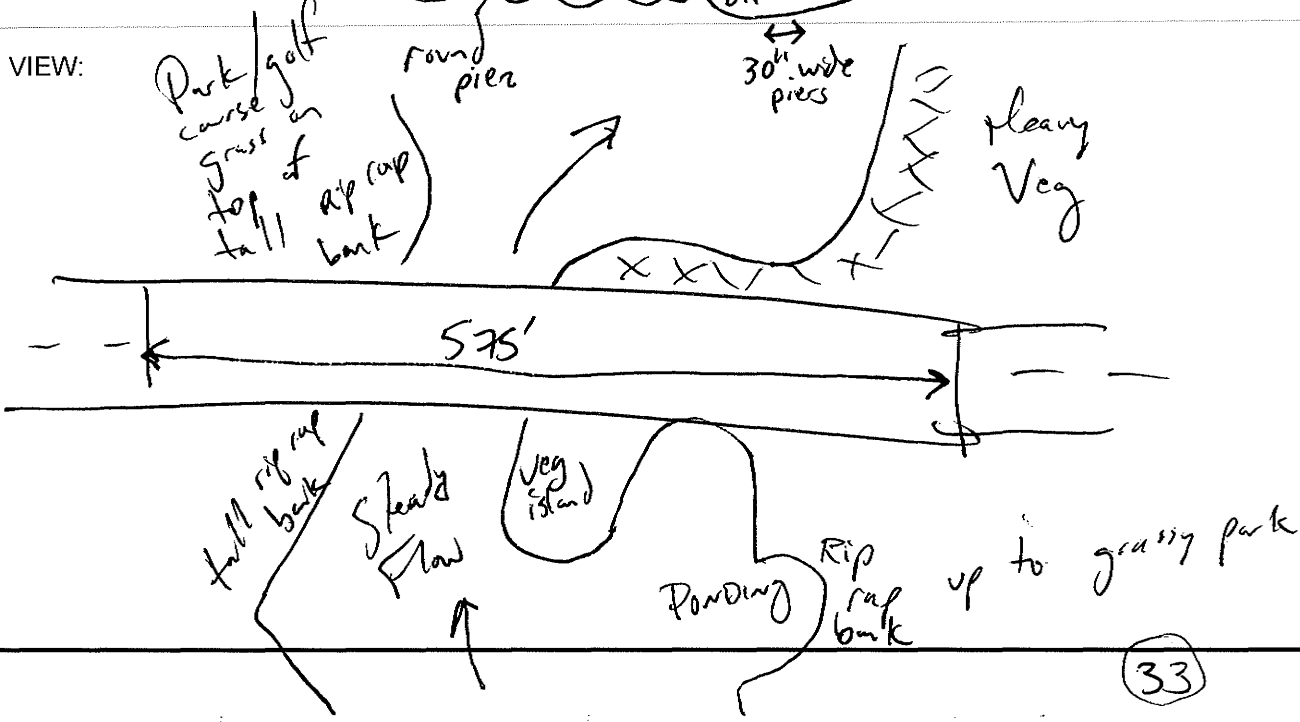
Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — Survey Field Sheet

PROJECT: 28411 SURVEY NAME: ____

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Parallel Rt. 80, South edge of Luling CREW: AB SC

Inline Structure

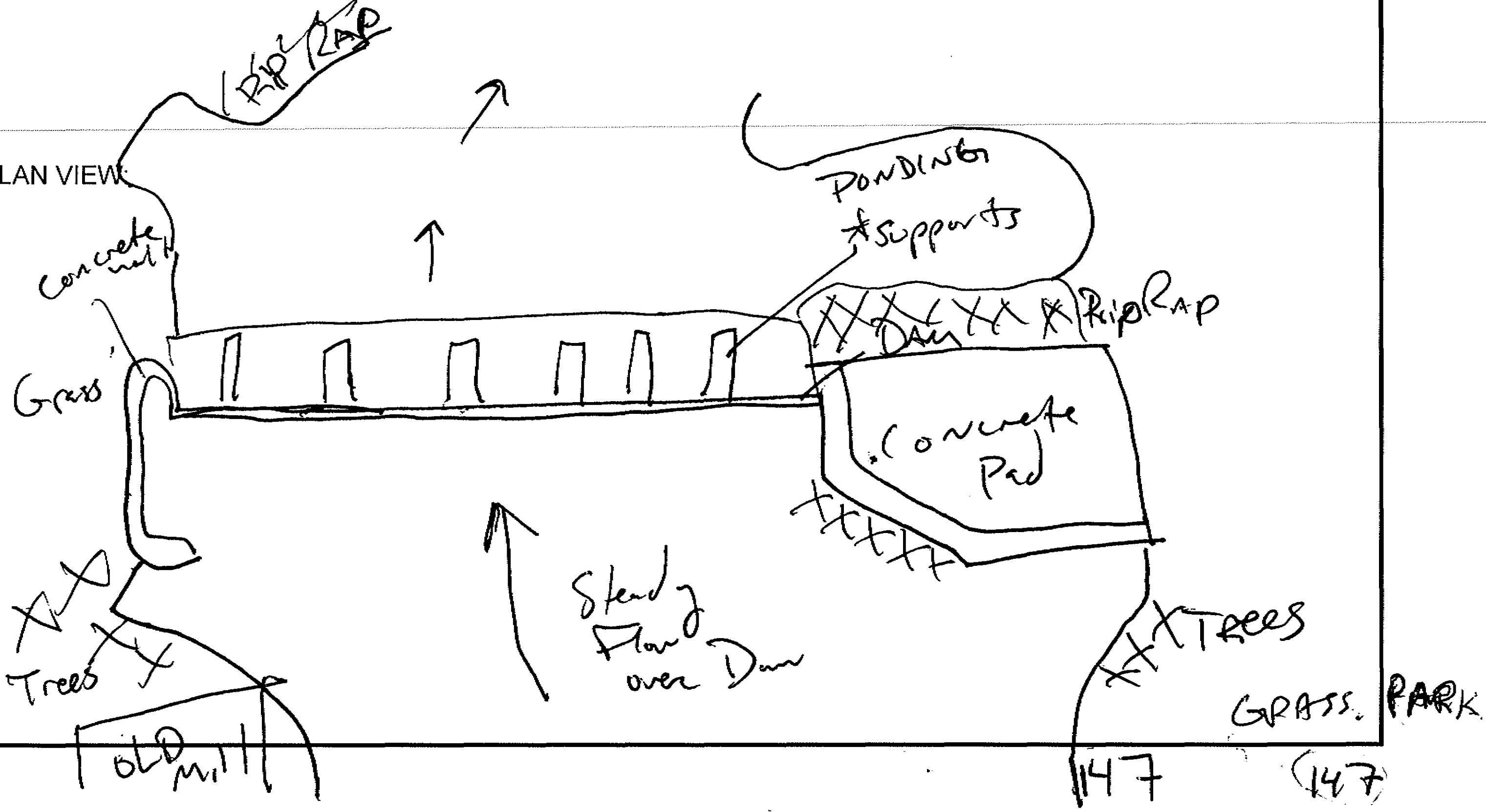
TYPE: BR( ) CUL( ) DAM(X) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):		@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	~~70~~	USF:	~~69~~	DSF:	70	DSC:		
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

Concrete Dam

PLAN VIEW:



147 (147)

HALFF

Survey Field Sheet

PROJECT: 28417 SURVEY NAME:

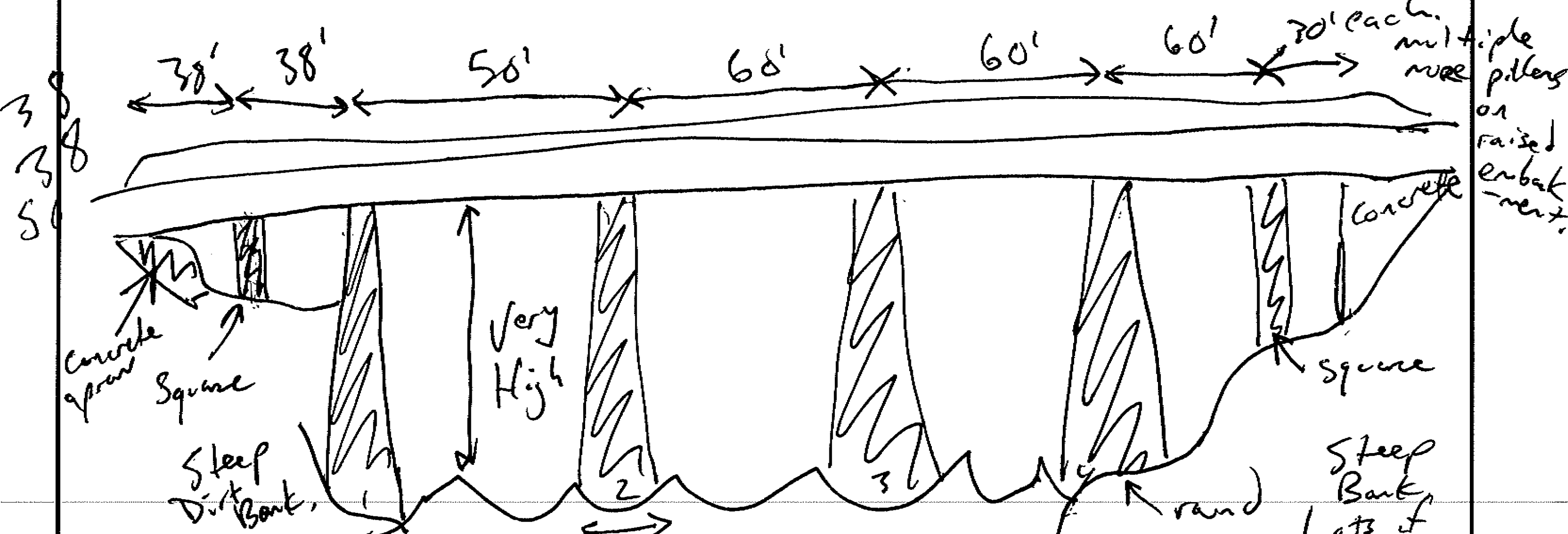
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: ~~[illegible]~~ 90 US HWY CREW: AB SC

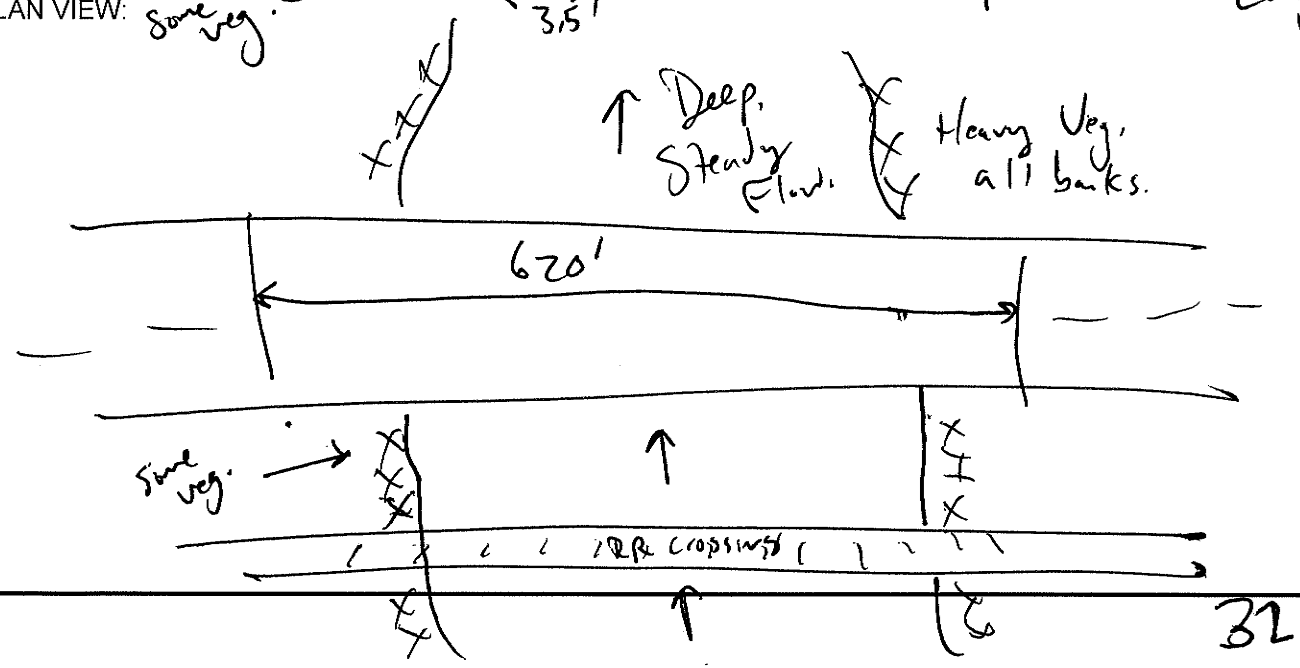
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'	Deck:	3.5'	Width:	48'	Pier(s):	4 in H_2O @ varies	Pier Shape:	round/square on ends
CULVERT:	Number:		Shape:		Length:		Height:	many more piers on embankment	Width / Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle			
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:
ERM Description:							Coordinate System:			
Photo Numbers:			USC:	66	USF:	~~64~~ 65	DSF:	~~65~~ 64	DSC:	~~64~~ 68 XS: ~~68~~ 67
Additional Info:										
File Name:										

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



32

HALFF | **Survey Field Sheet**

PROJECT: 28441 SURVEY NAME: ____

STREAM NAME: San Marcos River DATE: 10.31.12

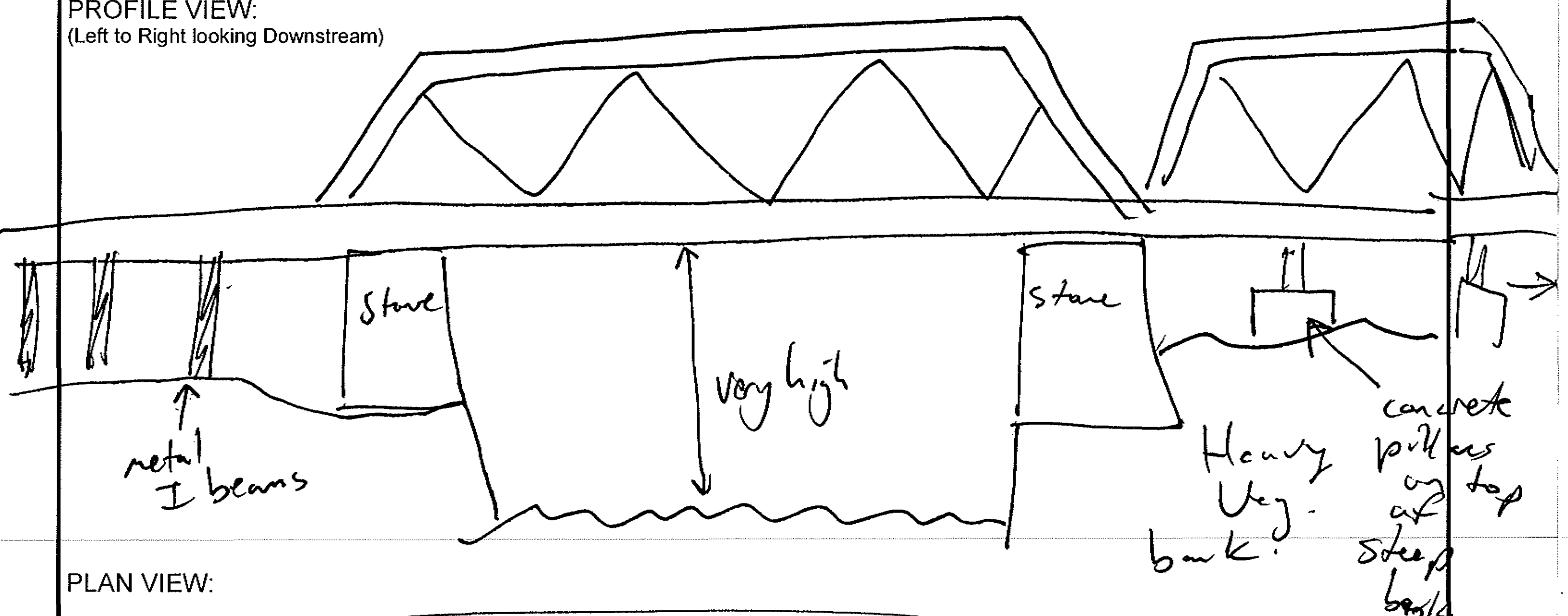
LOCATION: US HWY 90 Parallel RR. Crossing CREW: AB JC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ____ ERM ID: ____ GEOID: ____

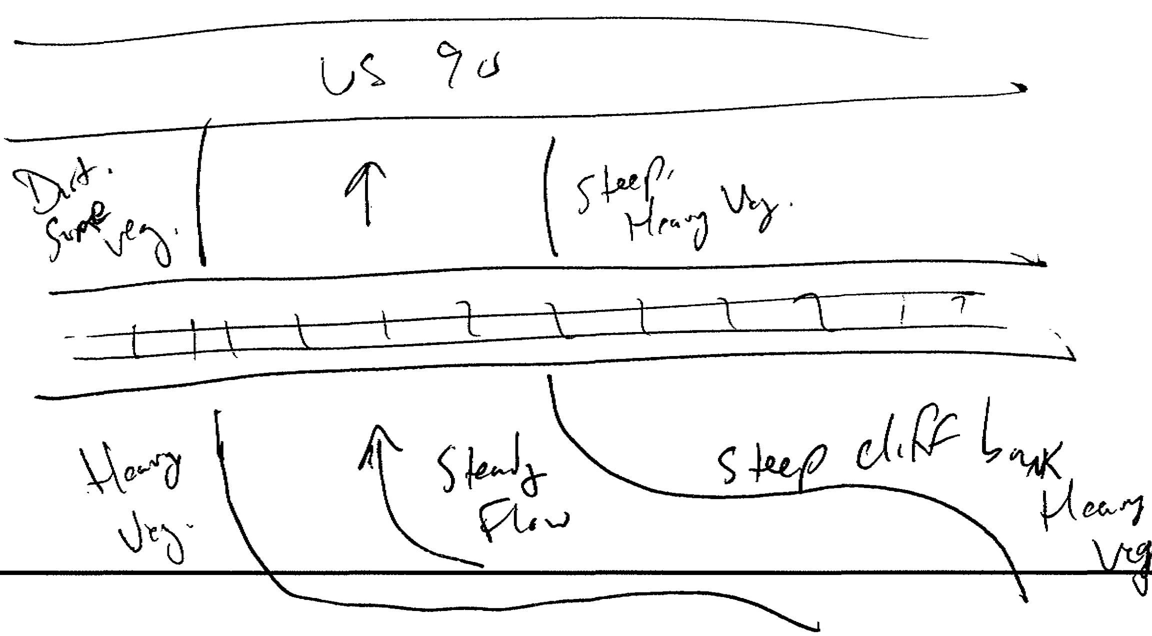
No measurements

BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):	0	@		Pier Shape:	
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:		USF:		DSF:		DSC:			
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

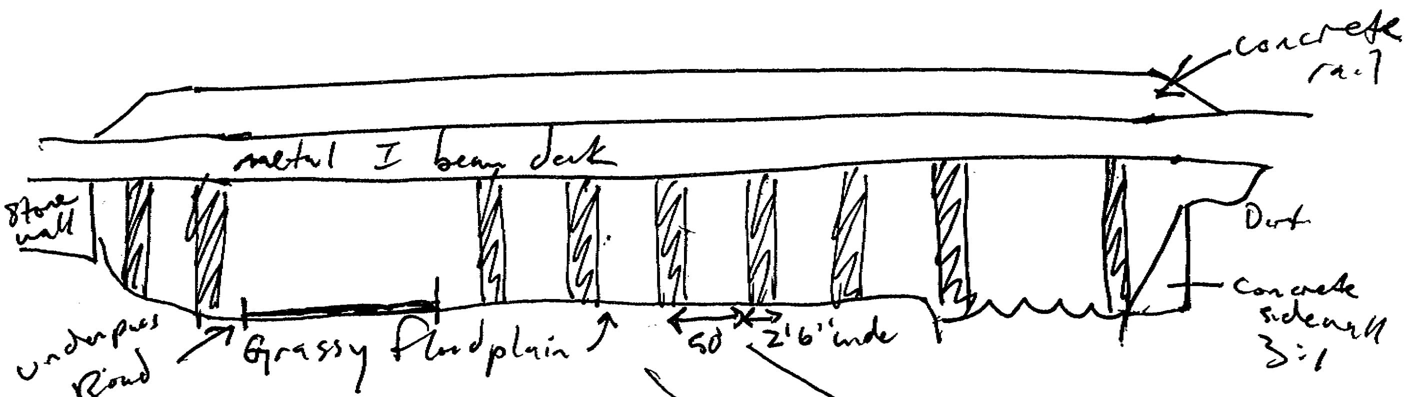
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: I35 Frontage Southbound CREW: AB SL

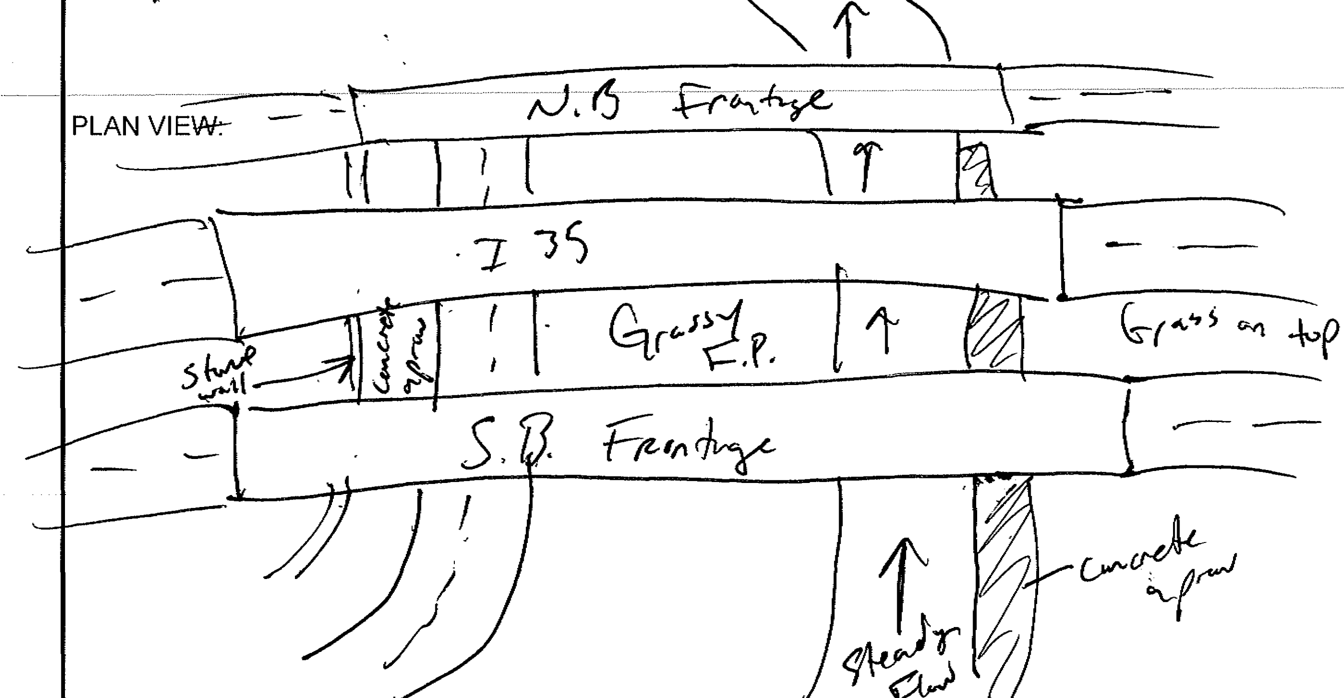
TYPE: BR(✓) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'4"	Deck:	4.5'	Width:	30'	Pier(s):	9	@	50'	Pier Shape:	Square 2 inch
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:	52	USF:	49	DSF:	50	DSC:	51	XS: 63	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW



J

HALFF

Survey Field Sheet

PROJECT: 28411

SURVEY NAME:

STREAM NAME: San Marcos River

DATE: 10.31.12

LOCATION: ~~[illegible]~~ I35, ~~[illegible]~~

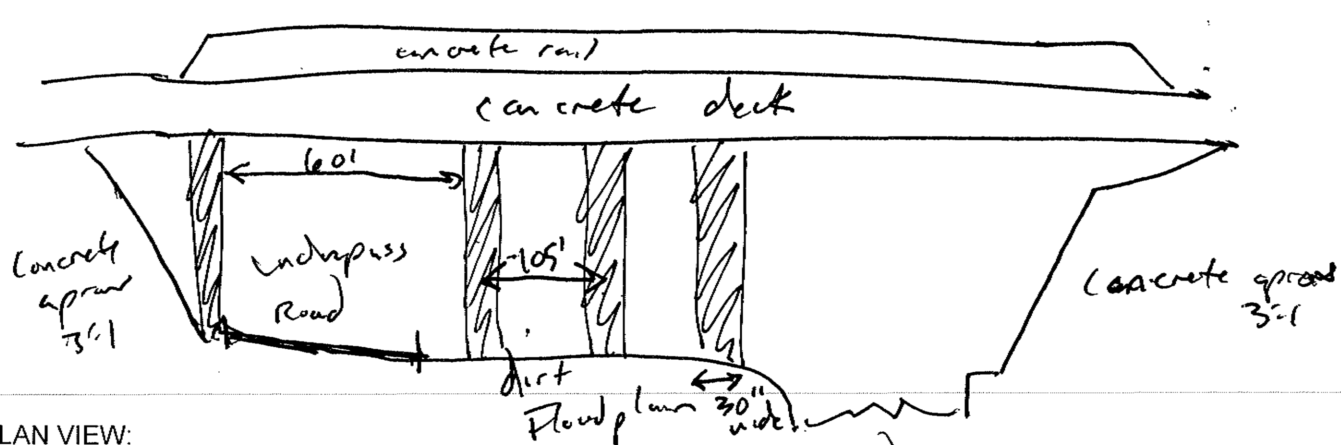
CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

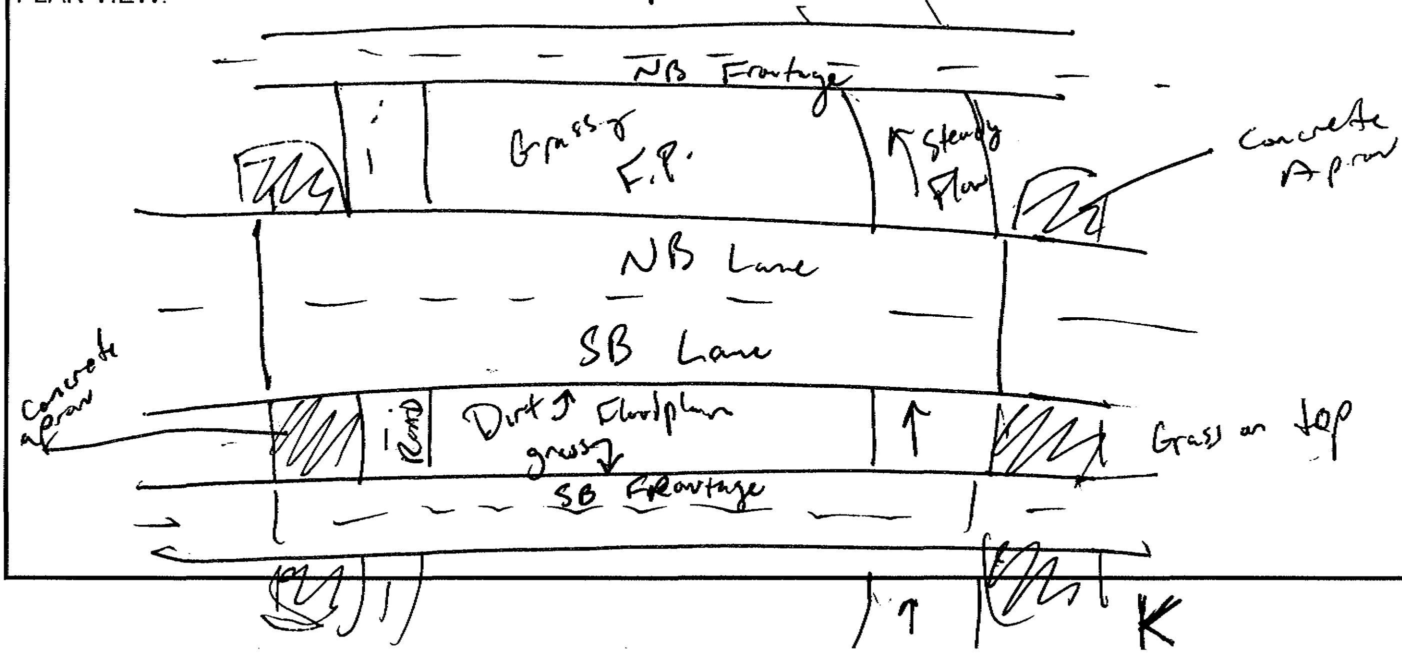
BRIDGE:	Rail Height:	2'8"	Deck:	~~[illegible]~~ 3' 8"	Width:	115'	Pier(s):	4	@ 105'	Pier Shape:	round
CULVERT:	Number:		Shape:		Length:		Height:		Width:	Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:	Outlet:	
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	55	USF:	53	DSF:	56	DSC: 54	XS: 62	
Additional Info:											
File Name:											

9 wide

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: I35 Frontage NB CREW: AB SL

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: 2'6" Deck: 2'4" Width: 30' Pier(s): 6 @ 30' Pier Shape: round 2 deep

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

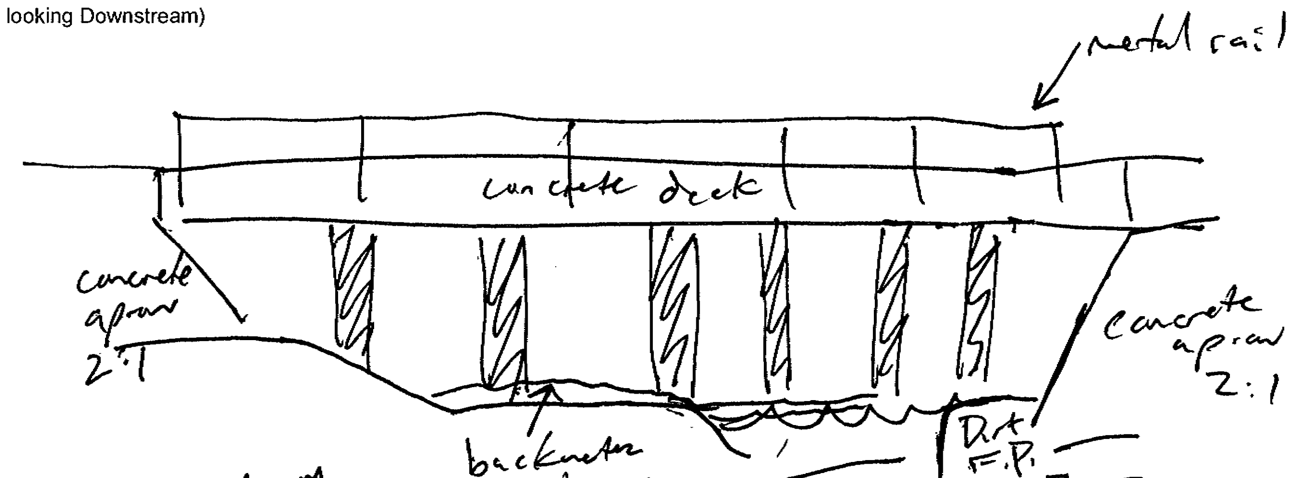
ERM Description: Coordinate System:

Photo Numbers: USC: 61 USF: 57 DSF: 60 DSC: 59 XS: 58

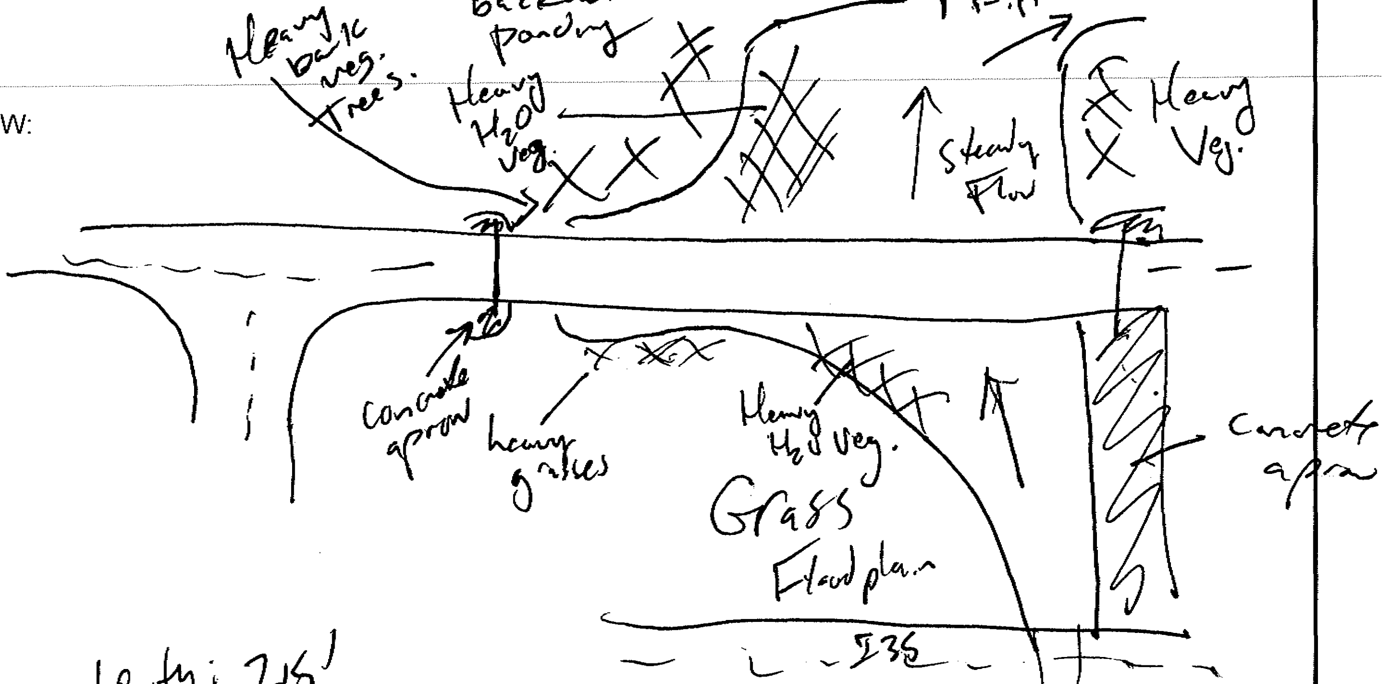
Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



Length: 218'

HALFF Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Cape Rd. Bridge CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE: Rail Height: Deck: Width: Pier(s): @ Pier Shape:

CULVERT: Number: Shape: Length: Height: Width: Skew:

CULVERT: I/O Type: Material: Wingwall Angle

DAM: Top Width: Side Slope Side Slope US: DS: Outlet:

ERM Description: Coordinate System:

Photo Numbers: USC: USF: DSF: DSC:

Additional Info:

File Name:

PROFILE VIEW:
(Left to Right looking Downstream)

*UNDER CONSTRUCTION

bridge will span overtop to avoid ~~rice~~ endangered rice veg. at least 15' off H_2O surface level

PLAN VIEW:

M

HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

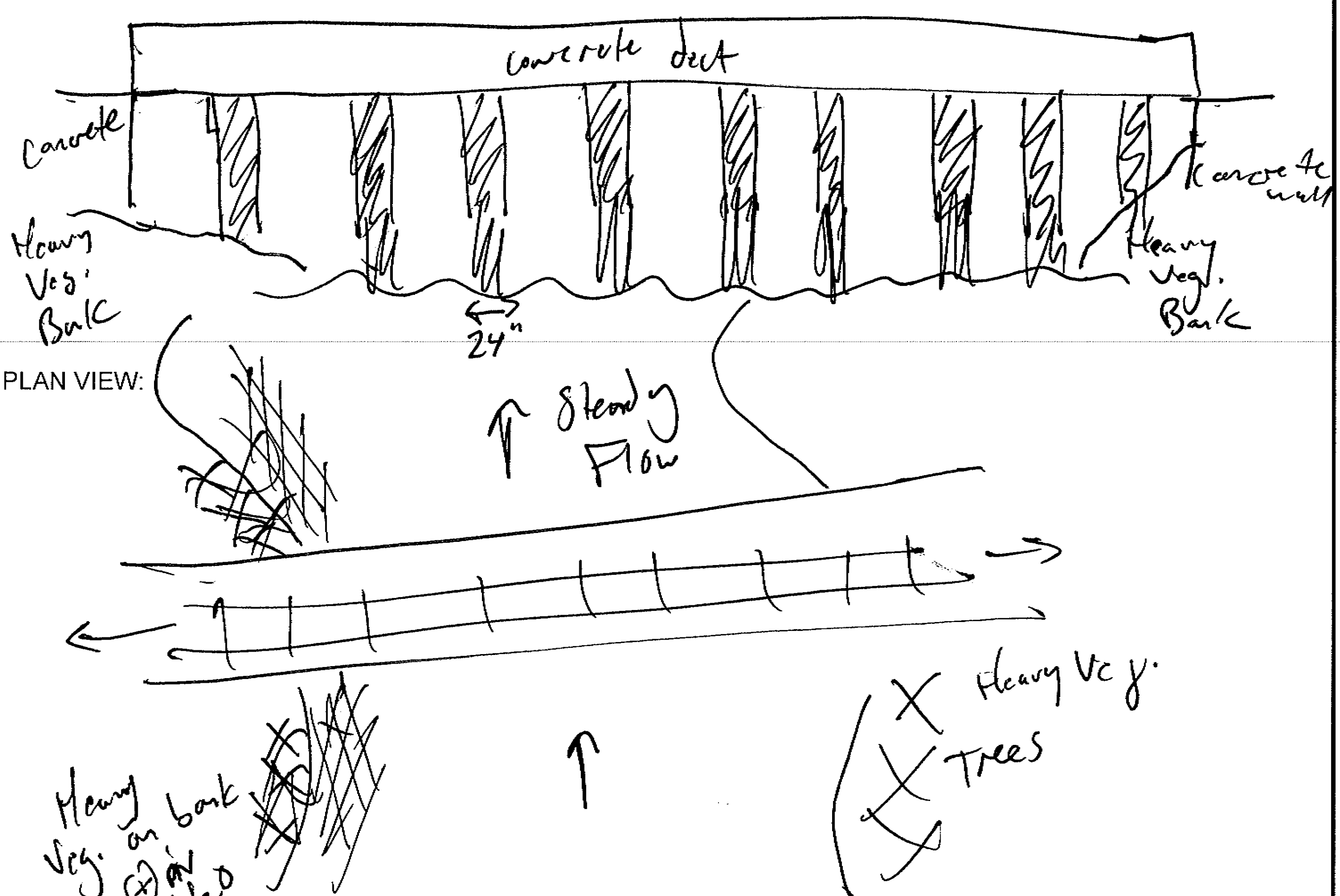
LOCATION: RR Crossing just north of Cheatham St. CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'5"	Deck:	4'	Width:	16'2"	Pier(s):	9 (2ft wide)	@	~26'	Pier Shape: Octagon 3 deep or 4
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	38	USF:	37 2	DSF:	40	DSC:	39	XS: 36
Additional Info:											
File Name:											

PROFILE VIEW:
(Left to Right looking Downstream)

Concrete octagon pillars



PLAN VIEW:

F

HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

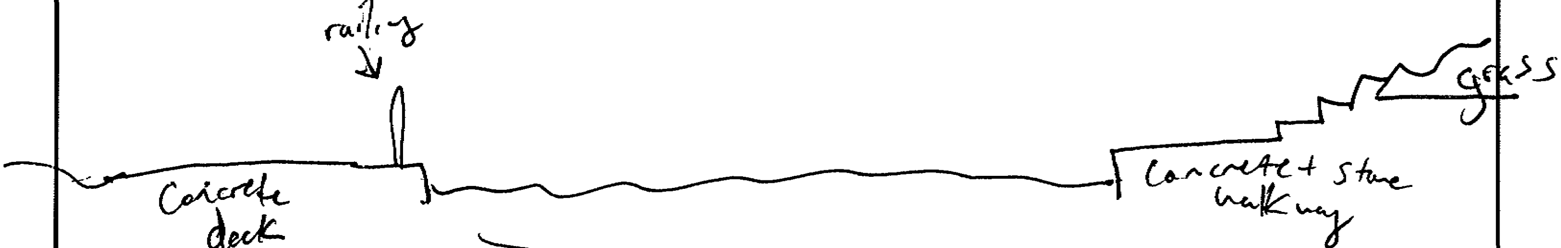
LOCATION: Dam just north of Cheatham St CREW: AB SL

TYPE: BR( ) CUL( ) DAM(✓) XS( ) ERM ELEV.: ERM ID: GEOID:

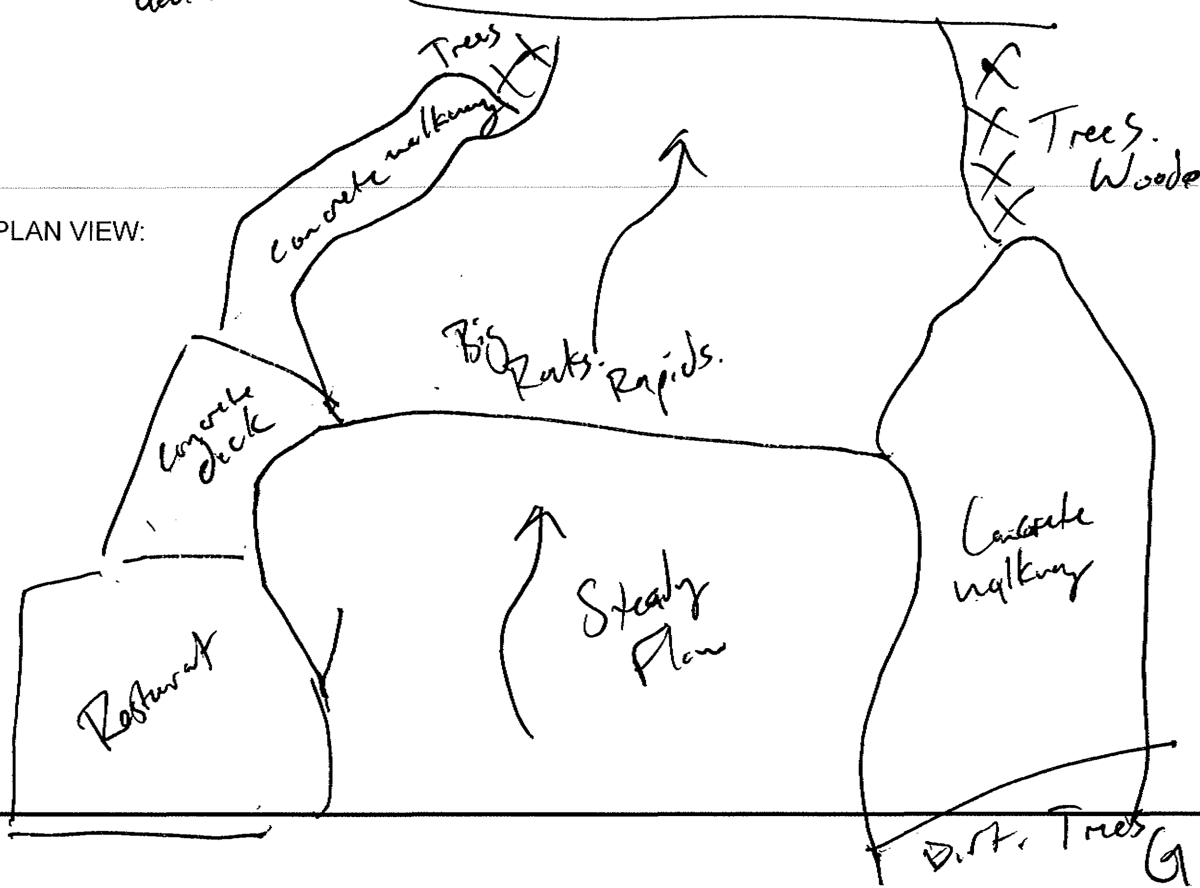
BRIDGE:	Rail Height:		Deck:		Width:		Pier(s):		@		Pier Shape:	
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:					
Photo Numbers:			USC:	42	USF:	~~DSF:~~			DSC:	43	XS 41	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)

Concrete + stone dam. H_2O flows at dam height.



PLAN VIEW:



HALFF

Survey Field Sheet

PROJECT: 28411 SURVEY NAME:

STREAM NAME: San Marcos River DATE: 10.31.12

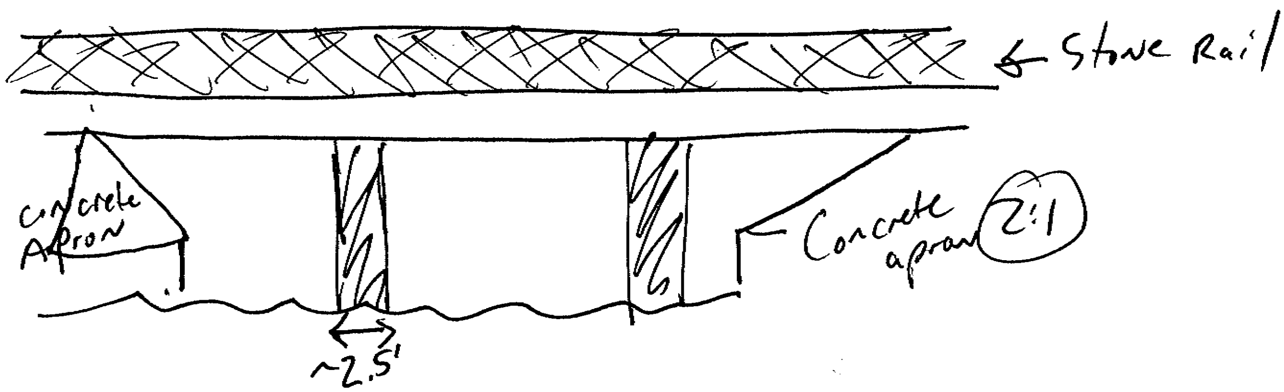
LOCATION: Cheatham St. Bridge CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

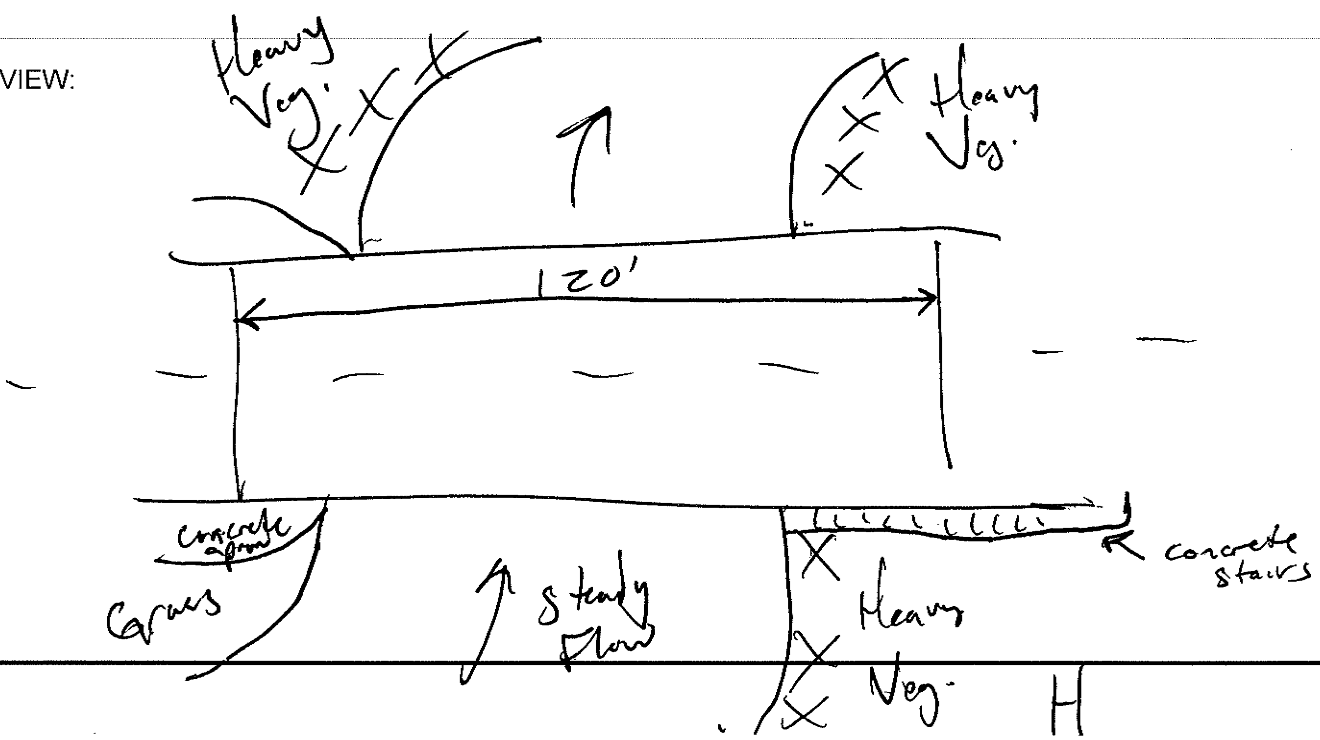
BRIDGE:	Rail Height:	3'9"	Deck:	2'9"	Width:	55'	Pier(s):	2	@	40'	Pier Shape: round
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:			USC:	45	USF:	48	DSF:	47	DSC:	46	XS: 44
Additional Info:											
File Name:											

4 deep

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



HALFF — **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

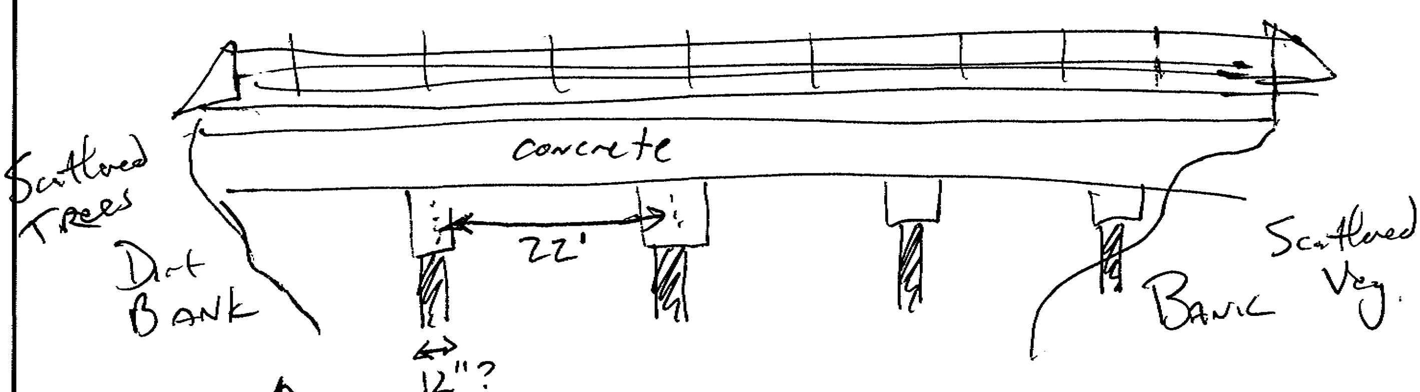
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Loop 82 Bridge at E. Sessom Dr. CREW: AR AB SC

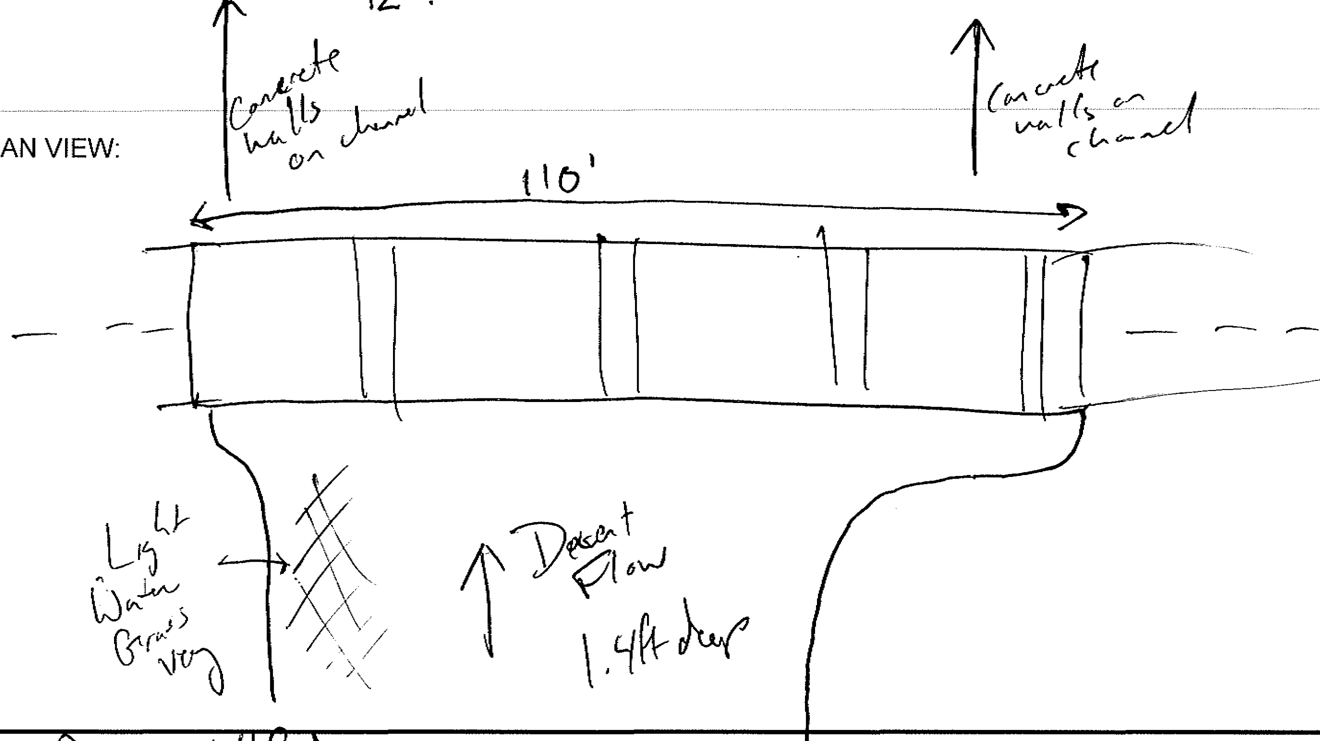
TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

BRIDGE:	Rail Height:	3'4"	Deck:	2.5'	Width:	~70'	Pier(s):	4	@	22'	Pier Shape:	SQUARE
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:	
CULVERT:	I/O Type:				Material:		Wingwall Angle					
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:	
ERM Description:							Coordinate System:	4				
Photo Numbers:			USC:	3	USF:	2	DSF:	5	DSC:	4	XS: 1	
Additional Info:												
File Name:												

PROFILE VIEW:
(Left to Right looking Downstream)



PLAN VIEW:



Gauge 1.4ft deep

A

HALFF **Survey Field Sheet**

PROJECT: 28411 SURVEY NAME:

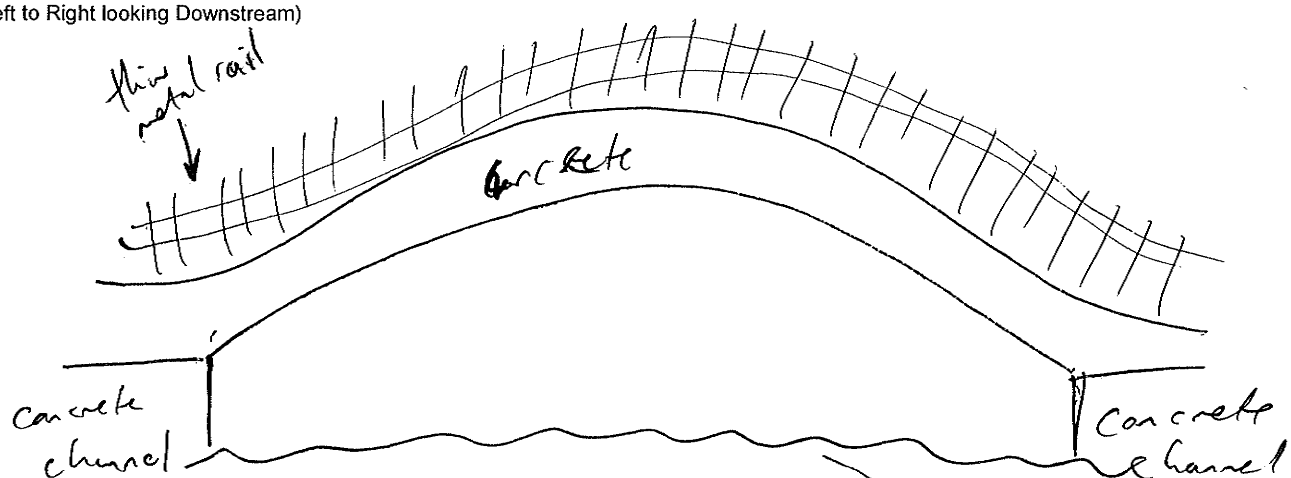
STREAM NAME: San Marcos River DATE: 10.31.12

LOCATION: Same as 'A' just downstream CREW: AB SC

TYPE: BR(X) CUL( ) DAM( ) XS( ) ERM ELEV.: ERM ID: GEOID:

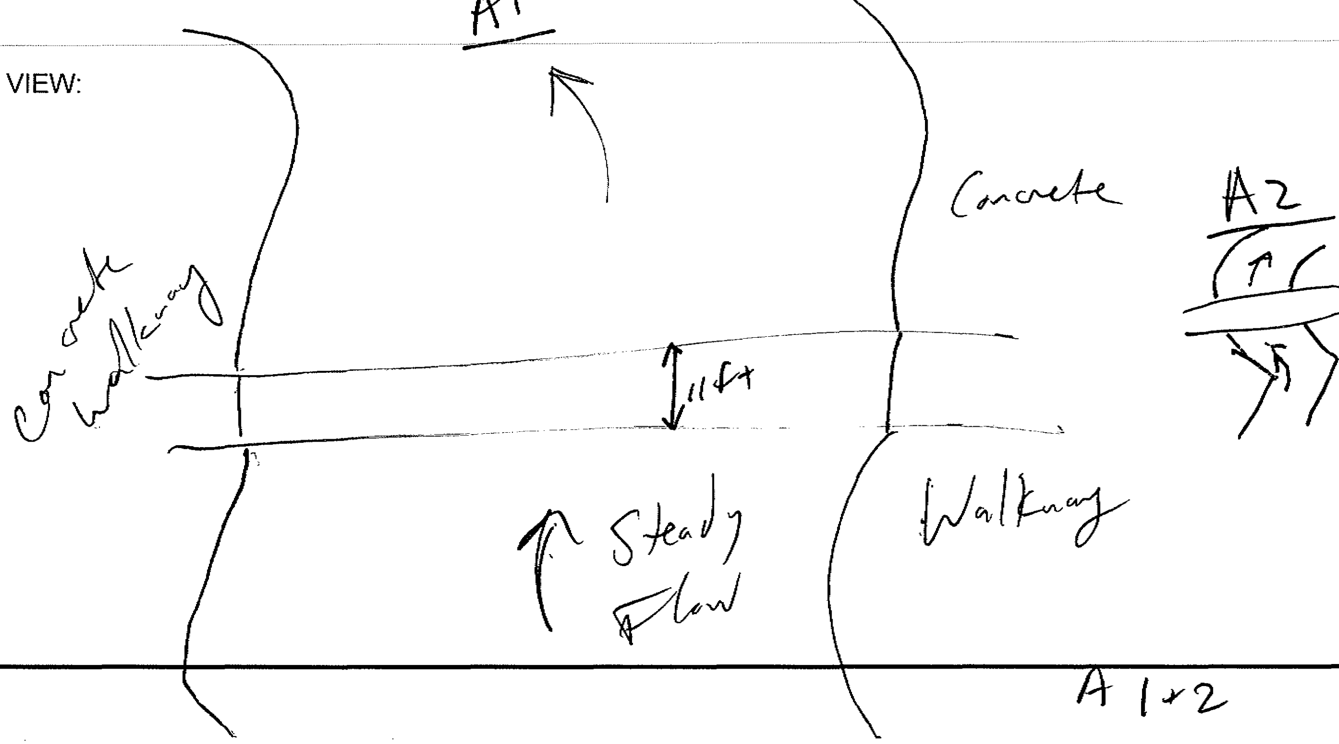
BRIDGE:	Rail Height:	3'10"	Deck:	3'	Width:	11'	Pier(s):	0	@		Pier Shape:
CULVERT:	Number:		Shape:		Length:		Height:		Width:		Skew:
CULVERT:	I/O Type:				Material:		Wingwall Angle				
DAM:	Top Width:		Side Slope		Side Slope		US:		DS:		Outlet:
ERM Description:							Coordinate System:				
Photo Numbers:	OF FIRST BRIDGE:		USC:	8	USF:	10	DSF:	9	DSC:	6	XS: 7
Additional Info:											
File Name:		2nd Bridge: 11				12		14		15	13

PROFILE VIEW:
(Left to Right looking Downstream)



A1

PLAN VIEW:



A 1+2

Appendix D.1.4

Quality Assurance

HALFF

Appendix D.1.4.a
Ford Consulting
QA/QC Review

Technical review:

Project	GBRA Interim Feasibility Study
Project task or phase	Guadalupe River– HEC-RAS routing models
Project manager	Brian Brown, PE
Client	Halff
Reviewer	Ric McCallan, PE and Brian Brown, PE
Review date	11-28-2012

Note: Instructions for the reviewer and responder and a sample comment are included at the end of this form.

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
1	All HEC-RAS models	The bridges, culverts, and inline structures were reviewed to determine if the information in the model was reasonable. No information was available to verify specific features. All structures were found to be reasonable except for specific comments below.	no	no	No repsonse	
2	All HEC-RAS Models	Recommend putting datum and coordinate system information in “Description” portion of HEC-RAS model.	no	no	Datum and coordinate system are being researched and will be included in the descriptions for all of the Guadalupe River Models in the final submittal.	
3	All HEC-RAS model	Downstream boundary conditions - What is the source of the downstream boundary conditions used in the model? I recommend adding this information to the plan description.	no	no	Starting boundary conditions were added to plan descriptions.	
4	Guadalupe_Dewitt.prj HEC-RAS model	RS 498940 – The ineffective flow area to the right of the channel looks to be very large. This ineffective flow area blocks more of the cross section than the corresponding ineffective flow area in the downstream cross section that is modeling the bridge embankment. This ineffective flow area should start further to the right to account for the contraction of flow in the downstream direction. Review the positioning of the ineffective flow area.	yes	no	Fixed.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
5	Guadalupe_Dewitt.prj HEC-RAS model	RS 497283 – The ineffective flow areas on both banks of the channel appear to be too large. These ineffective flow areas create an effective channel width that is almost the same as the upstream section. These ineffective flow areas should be smaller to account of the expansion of flow in the downstream direction. Review the positioning of the ineffective flow areas.	yes	no	Fixed.	
6	Guadalupe_Dewitt.prj HEC-RAS model	Bridge 498039– The ineffective flow area to the left of the channel is partially blocking the left bridge opening for the downstream section. Review the downstream section to see if the ineffective flow area should be configured the same as the upstream cross section for this area.	yes	no	Fixed.	
7	Guadalupe_Dewitt.prj HEC-RAS model	Bridge 679364 – The second ineffective flow area to the right of the channel is partially blocking the right hand bridge opening for the downstream section. Review the downstream section to see if the ineffective flow area should be configured the same as the upstream cross section for this area.	yes	no	Fixed.	
8	Guadalupe_Dewitt.prj HEC-RAS model	RS 570410 – This section is a wide valley with at least triple the section width than the upstream section width. A change in section width over the distance between the sections of this magnitude does not account for flow expansion between sections. Review this section and downstream sections and add ineffective flow areas as needed to account for flow expansion.	yes	no	Fixed.	
9	Guadalupe_Dewitt.prj HEC-RAS model	RS 416200 – This section is a wide valley with at a much larger section width than the upstream section width. A change in section width over the distance between the sections of this magnitude does not properly account for flow expansion between sections. Review this section and downstream sections and add ineffective flow areas as needed to account for flow expansion.	yes	no	Water does spill over into a diversion at that location.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
10	Guadalupe_Gonzales.prj HEC-RAS model	RS 1060633 to 1088058 – The upstream and downstream sections contain ineffective flow area for the side channel along the left side of the sections. 2 sections, 1081455 and 1086060, do not have ineffective flow areas for this side channel. Review the sections and determine if ineffective flow areas are needed to these sections for consistency between sections in this reach.	yes	no	Removed ineffectives on the side channel for XS 1060633 to 1088058	
11	Guadalupe_Gonzales.prj HEC-RAS model	RS 962630 to 966368 and 997742 to 1004840 – These sections allow flow in portions of the left overbank before the flow in the channel has overtopped the channel banks. Review the sections and determine if ineffective flow areas should be included to the left of the channel to cover the entire left overbank.	yes	no	Ineffective areas added to 962630-966368 and to 997742-1004840	
12	Guadalupe_Gonzales.prj HEC-RAS model	RS 899956 and 920140 - There are a low areas in the right overbank that is not covered by an ineffective flow area while in the approximately same area downstream does contain an ineffective flow area. Review this section to determine if ineffective flow areas are needed for consistency between sections.	yes	no	Ineffectives were adjusted	
13	Guadalupe_Gonzales.prj HEC-RAS model	RS 973943 to 986116 – The energy gradeline for the COE 2-yr profile dips over 6 feet in this reach. Review the reach and revise as needed to eliminate the dip in energy gradeline.	yes	no	Fixed	
14	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	RS 923059 – The low area in the left overbank should have an ineffective flow area since this area is significantly lower than the same location in the upstream and downstream sections.	yes	no	Agree. Ineffective added.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
15	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	RS 155706 and downstream – The sections in this reach have a side channel to the left of the channel configured with levee. Ineffective flow areas are included for this leveed side channel inconsistently through this reach. Review the sections in the reach and assign ineffective flow areas consistently throughout the reach.	yes	no	The Victoria HEC-RAS model was calibrated to the October 1998, July 2002, and November 2004 high water marks. The ineffective areas from XS 155706 to downstream produce water surface elevation similar to the calibration storms.	
16	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	Bridge 340068 – The upstream and downstream cross sections contain ineffective flow areas that block flow in the left side span of the bridge.	yes	no	Flow from the Guadalupe River is not effective in the bridge in the left overbank.	
17	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	Bridge 206946 – The last pier is missing upstream centerline and width data.	no	no	The last pier was deleted. Cross section 206946 should only have 113 piers.	
18	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	Bridge 13991 – The low chord of the bridge deck and a number of piers do not connect. Review the bridge deck and pier data and revise as needed.	no	no	The bridge is a Saltwater Barrier. Pictures of the structure have been included with the response to comments. The piers should not connect with the low chord of the bridge as shown in the pictures.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
19	Guadalupe_FEMA2008.prj (Victoria) HEC-RAS model	RS 59473 to 62580 – The energy gradeline for the COE 500-yr + 30% profile dips over 8 feet in this reach. Review the reach and revise as needed to eliminate the dip in energy gradeline.	yes	no	The model was not revised. The 500yr + 30% profile will only be used for routing purposes.	
20	Lguad.prj (Lower Guadalupe2) HEC-RAS model	We reviewed the Lower Guadalupe model found no comments.	no	no	No comment	
21	guadalupe.prj (5-23248) HEC-RAS model	Bridge 37427 and 37203 – Verify the momentum and Yarnell coefficients. They appear to be switched from what is normally seen with these 2 values.	no	no	No changes were made to the routing model. Bridge plans will be requested from TxDOT for the I-35 bridges	
22	guadalupe.prj (5-23248) HEC-RAS model	Bridge 37275 and 37345 – Verify the bridge widths for these bridges. The bridges appear to be much wider in the available aerials.	no	no	No changes were made to the routing model. Bridge plans will be requested from TxDOT for the I-35 bridges	
23	uguad.prj (6-Upper Guadalupe) HEC-RAS model	Manning's n values – Some sections have Manning's n values as high as 0.12 and 0.14. We have no information describing how the n values developed, but in general, n values in this range are considered high. Please verify that these values are reasonable.	yes	no	Manning's n-values are within the ranges of the other models. A summary of Manning's n-values are shown in the Guadalupe Hydraulic Notebook Entry #5.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check

Technical review:

Project	GBRA Interim Feasibility Study
Project task or phase	San Marcos Watersheds – HEC-RAS routing model
Project manager	Brian Brown, PE
Client	Halff
Reviewer	Ric McCallan, PE and Brian Brown, PE
Review date	11-20-12

Note: Instructions for the reviewer and responder and a sample comment are included at the end of this form.

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
1	HEC-RAS Model	RS 252342, 168947 and 165648 – Review the downstream reach lengths for the right overbank for these sections for reasonableness. The shape of the cross section and the angle at which the flow lines cross seems to overestimate the distance between the right overbanks.	yes	no	RS 252342 and RS 165648 appeared accurate regarding overbank reach distances. The layout for RS 168947 did create an overestimation of the downstream overbank reach length, so the section was moved to provide a more accurate distance.	
2		RS upstream and downstream of bridges 365105, 219332, 219159, 219450, 219349, 362272, and 362114 – The ineffective flow areas representing the bridge deck should be set as permanent.	yes	no	The ineffective flow areas representing the bridge deck were changed to permanent ineffective areas.	
3		RS 286989 and 286863 – The leftmost ineffective flow area is set as permanent upstream and not permanent downstream of the bridge. These should be consistent.	yes	no	Routing profiles are not affected by this ineffective area. However, at XS 286989 the ineffective was set as "not permanent" for consistency.	
4		RS 372678 to 368908 – Review the right ineffective flow area is these sections. I do not see a reason for the ineffective area elevation to be significantly higher than the high ground elevation for these sections.	no	no	I initially raised these ineffective areas due to stability issues. I lowered them just to check and they did not seem to have a negative impact on profiles, so I left them lowered as suggested	
5		RS 360998 – Review the left- and right-most ineffective flow areas. Should the ineffective flow area elevations be set to a higher elevation to exclude this area for the largest event to be consistent with the upstream and downstream sections?	no	no	There were some stabilization issues in this area too. I made some adjustments to the ineffective areas to make them more consistent with upstream and downstream sections and still remain stable.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
6		RS 202461 – Review the elevation of the leftmost ineffective flow area. Is it reasonable for the ineffective flow area elevation to be lower than the same ineffective flow area in the downstream section?	no	no	Ineffective areas along the left portions of RS 219450 – RS 199466 were revised to more accurately reflect existing conditions.	
7		Were the "n" values that were read in from the shapefile verified with aerial photos and field visits? Some sections show "sliver "n" values that do not seem to make sense based on the geometry and aerial imagery. For example the 0.07 value in the right overbank for RS 2445 to 21193.	no	no	Because the N-Value shapefile was hand delineated, there is more detail, and therefore a large number of "sliver" N-Values within the cross sections. For example, the N-Value of 0.07 for RS 2445 – RS 22676 was for the road ALT 90, which is approximately 100' wide.	
8		Recommend putting datum and coordinate system information in "Description" portion of HEC-RAS model.	no	no	Coordinate system and datum information added to model.	
9		How were the weir/embankment elevations assigned for the inline structures? There are elevated sections in the overbanks for each dam that do not seem to linearly connect to the low-flow dam.	no	no	IS 392752 and IS 365687 were both estimated primarily by LiDAR. IS 187026 was surveyed, so the data was added to the LiDAR and adjusted for stationing. Extraneous LiDAR points were removed from deck data were necessary.	
10		Were the pier number, shape, width, and roadway profile used in the model verified with field visits and\or plans? The values used look reasonable, but we have no information to verify if they are correct.	no	no	Majority of structures were verified with field visits, as builts and/or survey. Some inaccessible low water crossing may have been simply estimated from LiDAR and aerials.	

Technical review:

Project	GBRA Interim Feasibility Study
Project task or phase	"San Marcos Watersheds- Upper Reach Revised" – HEC-RAS routing model
Project manager	Brian Brown, PE
Client	Halff
Reviewer	Ric McCallan, PE and Brian Brown, PE
Review date	11-27-2012

Note: Instructions for the reviewer and responder and a sample comment are included at the end of this form.

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
1	HEC-RAS Model	RS 8814 has a blocked obstruction in the ROB yet upstream RS has ineffective area in LOB.	no	no	All ponds on ROB were updated to blocked obstructions. It is assumed that there would be no conveyance through these ponds should the water surface get that high.	
2	HEC-RAS Model	RS 14613 has dip in ROB. Recommend extending section or deleting small dip. The area is ineffective, but is still counting storage and there is no dip in the upstream or downstream section.	no	no	RS 14613 was shortened to omit the dip.	
3	HEC-RAS Model	RS 22323 – 22952 show elevated blocked obstructions on the left bank. What do they represent?	no	yes	There is a large Texas State University building that affects the mentioned RS.	
4	HEC-RAS Model	Were the "n" values that were read in from the shapefile verified with aerial photos and field visits? Some sections show "sliver "n" values that do not seem to make sense based on the geometry and aerial imagery. See downstream portion of model.	no	no	The landuse shapefile was created based on aerial images. The landuse codes and corresponding n-values were taken from previous shapefiles used for COE studies. Field observations were primarily utilized for channel n-values but were also referenced for overbank n-values.	
5	HEC-RAS Model	Recommend putting datum and coordinate system information in "Description" portion of HEC-RAS model.	no	no	Datum and coordinate system added to description.	

#	Page or item	Comment	Critical issue	Explanation required in report	Response	Reviewer back check
6	HEC-RAS Model	How were the weir/embankment elevations assigned for the inline structures? There are elevated sections in the overbanks for each dam that do not seem to linearly connect to the low-flow dam.	no	yes	The top of road elevations were initially cut from LiDAR and then enhanced with data from the existing converted HEC-2 model where applicable and/or from field visits. The areas that do not appear to connect are just from alignment and LiDAR differences between TOR and bounding cross-sections. They are minor and have minimal impact on the model.	

Appendix D.1.4.b
USACE Hydraulic Model
QA/QC Review

HALFF

9 April 2013

RE: Lower Guadalupe River Feasibility Study Routing Model Review

Review performed by: Bret Higginbotham, P.E.

Folder: GuadRouting_20121207

Filename: Guadalupe Hydraulic Notebook.docx

Entry #1 – Basic Project Notes
No comment. OK

Entry #2 – GeoRAS Development
No comment. OK

Entry #3 – HEC-RAS Naming Conventions
No comments. OK

Entry #4 – Routing Flows
No comment. OK

Entry #5 – Summary of Manning's N-Values in the New Detailed Study and Incorporated Guadalupe Hydraulic Models
N-Values appear to be within the typical range. OK

Entry #6 – Guadalupe Hydraulic Model Starting Boundary Conditions
No comment. OK

Entry #7 – Guadalupe River LOMRS
No comment. OK

Entry #8 – Guadalupe River Bridges
Bridge data needs to be verified as undersized bridges tend to result in large storage.
Surveys and as-built plans have been collected for all structures.

Entry #9 – GBRA Dam Data
Need to insure dam data at XS 880197 is correctly modeled upon receipt of as-builts
Dam data at XS 880197 will be checked and updated when as-built plans are received.

Filename: Guadalupe QC.docx

No comments. All Halff comments were concurred with and/or explained. OK

HEC-RAS Models

Filename: Guadalupe_FEMA2008.prj
Model runs to completion with no errors or warning. OK

Assumed no changes were made to the model since it was the latest map mod project.
Cursory review performed of "n" values. All within normal limits. OK

Crossing profiles from section 56161 to 69173 for 250-yr, 500-yr, and 500-yr + 30% profiles
Routing flows were adjusted to be closer to the flows produced by the HEC-HMS model. Crossing profiles were reduced to a crossing profile for the 50-year between XS 206523 up to XS 207638 and for the 100-year between XS -12017 up to XS -6979.

Section 61077 – 12+ foot dip in 500-yr + 30% profile
The dip in the 500-year + 30% profile was removed with the updated routing flows.

Channel slope of 0.0359 between last 2 cross sections of model in comparison to 0.0002 between first two sections of connecting model (Guadalupe_Dewitt.prj)
Channel slope will be adjusted in the DeWitt model when cross section survey data is completed.

Final section 370126 contains 490 ground points with no ineffective flow or blocked obstruction. Section 370126 of connecting model contains 490 ground points with ineffective flow and blocked obstructions. Test run results in different elevations for profiles 1-6.
Section 370126 was changed to be the same section in both the Victoria and DeWitt models.

Filename: Guadalupe_Dewitt.prj

Execution
Model runs to completion with no errors or warnings. OK

Steady Flow Data / Starting Conditions
XS 370126 - See comment above regarding differences in cross sections and resultant starting water surface elevations for profiles 1-6.
The cross section was updated to match the Victoria US XS and the resulting water surface elevations for all profiles were updated.

Manning's "n" Values
Manning's "n" values are within reasonable range. OK

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

XS 38452 – recommend extending second ineffective flow boundary left approx. 200 feet.
Ineffective was extended left approximately 200 ft.

Recommend removing ineffective flow lying entirely below the ground geometry in the following cross sections:
388149
389378
483080
484031
493996
529979
531547
550063
680145
Removed ineffective flow lying entirely below the ground at the above XS.

Recommend re-evaluating ineffective flow in the overbanks and possibly adding additional ineffective flow in the following cross sections:
408794
415503
416200
418807
422715
437723
473291
474870
475080
486764
513386
513734
547162
548008
575207
578883
583166
583692
586173
586987
605307
606756
630346
638510
642114
643676
651557
664157
669031
671441
674218
The ineffective flow areas were evaluated and additional areas were added in the overbanks to most of the listed cross sections.

XS's 551916 – 572845 – need to verify conveyance in left overbank through this entire range of cross sections. Could facilitate the need for a split flow if actively conveying flow.
It was determined that a split flow model was not needed.

Bridges / Culverts
No specific comments on bridge / culverts, but recommend verifying bridge/culvert geometry and top of road elevation upon receipt of any as-built plans or survey data is received.
Bridges and culverts have been updated with survey data and verified with TxDOT plans

Cont /Exp Coefficients
Check all expansion coefficients around bridge / culvert sections. Appears 0.05 was input rather than 0.5.
All expansion coefficients around bridge / culvert sections were checked and corrected.

Reach Lengths
370126 - Recommend setting downstream reach length for starting section the same at the corresponding section in the downstream model. This would provide connectivity between models and prevent future error if models are combined.
The downstream reach length for the starting section was set to match the upstream cross section from the downstream model.

Check flowpaths / reach lengths of all sections. The channel length in some sections is abnormally long compared to both left and right overbank lengths. This could facilitate the need for additional sections or validation of overbank flowpaths.
Flowpaths / reach lengths of all sections were checked.

Filename: Guadalupe_Gonzales.prj

Execution
Model runs to completion with no errors or warnings. OK

Steady Flow Data / Starting Conditions
Starting cross section 707937 different than ending cross section from downstream model. Different ineffective flow locations, "n" values, number of ground geometry points (280 vs. 419).
Starting cross section 707937 was adjusted to match the downstream model including ineffective flow, "n" values, number of ground geometry points.

Starting water surface elevations different than the results from the downstream model output.
Starting water surface elevations were adjusted to match the updated downstream model

Profiles
Crossing profiles from sections 899956 – 916768
Crossing profiles were removed

Verify dips in profile at sections 937370 and 1041418
Dips in profiles were adjusted using pilot channels in between survey.

Verify rises in stream profile at sections 965495, 1169263, 1188184, 1202654, 1210478 - 1228447

Rises in stream profile were removed with pilot channels.

Manning's "n" Values

Manning's "n" values are within reasonable range. OK

Ineffective and Blocked Obstructions

The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

Recommend re-evaluating ineffective flow in the overbanks and possibly adding additional ineffective flow in the following cross sections:

797087
801743
878188
883191
899956
903148
904054
940413
941452
999156
1004840
1060633 - 1088058
1113840
1118917
1233387
1234142
1247150

Ineffective flow in the overbanks was revaluated for all cross sections listed. Ineffective flow was added to most cross-sections where it seemed applicable.

Recommend evaluating and possibly adding blocked obstructions in overbanks at higher elevations that are not hydraulically connected in the following sections:

844059
1041545
1043011
1098742
1099128
1118917 - 1129981
1160128 – 1172566 (possibly split flow?)
1175305 – 1179498
1196456 – 1202654
1205985 – 1217959
1245520

Re-evaluated and added blocked obstructions in overbanks at higher elevations for areas that are not hydraulically connected in the cross sections shown in the comments.

Bridges / Culverts
Need to verify bridge geometry and road profile upon receipt of as-built plans and/or survey data.
Bridges and culverts have been updated with survey data and verified with TxDOT plans

1098592 – Need to verify upstream section was not cut along top of road in left overbank.
High spot in upstream left overbank is not associated with the top of road. It is simply a highspot in the LiDAR.

Cont /Exp Coefficients
Contraction and Expansion coefficients are within normal limits for steady flow computations. OK

Reach Lengths
707937 – Recommend setting downstream reach length for starting section the same at the corresponding section in the downstream model. This would provide connectivity between models and prevent future error if models are combined.
The downstream reach length for the starting section was set to match the upstream cross section from the downstream model.

Check flowpaths / reach lengths of all sections. The channel length in some sections is abnormally long compared to both left and right overbank lengths. This could facilitate the need for additional sections or validation of overbank flowpaths.
Flowpaths / reach lengths of all sections were checked.

Filename: lguad.prj

Performed a cursory review of the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data for storage extraction.

Execution
Model runs to completion with no errors or warnings. OK

Cross Section Stationing
Cross section stationing does not continue from downstream model. Makes it hard to compare cross section geometry, check starting water surface elevations, or confirm continuity between models. Recommend changing the cross section stationing to continue from downstream model and place original cross section numbering in description.
Cross section stationing was updated so that station continues from the downstream model. Original cross section stationing was placed in the description.

Steady Flow Data / Starting Conditions
XS 103378 - See comment above regarding differences in cross section stationing
Cross section stationing was adjusted. See response above.

Hard to determine if starting water surface elevations were from the upstream most cross section of the downstream model. Elevations do not match the resultant calculated water surface elevations.
Starting water surface elevations are from the most upstream cross section in the hydraulic model named Guadalupe_Gonzales.prj.

Recommend replacing cross section with topo section from downstream model or duplicate this section in the downstream model.
XS 1247902 geometry was copied into the Guadalupe_Gonzales.prj model.

Manning's "n" Values
Assumed no changes were made to the model since it was an incorporated model. OK

Cursory review performed of "n" values. All within normal limits. OK

Profiles
No crossing profiles but there are several dips in profiles at locations matching dips in ground profile. Would recommend checking ground profile for errors in original model.
The ground data will not be changed because the model is merely being incorporated and it is assumed that it has been previously checked and approved during the FEMA modeling process.

Ground profile contains numerous dips and rises. Would prefer a smoother ground profile unless topo depicts these abrupt changes.
The ground data will not be changed because the model is merely being incorporated and it is assumed that it has been previously checked and approved during the FEMA modeling process.

Ineffective and Blocked Obstructions
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

Recommend re-evaluating ineffective flow in the overbanks and possibly adding additional ineffective flow in all cross sections. There were numerous cross sections with no ineffective flow in dips and sags of ground geometry.
Ineffective areas were added in areas that were deemed necessary.

Recommend extending the endpoints of cross sections that do not fully contain the range of flows used in the storage evaluation.
This is an incorporated model and the XS layout and lengths will not be adjusted for routing. Final flows should be contained.

Recommend placing blocked obstructions in low points of cross sections at elevations well above the flowline and not hydraulically connected. (ie.. XS 173627, 174836, etc.)
Blocked obstructions were added to the areas not hydraulically connected.

Bridge / Culverts
Bridges appear to be modeled sufficiently. OK

Inline Structures
Inline structures appear sufficiently modeled. OK

Lateral Structures
Lateral structures appear to be modeled sufficiently. OK

Cont / Exp Coefficients
Contraction and expansion coefficients appear to be within normal range. OK

Reach Lengths
Recommend setting downstream reach length of first cross section to that of upmost cross section of the downstream model. This will prevent discontinuity of the models if they are ever combined.
Reach lengths for the first cross section were set to match the reach length of the upper most cross section in the downstream model.

Filename: Guadalupe.prj

Performed a cursory review of the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data for storage extraction.

Model is not georeferenced, however, there appears to be a shapefile of the cross sections.

Execution
Model runs to completion with no errors or warnings. OK

Cross Section Stationing
Cross section stationing does not continue from downstream model. Makes it hard to compare cross section geometry, check starting water surface elevations, or confirm continuity between models. Recommend changing the cross section stationing to continue from downstream model and place original cross section numbering in description.
Cross section stationing was adjusted to continue on from the downstream model and original cross section stationing was placed in the description.

Steady Flow Data / Starting Conditions
Starting water surface elevations in the flow data do not match the upstream most section of the downstream model. It appears, from the GIS file, the first cross sections lies in approximately the same location as section 234663 from the downstream model. However, the starting elevations are higher for the same discharge and the cross sections do not match.
The starting conditions for this model are the known water surface elevations at the Dunlap Dam. These values will not match the downstream model.

Manning's "n" Values
Assumed no changes were made to the model since it was an incorporated model.
Cursory review performed of "n" values. All within normal limits. OK

Profiles
There are no crossing profiles and ground profile is fairly smooth. OK

Ineffective and Blocked Obstructions
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

Recommend evaluating cross sections for the need for additional ineffective flow in overbank sags and swales that may not be hydraulically connected.
Ineffective areas were added to cross sections where deemed necessary.

Cross Section Geometry
A large number of cross sections do not fully contain the 500-yr and 500-yr +30% flow. There are also a number of them that do not contain the 100-yr. The storage values would be better represented by sections encompassing the full range of discharges.
This is an incorporated model and the XS layout and lengths will not be adjusted for routing. Final flows should be contained.

Bridge / Culverts
Bridges and culverts appear to be modeled sufficiently. OK

Cont / Exp Coefficients
Contraction and expansion coefficients are within normal range. OK

Reach Lengths
XS 60500 – Channel reach length is unusually low compared to both left and right overbank reach lengths.
The reach length was verified using aerial photos.

Filename: uguad.prj

Performed a cursory review of the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data for storage extraction.

Execution
Model runs to completion with no errors or warnings. OK

Cross Section Stationing
Cross section stationing is a continuation of the downstream model. In keeping with the comments from previous model reviews, it is recommended to have a continual stationing scheme from the downstream to up with original section stationing in the description.
Cross section stationing was adjusted to continue on from the downstream model and original cross section stationing was placed in the description.

Steady Flow Data / Starting Conditions
Starting section 88190 is identical to 88190 in downstream model and water surface elevations match between the two. OK

Manning's "n" Values
Assumed no changes were made to the model since it was an incorporated model.
Cursory review performed of "n" values. All within normal limits. OK

Profiles

There are no crossing profiles or ubrupt changes in water surface elevation in non-structural areas. OK

Ground geometry is fairly choppy. Recommend confirming with available topo for validity of flowline oscillation.
The ground data will not be changed because the model is merely being incorporated and it is assumed that it has been previously checked and approved during the FEMA modeling process.

Ineffective and Blocked Obstructions
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

Recommend evaluating cross sections for the need to place ineffective flow in overbank swales that actively conveying flow.
Ineffective areas were added to cross sections where deemed necessary.

Cross Section Geometry
Recommend extending cross sections that do not fully encompass the range of flows input for storage calculations.
This is an incorporated model and the XS layout and lengths will not be adjusted for routing. Final flows should be contained.

Bridge / Culverts
Bridges and culverts appear to be modeled sufficiently. OK

Inline Structures
Inline structures appear to be modeled sufficiently. OK

Cont / Exp Coefficients
Contraction and expansion coefficients appear to be within typical range. OK

Reach Lengths
Recommend making reach length in 1st cross section, 88190, the same as in the downstream model.
Reach length for XS 88190 was adjusted to be the same as the downstream model.

17 April 2013

RE: Lower Guadalupe River Feasibility Study Routing Model Review

Review performed by: Bret Higginbotham, P.E.

Folder: SanMarcosRouting_20121207

Filename: San Marcos Notebook.docx
Well documented. No Comments. OK

Filename: San Marcos QC.docx
No comments. All comments were concurred with and/or explained. OK

Filename: San Marcus QC_Upper_Reach.docx
No comments. All comments were concurred with and / or explained. OK

Filename: San_Marcus_Routing_Flows.xls
No comments. OK

HEC-RAS Models

Filename: SMAR.prj

Execution
Model runs to completion with no errors or warnings. OK

Profiles
XS 113802 – 115130 crossing profiles
Profiles uncrossed by adjusting ineffective flow area elevations

There are multiple instances of high Froude #'s in the results which is evident in the unstable profiles. Recommend validating all ineffective flow, blocked obstructions, and "n" values beyond those detailed in this review.
The instabilities arise from trying to model split flows between main channels and parallel channels with ineffective areas/block obstructions. N-values were reviewed and are appropriate. Configuration of ineffective areas/ blocked obstructions was reviewed as well. Another review will be conducted for final hydraulics.

XS 113193 – Recommend verifying flowline elevation at this section. There is a 3'+ rise in flowline elevation
LiDAR is catching the water surface elevation and not the channel bottom between surveys and will be adjusted to survey data in the final hydraulic model by interpolating a pilot channel between surveyed sections.

BR 186800 – 219259 – Recommend verifying elevations of all sections between these two structures.
LiDAR is catching the water surface elevation and not the channel bottom between surveys and will be adjusted to survey data in the final hydraulic model by interpolating a pilot channel between surveyed sections.
BR 271183 – 286932 – Recommend verifying elevations of all sections between these two structures.
LiDAR is catching the water surface elevation and not the channel bottom between surveys and will be adjusted to survey data in the final hydraulic model by interpolating a pilot channel between surveyed sections.

XS 337400 and 340245 – Recommend verifying flowline elevations of these two sections.
LiDAR is catching the water surface elevation and not the channel bottom between surveys and will be adjusted to survey data in the final hydraulic model by interpolating a pilot channel between surveyed sections.

XS 360998 – 370990 – Lots of up and downs that is evident by the flow profiles. Recommend verifying all flowline elevations and structure data.
LiDAR is catching the water surface elevation and not the channel bottom between surveys and will be adjusted to survey data in the final hydraulic model by interpolating a pilot channel between surveyed sections.

Steady Flow Data / Starting Conditions
No comments OK

Manning's "n" Values
Verify use of a roughness value of 1 in the following sections:
368908
Roughness value of 1 was changed to 0.09. LiDAR was taken before ponds were constructed (land is sloped in LiDAR) so the ponds could not be represented as block obstruction and an "n" value of 1 would be inaccurate.

347449
"n" value of 1 was changed to 0.09. The pond is already treated as a block obstruction so a roughness of 1 is unnecessary.

345398
"n" value of 1 was changed to 0.09. The pond is already treated as a block obstruction so a roughness of 1 is unnecessary.

314148
"n" value of 1 was changed to 0.09. The pond is already treated as a block obstruction so a roughness of 1 is unnecessary.

115130
"n" value of 1 was changed to 0.1. Instead ponded area was changed to a block obstruction.

114063
"n" value of 1 was changed to 0.1. Instead ponded area was changed to a block obstruction.

113802
“n” value of 1 was changed to 0.1. Instead ponded area was changed to a block obstruction.

100444
“n” value of 1 was changed to 0.09. Instead ponded area was changed to a block obstruction.

36980
“n” value of 1 was changed to 0.08. The pond is already treated as a block obstruction so a roughness of 1 is unnecessary.

32914
“n” value of 1 was changed to 0.09. The ponded area is not represented by the LiDAR used for the geometry.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

Most of the sections could use another look at the ineffective flow stationing and elevations. They may all be right, but there appears to be numerous occasions of missing ineffective flow in the overbanks or ineffective flow at elevation below what is typically considered.
Ineffective flow areas were reviewed and revised where needed

XS 36980 – Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Block obstruction in the LOB swale is representing a pond. The cross-sectional area of the pond will not act as conveyance.

XS 54721 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Block obstruction in the LOB swale represents a pond that does not extend to the US or DS sections.

XS 66706 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Block obstruction in the LOB swale represents a pond that does not extend to the US or DS sections.

XS 108107 – 113193 – Recommend verifying the flow in the LOB swale at high elevation. Verify it is hydraulically connected and can act as storage.
Changed to permanent ineffective area. Areas are hydraulically connected upstream.

XS 238058 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Block obstruction in the LOB swale represents a pond that does not extend to the US or DS sections.

XS 308861 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Block obstruction in the LOB swale represents a large embankment that is blocking water. The embankment does not extend to the US or DS sections.

XS 340245 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Only blocked obstruction is in the ROB swale. The blocked obstruction represents a pond that will not act as conveyance and does not extend to the US or DS sections.

XS 368908 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Blocked obstruction in the LOB swale represents an embankment that will block water. The embanked area does not extend to the US or DS sections.

XS 387013 - Recommend verifying the blocked obstruction in the LOB swale. The next US and DS sections do not contain it.
Blocked obstruction in the LOB swale represents a pond that will not act as conveyance. The pond area does not extend to the US or DS sections.

Bridges / Culverts
BR 22786 – Was a multiple opening analysis considered for this crossing?
The bridge was changed to multiple opening analysis in order to more accurately compute the lower flows through the bridge openings.

BR 113911 – Recommend verifying there is no drainage structure in the ROB swale.
It was verified through the terrain and aerial imagery that there is no other drainage structure in the ROB swale.

BR 165455 – Was a multiple opening analysis considered for this crossing?
Multiple opening analysis was added to the two bridge openings at this bridge cross-section.

BR 186600 – Was a multiple opening analysis considered for this crossing?
Multiple opening analysis was added to the bridge section. The bridge opening on the main channel was treated as a single bridge opening while the other two bridge openings on the right over bank were modeled together as a separate bridge opening.

BR 219259 - Was a multiple opening analysis considered for this crossing?
Multiple opening analysis was added to the bridge section. The bridge opening on the main channel and the other just to the left were treated as a single bridge opening while the bridge opening on the right over bank was modeled as a separate bridge opening.

BR 219393 - Was a multiple opening analysis considered for this crossing?
Multiple opening analysis was added to the bridge section. The bridge opening on the main channel and the other just to the left were treated as a single bridge opening while the bridge opening on the right over bank was modeled as a separate bridge opening.

BR 271183 – Pier modeling doesn't make sense. Recommend verifying placement of piers.
Pier modeling verified and corresponds to field survey.

BR 286932 – Is this a 223' clear span bridge with no piers? Recommend verifying this structure.
Piers and guard rails were added to the bridge geometry based on survey data.

BR 335302 – Recommend verifying downstream bridge opening. It appears severely constricted compared to the upstream face.
Downstream invert was confirmed to be 5 ft higher than the upstream invert. Most likely caused by silt buildup from private dam just downstream. The top of the downstream bridge opening was widened to mimic upstream bridge opening.

BR 389631 - Recommend verifying upstream bridge opening. It appears severely constricted compared to the downstream face.
The constriction is due to lack of complete channel survey at upstream XS. Survey at upstream XS was adjusted similar to the survey shots at upstream face of bridge.

Cont /Exp Coefficients
XS 390113 – 389568 – Recommend verifying 0.1/0.3 instead of 0.3/0.5 for these sections.
The cross-sections near BR 389785 were seen to have a gradual transition since the bridge crossing is relatively small; therefore the coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3.

XS 370990 – 370832 - Recommend verifying 0.1/0.3 instead of 0.3/0.5 for these sections.
The cross-sections near BR 370921 were seen to have a gradual transition since the bridge crossing is relatively small; therefore the coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3.

XS 365105 – 365077 - Recommend verifying 0.1/0.3 instead of 0.3/0.5 for these sections.
The cross-sections near BR 364827 were seen to have a gradual transition since the bridge crossing is relatively small; therefore the coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3.

XS 334539 – Recommend verifying 0.3/0.5 at this section. Typically, section 1 of a bridge routine is far enough downstream to be unaffected by the bridge opening.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since the cross-section is 750 ft downstream of DS the bridge bounding cross-section making it unaffected by the bridge opening.

XS 238696 – Recommend verifying the usage for 0.3/0.5 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

XS 238058 – Recommend verifying the usage of 0.3/0.5 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

XS 185598 - Recommend verifying 0.3/0.5 at this section. Typically, section 1 of a bridge routine is far enough downstream to be unaffected by the bridge opening.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since the cross-section is 1080 ft downstream of the DS bridge bounding cross-section making it unaffected by the bridge opening.

XS 162670 - Recommend verifying 0.3/0.5 at this section. Typically, section 1 of a bridge routine is far enough downstream to be unaffected by the bridge opening.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since the cross-section is 2500 ft downstream of the DS bridge bounding cross-section making it unaffected by the bridge opening.

XS 148426 - Recommend verifying the usage for 0.3/0.5 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

XS 135371 - Recommend verifying the usage for 0.3/0.5 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

XS 134198 - Recommend verifying the usage for 0.3/0.5 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

XS 111350 – 111204 – Recommend verifying the usage of 0.1/0.3 around this culvert structure.
The coefficient of expansion and contraction were reduced to 0.1/0.3 from 0.3/0.5 since the culvert structure in this area is relatively minor.

XS 62461 – Recommend verifying the usage 0.5/0.7 at this section.
The coefficients of expansion and contraction were changed from 0.3/0.5 to 0.1/0.3 since there is no bridge opening or major restriction in channel geometry in this area.

Reach Lengths
Typically a channel reach length substantially longer than the overbank reach lengths is indicative of the need for additional sections. Recommend verifying reach lengths and/or overbank flow paths for the following sections:
389263
378827
352446
334539
322388
317882
314148
300057
290291
286863

270356
257279
236263
233395
220560
219159 – 190738
185598
172390
168947
165192 – 161373
145185
142082
128130
125235
117113
111204
108107
97131 – 77416
70389 – 54721
49547
36980
31275
22786
21193
10250
All reach lengths and overbank flow paths were reviewed. Due to the meandering nature of the channel centerline it causes the channel reach length to vary from the overbank reach lengths considerably. The overbank flowpaths were verified to follow the nature of the existing FEMA floodplain.

Filename: SMAR_REV.prj

Execution
Model runs to completion with no errors or warnings. OK

Profiles
No crossing profiles OK

Recommend evaluating the general smoothness of the ground profile. Though most rises and falls have little to no impact on water surface elevations, extreme changes in slope can have dramatic effects on the profiles. An example location is XS 18901.
The drop at 18901 represents the Rio Vista dam. This is a series of three manmade cascades that drop the channel elevation considerably. Other rises and falls in profile appear to have little impact on water surfaces. Survey should be completed for this reach during Phase 2 of the GBRA project and the flowline will be updated at that time if necessary

Steady Flow Data / Starting Conditions
No comments OK

Manning's "n" Values
Verify use of a roughness value of 1 in the reach XS 9950 - 13624
Roughness value of 1 was adjusted to 0.09.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

Some of the sections could use another look at the ineffective flow stationing and elevations. They may all be right, but there appears to be occasions of missing ineffective flow in the overbanks.
Ineffective flows adjusted and added where necessary

Bridges / Culverts
CU 13261 – Recommend revising opening when/if as-built plans can be obtained or survey data is available once complete.
Structure will be surveyed during Phase 2 of the GBRA IFS.

BR 21082 – Is there no Roadway (rail) on the LOB of this crossing?
Railroad crosses RR 12 on LOB. Remainder of LOB was made ineffective to account for this.

BR 21321 – Is this a clear span structure? The next upstream pedestrian bridge appears similar in size and has two piers.
Yes, it is clear span. This was confirmed by field visit notes/photos.

Cont /Exp Coefficients
No comments. Contraction and expansion coefficients are within typical range of values. OK

Reach Lengths
Typically a channel reach length substantially longer than the overbank reach lengths is indicative of the need for additional sections. Recommend verifying reach lengths and/or overbank flow paths for the following sections:
10962
6825
4535
3414
2379
Meanders account for longer center flowlengths at these locations. Overbank flowpaths are shorter, but not drastically different. No changes made.

15 April 2013

RE: Lower Guadalupe River Feasibility Study Routing Model Review

Review performed by: Bret Higginbotham, P.E.

Folder: BlancoRouting_20121207

Filename: BlancoRiver_Hydraulics QAQC Responses.docx

No comments. All Halff comments were concurred with and/or explained.

HEC-RAS Models

Filename: 2012BlancoRiver.prj

Execution
Model runs to completion with no errors or warnings. OK

Profiles
There are no crossing profiles. OK

There are several sharp rises and dips in the ground profile which causes a rise or dip in the water surface profiles. Recommend validating the flowline elevation of the following sections:
We developed the sections using available LiDAR data. We have reviewed the area upstream and downstream of the cross sections cross section noted to see if there is a more representative invert elevation for use in the section. During Phase II of the study additional survey will be performed for final hydraulics and the cross section will be updated if necessary.

34759.09
47162.87
54025.42 – 58630.12
75256.77 – 75300.33
108361.8
122201.9 – 123038
124978.5
125015.9
136866.9
188617.62
189709 – 190204.6
197867.3
197390.37
212592.2
215660.1
216084.2
238086.4 – 238763.2

Steady Flow Data / Starting Conditions
River Station 67498.18 has flows to one decimal place. Recommend rounding flows for consistency.
The flows have been rounded as suggested.

Manning's "n" Values
XS 99883.06 – Need to verify ROB "n" values. Appears 0.8 was input rather than 0.08.
The Manning's n value has been revised.

XS 45152.25 – Need to verify LOB "n" values. Appears 1 was input rather than 0.1.
The Manning's n value has been revised.

XS 19721.98 – Need to verify channel "n" value. Appears 0.45 was input rather than 0.045.
The Manning's n value has been revised.

XS 11580.98 - Need to verify ROB "n" values. Appears 1 was input rather than 0.1.
The Manning's n value has been revised.

XS 11411.98 - Need to verify ROB "n" values. Appears 1 was input rather than 0.1.
The Manning's n value has been revised.

Remaining Manning's "n" values are within reasonable range. OK

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

Recommend extending cross sections to contain full range of flows in the steady flow table.

- Downstream of XS 32518.69, why are the sections so short on left? What is the constraint?

Looking at the topography, the terrain drops off in this location, so extending the cross sections does not add to the conveyance.

Recommend explaining reasoning for ineffective flow locations between sections 51029.3 and 66920.16. These section lie between two bridge / culverts and shouldn't be effected by the bridge contraction / expansion of those structures.
The ineffective areas were based on the previous model and were adjusted in areas to reflect existing conditions for high flows and the confluence behavior with the San Marcos River.

Recommend adding ineffective flow in the left overbank of section 66920.16.
We have added ineffective flow areas to the left overbank.

Recommend re-evaluating ineffective flow in the overbanks and possibly adding additional ineffective flow in all sections. There appears to be a lot of overbank flow that may or may not be hydraulically connected.
The ineffective areas were based on the previous model and were adjusted in areas to reflect existing conditions for high flows and the confluence behavior with the San Marcos River.

There appears to be several sections with abnormally high ineffective flow elevations completely removing all flow in the overbanks from being beneficial to the storage calculations. Recommend re-evaluating the ineffective flow elevations and revising and / or changing from normal to multiple ineffective flow.

The ineffective areas were based on the previous model and were adjusted in areas to reflect existing conditions for high flows and the confluence behavior with the San Marcos River.

Bridges / Culverts

BR 44580 – Recommend confirming flow in right side of bridge opening. If there is no flow, the Deck / Roadway should be revised to block the opening.

We have closed the opening in the right overbank.

BR 44680 - Recommend confirming flow in right sight of bridge opening. If there is no flow, the Deck / Roadway should be revised to block the opening.

We have closed the opening in the right overbank.

BR 144000 – Culverts lie completely below ground on the upstream side and partially below ground on downstream side. Recommend revising ground geometry of sections if survey data was used for culverts.

We based the culvert placement on available field notes, photos, and LiDAR data. We estimated the invert elevation of the culvert from road profile elevations taken from the LiDAR data and field estimates on the distance from top of road to top of the culvert. The upstream and downstream sections were based in the LiDAR data. It is likely that the LiDAR captured the water surface at the time of the LiDAR was flown obscuring the culvert inlets and outlets. The culvert will be surveyed in detail in Phase II of the project and the upstream and downstream cross sections will be revised at that time as needed.

BR 162350 - Culverts lie completely below ground on the upstream side and partially below ground on downstream side. Recommend revising ground geometry of sections if survey data was used for culverts.

See response to previous comment.

BR 197867.3 – Culverts in upstream section are partially below the ground geometry. Recommend revising ground geometry if culverts are confirmed. Deck / Roadway data also needs to be revised.

See response to previous comment concerning culverts. Shortly after crossing the river, the roadway turns sharply to the left (upstream). The rise seen in the roadway deck is the bridge abutment that is not entirely captured in the downstream section.

BR 211914.5 – Culverts lie completely below ground geometry on upstream and downstream sections. Recommend revising ground geometry if culverts are field verified. Deck / Roadway data also needs to be revised.

See response to previous comment concerning culverts. The roadway deck has been revised and the upstream section has been moved slightly to better represent the upstream channel.

BR 216600 – Structure appears to be box culverts, but is modeled as a bridge. Please confirm and revise as necessary.

This bridge is located in the upper reach of the Blanco River (above approximately section 313750). The upper reach was added to the HEC-RAS model prior to the planned Phase II field survey of this reach.

Therefore, no supplemental data is available for modeling the bridge and we used data from a previous HEC-2 model for the bridge at this location. This bridge will revised after the survey for the Phase II effort of this study has been completed.

BR 238120 – Is structure a clear span bridge with no piers or a box culvert. Please confirm and revise if needed.
See response to previous comment.

Recommend re-evaluating ineffective flow around all bridges and revising as necessary. Some seem overly wide, while others appear narrow.
The ineffective areas were based on the previous model and were adjusted in areas to reflect existing conditions for high flows and the confluence behavior with the San Marcos River.

Cont /Exp Coefficients
Recommend validating need to 0.3/0.5 at sections downstream of bridges / culverts. Typically, section 1 of a 4 section bridge method is far enough downstream to retain 0.1 / 0.3.
We used coefficients from the previous Corps model. We tested the coefficients, and decided to use 0.3/0.5 at only the upstream and downstream sections for each bridge.

Recommend validating 0.3/0.5 contraction and expansion coefficients between BR 19130 and BR 16720.
We used coefficients from the previous Corps model. We tested the coefficients, and decided to use 0.3/0.5 at only the upstream and downstream sections for each bridge.

Reach Lengths
LOB, Channel, and ROB reach length relationships are within reason. OK

Recommend additional sections be added to reaches greater than 1000 feet. Channel geometry between the sections may not be accurately portrayed, therefore the calculated storages could be inaccurate.
We initially used the layout from the previous Corps model. Additional sections have been added to the model as suggested. However, there are some locations where sections could not be added due to a tributary entering the river.

17 December 2013

RE: Lower Guadalupe River Feasibility Study Hydraulic Model Review

Review performed by: Bret Higginbotham, P.E.

HEC-RAS Models

Filename: Guadalupe_FEMA2008.prj
Model runs to completion with no errors or warning.

Assumed no major changes were made to the model since the routing submission.

Cursory review performed of:
Manning's "n" values - all within normal limits.
Ineffective flow and blocked obstructions –appear to be effectively modeled
Starting conditions / steady flow data – Normal depth method, no comment
Reach length / Section spacing – no comment
Profile – No crossing profiles
Bridge / Culvert data – Appear to be effectively modeled

Filename: Guadalupe_Dewitt.prj

Execution
Model runs to completion with no errors or warnings.

Steady Flow Data / Starting Conditions
Model started with known water surface elevations from downstream connecting model. Starting water surface elevations checked and match. No comments.

Manning's "n" Values
Manning's "n" values are within reasonable range.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

Recommend removing ineffective flow lying entirely below the ground geometry in the following cross sections:
470242
477251

This issue has been addressed

Recommend re-evaluating ineffective flow in the overbanks and possibly adding additional ineffective flow in the following cross sections:
481874

The ineffective flow areas in the overbanks were re-evaluated. Ineffective areas were added in the low areas in the far right overbank.

XS's 551916 – 572845 – need to verify conveyance in left overbank through this entire range of cross sections. Could facilitate the need for a split flow if actively conveying flow.
Conveyance in left overbank will be verified for the final hydraulic model and the determination for split flow will be made.
What was the final determination on this?

It was determined that split flow was not necessary. The tributary in the far left overbank does not actively convey flow so it was modified to be ineffective. However the tributary just to the left of the high point does convey flow and is hydraulically connect. It was determined that this small tributary did not need a split flow model.

Bridges / Culverts
No comments. Bridges / culverts appear to be effectively modeled.

Cont /Exp Coefficients
No comments.

Reach Lengths
No Comments.

Filename: Guadalupe_Gonzales.prj

Execution
Model runs to completion with no errors or warnings.

Steady Flow Data / Starting Conditions
Starting water surface elevations from downstream connecting model verified. No comments.

Profiles
Crossing profiles from sections 937370 – 937581

This issue has been addressed. Ineffective area in far right overbank of section 937581 was changed to permanent ineffective as reflected in the cross-sections both upstream and downstream of it.

Manning's "n" Values
Manning's "n" values are within reasonable range.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

No comments. Ineffective flow and blocked obstruction appear to be correctly modeled.

Bridges / Culverts
1098592 – Need to verify upstream section was not cut along top of road in left overbank.
High spot in upstream left overbank is not associated with the top of road. It is simply a highspot in the LiDAR.
Entire left overbank area is modeled as a blocked obstruction due to the "high spot". Would be less confusing if section's width was reduced to eliminate the blocked portions. This also applied to the next section upstream as well.

The area in the left overbank was left for mapping purposes since water does backwater into this area. In order to better reflect this, the blocked obstruction was removed and changed to an ineffective area set at the high point.

Cont /Exp Coefficients
Contraction and Expansion coefficients are within normal limits for steady flow computations.

Reach Lengths
No comments.

Filename: lguad.prj

Performed a cursory review of f the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data based on the Phase 1 hydrology.

Execution
Model runs to completion with no errors or warnings.

Steady Flow Data / Starting Conditions
No comments.

Manning's "n" Values
Cursory review performed of "n" values. All within normal limits.

Profiles
No crossing profiles.

Ineffective and Blocked Obstructions
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

No additional comments.

Bridge / Culverts
Bridges appear to be modeled sufficiently.

__Inline Structures__
Inline structures appear sufficiently modeled.

__Lateral Structures__
Lateral structures appear to be modeled sufficiently.

__Cont / Exp Coefficients__
Contraction and expansion coefficients appear to be within normal range.

__Reach Lengths__
No comments.

Filename: Guadalupe.prj

Performed a cursory review of the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data based on the Phase 1 hydrology.

Model is not georeferenced, however, there appears to be a shapefile of the cross sections.

__Execution__
Model runs to completion with no errors or warnings.

__Steady Flow Data / Starting Conditions__
Known water surface elevation from downstream dam used for starting conditions. No additional comments.

__Manning's "n" Values__
Assumed no changes were made to the model since it was an incorporated model.
Cursory review performed of "n" values. All within normal limits.

__Profiles__
There are no crossing profiles.

__Ineffective and Blocked Obstructions__
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

No additional comments.

__Cross Section Geometry__
A number of cross sections do not fully contain the full range of flows. Please extend sections.

All cross-sections not containing were extended in order to fully contain the range of flows.

__Bridge / Culverts__
Bridges and culverts appear to be modeled sufficiently.

Cont / Exp Coefficients
Contraction and expansion coefficients are within normal range.

Reach Lengths
No additional comments.

Filename: uguad.prj

Performed a cursory review of the model for critical errors only. Assumed the model was a previously reviewed and accepted model of the reach and changes were not made to the geometry, only the flow data based on the Phase 1 hydrology.

Execution
Model runs to completion with no errors or warnings.

Steady Flow Data / Starting Conditions
10%, 4%, and 2% flows are the same above XS 1470344. 1% is substantially less than the downstream 1%. Please verify or provide justification. Recommend adding a note in the model for future reference.

The 10%, 4%, and 2% flows are the same above XS 1470344 due to the dam operations. The 1% is substantially less than the downstream 1% because the flow is still significantly impacted by the dam operations and downstream is the confluence with the Comal River. A note was added to the model for future reference.

Manning's "n" Values
Assumed no changes were made to the model since it was an incorporated model.
Cursory review performed of "n" values. All within normal limits.

Profiles
There are no crossing profiles.

Ineffective and Blocked Obstructions
Ineffective flow and blocked obstructions were evaluated for critical errors only. Assume there were no changes made to the effective model other than those specified in the cross section descriptions.

No additional comments.

Cross Section Geometry
Recommend extending cross sections that do not fully encompass the range of flows. The following XS need to be extended:
1537061-1540820

These cross-sections have been extended to contain the full range of flows.

Bridge / Culverts
Bridges and culverts appear to be modeled sufficiently.

Inline Structures
Inline structures appear to be modeled sufficiently.

Cont / Exp Coefficients
Contraction and expansion coefficients appear to be within typical range.

18 December 2013

RE: Lower Guadalupe River Feasibility Study Model Review

Review performed by: Bret Higginbotham, P.E.

HEC-RAS Models

Filename: SMAR_HYDRA.prj

Execution
Model runs to completion with no errors or warnings. OK

General Comments
Appears cross sections were renumbered. Following comments were based on approximation of the cross section matching the previous routing model.

Profiles
There are multiple instances of high Froude #'s in the results which is evident in the unstable profiles. Recommend validating all ineffective flow, blocked obstructions, and "n" values beyond those detailed in this review.
The instabilities arise from trying to model split flows between main channels and parallel channels with ineffective areas/block obstructions. N-values were reviewed and are appropriate. Configuration of ineffective areas/ blocked obstructions was reviewed as well. Another review will be conducted for final hydraulics.
What is the status of this re-evaluation? There are still multiple locations of dips and rises in different profiles, indicating a need for additional ineffective flow, n-values, etc….
N-values were reviewed and are appropriate. Ineffective areas were reviewed and modified along the entire reach to appropriately represent field conditions. During this review several of dips and rises were removed. All ineffective areas/blocked obstructions were deemed to be modeled correctly after this final review.

Steady Flow Data / Starting Conditions
No comments

Manning's "n" Values
Manning's "n" values appear to be within typical range.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

There still appears to be multiple sections that could use additional ineffective flow in low areas. Recommend taking another look to verify model.

Ineffective areas were reviewed throughout the model. Many ineffective areas were added to low lying areas where it was deemed valid.

Bridges / Culverts
No comments. All previous comments have been addressed.

Cont /Exp Coefficients
Concur with previous comment responses regarding small structure openings and low top of road elevations. No additional comments.

Reach Lengths
No comments. Concur with the meandering nature of the channel being the main factor in the cross section layout and reach lengths.

Filename: SMAR_REV.prj

Execution
Model runs to completion with no errors or warnings.

Profiles
No crossing profiles

Steady Flow Data / Starting Conditions
No comments

Manning's "n" Values
No comments. Manning's "n" values appear to be within typical range.

Ineffective and Blocked Obstructions
The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

No comments. Sections appear to be well represented.

Bridges / Culverts
CU 13261 – Recommend revising opening when/if as-built plans can be obtained or survey data is available once complete.
Structure will be surveyed during Phase 2 of the GBRA IFS.
Please verify the use of field survey in Phase II of the feasibility study. May need to make an estimation based on best available data for this structure.
The structure will be surveyed and/or field verified during phase 2. Data shown in the model is best currently available.

Cont /Exp Coefficients
No comments. Contraction and expansion coefficients are within typical range of values.

Reach Lengths
No additional comments.

18 December 2013

RE: Lower Guadalupe River Feasibility Study Model Review

Review performed by: Bret Higginbotham, P.E.

HEC-RAS Models

Filename: 2012BlancoRiver.prj

Execution
Model runs to completion with no errors or warnings.

Profiles
Crossing 0.40% and 0.20% profile from section 33700 to 35534.05

This issue has been addressed.

Crossing 0.40% and 0.20% profile from section 61836.94 to

This issue has been addressed.

There are several sharp rises and dips in the ground profile which causes a rise or dip in the water surface profiles. Recommend validating the flowline elevation of the following sections:
We developed the sections using available LiDAR data. We have reviewed the area upstream and downstream of the cross sections cross section noted to see if there is a more representative invert elevation for use in the section. During Phase II of the study additional survey will be performed for final hydraulics and the cross section will be updated if necessary.

34759.09
47162.87
54025.42 – 58630.12
75256.77 – 75300.33
108361.8
122201.9 – 123038
124978.5
125015.9
136866.9
188617.62
189709 – 190204.6
197867.3
197390.37
212592.2

215660.1
216084.2
238086.4 – 238763.2
What is the status of this issue? I don't think survey is included in Phase II of the feasibility study. Recommend re-evaluating this issue and attempting some smoothing in these areas.

The ground surface profile was revaluated. Many of the cross-sections stated above are near inline structures or low water crossings. Siltation on the upstream side of these structures is causing a jump up in the ground surface profile. The cross-section invert not associated with inline structures were catching high spots in the LiDAR. These sections were adjusted based on the LiDAR a few feet upstream or downstream of the section.

Steady Flow Data / Starting Conditions

What is the source of the known water surface elevations for the starting conditions? Recommend adding comment in model for future reference.

The known water surface elevations for the starting conditions are from the San Marcos River hydraulic model. Comment added in the model for future reference.

Cross Section Geometry

Recommend rounding cross section numbering to no decimal places. Some have 3, 2, 1, and 0 decimal places.

This issue has been addressed.

Recommend extending sections to fully contain the range of flows being evaluated. A previous response stated the ground fell off on the topo, but there are several sections that experience this while the next upstream or downstream doesn't experience the same. Please revise or justify. This is primarily between sections 11411.98 and 36570.74.

Cross-sections 32519 - 37342 were extended in order to contain the range of flows. Cross-sections 19306 - 30842 do not contain but have a lateral weir on the LOB. Flow over this lateral weir enters Bypass Creek which will be modeled in Phase II. The cross-sections that do not contain downstream of section 19306 cannot be extended without crossing over into Bypass Creek. This will be addressed in Phase II.

Manning's "n" Values

Manning's "n" values are within reasonable range.

Ineffective and Blocked Obstructions

The following recommendations are based on observation of the model, but not the topographic data used to derive the model. In some instances there may be active conveyance in the low lying areas and the recommendations may not be valid.

No comments. Sections appear to be modeled effectively.

Bridges / Culverts

BR 144000 – Culverts lie completely below ground on the upstream side and partially below ground on downstream side. Recommend revising ground geometry of sections if survey data was used for culverts.

We based the culvert placement on available field notes, photos, and LiDAR data. We estimated the invert elevation of the culvert from road profile elevations taken from the LiDAR data and field

estimates on the distance from top of road to top of the culvert. The upstream and downstream sections were based in the LiDAR data. It is likely that the LiDAR captured the water surface at the time of the LiDAR was flown obscuring the culvert inlets and outlets. The culvert will be surveyed in detail in Phase II of the project and the upstream and downstream cross sections will be revised at that time as needed.
Need to re-evaluate this issue. Is field survey part of Phase II of the feasibility study? This same statement applies to the next 5 responses.
The structure will be surveyed and/or field verified during phase 2. Data shown in the model is best currently available.

BR 162350 - Culverts lie completely below ground on the upstream side and partially below ground on downstream side. Recommend revising ground geometry of sections if survey data was used for culverts.
See response to previous comment.
See comment to previous response concerning survey.
See response to previous comment.

BR 197867.3 – Culverts in upstream section are partially below the ground geometry. Recommend revising ground geometry if culverts are confirmed. Deck / Roadway data also needs to be revised.
See response to previous comment concerning culverts. Shortly after crossing the river, the roadway turns sharply to the left (upstream). The rise seen in the roadway deck is the bridge abutment that is not entirely captured in the downstream section.
See comment to previous response concerning survey.
See response to previous comment.

BR 211914.5 – Culverts lie completely below ground geometry on upstream and downstream sections. Recommend revising ground geometry if culverts are field verified. Deck / Roadway data also needs to be revised.
See response to previous comment concerning culverts. The roadway deck has been revised and the upstream section has been moved slightly to better represent the upstream channel.
See comment to previous response concerning survey.
See response to previous comment.

BR 216600 – Structure appears to be box culverts, but is modeled as a bridge. Please confirm and revise as necessary.
Field visit confirms structure is a bridge and the river station has been changed to 216604. Field recon bridge data has been input into the model.
See comment to previous response concerning survey.

BR 238120 – Is structure a clear span bridge with no piers or a box culvert. Please confirm and revise if needed.
Field visit confirms the structure is a combination of box and pipe culverts. Field recon culvert data has been input into the model.
See comment to previous response concerning survey.

Cont /Exp Coefficients
No additional comments from previous response.

Reach Lengths

LOB, Channel, and ROB reach length relationships are within reason.

Appendix D.1.5

Digital Data

HALFF

APPENDIX D.1.5: CD WITH ALL APPLICABLE DATA

- PDF Version of TRN
  - \Appendix D.1 GBRA Hydraulics TRN.pdf
- HEC-RAS Hydraulic Models
  - Blanco River
    - \HEC-RAS_Models\Blanco River\
  - Guadalupe River
    - \HEC-RAS_Models\Guadalupe River\
  - San Marcos River
    - \HEC-RAS_Models\San Marcos River\
- GIS Data
  - Affected Structures
    - GBRA_Affected_Structures.shp
  - \GIS_Data\Blanco
    - Stream Centerlines
      - 2013_Blanco_CL.shp
    - Hydraulic Cross-Sections
      - 2013_Blanco_XS.shp
    - Flow Paths
      - Blanco_Flowpaths.shp
    - 100-yr and 500-yr Floodplains
      - Blanco_100yr_Floodplain.shp
      - Blanco_500yr_Floodplain.shp
    - Land Use
      - Blanco_LU.shp
    - Structures
      - Blanco_Structures.shp
  - \GIS_Data\Guadalupe
    - Stream Centerlines
      - Guad_CL.shp
    - Hydraulic Cross-Sections
      - 1_Victoria_XS.shp
      - 2_Dewitt_XS.shp
      - 3_Gonzales_XS.shp
      - 4_LowerGuad_XS.shp
      - 5_MiddleGuad_XS.shp
      - 6_UpperGuad_XS.shp
    - Flow Paths
      - 2_Dewitt_Flowpaths.shp
      - 3_Gonzales_Flowpaths.shp
    - Surveyed Structures
      - 2_Dewitt_SurveyedStructures.shp

            - 3_Gonzales_SurveyedStructures.shp

        - 100-yr and 500-yr Floodplains
            - Guadalupe_100yr_Floodplain.shp
            - Guadalupe_500yr_Floodplain.shp
        - Landuse (Dewitt & Gonzales)
            - Guadalupe_LU.shp
        - 1998 Flood High Water Marks
            - GuadHWM_1998.shp
    - GIS_Data\San_Marcos_River
        - Stream Centerlines
            - San_Marcos_CL.shp
        - Hydraulic Cross-Sections
            - San_Marcos _XS.shp
        - Flow Paths
            - San_Marcos _Flowpaths.shp
        - 100-yr and 500-yr Floodplains
            - San_Marcos _100yr_FP.shp
            - B San_Marcos _500yr_FP.shp
        - Land Use
            - San_Marcos _LU.shp
        - Surveyed Structures
            - San_Marcos _SurveyedStructures.shp
        - Surveyed Cross-Sections
            - San_Marcos_SurveyedXS.shp
        - Structures
            - San_Marcos_Bridges.shp
            - San_Marcos_InlineStructures.shp
            - San_Marcos_LateralStructures.shp
- Hydraulic Work Maps
    - \Work_Maps\Blanco River
    - \Work_Maps\Guadalupe River
    - \Work_Maps\San Marcos River
- Field Reconnaissance Photos
    - Guadalupe River
        - Field_Recon_Photos\Guadalupe_River
    - San Marcos River
        - Field_Recon_Photos\San_Marcos_River
    - Blanco River
        - Field_Recon_Photos\Blanco_River

US Army Corps of Engineers
Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study - Phase 1

Technical Report Notebook (TRN)
Appendix E
Preliminary Alternative Development and Benefit-Cost Analysis

Guadalupe, Blanco, and San Marcos River Watersheds Including City of Luling and City of Woodcreek

Submitted to:

US Army Corps of Engineers®

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AVO 28411B

March 2014

Preliminary Alternatives Development and Benefit-Cost Analysis
TECHNICAL REPORT NOTEBOOK

APPENDIX E
TABLE OF CONTENTS

PRELIMINARY ALTERNATIVES DEVELOPMENT AND BENEFIT-COST ANALYSIS TECHNICAL REPORT NOTEBOOK

Overview:

The Guadalupe-Blanco River Authority (GBRA) Interim Feasibility Study is a $1.4 Million detailed engineering study located in the Lower Guadalupe River Basin. The study stretches along the Guadalupe River from Canyon Lake to the Victoria County line, along the Blanco River starting in Hays County, and along the San Marcos River to its confluence with the Guadalupe River. The study is being undertaken by the United States Army Corps of Engineers (USACE), the Texas Water Development Board (TWDB), and the GBRA. This Technical Report Notebook (TRN) gives an overview of preliminary proposed flood damage reduction alternatives in the Guadalupe, Blanco, and San Marcos River Watersheds, the City of Luling and The City of Woodcreek. Figure 1 shows the streams that are part of this study. Figures 2, 3, and 4 present the locations of the proposed alternatives.

The alternatives analysis task order focused on completing alternative development and evaluation for three main project areas:

Project Area 1 – Woodcreek Alternatives
Project Area 2 – Luling Alternatives
Project Area 3 – Regional Detention Alternatives throughout the Lower Guadalupe Basin

Alternatives Analysis Considerations:

The purpose of this flood risk management study is to identify areas of flood risk in the Guadalupe, Blanco, and San Marcos River watersheds in order to protect life, property, and the environment. By identifying these areas early, the local communities may more easily and efficiently plan and construct flood management projects which will benefit the communities within the watershed.

The goals of this analysis are to 1) identify water resource related problems, needs and opportunities specifically related to flood risk management, 2) develop and evaluate alternative solutions to reduce flood damages, 3) use sustainable design methodologies, and 4) provide recommendations for flood reduction that the County can prioritize and implement locally to reduce flood risks to people and the environment. The project alternatives discussed in this report were identified based on:

- The number of structures in the 1% Annual Chance Exceedance (ACE) floodplain based on the hydraulic modeling performed in Appendix D.1 and LiDAR ground elevations
- The feasibility of a design project
- Local input regarding flood risk issues

Each of the project locations presented a different set of hydrologic and hydraulic challenges. As potential alternatives were initially considered, some of them were intuitively not feasible and were not advanced. Generally, as the various alternatives were screened, plans were considered not viable if the plan required substantial activity by others or were not effective in solving the problem. The two main components leading toward an alternative's acceptability relate to implementation and satisfaction by the stakeholders. The proposed alternative must be doable.

The focus of this Task Order was not upon the creation of preliminary plan and profile sheets for construction projects, but instead was in the evaluation of "big-picture concepts" for each set of problems. Both structural and non-structural alternatives were considered. As the specific hydrologic and hydraulics problems at the damage centers were evaluated, the alternatives were held up against any environmental constraints that would affect compliance capability. Flood risk damages were identified, and general benefits were associated with each alternative (e.g., homes removed from flooding, structures removed, reduced floodplain area, minimized roadway overtopping). Conceptual design level estimates of project cost were also generated.

In an effort to determine acceptable levels of protection within each problem area, a wide range of flood events were evaluated (2-year to 500-year). Depending upon the needs of the problem area, hydrologic and/or, hydraulic models were developed as needed for specific alternatives. The goal for the regional detention alternatives was t o reduce the proposed 100-yr flow to the existing 50-yr level. The models and output results for each alternative are included on the CD in Appendix E.4. Each of the subsequent project specific "mini-reports" included in Appendices E.1 through E.3 contains details regarding the results of the modeling, specific maps depicting the alternatives, and opinions of probable cost for each project.

Benefit-Cost Analysis

Benefit-cost analyses are often used to prioritize flood risk management projects in municipalities and are also used by larger organizations such as the USACE. This report will present rough benefit-cost analyses for each recommended project. Flood damages were calculated for each alternative by a simplified method using eight hydraulic profiles (2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 250-yr, and 500-yr frequencies), median or appraised structure values depending on location, and approximate first floor elevations. Median structure values were taken from city-data.com, a website containing demographic data for communities across the nation. This data was used for DeWitt and Victoria Counties, where we had no useable appraisal district data and also to fill in holes in the remaining counties where appraisal district data was missing. Appraisal District improvement values were used as the basis for structure value in the remaining counties in the study area. A shapefile of all structures identified within the 500-yr floodplain is included in Appendix E4. Approximate first floor elevations were derived using LiDAR elevations plus one foot to account for average slab height.

The resulting first floor elevation for each structure was compared to the elevations of the eight frequency profiles from the nearest model cross-section. Structure values were totaled for homes inundated by each frequency event and multiplied by the respective frequency. The resulting values for each frequency were added together resulting in an approximate estimate of annual flood damages. Tables 1, 2, and 3 show the estimates of existing annual flood damage for the Guadalupe, Blanco, and San Marcos Rivers, City of Luling, and City of Woodcreek for each storm frequency.

Table 1: Basin-Wide Annual Flood Damage Calculations

Stream	Recurrence Interval	Storm Event	Structure Count	Existing Appraised Value	Existing Annual Damage
Guadalupe River	2-yr	50% ACE	1091	$263,780,959	$131,890,480
	5-yr	20% ACE	1146	$266,973,659	$53,394,732
	10-yr	10% ACE	1296	$282,119,746	$28,211,975
	25-yr	4% ACE	2382	$435,790,066	$17,431,603
	50-yr	2% ACE	3484	$567,992,900	$11,359,858
	100-yr	1% ACE	4860	$740,408,459	$7,404,085
	250-yr	0.4% ACE	7093	$1,009,358,962	$4,037,436
	500-yr	0.2% ACE	8760	$1,211,725,951	$2,423,452
			Total Values:	**$4,778,150,702**	**$256,153,619**
Blanco River	2-yr	50% ACE	1	$175,934	$87,967
	5-yr	20% ACE	4	$520,164	$104,033
	10-yr	10% ACE	91	$7,784,056	$778,406
	25-yr	4% ACE	875	$159,635,845	$6,385,434
	50-yr	2% ACE	1185	$251,047,137	$5,020,943
	100-yr	1% ACE	1406	$370,900,159	$3,709,002
	250-yr	0.4% ACE	1593	$452,223,456	$1,808,894
	500-yr	0.2% ACE	1695	$481,126,810	$962,254
			Total Values:	**$1,723,413,561**	**$18,856,931**
San Marcos River	2-yr	50% ACE	0	$0	$0
	5-yr	20% ACE	3	$177,736	$35,547
	10-yr	10% ACE	20	$1,442,247	$144,225
	25-yr	4% ACE	178	$15,428,158	$617,126
	50-yr	2% ACE	371	$35,917,218	$718,344
	100-yr	1% ACE	593	$56,958,344	$569,583
	250-yr	0.4% ACE	719	$74,781,393	$299,126
	500-yr	0.2% ACE	817	$81,739,717	$163,479
			Total Values:	**$266,444,813**	**$2,547,431**

Table 2: City of Luling Annual Flood Damage Calculations

Recurrence Interval	Storm Event	Structure Count	Existing Appraised Value	Existing Annual Damage
2-yr	50% ACE	0	$0	$0
5-yr	20% ACE	0	$0	$0
10-yr	10% ACE	0	$0	$0
25-yr	4% ACE	5	$671,760	$26,870.40
50-yr	2% ACE	10	$2,662,820	$53,256.40
100-yr	1% ACE	16	$2,772,720	$27,727.20
250-yr	0.4% ACE	28	$2,469,430	$9,877.72
500-yr	0.2% ACE	45	$7,565,090	$15,130.18
		Total Values:	**$16,141,820**	**$132,862**

Table 3: City of Woodcreek Annual Flood Damage Calculations

Recurrence Interval	Storm Event	Structure Count	Existing Appraised Value	Existing Annual Damage
2-yr	50% ACE	0	$0	
5-yr	20% ACE	5	$603,270	$120,654
10-yr	10% ACE	6	$722,040	$72,204
25-yr	4% ACE	8	$1,055,120	$42,205
50-yr	2% ACE	8	$1,055,120	$21,102
100-yr	1% ACE	8	$1,055,120	$10,551
250-yr	0.4% ACE	13	$1,783,400	$7,134
500-yr	0.2% ACE	17	$2,508,430	$5,017
		Total Values:	**$8,782,500**	**$278,867**

Woodcreek Alternatives B/C Analysis

Of the four alternatives presented in Appendix E1 for Woodcreek, only the upstream detention pond has a significant impact on flood damage reduction. The remaining three alternatives address drainage or infrastructure issues. The benefit-cost analysis for the upstream detention pond is presented in Table 4. Based on a simplified benefit-cost analysis methodology, the detention structure is showing a favorable B/C ratio of 1.23. However, easement acquisition costs must also be considered in the final B/C ratio.

Table 4: City of Woodcreek Upstream Detention Benefit-Cost Results

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	0	$0	0	$0	$0		
20% ACE	4	$97,688	4	$97,688	$0		
10% ACE	6	$72,204	4	$48,844	$303,883		
4% ACE	9	$49,940	5	$24,131	$335,744		
2% ACE	9	$24,970	6	$14,441	$136,971		
1% ACE	9	$12,485	6	$7,220	$68,486		
0.4% ACE	14	$7,907	8	$4,220	$47,958		
0.2% ACE	17	$5,112	8	$2,110	$39,042		
TOTAL	-	$270,306	-	$198,655	$932,085	$756,400	1.23

Luling Alternatives B/C Analysis

Three of the Luling alternatives presented in Appendix E.2 have flood damage reduction benefits. The remaining alternatives address infrastructure impacts (erosion) or were determined not to be feasible. Benefit-cost analysis results for the Logan Street, Laurel Avenue, and Oak Creek Circle alternatives are presented in Tables 5, 6, and 7. Based on a simplified benefit-cost analysis methodology, the three alternatives produced very low B/C ratios. The Laurel Avenue and Oak Creek Circle Alternatives simply do not produce enough benefits to outweigh the costs. Logan Street may still be worth considering since it allows access to the only local hospital during large flood events. If the benefit of allowing hospital access can be quantified a more favorable B/C ratio may be produced.

Table 5: City of Luling Logan Street Crossing Improvement and San Marcos Tributary Channelization

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	0	$0	0	$0	$0		
20% ACE	0	$0	0	$0	$0		
10% ACE	0	$0	0	$0	$0		
4% ACE	0	$0	0	$0	$0		
2% ACE	0	$0	0	$0	$0		
1% ACE	0	$0	0	$0	$0		
0.4% ACE	1	$227	0	$0	$3,136		
0.2% ACE	2	$208	0	$0	$2,875		
TOTAL	3	$436	0	$0	$6,010	$503,330	0.0119

Table 6: City of Luling Laurel Avenue Culvert Improvement and Salt Branch Channelization

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	0	$0	0	$0	$0		
20% ACE	0	$0	0	$0	$0		
10% ACE	0	$0	0	$0	$0		
4% ACE	1	$335	0	$0	$4,620		
2% ACE	5	$2,461	2	$1,872	$8,134		
1% ACE	5	$1,231	2	$936	$4,067		
0.4% ACE	8	$1,022	4	$870	$2,093		
0.2% ACE	9	$1,814	6	$1,755	$815		
TOTAL	28	$6,862	14	$5,433	$19,730	$1,140,070	0.0173

Table 7: City of Luling Oak Creek Circle Levee

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	0	$0	0	$0	$0		
20% ACE	0	$0	0	$0	$0		
10% ACE	0	$0	0	$0	$0		
4% ACE	0	$0	0	$0	$0		
2% ACE	1	$8,110	0	$0	$111,921		
1% ACE	5	$6,287	0	$0	$86,765		
0.4% ACE	6	$3,222	0	$0	$44,463		
0.2% ACE	11	$2,941	0	$0	$40,589		
TOTAL	23	$20,560	0	$0	$283,738	$3,422,800	0.0829

Regional Detention Alternative B/C Analysis

Table 8 details the benefit-cost analysis for the proposed detention on Bear Creek for the estimated $5.6 million project cost. Most of the flood damage reduction benefit occurs from the City of New Braunfels to the City of Seguin. With a B/C ratio of 3.53, the Bear Creek detention appears to be a very favorable alternative. The high B/C ratio also leaves room to consider easement acquisition costs once they are quantified.

Table 8: Summary of Proposed Bear Creek Detention Benefits

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	1091	$131,890,480	1091	$131,890,480	$0		
20% ACE	1145	$53,379,824	1145	$53,379,824	$0		
10% ACE	1293	$28,185,902	1287	$28,067,180	$1,638,436		
4% ACE	2370	$17,403,813	2276	$16,730,814	$9,287,857		
2% ACE	3462	$11,327,217	3380	$11,057,820	$3,717,866		
1% ACE	4825	$7,375,759	4666	$7,123,568	$3,480,406		
0.4% ACE	6638	$3,811,599	6451	$3,718,695	$1,282,145		
0.2% ACE	8080	$2,253,229	8025	$2,232,038	$292,456		
TOTAL	-	$255,627,822	-	$254,200,419	$19,699,166	$5,575,763	3.53

Table 9 details the benefit-cost analysis for the proposed detention on the Blanco River for the estimated $7.5 million project cost. Most of the flood damage reduction benefit occurs along the Blanco River from the confluence with Little Blanco River to the confluence with the San Marcos River within the Cities of Wimberley and San Marcos. With a B/C ratio of 1.45, the Blanco River detention appears to be a favorable alternative. However, easement acquisition costs must also be considered in the final B/C ratio.

Table 9: Summary of Proposed Blanco River Detention Benefits

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	7	$281,209	7	$281,209	$0		
20% ACE	51	$751,548	51	$751,548	$0		
10% ACE	197	$2,528,712	187	$2,387,377	$1,950,518		
4% ACE	974	$3,894,796	957	$3,835,919	$812,547		
2% ACE	1501	$2,918,094	1481	$2,878,780	$542,569		
1% ACE	1939	$1,935,484	1808	$1,744,774	$2,631,924		
0.4% ACE	2891	$1,384,550	2526	$1,078,238	$4,227,323		
0.2% ACE	3494	$827,066	3329	$781,420	$629,945		
TOTAL	-	$14,521,459	-	$13,739,265	$10,794,826	$7,467,179	1.45

Table 10 details the benefit-cost analysis for the proposed detention on York Creek for the estimated $12.1 million project cost. Most of the flood damage reduction benefit occurs along the San Marcos and Guadalupe Rivers from the confluence with York Creek through the Cities of Luling and Gonzales. With a B/C ratio of 1.57, the York Creek detention appears to be a favorable alternative. However, easement acquisition costs must also be considered in the final B/C ratio.

Table 10: Summary of Proposed York Creek Detention Benefits

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Estimated Damages	At Risk Structures	Estimated Damages			
50% ACE	14	$490,421	12	$419,110	$984,142		
20% ACE	37	$530,840	34	$486,316	$614,468		
10% ACE	116	$924,470	89	$682,208	$3,343,378		
4% ACE	645	$2,844,595	471	$2,166,141	$9,363,145		
2% ACE	1179	$2,383,430	1044	$2,161,696	$3,060,078		
1% ACE	1622	$1,570,809	1522	$1,481,712	$1,229,602		
0.4% ACE	2083	$787,780	2037	$770,162	$243,139		
0.2% ACE	2535	$468,175	2440	$455,235	$178,578		
TOTAL	-	$10,000,519	-	$8,622,579	$19,016,530	$12,100,303	1.57

Table 11 details the benefit-cost analysis for the proposed detention on Peach Creek for the estimated $6.3 million project cost. Most of the flood damage reduction benefit occurs along the Guadalupe Rivers from the confluence with Peach Creek through the Cities of Cuero and Victoria. With a B/C ratio of 0.77, the Peach Creek detention does not appear to be a favorable alternative. Benefits are minimal for Cuero and Victoria and do not outweigh the project costs.

Table 11: Summary of Proposed Peach Creek Detention Benefits

Storm Event	Existing Conditions		Post-Project Conditions		Project Benefit (Present Value)	Project Cost	Benefit to Cost Ratio
	At Risk Structures	Est. Annual Damages	At Risk Structures	Est. Annual Damages			
50% ACE	12	$445,196	11	$416,300	$398,785		
20% ACE	32	$475,662	29	$432,875	$590,485		
10% ACE	95	$736,522	77	$590,046	$2,021,470		
4% ACE	573	$1,653,832	543	$1,600,146	$740,905		
2% ACE	1077	$1,563,096	1045	$1,504,602	$807,262		
1% ACE	1447	$1,055,416	1435	$1,044,684	$148,098		
0.4% ACE	1814	$536,829	1798	$530,073	$93,234		
0.2% ACE	2173	$319,343	2172	$319,019	$4,471		
TOTAL	-	$6,785,896	-	$6,437,746	$4,804,710	$6,253,933	0.77

Summary and Conclusions

A summary of benefit-cost analysis results is presented in Table 12. With a little refinement of benefit and cost, the City of Woodcreek regional detention may attain favorable B/C ratio. The Woodcreek regional detention provides a significant amount of flood reduction within the City. The City of Luling does not appear to have a significant flood damage issue associated with flooding sources other than the San Marcos River. If the hospital access issue is important to the City, then the Logan Street improvement may be worth considering. The basin-wide regional detention alternatives appear to be more affective in the upper part of watershed than the lower part. The most favorable B/C ratio was calculated for the Bear Creek detention. The flood damage reduction impacts of this alternative are significant from New Braunfels through the City of Seguin. It is recommended that the Corps consider the Bear Creek detention for more detailed economic analysis.

Table 12: Summary of Benefit-Cost Analysis Results

Project Area	Alternative Description	B/C Ratio
Woodcreek	Regional Detention between Mountain Crest Drive and city limits	0.98
Luling	Logan Street culvert and channel improvements	0.012
	Laurel Avenue culvert and channel improvements	0.017
	Oak Creek Circle Levee	0.083
Regional Detention	Detention on Bear Creek above confluence with Guadalupe	3.53
	Detention on Blanco River above confluence with Little Blanco	1.45
	Detention on York Creek above confluence with San Marcos River	1.57
	Detention on Peach Creek upstream of FM 2814	0.77

Figures

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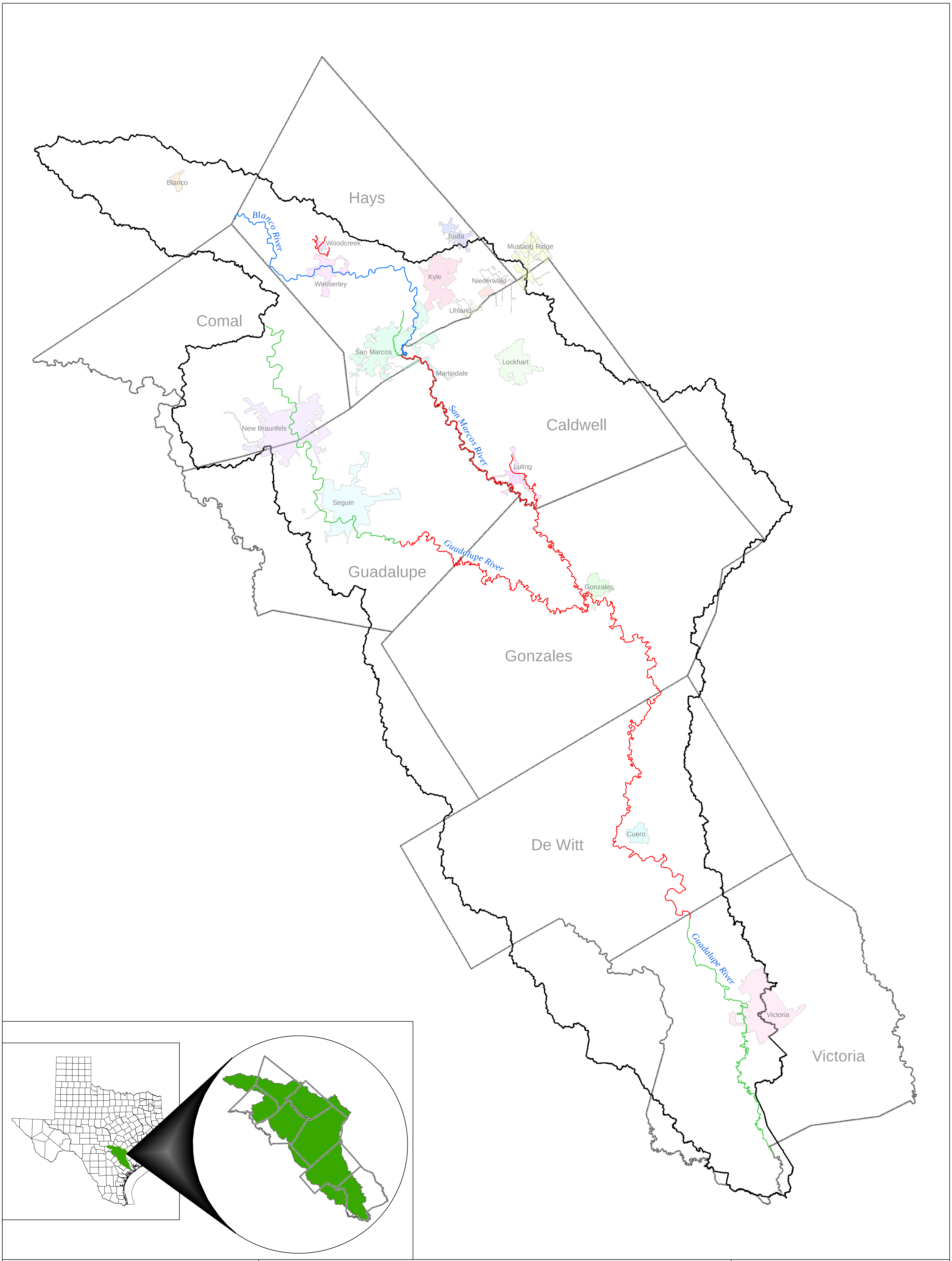

Key to Features

- New Detailed Study
- Blanco River
- Guad Incorp
- Lower Guadalupe River Basin
- County Boundary

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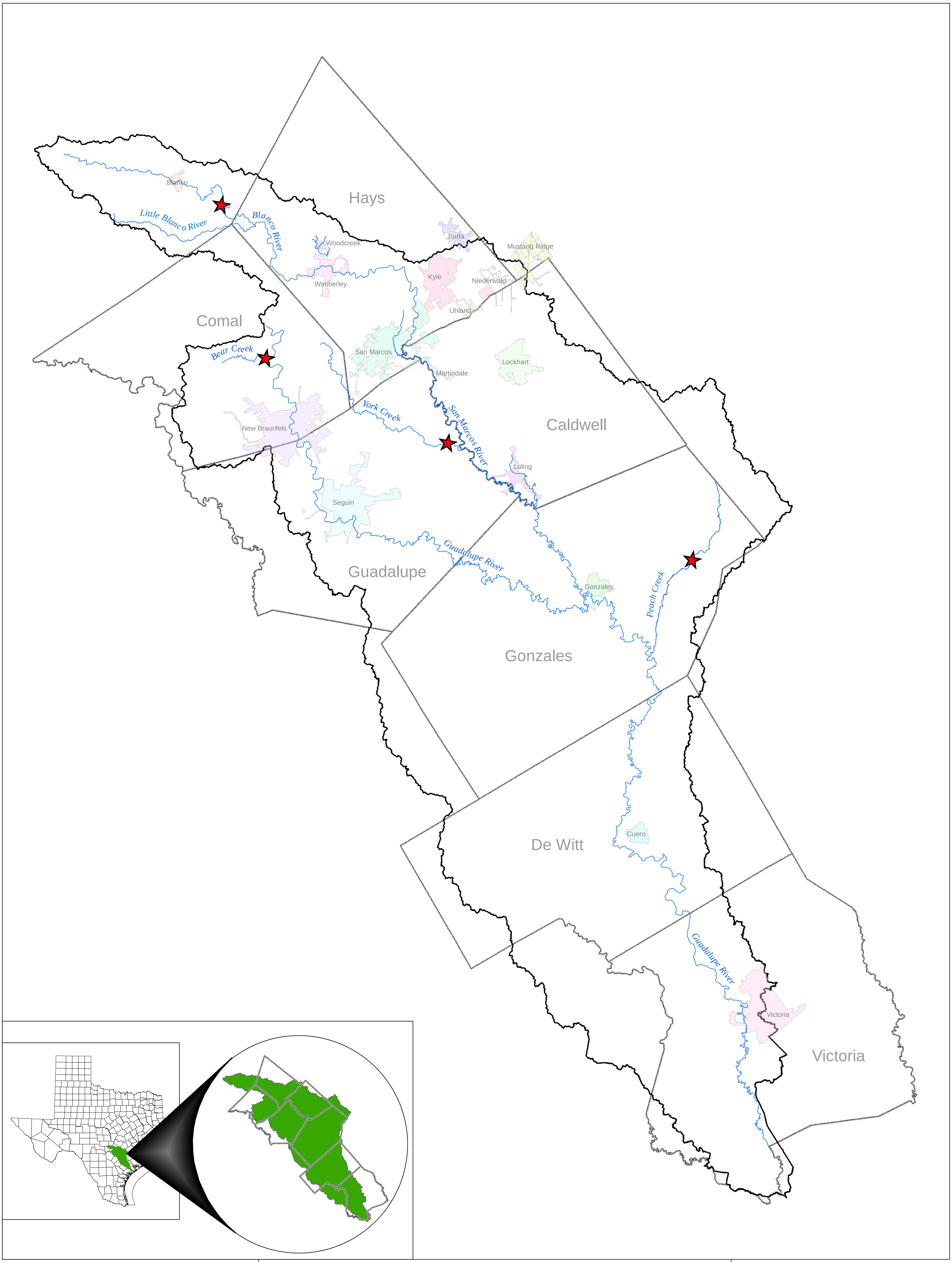
Figure 1.
Project Study Area

N W E S

0 10 20 Miles

1 inch = 5 miles



Key to Features

- Regional Detention Locations
- Study Streams
- Lower Guadalupe River Basin
- County Boundary

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Figure 2.
Regional Detention Locations

N W E S

0 10 20 Miles

1 inch = 5 miles

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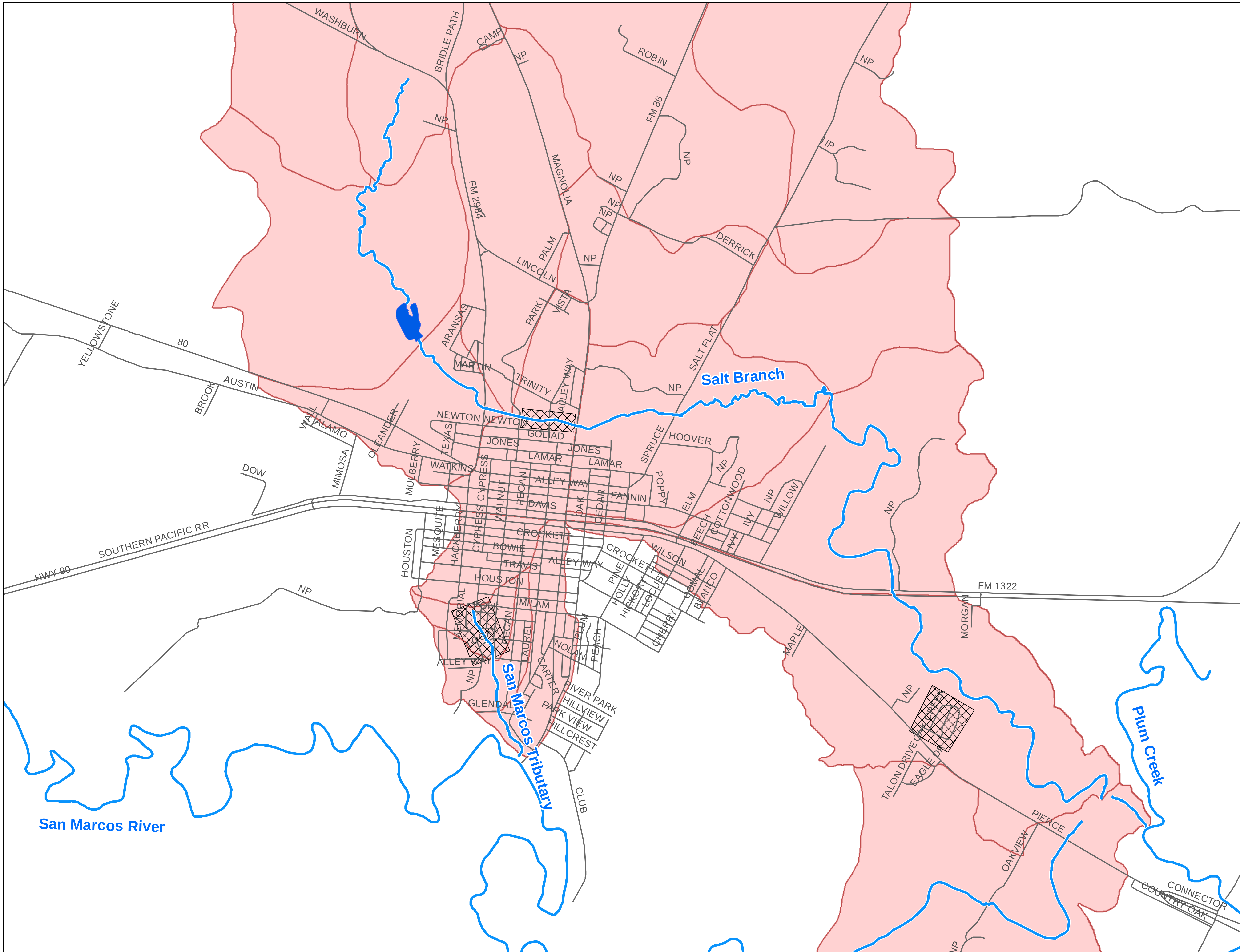
Interim Feasibility Study

Alternative Development and Benefit-Cost Analysis



Key to Features

- River
- Roads
- SCS Reservoir Site 38
- Project Alternative Locations
- Subbasins

Figure 3:

Luling Alternative Locations

N E S W

0 1,000 2,000 4,000 Feet

1 inch = 2,000 feet

HALFF
300 EAST SONTERRA BLVD., SUITE 230
SAN ANTONIO, TEXAS 78258-3991
TEL (210) 798-1895
FAX (210) 798-1896
TBPE FIRM REGISTRATION #312

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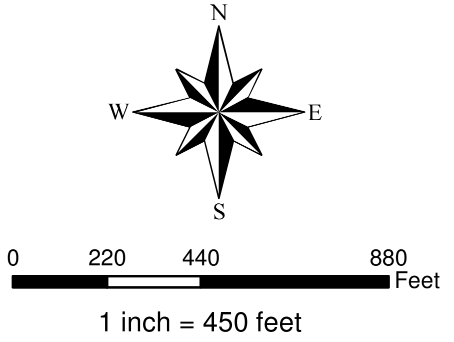
GBRA Interim Feasibility Study - Phase I

Key to Features

- Hog Creek
- Woodcreek City Limits
- Roadways

Woodcreek Alternatives



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Appendix E.1

PROJECT AREA 1 – WOODCREEK ALTERNATIVES

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Project Area 1
Hog Creek
City of Woodcreek Alternatives

The City of Woodcreek and the United States Army Corps of Engineers (USACE) – Fort Worth District requested Halff Associates to perform an alternatives analysis to address flooding and drainage issues within the City of Woodcreek. There are currently about 22 Woodcreek homes located within the 100-yr floodplain. Frequent "nuisance" flooding issues associated with run-off coming from the Woodcreek golf course have also been indicated by city staff.

Alternatives Analysis:

Four alternatives were evaluated to alleviate the flooding along Hog Creek as well as to address infrastructure and "nuisance flooding". These four alternatives are listed below.

Alternative 1 – Regional Detention South of Mountain Crest Drive

Project Description:
A regional detention pond between the Woodcreek city limits and Mountain Crest Drive can effectively reduce 100-yr flood elevations within the city up to 2.5 ft to approximately a 10-yr frequency level. The alternative consists of a 20 ft. tall detention structure with a 175 ac-ft detention capacity. The outflow control would consist of culverts for low flow and an overflow weir for high flow. At maximum capacity the head water of the pond will reach just upstream of Mountain Crest Drive but will not affect any existing houses. A conceptual layout of the regional detention can be seen in the "Figures" section of this appendix.

Summary:
The proposed detention pond will:

- Reduce the 100-yr frequency flood to approximately the 10-yr frequency flood
- Remove 8 structures from the 100 year floodplain.
- Reduce the severity and frequency of flooding along Hog Creek throughout the City of Woodcreek.
- Estimated project cost of $952,000.

Opinion of Probable Cost based on Concept Plan:

TxDOT Item No.	Description of Item	Probable Quantity	Unit	Unit Price	Cost
752-2022	Tree removal	110	EA	$ 400	$ 44,000
160-2003	Furnish and place Topsoil (4")	34000	SY	$ 1	$ 34,000
132-2005	Embankment (Type C)	8600	CY	$ 14	$ 120,400
432-2066	4" Concrete Rip Rap	200	CY	$ 305	$ 94,000
464-2030	60" RC Pipe (Class III)	400	LF	$ 190	$ 76,000
5941-2014	Hydromulch Seeding	34000	SY	$ 1	$ 34,000
169-2001	Soil retention blankets	3500	SY	$ 1	$ 4,000
500-2001	Mobilization (10%)	1	LS	$ 40,600	$ 40,600
	Eng/Surv/Permit Fees	1	LS	$ 89,400	$ 89,400
	SUBTOTAL				$ 536,400
	30% CONTINGENCY				$ 220,000
	TOTAL				$ 756,400
		Excludes land acquisition costs			

Alternative 2 – Improvements to Brookside Drive Culvert Crossing

Project Description:

Currently, the culvert crossing at Brookside Drive contains a blocked culvert barrel likely causing water to flow over the road toward the left bank. The water is flowing back into the channel from the road causing erosion of the road embankment and undercutting of the road on the downstream side. The proposed alternative will increase the culvert flow capacity and reinforce the road embankment to eliminate road undercutting. The culvert opening will be increased to three 36" concrete pipes to match the culvert capacity just downstream at Brook Meadow Dr. and also involve some minimal re-grading of the stream flowline. The undercutting will be repaired and the road embankment reinforced to prevent future erosion and undercutting.

Summary:

The proposed Brookside Drive culvert crossing improvements will:

- Improve culvert conveyance under Brookside Drive
- Repair undercutting and prevent future road embankment erosion
- Provide a minimal decrease in the 100-yr flood elevation upstream of the crossing
- Estimated project cost of $22,400.

Opinion of Probable Cost based on Concept Plan:

TxDOT Item No.	Description of Item	Probable Quantity	Unit	Unit Price	Cost
400-2006	Cut and Restore paving	26.7	SY	$ 76	$ 2,000
464-2009	36" RC Pipe (Class III)	60	LF	$ 98	$ 6,000
110-2002	Excavation (Channel)	30	CY	$ 11	$ 325
132-2007	Type D embankment	26	CY	$ 35	$ 900
432-2001	4" Concrete Rip Rap	5	CY	$ 367	$ 2,000
432-2016	8" Rock Rip Rap	25	CY	$ 81	$ 2,000
500-2001	Mobilization (10%)	1	LS	$ 1,300	$ 1,300
	Eng/Surv/Permit Fees	1	LS	$ 5,000	$ 10,000
	SUBTOTAL				$ 24,525
	30% CONTINGENCY				$ 6,000
	TOTAL				$ 30,525

Alternative 3 – Nuisance flooding near Overbrook Court – Brookmeadow Dr. Ditch

Project Description:

A portion of the run-off affecting Overbrook Court appears to be coming from the north side of Brookmeadow Drive and flowing across the road. The road side ditches are not substantial in this area and likely do not have enough capacity to handle the amount of flow that could be coming across Brookmeadow Drive. The proposed alternative consists of a rip rap ditch along the south side of Brookmeadow Drive, under Overbrook Court and down to Hog Creek. The capacity of the ditch would be enough to hold the most frequent flows (possibly up to the 10-year event) and prevent overflow into the Overbrook Court houses.

Summary:

The proposed ditch along Brookmeadow Drive will:

- Contain the most frequent flow events (up to 10-yr event).
- Prevent these frequent events from affecting the houses along Overbrook Court.

- Provide more effective conveyance of flood event run-off to Hog Creek.
- Estimated project cost of $51,600.

Opinion of Probable Cost based on Concept Plan:

Ditch					
TxDOT Item No.	Description of Item	Probable Quantity	Unit	Unit Price	Cost
400-2006	Cut and Restore paving	138	SY	$ 76	$ 10,500
110-2002	Excavation (Channel)	334	CY	$ 11	$ 3,700
464-2005	24" RCPipe (Class III)	100	LF	$ 45	$ 4,500
432-2008	8" Rock Rip Rap (Grouted)	84	CY	$ 93	$ 7,800
162-2002	Block sodding	222	SY	$ 2.6	$ 600
500-2001	Mobilization (10%)	1	LS	$ 2,700	$ 2,700
	Eng/Surv/Permit Fees	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 39,800
	30% CONTINGENCY				$ 12,000
	TOTAL				$ 51,800

Alternative 4 – Nuisance flooding near Overbrook Court – Golf Course Rain Gardens

Project Description:

Another concern along Overbrook Court is water running off the golf course and affecting homes. In keeping with the low impact aesthetic of the neighborhood, the proposed alternative is a series of four rain gardens along the side of the fairway behind the homes along Overbrook Court. Rain gardens consist of vegetated strips underlain by bio-filtration media. This combination allows for the storage and enhanced infiltration of frequent run-off events. The rain gardens will be approximately 100 feet long and contain up to a 4 foot depth of bio-filtration media. Deployment of other rain gardens throughout the golf course could help with other nuisance flooding conditions and even help reduce flooding in Hog Creek.

Summary:

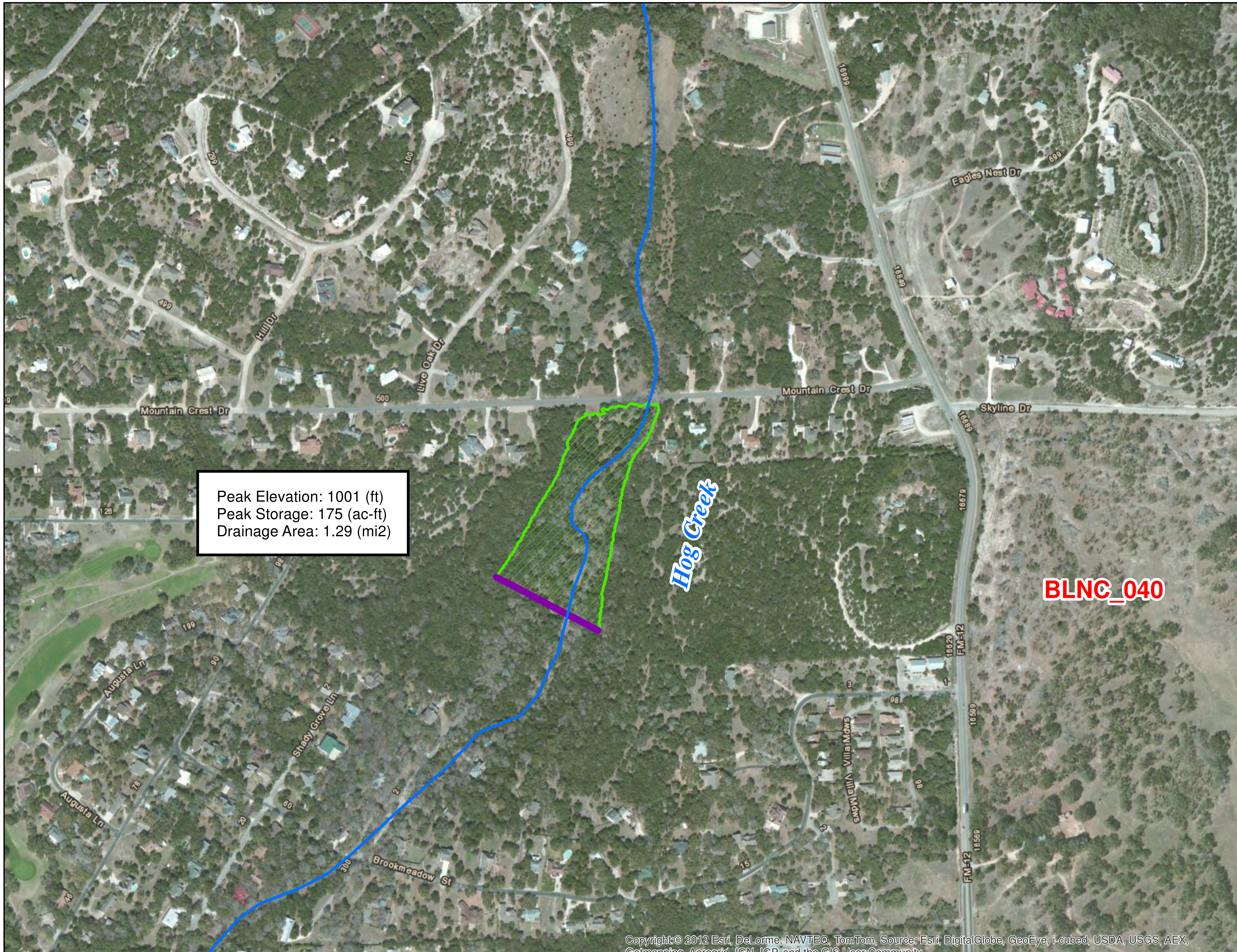
The proposed rain gardens along the golf course will:

- Contain the most frequent flow events (up to 5-yr event).
- Prevent these frequent events from affecting the houses along Overbrook Court.
- Provide an aesthetic enhancement to the golf course and neighborhood.
- Estimated project cost of $47,200 ($11,800 per rain garden).

Opinion of Probable Cost based on Concept Plan:

COA Item No.	Description of Item	Probable Quantity	Unit	Unit Price	Cost
	Excavation	474	CY	$ 11	$ 5,200
SS508BM	biofiltration medium	474	CY	$ 45	$ 21,300
SP608S-2D	3 in mulch for Rain Garden	30	CY	$ 37	$ 1,100
608S-1B	Native plantings	356	EA	$ 11	$ 3,900
	Eng/Surv/Permit Fees	1	LS	$ 10,000	$ 10,000
	SUBTOTAL				$ 36,300
	30% CONTINGENCY				$ 10,900
	TOTAL				$ 47,200

Figures



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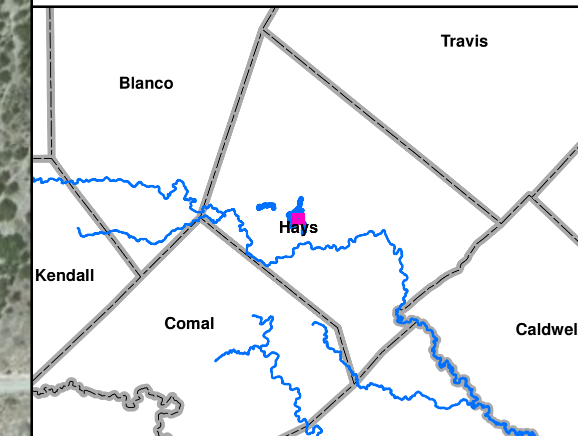

Key to Features

- Proposed Dam
- Proposed Footprint
- Subbasins
- Alternative Streams

Figure 1.
Woodcreek
Proposed Alternative

N
W E
S

0 400 800 Feet

1 inch = 400 feet

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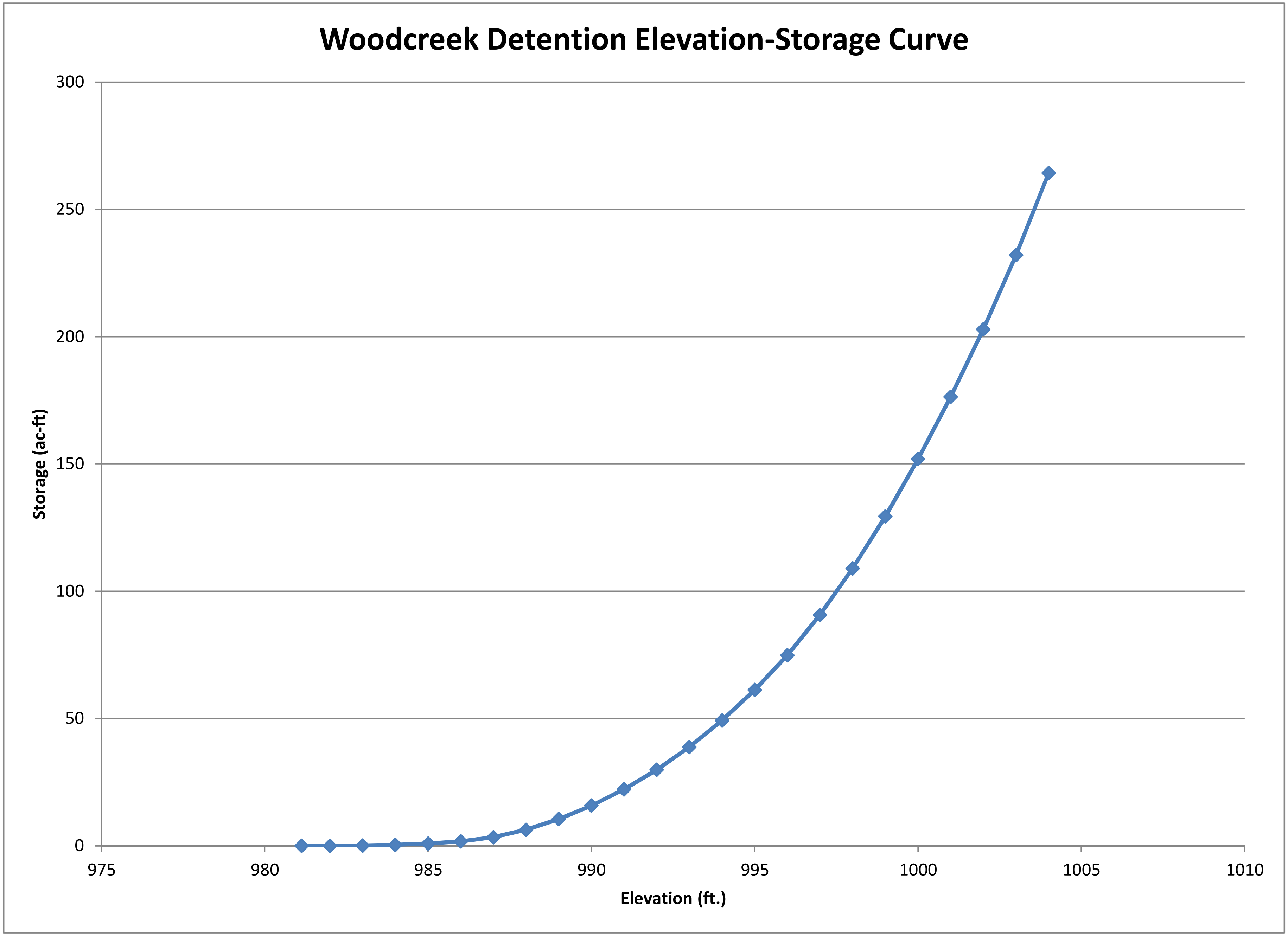

Woodcreek Detention Elevation-Storage Curve
Storage (ac-ft)
300
250
200
150
100
50
0
975
980
985
990
995
1000
1005
1010
Elevation (ft.)

Appendix E.2

PROJECT AREA 2 –
LULING ALTERNATIVES

HALFF

Project Area 2
Salt Branch, Plum Creek, San Marcos Tributary
City of Luling Alternatives

Alternative 1 – Crossing at Logan Street on San Marcos Tributary

Concerns have been raised about safe access to the Seton Edgar B Davis Hospital close to the San Marcos Tributary. The hydraulic analysis of the San Marcos Tributary in Appendix D.2 revealed that all eight frequency storms overtopped Logan Street, which is a major access route to the hospital. This crossing can be avoided by taking E. Milam Street to Memorial Drive to get to the hospital, but it is also frequently flooded. The hydraulic analysis revealed that flood waters are being restricted by the Logan Street culvert and rising upstream as a result, causing E. Milam Street to flood and houses along the San Marcos Tributary to flood during the 0.4% and 0.2% ACE storm events. Initial mapping of the San Marcos Tributary located a few of the houses in the upper portions of the stream in the 1% ACE floodplain as well, but later analysis of estimated slab elevations illustrated that these structures are safe from the 1% ACE floodplain, if only by an inch. Given the error associated with the rough estimations of slab elevations in this study, residents in this area should be aware that their houses are flood-prone.

Figure 1 presents a conceptual layout of the proposed alternative for this area. The alternative would raise Logan Street within the limits shown, enlarge the culvert, and provide channel improvements upstream of the crossing. The existing culvert is a 5.5-ft circular concrete pipe and is undersized for all frequency storm events in the San Marcos Tributary. The alternative would include enlargement of this culvert to two 10’ x 8’ reinforced concrete box (RCB) culverts and lowering the channel flowline 1.3-ft through the roadway crossing. To accomplish this, a drop-structure would be placed just upstream of Logan Street with a 4:1 drop slope, which would be reinforced with rip-rap. The flowline elevations upstream of this drop structure and downstream of the Logan Street crossing are proposed to remain the same as existing conditions. Through the culvert and for roughly 200-ft upstream of the crossing a 25-ft bottom width grass-lined trapezoidal channel with 3:1 side slopes is included in the proposed alternative. From the most upstream limit of the channel excavation to Memorial Drive, channel clearing is proposed to reduce water surface elevations. See Figure 1 for reference.

The “Figure and Tables” section of this appendix contains the water surface elevation and velocity comparisons from existing to proposed conditions for all eight frequency storm events. The largest reduction in water surface elevations occurs just upstream of the Logan Street crossing and is over 4-ft for the smaller storm events. The larger storm events show reductions of around 2-ft in water surface elevations, which is enough to remove all houses in the project area from the 0.2% ACE floodplain. Figure 2 shows a comparison of the existing and proposed 1% ACE floodplain mapping. Most of the velocity increases in the channel occur where clearing is proposed. However, all of the final velocities are under 12 ft/s, and therefore channel reinforcement is only proposed in the vicinity of the drop structure.

Table 1: San Marcos Tributary Proposed Improvements Opinion of Probable Cost

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
1	BARRICADES, SIGNS, AND TRAFFIC HANDLING	2	MO	$5,000.00	$10,000
2	EASEMENT/ ROW ACQUISITION	Refer to Appendix E.2.2 for details			$148,700
3	PREPARATION OF RIGHT OF WAY	0.700	AC	$10,000	$7,000
4	UTILITY RELOCATIONS	1	LS	$25,000	$25,000
5	STREET DEMOLITION / CULVERT REMOVAL	1	LS	$10,000	$10,000
6	EXCAVATION (CHANNEL)	2,770	CY	$10	$27,700
7	EMBANKMENT	680	CY	$10	$6,800
8	10' x 8' RCB CULVERTS	74	LF	$750	$55,500
9	PARALLEL WING HEADWALL	2	EA	$20,000	$40,000
10	10-FT CURB INLETS	3	EA	$5,000	$15,000
11	36-INCH RCP	150	LF	$80	$12,000
12	18" ROCK RIP RAP	380	SY	$50	$19,000
13	FULL WIDTH PAVEMENT REPAIR	1,150	SY	$75	$86,250
14	TOPSOIL/SEED/HYDROMULCH	3,400	SY	$2.0	$6,800
				SUBTOTAL	**$314,250**
				Mobilization (10%)	$31,430
				Engineering & Surveying (12%)	$41,500
				Contingencies (30%)	$116,150
				GRAND TOTAL	**$503,330**

The engineer's opinion of probable cost for this design project can be seen in Table 1. The estimated cost of the project comes to $503,330, and includes unit prices that were generally based on TXDOT item numbers. The cost of easement acquisition is not included in this opinion of probable cost: It should also be noted that the cost estimate does not include expenses associated with environmental challenges that are often encountered during planning and construction.

Alternative 2 – Salt Branch between Walnut and Magnolia Avenues

The second proposed project is also a culvert crossing and channel improvement alternative. The project is located at the crossing of Laurel Avenue and Salt Branch, and is aimed at reducing the floodplain in order to remove surrounding structures as well as Goliad Street from the 1% ACE floodplain. The proposed alternative would introduce a drop structure just downstream of Walnut Avenue and provide channel improvements down to Magnolia Avenue (HWY 183). The channel improvements would consist of a 50-ft grass-lined trapezoidal channel beginning just downstream of Walnut Avenue and widening to 100-ft about halfway between Walnut and Laurel Avenue. The 100-ft channel would continue through Laurel Avenue and HEC-RAS section 22787 (see Figure 3 for the conceptual design layout), and constricting to 50-ft at HEC-RAS section 22668. A 0.2% channel slope and 4:1 side slopes were applied to the channel modification design. Nine 10 x 6 RCB culverts are proposed at the Laurel Avenue crossing to increase the flow of water through the roadway. The purpose of this roadway crossing improvement is not for the road the pass the 1% ACE storm event, as with many improvements, but rather to decrease the channel blockage caused by the culverts, thereby decreasing water surface elevations in the surrounding areas. It should be noted that a bridge crossing may also be appropriate for this alternative given the 100-ft bottom width of the proposed crossing. Should this design be pursued, an analysis should be completed comparing the cost of constructing a culvert crossing vs. a bridge crossing.   At Laurel Avenue, the proposed alternative would lower the channel flowline by about 2-ft, resulting in a maximum decrease of 2.3-ft in the 1% ACE storm event between Walnut and Laurel Avenues.

The “Figure and Tables” section of this appendix provides the existing and proposed water surface elevations and velocities for the proposed design, and Table 2 details the engineer’s opinion of probable cost. Figure 4 also illustrates the existing and proposed floodplain mapping for the area, showing that the proposed design removes most structures from the 1% ACE floodplain and provides safe access along Goliad Street. The final estimate for this project comes to $1,140,070, and includes unit prices that were generally based on TXDOT item numbers. The cost of easement acquisition is not included in this opinion of probable cost: It should also be noted that the cost estimate does not include expenses associated with environmental challenges that are often encountered during planning and construction.

Table 2: Salt Branch Proposed Improvements Opinion of Probable Cost

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
1	BARRICADES, SIGNS, AND TRAFFIC HANDLING	2	MO	$5,000.00	$10,000
3	PREPARATION OF RIGHT OF WAY	3.2	AC	$5,000	$16,000
4	UTILITY RELOCATIONS	1	LS	$10,000	$10,000
5	STREET DEMOLITION / CULVERT REMOVAL	1	LS	$10,000	$10,000
6	EXCAVATION (CHANNEL)	33,600	CY	$10	$336,000
7	EMBANKMENT	336	CY	$10	$3,360
8	10' x 6' RCB CULVERTS	270	LF	$600	$162,000
9	PARALLEL WING/HEADWALL	2	EA	$40,000	$80,000
10	18" ROCK RIP RAP	560	SY	$50	$28,000
11	FULL WIDTH PAVEMENT REPAIR	340	SY	$75	$25,500
12	TOPSOIL/SEED/HYDROMULCH	15,490	SY	$2	$30,980
				SUBTOTAL	**$711,840**
				Mobilization (10%)	$71,180
				Engineering & Surveying (12%)	$93960
				Contingencies (30%)	$263090
				GRAND TOTAL	**$1,140,070**

Alternative 3 – SCS Dam Site 38 Rip-Rap Reinforcement

Concerns have been raised by city staff about possible erosion at the outfall of the SCS Dam Site 38. As a result, one of the proposed projects is to reinforce this outfall. The proposed design is similar to the existing reinforcement, but has been modified slightly to increase the design life. The dam as-built plans indicate that a rip-rap scour hole (i.e. dissipater pool) is currently in place at the dam outfall. Since a rip-rap reinforced scour hole dissipates energy coming from the outfall, Halff Associates highly recommends that this scour hole remain in place. Since 24” rip-rap is currently placed in this scour hole, 36” rip-rap is recommended to improve the life of the design. Downstream of the dissipater pool, rock rip-rap is proposed for an additional 150-ft in order to direct flow around a bend in the river. This portion of rip-rap is proposed to cover the width of the floodplain and be 18” thick. Figure 5 shows the conceptual layout of the rip-rap reinforcement, and Table 3 details the engineer’s opinion of probable cost. The estimate comes to $182,170, and includes 900 square yards of 18” rock rip-rap and 1,030 square yards of 36” rock rip-rap. It should be noted that the cost estimate does not include right-of-way acquisition or expenses associated with environmental challenges that are often encountered during planning and construction.

Table 3: SCS Dam Site 38 Rip-Rap Reinforcement Opinion of Probable Cost

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
1	Preparation of Right of Way	1,930	SY	$5,000.00	$6,930
2	18" ROCK RIP RAP	900	SY	$50	$45,000
3	36" ROCK RIP RAP	1,030	SY	$60	$61,800
				SUBTOTAL	**$113,730**
				Mobilization (10%)	$11,400
				Engineering & Surveying (12%)	$15,000
				Contingencies (30%)	$42,040
				GRAND TOTAL	**$182,170**

Other Areas Investigated

Though only two projects are proposed in this report, several other flood mitigation alternatives were analyzed and not deemed to be feasible. Each of these is discussed below.

1. Oak Creek Circle Levee

Oak Creek Circle is a neighborhood influenced by backwater from Plum Creek. Several houses in the neighborhood are within the 1% ACE floodplain, and almost all of the outer houses are within the 0.2% ACE floodplain. Given the large amount of water flowing in Plum Creek, channel improvements would not be a feasible alternative to solve this situation. The 1% ACE water surface elevation in Plum Creek is almost 10-ft higher than the elevation in Salt Branch at this location. Therefore, either the flow in Plum Creek must be drastically reduced, or a levee must be constructed to protect the neighborhood. Since Plum Creek alternatives are scheduled for the next phase of this project, this section discusses a levee alternative that was analyzed.

Figure 6 shows the levee design layout that was investigated around the Oak Creek Circle neighborhood. The levee was given 4:1 side slopes, at least a 15-ft wide top width, and was set to be 4-ft higher than the 1% ACE storm elevation in Plum Creek. The main obstacle with this design proved to be room for design and the amount of fill that would be required to successfully protect the neighborhood. To obtain enough right-of-way (ROW) for construction, several houses on the northern side of Oak Creek Circle would need to be purchased in order to make room for the levee and to construct a channel that would divert internal drainage to a nearby sump area. Table 4 presents the engineer's opinion of probable cost for the levee design. The cost of easement acquisition is not included in this opinion of probable cost: It should also be noted that the cost estimate does not include expenses associated with environmental challenges that are often encountered during planning and construction.

Table 4: Salt Branch Levee Opinion of Probable Cost

ITEM	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
1	PREPARATION OF RIGHT OF WAY	3.13	AC	$5,000	$15,700
3	UTILITY RELOCATIONS	1	LS	$25,000	$25,000
4	EXCAVATION (LEVEE)	12,500	CY	$10	$125,000
5	EXCAVATION (POND)	39,500	CY	$10	$395,000
6	LEVEE EMBANKMENT	112,000	CY	$10	$1,120,000
7	60" RCP POND OUTFALL	230	LF	$180	$41,400
8	POND OUTFALL STRUCTURE/SLUICE GATE/FLAP GATE	1	LS	$40,000	$40,000
9	TOPSOIL/SEED/HYDROMULCH	45,000	SY	$2	$90,000
10	LEVEE ACCESS ROAD - 12' WIDE	3,800	SY	$75	$285,000
				SUBTOTAL	**$2,137,100**
				Mobilization (10%)	$213,700
				Engineering & Surveying (12%)	$282,100
				Contingencies (30%)	$789,900
				GRAND TOTAL	**$3,422,800**

The final estimate for this project comes to $3,422,800, and includes unit prices that were generally based on TXDOT item numbers. The cost of easement acquisition is not included in this opinion of probable cost: It should also be noted that the cost estimate does not include expenses associated with environmental challenges that are often encountered during planning and construction. This cost estimate includes, but is not limited to, the levee embankment, levee excavation, and sump area excavation. This preliminary investigation suggests that it would most likely be more cost effective to purchase the houses in the floodplain than to construct the levee design, since the design would require many of these houses to be purchased anyway.

2. Floodplain Reduction on Country Oaks Drive

Another area of concern is Country Oaks Drive, which contains ten houses and eight empty lots. The first five houses on this street were said to have flooded during the October 1998 flood event, and the first nine properties are all in the 1% ACE floodplain. Flooding on this street is directly related to water surface elevations in Plum Creek. As with the houses on Oak Creek Circle, the most feasible ways to protect against Plum Creek are either to lower elevations in Plum Creek (which is included in Phase 2 of this project), or to construct levee protection. Several issues arise regarding the placement of a levee along this street. One issue is that Country Oaks Drive is parallel to East Pierce Street (HWY 183). Levee protection for Country Oaks Drive would require raising surrounding roads such as Southern Way, which runs underneath East Pierce Street. Due to clearance requirements underneath Pierce Street, raising Southern Way is not a feasible option. Raising Country Oaks Drive is also not feasible since the design would still need to tie-in to the existing home-site foundations. Furthermore, there is not enough room for both a levee and a drainage ditch to collect runoff along Country Oaks Drive. Though floodplain reduction along Country Oaks Drive is not feasible for the existing structures, one option may be to fill the land on the vacant lots. About 10-ft of fill would be required in some areas in order to raise ground elevations to the 1% ACE flood elevations. However, since the fill would be located in the ineffective flow shadow of the East Pierce Street bridge structure, there would mostly likely not be any negative hydraulic or hydrologic impacts cause by the fill. This option would have to be approached carefully in order to tie-in to Country Oaks Drive and to avoid negative local drainage impacts caused by raising the plots of land.

3. Floodplain Reduction along Oakview Road

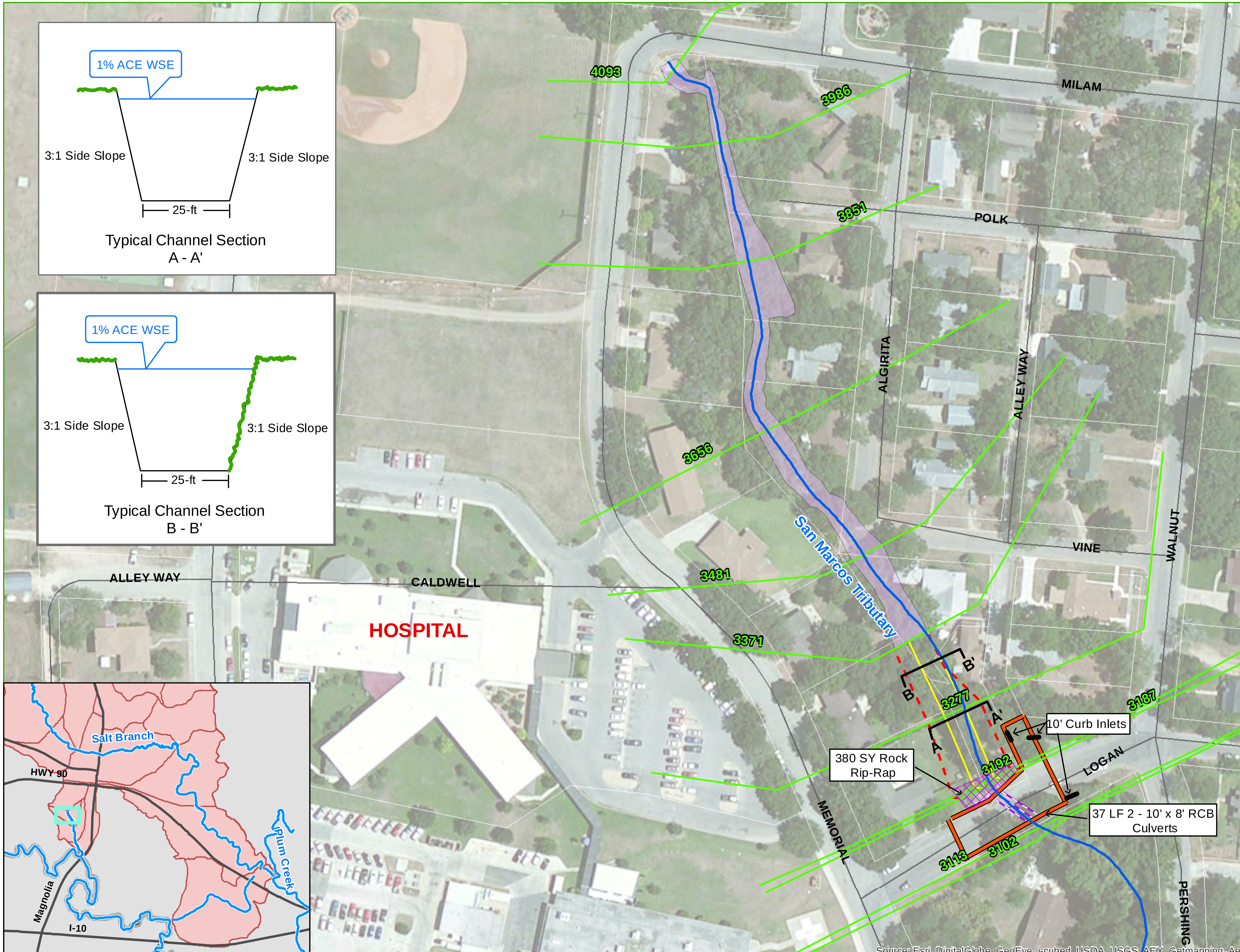
Oakview Road is located off of East Pierce Street and contains around 20 homes. About six of these homes are in the 1% ACE floodplain, and about ten are in the 0.2% ACE floodplain. Oakview Road is located in an area of spill flow from the San Marcos River to Plum Creek, which reaches a peak flow of approximately 44,800 cfs during the 1% ACE storm event, and around 105,200 cfs during the 0.2% ACE storm event. This spill area also contains flow moving from Plum Creek to the San Marcos River, though it is small in comparison. During the 1% ACE storm event, approximately 2,600 cfs spills from Plum Creek, and 5,200 cfs spills during the 0.2% ACE storm event.

Initial thoughts were to provide channel excavation in the spill flow area to lower water surface elevations. However, such improvements would hardly make a difference when faced with the 47,400 cfs moving through the overflow area. A second option would be to build a ring levee surrounding the homes similar to the Oak Creek Circle Levee. However, such a structure would need to essentially completely surround the homes since water is spilling both from the San Marcos River and from Plum Creek. This option would end up being very costly not only because of the fill needed for the levee design, but also because of internal drainage issues that would need to be addressed. Similar to the Oak Creek Circle Levee, the more economical and feasible option would be to purchase the properties in the floodplain. The San Marcos Overflow area also has a second group of homes bordering the 1% ACE floodplain on Eagle Dr., many of which are in the 0.2% ACE floodplain. However, because these structures are not in the 1% ACE floodplain and are not critical facilities, no project designs were pursued.

4. Confluence of the San Marcos River and the San Marcos Tributary

One of the most flood-prone areas in the City of Luling is the confluence of the San Marcos Tributary with the San Marcos River. Backwater from the San Marcos River reaches past Glendale Lane and puts several homes and businesses in the floodplain. However, similar to other areas discussed above in relation to Plum Creek, the water surface elevations in this area are controlled by the San Marcos River; the structures surrounding the creek do not flood due to influences from the tributary itself. Therefore, to reduce the flood risk at the confluence, flows in the San Marcos River must be reduced or a levee must be built to protect the structures. Unfortunately, a levee in this area is not feasible. The area is fully developed and there is no room for such a structure. If a levee design were to be pursued, many of the structures that are at risk would need to be purchased in order to make room for the levee, similar to the Oak Creek Circle levee option. The Zedler Mill is one of the most flood-prone structures in this area, as it has the lowest slab elevation and is located directly at the confluence. A regional detention alternative is proposed in the Upper Blanco River watershed (See Project Area 3 Regional Detention), but is likely too far upstream to provide much benefit to the area.

Figures and Tables



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GBRA
Interim Feasibility Study

Alternative Development and Benefit-Cost Analysis

Key to Features

- San Marcos Tributary
- Cross Sections

Improvements Conceptual Layout

- Proposed 10 x 8 RCB Culverts
- Proposed Limit of Roadway Raising
- Proposed Channel Toes
- Proposed Channel Tops
- Proposed Clearing of Trees

* NOTE: Design Items not drawn to scale

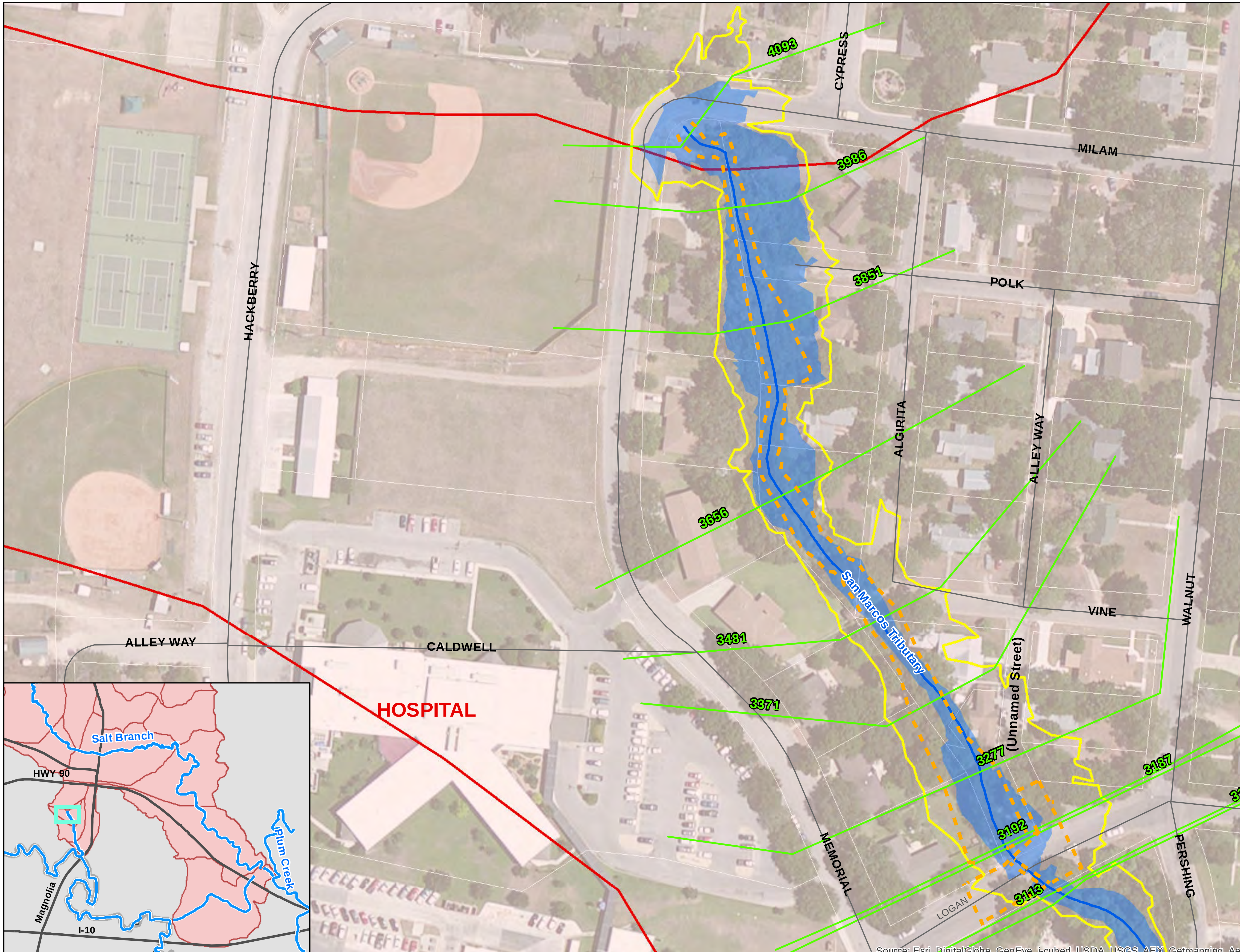
Figure 1:

San Marcos Tributary Proposed Improvements Conceptual Layout

0 50 100 200 Feet

1 inch = 100 feet

HALFF
300 EAST SONTERRA BLVD., SUITE 230
SAN ANTONIO, TEXAS 78258-3991
TEL (210) 798-1895
FAX (210) 798-1896
TBPE FIRM REGISTRATION #312



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Alternative Development and Benefit-Cost Analysis

Key to Features

- Proposed Improvements
- Cross Sections
- San Marcos Tributary
- Proposed 100-Year Floodplain
- Existing 100-YR Floodplain
- Subbasins

Figure 2:

San Marcos Tributary Floodplain Mapping

N W E S

0 50 100 200 Feet

1 inch = 100 feet

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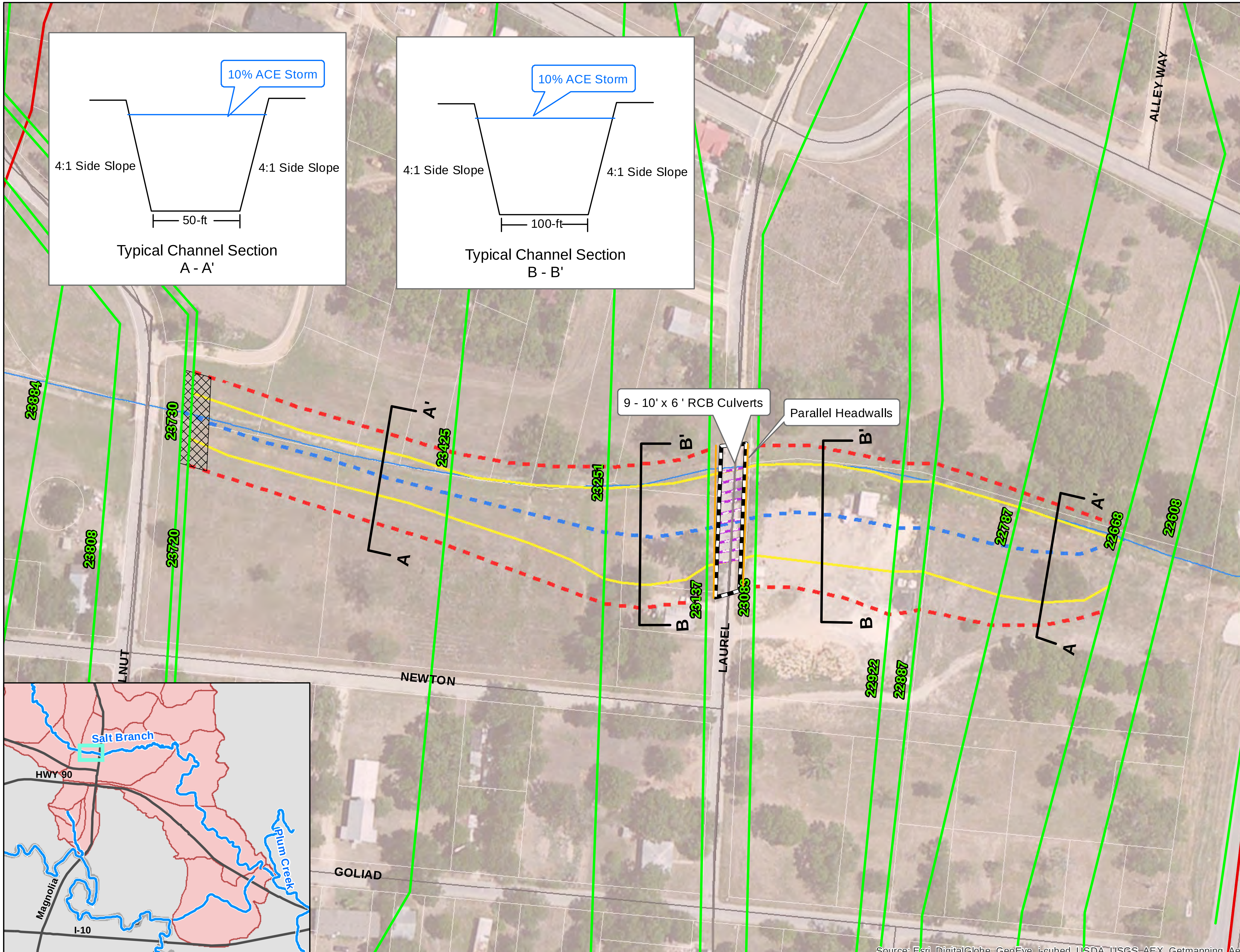
FAX (210) 798-1896
TBPE FIRM REGISTRATION #312



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Alternative Development and Benefit-Cost Analysis

Key to Features

- Salt Branch
- Cross Sections
- Subbasins

Improvements Conceptual Layout

- Proposed 10 x 6 RCB Culverts
- Proposed Channel Toes
- Proposed Channel Tops
- Proposed Channel Centerline
- Proposed Rock Rip-Rap
- Proposed Pavement Repair

* NOTE: Design Items not drawn to scale

Figure 3:

Salt Branch
Proposed Improvements
Conceptual Layout

N W E S

0 50 100 200 Feet

1 inch = 100 feet

HALFF

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SAN ANTONIO, TEXAS 78258-3991
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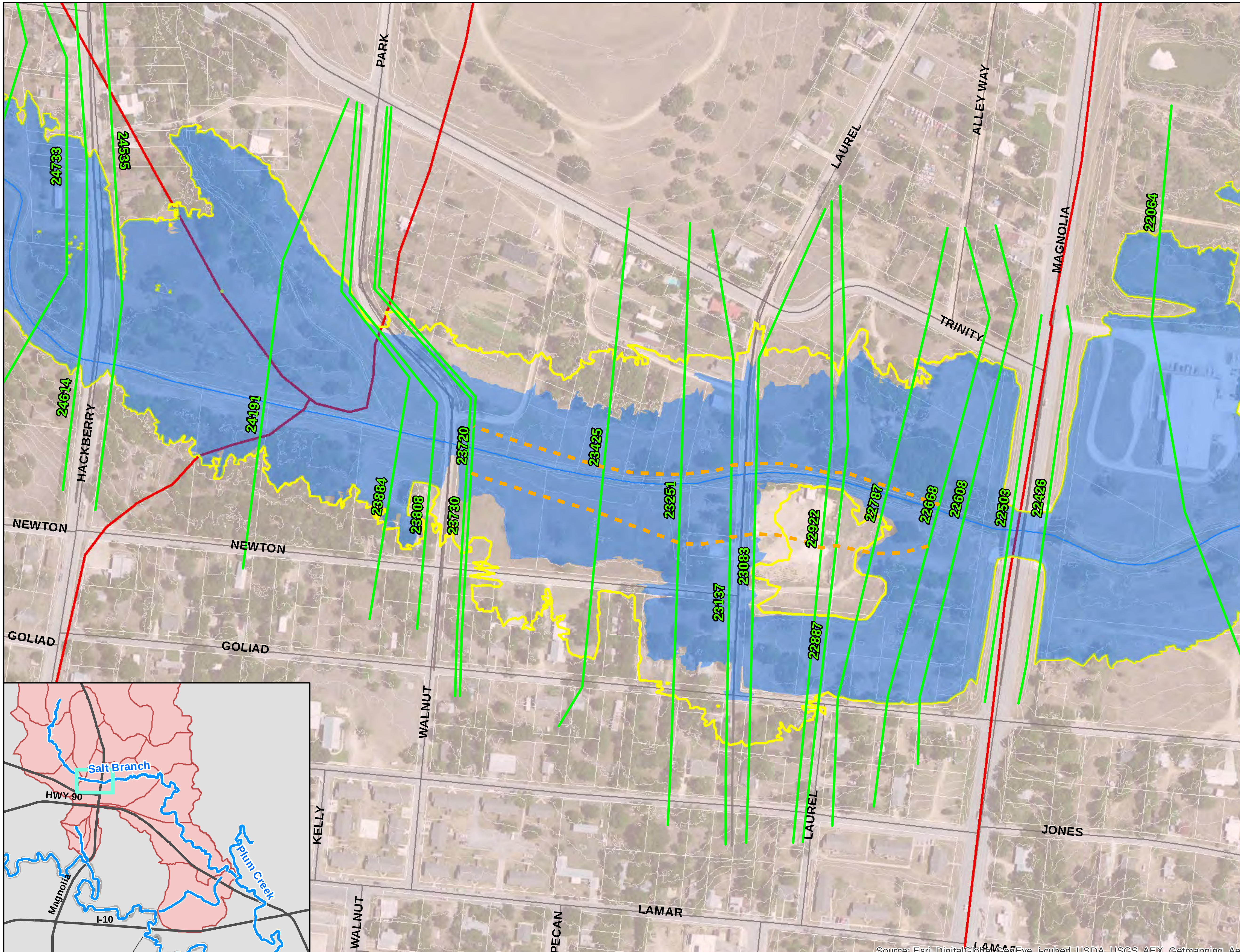

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Alternative Development and Benefit-Cost Analysis

Key to Features

- Proposed Improvements
- Salt Branch
- Cross Sections
- Proposed 100-Year Floodplain
- Existing 100-Year Floodplain
- Subbasins

Figure 4:

Salt Branch
Floodplain Mapping

N
W E
S

0 100 200 400
Feet

1 inch = 200 feet

HALFF

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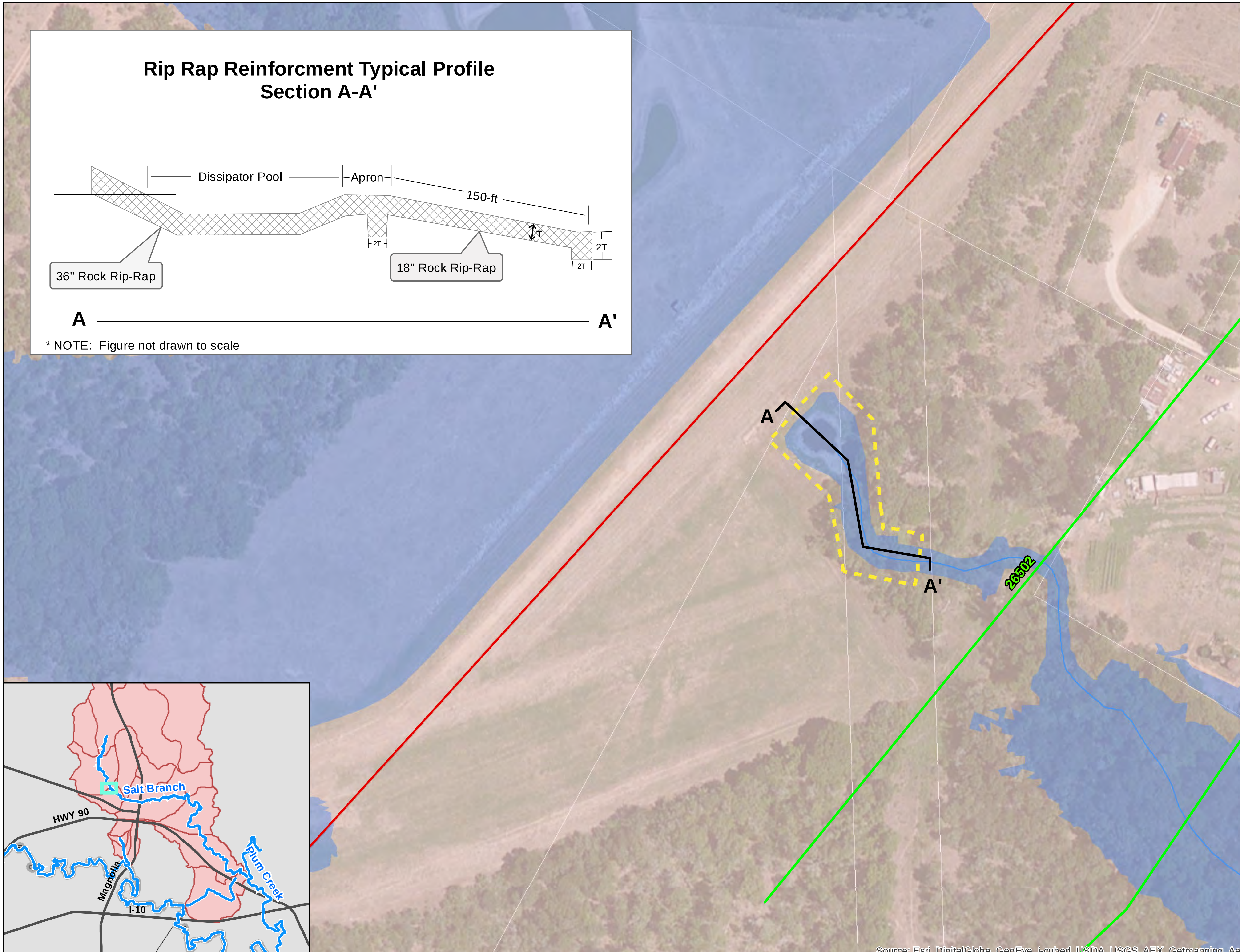

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Alternative Development and Benefit-Cost Analysis

Key to Features

- Salt Branch
- Cross Sections
- Subbasins
- Rock Rip Rap Reinforcement
- Existing 100-YR Floodplain

* NOTE: Design Items not drawn to scale

Figure 5:

NRCS Dam Outfall
Rip-Rap Reinforcement
Conceptual Layout

N
W
E
S

0 50 100 200
Feet

1 inch = 100 feet

HALFF

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SAN ANTONIO, TEXAS 78258-3991
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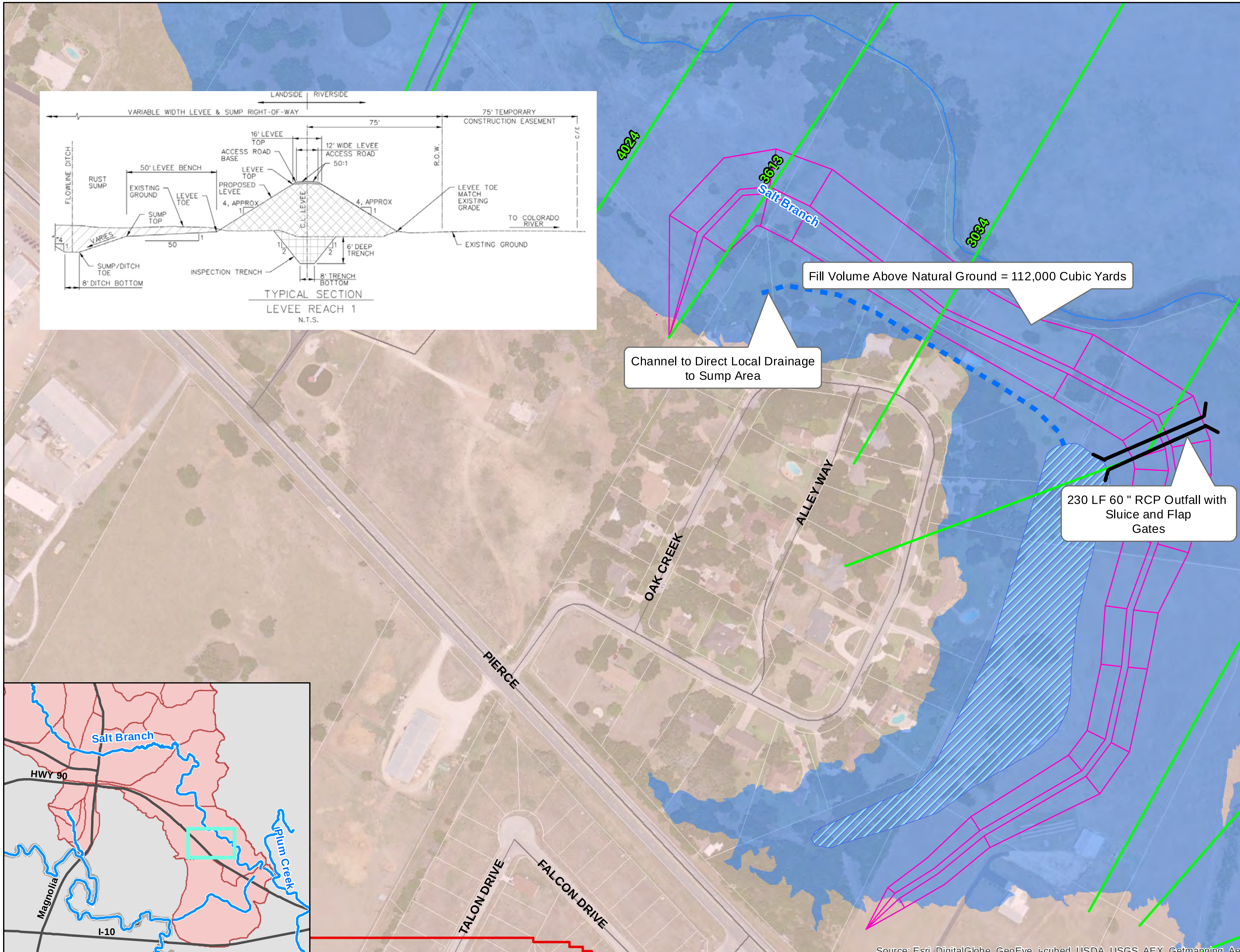

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Interim Feasibility Study

Alternative Development and Benefit-Cost Analysis

Key to Features

- Salt Branch
- Cross Sections
- Levee Conceptual Layout
- Sump Area
- 100-Year Floodplain (Plum Backwater)
- Subbasins

* NOTE: Design Items not drawn to scale

Figure 6:

Salt Branch Levee Conceptual Layout

N W E S

0 100 200 400 Feet

1 inch = 200 feet

HALFF

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San Marcos Tributary Existing and Proposed Water Surface Elevations

Location	Improvements	River Station	Exis 50% ACE WSE (ft)	Prop 50% ACE WSE (ft)	Diff (ft)	Exis 20% ACE WSE (ft)	Prop 20% ACE WSE (ft)	Diff (ft)	Exis 10% ACE WSE (ft)	Prop 10% ACE WSE (ft)	Diff (ft)	Exis 4% ACE WSE (ft)	Prop 4% ACE WSE (ft)	Diff (ft)
		4093	390.14	389.54	-0.6	390.84	390.36	-0.48	391.21	390.78	-0.43	391.66	391.22	-0.44
	Culvert Crossing and Channel Improvements	3986	389.26	388.64	-0.62	389.77	389.12	-0.65	390.07	389.44	-0.63	390.43	389.95	-0.48
		3851	387.94	387.3	-0.64	388.52	387.94	-0.58	388.78	388.25	-0.53	389.17	388.62	-0.55
		3656	384.9	384.52	-0.38	385.99	385.35	-0.64	386.53	385.85	-0.68	387.05	386.31	-0.74
		3481	383.61	381	-2.61	384.44	381.84	-2.6	384.91	382.34	-2.57	385.37	382.99	-2.38
		3371	382.92	379.2	-3.72	383.58	379.37	-4.21	383.9	379.62	-4.28	384.32	380.14	-4.18
		3277	382.52	377.64	-4.88	383.09	378.57	-4.52	383.31	379.05	-4.26	383.69	379.98	-3.71
		3192	382.42	377.62	-4.8	382.93	378.57	-4.36	383.1	379.05	-4.05	383.42	379.98	-3.44
		3187	382.37	377.58	-4.79	382.86	378.46	-4.4	383.04	378.92	-4.12	383.33	379.74	-3.59
Logan Street		3153	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		3113	377.51	377.44	-0.07	378.67	378.23	-0.44	379.27	378.63	-0.64	380.94	379.33	-1.61
		3102	376.98	376.98	0	377.59	377.59	0	377.89	377.89	0	378.4	378.4	0
		2863	373.58	373.58	0	374.22	374.21	-0.01	374.54	374.53	-0.01	375.11	375.11	0
		2686	369.58	369.58	0	370.1	370.11	0.01	370.38	370.38	0	370.84	370.85	0.01
		2642	369.37	369.37	0	370.02	370.01	-0.01	370.35	370.35	0	370.93	370.92	-0.01
		2495	366.45	366.45	0	367.1	367.1	0	367.43	367.43	0	367.91	367.91	0
		2340	361.55	361.55	0	362.75	362.74	-0.01	363.33	363.33	0	364.45	364.44	-0.01
		2155	360.7	360.7	0	361.83	361.83	0	362.36	362.36	0	363.52	363.52	0
		1873	358.54	358.54	0	359.56	359.56	0	360.13	360.13	0	361.53	361.53	0
		1618	356.16	356.16	0	357.77	357.77	0	358.57	358.56	-0.01	360.51	360.51	0
		1522	355.64	355.64	0	357.37	357.37	0	358.2	358.2	0	360.29	360.29	0
		1420	354.68	354.68	0	356.28	356.28	0	357.04	357.04	0	359.84	359.84	0
Glendale Lane		1406	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		1388	351.9	351.9	0	352.83	352.83	0	353.22	353.21	-0.01	354.19	354.19	0
		1273	350.79	350.8	0.01	351.79	351.79	0	352.22	352.22	0	353.2	353.2	0
		1158	350.19	350.19	0	351.05	351.05	0	351.41	351.41	0	352.26	352.26	0
		1114	349.89	349.89	0	350.64	350.64	0	350.95	350.94	-0.01	351.64	351.63	-0.01
		1055	348.45	348.45	0	348.98	348.98	0	349.24	349.24	0	349.77	349.77	0
		918	347.17	347.17	0	348.29	348.29	0	348.72	348.72	0	349.75	349.75	0
		726	347	347	0	347.94	347.93	-0.01	348.28	348.28	0	349.1	349.1	0
		628	346.96	346.96	0	347.85	347.85	0	348.17	348.17	0	348.93	348.93	0
		618	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		605	346.96	346.96	0	347.84	347.84	0	348.16	348.16	0	348.91	348.91	0
		586	346.96	346.96	0	347.84	347.84	0	348.17	348.17	0	348.92	348.92	0
		565	346.96	346.96	0	347.83	347.83	0	348.16	348.16	0	348.91	348.91	0
		556	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		545	346.95	346.95	0	347.8	347.8	0	348.12	348.12	0	348.84	348.84	0
		439	346.92	346.92	0	347.74	347.74	0	348.04	348.04	0	348.73	348.73	0
		377	346.92	346.92	0	347.73	347.73	0	348.03	348.03	0	348.71	348.71	0
		323	346.92	346.92	0	347.73	347.73	0	348.03	348.03	0	348.71	348.71	0
		225	346.91	346.91	0	347.72	347.72	0	348.01	348.01	0	348.69	348.69	0
		183	0	0	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		129	329.6	329.6	0	330.64	330.64	0	331	331	0	331.86	331.86	0
		113	329.23	329.23	0	330.16	330.16	0	330.44	330.44	0	331.21	331.21	0

San Marcos Tributary Existing and Proposed Water Surface Elevations

Location	Improvements	River Station	Exis 2% ACE WSE (ft)	Prop 2% ACE WSE (ft)	Diff (ft)	Exis 1% ACE WSE (ft)	Prop 1% ACE WSE (ft)	Diff (ft)	Exis 0.4% ACE WSE (ft)	Prop 0.4% ACE WSE (ft)	Diff (ft)	Exis 0.2% ACE WSE (ft)	Prop 0.2% ACE WSE (ft)	Diff (ft)
		4093	391.92	391.45	-0.47	392.19	391.69	-0.5	392.53	392.03	-0.5	392.84	392.37	-0.47
		3986	390.66	390.27	-0.39	390.87	390.52	-0.35	391.18	390.82	-0.36	391.42	390.95	-0.47
		3851	389.41	388.85	-0.56	389.66	389.08	-0.58	390.02	389.41	-0.61	390.28	389.68	-0.6
		3656	387.34	386.59	-0.75	387.61	386.89	-0.72	387.98	387.3	-0.68	388.26	387.62	-0.64
		3481	385.61	383.38	-2.23	385.86	383.79	-2.07	386.19	384.35	-1.84	386.43	384.87	-1.56
		3371	384.59	380.89	-3.7	384.88	382.25	-2.63	385.25	383.39	-1.86	385.49	383.86	-1.63
		3277	383.97	380.86	-3.11	384.3	382.27	-2.03	384.64	383.42	-1.22	384.88	383.91	-0.97
		3192	383.7	380.87	-2.83	384.04	382.27	-1.77	384.37	383.43	-0.94	384.58	383.92	-0.66
		3187	383.54	380.5	-3.04	383.77	382.13	-1.64	383.99	383.21	-0.78	384.12	383.65	-0.47
Logan Street		3153	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		3113	381.46	379.95	-1.51	382.03	381.21	-0.82	382.65	382.05	-0.6	382.99	382.59	-0.4
		3102	378.86	378.86	0	379.45	379.45	0	380.02	380.02	0	380.41	380.41	0
		2863	375.62	375.62	0	376.27	376.27	0	376.89	376.89	0	377.31	377.31	0
		2686	371.3	371.3	0	371.96	371.96	0	372.61	372.61	0	373.02	373.02	0
		2642	371.44	371.44	0	372.11	372.11	0	372.74	372.74	0	373.16	373.16	0
		2495	368.33	368.33	0	368.87	368.87	0	369.37	369.37	0	369.7	369.7	0
		2340	365.28	365.27	-0.01	366.28	366.28	0	367.2	367.19	-0.01	367.79	367.79	0
		2155	364.37	364.37	0	365.36	365.36	0	366.27	366.27	0	366.88	366.88	0
		1873	362.25	362.25	0	363.1	363.1	0	363.77	363.77	0	364.21	364.2	-0.01
		1618	361.16	361.16	0	362.1	362.1	0	362.73	362.73	0	363.13	363.13	0
		1522	360.9	360.9	0	361.82	361.82	0	362.39	362.38	-0.01	362.73	362.73	0
		1420	360.35	360.35	0	361.33	361.33	0	361.86	361.86	0	362.17	362.17	0
Glendale Lane		1406	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		1388	355.23	355.23	0	357.33	357.33	0	357.86	357.86	0	358.27	358.27	0
		1273	354.01	354.01	0	354.86	354.86	0	355.71	355.72	0.01	356.29	356.3	0.01
		1158	352.95	352.95	0	353.72	353.72	0	354.58	354.59	0.01	355.21	355.21	0
		1114	352.14	352.13	-0.01	352.58	352.58	0	353.24	353.24	0	353.83	353.83	0
		1055	350.41	350.41	0	351.8	351.8	0	352.93	352.93	0	353.76	353.76	0
		918	350.81	350.81	0	351.93	351.93	0	352.98	352.98	0	353.77	353.77	0
		726	349.93	349.93	0	350.78	350.78	0	351.57	351.57	0	352.25	352.25	0
		628	349.68	349.68	0	350.44	350.44	0	351.13	351.14	0.01	351.7	351.7	0
		618	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		605	349.65	349.65	0	350.4	350.4	0	351.07	351.07	0	351.61	351.62	0.01
		586	349.68	349.68	0	350.46	350.46	0	351.16	351.17	0.01	351.75	351.75	0
		565	349.67	349.67	0	350.44	350.44	0	351.15	351.15	0	351.73	351.73	0
		556	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		545	349.56	349.56	0	350.29	350.29	0	350.95	350.95	0	351.5	351.5	0
		439	349.4	349.4	0	350.08	350.08	0	350.69	350.69	0	351.19	351.19	0
		377	349.39	349.39	0	350.07	350.07	0	350.69	350.69	0	351.2	351.2	0
		323	349.38	349.38	0	350.06	350.06	0	350.68	350.68	0	351.19	351.19	0
		225	349.35	349.35	0	350.02	350.02	0	350.63	350.63	0	351.13	351.13	0
		183	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		129	332.72	332.72	0	333.57	333.57	0	334.31	334.31	0	334.88	334.88	0
		113	331.83	331.83	0	332.45	332.45	0	333.03	333.03	0	333.5	333.5	0

San Marcos Tributary Existing and Proposed Velocities

Location	Improvements	River Station	Exis 50% ACE VEL (ft/s)	Prop 50% ACE VEL (ft/s)	Diff (ft/s)	Exis 20% ACE VEL (ft/s)	Prop 20% ACE VEL (ft/s)	Diff (ft/s)	Exis 10% ACE VEL (ft/s)	Prop 10% ACE VEL (ft/s)	Diff (ft/s)	Exis 4% ACE VEL (ft/s)	Prop 4% ACE VEL (ft/s)	Diff (ft/s)
		4093	2.84	3.56	0.72	3.63	4.21	0.58	4.14	4.68	0.54	4.83	5.46	0.63
	Culvert Crossing and Channel Improvements	3986	4.29	5.79	1.5	5.26	7.29	2.03	5.69	7.97	2.28	6.19	8.29	2.1
		3851	3.02	4.69	1.67	3.45	4.83	1.38	3.8	5.11	1.31	4.13	5.53	1.4
		3656	5.44	6.56	1.12	5.26	7.03	1.77	5.21	7.11	1.9	5.5	7.69	2.19
		3481	2.93	8.14	5.21	3.57	8.92	5.35	3.88	9.27	5.39	4.4	9.62	5.22
		3371	3.3	5.04	1.74	3.94	7.19	3.25	4.37	7.92	3.55	4.79	8.08	3.29
		3277	2.56	6.25	3.69	3.27	5.37	2.1	3.8	5.41	1.61	4.32	5.01	0.69
		3192	1.59	2.69	1.1	2.16	2.99	0.83	2.57	3.24	0.67	3.03	3.31	0.28
		3187	2.19	2.88	0.69	2.8	3.56	0.76	3.15	3.91	0.76	3.79	4.53	0.74
Logan Street		3153	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		3113	10.88	2.93	-7.95	12.54	3.69	-8.85	13.42	4.09	-9.33	8.75	4.82	-3.93
		3102	5.43	5.43	0	6.58	6.57	-0.01	7.16	7.16	0	8.18	8.17	-0.01
		2863	3.74	3.75	0.01	4.2	4.2	0	4.45	4.46	0.01	4.89	4.89	0
		2686	6.57	6.56	-0.01	7.73	7.71	-0.02	8.25	8.24	-0.01	9.2	9.18	-0.02
		2642	3.16	3.16	0	3.7	3.71	0.01	3.98	3.99	0.01	4.5	4.5	0
		2495	7.45	7.45	0	7.92	7.92	0	8.06	8.06	0	8.58	8.58	0
		2340	3.26	3.27	0.01	3.72	3.72	0	3.96	3.97	0.01	4.32	4.32	0
		2155	3.4	3.4	0	3.92	3.92	0	4.19	4.19	0	4.45	4.45	0
		1873	4.63	4.63	0	5.16	5.16	0	5.23	5.23	0	5.27	5.27	0
		1618	4.32	4.32	0	4.07	4.07	0	3.91	3.91	0	3.42	3.42	0
		1522	3.46	3.47	0.01	3.52	3.52	0	3.45	3.45	0	3.17	3.17	0
		1420	5.36	5.36	0	6.18	6.18	0	6.51	6.51	0	4.19	4.19	0
Glendale Lane		1406	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		1388	9.45	9.46	0.01	10.77	10.78	0.01	11.48	11.49	0.01	12.97	12.97	0
		1273	4.21	4.2	-0.01	4.87	4.87	0	5.16	5.16	0	5.78	5.77	-0.01
		1158	3.53	3.53	0	4.27	4.27	0	4.61	4.61	0	5.33	5.33	0
		1114	3.98	3.98	0	4.91	4.91	0	5.34	5.35	0.01	6.33	6.34	0.01
		1055	7.11	7.11	0	7.81	7.81	0	7.95	7.95	0	8.57	8.57	0
		918	1.36	1.36	0	1.7	1.7	0	1.87	1.87	0	2.27	2.27	0
		726	2.16	2.16	0	3.45	3.45	0	3.9	3.9	0	5	5	0
		628	1.59	1.59	0	2.63	2.63	0	3.02	3.02	0	3.99	3.99	0
		618	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		605	1.42	1.42	0	2.38	2.38	0	2.74	2.74	0	3.65	3.65	0
		586	1.22	1.22	0	1.99	1.99	0	2.27	2.27	0	2.96	2.96	0
		565	1.11	1.11	0	1.82	1.82	0	2.08	2.08	0	2.73	2.73	0
		556	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		545	1.29	1.29	0	2.12	2.12	0	2.42	2.42	0	3.18	3.18	0
		439	1.21	1.21	0	1.98	1.98	0	2.27	2.27	0	2.99	2.99	0
		377	0.93	0.93	0	1.53	1.53	0	1.75	1.74	-0.01	2.28	2.28	0
		323	0.73	0.73	0	1.22	1.22	0	1.4	1.4	0	1.86	1.86	0
		225	0.66	0.66	0	1.1	1.1	0	1.26	1.26	0	1.67	1.67	0
		183	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		129	8.06	8.06	0	9.43	9.43	0	9.85	9.85	0	10.74	10.74	0
		113	4.25	4.25	0	5.01	5.01	0	5.3	5.3	0	5.74	5.74	0

San Marcos Tributary Existing and Proposed Velocities

Location	Improvements	River Station	Exis 2% ACE VEL (ft/s)	Prop 2% ACE VEL (ft/s)	Diff (ft/s)	Exis 1% ACE VEL (ft/s)	Prop 1% ACE VEL (ft/s)	Diff (ft/s)	Exis 0.4% ACE VEL (ft/s)	Prop 0.4% ACE VEL (ft/s)	Diff (ft/s)	Exis 0.2% ACE VEL (ft/s)	Prop 0.2% ACE VEL (ft/s)	Diff (ft/s)
		4093	5.25	6.01	0.76	5.63	6.55	0.92	6.25	7.27	1.02	5.61	7.71	2.1
		3986	6.49	8.42	1.93	6.87	8.78	1.91	7.25	9.45	2.2	7.61	10.36	2.75
		3851	4.32	5.79	1.47	4.47	6.05	1.58	4.67	6.4	1.73	4.84	6.62	1.78
		3656	5.71	7.99	2.28	5.96	8.24	2.28	6.34	8.59	2.25	6.57	8.86	2.29
		3481	4.75	9.84	5.09	5.04	9.96	4.92	5.44	10.09	4.65	5.74	9.85	4.11
		3371	4.97	7.07	2.1	5.11	5.51	0.4	5.24	5.1	-0.14	5.47	5.27	-0.2
		3277	4.48	4.48	0	4.52	3.66	-0.86	4.92	3.43	-1.49	5.09	3.56	-1.53
		3192	3.2	3.14	-0.06	3.29	2.72	-0.57	3.53	2.64	-0.89	3.76	2.77	-0.99
		3187	4.4	5.09	0.69	5.24	3.94	-1.3	6.05	4.4	-1.65	6.61	4.78	-1.83
Logan Street		3153	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		3113	8.91	5.49	-3.42	9.33	4.38	-4.95	9.27	4.95	-4.32	9.34	5.31	-4.03
		3102	9.03	9.03	0	10.05	10.05	0	10.9	10.9	0	11.36	11.36	0
		2863	5.3	5.3	0	5.82	5.82	0	6.3	6.3	0	6.61	6.61	0
		2686	9.91	9.91	0	10.63	10.63	0	11.19	11.19	0	11.62	11.62	0
		2642	4.96	4.97	0.01	5.55	5.56	0.01	6.12	6.12	0	6.48	6.49	0.01
		2495	9.07	9.07	0	9.7	9.7	0	10.3	10.3	0	10.75	10.75	0
		2340	4.77	4.77	0	5.4	5.4	0	6.01	6.02	0.01	6.43	6.43	0
		2155	4.82	4.82	0	5.33	5.33	0	5.78	5.78	0	6.04	6.04	0
		1873	6	6.01	0.01	6.78	6.78	0	7.63	7.63	0	8.22	8.22	0
		1618	3.92	3.93	0.01	4.29	4.29	0	4.8	4.8	0	5.14	5.14	0
		1522	3.75	3.75	0	4.24	4.24	0	4.87	4.87	0	5.32	5.33	0.01
		1420	4.91	4.91	0	5.11	5.11	0	5.69	5.69	0	6.11	6.11	0
Glendale Lane		1406	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		1388	14.22	14.22	0	10.05	10.05	0	10.81	10.81	0	11.2	11.2	0
		1273	6.46	6.46	0	7.29	7.29	0	8	7.99	-0.01	8.45	8.44	-0.01
		1158	6.13	6.13	0	7.03	7.03	0	7.67	7.66	-0.01	8.02	8.02	0
		1114	7.5	7.51	0.01	9.02	9.03	0.01	10.08	10.09	0.01	10.49	10.5	0.01
		1055	8.67	8.66	-0.01	7.28	7.27	-0.01	6.98	6.98	0	6.86	6.86	0
		918	2.64	2.64	0	3.08	3.08	0	3.5	3.5	0	3.76	3.76	0
		726	6.06	6.06	0	7.16	7.16	0	8.13	8.13	0	8.69	8.69	0
		628	4.99	4.99	0	6.07	6.07	0	7.12	7.12	0	8	8	0
		618	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		605	4.59	4.59	0	5.63	5.63	0	6.64	6.64	0	7.49	7.49	0
		586	3.65	3.65	0	4.38	4.38	0	5.08	5.08	0	5.64	5.64	0
		565	3.38	3.38	0	4.08	4.08	0	4.74	4.74	0	5.27	5.27	0
		556	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		545	3.94	3.94	0	4.74	4.74	0	5.49	5.49	0	6.1	6.1	0
		439	3.72	3.72	0	4.48	4.48	0	5.18	5.18	0	5.73	5.73	0
		377	2.81	2.81	0	3.37	3.37	0	3.91	3.91	0	4.34	4.34	0
		323	2.33	2.33	0	2.83	2.83	0	3.32	3.32	0	3.71	3.71	0
		225	2.09	2.09	0	2.54	2.54	0	2.98	2.98	0	3.33	3.33	0
		183	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		129	11.41	11.41	0	12.13	12.13	0	12.86	12.86	0	13.53	13.53	0
		113	6.28	6.28	0	6.88	6.88	0	7.4	7.4	0	7.82	7.82	0

Salt Branch Existing and Proposed Water Surface Elevations

Location	Improvements	River Station	Exis 50% ACE WSE (ft)	Prop 50% ACE WSE (ft)	Diff (ft)	Exis 20% ACE WSE (ft)	Prop 20% ACE WSE (ft)	Diff (ft)	Exis 10% ACE WSE (ft)	Prop 10% ACE WSE (ft)	Diff (ft)	Exis 4% ACE WSE (ft)	Prop 4% ACE WSE (ft)	Diff (ft)
		26502	380.68	380.68	0	380.73	380.73	0	380.79	380.79	0	380.93	380.93	0
		26153	380.17	380.17	0	380.21	380.21	0	380.25	380.25	0	380.34	380.34	0
		25722	378.55	378.55	0	378.56	378.56	0	378.58	378.58	0	378.62	378.62	0
		25360	376.39	376.39	0	376.89	376.89	0	377.22	377.22	0	377.85	377.85	0
		25137	376.09	376.09	0	376.57	376.57	0	376.89	376.89	0	377.53	377.53	0
		24733	375.98	375.98	0	376.32	376.32	0	376.51	376.51	0	376.93	376.93	0
		24614	375.96	375.96	0	376.28	376.28	0	376.45	376.45	0	376.82	376.82	0
N. Hackberry Ave.		24579	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		24535	374.01	374.01	0	374.52	374.52	0	374.81	374.81	0	375.19	375.19	0
		24191	371.73	371.49	-0.24	372.88	372.8	-0.08	373.54	373.54	0	374.42	374.35	-0.07
		23884	371.17	370.25	-0.92	372.39	372.05	-0.34	373.22	373.21	-0.01	374.13	374.03	-0.1
		23808	371.06	369.98	-1.08	372.06	371.63	-0.43	373.08	373.08	0	373.99	373.75	-0.24
N. Walnut Ave.	Culvert Crossing and Channel Improvements	23770	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23730	370.92	368.63	-2.29	371.51	369.69	-1.82	372.14	370.46	-1.68	373.16	372.11	-1.05
		23720	370.94	366.61	-4.33	371.63	367.97	-3.66	372.16	368.83	-3.33	373.19	370.37	-2.82
		23425	370.84	366.22	-4.62	371.39	367.56	-3.83	371.84	368.41	-3.43	372.79	369.85	-2.94
		23251	370.8	366.12	-4.68	371.27	367.45	-3.82	371.68	368.3	-3.38	372.62	369.74	-2.88
		23137	370.77	366.09	-4.68	371.16	367.42	-3.74	371.53	368.26	-3.27	372.48	369.69	-2.79
N. Laurel Ave.		23108	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23083	369.5	366.08	-3.42	370.74	367.39	-3.35	371.45	368.22	-3.23	372.42	369.56	-2.86
		22922	368.47	366.05	-2.42	369.46	367.35	-2.11	370.09	368.17	-1.92	370.87	369.5	-1.37
		22887	368.22	366.04	-2.18	369	367.34	-1.66	369.51	368.16	-1.35	370.6	369.48	-1.12
		22787	367.84	366.02	-1.82	368.61	367.32	-1.29	369.19	368.13	-1.06	370.21	369.46	-0.75
		22668	367.31	365.97	-1.34	368.05	367.24	-0.81	368.69	368.05	-0.64	369.85	369.37	-0.48
		22608	365.99	365.49	-0.5	367.26	367	-0.26	368.09	367.83	-0.26	369.43	369.19	-0.24
		22503	365.35	365.26	-0.09	366.83	366.76	-0.07	367.64	367.56	-0.08	368.91	368.8	-0.11
HWY 183/Magnolia		22473	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		22426	364.36	364.36	0	365.86	365.86	0	366.62	366.62	0	367.78	367.78	0
		22064	363.6	363.6	0	364.95	364.95	0	365.62	365.62	0	366.66	366.66	0
		21674	363.12	363.12	0	364.3	364.3	0	364.89	364.89	0	365.92	365.92	0
		21418	362.64	362.64	0	363.74	363.74	0	364.12	364.12	0	365.01	365.01	0
		21025	361.7	361.7	0	362.81	362.81	0	363.29	363.29	0	363.43	363.43	0
		20755	360.45	360.45	0	361.13	361.13	0	361.43	361.43	0	361.9	361.9	0
		20464	359.25	359.25	0	360.69	360.69	0	360.85	360.85	0	361.21	361.21	0
		20316	358.28	358.28	0	359.35	359.35	0	359.62	359.62	0	360.21	360.21	0
		20228	358.1	358.1	0	359.13	359.13	0	359.46	359.46	0	359.86	359.86	0
Spruce Ave.		20185	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		20160	357.89	357.89	0	358.63	358.63	0	359.06	359.06	0	359.59	359.59	0
		19897	357.39	357.39	0	358.29	358.29	0	358.75	358.75	0	359.22	359.22	0
		19327	356.29	356.29	0	356.83	356.83	0	357.32	357.32	0	357.77	357.77	0
		18769	355.08	355.08	0	355.48	355.48	0	355.87	355.87	0	356.53	356.53	0
		18439	354.17	354.17	0	354.88	354.88	0	355.26	355.26	0	356.04	356.04	0
		18291	353.88	353.88	0	354.59	354.59	0	354.99	354.99	0	355.82	355.82	0
		17852	353.39	353.39	0	353.67	353.67	0	354.23	354.23	0	355.09	355.09	0

Salt Branch Existing and Proposed Water Surface Elevations

Location	Improvements	River Station	Exis 2% ACE WSE (ft)	Prop 2% ACE WSE (ft)	Diff (ft)	Exis 1% ACE VEL WSE (ft)	Prop 1% ACE WSE (ft)	Diff (ft)	Exis 0.4% ACE WSE (ft)	Prop 0.4% ACE WSE (ft)	Diff (ft)	Exis 0.2% ACE WSE (ft)	Prop 0.2% ACE WSE (ft)	Diff (ft)
		26502	380.98	380.98	0	381.08	381.08	0	382.33	382.33	0	383.15	383.15	0
		26153	380.38	380.38	0	380.44	380.44	0	381.17	381.17	0	381.88	381.88	0
		25722	378.64	378.64	0	378.67	378.67	0	379.08	379.08	0	379.8	379.8	0
		25360	378.29	378.29	0	378.56	378.56	0	378.91	378.91	0	379.24	379.24	0
		25137	377.97	377.97	0	378.25	378.25	0	378.55	378.54	-0.01	378.78	378.78	0
		24733	377.24	377.24	0	377.45	377.45	0	377.62	377.6	-0.02	377.75	377.75	0
		24614	377.08	377.08	0	377.21	377.21	0	377.35	377.3	-0.05	377.45	377.45	0
N. Hackberry Ave.		24579	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		24535	375.46	375.46	0	375.59	375.59	0	375.78	375.77	-0.01	376.07	375.97	-0.1
		24191	375.02	374.89	-0.13	375.36	375.23	-0.13	375.68	375.58	-0.1	375.93	375.82	-0.11
		23884	374.68	374.5	-0.18	375	374.81	-0.19	375.28	375.12	-0.16	375.51	375.34	-0.17
		23808	374.47	374.25	-0.22	374.73	374.46	-0.27	374.93	374.69	-0.24	375.11	374.82	-0.29
N. Walnut Ave.	Culvert Crossing and Channel Improvements	23770	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23730	373.91	372.82	-1.09	374.39	372.97	-1.42	374.77	373.45	-1.32	375.08	373.64	-1.44
		23720	373.9	371.46	-2.44	374.37	372.2	-2.17	374.75	372.79	-1.96	375.06	373.25	-1.81
		23425	373.51	370.93	-2.58	373.99	371.68	-2.31	374.35	372.23	-2.12	374.66	372.71	-1.95
		23251	373.33	370.82	-2.51	373.8	371.57	-2.23	374.14	372.14	-2	374.45	372.62	-1.83
		23137	373.19	370.76	-2.43	373.68	371.51	-2.17	374.02	372.06	-1.96	374.33	372.54	-1.79
N. Laurel Ave.		23108	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23083	373.11	370.48	-2.63	373.58	371.35	-2.23	373.96	371.99	-1.97	374.25	372.47	-1.78
		22922	371.47	370.42	-1.05	372.18	371.29	-0.89	372.7	371.94	-0.76	373.1	372.42	-0.68
		22887	371.33	370.4	-0.93	372.08	371.26	-0.82	372.62	371.9	-0.72	373.02	372.38	-0.64
		22787	370.94	370.37	-0.57	371.71	371.24	-0.47	372.31	371.87	-0.44	372.77	372.35	-0.42
		22668	370.65	370.29	-0.36	371.48	371.15	-0.33	372.1	371.79	-0.31	372.57	372.27	-0.3
		22608	370.35	370.13	-0.22	371.24	371.01	-0.23	371.88	371.66	-0.22	372.37	372.13	-0.24
		22503	369.79	369.66	-0.13	370.6	370.44	-0.16	371.18	371.01	-0.17	371.61	371.43	-0.18
HWY 183/Magnolia		22473	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		22426	368.56	368.56	0	369.27	369.27	0	369.76	369.76	0	370.13	370.13	0
		22064	367.32	367.32	0	367.94	367.94	0	368.4	368.4	0	368.73	368.73	0
		21674	366.52	366.52	0	367.07	367.07	0	367.48	367.48	0	367.78	367.78	0
		21418	365.54	365.54	0	366.02	366.02	0	366.37	366.37	0	366.63	366.63	0
		21025	363.75	363.75	0	364.07	364.07	0	364.32	364.32	0	364.5	364.5	0
		20755	362.29	362.29	0	362.62	362.62	0	362.86	362.86	0	363.04	363.04	0
		20464	361.55	361.55	0	361.84	361.84	0	362.06	362.06	0	362.23	362.23	0
		20316	360.57	360.57	0	360.91	360.91	0	361.14	361.14	0	361.35	361.35	0
		20228	360.13	360.13	0	360.42	360.42	0	360.67	360.67	0	360.92	360.92	0
Spruce Ave.		20185	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		20160	359.94	359.94	0	360.34	360.34	0	360.65	360.65	0	360.89	360.89	0
		19897	359.56	359.56	0	359.97	359.97	0	360.29	360.29	0	360.54	360.54	0
		19327	358.25	358.25	0	358.76	358.76	0	359.14	359.14	0	359.43	359.43	0
		18769	357.11	357.11	0	357.68	357.68	0	358.11	358.11	0	358.43	358.43	0
		18439	356.7	356.7	0	357.3	357.3	0	357.75	357.75	0	358.09	358.09	0
		18291	356.51	356.51	0	357.12	357.12	0	357.58	357.58	0	357.92	357.92	0
		17852	355.76	355.76	0	356.36	356.36	0	356.8	356.8	0	357.13	357.13	0

Salt Branch Existing and Proposed Velocities

Location	Improvements	River Station	Exis 50% ACE VEL (ft/s)	Prop 50% ACE VEL (ft/s)	Diff (ft/s)	Exis 20% ACE VEL (ft/s)	Prop 20% ACE VEL (ft/s)	Diff (ft/s)	Exis 10% ACE VEL (ft/s)	Prop 10% ACE VEL (ft/s)	Diff (ft/s)	Exis 4% ACE VEL (ft/s)	Prop 4% ACE VEL (ft/s)	Diff (ft/s)
		26502	1.42	1.42	0	1.47	1.47	0	1.55	1.55	0	1.72	1.72	0
		26153	0.81	0.81	0	0.83	0.83	0	0.85	0.85	0	0.9	0.9	0
		25722	3.06	3.06	0	3.11	3.11	0	3.18	3.18	0	3.38	3.38	0
		25360	0.68	0.68	0	0.44	0.44	0	0.37	0.37	0	0.28	0.28	0
		25137	1.76	1.76	0	2.3	2.3	0	2.66	2.66	0	3.07	3.07	0
		24733	0.68	0.68	0	1.13	1.13	0	1.48	1.48	0	2.2	2.2	0
		24614	0.83	0.83	0	1.28	1.28	0	1.62	1.62	0	2.27	2.27	0
N. Hackberry Ave.		24579	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		24535	5.59	5.59	0	7.85	7.85	0	5.94	5.94	0	7.07	7.07	0
		24191	1.77	2.05	0.28	1.75	1.83	0.08	1.56	1.56	0	1.2	1.25	0.05
		23884	1.56	2.64	1.08	1.9	2.26	0.36	1.92	1.92	0	2.41	2.52	0.11
		23808	2.23	3.38	1.15	3.99	4.45	0.46	2.79	2.79	0	3.17	4.13	0.96
N. Walnut Ave.	Culvert Crossing and Channel Improvements	23770	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23730	2.51	6.67	4.16	5.08	8.88	3.8	4.34	10.15	5.81	4.94	8.21	3.27
		23720	1.71	1.98	0.27	2.85	2.7	-0.15	3.33	3.15	-0.18	3.67	4.13	0.46
		23425	1.01	1.8	0.79	1.84	2.55	0.71	2.33	3.02	0.69	3.06	4.07	1.01
		23251	0.82	0.85	0.03	1.56	1.27	-0.29	1.91	1.54	-0.37	2.23	2.1	-0.13
		23137	1.18	0.78	-0.4	2.27	1.2	-1.07	2.81	1.46	-1.35	3.11	2.06	-1.05
N. Laurel Ave.		23108	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23083	2.78	1.01	-1.77	3.22	1.39	-1.83	3.36	1.67	-1.69	3.36	2.18	-1.18
		22922	3.01	0.9	-2.11	4.38	1.29	-3.09	5.2	1.56	-3.64	6.66	2.04	-4.62
		22887	3.37	0.89	-2.48	5.19	1.28	-3.91	6.32	1.56	-4.76	6.18	2.05	-4.13
		22787	2.05	0.84	-1.21	2.59	1.23	-1.36	2.82	1.46	-1.36	3.36	1.8	-1.56
		22668	2.52	1.45	-1.07	3.07	2.07	-1	3.25	2.38	-0.87	3.18	2.79	-0.39
		22608	2.72	4.48	1.76	2.27	2.65	0.38	2.22	2.49	0.27	2.18	2.39	0.21
		22503	1.95	2.02	0.07	2.35	2.4	0.05	2.74	2.79	0.05	3.46	3.54	0.08
HWY 183/Magnolia		22473	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		22426	2.2	2.2	0	2.49	2.49	0	2.9	2.9	0	3.71	3.71	0
		22064	2.01	2.01	0	2.73	2.73	0	3.13	3.13	0	3.77	3.77	0
		21674	1.35	1.35	0	1.81	1.81	0	2.14	2.14	0	2.49	2.49	0
		21418	2.13	2.13	0	2.84	2.84	0	3.7	3.7	0	4.67	4.67	0
		21025	1.76	1.76	0	1.96	1.96	0	1.84	1.84	0	2.85	2.85	0
		20755	3.6	3.6	0	5.53	5.53	0	7.17	7.17	0	4.57	4.57	0
		20464	1.71	1.71	0	1.36	1.36	0	1.72	1.72	0	1.8	1.8	0
		20316	3.17	3.17	0	4.41	4.41	0	5.64	5.64	0	5.27	5.27	0
		20228	1.86	1.86	0	2.23	2.23	0	2.23	2.23	0	2.67	2.67	0
Spruce Ave.		20185	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		20160	1.9	1.9	0	1.87	1.87	0	1.88	1.88	0	2.04	2.04	0
		19897	1.89	1.89	0	1.59	1.59	0	1.53	1.53	0	1.92	1.92	0
		19327	1.77	1.77	0	3.07	3.07	0	3.39	3.39	0	3.32	3.32	0
		18769	1.88	1.88	0	1.73	1.73	0	1.88	1.88	0	2.15	2.15	0
		18439	2.02	2.02	0	2.3	2.3	0	2.6	2.6	0	2.46	2.46	0
		18291	1.61	1.61	0	1.93	1.93	0	1.98	1.98	0	2.11	2.11	0
		17852	1.37	1.37	0	2.42	2.42	0	2.36	2.36	0	2.73	2.73	0

Salt Branch Existing and Proposed Velocities

Location	Improvements	River Station	Exis 2% ACE VEL (ft/s)	Prop 2% ACE VEL (ft/s)	Diff (ft/s)	Exis 1% ACE VEL (ft/s)	Prop 1% ACE VEL (ft/s)	Diff (ft/s)	Exis 0.4% ACE VEL (ft/s)	Prop 0.4% ACE VEL (ft/s)	Diff (ft/s)	Exis 0.2% ACE VEL (ft/s)	Prop 0.2% ACE VEL (ft/s)	Diff (ft/s)
		26502	1.8	1.8	0	1.91	1.91	0	4.08	4.08	0	3.9	3.9	0
		26153	0.92	0.92	0	0.95	0.95	0	1.65	1.65	0	2.29	2.29	0
		25722	3.44	3.44	0	3.55	3.55	0	2.79	2.81	0.02	2.9	2.9	0
		25360	0.23	0.23	0	0.22	0.22	0	0.68	0.68	0	1.38	1.38	0
		25137	3.35	3.35	0	3.49	3.49	0	3.68	3.7	0.02	3.84	3.84	0
		24733	2.71	2.71	0	3	3	0	3.44	3.47	0.03	3.78	3.79	0.01
		24614	2.87	2.87	0	4.05	4.05	0	4.33	4.54	0.21	4.56	4.58	0.02
N. Hackberry Ave.		24579	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		24535	7.8	7.8	0	8.34	8.34	0	8.82	8.88	0.06	8.92	8.9	-0.02
		24191	1.29	1.36	0.07	1.35	1.42	0.07	1.47	1.52	0.05	1.55	1.61	0.06
		23884	2.89	3.07	0.18	3.18	3.37	0.19	3.44	3.68	0.24	3.61	3.86	0.25
		23808	3.94	4.24	0.3	4.48	4.92	0.44	5.1	5.51	0.41	5.53	6.08	0.55
N. Walnut Ave.	Culvert Crossing and Channel Improvements	23770	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23730	4.11	8.42	4.31	4.18	9.71	5.53	4.26	9.52	5.26	4.29	10	5.71
		23720	3.82	4.79	0.97	4.04	5.04	1	4.19	5.29	1.1	4.2	5.36	1.16
		23425	3.34	4.59	1.25	3.44	4.84	1.4	3.67	5.25	1.58	3.8	5.34	1.54
		23251	2.45	2.45	0	2.59	2.6	0.01	2.84	2.76	-0.08	2.97	2.83	-0.14
		23137	3.31	2.49	-0.82	3.35	2.68	-0.67	3.58	2.91	-0.67	3.66	3.02	-0.64
N. Laurel Ave.		23108	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		23083	3.48	2.58	-0.9	3.69	2.93	-0.76	3.82	3.14	-0.68	3.89	3.28	-0.61
		22922	7.45	2.33	-5.12	7.15	2.55	-4.6	6.93	2.67	-4.26	6.73	2.74	-3.99
		22887	6.14	2.39	-3.75	5.83	2.69	-3.14	5.62	2.87	-2.75	5.51	2.97	-2.54
		22787	3.59	2.09	-1.5	3.76	2.32	-1.44	3.7	2.49	-1.21	3.59	2.58	-1.01
		22668	3.06	2.98	-0.08	3.02	3.14	0.12	3.04	3.27	0.23	3.06	3.36	0.3
		22608	2.22	2.39	0.17	2.31	2.46	0.15	2.4	2.54	0.14	2.48	2.61	0.13
		22503	4.04	4.14	0.1	4.61	4.74	0.13	5.03	5.18	0.15	5.34	5.51	0.17
HWY 183/Magnolia		22473	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		22426	4.39	4.39	0	5.07	5.07	0	5.59	5.59	0	5.98	5.98	0
		22064	4.23	4.23	0	4.61	4.61	0	4.88	4.88	0	5.08	5.08	0
		21674	2.83	2.83	0	3.17	3.17	0	3.42	3.42	0	3.61	3.61	0
		21418	5.08	5.08	0	5.48	5.48	0	5.79	5.79	0	6	6	0
		21025	3.25	3.25	0	3.6	3.6	0	3.84	3.84	0	4.02	4.02	0
		20755	4.24	4.24	0	4.22	4.22	0	4.28	4.28	0	4.32	4.32	0
		20464	2.07	2.07	0	2.29	2.29	0	2.45	2.45	0	2.56	2.56	0
		20316	5.04	5.04	0	4.85	4.85	0	4.7	4.7	0	4.56	4.56	0
		20228	3.03	3.03	0	3.33	3.33	0	3.42	3.42	0	3.29	3.29	0
Spruce Ave.		20185	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--	Bridge/Culvert	Bridge/Culvert	--
		20160	2.25	2.25	0	2.38	2.38	0	2.41	2.41	0	2.45	2.45	0
		19897	1.97	1.97	0	2.06	2.06	0	2.12	2.12	0	2.15	2.15	0
		19327	3.4	3.4	0	3.42	3.42	0	3.48	3.48	0	3.55	3.55	0
		18769	2.27	2.27	0	2.47	2.47	0	2.55	2.55	0	2.6	2.6	0
		18439	2.44	2.44	0	2.5	2.5	0	2.55	2.55	0	2.6	2.6	0
		18291	2.19	2.19	0	2.27	2.27	0	2.36	2.36	0	2.41	2.41	0
		17852	3.11	3.11	0	3.43	3.43	0	3.65	3.65	0	3.81	3.81	0

Appendix E.3

PROJECT AREA 3 – REGIONAL DETENTION ALTERNATIVES

HALFF

Project Area 3
Guadalupe, San Marcos, and Blanco Rivers
Regional Detention Alternatives

Alternative 1: Detention on Bear Creek

The Bear Creek watershed is a 16.7 mi^2 watershed that empties into the Guadalupe River just upstream of New Braunfels, TX. The basin was chosen for alternative analysis because it is located upstream of New Braunfels and Seguin, which have approximately 1982 structures in the located in the 1% Annual Chance Exceedance (ACE) floodplain based on the hydraulic modeling performed in Appendix D.1.

The Bear Creek watershed resides within sub-basin Guad_010 within the hydrology model from Appendix B.1. In order to analyze the flow from the Bear Creek watershed the Guad_010 sub-basin was split into three smaller basins at the confluence of Bear Creek and the Guadalupe River. All hydrologic parameters were kept consistent with the original sub-basin except for the lag time. The lag times were adjusted for each of the three new sub-basins based on respective drainage area. A graphic showing the original sub-basin and split sub-basin is provided in Figure 1. Once the basin was split, the peaks arriving at the confluence of the Guadalupe River and Bear Creek were analyzed. It was determined that reducing the peak from Bear Creek through detention would provide benefits to the City of New Braunfels and Seguin. The resulting hydrographs at the confluence of Bear Creek and the Guadalupe River are shown in the “Figures and Tables” section.

Figure 2 presents a conceptual layout of the proposed detention site in the Bear Creek watershed. The proposed dam height of 85 ft. and dam length of 620 ft. will provide a maximum storage capacity of approximately 3,375 ac-ft. The dam size and location were chosen to minimize impacts on existing structures while minimizing construction cost and maximizing flood reduction benefits. A storage-elevation curve was created based upon 2007-2008 TNRIS LiDAR data and was entered into the updated HEC-HMS model with the split sub-basin at the Bear Creek confluence. Outlet structures were sized to pass the 1% ACE with at least one foot of freeboard and to contain the 0.2% ACE event without overtopping the dam. The outlet structure was composed of a reinforced concrete box culvert designed to pass the low flows. The overflow spillway for the dam was set at an elevation of 845 ft. The HEC-HMS model is provided in Appendix E.4.

The “Figures and Tables” section in this appendix contains tables showing the peak flow reduction and water surface reductions from existing to proposed conditions for all eight frequency storm events. The COE gage analysis, which is provided in Appendix B.1, was used for the flows in final hydraulic models instead of the resulting flows from the hydrology model. Therefore, the percent reduction in peak from the hydrology model for the pre and post-project conditions was applied to the COE gage analysis flows used in the final hydraulic model. These post-project flows were then entered into the hydraulic model to determine the reduction in water surface. The largest reduction in flow and water surface occurs within the City of New Braunfels. The post-project hydrology model shows a 20% reduction in peak flow for the 1% ACE event and water surface reduction over 1.5 ft. The detention on Bear Creek also reduces the peak elevation in the City of Seguin by 4% and reduces the water surface by more than 0.6 ft.

The engineer’s opinion of probable cost for this design project can be seen in Table 1. The estimated cost of the project comes to $5,575,763, and includes unit prices that were generally based on TXDOT item numbers. The cost of land acquisition is not included in the opinion of probable cost as it is variable and depends on the real estate market at the time of acquisition.

Table 1: Proposed Detention on Bear Creek Opinion of Probable Cost

TxDOT Item No.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
752-2022	Tree removal	150	EA	$400	$60,000
160-2003	Furnish and place Topsoil (4")	18800	SY	$1	$18,800
132-2005	Embankment (Type C)	220412	CY	$14	$3,085,768
432-2021	18" Concrete Rip Rap	700	CY	$90	$63,000
462-2030	10'x12' RC Box Culvert	450	LF	$618	$278,100
5941-2014	Hydromulch Seeding	18800	SY	$1	$18,800
169-2001	Soil retention blankets	20200	SY	$1	$20,200
	MOBILIZATION (10%)	1	LS	$354,467	$354,467
	ENGINEERING FEES (10%)	1	LS	$389,913	$389,913
				SUBTOTAL	**$4,289,048**
				Contingencies (30%)	$1,286,714
				TOTAL	**$5,575,763**

Alternative 2: Detention on the Blanco River

The next proposed project is a detention site located on the mainstem of the Blanco River upstream of the confluence with the Little Blanco River. The Blanco watershed upstream of the proposed dam site is 169 mi^2. This project area was chosen for analysis because it is upstream of the City of Wimberley and the City of San Marcos. There are approximately 330 structures at risk during the 1% ACE event according to the results in Appendix D.1. Most of these structures are located in the general area of the City of Wimberley and the City of San Marcos. It was determined that any reduction in peak along the Blanco River would be beneficial. Upon investigation of the hydrology model from Appendix B.1, it was found that the peak from the Little Blanco River sub-basin coincided with the peak from the Blanco River. A reduction and/or delay of either peak would help reduce the peak flow through the Blanco River downstream. A site on the Blanco mainstem was chosen because it was determined that reducing the flows coming down the Blanco River would have a greater impact downstream.

A graphic showing the proposed detention on the Blanco River is provided in Figure 3. The proposed dam height of 102 ft. and dam length of 1,840 ft. will provide a maximum storage capacity of approximately 1128 ac-ft. The dam size and location were chosen to minimize impacts on existing structures while minimizing construction cost and maximizing flood reduction benefits. A storage-elevation curve was created based upon 2007-2008 TNRIS LiDAR data and was entered into the HEC-HMS model for the Blanco River. Outlet structures were sized to pass the 1% ACE with at least one foot of freeboard and to contain the 0.2% ACE event without overtopping the dam. The outlet structure was composed of a reinforced concrete box culvert designed to pass the low flows. The overflow spillway for the dam was set at an elevation of 1,118 ft. The HEC-HMS model is provided in Appendix E.4.

The “Figures and Tables” section in this appendix contains tables showing the peak flow reduction and water surface reductions from existing to proposed conditions for all eight frequency storm events. The COE gage analysis, which is provided in Appendix B.1, was used for the flows in the final hydraulic models instead of the resulting flows from the hydrology model. However, for the Blanco watershed there were difficulties calibrating the hydrology model to existing gage data and resulting calibrated hydrology model flows were much less than the gage analysis flows. Therefore, for the Blanco detention alternative, hydrology model results were used for pre- and post-project comparison instead of adjusted gage analysis flows. The hydrology model pre- and post-project flows were then entered into the hydraulic model to determine the reduction in water surface. The largest reduction in flow and water surface occurs at the City of Wimberley. The post-project hydrology model shows an 18% reduction in peak for the 1% ACE event and water surface reduction over 2.5 ft. The detention on the Blanco River also reduces the 1% ACE peak flow in the City of San Marcos by 16% and reduces the water surface by more than 1.8 ft.

The engineer's opinion of probable cost for this design project can be seen in Table 4. The estimated cost of the project comes to $7,467,179, and includes unit prices that were generally based on TXDOT item numbers. The cost of land acquisition is not included in the opinion of probable cost as it is variable and depends on the real estate market at the time of acquisition.

Table 2: Proposed Detention on Blanco River Opinion of Probable Cost

TxDOT Item No.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
752-2022	Tree removal	300	EA	$400	$120,000
160-2003	Furnish and place Topsoil (4")	41300	SY	$1	$23,800
132-2005	Embankment (Type C)	270471	CY	$14	$5,222,000
432-2021	18" Concrete Rip Rap	4500	CY	$90	$189,000
462-2074	10'x12' RC Box Culvert	550	LF	$618	$339,900
5941-2014	Hydromulch Seeding	41300	SY	$1	$41,300
169-2001	Soil retention blankets	13000	SY	$1	$13,000
	MOBILIZATION (10%)	1	LS	$474,709	$474,709
	ENGINEERING FEES (10%)	1	LS	$522,180	$522,180
				SUBTOTAL	**$5,743,984**
				Contingencies (30%)	$1,723,195
				TOTAL	**$7,467,179**

Alternative 3: Detention on York Creek

The third proposed project is a detention site located on York Creek upstream of the confluence with the San Marcos River. This project area was chosen for analysis because it is upstream of the City of Luling and the City of Gonzales, which have approximately183 structures at risk during the 1% ACE event based on results from Appendix D.1. LiDAR data also showed that this area had adequate storage capacity compared to other tributaries of the San Marcos River. Further analysis of the hydrology model from Appendix B.1 showed that the peak from the York Creek watershed arrives at the confluence with the San Marcos about 6 hours before the peak of the San Marcos River for the 1% ACE event.

Sub-basin SMAR_020 in the hydrology model from Appendix B.1 represents the York Creek watershed. A graphic showing the proposed detention on York Creek is provided in Figure 3. The proposed dam height of 48 ft. and dam length of 4800 ft. will provide a maximum storage capacity of approximately 48130 ac-ft. The dam size and location were chosen to minimize impacts on existing structures while minimizing construction cost and maximizing flood reduction benefits. A storage-elevation curve was created based upon 2007-2008 TNRIS LiDAR data and was entered into the HEC-HMS model for the San Marcos River. Outlet structures were sized to pass the 1% ACE with at least one foot of freeboard and to contain the 0.2% ACE event without overtopping the dam. The outlet structure was composed of a reinforced concrete box culvert designed to pass the low flows. The overflow spillway for the dam was set at an elevation of 442 ft. The HEC-HMS model is provided in Appendix E.4.

The “Figures and Tables” section in this appendix contains tables showing the peak flow reduction and water surface reductions from existing to proposed conditions for all eight frequency storm events. The COE gage analysis, which is provided in Appendix B.1, was used for the flows in the final hydraulic models instead of the resulting flows from the hydrology model. Therefore, the percent reduction in peak from the hydrology model for the pre and post-project conditions was applied to the COE gage analysis flows used in the final hydraulic model. These post-project flows were then entered into the hydraulic model to determine the reduction in water surface. In the City of Luling, the post-project hydrology model shows a 11% reduction in peak for the 1% ACE event and water surface reduction over 0.8 ft. The detention on York Creek also reduces the 1% ACE peak flow in the City of Gonzales by 2% and reduces the water surface by approximately 0.4 ft.

The engineer’s opinion of probable cost for this design project can be seen in Table 4. The estimated cost of the project comes to $12.1, and includes unit prices that were generally based on TXDOT item numbers. The opinion of probable cost for York Creek detention includes quantities associated with raising FM 20 above the 100-yr backwater elevation. The cost of land acquisition is not included in the opinion of probable cost as it is variable and depends on the real estate market at the time of acquisition.

Table 3: Proposed Detention on York Creek Opinion of Probable Cost

TxDOT Item No.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
752-2022	Tree removal	300	EA	$400	$120,000
160-2003	Furnish and place Topsoil (4")	50000	SY	$1	$50,000
132-2005	Embankment (Type C)	503000	CY	$14	$7,042,000
432-2021	18" Concrete Rip Rap	2100	CY	$90	$189,000
462-2074	7'x7' RC Box Culvert	200	LF	$534	$106,800
5941-2014	Hydromulch Seeding	50000	SY	$1	$50,000
105-2008	Remove Asphalt	12100	SY	$4	$48,400
354-2110	Add Asphalt	12100	SY	$3	$36,300
169-2001	Soil retention blankets	50000	SY	$1	$50,000
752-2022	Tree removal	300	EA	$400	$120,000
	MOBILIZATION (10%)	1	LS	$769,250	$769,250
	ENGINEERING FEES (10%)	1	LS	$846,175	$846,175
				SUBTOTAL	**$9,307,925**
				Contingencies (30%)	$2,792,378
				TOTAL	**$12,100,303**

Alternative 4: Detention on Peach Creek

Detention on Peach Creek was chosen for analysis to benefit the City of Cuero and City of Victoria which are downstream along the Guadalupe River. These two cities have approximately 600 structures in their surrounding areas that are at risk during the 1% ACE event according to the results provided in Appendix D.1.

A site located on Peach Creek just upstream of the FM 2814 crossing which has a drainage area of 219.2 mi^2 was determined to be the best site based upon storage area and minimal number of properties impacted by the site (see Figure 5). A 29 ft. high dam with a length of 5780 ft. would provide approximately 41,774 ac-ft of storage. This site would be able to store a large volume of water and greatly reduce the peak from the Peach Creek watershed. A storage-elevation curve was created based upon 2007-2008 TNRIS LiDAR data and was entered into the HEC-HMS model for the Guadalupe River. Outlet structures were sized to pass the 1% ACE with at least one foot of freeboard and to contain the 0.2% ACE event without overtopping the dam. The outlet structure was composed of a reinforced concrete box culvert designed to pass the low flows. The overflow spillway for the dam was set at an elevation of 295 ft. The HEC-HMS model is provided in Appendix E.4.

The “Figures and Tables” section in this appendix contains tables showing the peak flow reduction and water surface reductions from existing to proposed conditions for all eight frequency storm events. The COE gage analysis, which is provided in Appendix B.1, was used for the flows in the final hydraulic models instead of the resulting flows from the hydrology model. Therefore, the percent reduction in peak from the hydrology model for the pre and post-project conditions was applied to the COE gage analysis flows used in the final hydraulic model. These post-project flows were then entered into the hydraulic model to determine the reduction in water surface. In the City of Cuero, the post-project results show no reductions in the 1% ACE even. However, reductions in flow and water surface elevation do occur for the 50% to 2% ACE events. The detention on Peach Creek reduces the1% ACE peak flow in the City of Victoria by 3% and reduces the water surface by more than 0.3ft.

The engineer’s opinion of probable cost for this design project can be seen in Table 4. The estimated cost of the project comes to $6,211,777, and includes unit prices that were generally based on TXDOT item numbers. The cost of land acquisition is not included in the opinion of probable cost as it is variable and depends on the real estate market at the time of acquisition.

Table 4: Proposed Detention on Peach Creek Opinion of Probable Cost

TxDOT Item No.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	COST
752-2022	Tree removal	300	EA	$400	$120,000
160-2003	Furnish and place topsoil (4")	27500	SY	$1	$27,500
132-2005	Embankment (Type C)	240000	CY	$14	$3,360,000
432-2021	18" Concrete Rip Rap	3300	CY	$90	$297,000
462-2074	7'x7' RC Box Culvert	200	LF	$534	$106,800
5941-2014	Hydromulch Seeding	27500	SY	$1	$27,500
169-2001	Soil retention blankets	37000	SY	$1	$37,000
	MOBILIZATION (10%)	1	LS	$397,580	$397,580
	ENGINEERING FEES (10%)	1	LS	$437,338	$437,338
				SUBTOTAL	**$4,810,718**
				Contingencies (30%)	$1,443,215
				TOTAL	**$6,253,933**

Alternative 5: Off-Channel Reservoir on Lower San Marcos River

Most of the flood volume in the lower portion of the basin comes from the Blanco and San Marcos River watersheds. An off-channel storage area was investigated on the San Marcos River just upstream of the confluence with the Guadalupe River. To reduce the 100-yr to approximately the 50-yr flow at this location, approximately 80,000 ac-ft of water must be diverted to off-channel storage at this location. That storage volume would require approximately a 6 sq. mi. footprint up to 20 feet deep. The cost of land acquisition and excavation alone would be extremely high. An inline detention might be another option at this location, but upstream impacts to Palmetto State Park would need to be considered. Since the impacts and cost of this alternative are expected to be nigh, no further detailed analysis was performed.

Figures and Tables

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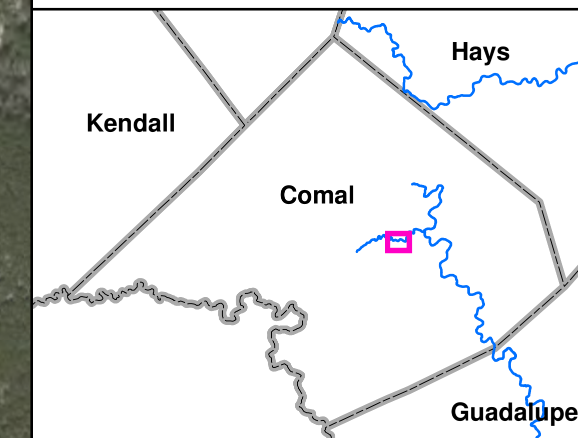

Key to Features

Proposed Dam

Proposed Footprint

Subbasins

Alternative Streams

Figure 1.
Bear Creek
Proposed Alternative

N
W E
S

0 800 1,600 Feet

1 inch = 689.790637 feet

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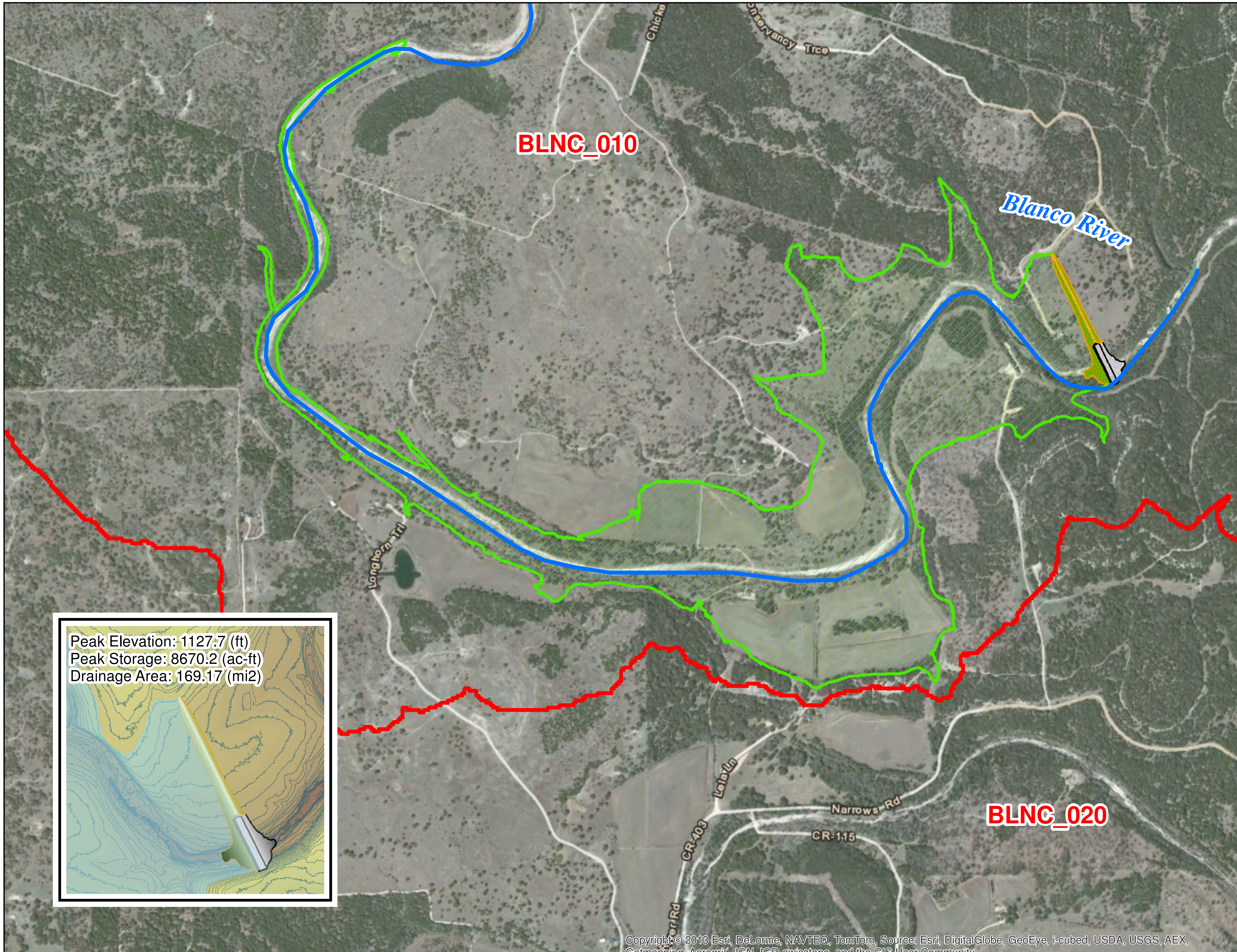

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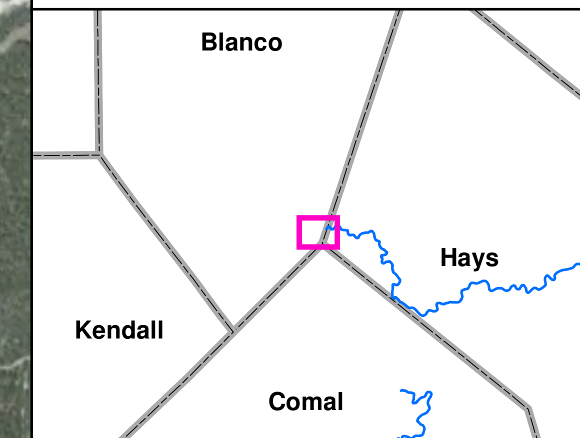
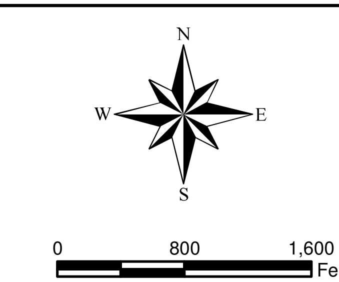


Key to Features

Proposed Dam
Proposed Footprint
Subbasins
Alternative Streams

Figure 2.
Blanco River
Proposed Alternative



1 inch = 1,207.986111 feet

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Key to Features

Proposed Dam

Proposed Footprint

Subbasins

Alternative Streams

Figure 3. York Creek Proposed Alternative

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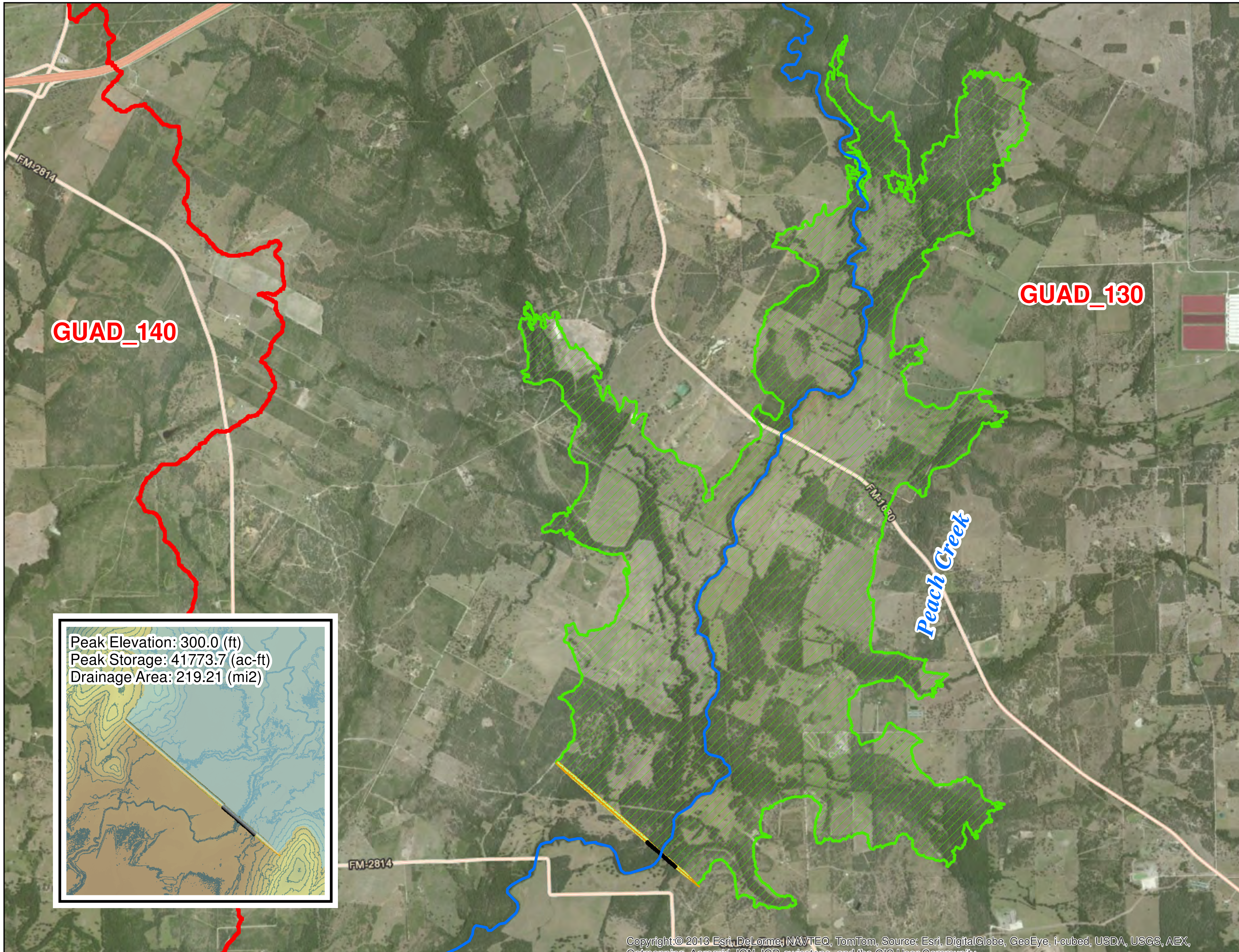

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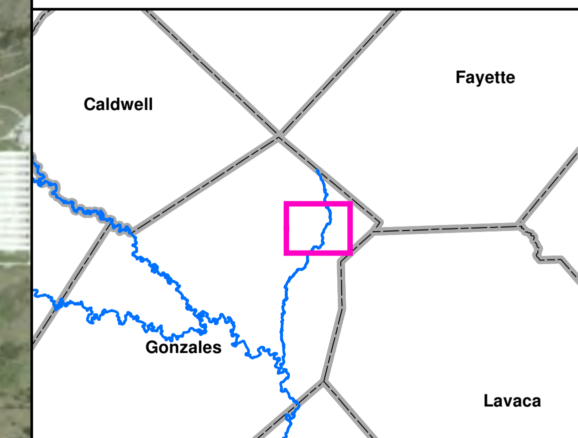

Key to Features

Proposed Dam

Proposed Footprint

Subbasins

Alternative Streams

Figure 4.
Peach Creek
Proposed Alternative

N
W
E
S

0 800 1,600 Feet

1 inch = 2,923.559762 feet

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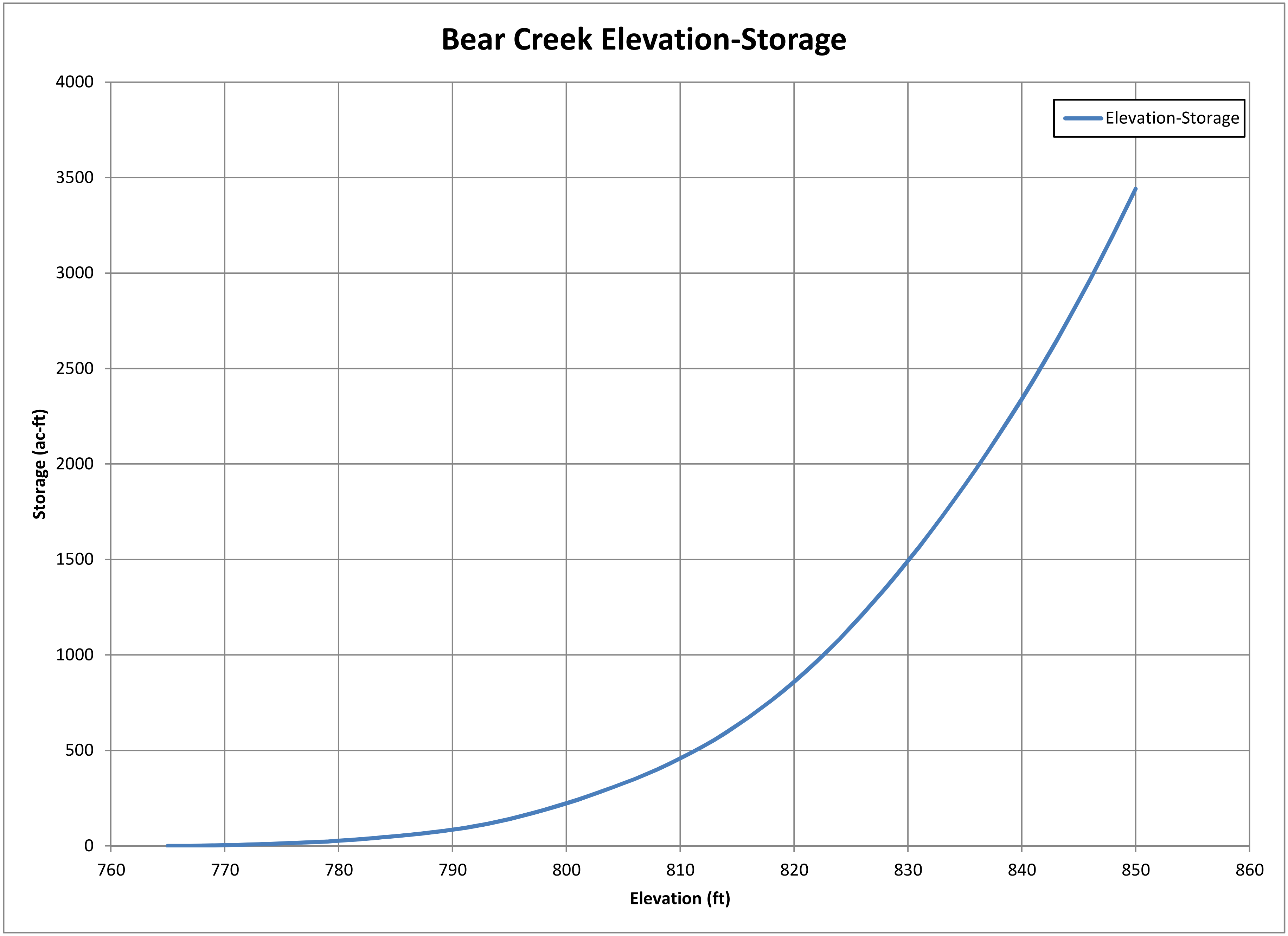
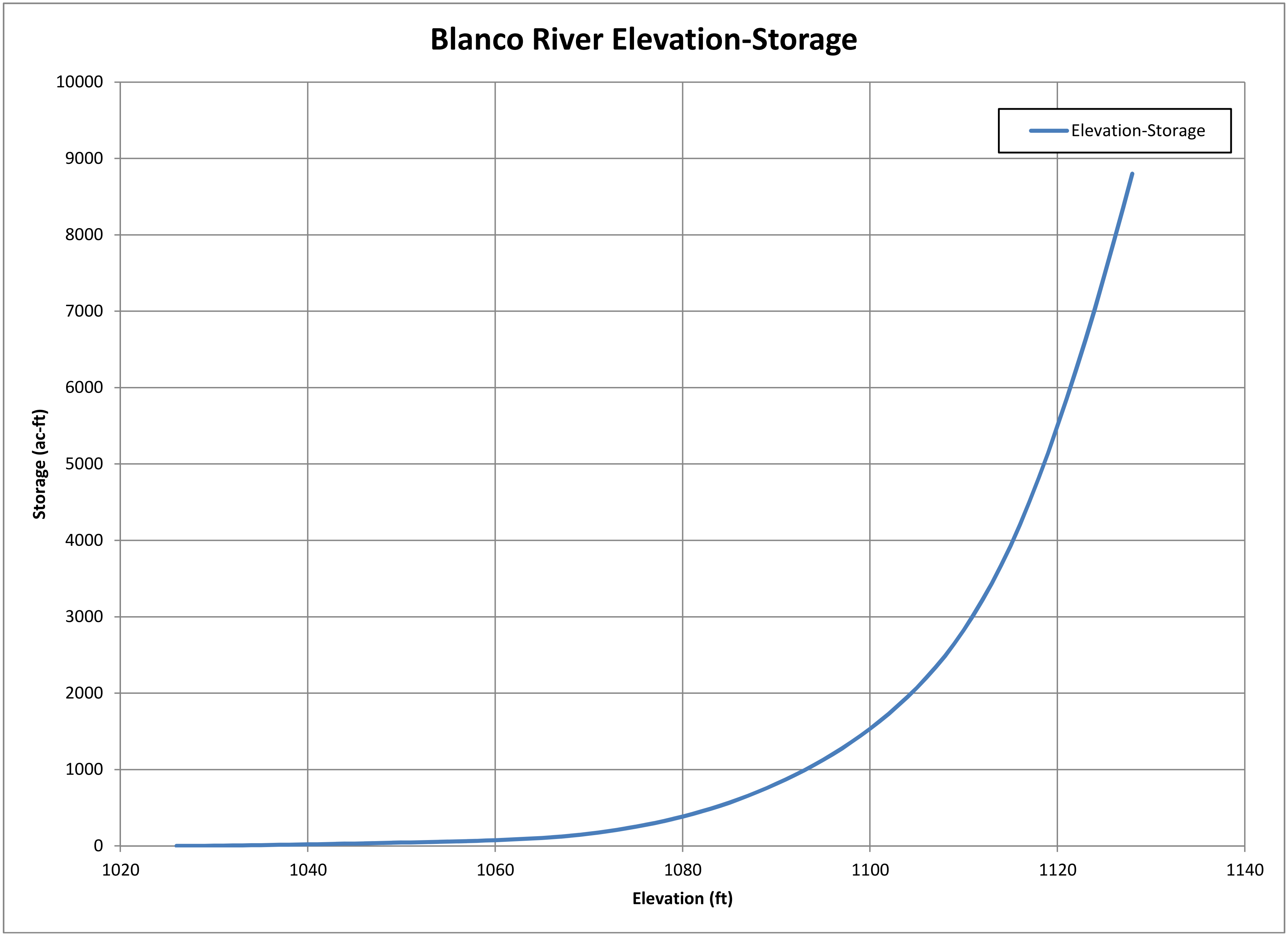
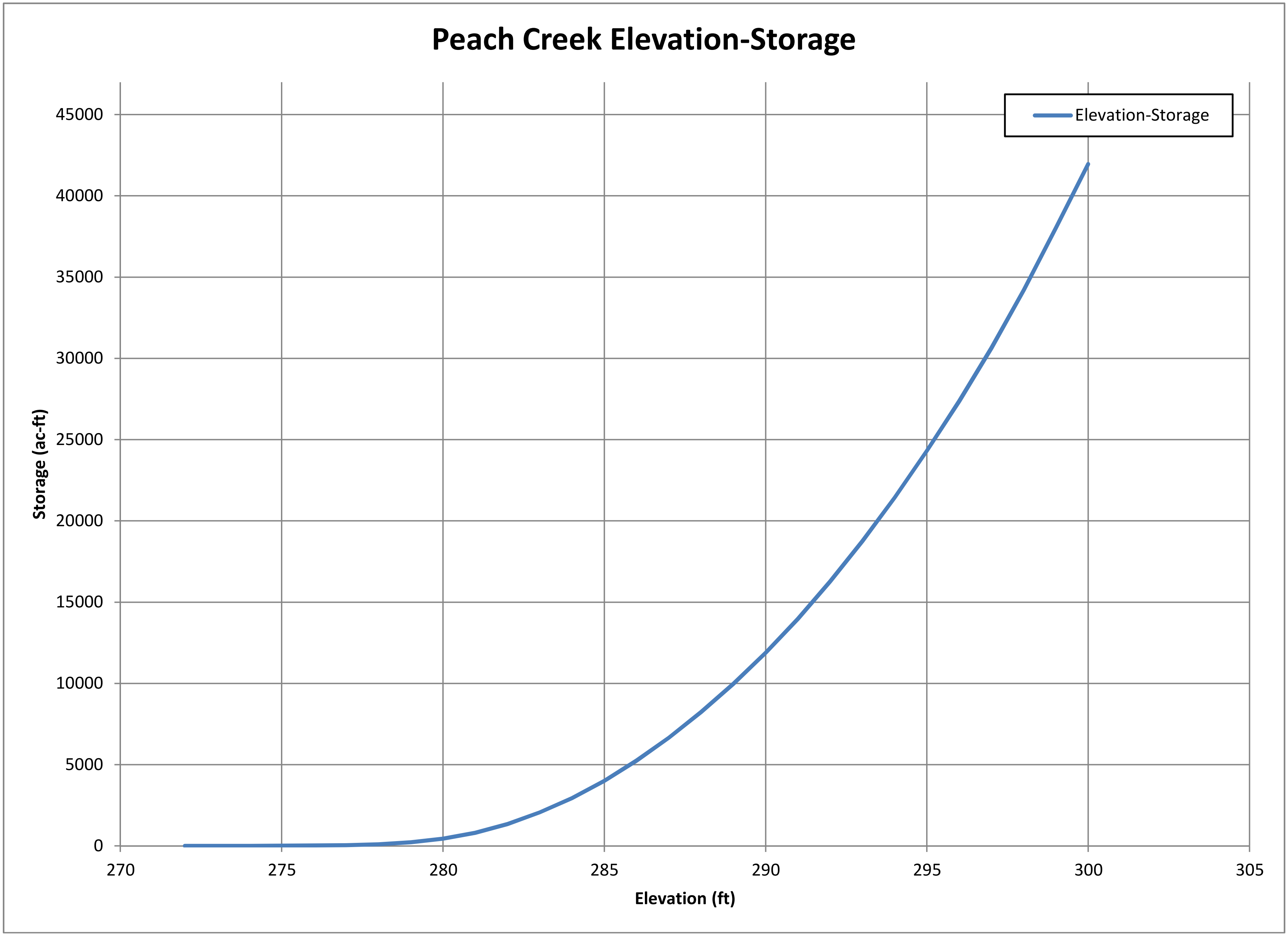
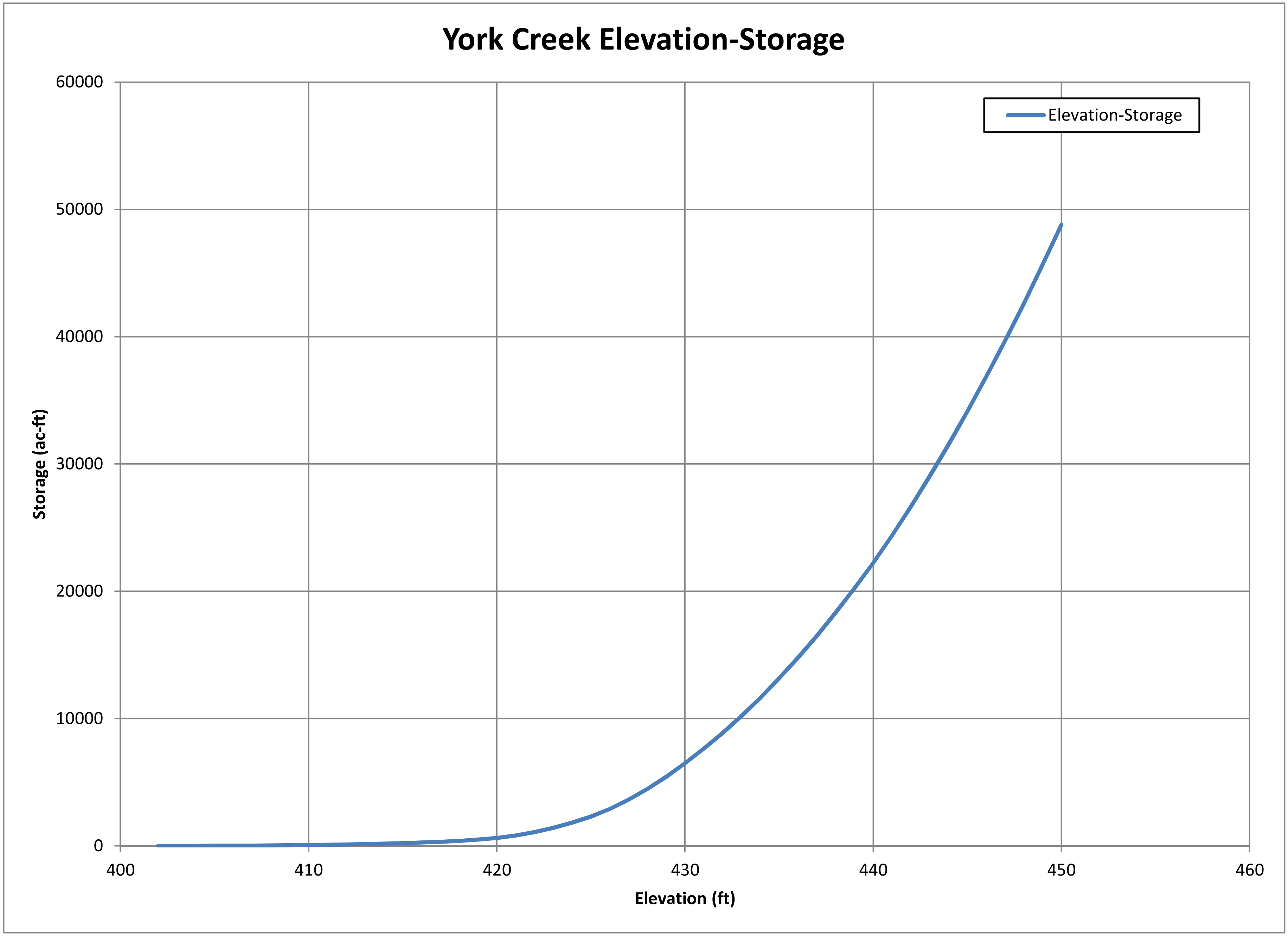
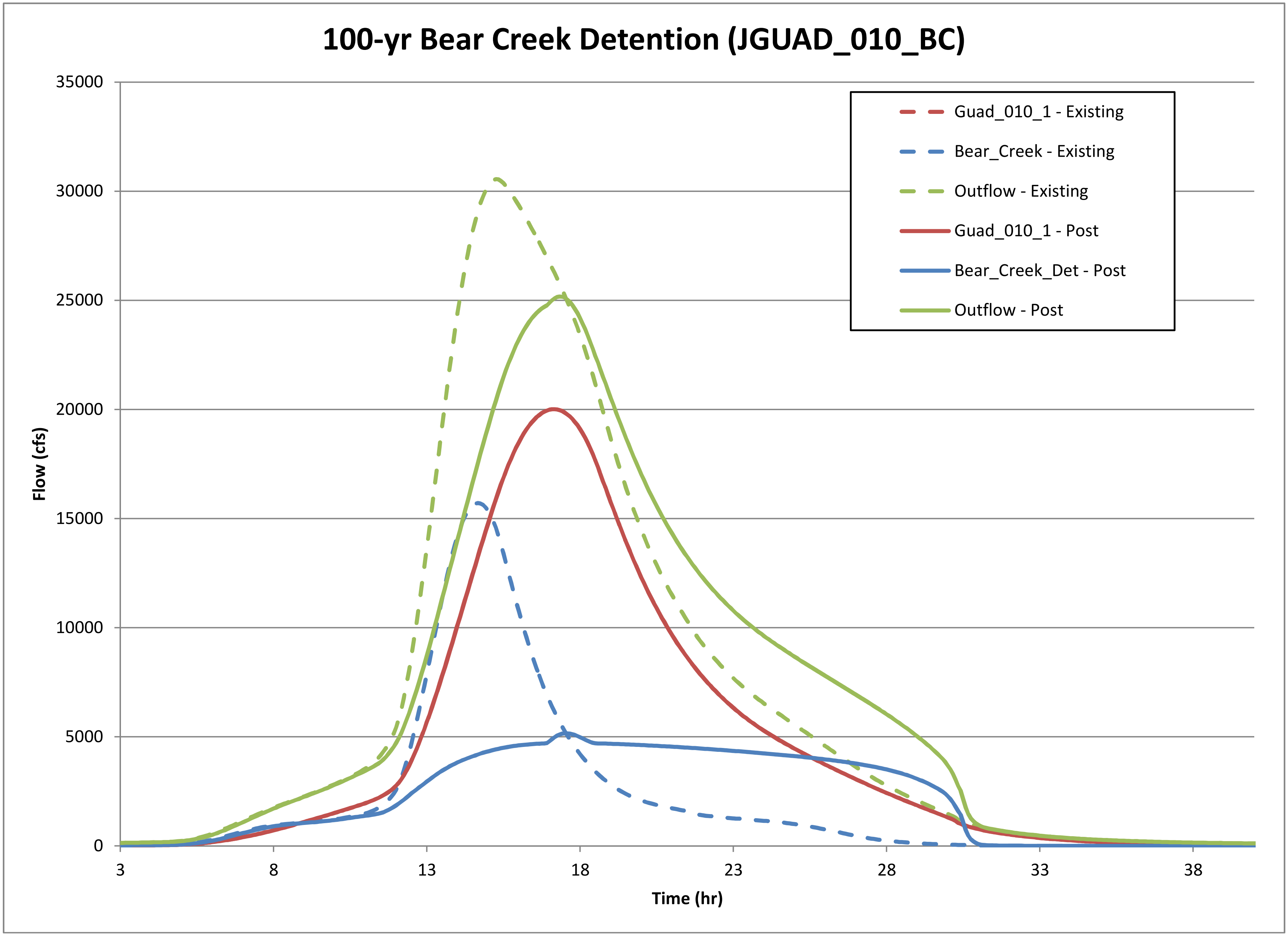

Bear Creek Elevation-Storage
Elevation-Storage
Storage (ac-ft)
4000
3500
3000
2500
2000
1500
1000
500
0
760
770
780
790
800
810
820
830
840
850
860
Elevation (ft)

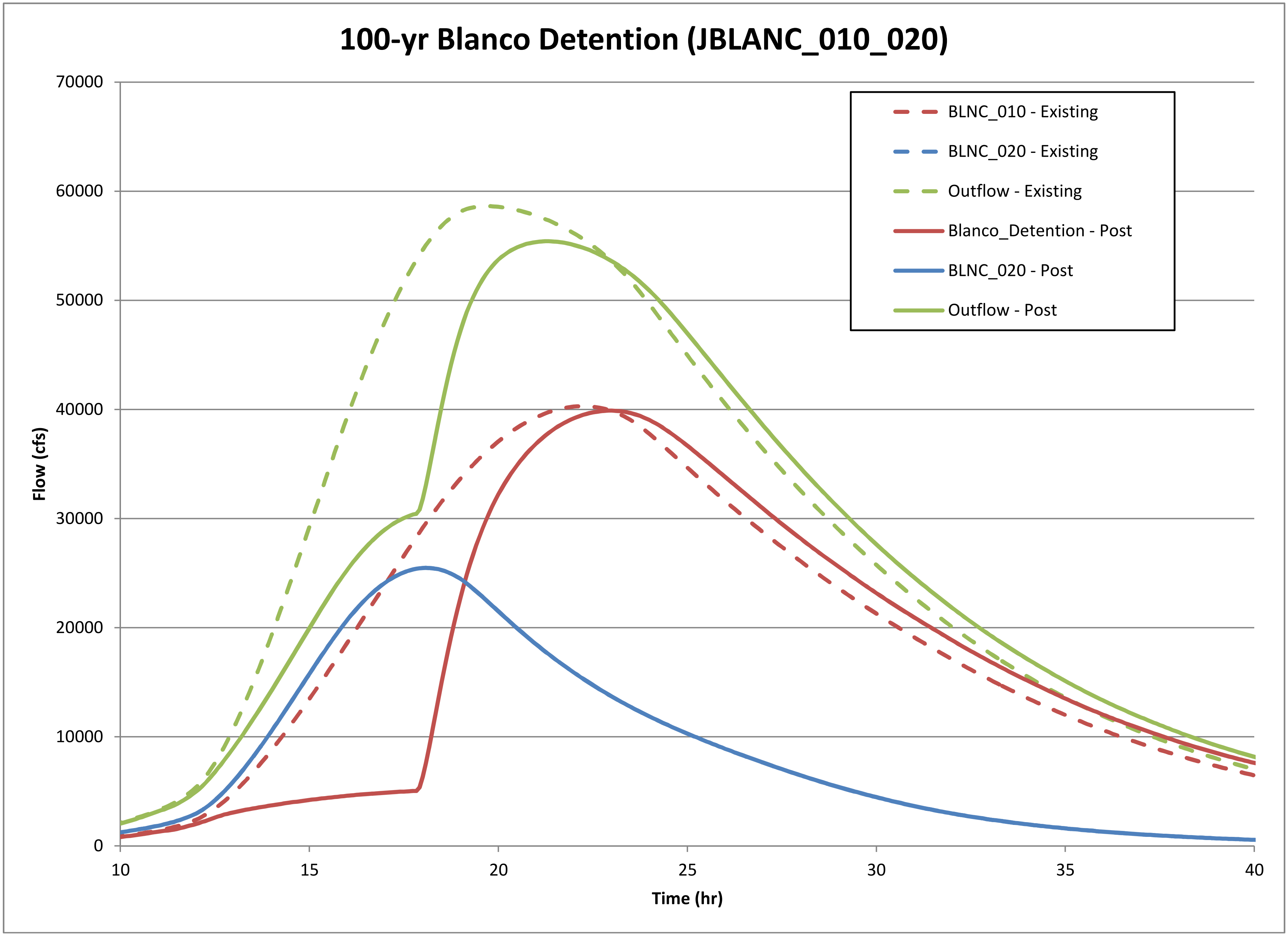


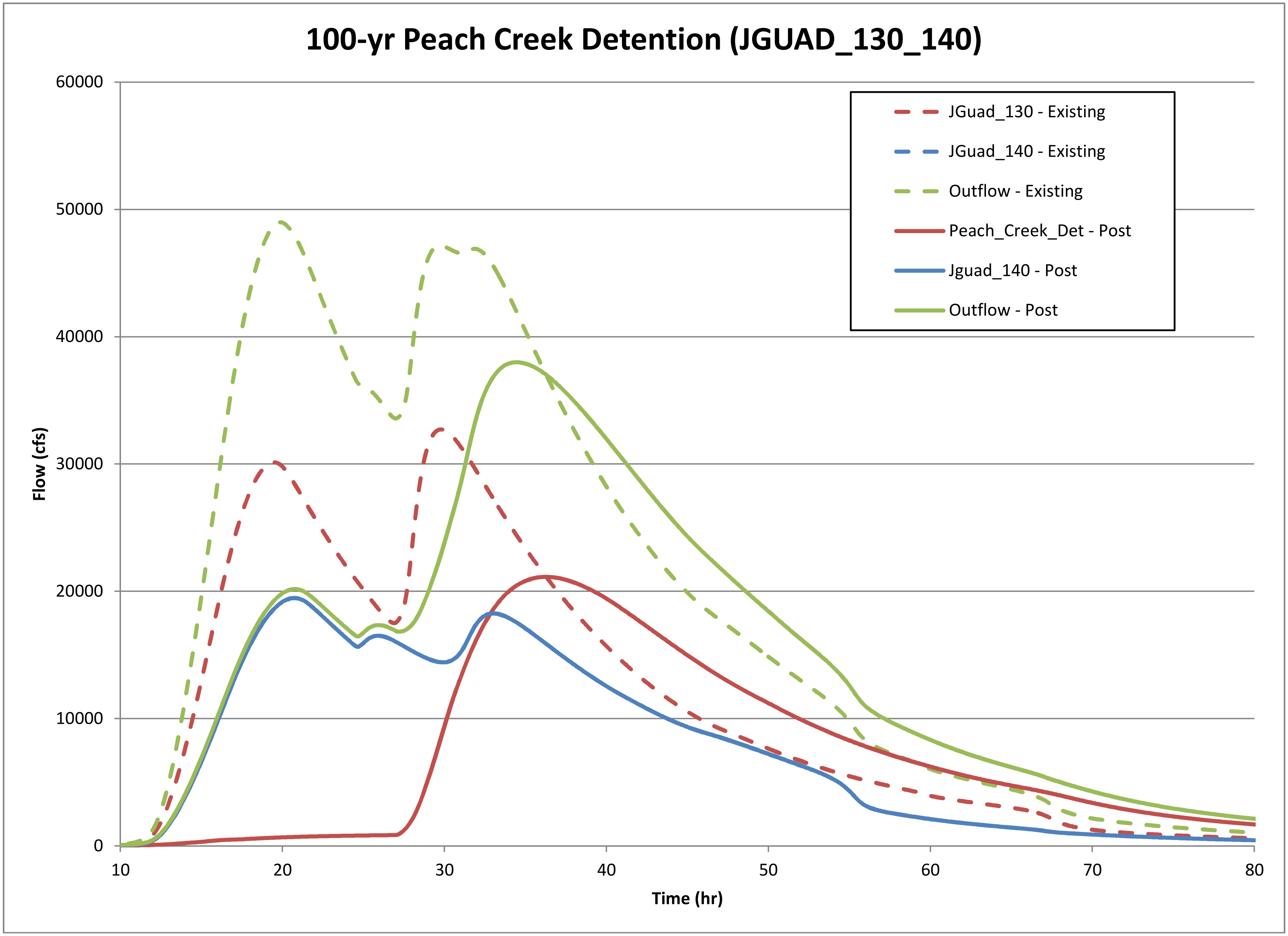
Blanco River Elevation-Storage
Elevation-Storage
Storage (ac-ft)
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
1020
1040
1060
1080
1100
1120
1140

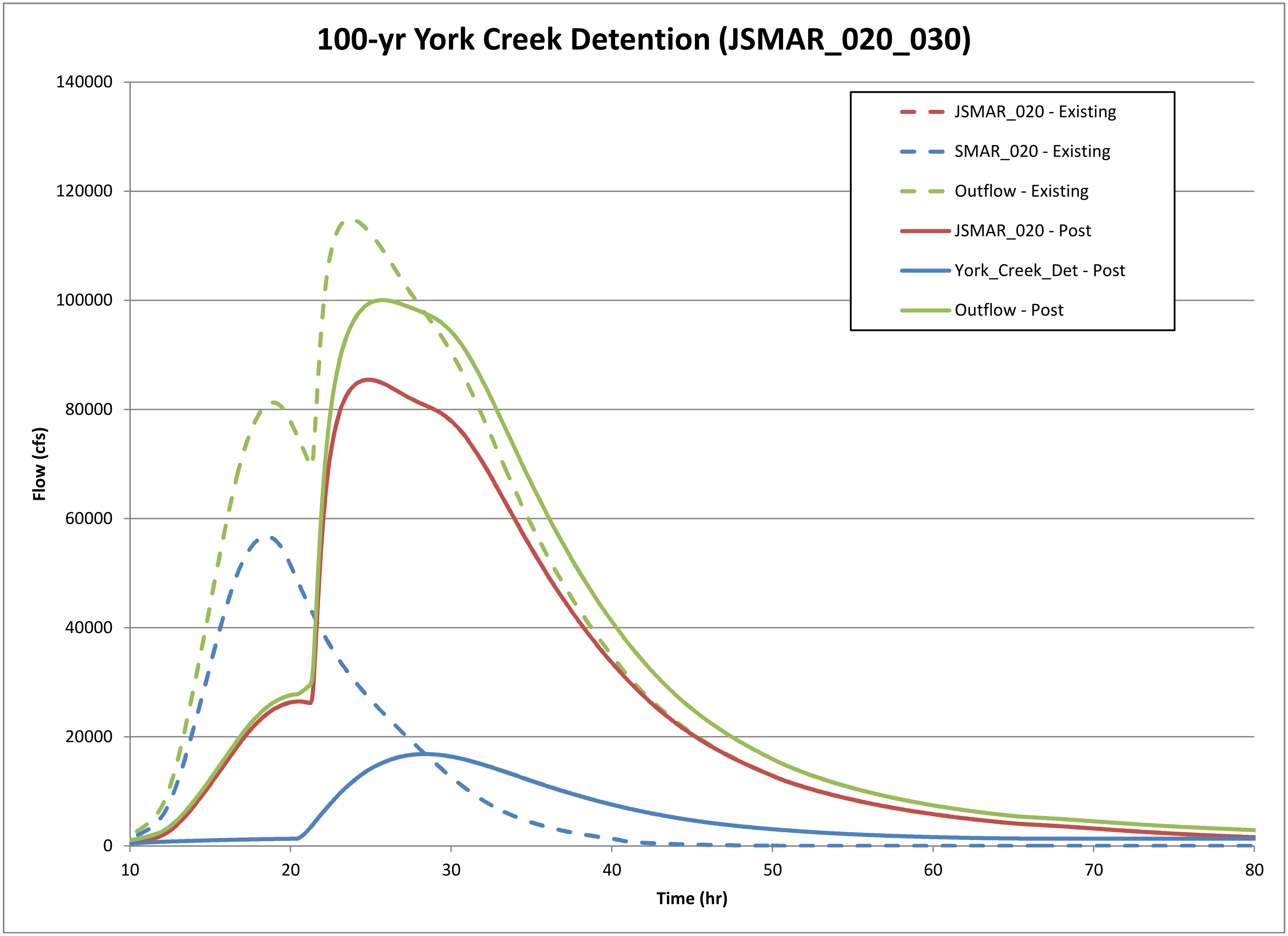

Peach Creek Elevation-Storage
Elevation-Storage
Storage (ac-ft)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
270
275
280
285
290
295
300
305
Elevation (ft)


York Creek Elevation-Storage
Elevation-Storage
Storage (ac-ft)
0
10000
20000
30000
40000
50000
60000
400
410
420
430
440
450
460
Elevation (ft)


100-yr Bear Creek Detention (JGUAD_010_BC)
Flow (cfs)
Time (hr)
Guad_010_1 - Existing
Bear_Creek - Existing
Outflow - Existing
Guad_010_1 - Post
Bear_Creek_Det - Post
Outflow - Post
35000
30000
25000
20000
15000
10000
5000
0
3
8
13
18
23
28
33
38


100-yr Blanco Detention (JBLANC_010_020)
70000
60000
50000
40000
30000
20000
10000
0
Flow (cfs)
10
15
20
25
30
35
40
Time (hr)
BLNC_010 - Existing
BLNC_020 - Existing
Outflow - Existing
Blanco_Detention - Post
BLNC_020 - Post
Outflow - Post


100-yr Peach Creek Detention (JGUAD_130_140)
JGuad_130 - Existing
JGuad_140 - Existing
Outflow - Existing
Peach_Creek_Det - Post
Jguad_140 - Post
Outflow - Post
Flow (cfs)
Time (hr)
60000
50000
40000
30000
20000
10000
0
10
20
30
40
50
60
70
80



100-yr York Creek Detention (JSMAR_020_030)
140000
120000
100000
80000
60000
40000
20000
0
Flow (cfs)
10
20
30
40
50
60
70
80
Time (hr)
JSMAR_020 - Existing
SMAR_020 - Existing
Outflow - Existing
JSMAR_020 - Post
York_Creek_Det - Post
Outflow - Post

Bear Creek

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Water Surface Reduction																							
				Annual Chance Exceedance																							
				50%			20%			10%			4%			2%			1%			0.40%			0.20%		
				Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction
Up Guad	JGUAD_010	Upstream of Comal Conf.	1470344	662.42	662.19	0.23	668.16	667.68	0.48	672.02	671.32	0.7	677.65	676.61	1.04	682.27	681.07	1.2	687.21	685.98	1.23	691.79	690.92	0.87	694.86	694.28	0.58
Mid Guad	JGUAD_010_020	at I-35	1420964	586.2	586.1	0.1	590.47	590.13	0.34	594.43	593.87	0.56	601.42	600.36	1.06	607.66	606.04	1.62	613.78	612.22	1.56	625.43	621.76	3.67	628.38	628.35	0.03
Low Guad	JGUAD_040		1341919	520.19	520.19	0	524.92	524.82	0.1	528.73	528.45	0.28	533.89	533.42	0.47	537.81	537.27	0.54	542.39	541.77	0.62	548.31	547.75	0.56	552.88	552.49	0.39
	JGUAD_050	Upstream of Geronimo Cr.	1281422	456.09	456.15	-0.06	463.4	463.31	0.09	468.64	468.37	0.27	472.07	471.56	0.51	476.78	476.18	0.6	482.11	481.45	0.66	486	486.06	-0.06	487.73	487.61	0.12
	JGUAD_030_050	Conf. with Geronimo Cr.	1253887	434.72	434.74	-0.02	441.51	441.48	0.03	445.77	445.64	0.13	450.67	450.38	0.29	455.08	454.62	0.46	460.2	459.68	0.52	465.62	465.34	0.28	469.61	469.26	0.35
Gonzales	JGUAD_060		1210478	407.73	407.73	0	412.19	412.17	0.02	415.31	415.18	0.13	420.34	420.03	0.31	424.8	424.36	0.44	429.24	428.77	0.47	434.53	434.23	0.3	437.41	437.11	0.3
	JGUAD_070		1103587	354.13	354.13	0	359.87	359.84	0.03	363.27	363.19	0.08	366.97	366.82	0.15	370.29	370.06	0.23	372.62	372.42	0.2	375.72	375.51	0.21	378.73	378.5	0.23
	JGUAD_090		960490	303.33	303.33	0	304.38	304.37	0.01	305.22	305.21	0.01	307.06	307.02	0.04	308.4	308.34	0.06	311.22	311.14	0.08	313.2	313.12	0.08	314.53	314.44	0.09
	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	271.38	271.38	0	276.63	276.65	-0.02	277.99	277.96	0.03	281.02	280.97	0.05	282.57	282.54	0.03	284.5	284.47	0.03	286.53	286.53	0	288.6	288.56	0.04
	JGUAD_160		804436	249.74	249.74	0	254.25	254.24	0.01	256.35	256.33	0.02	259.14	259.1	0.04	261.53	261.5	0.03	264.11	264.08	0.03	267.86	267.82	0.04	270.94	270.9	0.04
	JGUAD_150_160		749694	233.07	233.07	0	235.47	235.45	0.02	237.29	237.27	0.02	240.18	240.15	0.03	242.32	242.29	0.03	244.93	244.91	0.02	248.43	248.4	0.03	251.44	251.41	0.03
	JGUAD_170	Conf. with Peach Cr.	715919	221.19	221.19	0	224.96	224.95	0.01	225.38	225.37	0.01	227.7	227.69	0.01	229.76	229.75	0.01	232.03	232.02	0.01	235.45	235.44	0.01	238.02	238.01	0.01
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	194.84	194.84	0	198.57	198.57	0	201.34	201.32	0.02	205.3	205.28	0.02	208.7	208.68	0.02	212.35	212.31	0.04	217.54	217.5	0.04	221.74	221.69	0.05
	JGUAD_210_220	Cuero Gage	518448	160.91	160.85	0.06	167.71	167.69	0.02	170.89	170.87	0.02	175.23	175.21	0.02	178.41	178.38	0.03	181.43	181.41	0.02	184.17	184.14	0.03	186.56	186.54	0.02
	JGUAD_230		465183	141.09	141.09	0	147.49	147.49	0	150.87	150.86	0.01	154.66	154.64	0.02	157.74	157.71	0.03	160.79	160.76	0.03	164.84	164.82	0.02	168.3	168.27	0.03
	JGUAD_260		390263	108.47	108.47	0	121.8	121.8	0	127.37	127.36	0.01	130.26	130.25	0.01	132.32	132.31	0.01	133.98	133.97	0.01	136.74	136.73	0.01	139.17	139.16	0.01
Victoria	JGUAD_270	Victoria Gage	314224	80.65	80.65	0	85.41	85.4	0.01	87.8	87.79	0.01	90.7	90.68	0.02	92.89	92.87	0.02	95.16	95.14	0.02	98.25	98.23	0.02	101.51	101.49	0.02
	JGUAD_310	Above Coleto Cr.	212473	43.32	43.32	0	46.19	46.19	0	47.97	47.96	0.01	49.6	49.59	0.01	50.2	50.19	0.01	50.93	50.92	0.01	52.57	52.56	0.01	53.68	53.67	0.01
	JGUAD_300_310	Conf. with Coleto Cr.	155706	30.67	30.67	0	33.17	33.17	0	34.86	34.85	0.01	35.36	35.36	0	36.36	36.35	0.01	37.86	37.85	0.01	39.79	39.78	0.01	42.06	42.05	0.01
	OUTLET 1	Calhoun County Boundary	67943	14.87	14.87	0	17.53	17.53	0	19.38	18.74	0.64	21.77	21.76	0.01	23.6	23.6	0	25.53	25.52	0.01	28.16	28.16	0	30.89	30.88	0.01

Blanco River

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Water Surface Reduction																							
				Annual Chance Exceedance																							
				50%			20%			10%			4%			2%			1%			0.40%			0.20%		
				Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction
Blanco	JBLNC_010_020	Hays County Line	270055	1082.41	1080.93	1.48	1086.07	1083.68	2.39	1087.97	1086.51	1.46	1089.95	1089.37	0.58	1091.15	1090.72	0.43	1092.68	1092.16	0.52	1095.12	1094.63	0.49	1096.99	1096.56	0.43
	JBLNC_030	Above Cypress	194521	888.22	887.23	0.99	893.13	891.3	1.83	895.71	893.5	2.21	898.79	896	2.79	901.18	898.79	2.39	903.56	901.63	1.93	906.81	905.36	1.45	909.19	908.1	1.09
	JBLNC_040	Wimberley Gage	155899	815.36	814.59	0.77	820.45	818.86	1.59	823.31	821.37	1.94	826.64	824.27	2.37	829.32	826.51	2.81	831.93	829.36	2.57	836.17	833.76	2.41	840	837.73	2.27
	JBLNC_050	Kyle Gage	103847	709.79	709.79	0	715.21	714.53	0.68	718.4	717.05	1.35	722.03	719.94	2.09	724.85	722.45	2.4	727.69	725.04	2.65	731.5	729.1	2.4	734.47	732.45	2.02
	JBLNC_060	Above San Marcos	42922	600.21	600.21	0	603.64	603.36	0.28	606.01	605.33	0.68	608.97	607.71	1.26	611.31	609.68	1.63	613.64	611.78	1.86	616.73	614.77	1.96	619.06	617.42	1.64
San Marcos	JBLNC_060_SMAR_010	San Marcos Conf	403769	554.09	554.09	0	556.55	556.55	0	557.96	557.95	0.01	559.25	559.25	0	559.54	559.52	0.02	561.08	561.03	0.05	563.52	563.41	0.11	565.24	565.18	0.06
	JSMAR_020	Above York	356498	479.64	479.64	0	485.95	485.95	0	488.49	488.47	0.02	491.32	491.3	0.02	493.11	493.1	0.01	494.67	494.66	0.01	496.12	496.09	0.03	496.95	496.93	0.02
	JSMAR_020_030	York Conf	272222	399.61	399.61	0	406.73	406.71	0.02	410.52	410.48	0.04	414.75	414.72	0.03	417.38	417.36	0.02	419.98	419.97	0.01	421.33	421.32	0.01	423	422.99	0.01
	JSMAR_090	Luling Gage	196464	352.34	352.34	0	357.27	357.27	0	360.57	360.56	0.01	362.6	362.58	0.02	363.78	363.77	0.01	365.19	365.17	0.02	367.31	367.27	0.04	369.15	369.13	0.02
	JSMAR_090_100	Plum Conf	138828	318.79	318.79	0	328.05	328.05	0	331.09	331.09	0	334.9	334.88	0.02	337.74	337.73	0.01	338.67	338.66	0.01	340.41	340.4	0.01	341.77	341.77	0
	JSMAR_120	Above Guad	55586	285.74	285.74	0	297.1	297.05	0.05	301.35	301.32	0.03	304.85	304.83	0.02	306.61	306.56	0.05	308.59	308.54	0.05	309.49	309.42	0.07	310.9	310.84	0.06
Gonzales	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	270.54	270.54	0	276.88	276.82	0.06	279.09	279.04	0.05	281.53	281.48	0.05	282.74	282.69	0.05	283.85	283.79	0.06	285.06	285	0.06	285.93	285.85	0.08
	JGUAD_160		804436	246.27	246.27	0	254.8	254.8	0	257.03	256.98	0.05	259.4	259.35	0.05	261.11	261.05	0.06	262.62	262.54	0.08	264.79	264.7	0.09	266.58	266.49	0.09
	JGUAD_150_160		749694	229.72	229.71	0.01	235.95	235.89	0.06	238.07	238.02	0.05	240.71	240.67	0.04	242.52	242.47	0.05	244.23	244.16	0.07	246.47	246.39	0.08	248.29	248.21	0.08
	JGUAD_170	Conf. with Peach Cr.	715919	220.02	219.99	0.03	225.25	225.19	0.06	225.81	225.78	0.03	227.94	227.92	0.02	229.72	229.7	0.02	231.72	231.7	0.02	234.91	234.89	0.02	237.31	237.3	0.01
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	193.35	193.22	0.13	199.06	198.98	0.08	201.97	201.9	0.07	205.58	205.52	0.06	208.11	208.02	0.09	210.52	210.42	0.1	213.76	213.65	0.11	216.35	216.25	0.1
	JGUAD_210_220	Cuero Gage	518448	156.78	156.59	0.19	169.36	169.22	0.14	172.89	172.81	0.08	176.84	176.77	0.07	181.02	180.99	0.03	181.44	181.38	0.06	183.55	183.48	0.07	184.75	184.68	0.07
	JGUAD_230		465183	137.81	137.63	0.18	148.32	148.21	0.11	152.37	152.28	0.09	156.06	156	0.06	158.71	158.63	0.08	161.26	161.18	0.08	164.47	164.4	0.07	167.07	167	0.07
	JGUAD_260		390263	105.22	105.13	0.09	122.85	122.74	0.11	128.16	128.07	0.09	130.88	130.84	0.04	132.76	132.71	0.05	134.11	134.07	0.04	136.47	136.43	0.04	138.48	138.45	0.03
Victoria	JGUAD_270	Victoria Gage	314224	76.25	76.07	0.18	85.82	85.75	0.07	88.58	88.51	0.07	91.8	91.75	0.05	94.01	93.95	0.06	96.11	96.05	0.06	98.96	98.9	0.06	101.27	101.21	0.06
	JGUAD_310	Above Coleto Cr.	212473	41.62	41.56	0.06	46.35	46.29	0.06	48.52	48.48	0.04	49.57	49.55	0.02	50.63	50.65	-0.02	51.31	51.29	0.02	53.02	52.79	0.23	53.66	53.64	0.02
	JGUAD_300_310	Conf. with Coleto Cr,	155706	29.14	29.12	0.02	32.87	32.83	0.04	34.89	34.84	0.05	35.44	35.42	0.02	36.41	36.37	0.04	37.73	37.69	0.04	39.47	39.43	0.04	40.84	40.8	0.04
	OUTLET 1	Calhoun County Boundary	67943	10.03	10.03	0	16.99	16.94	0.05	19.27	19.22	0.05	21.66	21.63	0.03	23.34	23.3	0.04	24.99	24.95	0.04	27.25	27.22	0.03	29.05	29.02	0.03

Note: Complete Gonzalez upstream flows updated in HEC-RAS model.

Peach Creek

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Water Surface Reduction – Annual Chance Exceedance: 50%			20%			10%			4%			2%			1%			0.40%			0.20%		
				Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction
Gonzales	JGUAD_150_160		749694	233.07	233.02	0.05	235.47	235.31	0.16	237.29	237.19	0.1	240.18	240.08	0.1	242.32	242.36	-0.04	244.93	245.03	-0.1	248.43	248.59	-0.16	251.44	251.63	-0.19
	JGUAD_170	Victoria Gage	715919	221.19	221.15	0.04	224.96	224.72	0.24	225.38	225.28	0.1	227.7	227.65	0.05	229.76	229.76	0	232.03	232.06	-0.03	235.45	235.49	-0.04	238.02	238.06	-0.04
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	194.84	194.84	0	198.57	198.43	0.14	201.34	201.07	0.27	205.3	205.1	0.2	208.7	208.64	0.06	212.35	212.37	-0.02	217.54	217.63	-0.09	221.74	221.87	-0.13
	JGUAD_210_220	Cuero Gage	518448	160.91	160.91	0	167.71	167.35	0.36	170.89	170.55	0.34	175.23	175	0.23	178.41	178.31	0.1	181.43	181.4	0.03	184.17	184.18	-0.01	186.56	186.59	-0.03
	JGUAD_230		465183	141.09	141	0.09	147.49	146.98	0.51	150.87	150.43	0.44	154.66	154.33	0.33	157.74	157.51	0.23	160.79	160.64	0.15	164.84	164.73	0.11	168.3	168.22	0.08
	JGUAD_260		390263	108.47	108.47	0	121.8	121.25	0.55	127.37	126.85	0.52	130.26	130.01	0.25	132.32	132.13	0.19	133.98	133.85	0.13	136.74	136.64	0.1	139.17	139.1	0.07
Victoria	JGUAD_270	Victoria Gage	314224	80.65	80.65	0	85.41	85.08	0.33	87.8	87.35	0.45	90.7	90.36	0.34	92.89	92.61	0.28	95.16	94.92	0.24	98.25	98.04	0.21	101.51	101.33	0.18
	JGUAD_310	Above Coleto Cr.	212473	43.32	43.32	0	46.19	45.93	0.26	47.97	47.63	0.34	49.6	49.37	0.23	50.2	50.01	0.19	50.93	50.87	0.06	52.57	52.25	0.32	53.68	53.69	-0.01
	JGUAD_300_310	Conf. with Coleto Cr,	155706	30.67	30.67	0	33.17	32.94	0.23	34.86	34.52	0.34	35.36	35.03	0.33	36.36	36.16	0.2	37.86	37.67	0.19	39.79	39.61	0.18	42.06	41.94	0.12
	Outlet 1	Calhoun County Boundary	67943	14.87	14.87	0	17.53	17.14	0.39	19.38	18.99	0.39	21.77	21.46	0.31	23.6	23.33	0.27	25.53	25.28	0.25	28.16	27.94	0.22	30.89	30.67	0.22

York Creek

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Water Surface Reduction – Annual Chance Exceedance: 50%			20%			10%			4%			2%			1%			0.40%			0.20%		
				Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction	Existing	Proposed	Reduction
San Marcos	JSMAR_020_030	York Conf	272222	398.89	399.41	-0.52	407.53	405.53	2	412.73	409.76	2.97	418.58	415.46	3.12	420.78	420.14	0.64	423.34	422.05	1.29	426.41	425.44	0.97	428.73	427.92	0.81
	JSMAR_090	Luling Gage	196464	349.71	347.62	2.09	355.62	354.24	1.38	359.18	357.27	1.91	362.21	361.29	0.92	363.77	363.01	0.76	365.53	364.7	0.83	368.27	367.34	0.93	370.47	369.72	0.75
	JSMAR_090_100	Plum Conf	138828	317.56	314.08	3.48	326.79	325.8	0.99	330.26	328.37	1.89	332.87	331.54	1.33	335.53	333.65	1.88	337.96	336.23	1.73	338.9	338.25	0.65	340.04	339.42	0.62
	JSMAR_120	Above Guad	55586	286.66	286.53	0.13	295.81	294.41	1.4	300.46	298.74	1.72	303.91	302.27	1.64	304.97	304.19	0.78	306.29	305.65	0.64	308.33	307.31	1.02	309.81	308.86	0.95
Gonzales	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	271.38	271.37	0.01	276.63	276.17	0.46	277.99	277.4	0.59	281.02	280.46	0.56	282.57	282.44	0.13	284.5	284.11	0.39	286.53	286.4	0.13	288.6	288.52	0.08
	JGUAD_160		804436	249.74	249.3	0.44	254.25	254.1	0.15	256.35	255.79	1	259.14	258.51	1	261.53	260.98	1	264.11	263.64	0	267.86	267.46	0	270.94	270.58	0
	JGUAD_150_160		749694	233.07	231.58	1.49	235.47	235.17	0.3	237.29	236.83	0	240.18	239.5	1	242.32	241.73	1	244.93	244.36	1	248.43	247.95	0	251.44	250.95	0
	JGUAD_170	Conf. with Peach Cr.	715919	221.19	221.03	0.16	224.96	224.67	0.29	225.38	225.03	0	227.7	227.4	0	229.76	229.53	0	232.03	231.85	0	235.45	235.32	0	238.02	237.91	0
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	194.84	194.75	0.09	198.57	198.26	0	201.34	200.57	1	205.3	204.38	1	208.7	207.81	1	212.35	211.55	1	217.54	216.81	1	221.74	221.06	1
	JGUAD_210_220	Cuero Gage	518448	160.91	160.73	0.18	167.71	166.99	0.72	170.89	170.46	0	175.23	174.32	1	178.41	177.68	1	181.43	180.74	1	184.17	184.08	0	186.56	186.05	1
	JGUAD_230		465183	141.09	140.84	0.25	147.49	146.77	0.72	150.87	149.96	1	154.66	153.93	1	157.74	156.91	1	160.79	160.1	1	164.84	164.2	1	168.3	167.69	1
	JGUAD_260		390263	108.47	108.23	0.24	121.8	121.04	0.76	127.37	126.51	1	130.26	129.68	1	132.32	131.86	0	133.98	133.62	0	136.74	136.43	0	139.17	138.89	0
Victoria	JGUAD_270	Victoria Gage	314224	80.65	80.47	0.18	85.41	84.98	0.43	87.8	87.1	1	90.7	90.06	1	92.89	92.29	1	95.16	94.61	1	98.25	97.75	1	101.51	101.02	0
	JGUAD_310	Above Coleto Cr.	212473	43.32	43.13	0.19	46.19	45.87	0.32	47.97	47.47	1	49.6	49.17	0	50.2	49.91	0	50.93	50.72	0	52.57	52.12	0	53.68	53.56	0
	JGUAD_300_310	Conf. with Coleto Cr,	155706	30.67	30.52	0.15	33.17	32.89	0.28	34.86	34.36	1	35.36	34.83	1	36.36	35.99	0	37.86	37.51	0	39.79	39.5	0	42.06	41.77	0
	OUTLET 1	Calhoun County Boundary	67943	14.87	14.87	0	17.53	17.08	0.45	19.38	18.89	0	21.77	21.35	0	23.6	23.22	0	25.53	25.19	0	28.16	27.84	0	30.89	30.57	0

Bear Creek

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Upstream Drainage Area (mi2)	Pre-Project Gage Analysis Peak Discharge (cfs)								Post-Project Gage Analysis Peak Discharge (cfs)								Percent Reduction in Peak Discharge							
					Annual Chance Exceedance								Annual Chance Exceedance								Annual Chance Exceedance							
					50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%
Up Guad	JGUAD_010	Upstream of Comal Conf.	1470344	1518	4200	12300	21800	40100	59500	85000	112400	132900	3900	10600	18200	32700	48000	68100	97500	121500	7%	14%	17%	18%	19%	20%	13%	9%
Mid Guad	JGUAD_010_020	at I-35	1420964	1652	6000	16300	27900	50400	74400	106000	159100	188300	5800	15300	25900	46500	68400	97200	151600	183700	3%	6%	7%	8%	8%	8%	5%	2%
Low Guad	JGUAD_040		1341919	1742	7100	19700	34100	61000	89300	126800	180700	220800	7100	19400	32900	58200	85000	122300	175200	214800	0%	2%	4%	5%	5%	4%	3%	3%
	JGUAD_050	Upstream of Geronimo Cr.	1281422	1801	7700	21200	36500	65000	95000	134700	192800	237100	7800	21000	35500	62400	90600	129700	187200	230900	-1%	1%	3%	4%	5%	4%	3%	3%
	JGUAD_030_050	Conf. with Geronimo Cr.	1253887	1871	8300	22700	39000	69200	101000	143000	205600	254400	8400	22500	37900	66600	96400	137800	202400	248200	-1%	1%	3%	4%	5%	4%	2%	2%
Gonzales	JGUAD_060		1210478	1960	9000	24400	41800	74000	107800	152300	220200	274200	9000	24300	41000	71800	104000	147000	215700	268600	0%	0%	2%	3%	4%	3%	2%	2%
	JGUAD_070		1103587	2047	9600	26000	44400	78300	113800	160600	233100	292000	9600	25900	43900	76900	111400	157400	229100	287400	0%	0%	1%	2%	2%	2%	2%	2%
	JGUAD_090		960490	2104	10000	26900	45900	80800	117400	165600	240900	302700	10000	26700	45700	79800	115700	163100	237400	298500	0%	1%	0%	1%	1%	2%	1%	1%
	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	3462	16300	41900	70200	120900	173400	243600	363000	474500	16300	41700	69800	120000	172600	243200	362700	472200	0%	0%	1%	1%	0%	0%	0%	0%
	JGUAD_160		804436	3531	16600	43100	72300	125100	179900	250000	369800	485800	16600	43000	72000	124400	179200	249000	368300	484000	0%	0%	0%	1%	0%	0%	0%	0%
	JGUAD_150_160		749694	4014	17900	45800	76300	130800	187000	258300	379800	498800	17900	45600	76000	130200	186300	257600	378800	497500	0%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_170	Conf. with Peach Cr.	715919	4069	18000	45900	76500	130900	187000	258100	379200	497900	18000	45800	76200	130400	186400	257200	378100	496500	0%	0%	0%	0%	0%	0%	0%	0%
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	4215	18200	46100	76600	130600	186200	256400	375700	493300	18200	46100	76400	130200	185800	255600	374600	492000	0%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_210_220	Cuero Gage	518448	4934	16900	42500	70100	121000	174000	242000	362000	481000	16800	42400	69900	120700	173500	241300	361100	480000	1%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_230		465183	5028	17600	42600	69500	114700	160200	216100	309500	405900	17600	42600	69400	114400	159800	215500	308900	405000	0%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_260		390263	5092	17500	42000	68300	112400	156600	210700	300900	394500	17500	42000	68200	112200	156400	210300	300400	393700	0%	0%	0%	0%	0%	0%	0%	0%
Victoria	JGUAD_270	Victoria Gage	314224	5198	18000	41900	65700	105000	142000	187000	259000	347000	18000	41800	65600	104800	141700	186600	258500	346400	0%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_310	Above Coleto Cr.	212473	5245	17400	40500	63500	101400	137200	180600	250200	335200	17400	40500	63400	101200	137000	180300	249800	334700	0%	0%	0%	0%	0%	0%	0%	0%
	JGUAD_300_310	Conf. with Coleto Cr.	155706	5784	19800	46200	72400	115700	156500	206100	285500	382500	19800	46200	72300	115600	156300	205800	285000	381900	0%	0%	0%	0%	0%	0%	0%	0%
	OUTLET 1	Calhoun County Boundary	67943	5959	18100	42200	66100	105700	142900	188200	260700	349300	18100	42200	57200	105600	142800	188000	260500	348900	0%	0%	13%	0%	0%	0%	0%	0%

Blanco River

River	Hydraulic Element	Location Description	HEC-RAS Section Station	Upstream Drainage Area (mi2)	Pre-Project Non-Gage Analysis Peak Discharge (cfs)								Post-Project Non-Gage Analysis Peak Discharge (cfs)								Percent Reduction in Peak Discharge							
					Annual Chance Exceedance								Annual Chance Exceedance								Annual Chance Exceedance							
					50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%
Blanco	JBLNC_010_020	Hays County Line	270055	238	12500	23300	30400	40000	48700	58600	73900	87300	9500	15900	24900	36000	45300	55400	70700	84000	24%	32%	18%	10%	7%	5%	4%	4%
	JBLNC_030	Above Cypress	194521	317	12600	25500	34300	46600	57600	70100	89400	106400	10600	20100	26700	35400	46600	59800	80400	98300	16%	21%	22%	24%	19%	15%	10%	8%
	JBLNC_040	Wimberley Gage	155899	355	13100	27300	37500	51400	64100	78300	100300	119700	11500	22300	30400	41300	50800	64300	88000	108800	12%	18%	19%	20%	21%	18%	12%	9%
	JBLNC_050	Kyle Gage	103847	412	10700	23100	33000	46600	58800	72500	93700	112400	10700	21300	28600	38500	48300	59700	80000	99500	0%	8%	13%	17%	18%	18%	15%	11%
	JBLNC_060	Above San Marcos	42922	435	8700	18700	27000	38800	49500	61400	79700	95100	8700	17800	24500	33600	41900	51800	67700	84200	0%	5%	9%	13%	15%	16%	15%	11%
San Marcos	JBLNC_060_SMAR_010	San Marcos Conf	403769	531	10300	24400	35600	49300	61200	76300	100500	120700	10300	24400	35500	49300	61100	76000	99300	119900	0%	0%	0%	0%	0%	0%	1%	1%
	JSMAR_020	Above York	356498	614	9300	25600	38200	54500	68800	85400	111600	132700	9300	25600	38100	54400	68700	85300	111300	132300	0%	0%	0%	0%	0%	0%	0%	0%
	JSMAR_020_030	York Conf	272222	756	14400	33300	51100	73800	92900	114800	149600	178700	14400	33200	50900	73600	92700	114700	149500	178600	0%	0%	0%	0%	0%	0%	0%	0%
	JSMAR_090	Luling Gage	196464	838	14700	33900	51300	76600	98700	123900	163200	196400	14700	33900	51200	76400	98500	123500	162600	196000	0%	0%	0%	0%	0%	0%	0%	0%
	JSMAR_090_100	Plum Conf	138828	1250	16800	49200	77400	117600	153300	193300	255700	309500	16800	49200	77400	117400	153100	193000	255400	309300	0%	0%	0%	0%	0%	0%	0%	0%
	JSMAR_120	Above Guad	55586	1358	12100	40300	64900	105800	136800	171400	225200	271800	12100	40100	64700	105500	136200	170400	223600	270200	0%	0%	0%	0%	0%	1%	1%	1%
Gonzales	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	3462	12300	51500	86000	137100	178200	217300	275900	335300	12300	50800	85300	136100	176800	215500	273400	331500	0%	1%	1%	1%	1%	1%	1%	1%
	JGUAD_160		804436	3531	12200	48700	82300	130500	169500	208200	269800	325500	12200	47900	81500	129500	168000	206000	267000	322500	0%	2%	1%	1%	1%	1%	1%	1%
	JGUAD_150_160		749694	4014	12700	54400	91000	147500	192300	237800	309600	374600	12700	53700	90300	146500	190900	235800	307000	371800	0%	1%	1%	1%	1%	1%	1%	1%
	JGUAD_170	Conf. with Peach Cr.	715919	4069	11600	52700	88000	141600	184700	229400	299700	362600	11400	52000	87200	140700	183200	227400	297100	359900	2%	1%	1%	1%	1%	1%	1%	1%
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	4215	11000	50800	84400	134900	175900	219800	286300	345900	10800	50000	83500	133900	174500	217900	284000	343600	2%	2%	1%	1%	1%	1%	1%	1%
	JGUAD_210_220	Cuero Gage	518448	4934	11200	53200	89800	144400	190500	241900	319900	389400	11000	52400	89000	143400	189100	240000	317700	387100	2%	2%	1%	1%	1%	1%	1%	1%
	JGUAD_230		465183	5028	11000	48900	83400	134300	177300	225500	300000	369300	10700	48100	82600	133400	176000	223900	298100	367200	3%	2%	1%	1%	1%	1%	1%	1%
	JGUAD_260		390263	5092	10800	47000	77300	127300	169000	215400	287400	352800	10600	46500	76400	126500	167700	213900	285600	351000	2%	1%	1%	1%	1%	1%	1%	1%
Victoria	JGUAD_270	Victoria Gage	314224	5198	10400	45400	75000	122800	162900	207700	276900	339700	10200	44800	74100	122000	161800	206300	275400	338000	2%	1%	1%	1%	1%	1%	1%	1%
	JGUAD_310	Above Coleto Cr.	212473	5245	10100	42200	72700	118400	157300	200600	276700	328300	9900	41600	71900	117700	156300	199300	266200	326800	2%	1%	1%	1%	1%	1%	4%	0%
	JGUAD_300_310	Conf. with Coleto Cr,	155706	5784	10100	42300	72900	119000	158300	202200	270400	332100	10000	41700	72100	118200	157200	200900	268900	330600	1%	1%	1%	1%	1%	1%	1%	0%
	OUTLET 1	Calhoun County Boundary	67943	5959	1900	36300	64500	103700	137200	174800	234200	288100	1900	35800	63800	103100	136400	173800	233200	287000	0%	1%	1%	1%	1%	1%	0%	0%

Note: Complete Gonzalez upstream flows updated in HEC-RAS model.

Peach Creek																												
River	Hydraulic Element	Location Description	HEC-RAS Section Station	Upstream Drainage Area (mi2)	Pre-Project Gage Analysis Peak Discharge (cfs)								Post-Project Gage Analysis Peak Discharge (cfs)								Percent Reduction in Peak Discharge							
					Annual Chance Exceedance								Annual Chance Exceedance								Annual Chance Exceedance							
					50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%
Gonzales	JGUAD_150_160		749694	4014	17900	45800	76300	130800	187000	258300	379800	498800	17800	43400	73800	128800	188000	261200	385700	507200	1%	5%	3%	2%	-1%	-1%	-2%	-2%
	JGUAD_170	Conf. with Peach Cr.	715919	4069	18000	45900	76500	130900	187000	258100	379200	497900	17800	43500	73700	128400	187200	260500	384000	505000	1%	5%	4%	2%	0%	-1%	-1%	-1%
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	4215	18200	46100	76600	130600	186200	256400	375700	493300	18200	43600	73400	127500	185000	256900	377900	497200	0%	5%	4%	2%	1%	0%	-1%	-1%
	JGUAD_210_220	Cuero Gage	518448	4934	16900	42500	70100	121000	174000	242000	362000	481000	16900	40100	67200	117900	172300	241200	362600	482600	0%	6%	4%	3%	1%	0%	0%	0%
	JGUAD_230		465183	5028	17600	42600	69500	114700	160200	216100	309500	405900	17400	39700	65600	110500	156500	212700	306500	403400	1%	7%	6%	4%	2%	2%	1%	1%
	JGUAD_260		390263	5092	17500	42000	68300	112400	156600	210700	300900	394500	17500	39500	62800	107400	151600	205800	296000	389700	0%	6%	8%	4%	3%	2%	2%	1%
Victoria	JGUAD_270	Victoria Gage	314224	5198	18000	41900	65700	105000	142000	187000	259000	347000	18000	39200	60500	99900	136900	181900	253800	341500	0%	6%	8%	5%	4%	3%	2%	2%
	JGUAD_310	Above Coleto Cr.	212473	5245	17400	40500	63500	101400	137200	180600	250200	335200	17400	37800	58400	96200	131900	175100	236500	329000	0%	7%	8%	5%	4%	3%	5%	2%
	JGUAD_300_310	Conf. with Coleto Cr,	155706	5784	19800	46200	72400	115700	156500	206100	285500	382500	19800	43100	66600	109700	150300	199700	278700	375200	0%	7%	8%	5%	4%	3%	2%	2%
	Outlet 1	Calhoun County Boundary	67943	5959	18100	42200	66100	105700	142900	188200	260700	349300	18100	37900	60600	100100	137000	182000	253900	341800	0%	10%	8%	5%	4%	3%	3%	2%

York Creek																												
River	Hydraulic Element	Location Description	HEC-RAS Section Station	Upstream Drainage Area (mi2)	Pre-Project Gage Analysis Peak Discharge (cfs)								Post-Project Gage Analysis Peak Discharge (cfs)								Percent Reduction in Peak Discharge							
					Annual Chance Exceedance								Annual Chance Exceedance								Annual Chance Exceedance							
					50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%	50%	20%	10%	4%	2%	1%	0.40%	0.20%
San Marcos	JSMAR_020_030	York Conf	272222	756	12900	37000	61600	102800	140600	185300	252500	311600	9200	29800	47600	78400	116200	161600	229900	290200	29%	19%	23%	24%	17%	13%	9%	7%
	JSMAR_090	Luling Gage	196464	838	9800	26600	43500	72000	98400	130000	178000	221000	6700	21400	33900	57300	83600	115200	163700	206900	32%	20%	22%	20%	15%	11%	8%	6%
	JSMAR_090_100	Plum Conf	138828	1250	15200	41100	67200	111100	151900	200700	274800	341200	11700	36100	53300	90700	128700	175500	247100	310600	23%	12%	21%	18%	15%	13%	10%	9%
	JSMAR_120	Above Guad	55586	1358	13400	36200	59200	97900	133800	176800	242100	300500	13200	30600	47400	78600	112400	152800	214600	270900	1%	15%	20%	20%	16%	14%	11%	10%
Gonzales	JSMAR_120_GUAD_090	Conf. with San Marcos	883191	3462	16300	41900	70200	120900	173400	243600	363000	474500	16300	38300	62000	109900	161200	228200	356600	470400	0%	9%	12%	9%	7%	6%	2%	1%
	JGUAD_160		804436	3531	16600	43100	72300	125100	179900	250000	369800	485800	15900	39500	63400	112500	166300	236400	356100	471600	4%	8%	12%	10%	8%	5%	4%	3%
	JGUAD_150_160		749694	4014	17900	45800	76300	130800	187000	258300	379800	498800	17200	42100	67100	117100	172000	241600	361400	479000	4%	8%	12%	10%	8%	6%	5%	4%
	JGUAD_170	Conf. with Peach Cr.	715919	4069	18000	45900	76500	130900	187000	258100	379200	497900	17200	41900	67200	117000	171600	241700	360300	477000	4%	9%	12%	11%	8%	6%	5%	4%
DeWitt	JGUAD_210	Conf. with Sandies Cr.	621206	4215	18200	46100	76600	130600	186200	256400	375700	493300	17900	41900	67500	117000	171100	240200	357300	472800	2%	9%	12%	10%	8%	6%	5%	4%
	JGUAD_210_220	Cuero Gage	518448	4934	16900	42500	70100	121000	174000	242000	362000	481000	16600	38500	61800	108200	158900	224800	342000	458100	2%	9%	12%	11%	9%	7%	6%	5%
	JGUAD_230		465183	5028	17600	42600	69500	114700	160200	216100	309500	405900	17000	38600	61600	103300	147100	201700	293300	387000	3%	9%	11%	10%	8%	7%	5%	5%
	JGUAD_260		390263	5092	17500	42000	68300	112400	156600	210700	300900	394500	17000	38500	59400	101500	144200	197300	285600	377300	3%	8%	13%	10%	8%	6%	5%	4%
Victoria	JGUAD_270	Victoria Gage	314224	5198	18000	41900	65700	105000	142000	187000	259000	347000	17500	38400	57700	95300	131300	175600	246500	332500	3%	8%	12%	9%	8%	6%	5%	4%
	JGUAD_310	Above Coleto Cr.	212473	5245	17400	40500	63500	101400	137200	180600	250200	335200	16400	37200	56100	92300	127300	170100	230800	321800	6%	8%	12%	9%	7%	6%	8%	4%
	JGUAD_300_310	Conf. with Coleto Cr,	155706	5784	19800	46200	72400	115700	156500	206100	285500	382500	18600	42500	64000	105200	145100	194100	272100	367200	6%	8%	12%	9%	7%	6%	5%	4%
	OUTLET 1	Calhoun County Boundary	67943	5959	18100	42200	66100	105700	142900	188200	260700	349300	18100	37300	59300	98000	134700	179700	251100	338400	0%	12%	10%	7%	6%	5%	4%	3%

Appendix E.4

DIGITAL DATA

HALFF

US Army Corps of Engineers
Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study

Technical Report Notebook (TRN)
Alternative Development

Blanco and San Marcos
Rivers Confluence

Submitted to:

US Army Corps
of Engineers®

Prepared by:

HALFF

9500 AMBERGLEN BLVD, BLDG F, SUITE 125
AUSTIN, TEXAS 78729

AVO 32797

November 2017

Alternatives Development
TECHNICAL REPORT NOTEBOOK

TABLE OF CONTENTS

ALTERNATIVES DEVELOPMENT
TECHNICAL REPORT NOTEBOOK

OVERVIEW

The Guadalupe-Blanco River Authority (GBRA) Interim Feasibility Study is a detailed engineering study located in the Lower Guadalupe River Basin. The study stretches along the Guadalupe River from Canyon Lake to the Victoria County line, along the Blanco River starting in Hays County, and along the San Marcos River to its confluence with the Guadalupe River. The study is being undertaken by the United States Army Corps of Engineers (USACE), the Texas Water Development Board (TWDB), and the GBRA. This Technical Report Notebook (TRN) gives an overview of proposed flood damage reduction alternatives for the confluence of the Blanco and San Marcos Rivers.

The confluence of the Blanco and San Marcos Rivers has been the focus of repeated historical flooding. The largest recorded flood event to date on the Blanco River occurred on Memorial Day weekend in May 2015, inundating many buildings and homes in the overflow areas between the Blanco and San Marcos Rivers. The May 2015 flood event revealed the need for a better understanding of the flow dynamics and flooding extents in the neighborhoods and business centers in the overflow area to improve the floodplain permitting process and determine the impacts of recent developments.

A brief summary of recent hydraulic simulations of the Blanco / San Marcos confluence are described below.

- **GBRA/USACE/TWDB IFS:** Halff developed the initial steady-state 1D hydraulic models for the Blanco and San Marcos Rivers. From this original analysis, it was evident that the Blanco/San Marcos confluence area required a more dynamic analysis to better evaluate flood risks. The 1D hydraulic models were then converted to 1D unsteady hydraulic models.
- **San Marcos 2D Model:** After the May 2015 flood, the City wanted to develop a more sophisticated model of the Blanco / San Marcos confluence for planning purposes. To improve on the ID models of the Blanco and San Marcos Rivers recently developed for the IFS, the City of San Marcos contracted Halff to develop a 2D hydraulic analysis of the confluence and overflow areas to better model the complex multi-directional flow patterns occurring in the overflow area. The IFS 1D unsteady hydraulic models were truncated to represent the 1D portions of the Blanco River and San Marcos while the overland mesh was formed using the Hays County 2008 LiDAR. The 2D model was calibrated to surveyed and observed high water marks from the May 2015 flood event. The Innovyze Integrated Catchment Modeling (ICM) version 6.5.9 platform was utilized to complete the requested 2D simulations.
- **FEMA Physical Map Revision:** Near the completion of the City of San Marcos 2D model development, FEMA initiated the Physical Map Revision (PMR) of the Guadalupe-Blanco River Basin. The City's 2D ICM model was used to refine the 1D HEC-RAS simulations for FEMA modeling and mapping purposes. The graphic below displays the various PMR 1D HEC-RAS simulations that were used to develop the preliminary floodplains and associated water surface elevations. The main stem Blanco River and San Marcos Rivers are simulated using 1D unsteady HEC-RAS, but all other models are 1D steady-state models. The 1D conversion was conducted with the goal of achieving similar flows and resulting water surface elevations as the 2D simulation (primarily for the 1% annual chance event).

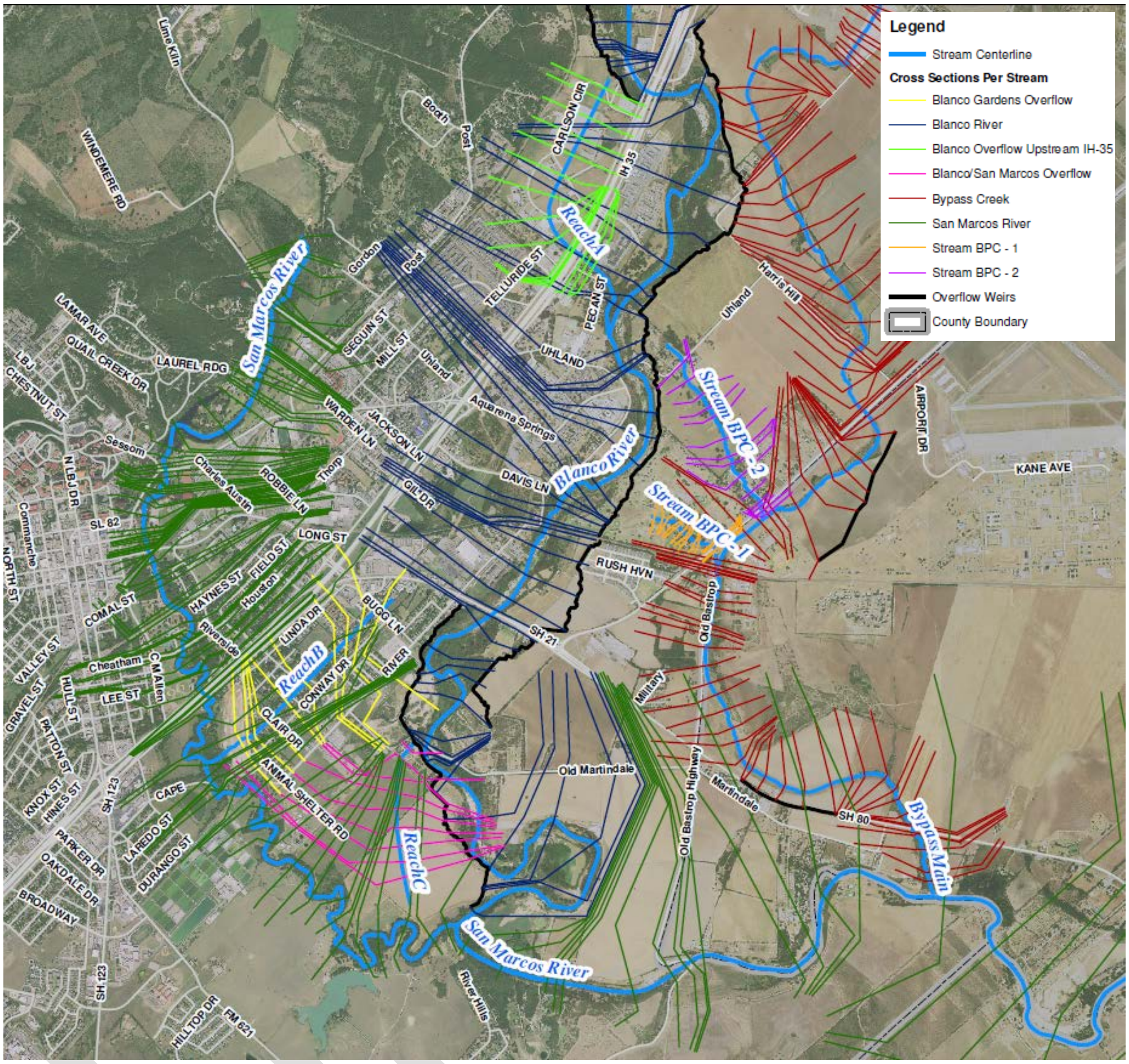


Figure 1. FEMA Physical Map Revision Hydraulics

The Infoworks ICM platform was selected for the City of San Marcos simulations. Although XPSWMM and HEC-RAS 5.0 are 2D modeling platforms that are accepted by FEMA, Infoworks ICM was selected due to the model's stability with large datasets, ability to simulate underground conveyance systems, and time efficiency to execute multiple 2D simulations. Given the USACE's need for expedited alternatives analysis of this complex area, it was recommended that the City's available Infoworks ICM model be utilized to advance the Tentatively Selected Plan (TSP) analysis. A 2D simulation is preferred rather than utilizing multiple PMR 1D HEC-RAS simulations to observe overall risk. Time constraints did not allow for the model to be converted and re-calibrated to a USACE approved platform such as HEC-RAS 5.0. Additionally, HEC-RAS 5.0 does not allow for the simulation of underground conveyance systems or complex alternatives analysis in the overland 2D mesh.

The recently refined Infoworks ICM 2D model extends from just west of I-35 down to the confluence of the San Marcos River and Bypass Creek and can be seen in the figure below. The red line represents the 2D modeling extents and the blue shaded area is the preliminary FEMA 1% annual chance event (ACE) floodplain.

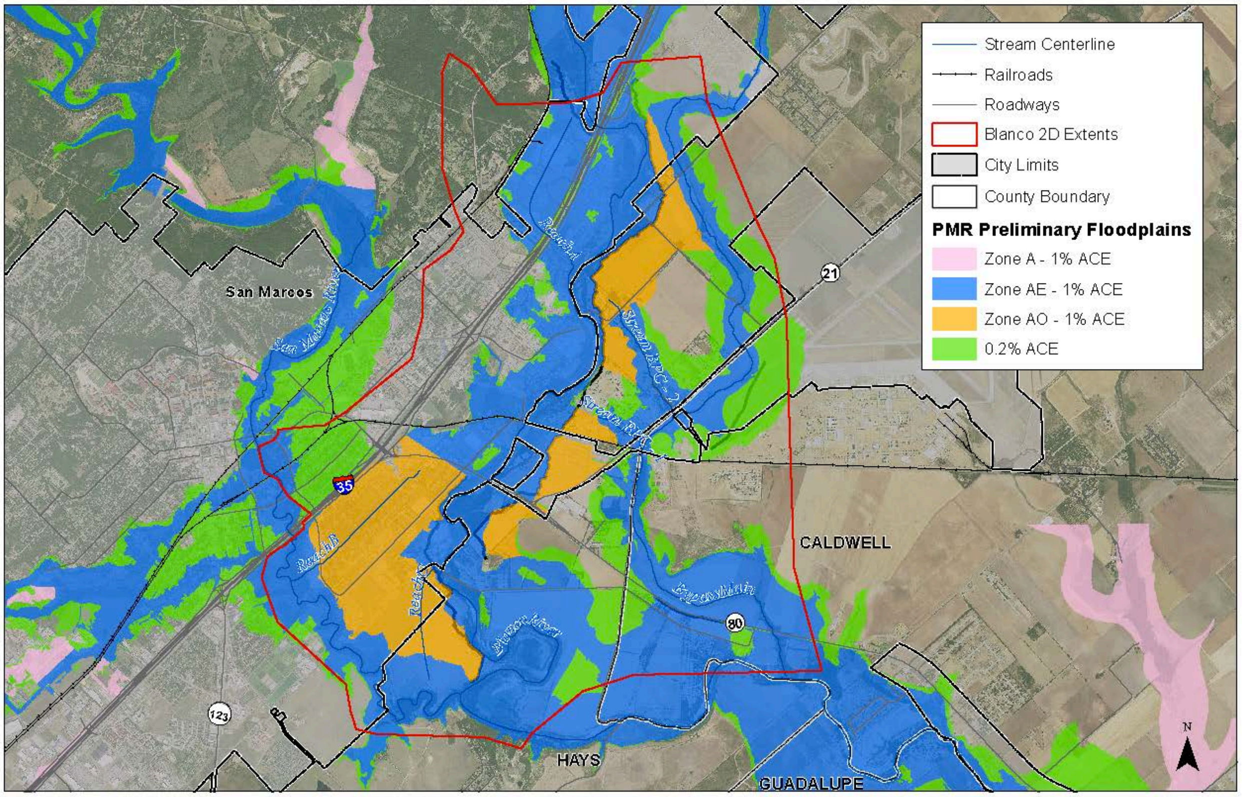


Figure 2. 2D Model Extents

A calibration of the ICM model was performed to the May 2015 flood event. The model was calibrated to surveyed high water marks (provided by GBRA), a stage hydrograph, and estimated high water marks in the Blanco Gardens neighborhood. Ten surveyed high water marks were collected throughout the study region and compared to the results of the hydraulic model. The stage hydrograph for the Blanco River located at State Highway 80 was obtained from the USGS website and compared to the stage hydrograph from the ICM model. The vertical datum of the USGS gage was adjusted to match the vertical datum of the surveyed high water mark at HWY 80. The peak stage of the model results are within 0.1 feet of the observed stage.

A validation of the calibrated model results was also performed to hand measured high water marks along Conway Street in the Blanco Gardens neighborhood. City staff provided high water marks taken at several addresses throughout the Blanco Gardens neighborhood. More than half of the measured high water marks were within 1 foot of the model results despite known inconsistencies in the determination of the measured depths. In summary, the computed results of the 2D compared favorably to the May 2015 high water marks.

HYDROLOGY

The primary hydrology utilized for this analysis was the Interagency Flood Risk Management (InFRM) San Marcos River Basin Hydrology prepared by the USACE Fort Worth District. The secondary hydrology utilized for this analysis was the FEMA PRM Bypass Creek Hydrology prepared by Halff Associates. Both hydrologic simulations utilized Hydraulic Engineering Center's Hydrologic Modeling System (HEC-HMS) version 3.5. The baseline hydrology was provided by the USACE dated July 2017. This new simulation had been slightly modified since the PMR analysis, resulting in discharge differences less than 10 cubic feet per second (cfs).

In addition to the updated USACE hydrology model, the PMR Bypass Creek hydrology model was utilized at various nodes along Bypass Creek in the ICM model. Bypass Creek was modeled with a 2D zone in the original model and is modeled as a 1D river reach for this analysis. The frequency storm events analyzed included the 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year storms. Application of the hydrologic results into the 2D model are described in Table 1 below.

Table 1. Application of Hydrology

River	Cross Section	HMS Model	HMS Element Name	Boundary Condition
San Marcos River	437930	July 2017 USACE San Marcos Basin HMS	J_USM0650	Flow Hydrograph
	434563		USM0660	Uniform Lateral Inflow
	430570		J_USM0700	Lateral Inflow Hydrograph
	429361		USM0710	Uniform Lateral Inflow
	428075		USM0720	
	427505		J_USM0320[A]	Lateral Inflow Hydrograph
	427343		USM0730	Uniform Lateral Inflow
	426620		USM0740	
	426196		USM0750	
	425437		USM0760	
	423396		USM0770	
	420755		J_USM1000_DIV_USM0910	
	419476		USM1010	
	415578		USM1020	
	412077		USM1030	
	410041		USM1040	
Blanco River	51519	July 2017 USACE San Marcos Basin HMS	Blanco_nr_Kyle_Gage & Blanco_S160[B]	Flow Hydrograph
	49825		Blanco_S160[C]	Uniform Lateral Inflow
	32463		Blanco_S170	
Bypass Creek	28960	April 2017 PMR HMS	J_BC030	Flow Hydrograph
	28067		BC040	Uniform Lateral Inflow
	24227		BC050	
	18904		BC060	
	17126		J_BC080	Lateral Inflow Hydrograph
	16962		BC090	Uniform Lateral Inflow
	13241		BC110	
	11399		BC130	
	9833		BC140	
			BC150	
			BC160	
	1552		BC170	

[A] Hydrograph for this element utilized an already reduced discharge assuming a 16.74mi^2 between 10 and 20 mi^2.
[B] Hydrograph for this element utilized an already reduced junction discharge combined with 59% of the subbasin.
[C] Hydrograph for this element utilized 41% of the subbasin.

2D MODEL DEVELOPMENT

As noted previously, the 2D Blanco / San Marcos ICM model prepared for the City of San Marcos was utilized for this analysis. The 2D hydraulic model consisted of two types of flow regimes: 1D and 2D. The main stems of the Blanco River, San Marcos River, and Bypass Creek were modeled as 1D channel flow between channel bank stations. Overflow from each of these creeks was modeled as 2D overland flow which allows the flow to travel in multiple directions between mesh points.

Original Model Development

Hydraulic model data for the 1D channels were extracted from the 1D HEC-RAS hydraulic simulations. Data included the channel cross-sections, bank stations, roughness values, and bridge crossing information. ICM utilizes mesh triangles to distribute flow through the overland 2D extents. The mesh triangles are assigned elevations from the 2008 LiDAR that was confirmed with 2016 field survey spot shots in Blanco Gardens area. Roughness values are based on the assigned land use type. Manning's roughness values used for the 2D mesh ranged from 0.03 - 0.08 with buildings and homes being modeled as voids in the mesh. These values are consistent with standard modeling procedures as published in a document by W. J. Syme (2008) entitled "*Flooding in Urban Areas – 2D Modelling Approaches for Buildings and Fences*." Roughness values as identified in Table 1 of the *FLO 2D Manual* are intended for shallow (<0.5 foot) overland flows. The roughness values in the Blanco / San Marcos ICM were selected for overland flows with 1 to 3 feet of depth. They were also selected as to not double count the assumed roughness through the neighborhood by using a high roughness value combined with voids in the mesh. Existing storm drain plans received from the City of San Marcos were also used to enhance the 2D section within the Blanco Gardens area. Finally, as-built plans were used to model the storm drain system under the Woodlands apartments. For more information on the original 2D model development, please see the *Blanco/San Marcos Confluence 2D Modeling Technical Memorandum* dated March 2016.

Model Refinement

With subsequent analysis in the Blanco / San Marcos confluence area since the development of the original 2D model, a few modifications were warranted. The modifications to the original 2D model are described below.

- **1D/2D Weir Locations:** The USACE provided a structure inventory point shapefile that represented structures (homes and businesses) that are potentially impacted by flood waters. These points were added into the 2D model to allows for a graphical representation and understanding of where impacted structures were located within the 2D model extents. Using the added structures (houses), the 1D river extents were trimmed (modified weir locations) such that most structures would be located in the overland 2D mesh. This weir relocation was performed such that water surface elevations for the impacted structures were consistently identified for the USACE benefit estimation.
- **Model Extents:** The 2D mesh extents on the upstream side of IH-35 were extended to identify additional impacted structures. It should be noted that the IH-35 configuration was raised to account for the existing concrete barrier between the northbound and southbound lanes.
- **Hydrologic Flows:** As noted above the USACE refined the InFRM San Marcos River Basin Hydrology in July 2017. This updated simulation was utilized for this analysis and applied to the 2D model as noted in Table 1 above.
- **Bypass Creek Flow Regime:** The original model simulated Bypass Creek as an overland 2D mesh. For this analysis, Bypass Creek was added as a 1D segment in order to best define the Bypass

Creek crossings and constrictions. This transition was also beneficial for the evaluation of Bypass Creek alternatives. The FEMA PMR 1D Bypass Creek hydraulic model (HEC-RAS version 4.1) was modified and imported into ICM. Cross sections in the HEC-RAS model were truncated on both the left and right overbanks to keep the 1D analysis to just outside the channel and to keep structures/voids outside of the 1D boundary. Once the cross sections were truncated, the updated geometry was imported into ICM and was finalized by checking the 1D cross sections to ensure the geometry and roughness values were imported correctly.

Crossings along Bypass Creek were input into the 1D river reach per the structure information provided in the unsteady HEC-RAS model. Bridges were input into the model in accordance to ICM practices and were separated by break nodes in between 1D river reaches. Culverts were modeled using conduits separated by break nodes in between 1D river reaches. Once the structures were added into the model, bank lines were created from the cross section extents and updated from the terrain in the ICM model. 1D/2D weir coefficients were set to 0.5 and the modular limit set to 0.9 for all the bank lines along Bypass Creek to maintain stability between the 1D/2D interaction.

- **Downstream Boundary Conditions:** In accordance with the FEMA PMR simulations, the downstream boundary conditions of the 2D model were refined. The boundary conditions of each frequency simulation were updated to match the San Marcos River PMR unsteady HEC-RAS simulations.
- **Recalibration:** With all the modifications listed above, it was necessary to recalibrate the model to the May 2015 historical event. Recalibration was conducted by using discharges from the May 2015 hydrologic simulation as provided by the USACE. Consistent with the original calibration, the updated model was calibrated to surveyed high water marks (provided by GBRA), a stage hydrograph, and estimated high water marks in the Blanco Gardens neighborhood. In order to replicate high water marks, 1D/2D weir coefficients were adjusted upstream of the Railroad and near the overflow at Bypass Creek. Coefficients were reduced from 0.5 to 0.4 and 0.3 depending on the location of the overflow. The peak stage of the updated historical simulation was within 0.1 feet of the observed stage and more than half of the measured high water marks were within 1 foot of the model results despite known inconsistencies in the determination of the measured depths. In summary, the computed results of the refined 2D model compared favorably to the May 2015 high water marks.

Existing Condition Results

Once the recalibration was completed in the ICM model, an updated existing conditions analysis was run for all storm events. Once all of the storm events were simulated, areas of interest were chosen to examine and compare results. For the 10-yr and smaller storm events, there was no ponding in the areas of interest. For the 25-yr and larger storm events, water from the Blanco River spilled outside of the banks downstream of the Highway 80 bridge, inundating the Blanco Gardens area and overflowed just upstream of West Uhland Road into a low lying area through Bogie St. The large storm events such as the 100-yr and higher show more inundation upstream of Highway 80 and begin to flood the apartment complexes located along the Blanco River. Results for the areas of interest for all the studied storm events is shown below in Table 2.

Table 2: Existing Conditions Results

Existing Conditions								
Location	**2-YR**	**5-YR**	**10-YR**	**25-YR**	**50-YR**	**100-YR**	**250-YR**	**500-YR**
Bypass Flow (cfs)	520	1,410	1,920	2,550	3,080	3,700	11,000	17,600
Bypass Outflow (cfs)	970	2,570	3,800	5,050	6,010	16,000	26,600	32,600
Flow D/S of HWY 80 (cfs)	9,650	31,600	51,450	87,800	109,700	129,500	130,600	151,400
WSEL D/S of HWY 80 (ft)	563.2	571.4	576.9	583.9	586.0	586.2	587.5	588.1
WSEL San Marcos Substation (ft)	-	-	-	581.6	583.3	584.5	584.8	585.3
WSEL Barbara Drive (ft)	-	-	-	576.0	578.1	578.9	579.5	579.9
WSEL Wal-Mart Parking Lot (ft)	-	-	-	-	-	587.5	588.2	589.0
WSEL Aspen Apartments (ft)	-	-	-	-	595.7	597.2	598.4	599.7
WSEL The Grove Apartments (ft)	-	-	-	-	600.3	602.5	604.9	606.7
WSEL Bogie St (ft)	-	-	-	570.2	574.7	579.3	582.9	584.5

(-) Indicates no ponding occurs

ALTERNATIVES ANALYSIS

The purpose of this flood risk management study is to identify areas of flood risk in the Blanco / San Marcos confluence area in order to protect life, property, and the environment. By identifying these areas early, the local communities may more easily and efficiently plan and construct flood management projects which will benefit the communities within the watershed.

The goals of this analysis are to 1) identify water resource related problems, needs and opportunities specifically related to flood risk management, 2) develop and evaluate alternative solutions to reduce flood damages, 3) use sustainable design methodologies, and 4) provide recommendations for flood reduction that the GBRA can prioritize and implement to reduce flood risks to people and the environment. Each of the alternatives presented a different set of hydrologic and hydraulic challenges. As potential alternatives were initially considered, some of them were intuitively not feasible and were not advanced. Generally, as the various alternatives were screened, plans were considered not viable if the plan required substantial activity by others or were not effective in solving the problem. The two main components leading toward an alternative's acceptability relate to implementation and satisfaction by the stakeholders. The proposed alternative must be viable.

The flood mitigation concepts discussed within this report are conceptual evaluations of potential flood mitigation solutions. They are high-level feasibility concepts that may be refined through subsequent preliminary engineering analysis and coordination with project stakeholders. Both structural and non-structural alternatives were considered by the USACE. Halff's analysis only included structural alternatives in the Blanco / San Marcos confluence area. As the hydrologic and hydraulics area of risk were evaluated, the alternatives were evaluated for environmental constraints that would affect compliance capability. Flood risk damages were identified, and general benefits were associated with each alternative (e.g., homes removed from flooding, structures removed, reduced floodplain area, etc.) This task was completed by the USACE. Conceptual design level estimates of project cost were also generated.

Conceptual Alternatives

For this study, seven alternative concepts were analyzed to mitigate the flooding impacts in the Blanco / San Marcos confluence area. The modeled alternative results were compared with the existing condition results to determine the preferred alternative based on feasibility of implementation and flood reduction benefits to the community. The location of these alternatives are displayed in Figure 3. Each alternative concepts consisted of a combination of improvements including:

- **Channelization of Bypass Creek:** Channelizing Bypass Creek from the Blanco overflow near IH-35 to the confluence with the San Marcos River increases the capacity of Bypass Creek allowing more overflow from the Blanco River into the improved channel while avoiding heavily populated areas. The conceptual diversion consisted of a 125-foot, 20-feet deep channel. In addition to the channel improvements, this alternative also requires lowering the topography between the Blanco River and Bypass Creek upstream of County Road 160 to allow more flow to divert into Bypass Creek. Channel improvements will also require each of the crossing structures to be removed and reconstructed as bridges that span the channel. The bridges were not included in the hydraulic modeling as it was assumed the bridges would be designed to generate minimal headloss.
- **Bypass of Bypass Creek:** Channelization of Bypass Creek from the Blanco overflow near IH-35 and rerouting the channel to the confluence with the San Marcos River increases the capacity of Bypass Creek and the Bypass of Bypass Creek allowing more overflow from the Blanco River into the improved channel while avoiding heavily populated areas. This alternative reroutes Bypass Creek between Airport Highway and Highway 80 creating a shorter channel with less crossings, development, and constraints. Two conceptual channel options were investigated: 1) 125-foot, 20-feet deep channel and 2) 200-ft, 20-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires lowering the topography between the Blanco River and Bypass Creek and construction of bridges.
- **Diversion 1:** Diverting water from the Blanco River downstream of the Highway 80 bridge crossing to the San Marcos River downstream of the Old Bastrop Highway efficiently transfers flow to the San Marcos River allowing for water surface elevation reductions along the Blanco River downstream of the Highway 80. The conceptual diversion consisted of a 125-foot, 20-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires each of the roadway crossings to be constructed as bridges that span the channel generating minimal headloss.
- **Diversion 2:** Diverting water from the Blanco River near Old Martindale Road to the San Marcos River between Cape Street and Scrutchin Lake efficiently transfers flow to the San Marcos River allowing for water surface elevation reductions along the Blanco River downstream of the Highway 80. This diversion is primarily located on the City of San Marcos property in between the Blanco and San Marcos Rivers. The conceptual diversion consisted of a 300-foot, 10-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires each of the roadway crossings to be constructed as bridges that span the channel generating minimal headloss.
- **Blanco Gardens Berm:** A berm located on the west side of the Blanco River near the Blanco Gardens Neighborhood decreases overflows from the Blanco River. A berm with an elevation of the 50-year existing condition Blanco River water surface elevations is used to reduce the neighborhood's flood risk for more frequent storm events.

- **Upstream Detention:** The USACE provided the hydrologic results from the simulated Blanco2 regional detention site in Blanco County. The post-detention flow rates were applied to the 2D model to evaluate flood mitigation benefit. The detention as proposed by the USACE conceptually reduced the flow in the Blanco River to near the 50-year storm event.

These alternatives include the construction of diversion channels, detention and berms in order to reduce the computed 100-year water surface elevations. Any downstream adverse impacts or increases in water surface elevation associated with hydraulic alternative options would be evaluated and mitigated should any of the projects mentioned in this analysis be recommended for further evaluation. All of the alternatives were evaluated for locations to dissipate flood waters prior to release into the San Marcos River. Although not included in the conceptual simulations, each diversion alternative has adequate locations for energy dissipation outside the banks of the San Marcos River. The flood mitigation concepts were simulated using the boundary condition of the existing conditions analysis for the alternative analysis with the exception of Bypass Creek. For alternatives with the channelized or rerouted Bypass Creek, additional tailwater hydrographs were developed to include the downstream boundary condition of the San Marcos River since the model was altered from existing condition. Tailwater hydrographs were established using a rating curve of the hydraulic cross section nearest to the outfall from the PMR San Marcos River HEC-RAS model and the flow hydrograph from the junction at the Blanco and San Marcos River confluence in the USACE's HEC-HMS model. These tailwater conditions were derived for each simulated storm event.

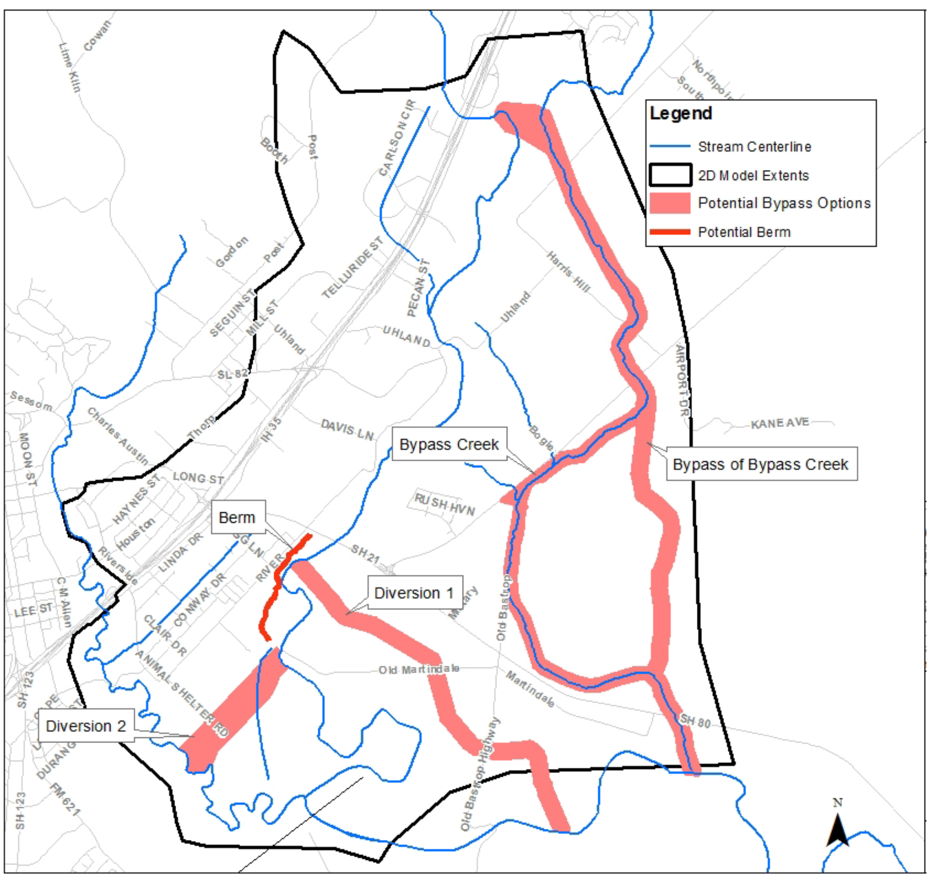


Figure 3. Potential Mitigation Options

The conceptual alternatives were evaluated independent of other flood mitigation alternatives to observe mitigation benefits. Using the results from the initial analysis, the study team was able to identify favorable alternatives for combined evaluation. Table 3 includes each alternative combination simulated for this analysis. Each combined alternative was simulated for the 100-year storm event to determine the impacts to the existing floodplain.

Table 3: Alternative Summary Chart

Alternative	Bypass Creek Channel	Rerouted Bypass Creek Channel	Diversion 1 Channel	Diversion 2 Channel	Larger Rerouted Bypass Creek Channel	Blanco Gardens Berm	Upstream Detention
Alternative 1	✓						
Alternative 1A	✓			✓			
Alternative 2		✓					
Alternative 2A		✓		✓			
Alternative 2B		✓	✓				
Alternative 2C		✓	✓			✓	
Alternative 2D		✓				✓	
Alternative 3			✓				
Alternative 3A			✓	✓			
Alternative 4					✓		
Alternative 4A					✓	✓	
Alternative 5						✓	✓
Alternative 6				✓		✓	

Alternatives Results

Once all of the alternatives were developed in the Infoworks ICM model, each alternative was simulated to observe the 100-year storm event impacts. Results were collected at the areas of interest that were analyzed in the existing conditions as follows. Figure 4 provides a graphical location of these analysis points in relation to the May 2015 resulting floodplain extents.

1. Blanco River just downstream of Highway 80
2. Blanco overflow near the San Marcos Substation
3. Blanco overflow along Barbra Drive in the Blanco Gardens neighborhood
4. Blanco overflow in the Wal-Mart parking lot just north of Highway 80
5. Blanco overflow at the Aspen Heights Apartments
6. Blanco overflow at the Grove Apartments
7. Bypass Creek 1 along Bogie Drive

These results of the alternatives analysis are listed below in Table 4. This table provides a comparison of computed flows in three locations as well as the computed water surface elevations in the locations listed above.

Table 4: Alternative Summary Results

Alternative	Flow Rate (cfs)			Analysis Point Computed 100-yr Water Surface Elevation (ft)						
	Diverted (Bypass) Flow	Bypass Creek Outflow	Blanco River D/S Hwy 80	1	2	3	4	5	6	7
Existing	3,700	16,000	129,500	586.2	584.5	578.9	587.5	597.2	602.5	579.3
Alternative 1	35,700	34,200	116,000	586.1	583.4	578.2	585.4	595.8	600.5	575.3
Alternative 1A	36,000	33,900	116,700	585.9	583.1	577.8	-	595.9	600.6	575.4
Alternative 2	36,400	28,900	116,400	586.1	583.4	578.2	-	595.9	600.8	575.5
Alternative 2A	36,100	28,600	116,200	585.9	583.0	577.8	-	595.8	600.8	575.3
Alternative 2B	36,000	21,900	116,300	585.0	582.2	576.6	-	595.7	600.7	575.0
Alternative 2C	35,900	21,900	116,200	585.1	-	-	-	595.7	600.7	575.0
Alternative 2D	36,600	29,500	114,600	586.7	582.6	577.1	586.2	595.9	600.5	575.3
Alternative 3	3,700	12,400	131,000	586.3	583	577.5	587.3	597.1	602.5	579.3
Alternative 3A	3,700	12,400	131,100	586.2	582.9	577.4	587.3	597.1	602.5	579.3
Alternative 4	50,600	48,900	106,300	585.5	582.9	577.7	-	595.0	-	571.4
Alternative 4A	52,000	50,000	103,000	585.9	581.2	-	-	594.8	-	570.4
Alternative 5	3,700	5,700	112,500	586.7	582.6	577.2	586.4	595.9	600.6	575.5
Alternative 6	3,700	16,000	128,600	586.5	583.1	577.6	587.6	597.2	602.5	579.3

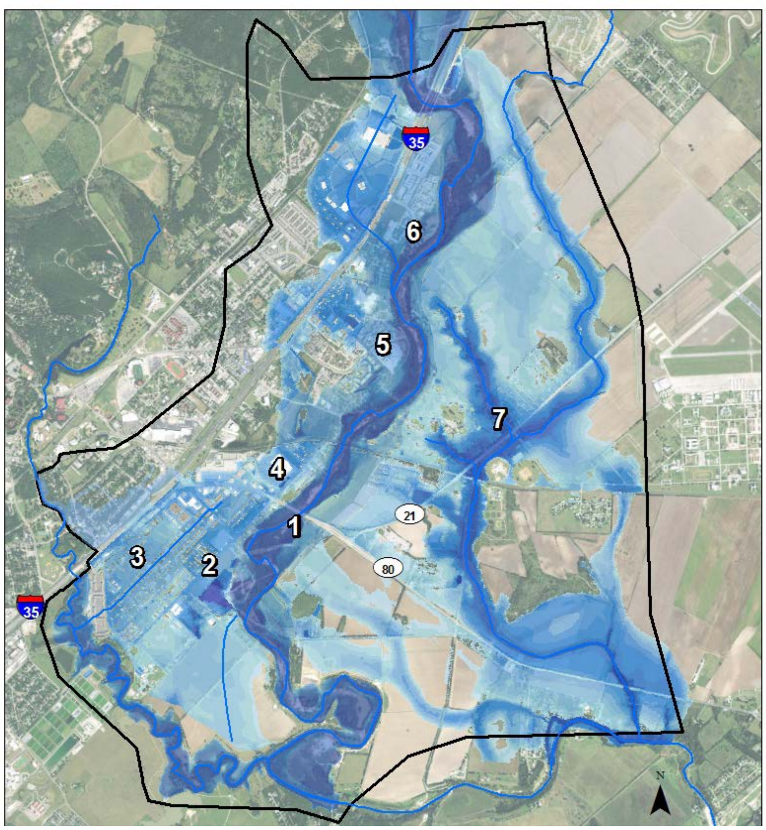


Figure 4. Analysis Locations

Based on the results in Table 4, flow rates and water surface elevations vary depending on what improvements are used for the specific alternative. Certain improvements have more hydraulic impact based on the location of the improvement relative to the watershed, the size of the proposed channels, and the reduction in flow through the Blanco River. The alternative results reveal the following hydraulic conclusions regarding the proposed improvements.

- **Channelization of Bypass Creek:** Channelization of Bypass Creek provides reduction in flood risk for all analysis points since flows in the Blanco River are decreased from near IH-35 to the confluence with the San Marcos River. Due to the constriction limitations along Bypass Creek, a larger channel was not feasible to further reduce flood risk. Alternative 1 flood risk reduction benefits average approximately 1.8 feet upstream of Highway 80 and approximately 0.6 feet in the Blanco Gardens area.
- **Bypass of Bypass Creek:** Similar to the channelization of Bypass Creek, the channelization and relocation of Bypass Creek provides reduction in flood risk for all analysis points since flows in the Blanco River are decreased from near IH-35 to the confluence with the San Marcos River. Since two channel dimensions were evaluated for this option, it was evident that a larger channel provides greater benefits. Alternative 2 simulates the impacts of the smaller channel while Alternative 4 simulates the benefits of the larger channel. Alternative 2 flood risk reduction benefits average approximately 1.5 feet upstream of Highway 80 and approximately 0.6 feet in the Blanco Gardens area. Alternative 4 flood risk reduction benefits average approximately 2.2 feet upstream of Highway 80 and approximately 1.2 feet in the Blanco Gardens area.
- **Diversion 1:** The diversion channel located downstream of Highway 80 provides reduction in flood risk for only areas downstream of Highway 80 through the Blanco Gardens neighborhood. Since the flow is diverted downstream of the road crossing, this improvement only impacts structures downstream of the highway. The diversion channel in Alternative 3 flood risk reduction benefits average approximately 0.9 feet in the Blanco Gardens area. This improvement alone does not provide benefits for all at risk structures in the Blanco / San Marcos confluence area. However, the channel could be combined with other options to provide a comprehensive flood risk reduction.
- **Diversion 2:** The Diversion 2 channel from Old Martindale Road to the San Marcos River does not provide benefit for the Blanco / San Marcos confluence area as an independent alternative. Therefore, Diversion 2 was simulated in combination with other improvements though Alternatives 1A, 2A, 3A, and 6. Majority of these simulations did not gain additional benefits with the addition of Diversion 2 with the exception of Alternative 6. In Alternative 6, the Diversion 2 channel is used to mitigate some of the rise caused by the Blanco Gardens Berm. Simulation of the berm increases flow in the Blanco River disconnecting the overflow for the more frequent storm events. The diversion channel reduces that impact by adding additional storage volume and conveyance to the San Marcos River.
- **Blanco Gardens Berm:** The Blanco Gardens berm provides reduction in flood risk for most storm events and prevents overflow into the Blanco Gardens neighborhood for storm events lower than the 50-year event. The berm's reduction benefit is limited only to the Blanco Gardens neighborhood and slightly increases flow and water surface elevation downstream along the Blanco River. As mentioned above, this alternative combined with Diversion 2 mitigates the potential adverse impact.

- **Upstream Detention:** Large upstream detention produces benefits to most analysis points since flows in the Blanco River are decreased to the confluence with the San Marcos River. Alternative 5 flood risk reduction benefits average approximately 1.4 feet upstream of Highway 80 and approximately 1.0 feet in the Blanco Gardens area.
- **Least Benefit:** The independent alternative with the least flood reduction benefit for the analysis points is Alternative 3. The combined alternative with the least flood reduction benefit for the analysis points is Alternative 3A. These alternatives are best used in combination with other alternatives.
- **Greatest Benefit:** The independent alternative with the greatest flood reduction benefit for the analysis points is Alternative 4. The combined alternative with the greatest flood reduction benefit for the analysis points is Alternative 4A. Although these alternatives provide the greatest benefit, they are also the most expensive options.

FINAL FLOOD MITIGATION ALTERNATIVES

An extensive set of potential flood mitigation alternatives were evaluated based upon expected flood mitigation benefits, high-level engineering feasibility, and cost effectiveness of each individual alternative. Based on the analysis, two combined alternatives were selected for further engineering analysis and consideration by the USACE. Alternatives 2D and 6 were selected for further evaluation and simulated for the 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year events. The results of the simulations were provided to the USACE to estimate economic benefits.

These selected alternatives were chosen considering their technical feasibility, cost, and input from project stakeholders. A structure inventory spatial file was obtained from the USACE representing a point for each structure (home or building) in the Blanco / San Marcos confluence area. Simulated water surface elevations were populated to the spatial file for the existing condition simulation, the Alternative 2D simulation, and the Alternative 6 simulation for the 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year storm events. This file was provided to the USACE for the estimation of economic benefit.

An opinion of probable cost was developed for each alternative. Unit prices for probable costs were developed using the Texas Department of Transportation (TxDOT) bid tabulations from projects within the Austin District within the last calendar year. For specific elements that were not listed within the TxDOT tabulation, unit prices were derived using recent land development and drainage projects in the Central Texas region. Since both of these alternatives require the excavation of a channel the unit cost associated with excavation is estimated with the assumption that material will be spread nearby rather than hauling. Property acquisition is estimated using average Hays County Appraisal District land values with an applied multiplier. It should be noted that these opinions of cost use standard practice and are only considered an estimate. These estimates should be refined should any of the projects mentioned in this analysis be recommended for further evaluation. Opinions of probable cost for each alternative can be found in Appendix A.

Alternative 2D: Bypass of Bypass Creek combined with Blanco Gardens Berm

This alternative includes the combination of the Bypass of Bypass Creek and the Blanco Gardens Berm. This alternative provides flood mitigation benefits for all analysis points since flows in the Blanco River are decreased from near IH-35 to the confluence with the San Marcos River. A schematic of the alternative is displayed in Figure 5 below.

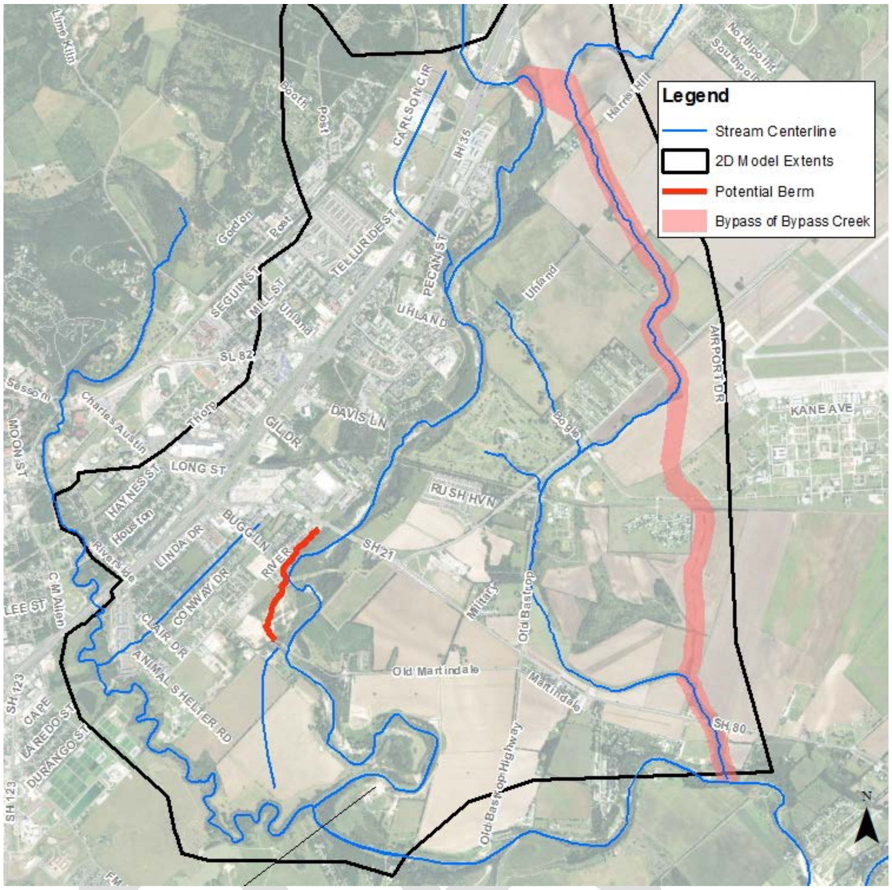


Figure 5. Alternative 2D Schematic

This alternative lowers the topography between the Blanco River and Bypass Creek upstream of County Road 160 to allow approximately 33,000 cfs to flow from the Blanco River into Bypass Creek. The conceptual diversion consists of a 125-foot, 20-feet deep channel that follows the Bypass Creek alignment to Airport Highway then flows south ultimately rejoining the Bypass Creek alignment near Highway 80. This alignment is preferred over the Bypass Creek alignment creating a shorter channel with less crossings, development, and constraints. The proposed channel improvements will require each of the crossing structures to be removed and reconstructed as bridges that span the channel. The bridges were not included in the hydraulic modeling as it was assumed the bridges would be designed to generate minimal headloss. As noted above, this the Bypass of Bypass Creek reduces flows along the mainstem of the Blanco River. The lower flow rates combined with the Blanco Gardens Berm significantly reduce overflows into the Blanco Gardens neighborhood. The conceptual berm is located on the western bank of the Blanco River downstream of Highway 80. The berm is simulated at the 50-year existing condition Blanco River water surface elevations protecting the neighborhood from the more frequent storm events.

The estimated project cost for this flood mitigation alternative is **$52,500,000**. The benefits and constraints of this alternative are listed below:

Benefits

- **Water surface mitigation benefits:** This flood mitigation alternative results in an average 100-year water surface depth reduction of approximately 1.5 feet upstream of Highway 80, 1.1 feet in the Blanco Gardens area, 4.0 feet along Bogie Drive.
- **Structural mitigation benefits:** This flood mitigation alternative reduces the computed structural flooding of approximately XX out of XX structures for the 100-year event in the Blanco / San Marcos confluence area.
- **Flood mitigation benefits:** These flood mitigation alternatives provides flood reduction benefits to in the entire 2D study area. Not only does this alternative reduce water surface elevations along the Blanco River, this alternatives significantly reduces overflows and associated flood depths from IH-35 to Highway 80 toward Bypass Creek, Blanco Gardens overflows, and overtopping if IH-35.

Constraints

- **Multi-stakeholder coordination:** Since the proposed project crosses many jurisdictional boundaries negotiations with project stakeholders would be required.
- **Perpetual channel maintenance:** Once the channel improvements are complete, great efforts would be required to maintain an effective channel.
- **Property acquisition required:** The project stakeholders do not currently own easement or property along this proposed alignment of the bypass channel or berm location. Property acquisition would be required in the areas where channel clearing is proposed.
- **Significant long-term environmental impacts:** Altering natural channels impacts water quality, creek stability, wildlife, and trees. To maintain the flood mitigation benefits of this alternative, perpetual maintenance is required prolonging the environmental impact.
- **Permitting:** A USACE 404 Individual Permit is anticipated due to the proposed channel improvements along Bypass Creek, near the Blanco River, and near the San Marcos Rivers. In addition, permitting is likely required from the City of San Marcos, Hays County, Caldwell County, TCEQ, and US Fish and Wildlife.

Alternative 6: Blanco Gardens Berm combined with Diversion 2

This alternative includes the combination of the Blanco Gardens Berm and Diversion 2 from Old Martindale Road to the San Marcos River. This alternative only provides flood mitigation benefits for the Blanco Gardens neighborhood. A schematic of the alternative is displayed in Figure 6 below.

This alternative raises the topography of the western Blanco River bank from Highway 80 to Old Martindale Road. This elevation of the bank reduces the overflow from the Blanco River into the Blanco Gardens neighborhood. The berm is simulated at the 50-year existing condition Blanco River water surface elevations protecting the neighborhood from the more frequent storm events. Reduction of overflow into the neighborhood increases flows in the Blanco River causing a slight increase in the water surface. A diversion from near Old Martindale Road to the San Marcos River is used to mitigate that rise. The conceptual diversion consists of a 300-foot, 10-feet deep channel. Additionally this alignment significantly reduces the required property acquisition because the majority of the land along this alignment is owned by the City of San Marcos. The proposed channel will require each of the crossing structures to be constructed as bridges that span the channel. The bridges were not included in the hydraulic modeling as it was assumed the bridges would be designed to generate minimal headloss.

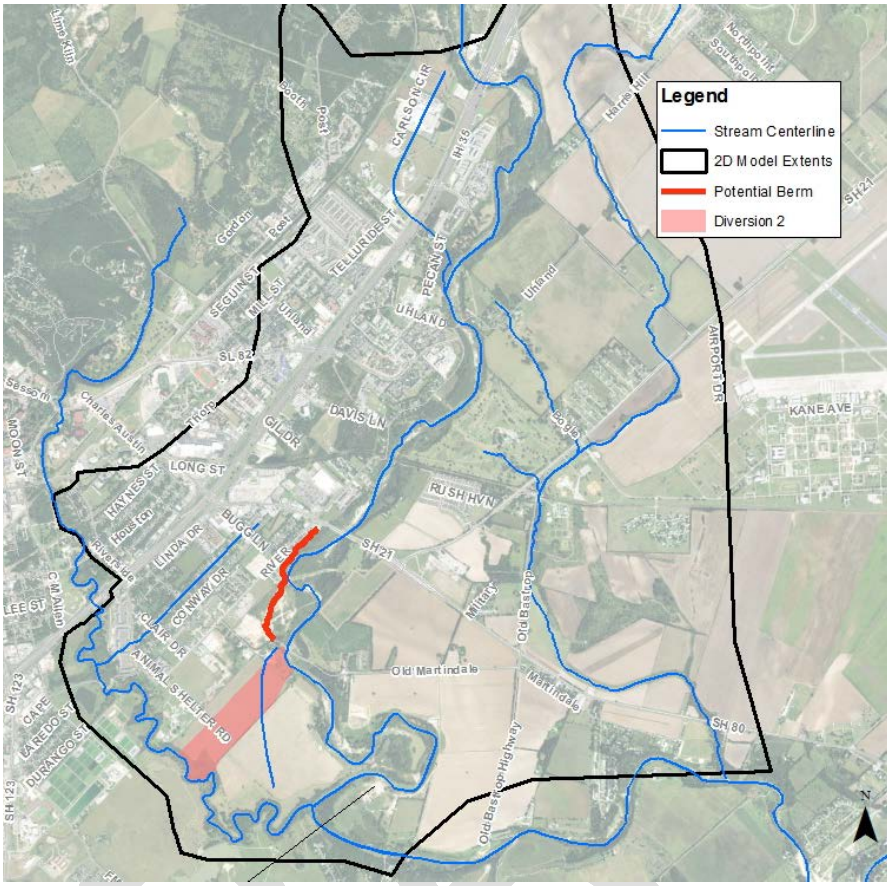


Figure 6. Alternative 6 Schematic

The estimated project cost for this flood mitigation alternative is **$9,400,000**. The benefits and constraints of this alternative are listed below:

Benefits

- **Water surface mitigation benefits:** This flood mitigation alternative results in an average 100-year water surface depth reduction of approximately 0.8 feet in the only in the Blanco Gardens area.
- **Structural mitigation benefits:** This flood mitigation alternative reduces the computed structural flooding of approximately XX out of XX structures for the 100-year event in the Blanco / San Marcos confluence area.
- **Property acquisition required:** The City of San Marcos currently owns property along the proposed alignment of the diversion channel. Ownership of property in this area reduces the required property acquisition for the project.
- **Permitting:** A USACE Nationwide Permit is anticipated due to the proposed connections to the Blanco River and San Marcos Rivers. In addition, permitting is likely required from the City of San Marcos, Hays County, TCEQ, and US Fish and Wildlife.

Constraints

- **Limited flood mitigation benefits:** Since improvements are only proposed downstream of Highway 80, this alternative only provides mitigation benefits to the Blanco Gardens neighborhood. Additionally, the elevation of the proposed berm is at the 50-year existing condition Blanco River water surface elevations. This elevation protects the neighborhood from the more frequent storm events, but does not protect the neighborhood from events greater than the 50-year event.
- **Multi-stakeholder coordination:** Since the proposed project crosses many jurisdictional boundaries negotiations with project stakeholders would be required.
- **Perpetual channel maintenance:** Once the channel construction is complete, great efforts would be required to maintain an effective channel.
- **Significant long-term environmental impacts:** Altering natural channels impacts water quality, creek stability, wildlife, and trees. To maintain the flood mitigation benefits of this alternative, perpetual maintenance is required prolonging the environmental impact.

PROJECT SUMMARY

The GBRA Interim Feasibility Study is a detailed engineering study of the Lower Guadalupe River Basin. The study is being undertaken by the USACE, the TWDB, and the GBRA. This report documents a portion of the overall study focusing on flood damage reduction alternatives for the confluence of the Blanco and San Marcos Rivers. Given the USACE's need for expedited alternatives analysis of this complex area, it was recommended that the City's available Infoworks ICM model be utilized to advance the TSP analysis.

This report documents the 2D analysis and subsequent alternatives analysis that was conducted for the Blanco / San Marcos confluence area. The study team identified two viable alternatives to reduce flood risks along the Blanco and San Marcos Rivers from IH-35 to the confluence. One alternatives provides greater flood reduction benefits over the entire study area through the construction of a channelized and rerouted Bypass Creek combined with. The other alternative provides less flood reduction benefits only providing reduction of water surface elevations in the Blanco Gardens neighborhood through the construction of a berm to elevate the western bank of the Blanco River near the Blanco Gardens neighborhood and construction of a diversion channel to mitigate the rise caused by the berm.

Although the first alternative provides the greatest flood reduction benefits, it is also the most expensive alternative. In support of the greater USACE project, Halff was contracted to conduct 2D analysis, alternatives analysis using the 2D model, computation of existing condition and proposed condition water surface elevations, and development of opinions of probable cost for the viable alternatives. This data will be utilized by the USACE to evaluate project economics and overall viability.

Appendix A

Estimates of Probable Cost

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCITON COST

Alternative 2D

Combined Estimate of Probable Cost

BYPASS CHANNEL OF BYPASS CREEK	
Total Project Cost	$ 45,141,125
Engineering and Survey Fees	$ 4,520,000
Regulatory Permitting	$ 460,000
Property/Easement Acquisition	$ 1,161,000
PROJECT GRAND TOTAL	**$ 51,282,125**

BERM	
Total Project Cost	$ 968,500
Engineering and Survey Fees	$ 100,000
Regulatory Permitting	$ 10,000
Property/Easement Acquisition	$ 142,000
PROJECT GRAND TOTAL	**$ 1,220,500**

BYPASS CHANNEL & BERM COMBINED	
Total Project Cost	$ 46,109,625
Engineering and Survey Fees	$ 4,620,000
Regulatory Permitting	$ 470,000
Property/Easement Acquisition	$ 1,303,000
PROJECT GRAND TOTAL	**$ 52,502,625**

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 10/5/2017

AVO: 32797

PROJECT: Blanco/San Marcos 2D Analysis Feasibilty

Alternative: Bypass Channel of Bypass Creek

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Channel Excavation (assumes no	CY	$ 5	3,561,500	$ 17,807,500
2	Bridge Construction	SF	$ 100	84,600	$ 8,460,000
3	Railroad Improvement	SF	$ 200	19,600	$ 3,920,000
4	Clearing and grubbing	AC	$ 8,000	156	$ 1,248,000
5	Hydromulch Seeding	SY	$ 0.40	756,000	$ 302,400
6	Soil Retention Blankets	SY	$ 2	756,000	$ 1,512,000
7	Channel Outlet at San Marcos River	LS	$ 500,000	1	$ 500,000
8	Temporary Erosion and Sediment Control (2%)	LS	$ 675,000	1	$ 675,000
9	Mobilization (5%)	LS	$ 1,688,000	1	$ 1,688,000
				SUBTOTAL	**$ 36,112,900**
				CONTINGENCY (25%)	**$ 9,028,225**
				TOTAL PROJECT COST	**$ 45,141,125**
9	Engineering and Survey Fees (10%)	LS	$ 4,520,000	1	$ 4,520,000
10	Regulatory Permitting (1%)	LS	$ 460,000	1	$ 460,000
11	Property/Easement Acquisition	AC	$ 13,500	86	$ 1,161,000
				PROJECT GRAND TOTAL	**$ 51,282,125**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities.

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and the Engineer shall not be held liable to Owner or third party for any failure to accurately estimate the cost of the project, or any part thereof. Unit Prices are in current dollars and should be adjusted as required when schedule for project is determined.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 10/5/2017
AVO: 32797
PROJECT: Blanco/San Marcos 2D Analysis Feasibilty
Alternative: Berm

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing	AC	$ 11,000	4	$ 44,000
2	Embankment	CY	$ 30	3,500	$ 105,000
3	Subgrade Preparation	SY	$ 15	19,400	$ 291,000
4	Soil Retention Blankets	SY	$ 5	19,400	$ 97,000
5	Placing Topsoil (4")	SY	$ 5	19,400	$ 97,000
6	Hydromulch Seeding	SY	$ 2	19,400	$ 38,800
7	Temporary Erosion and Sediment Control (5%)	LS	$ 34,000	1	$ 34,000
8	Mobilization (10%)	LS	$ 68,000	1	$ 68,000
				SUBTOTAL	**$ 774,800**
				CONTINGENCY (25%)	**$ 193,700**
				TOTAL PROJECT COST	**$ 968,500**
8	Engineering and Survey Fees (10%)	LS	$ 100,000	1	$ 100,000
9	Regulatory Permitting (1%)	LS	$ 10,000	1	$ 10,000
10	Property/Easement Acquisition	AC	$ 35,500	4	$ 142,000
				PROJECT GRAND TOTAL	**$ 1,220,500**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and the Engineer shall not be held liable to Owner or third party for any failure to accurately estimate the cost of the project, or any part thereof. Unit Prices are in current dollars and should be adjusted as required when schedule for project is determined.

ENGINEER'S OPINION OF PROBABLE CONSTRUCITON COST

Alternative 6

Combined Estimate of Probable Cost

DIVERSION 2 CHANNEL	
Total Project Cost	$7,241,500
Engineering and Survey Fees	$730,000
Regulatory Permitting	$80,000
Property/Easement Acquisition	$140,000
PROJECT GRAND TOTAL	**$8,191,500**
BERM	
Total Project Cost	$968,500
Engineering and Survey Fees	$100,000
Regulatory Permitting	$10,000
Property/Easement Acquisition	$142,000
PROJECT GRAND TOTAL	**$1,220,500**
DIVERSION CHANNEL & BERM COMBINED	
Total Project Cost	$8,210,000
Engineering and Survey Fees	$830,000
Regulatory Permitting	$90,000
Property/Easement Acquisition	$282,000
PROJECT GRAND TOTAL	**$9,412,000**

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 10/23/2017

AVO: 32797

PROJECT: Blanco/San Marcos 2D Analysis Feasibilty

Alternative: Diversion 2 from Blanco River

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Channel Excavation (assumes no	CY	$ 5	530,000	$ 2,650,000
2	Bridge Construction	SF	$ 100	16,400	$ 1,640,000
4	Clearing and grubbing	AC	$ 8,000	32	$ 256,000
5	Hydromulch Seeding	SY	$ 0.40	153,000	$ 61,200
6	Soil Retention Blankets	SY	$ 2	153,000	$ 306,000
7	Channel Outlet at San Marcos River	LS	$ 500,000	1	$ 500,000
8	Temporary Erosion and Sediment Control (2%)	LS	$ 109,000	1	$ 109,000
9	Mobilization (5%)	LS	$ 271,000	1	$ 271,000
				SUBTOTAL	**$ 5,793,200**
				CONTINGENCY (25%)	**$ 1,448,300**
				TOTAL PROJECT COST	**$ 7,241,500**
9	Engineering and Survey Fees (10%)	LS	$ 730,000	1	$ 730,000
10	Regulatory Permitting (1%)	LS	$ 80,000	1	$ 80,000
11	Property/Easement Acquisition	AC	$ 35,000	4	$ 140,000
				PROJECT GRAND TOTAL	**$ 8,191,500**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities.

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and the Engineer shall not be held liable to Owner or third party for any failure to accurately estimate the cost of the project, or any part thereof. Unit Prices are in current dollars and should be adjusted as required when schedule for project is determined.

HALFF

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

DATE: 10/23/2017
AVO: 32797
PROJECT: Blanco/San Marcos 2D Analysis Feasibilty
Alternative: Berm

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing	AC	$ 11,000	4	$ 44,000
2	Embankment	CY	$ 30	3,500	$ 105,000
3	Subgrade Preparation	SY	$ 15	19,400	$ 291,000
4	Soil Retention Blankets	SY	$ 5	19,400	$ 97,000
5	Placing Topsoil (4")	SY	$ 5	19,400	$ 97,000
6	Hydromulch Seeding	SY	$ 2	19,400	$ 38,800
7	Temporary Erosion and Sediment Control (5%)	LS	$ 34,000	1	$ 34,000
8	Mobilization (10%)	LS	$ 68,000	1	$ 68,000
				SUBTOTAL	**$ 774,800**
				CONTINGENCY (25%)	**$ 193,700**
				TOTAL PROJECT COST	**$ 968,500**
8	Engineering and Survey Fees (10%)	LS	$ 100,000	1	$ 100,000
9	Regulatory Permitting (1%)	LS	$ 10,000	1	$ 10,000
10	Property/Easement Acquisition	AC	$ 35,500	4	$ 142,000
				PROJECT GRAND TOTAL	**$ 1,220,500**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

This statement was prepared utilizing standard cost estimate practices. It is understood and agreed that this is an estimate only, and the Engineer shall not be held liable to Owner or third party for any failure to accurately estimate the cost of the project, or any part thereof. Unit Prices are in current dollars and should be adjusted as required when schedule for project is determined.

Appendix B

Digital Data

HALFF