US Army Corps of Engineers
Lower Guadalupe River Basin
Guadalupe-Blanco River Authority
Interim Feasibility Study – Phase 2
Technical Report Notebook (TRN)
Engineering Analysis – Hydrology and Hydraulics

Blanco and San Marcos River Confluence Unsteady Modeling

Submitted to:

US Army Corps of Engineers®

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BLANCO/SAN MARCOS UNSTEADY MODELING
TECHNICAL REPORT NOTEBOOK

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EXECUTIVE SUMMARY

Frequent flooding is a problem throughout the Lower Guadalupe-Blanco Watershed and especially in the City of San Marcos at the confluence of the Blanco and San Marcos Rivers. To address this issue of flooding and backwater conditions at this confluence and better equip the City of San Marcos, the U.S. Army Corps of Engineers (USACE) has agreed to improve the modeling completed under Phases 1 and 2 of the Guadalupe Blanco River Authority (GBRA) Interim Feasibility study that included the development of hydrologic and hydraulic models with an unsteady hydraulic model for the Blanco/San Marcos confluence. The study limits on the Blanco River extend from 5100 feet upstream of Five Mile Dam near the Blanco Vista subdivision down to the confluence with the San Marcos River and from 840 feet upstream of Lime Kiln Road to 2900 feet downstream of the Blanco River confluence on the San Marcos River. The Blanco River basin is approximately 435 square miles at its confluence with the San Marcos River near the City of San Marcos.

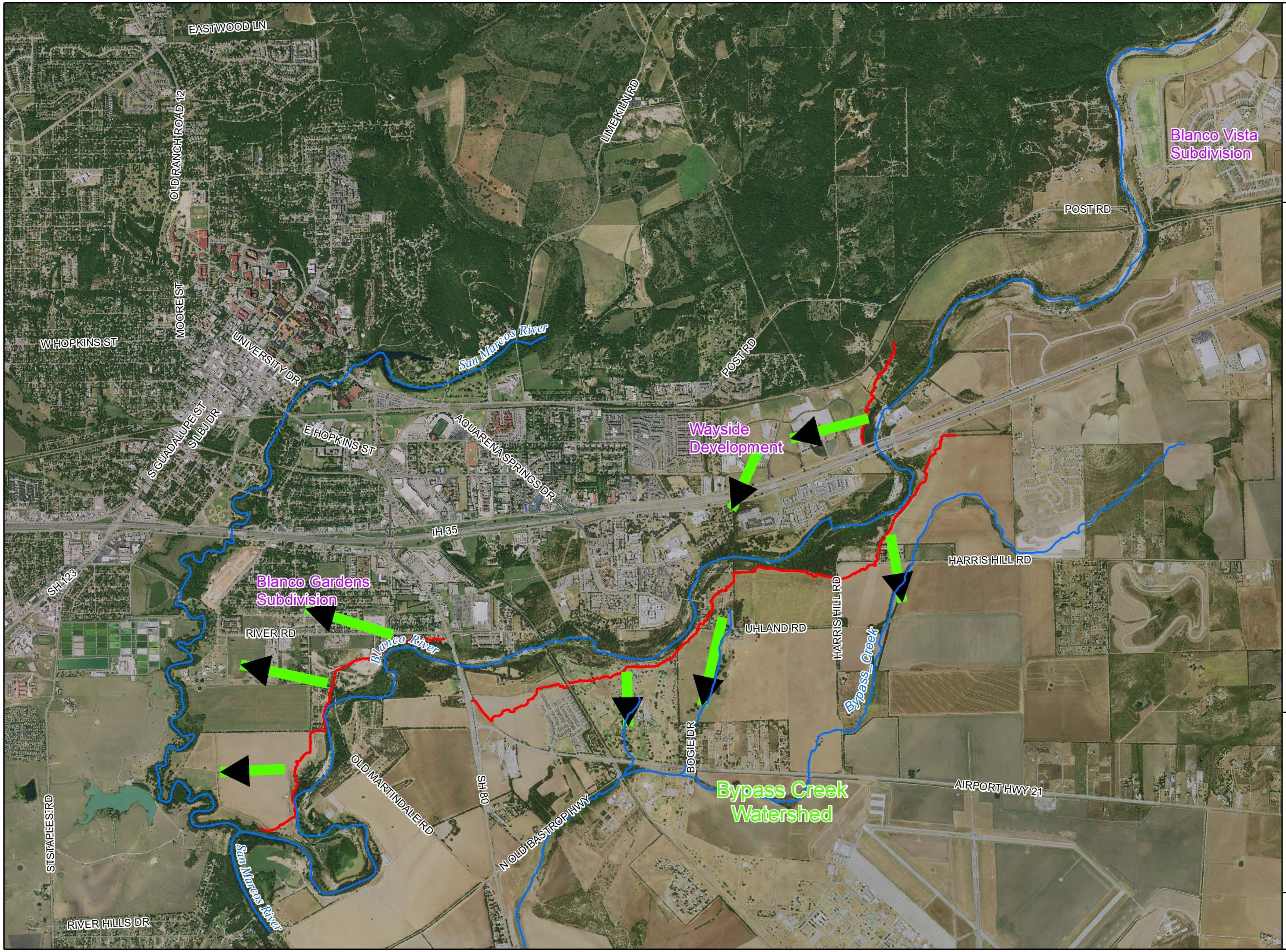
Hydrograph inflows and hydraulic geometry for the unsteady model were taken from existing hydrologic and hydraulic models previously developed under Phases 1 of the GBRA Interim Feasibility Study. Lateral weirs were added to the unsteady model at overflow locations to determine the amount of overland flow leaving the Blanco River system. These overflow areas were modeled with simplified hydraulic models to determine flooding impacts in those adjacent overland areas. The modeling resulted in updated and more accurate flows and water surface elevations for the 2, 5, 10, 25, 50, 100, 250, and 500-yr storm events and established the backwater effects of the Blanco River flooding on the San Marcos River as a result of interconnected overland flows. The resulting hydraulic data can be used to analyze various flood reduction alternatives such as a Blanco River bypass channel along Bypass Creek.

INTRODUCTION

The US Army Corps of Engineers (USACE) Lower Guadalupe River Basin Interim Feasibility Study is a multi-phase basin-wide study to define flood risk and flood reduction alternatives. During Phase 1 of the study, steady-state hydraulic models were developed of the Blanco River from the Hays/Blanco County line down to the confluence with the San Marcos River and the San Marcos from the Blanco River confluence down to the confluence with the Guadalupe River. Survey data was also captured and added to the Phase 1 San Marcos River study. Flow data utilized in the Phase 1 hydraulic models was the result of an interpolation between USACE gage analyses at the Kyle and Luling gages. During Phase 2 of the study, a steady–state hydraulic model was developed of the San Marcos River from its headwaters down to the confluence with the Blanco River through the City of San Marcos including new survey data and flows from a new detailed hydrology model of the Upper San Marcos watershed. Survey data was also captured and added to the Blanco River hydraulic model through the City of San Marcos. At the request of the City of San Marcos and USACE, the interpolation methodology utilized for the Blanco flows was revised to produce more reasonable flows through the city. A technical memo documenting the revised gage analysis interpolation is provided in Appendix A

Large historical storm events on the Blanco River have shown a significant backwater impact on the San Marcos River due to overflows from the Blanco River flowing into the San Marcos River downstream of Interstate 35. A steady-state hydraulic model cannot replicate the dynamic nature of this interaction between the San Marcos and Blanco Rivers during flood events. Therefore, USACE contracted with Halff Associates to develop an unsteady hydraulic model of the Blanco and San Marcos River confluence area to better understand the overflows from the Blanco River and the backwater impact on the San Marcos River.

The Blanco River reach included in the unsteady hydraulic model extends from 5100 feet upstream of Five Mile Dam near the Blanco Vista subdivision down to the confluence with the San Marcos River. The San Marcos River reach extends from 840 feet upstream of Lime Kiln Road to 2900 feet downstream of the Blanco River confluence. The Blanco watershed drains 435 sq. mi. and the Upper San Marcos watershed drains 95 sq. mi. The unsteady model reaches are illustrated in Figure 1. Modeled overflows from the Blanco River are indicated by the arrows and overflow areas are shown as red lines. This report includes documentation of topography, hydrology, and hydraulics associated with the newly developed unsteady model.



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GBRA Interim Feasibility Study - Phase 2

Key to Features

- Study Streams
- Blanco Overflows
- Overflow Zones

Figure 1: Blanco/San Marcos Unsteady Study Area

0 1,250 2,500 5,000 Feet

1 inch = 2,500 feet

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TOPOGRAPHY DEVELOPMENT

LiDAR Data Sources

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 basin-wide bare earth terrain dataset using the LiDAR described in Table 1. In association with the Phase 1 and 2 studies, Halff Associates used the terrain dataset to generate 10 ft. by 10 ft. digital elevation models (DEMs) for the hydrologic studies and 3 ft. by 3 ft. digital DEMs for hydraulic studies.

Table 1: LiDAR Data Source

County	Year Flown	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 North American Datum (NAD) 83 (1993) State Plane Coordinates, Texas South Central (Zone 4204) presented in US Survey Feet with a Vertical Datum set to North American Vertical Datum of 1988.

HYDROLOGIC METHODOLOGY

The hydrologic inputs for the unsteady modeling were derived from two previously created hydrology models. The San Marcos River hydrographs were taken from the Upper San Marcos watershed hydrology model originally developed under Phase 2 of the GBRA Feasibility Study. Details of the Upper San Marcos hydrology model can be found in the Phase 2 Technical Report Notebook, dated May 2015 included with the digital data in Appendix D. The Blanco River hydrographs were extracted from a model that was originally developed under Phase 1 of the GBRA Feasibility Study. This Phase 1 basin-wide model focused on the entire Lower Guadalupe River Basin and only contains six sub-basins representing the Blanco River watershed. Further details of the development of the Phase 1 hydrology model can be found in the Phase 1 Hydrology Technical Report Notebook, dated March 2014, included with the digital data in in Appendix D. The USACE Fort Worth District incorporated this model into their Corps Water Management System (CWMS) platform for the Guadalupe River Basin and improved the calibration of the Blanco River portion of the model by further adjusting losses, lag time and peaking factor. USACE Fort Worth District did not include areal reduction in their updated Blanco model. Therefore, areal reduction was not applied to San Marcos inflows as well. Details of the adjustments made by USACE can be found in the technical memo included in Appendix A. Both the Phase 2 Upper San Marcos and USACE adjusted Blanco hydrology models are included with the digital data in Appendix D as well.

HYDRAULIC METHODOLOGY

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 unsteady model was used to calculate water surface profiles for the study streams. The following is a summary of data sources, assumptions, and procedures used to create new unsteady HEC-RAS models for the study area. Further details of all methodology and assumptions can also be found in the Hydraulic Modeling Notebook in Appendix A. The unsteady hydraulic model developed for this study is located with the digital data in Appendix D.

Surveys

Field surveys of bridges/culverts along the San Marcos and Blanco Rivers within the unsteady study area were conducted from May 2014 through July 2014. Additional survey was performed in August 2015 in the right overbank of cross-sections 36596 to 43417 to capture the impact of fill applied at that location since the last LiDAR update (see Figure 2). The survey data was collected using data capture standards set by FEMA as specified in the current Guidelines and Standards for Flood Risk Analysis and Mapping. Electronic files including shapefiles and field notes for the Blanco River surveys are included on the DVD in Appendix D. The San Marcos River survey data is included in the Phase 2 Hydrology and Hydraulics Technical Report Notebook (TRN). A summary of Blanco and San Marcos River survey locations is provided in Table 2 below.

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GBRA Interim Feasibility Study - Phase 2

Key to Features

- Overbank Fill Survey
- Cross-Sections
- Study Streams

Figure 2: Blanco Overbank Fill Survey Points

N E S W

0 400 800 1,600 Feet

1 inch = 800 feet

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Table 2: Survey Locations for Blanco and San Marcos Rivers

Study Stream	Location	HEC-RAS Station	Survey Type	Date Surveyed
San Marcos River	Cape Rd.	13635	Structure	May-2014
	I 35 NB Frontage Rd.	16966	Structure	May-2014
	I 35	17126	Structure	May-2014
	I 35 SB Frontage Rd.	17203	Structure	May-2014
	Cheatham St.	19013	Structure	May-2014
	Amtrak Railroad Bridge	20191	Structure	May-2014
	Railroad D/S SH 80	21617	Structure	May-2014
	SH 80	21734	Structure	May-2014
	Pedestrian Bridge 125 ft. U/S SH 80	21859	Structure	Jun-2014
	Pedestrian Bridge 399 ft. U/S SH 80	22133	Structure	Jun-2014
	Pedestrian Bridge 619 ft. D/S Aquarena Springs Dr.	23323	Structure	May-2014
	Pedestrian Bridge 384 ft. D/S Aquarena Springs Dr.	23558	Structure	May-2014
	Aquarena Springs Dr.	23942	Structure	May-2014
	Laurel St.	27341	Structure	May-2014
	Pedestrian Bridge 373 ft. U/S Laurel St.	27714	Structure	May-2014
	Bert Brown Rd.	28460	Structure	May-2014
	Lime Kiln Rd.	29520	Structure	May-2014
Blanco River	Martindale Rd.	11840	Structure	Jul-2014
	SH 80	16737	Structure	Jul-2014
	Railroad U/S SH80	19148	Structure	Jul-2014
	Uhland Rd.	24444	Structure	Jul-2014
	Culvert upstream of I-35	34774	Structure	Jul-2014
	Post Rd.	44960	Structure	Jul-2014
	Railroad U/S Post Rd.	45093	Structure	Jul-2014
	Five Mile Dam	47432	Structure	Jul-2014

High water marks from the May 2015 flood event were surveyed in coordination with GBRA using similar data capture standards in early June 2015. The surveyed high water marks were used for calibration of the unsteady hydraulic model. Figure 3 shows the locations of these high water marks.

Model Geometry

The unsteady model geometry developed for this study was created by combining the Phase 2 San Marcos River hydraulic geometry with the Phase 1 Blanco River hydraulic geometry. The combined model was truncated at the upstream unsteady study limit and a junction was added at the confluence of the Blanco and San Marcos Rivers. A small portion of the San Marcos River downstream of the Blanco and San Marcos River confluence was also added to establish a more accurate downstream tailwater estimate for the unsteady model. Several small updates were made to the hydraulic geometry to stabilize the unsteady model including the addition of pilot channels interpolated between cross-sections with survey data. A detailed description of

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GBRA Interim Feasibility Study - Phase 2

Key to Features

- May 2015 HWMs
- Study Streams

Figure 3: May 2015 Event High Water Marks

0 1,100 2,200 4,400 Feet

1 inch = 2,200 feet

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all updates made to the incorporated hydraulic geometry is included in the modeling notebook in Appendix A.

Blanco River Overflows

When the Blanco River reaches flood stage several natural overflows occur that were added to the unsteady model as lateral weirs to determine the dynamic overflow of the system. These overflows are illustrated in Figure 1 and occur just upstream of I-35 on the right bank, between I-35 and SH 80 on the left bank into the Bypass Creek watershed, and finally downstream of SH 80 to the confluence on the right bank into the San Marcos River. Weirs were delineated in HEC-GeoRAS along the high points through the overflow areas using the DEM developed as discussed above. The overflows to Bypass Creek watershed and the San Marcos River were modeled with three separate weirs each in the model. The three lateral weirs representing the overflow to the Bypass Creek watershed calculate overflows into the Bypass Creek mainstem as well as the two Bypass Creek tributaries. For the overflows to the San Marcos River, two lateral weirs represent overflow upstream of Martindale Rd. and one lateral weir represents overflows downstream of Martindale Rd. The overflows to Bypass Creek were sent out of the system, but they can be used in the future as inflows to the Bypass Creek hydraulic models. The overflows to the San Marcos River were tailwater connected to the appropriate San Marcos River cross-sections. The overflow upstream of I-35, near the Wayside commercial development, eventually re-enters the Blanco River further downstream via an underpass and culvert crossing. Table 3 summarizes the 100-yr overflow amounts at each location.

Table 3: 1% Annual Chance Overflows

Overflow Location	1% Annual Chance Flow
Upstream of I-35	7900 cfs
Bypass Mainstem	11900 cfs
Bypass Tributary 2	24900 cfs
Bypass Trubitary 1	11700 cfs
Upstream SH 80	100 cfs
Downstream SH 80 (Blanco Gardens)	5900 cfs
Downstream of Martindale Rd.	2900 cfs
Upstream of Confluence	7800 cfs

Simplified steady state hydraulic models were created for the overflow upstream of I-35 as well as the overflows from the Blanco to the San Marcos River. These simple models were developed to determine the extents of flooding in these overflow areas since they are not included in the unsteady model. Due to the depth of flooding ranging from 1-3 ft. for the overflows from the Blanco River to San Marcos River, these areas should be designated as shallow flooding zones with base flood elevations available from the overflow models.

Flow Data

Inflow hydrographs for the unsteady model were extracted from the models from the Phase 1 and 2 studies described above in the hydrologic methodology section. For the San Marcos inflows, the hydrographs were linked directly to the hydrology model DSS output file. Sub-basin flows were considered to be uniform lateral inflows and tributaries were entered as lateral inflows. The inflow hydrograph at the upstream end of the San Marcos River was taken from the hydrology model junction just downstream of the Sink Creek confluence. Blanco River hydrographs were extracted from the USACE adjusted Blanco hydrology model and entered into the unsteady model manually. The upstream inflow hydrograph reflects the flow at the Kyle gage junction. The proportional hydrograph from the sub-basin downstream of the Kyle gage was entered as a uniform lateral inflow.

Calibration

The unsteady hydraulic model results were compared to known high water marks from May 2015 flood event. The estimated flow for the May 2015 flood event at the Kyle gage is 180,000 cfs which falls between 1% and 0.4% annual chance peak events. Therefore the model was calibrated as closely as possible to place the May 2015 high water marks slightly above the 1% annual chance water surface elevations. Some of the high water marks were difficult to calibrate to due to their distance from the main channel and the dynamic affect of an observed event versus a hypothetical frequency flow event. The calibration consisted of adjusting the lateral weir coefficients so that the 1% annual chance water surface profile was slightly below the May 2015 high water marks elevations. This resulted in higher weir coefficients for the overflows to Bypass Creek. However, the overflows to Bypass Creek were not inconsistent in proportion to those that occurred during the 2015 flood event.

MODEL RESULTS

Profiles and Floodplain Delineation

Profiles for 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, and 0.2% annual chance events (ACE) were created for both the Blanco and San Marcos Rivers. Profile panels showing the unsteady model results including the overflow model area are provided in Appendix B. A comparison of the 1% ACE profiles of the GBRA (Phase1) steady state, GBRA unsteady, and FEMA effective models is presented in Figures 4 and 5. 1% ACE flow and water surface elevation comparisons at key locations are provided in Table 4. In most locations, there was an increase in flood elevations due to the modeled peak flows in the current study being higher than the regression flows used in the effective study. The reach between SH 80 and Martindale Rd. is the only location where the effective elevations are slightly higher. This is likely due to different overflow modeling procedures between the current unsteady and effective models.

Table 4: Unsteady vs. Effective 1% ACE Flow and Flood Elevation Comparison

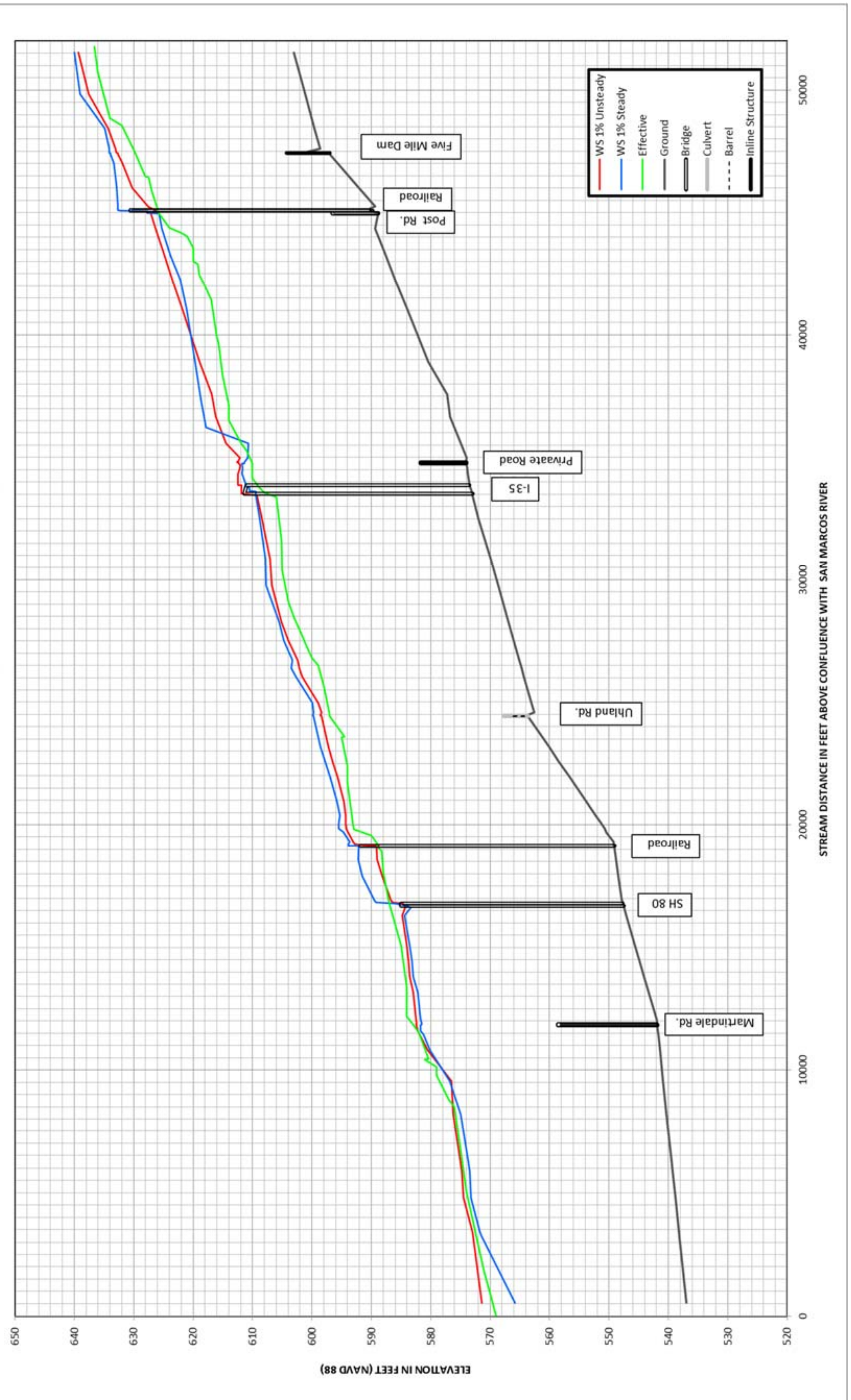
Stream	Location	1% ACE Flows (cfs)		1% ACE Flood Elevations (ft.)	
		Unsteady	Effective	Unsteady	Effective
San Marcos	Cape Rd.	22800	10780	572.7	570.7
	Upstream of I-35	15600	N/A	572.8	570.7
	Cheatham St.	16000	N/A	572.9	570.7
	SH 80	10800	7860	574.0	570.7
	Aquarena Springs Dr.	11000	6920	576.2	573.0
	Lime Kiln Rd.	12200	N/A	585.9	584.0
Blanco	Martindale Rd.	109400	N/A	582.6	583.0
	SH 80	118100	N/A	586.4	587.0
	Uhland Rd.	137700	N/A	598.5	597.0
	I-35	157900	124680	612.4	609.0
	Post Rd.	165000	N/A	626.6	626.0
	Five Mile Dam	165300	N/A	633.0	630.0

The existing conditions 0.2% and 1% ACE Floodplains were delineated using HEC-RAS output data from the unsteady and overflow hydraulic models and GIS tools. The HEC-RAS water surface elevation results for the 0.2% and 1% frequencies were converted to water surface DEMs. These water surface DEMs were intersected with the ground surface DEM to create floodplains for each model area. The floodplains, depth grids, and water surface elevation grids were merged together is such a way that the controlling water surface was represented. For example, the San Marcos River floodplain elevations control on the San Marcos side, overflow elevation control from that point over to the Blanco side where the Blanco elevations control. Floodplain delineations were plotted on hydraulic work maps with additional GIS data including LiDAR contours and aerial photos. Hydraulic work map indices and hydraulic work maps containing the existing conditions 1% and 0.2 % ACE floodplains are included in Appendix B.

Conclusion

The results of the unsteady hydraulic analysis of the Blanco/San Marcos confluence have defined the effects of the Blanco River backwater on the San Marcos River floodplain providing accurate base flood elevations for regulatory purposes. Differences between effective and unsteady flood elevations are the results of updated hydrology models and LiDAR topography data. Updated flood extents have been provided for the Blanco and San Marcos Rivers as well as the key overflow areas upstream of I-35 and downstream of SH 80. The overflows into the Bypass Creek watershed can be used in future updates to the modeling and mapping along Bypass Creek and its tributaries and are not included as part of this study effort.

Figure 4: Blanco River 100 yr. Flood Profile Comparison



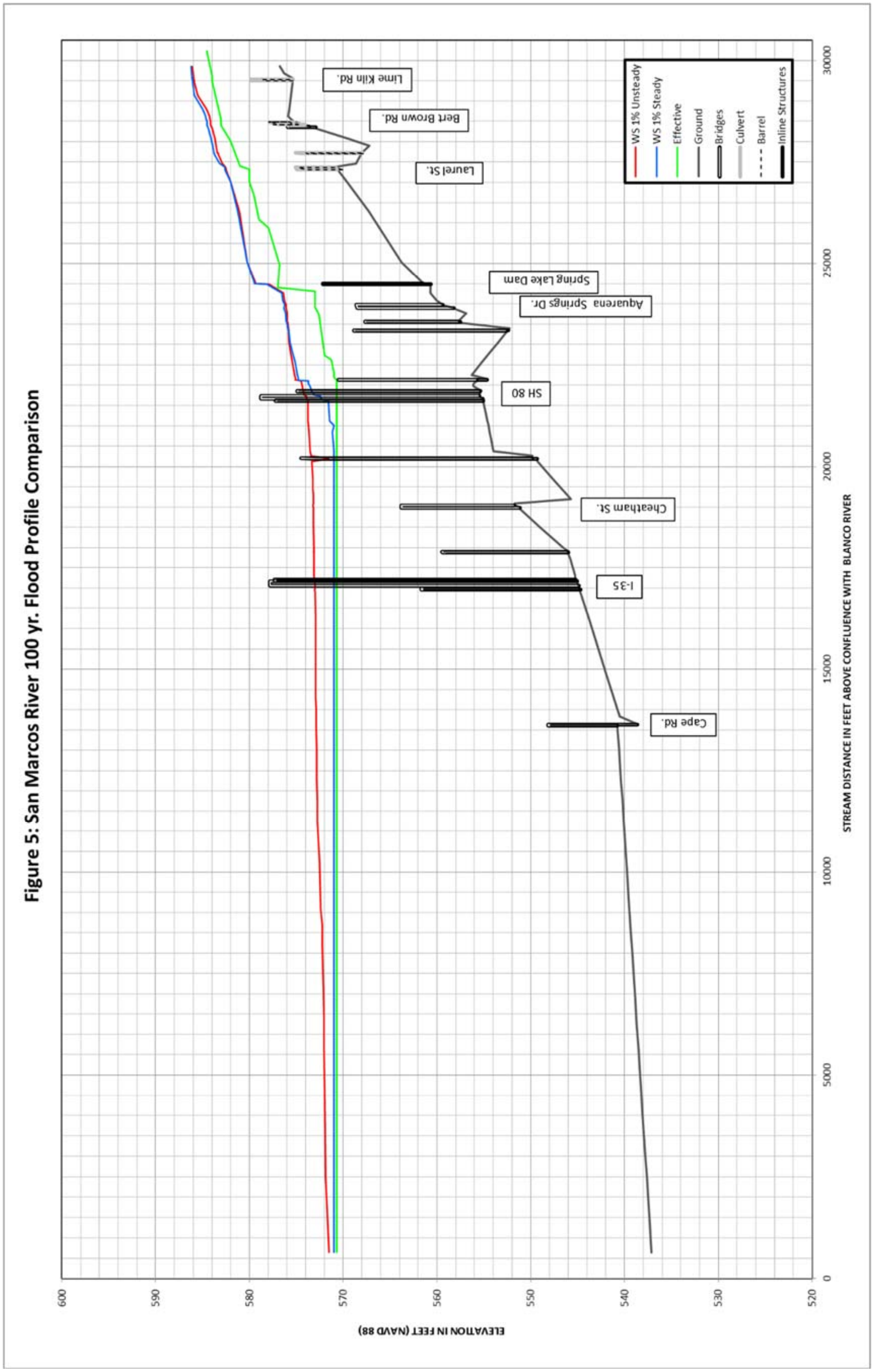


Figure 5: San Marcos River 100 yr. Flood Profile Comparison

Appendix A

Supporting Documents

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USACE Blanco Hydrology Memo

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Documentation for FEMA Flood Recovery Model for the Blanco River
July 2015

I. INTRODUCTION

Since early 2014, the USACE Fort Worth District has been participating in a nationwide USACE effort known as CWMS (Corps Water Management System) Implementation. This effort includes developing basin-wide models to assist USACE water managers with decision making during flood events. Some of the models being developed include HEC-HMS, HEC-ResSim, HEC-RAS, and HEC-FIA. These models are developed separately and later implemented into a single interface that allows water managers to obtain observed and forecasted precipitation and estimate lake level, potential economic damages, and potential risk to human lives.

Since the CWMS implementation effort was initiated, numerous conversations between the USACE and other water resources agencies have taken place to find ways to partner and best utilize the models that have been developed. In early 2015 the Fort Worth District completed the CWMS implementation effort for the Guadalupe River Basin. More information on the CWMS model development is given in the final report for the Guadalupe River Basin (USACE, 2014).

Shortly after that, the devastating flood events of May 2015 occurred. During the flood, the Guadalupe CWMS HEC-HMS and HEC-RAS models were used to forecast pool elevations at Canyon Dam and to estimate flood inundation on the Guadalupe River downstream of the dam. The Blanco River experienced some of the most severe flooding as a result of this storm. As part of the flood recovery effort, the CWMS HEC-HMS model for the Guadalupe River Basin was utilized to develop new flood frequency estimates for the Blanco River.

STUDY AREA

The study area is the Blanco River Basin. The Blanco River basin includes approximately 436 square miles above the confluence with the San Marcos River near San Marcos, Texas. The watershed intersects Kendall, Blanco, Hays, and Comal County. The watershed is approximately 50 miles long and 9 miles wide and flows from West to East. A figure showing the Blanco River Basin is below.

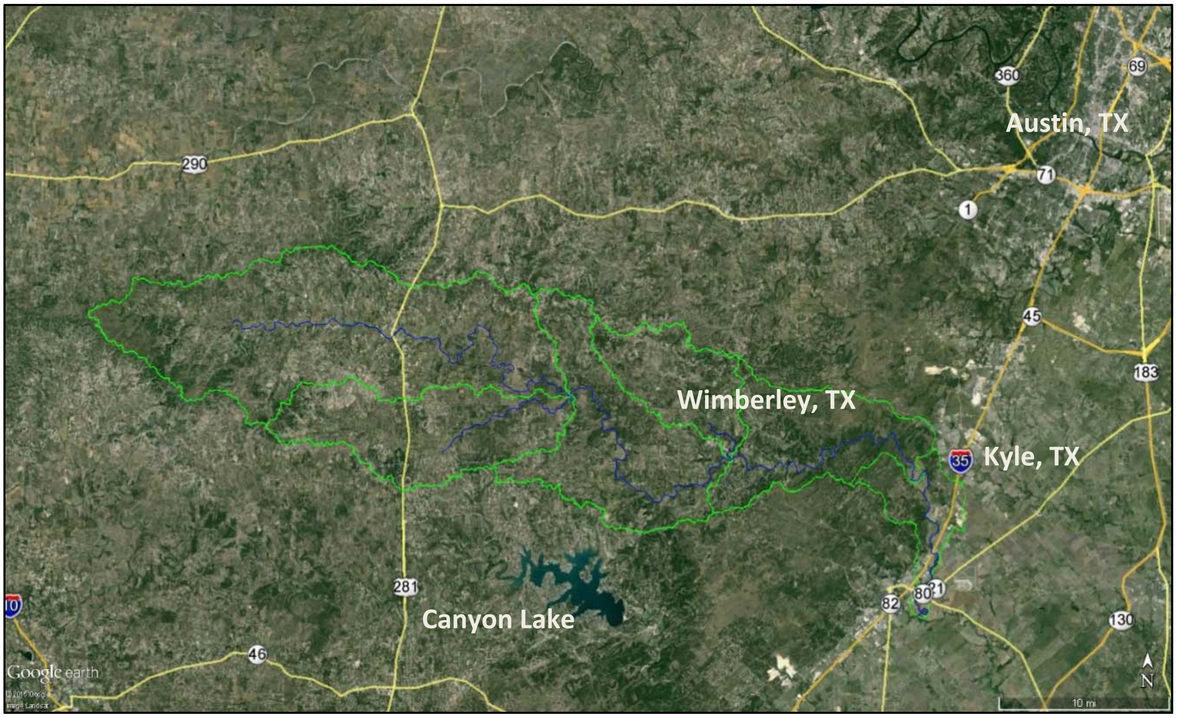

Figure 1 – Blanco River Basin Map

The CWMS model for the Guadalupe River Basin included the Guadalupe River drainage area above Victoria, TX. This model contained significantly more drainage area than was necessary to develop flow frequency estimates for the Blanco River. For this reason the model was trimmed of the unnecessary elements. The final HEC-HMS subbasin map for the Blanco River basin is shown below.

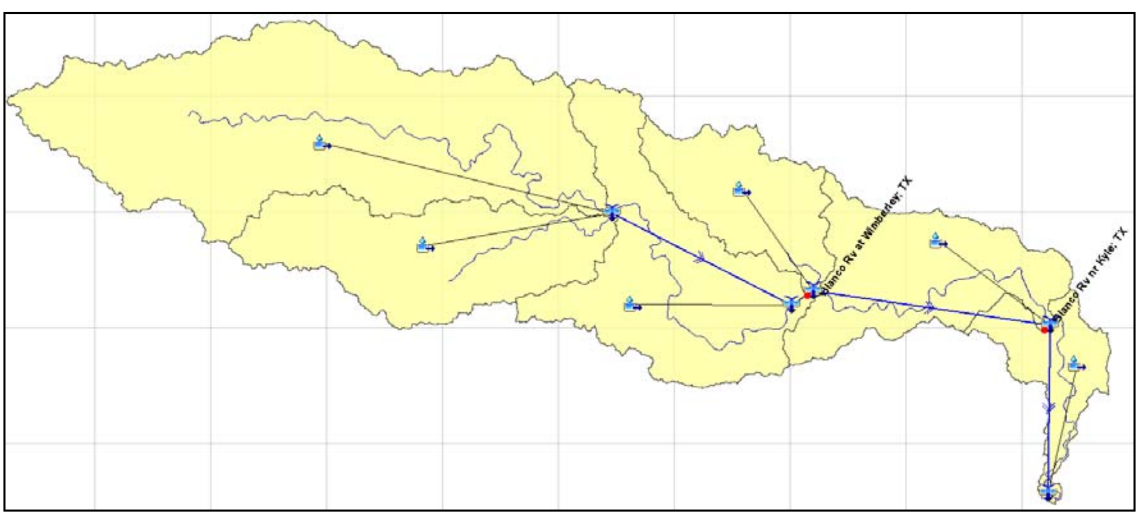

Figure 2 – Blanco River HMS Schematic

II. DATA AND METHODOLOGY

MODELING METHODS

The Blanco River HMS model contains 6 subbasins totaling about 436 square miles. The subbasins were delineated using the HEC-GeoHMS program and utilized 30 meter National Elevation Dataset (NED) terrain data. The Blanco River HMS model uses the following methods.

- **Losses** – Initial and Constant
- **Transform** – Snyder Unit Hydrograph
- **Baseflow** – Recession
- **Routing** – Modified Puls
- **Computation Interval** – 15 minutes

INITIAL PARAMETERS

A list of model parameters as well as the source of for the initial estimates is given below.

- **Initial Deficit, Maximum Deficit, and Constant Loss Rate** – The USACE Fort Worth District equations for losses in the NUDALLAS program were used. These equations utilize estimates of percent sand in the soil to develop initial deficit and constant loss rates. The 25-YR losses were used as a starting point. The loss method was later converted from "Deficit and Constant" to "Initial and Constant" for this analysis. Percent sand estimates were obtained from NRCS SSURGO data.
- **Impervious Percentage** – The % impervious values were developed based on the 2006 National Land Cover Dataset (NLCD) percent developed impervious dataset.
- **Snyder Transform Parameters** – The time to peak and peaking coefficients were developed from the USACE Fort Worth District urban curves based on watershed characteristics extracted from HEC-GeoHMS as well as percent sand values taken from NRCS SSURGO data.
- **Baseflow Parameters** – Initial baseflow parameters were taken from the existing USACE HEC-1 Guadalupe River Forecasting Model.
- **Routing (Modified Puls)** – Modified-Puls routing data was extracted from the Blanco river HEC-RAS model (dated Dec 2012) from the Lower Guadalupe River Feasibility Study performed by Halff Associates. The Guadalupe CWMS implementation effort began Dec. 2013.

CALIBRATION

Following the initial parameter estimates, simulations were made using NEXRAD precipitation data obtained from the West Gulf River Forecast Center. The model parameters were adjusted to improve the models ability to simulate historical events. The initial deficit, constant loss rate, and lag times were adjusted during calibration. The peaking coefficients, baseflow parameters, and routing parameters were not adjusted between events.

Overall the model appears to simulate historical events reasonably well. The peak flows for the 2002 event was the exception to this. It can be observed however that the timing and shape of the hydrographs are represented well. It is likely additional refinement of the initial and constant losses would improve the relationship between the simulated and observed hydrographs. It would also be worth comparing the NEXRAD precipitation to surrounding gages. The resulting hydrograph comparisons can be seen below. Where figures for the Kyle gage do not exist, the USGS was not recording data for that event.

1998 CALIBRATION RESULTS

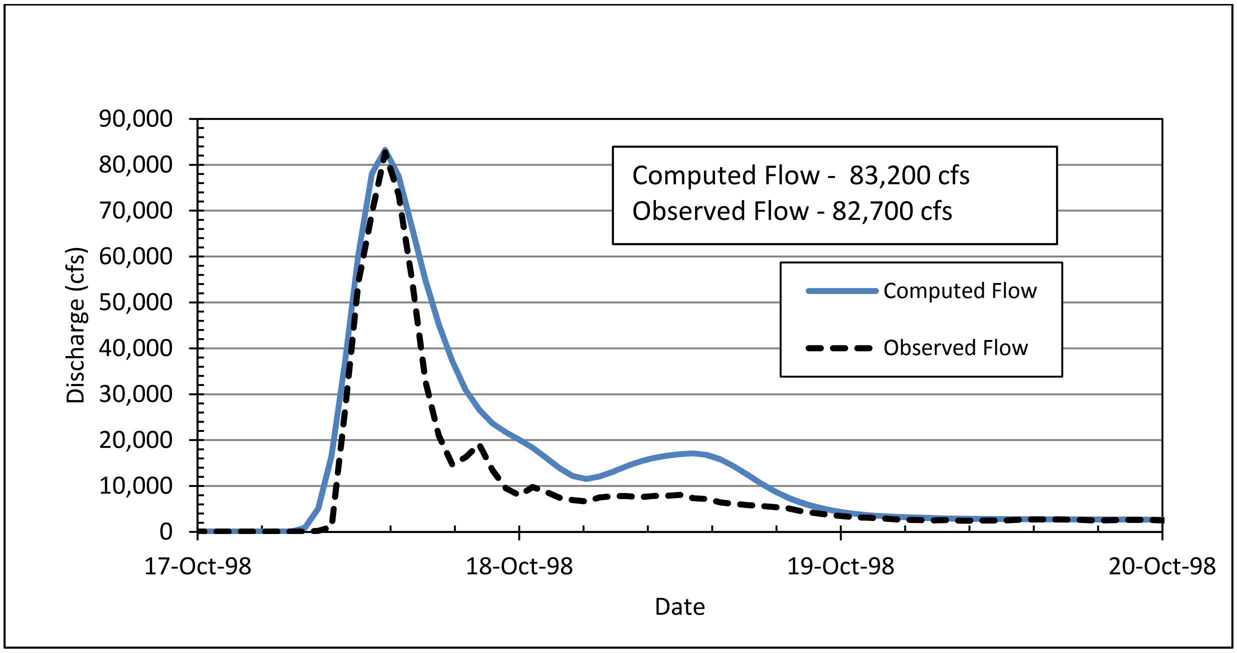

Figure 3 - 1998 Hydrograph Results for Blanco at Wimberley Gage

2002 CALIBRATION RESULTS

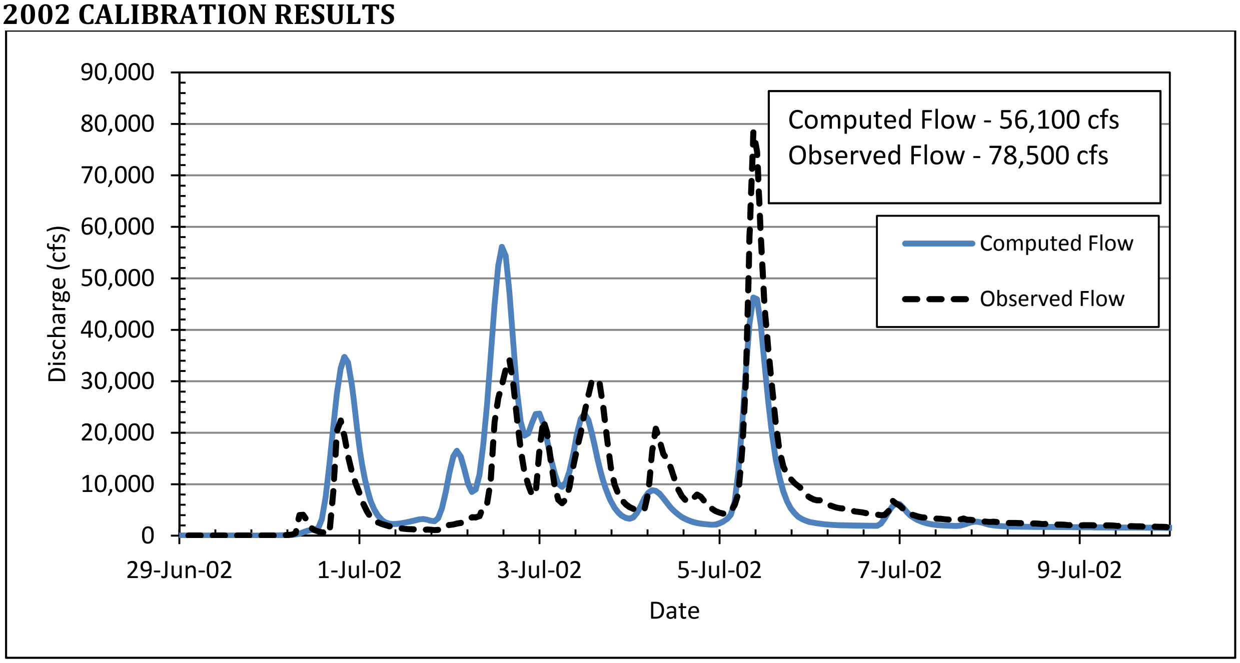

Figure 4 - 2002 Hydrograph Results for Blanco at Wimberley Gage

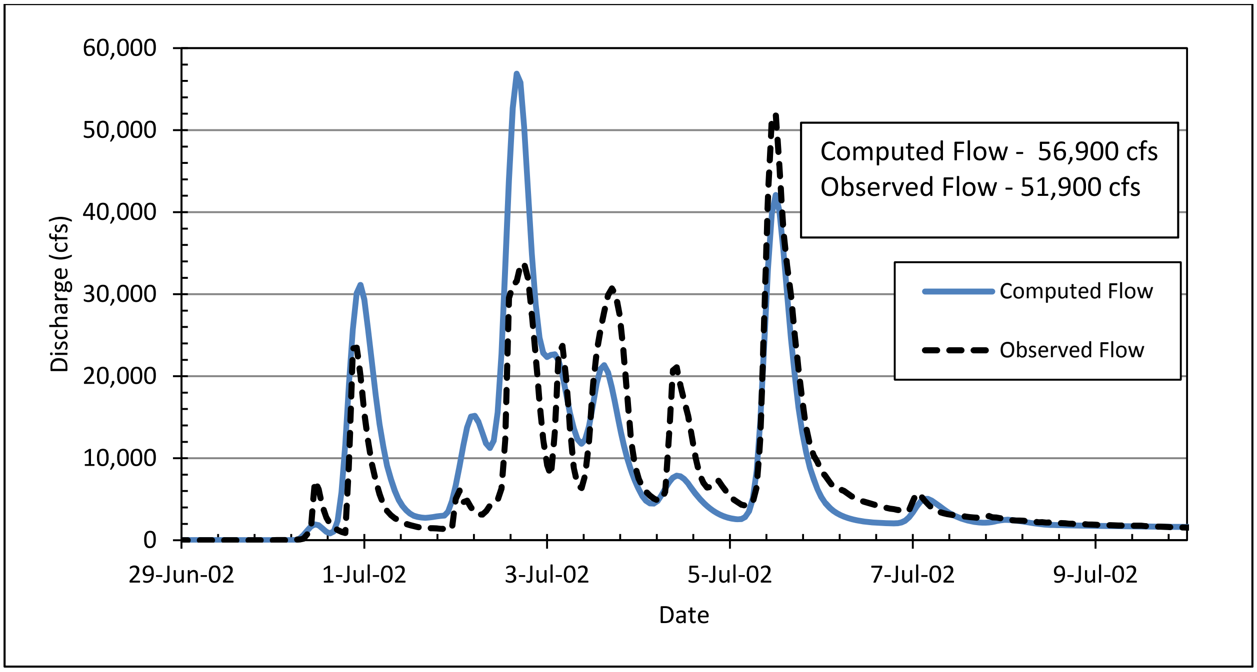

Figure 5 - 2002 Hydrograph Results for Blanco nr Kyle Gage

2004 CALIBRATION RESULTS

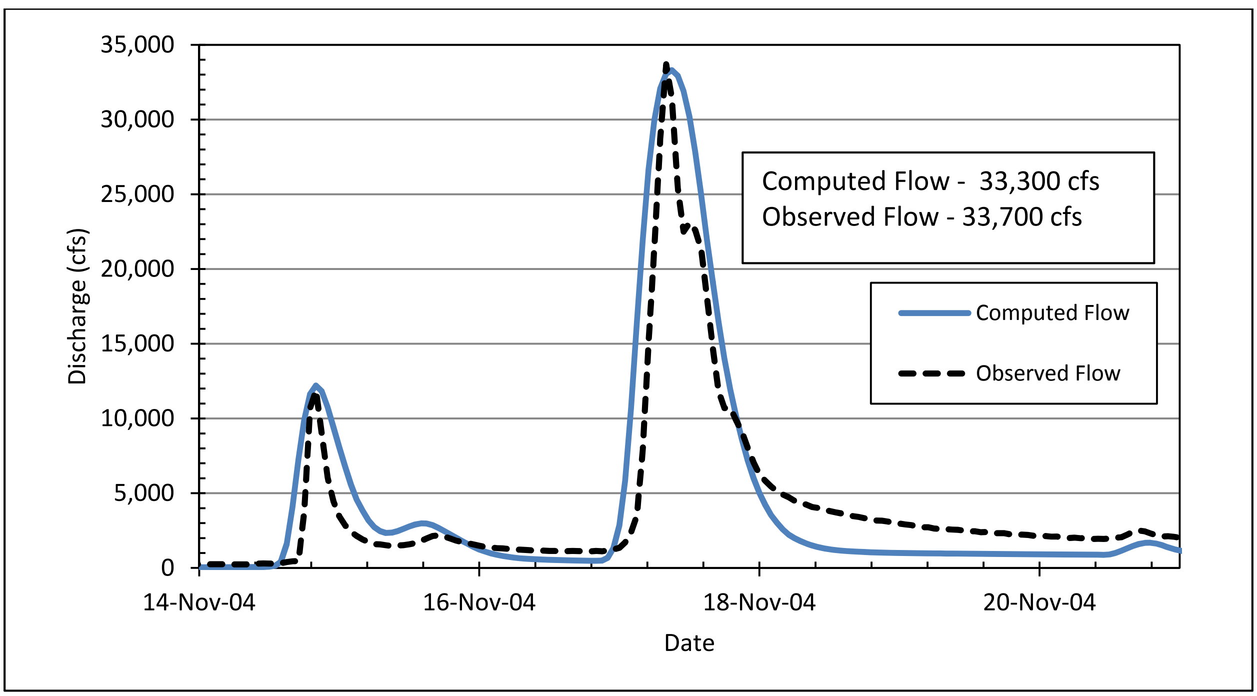

Figure 6 - 2004 Hydrograph Results for Blanco at Wimberley Gage

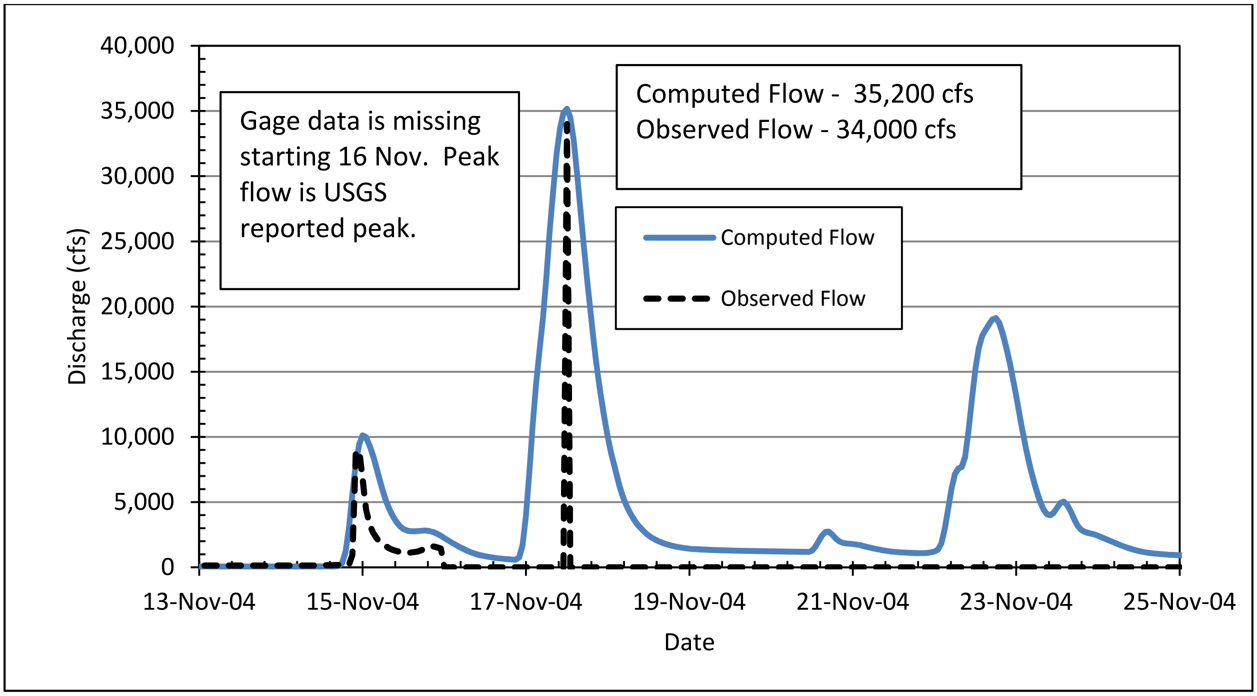

Figure 7 - 2004 Hydrograph Results for Blanco nr Kyle Gage

FINAL PARAMETERS

After the initial parameter estimates were made and the calibration process was completed, final parameters were established. The final lag times were developed by averaging the lag times from the calibration events. The losses were developed using the USACE Fort Worth District Method for determining losses based on percent sand. This method produces a different set of loss rates for each storm frequency. The initial and constant losses for the 2-YR through 50-YR were increased uniformly through the watershed for each given frequency in order to have a better correlation with the most current frequency curve estimated from the USGS gage record (Asquith, 2015). This was done because of the increased confidence level in the frequency curve, particularly for the more common recurrence intervals (2-10-YR). The 25- and 50-YR losses were adjusted to create a smooth transition between the 100-YR to the 10-YR values. The final relationship between the Blanco River HMS model and the USGS frequency curve can be seen in the results section. The final HMS model parameters are located in the tables below.

Subbasin	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
Blanco_S010	1.77	1.88	1.73	1.37	1.02	0.78	0.52
LittleBlanco_S010	1.77	1.88	1.73	1.37	1.02	0.78	0.52
Blanco_S020	1.72	1.83	1.68	1.33	1.00	0.77	0.51
CypressCr_BR_S010	1.73	1.84	1.69	1.34	1.00	0.77	0.51
Blanco_S030	1.73	1.83	1.69	1.34	1.00	0.77	0.51
Blanco_S040	1.89	2.00	1.82	1.45	1.07	0.80	0.54

Table 1 - Initial Losses

Subbasin	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
Blanco_S010	0.23	0.23	0.21	0.17	0.12	0.08	0.06
LittleBlanco_S010	0.23	0.23	0.21	0.17	0.12	0.08	0.06
Blanco_S020	0.23	0.22	0.21	0.17	0.12	0.07	0.05
CypressCr_BR_S010	0.23	0.22	0.21	0.17	0.12	0.07	0.05
Blanco_S030	0.23	0.22	0.21	0.17	0.12	0.07	0.05
Blanco_S040	0.24	0.24	0.22	0.18	0.13	0.08	0.06

Table 2 - Constant Losses

Subbasin	Lag (Hr)	Cp
Blanco_S010	5.4	0.7813
LittleBlanco_S010	3.7	0.7813
Blanco_S020	6.2	0.7813
CypressCr_BR_S010	5.1	0.7813
Blanco_S030	4.7	0.7813
Blanco_S040	5	0.7813

Table 3– Transform Parameters

Subbasin	Initial Discharge (cfs/sq mi)	Recession Constant	Ratio to Peak
Blanco_S010	0.2	0.92	0.03
LittleBlanco_S010	0.2	0.92	0.03
Blanco_S020	0.2	0.92	0.03
CypressCr_BR_S010	0.2	0.92	0.03
Blanco_S030	0.2	0.89	0.03
Blanco_S040	0.3	0.89	0.05

Table 4 – Baseflow Parameters

PRECIPITATION

The precipitation used in the Blanco River HMS model was obtained from the Lower Guadalupe River Basin Feasibility Study. The study utilized frequency precipitation estimates previously developed by the USGS (Asquith and Rousell, 2004). 5-minute duration rainfall was developed by extrapolating the data from the 15-minute and 30-minute durations. The rainfall table can be seen below.

Recurrence Interval								
Duration	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**250-yr**	**500-yr**
5min	0.7	0.94	1.09	1.33	1.56	1.83	2.18	2.53
15min	1.07	1.41	1.66	2.02	2.33	2.69	3.23	3.71
1hr	1.83	2.41	2.82	3.41	3.9	4.45	5.29	6.01
2hr	2.30	3.07	3.61	4.39	5.06	5.8	6.94	7.93
3hr	2.41	3.29	3.94	4.87	5.68	6.59	8	9.25
6hr	2.73	3.68	4.38	5.39	6.27	7.27	8.82	10.2
12hr	3.14	4.26	5.08	6.27	7.31	8.49	10.32	11.95
1day	3.60	5.1	6.18	7.67	8.9	10.23	12.15	13.75

Table 5 - Frequency Point Rainfall Depths (inches)

III. RESULTS

The simulated 100-YR peak discharge at the Wimberley and Kyle gages are 168,000 and 162,000 cfs respectively. The simulated discharge decreases between the two gages due to a combination of peak attenuation due to river routing as well as the difference in timing between the peak from the Wimberly gage and the local subbasin above the Kyle gage. Due to the uniform rainfall assumption, the local subbasin above Kyle peaks before the main peak arrives from the Wimberley gage. The final discharges as well as the discharges for the USGS frequency curve can be seen in the tables below. The comparison between the final HMS frequency curves and the USGS frequency curves is also show below.

Description	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
Below conf. with Little Blanco River	12800	32800	52500	81200	106000	132000	192000
At Blanco River at Wimberley Gage	12500	36200	60900	98200	132000	168000	248000
At Blanco River near Kyle Gage	10500	32900	56700	93200	127000	162000	242000
Above conf. with San Marcos River	8100	26500	47800	78600	109000	142000	220000

Table 6 – Summary of Discharges Table from HEC-HMS

Description	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
At Blanco River at Wimberley Gage	8080	25700	44900	78600	111000	149000	262000
At Blanco River near Kyle Gage	9270	29800	51400	88100	122000	160000	268000

Table 7 – Discharges for USGS Frequency Curve

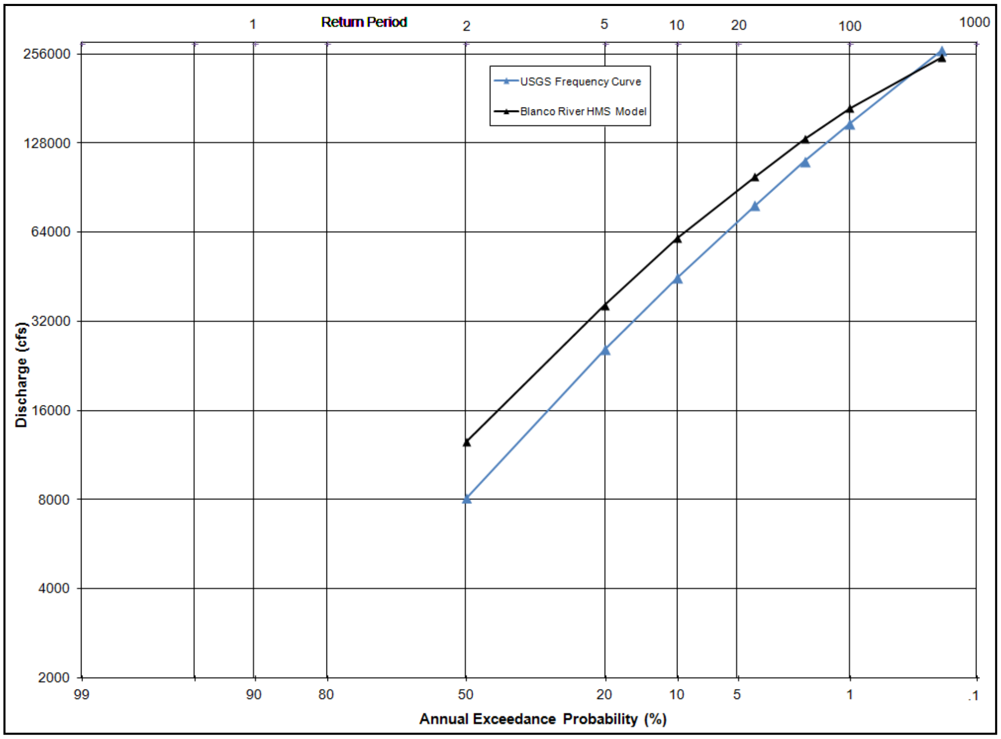

Figure 8 - Frequency Curve – Blanco River at Wimberley, TX

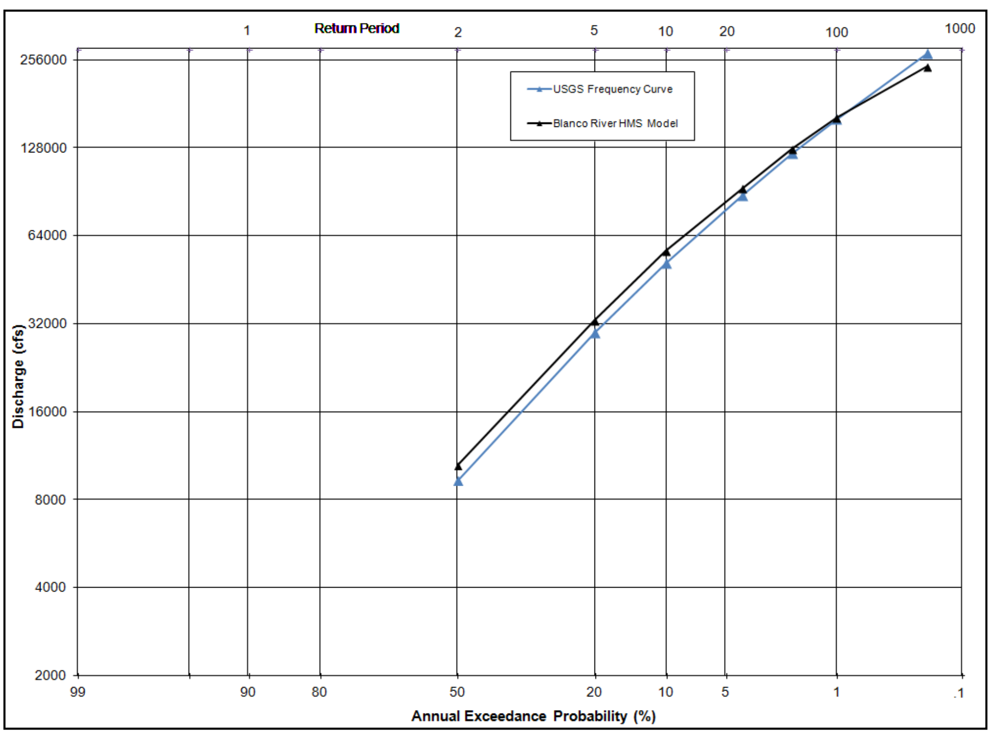

Figure 9 - Frequency Curve – Blanco River near Kyle, TX

IV. RECOMMENDATIONS

The CWMS model for the Guadalupe River Basin was developed with limited funds and with a focus of estimating lake levels and flows at USACE control points along the Guadalupe River. There is likely room to improve the parameter estimates with additional calibration, particularly in the routing reach between the Wimberley and Kyle gages. The validity of the routing through this reach can be verified or improved by using the blending option within a forecast simulation. The observed hydrograph can be blended at Wimberley and the routing effects better compared to observed data.

V. REFERENCES

Asquith, William H., Roussel, M.C., Atlas of *Depth-Duration Frequency of Precipitation Annual Maxima for Texas*; U.S. Geological Survey Scientific Investigations Report 2004-5041; 2004

Asquith, William H. "Peak-streamflow frequency analysis for two stream gages along the Blanco River," Technical Memorandum, July 7, 2015.

USACE. "Corps Water Management System (CWMS) Final Report for the Guadalupe River Watershed." November 2014.

Modeling Notebook

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Hydraulic Project Notebook
United States Army Corp of Engineers

Project: USACE – San Marcos Unsteady Modeling **AVO:** 28411E

Entry # : 1

Subject : Unsteady Model Build Overview

Notes :

Portions of two (2) existing steady flow HEC-RAS 4.1 hydraulic models were used to develop the San Marcos Unsteady Model:

- GBRA Phase 1 Blanco River – XS range "51519-528"
- GBRA Phase 2 Tier 1 San Marcos River – XS range "29849-645"

A new HEC-RAS 4.1 project was created and these model geometries were imported into a single geometry and joined with a junction. A small reach was then created in GeoRAS and added downstream of the junction. **ALL** of the existing model properties were carried into the new project geometry. A GeoRAS project was created with the existing models' spatial files to modify the HEC-RAS model for unsteady flow analysis.

Entry # : 2

Subject : Flow Boundary Conditions

Notes :

Flow data was developed using two (2) existing HMS 3.5 hydrology models and applied to the most upstream cross-sections of the reaches via Flow Hydrographs, individual cross-sections via Lateral Inflow Hydrographs or across a range of cross-sections via Uniform Lateral Inflow Hydrographs. San Marcos River flows were linked to the Upper San Marcos Watershed DSS file. The Blanco River Flow Hydrograph was developed by using the aerially reduced Blanco_nr_Kyle junction flow combined with the portion of subbasin Blanco_S040 (62.17%) that is contributing to the most upstream XS. The lower portion of subbasin Blanco_S040 (37.83%) was applied uniformly across the range of XS that make up the Blanco portion of the model DS of XS 51519. The reach downstream of the junction did not receive any additional inflow.

- GBRA Phase 1 Blanco Watershed – USACE updated parameters (MANUAL) –
  - Blanco_nr_Kyle & Blanco_S040 (62.17%) – Flow Hydrograph – XS "51519"
  - Blanco_S040 (37.83%) – Uniform Lateral Inflow Hydrograph – XS "49825-528"

- GBRA Phase 2 Tier 1 Upper San Marcos Watershed (DSS) –
  - J_USM0650 – Flow Hydrograph – XS "29849"
  - USM0660 – Uniform Lateral Inflow Hydrograph – XS "28068-24259"
  - J_USM0700 – Lateral Inflow Hydrograph – XS "24075"
  - USM0710 – Uniform Lateral Inflow Hydrograph – XS "22866-21633"
  - USM0720 – Uniform Lateral Inflow Hydrograph – XS "21580-21121"
  - J_USM0320 – Lateral Inflow Hydrograph – XS "21010"
  - USM0730 – Uniform Lateral Inflow Hydrograph – XS "20848-20261"
  - USM0740 – Uniform Lateral Inflow Hydrograph – XS "20125-19701"

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- USM0750 – Uniform Lateral Inflow Hydrograph – XS "19701-19080"
- USM0760 – Uniform Lateral Inflow Hydrograph – XS "18942-17289"
- USM0770 – Uniform Lateral Inflow Hydrograph – XS "16901-14852"
- J_USM1000_DIV_USM0910 – Uniform Lateral Inflow Hydrograph – XS "14260-13995"
- USM1010 – Uniform Lateral Inflow Hydrograph – XS "12981-10233"
- USM1020 – Uniform Lateral Inflow Hydrograph – XS "9083-6303"
- USM1030 – Uniform Lateral Inflow Hydrograph – XS "5582-4678"
- USM1040 – Uniform Lateral Inflow Hydrograph – XS "3546-645"

Entry # : 3

Subject : Downstream Boundary Condition

Notes :

The boundary condition in the GBRA Phase 1 Blanco model was initially set to a known water surface taken from the upstream end of the GBRA Phase 1 San Marcos model. Unsteady models can use normal depth or a rating curve as downstream boundaries, but cannot use individual known water surfaces. A rating curve was developed from the GBRA San Marcos model, but produced instabilities and erroneous results. It decided to use normal depth with a channel slope that matched closely the known water surface boundary condition from the GBRA steady model and also produce stable and smooth profiles at the downstream end. A slope of 0.0007 was used for the normal depth calculation and appears to produce reasonable results.

Entry # : 4

Subject : XS Addition, Removal, and Realignment

Notes :

One (1) XS was added to the San Marcos River model: XS "197". This XS was added to assist in stability across the junction and to aid in future mapping tasks.

One (1) XS was moved and realigned from station 19064 to 19080. This XS was moved because the LOB was catching high ground near Cheatham Rd. and causing instabilities in the area. Survey was applied.

Two (2) XS were added to the Blanco River model: XS "34877 & 34672". These were added to help ease the contraction/expansion associated with Low Water Crossing "34804".

Six (6) XS were removed from the Blanco model XS "33792-33569" when the I-35 bridge group was merged from three (3) bridges to one (1) bridge. The three bridges are very similar and were consolidated to one to simplify and stabilize the model.

Several XS were adjusted on both reaches for varying reasons:

- San Marcos River –
  - XS 21633 – ROB lengthened for containment.
  - XS 16901 – LOB lengthened to account for flow moving through I-35.
  - XS 14852 – ROB lengthened and adjusted for containment.

  - XS 14260 – ROB lengthened and adjusted for containment.

- Blanco River –
  - XS 36216 – LOB adjusted to minimize extraneous length across I-35.
  - XS 35560 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 34976 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 34804 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 34744 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 34546 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 34329 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 33875 – ROB clipped to LS 36215. LOB adjusted to minimize extraneous length across I-35.
  - XS 33455 – LOB clipped to LS 33454.
  - XS 32463 – LOB clipped to LS 33454.
  - XS 30842 – LOB clipped to LS 33454.
  - XS 29773 – LOB clipped to LS 33454.
  - XS 28252 – LOB clipped to LS 33454 & LS 28251.
  - XS 27514 – LOB clipped to LS 28251.
  - XS 26704 – LOB clipped to LS 26704.
  - XS 26397 – LOB clipped to 26397.
  - XS 26035 – LOB clipped to 26035.
  - XS 24970 – LOB clipped to LS 28251.
  - XS 24463 – LOB clipped to LS 28251.
  - XS 24416 – LOB clipped to LS 28251.
  - XS 23170 – LOB clipped to LS 28251.
  - XS 22597 – LOB clipped to LS 28251 & LS 22596.
  - XS 21940 – LOB clipped to LS 22596.
  - XS 19842 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 19697 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 19298 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 19205 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 19108 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 18581 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 17898 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 16930 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 16821 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 16623 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 16294 – ROB clipped to high ground to maintain spatial separation between reaches.
  - XS 15068 – ROB clipped to LS 16293.
  - XS 14438 – ROB clipped to LS 16293 & LS 14437. LOB adjusted for containment.
  - XS 13802 – ROB clipped to LS 14437.
  - XS 13166 – ROB clipped to LS 14437.
  - XS 12057 – ROB clipped to LS 14437.
  - XS 11884 – ROB clipped to LS 14437.
  - XS 11785 – ROB clipped to LS 14437.
  - XS 11589 – ROB clipped to LS 14437.
  - XS 11447 – ROB clipped to LS 14437.
  - XS 10815 – ROB adjusted and clipped to LS 14437.
  - XS 09545 – ROB clipped to LS 14437.
  - XS 08190 – ROB clipped to LS 14437.
  - XS 05849 – ROB clipped to LS 14437.
  - XS 04774 – ROB clipped to LS 14437.

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- XS 03366 – ROB clipped to LS 14437.
- XS 00528 – ROB clipped to LS 14437. LOB adjusted to maintain separation between reaches.

Entry # : 5

Subject : Interpolated Channel Invert Elevations

Notes :

Irregularities in the ground surface were causing instabilities within the unsteady model. Channel invert elevations were linearly interpolated between surveyed channel inverts and used to dampen the instabilities.

Entry # : 6

Subject : Lateral Structures (Blanco River)

Notes :

Six (6) Lateral Structures exist in the Blanco reach of the unsteady model. These are necessary to represent overflow in three (3) significant areas – Wayside, Bypass Creek and Tribs Watershed, and San Marcos River. Weir coefficients were adjusted in an effort to calibrate with respect to May 2015 flood high water marks. A rating curve was used at LS 16293 to account for right overbank flow at SH 80 also leaving through the Blanco Gardens overflow area.

- LS 36215 – XS "36216-33875" – Allows for overflow from just upstream of I-35 into Wayside via tailwater (TW) connection XS "28252-26397". In the current effective model this area is modeled as split-flow. This area may be covered by future 2D modeling and was therefore not modeled in detail with a split flow reach.
- LS 33454 – XS "33455-28252" – Allows for overflow from just downstream of I-35 into Bypass Creek and Tribs Watershed via Out of the System connection.
- LS 28251 – XS "28252-22597" – Allows for overflow into Bypass Creek and Tribs Watershed via Out of the System connection.
- LS 22596 – XS "22597-19205" – Allows for overflow into Bypass Creek and Tribs Watershed via Out of the System connection.
- LS 19107 – Allows for overflow into Bypass Creek and Tribs Watershed via Out of the System connection.
- LS 16293 – XS "16294-14438" – Allows for overflow into San Marcos River via TW connection XS "16901".
- LS 14437 – XS "14438-528" – Allows for overflow into San Marcos River via TW connection XS "12224".
- LS 11784 – Allows for overflow into San Marcos River via TW connection.

Entry # : 7

Subject : I-35 Bridge - BR "33676" (Blanco River)

Notes :

I-35 was modeled using three (3) bridges in the GBRA Phase 1 steady flow model. It included an upstream frontage road, a main multi-lane main road, and a downstream frontage road. The

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Phase 1 model used TxDOT as-built plans and was verified with spot survey points. Because the bridge group low chord elevations were relatively the same and for unsteady stability purposes the I-35 bridge group was modeled as a single bridge.

Entry # : 8

Subject : Low Water Crossing – IS “34804” (Blanco River)

Notes :

IS “34804” was originally a culvert group in the GBRA Phase 1 model with two (2) 5 ft diameter culverts. The unsteady model was having difficulties balancing calculations through the culverts and was producing unreasonable results. For this reason the culverts were removed and replaced with an inline structure. Since this structure is relatively small compared to the I-35 bridge just downstream, it is assumed that it has little impact on the 1% and higher floods.

Entry # : 9

Subject : Post Rd. Bridge – BR “44960” (Blanco River)

Notes :

Post Rd. Bridge was originally a culvert in the GBRA Phase 1 model. It was changed to a bridge based on imagery, field photos and, survey.

Entry # : 10

Subject : Ineffective Flow Areas near I-35 (Blanco River)

Notes :

Normal ineffective flow areas were emplaced in the LOB for XS “35560-34329” upstream of I-35. There is a section of these XS that is skewed to flow where they parallel I-35 that should not be counted as effective flow. Stability was added to the model by accounting for this portion of skew with an ineffective flow.

Entry # : 11

Subject : Ineffective Flow Areas and Blocked Obstructions near SH-80 (San Marcos River)

Notes :

A railroad exists on the LOB of the San Marcos River that runs from upstream of the San Marcos section of the model and intersects SH-80; XS “29672-21764”. It was determined that flow getting over the railroad does not come back in downstream as effective flow. This area has many small drainage channels and blocked obstructions were emplaced throughout at the adjacent grade elevations. The top of the railroad extending to the extreme LOB was modeled with permanent ineffective areas to block out the flow conveyance in the area. Jowers Center and Strahan Coliseum were also blocked out of flow conveyance and storage between the channel and railroad for XS “23767-22866” via elevated blocked obstructions.

Appendix B

Profiles and Workmaps

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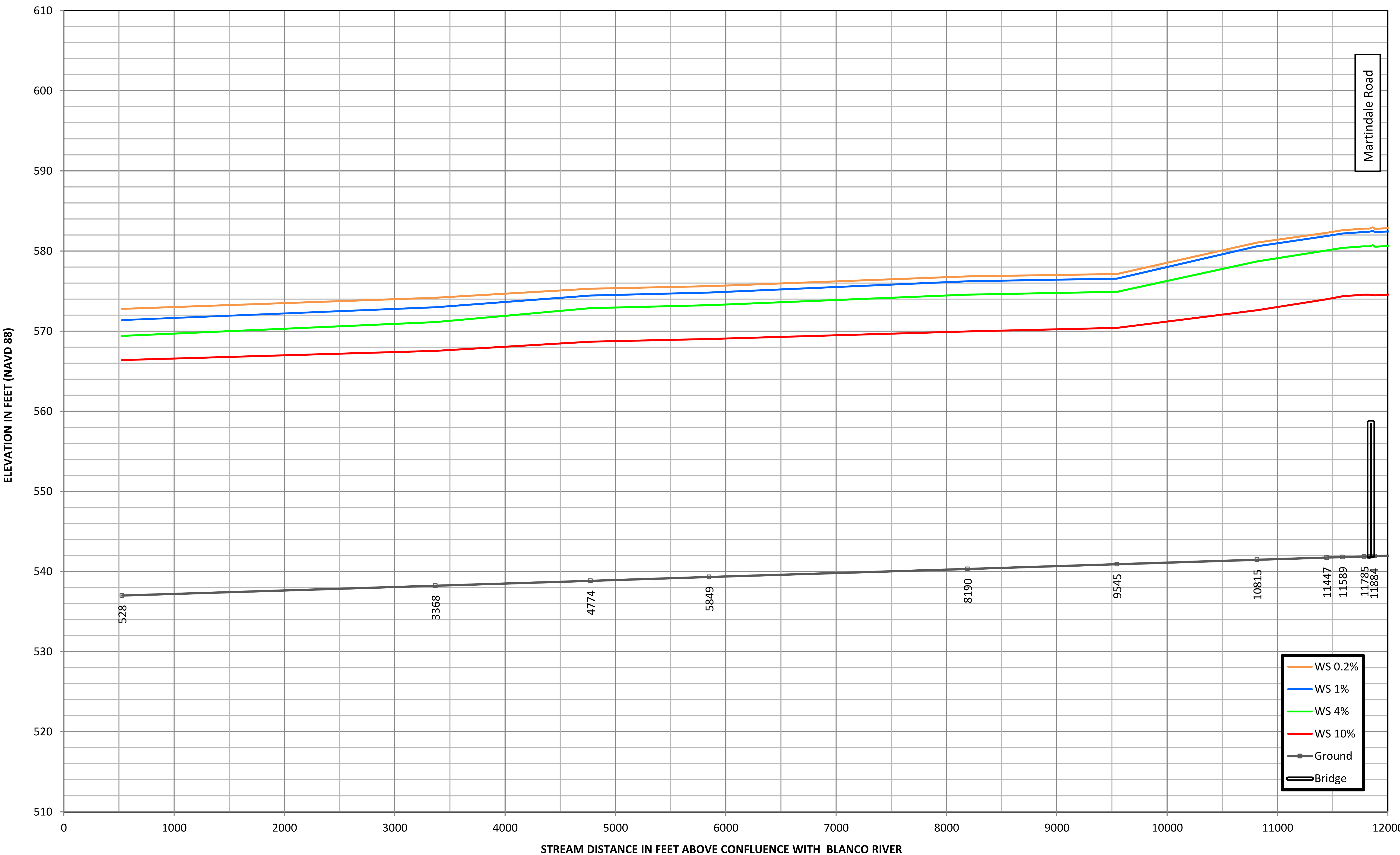
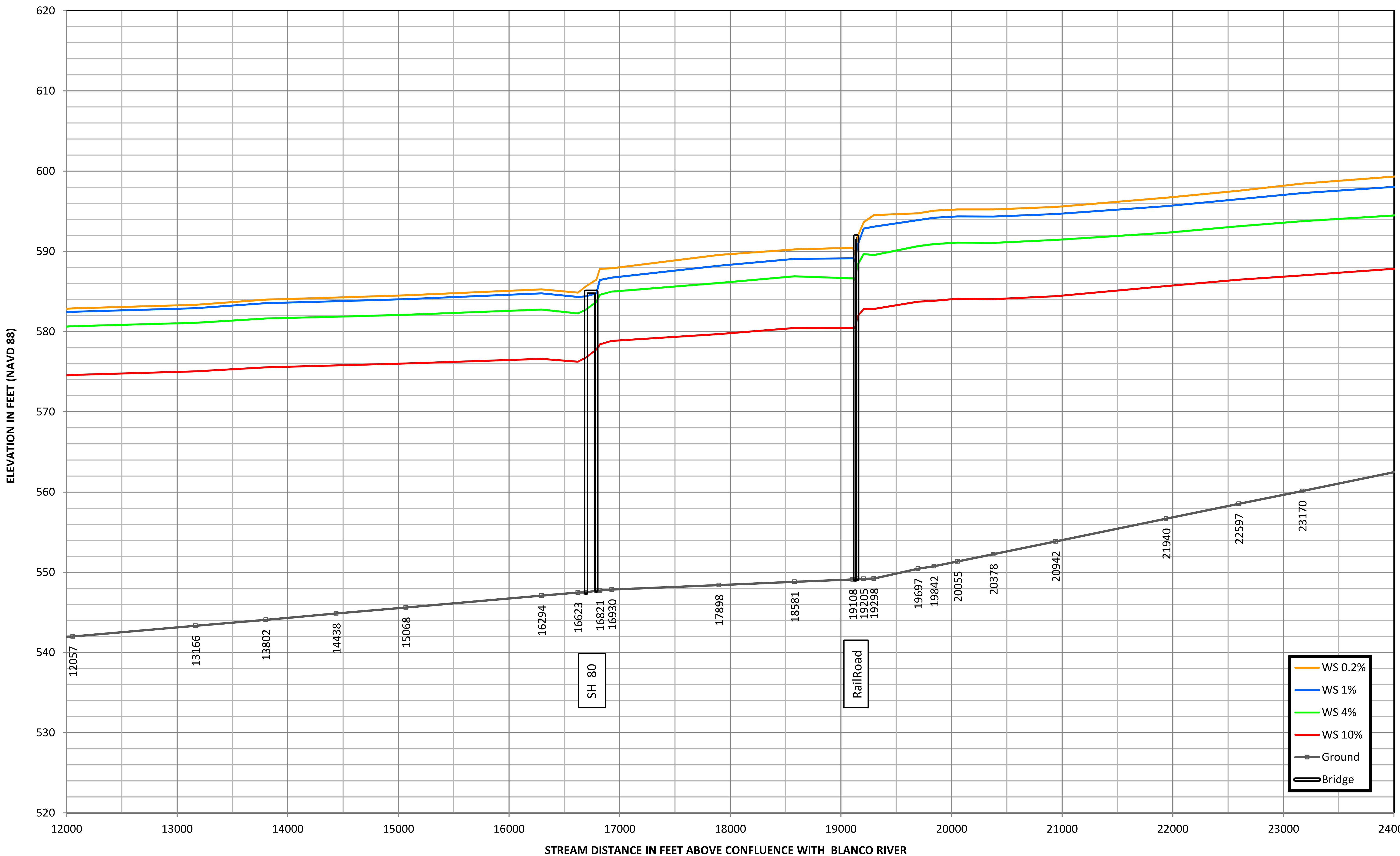
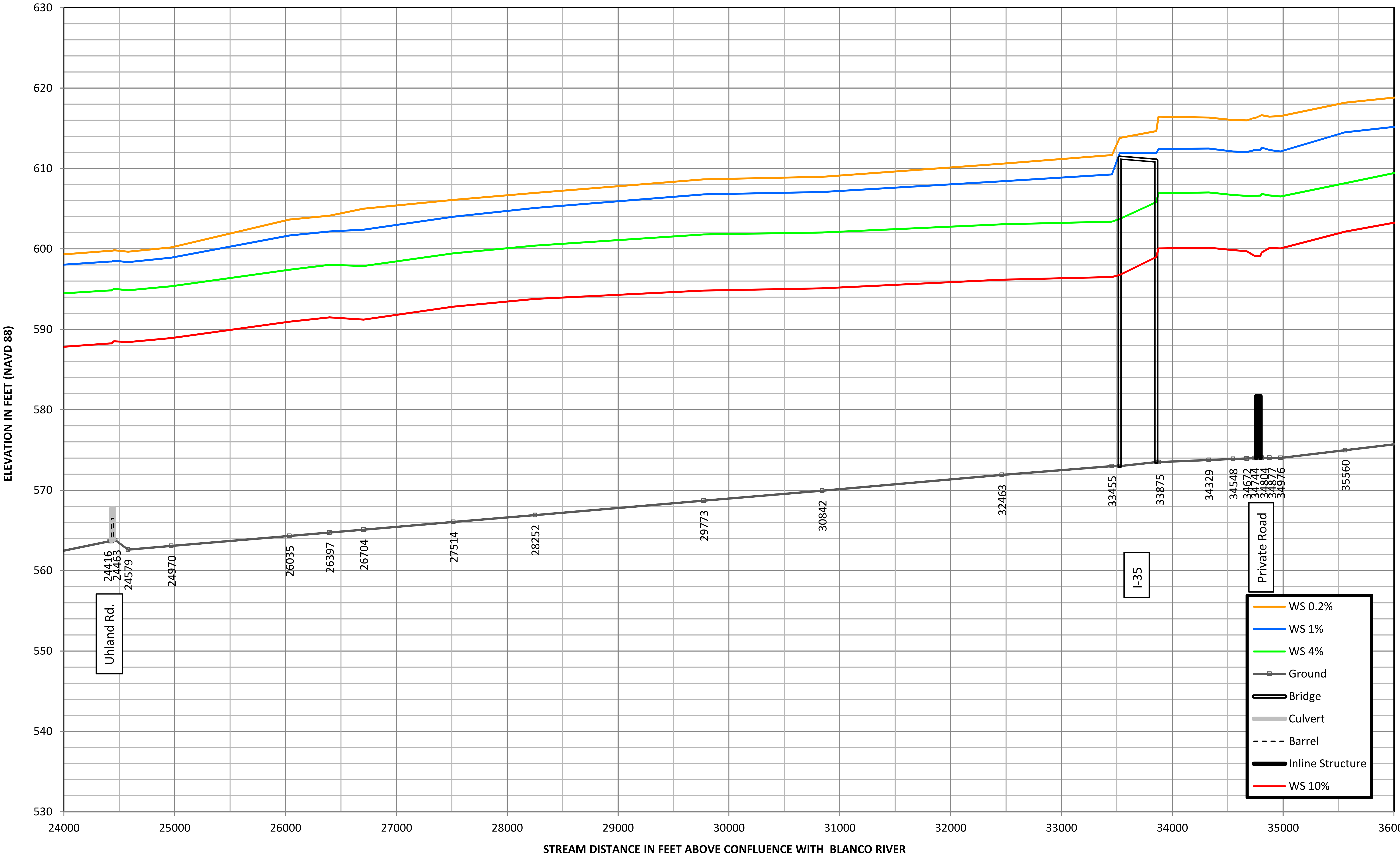
Blanco River Existing Flood Profiles - Panel 1

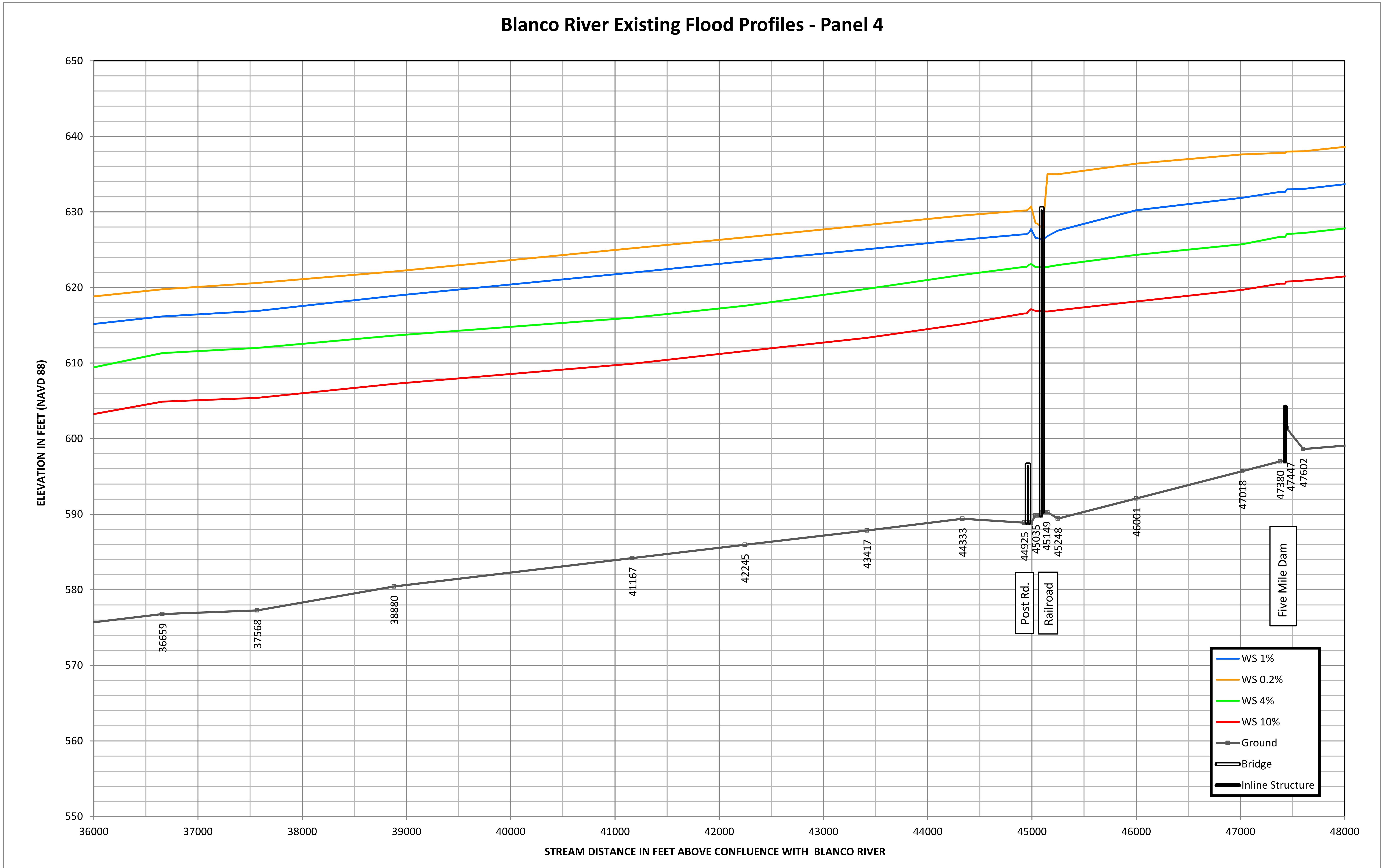


Blanco River Existing Flood Profiles - Panel 2

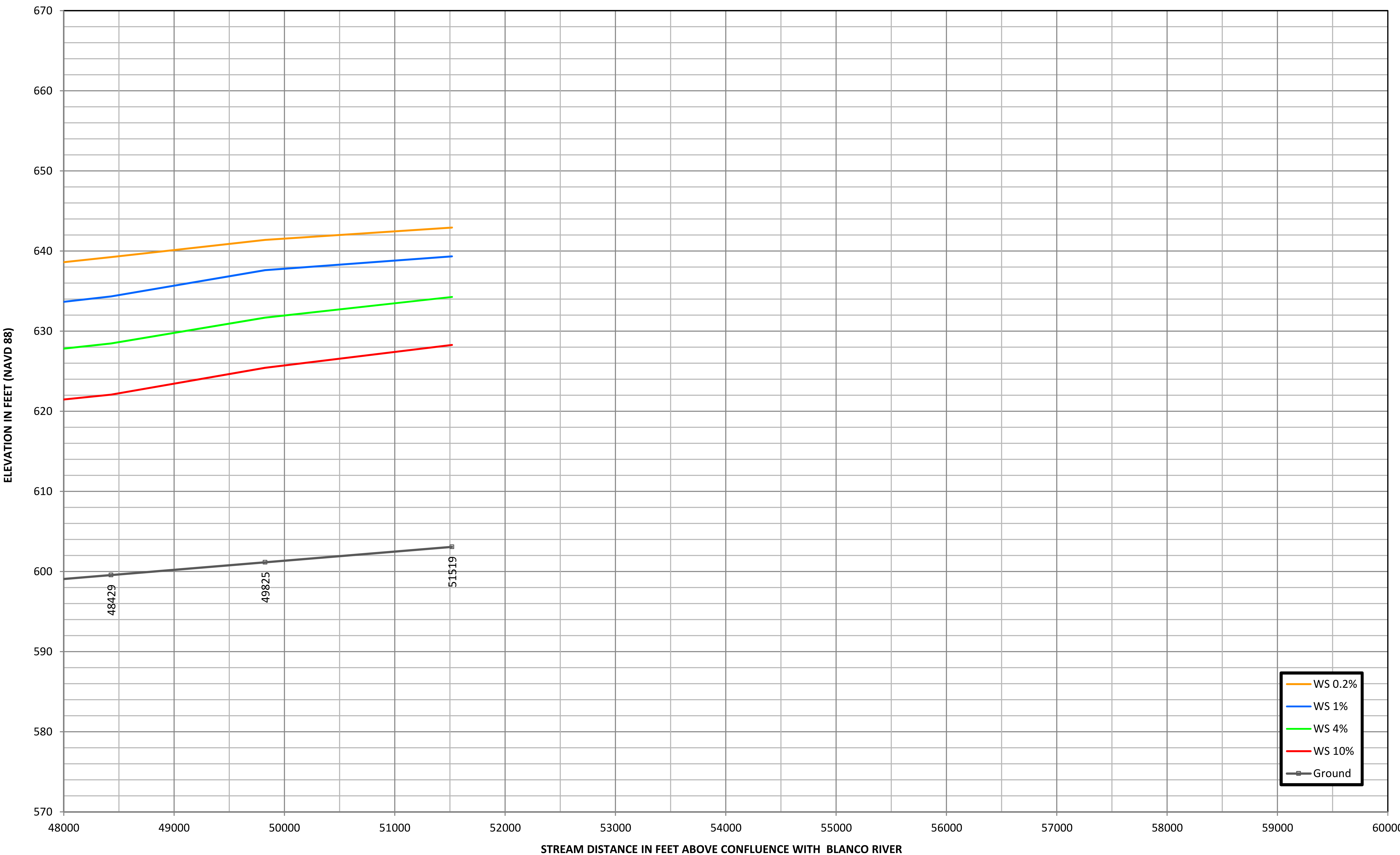


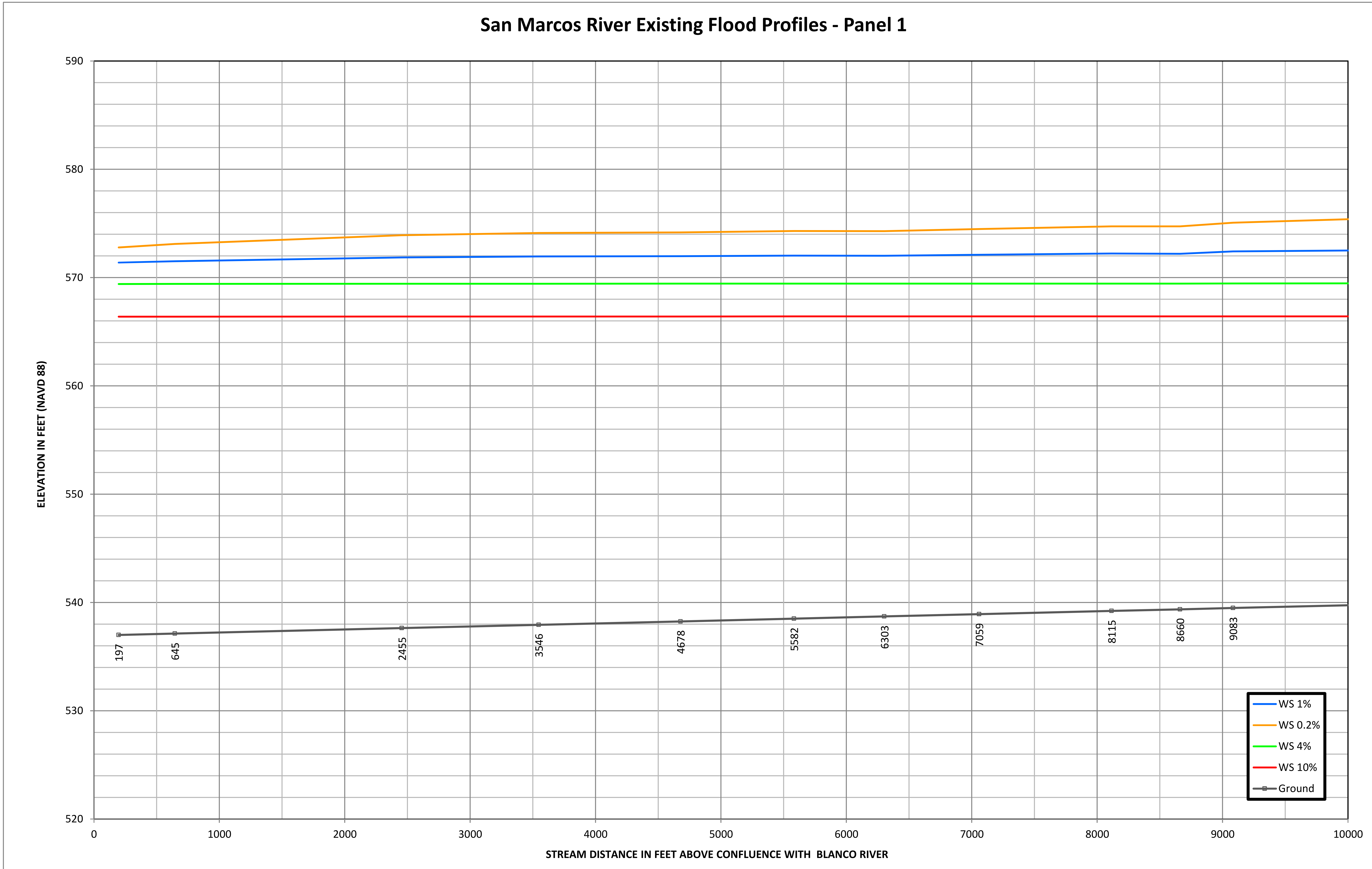
Blanco River Existing Flood Profiles - Panel 3



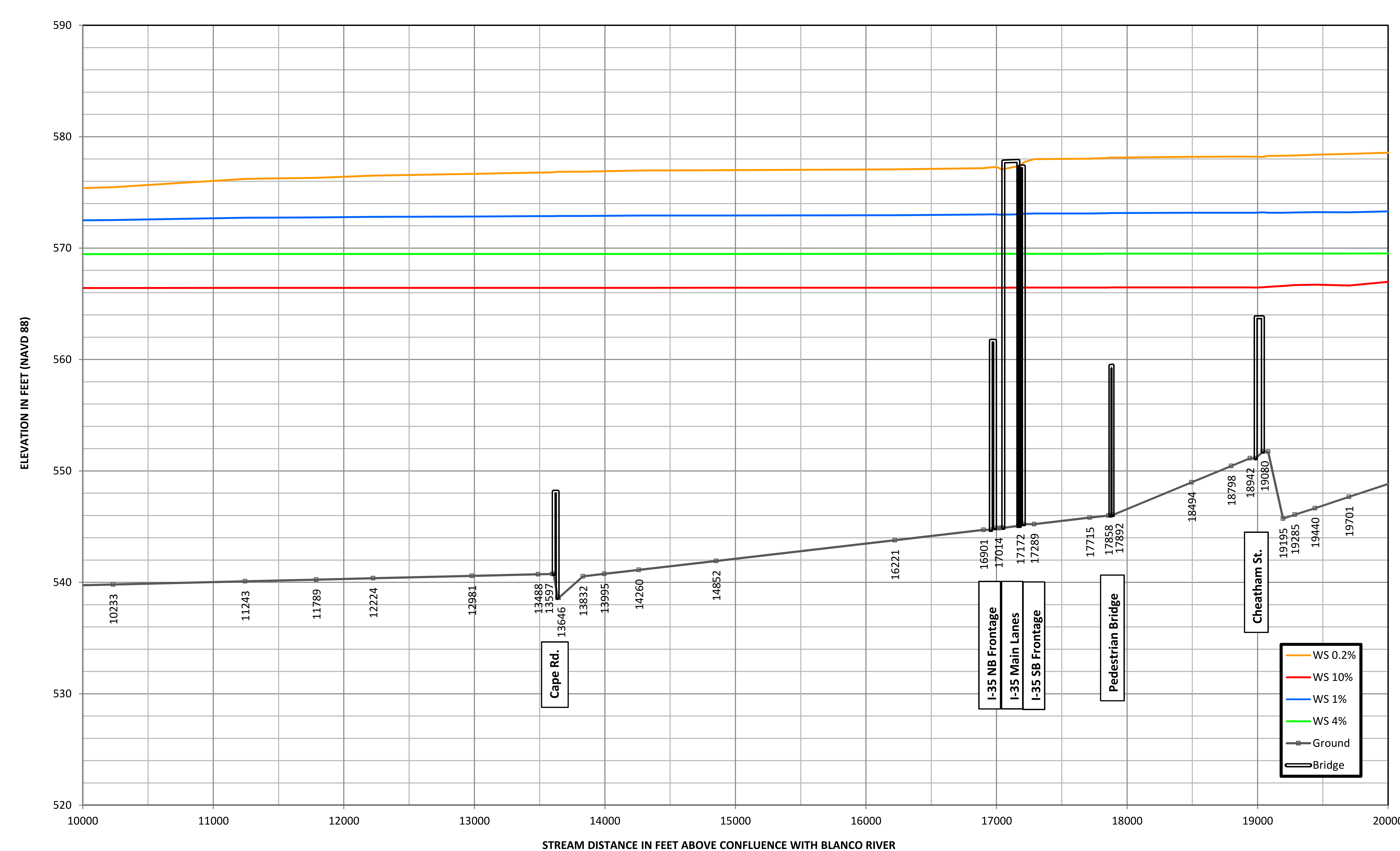

Blanco River Existing Flood Profiles - Panel 4
ELEVATION IN FEET (NAVD 88)
650
640
630
620
610
600
590
580
570
560
550
36000
37000
38000
39000
40000
41000
42000
43000
44000
45000
46000
47000
48000
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH BLANCO RIVER
36659
37568
38880
41167
42245
43417
44333
44925
45035
45149
45248
46001
47018
47380
47447
47602
Post Rd.
Railroad
Five Mile Dam
WS 1%
WS 0.2%
WS 4%
WS 10%
Ground
Bridge
Inline Structure

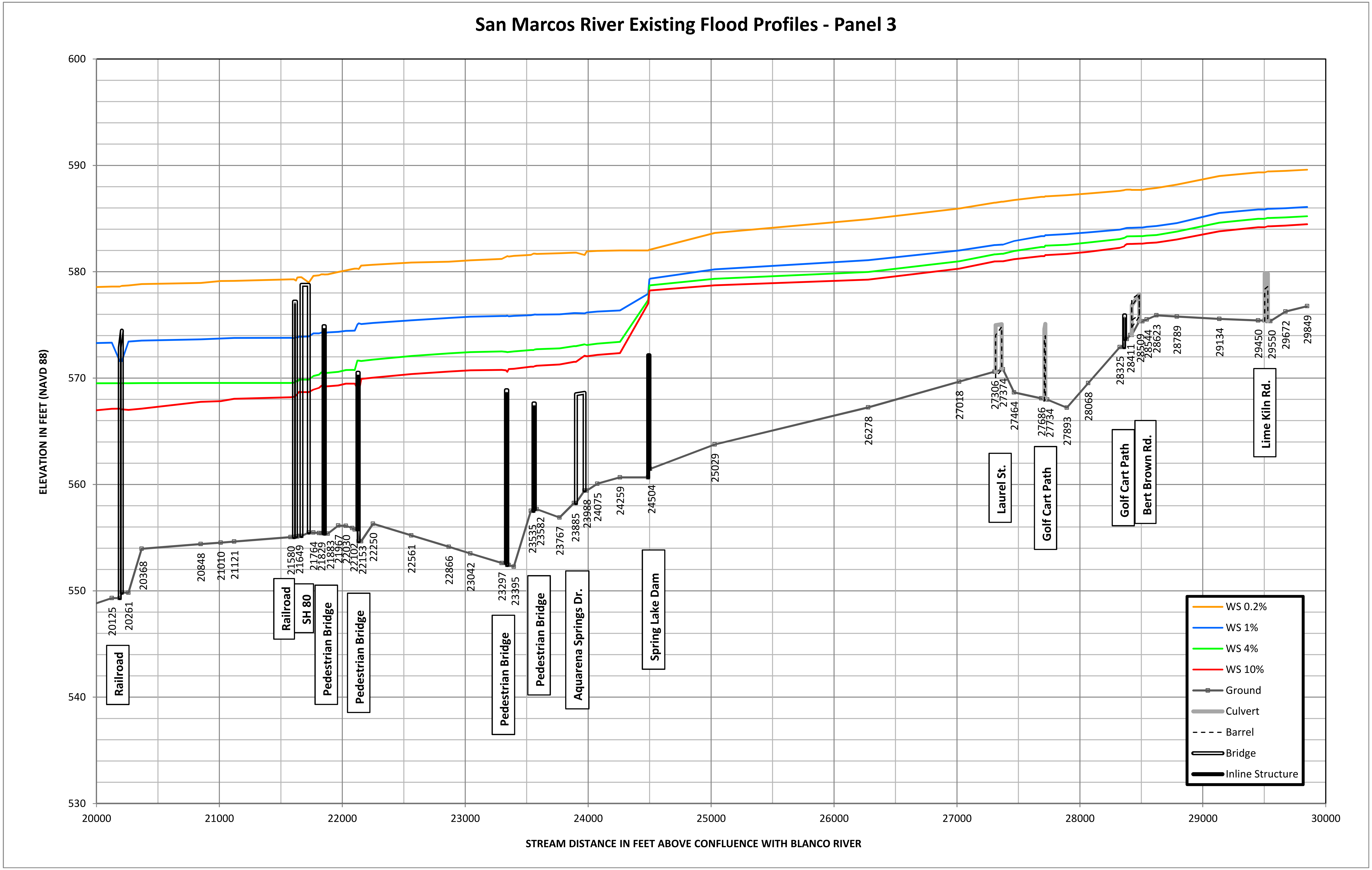
Blanco River Existing Flood Profiles - Panel 5



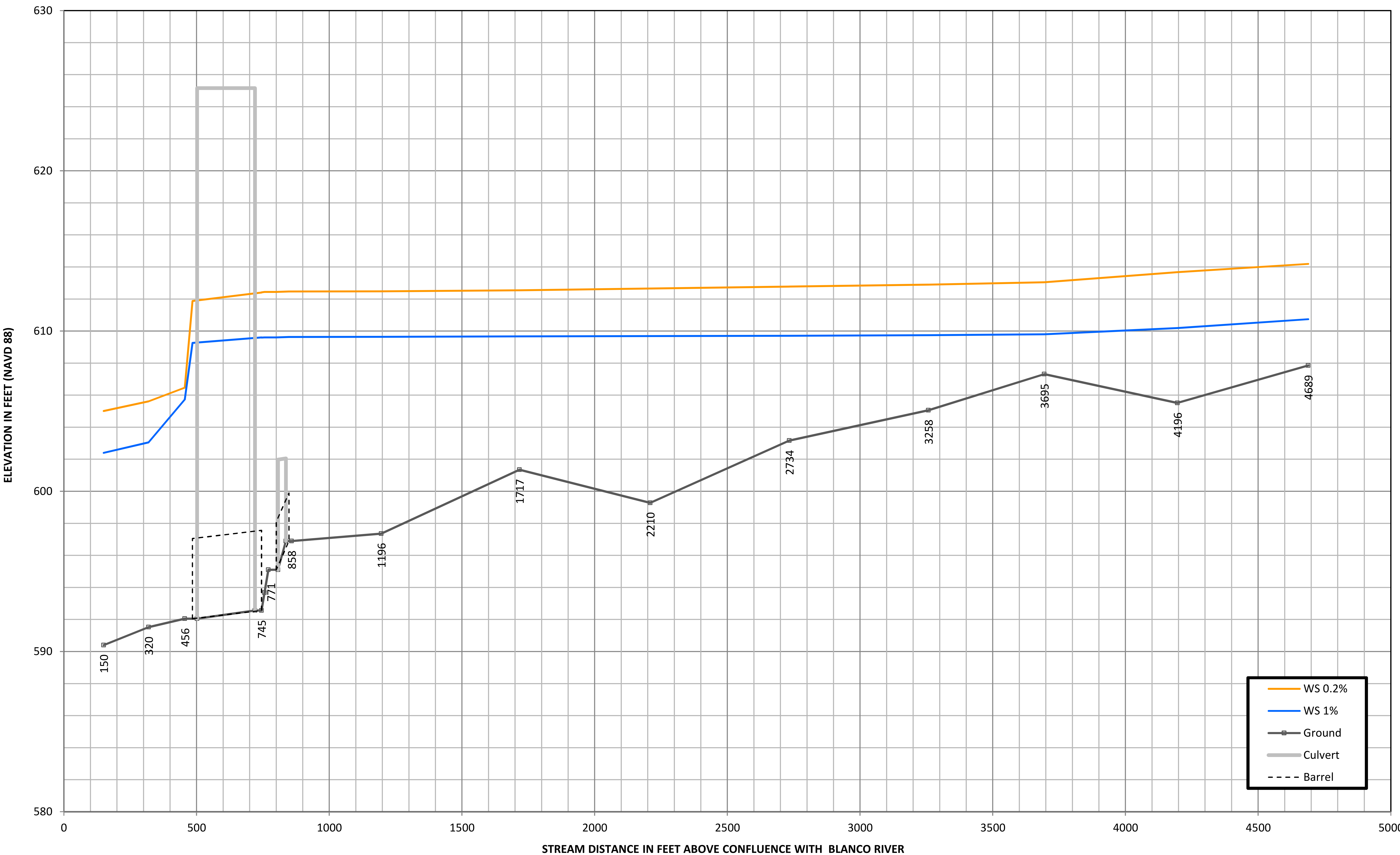

San Marcos River Existing Flood Profiles - Panel 1
ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH BLANCO RIVER
590
580
570
560
550
540
530
520
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
197
645
2455
3546
4678
5582
6303
7059
8115
8660
9083
WS 1%
WS 0.2%
WS 4%
WS 10%
Ground

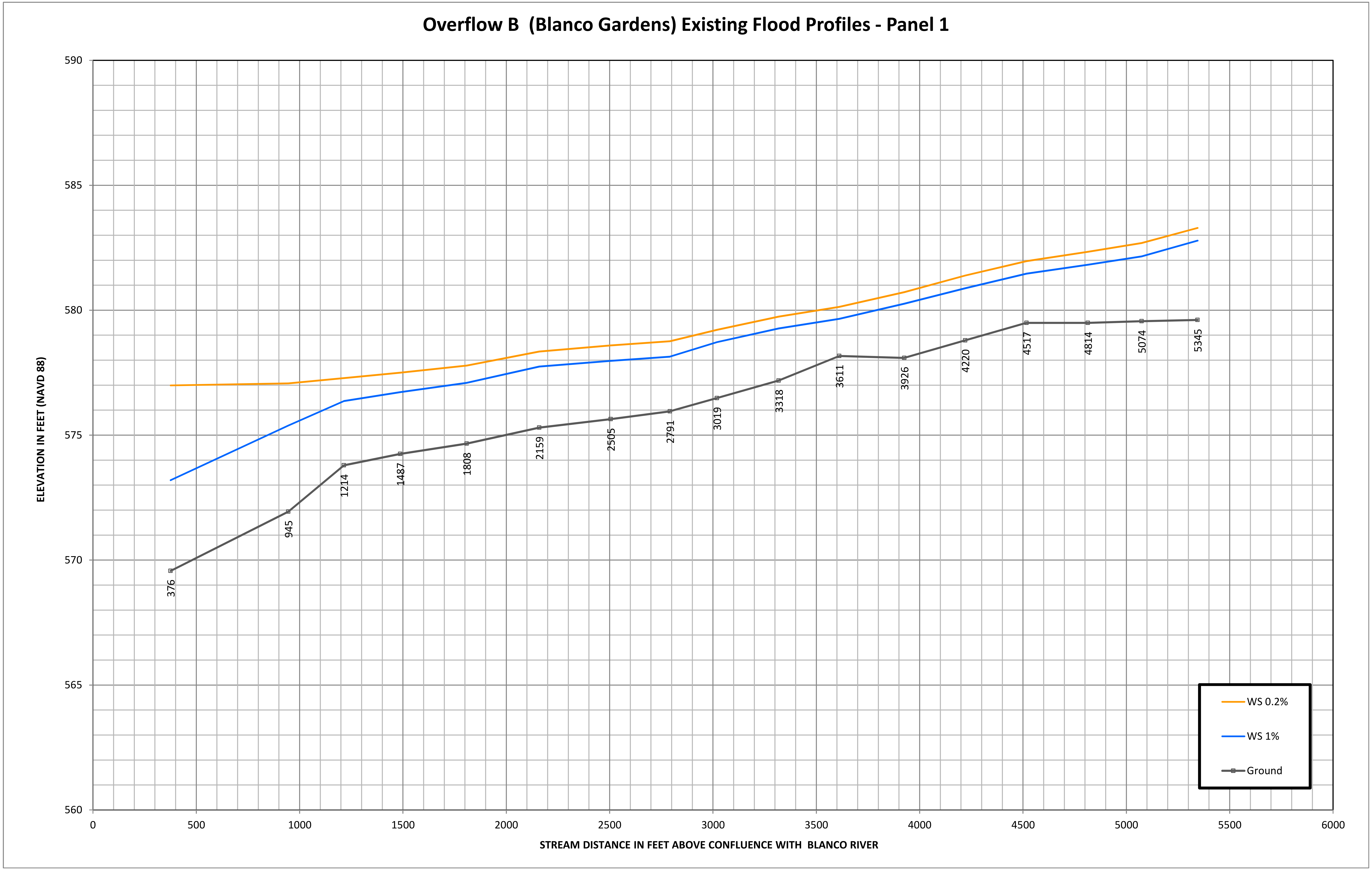
San Marcos River Existing Flood Profiles - Panel 2



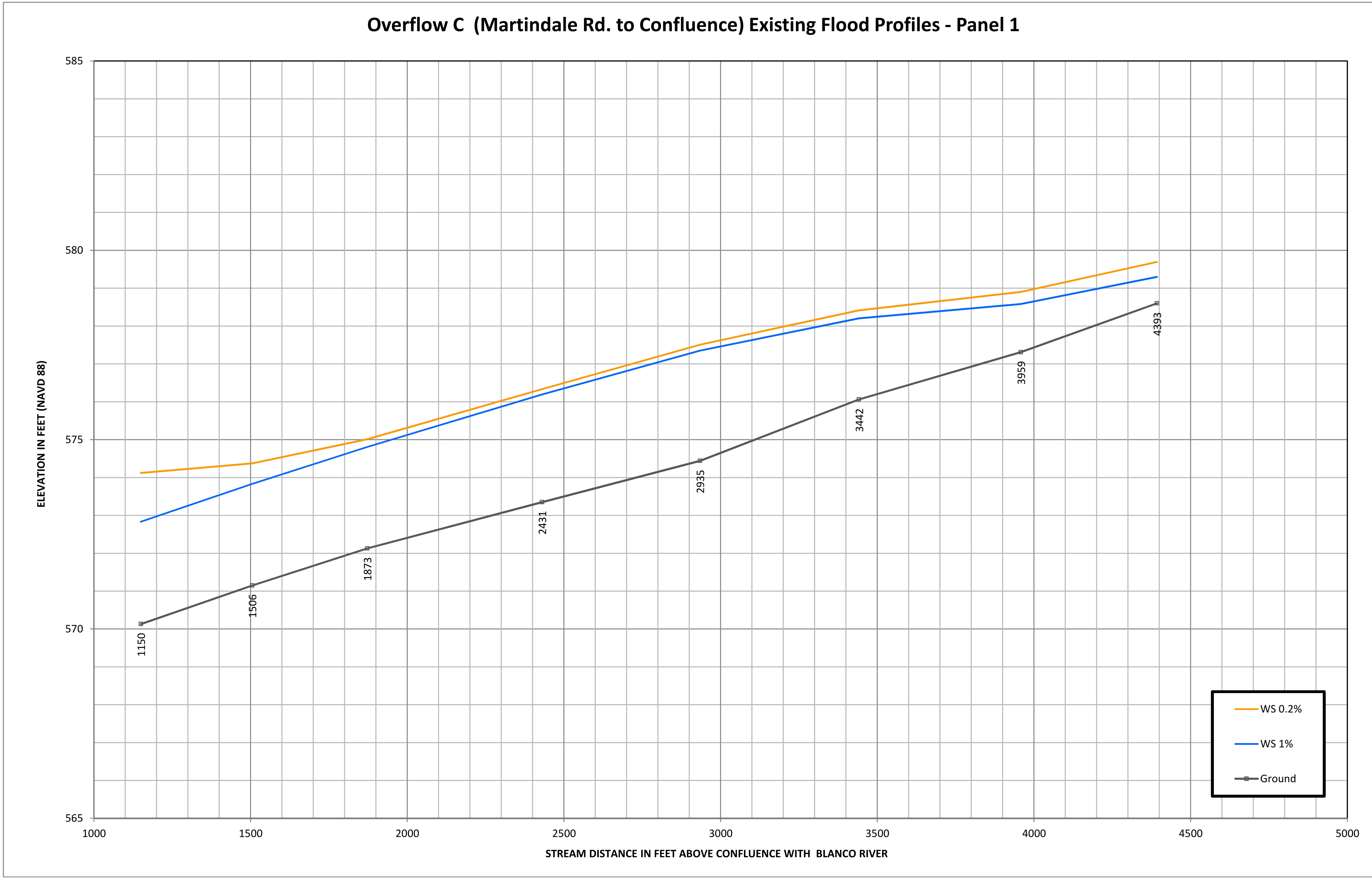

San Marcos River Existing Flood Profiles - Panel 3
ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH BLANCO RIVER
600
590
580
570
560
550
540
530
20000
21000
22000
23000
24000
25000
26000
27000
28000
29000
30000
Railroad
Railroad
SH 80
Pedestrian Bridge
Pedestrian Bridge
Pedestrian Bridge
Pedestrian Bridge
Aquarena Springs Dr.
Spring Lake Dam
Laurel St.
Golf Cart Path
Golf Cart Path
Bert Brown Rd.
Lime Kiln Rd.
20125
20261
20368
20848
21010
21121
21580
21649
21764
21829
21883
21967
22030
22102
22153
22250
22561
22866
23042
23297
23395
23535
23582
23767
23885
23988
24075
24259
24504
25029
26278
27018
27306
27374
27464
27686
27734
27893
28068
28325
28411
28509
28544
28623
28789
29134
29450
29550
29672
29849
WS 0.2%
WS 1%
WS 4%
WS 10%
Ground
Culvert
Barrel
Bridge
Inline Structure

Overflow A (Upstream of I-35) Existing Flood Profiles - Panel 1

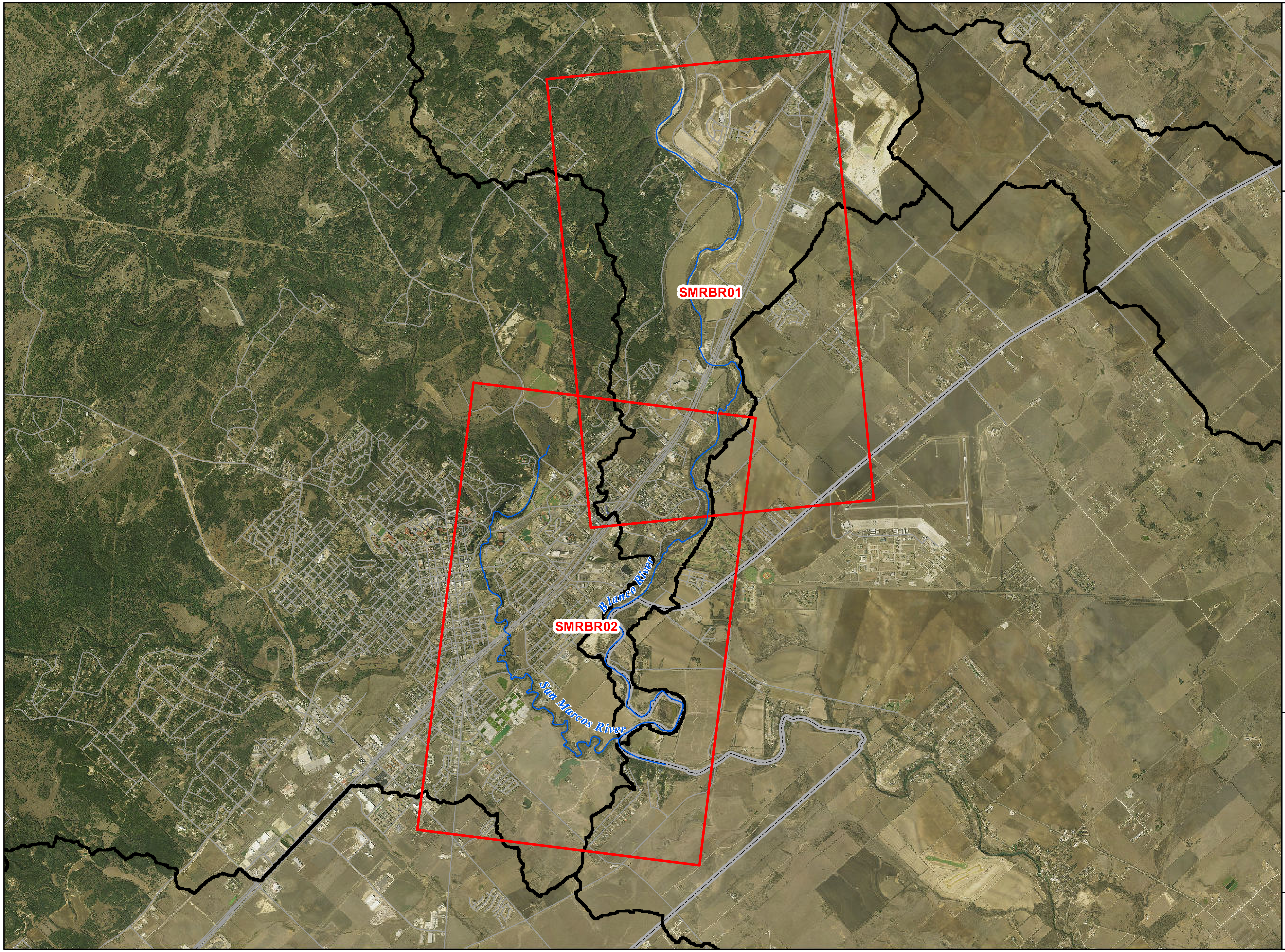




Overflow B (Blanco Gardens) Existing Flood Profiles - Panel 1
ELEVATION IN FEET (NAVD 88)
590
585
580
575
570
565
560
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH BLANCO RIVER
376
945
1214
1487
1808
2159
2505
2791
3019
3318
3611
3926
4220
4517
4814
5074
5345
WS 0.2%
WS 1%
Ground



Overflow C (Martindale Rd. to Confluence) Existing Flood Profiles - Panel 1
ELEVATION IN FEET (NAVD 88)
585
580
575
570
565
1000
1500
2000
2500
3000
3500
4000
4500
5000
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH BLANCO RIVER
1150
1506
1873
2431
2935
3442
3959
4393
WS 0.2%
WS 1%
Ground



US Army Corps of Engineers

GBRA Interim Feasibility Study - Phase 2 Blanco Unsteady Modeling

Key to Features

- Stream Centerline
- Watershed Boundary
- Hays County Boundary
- Workmap Panel

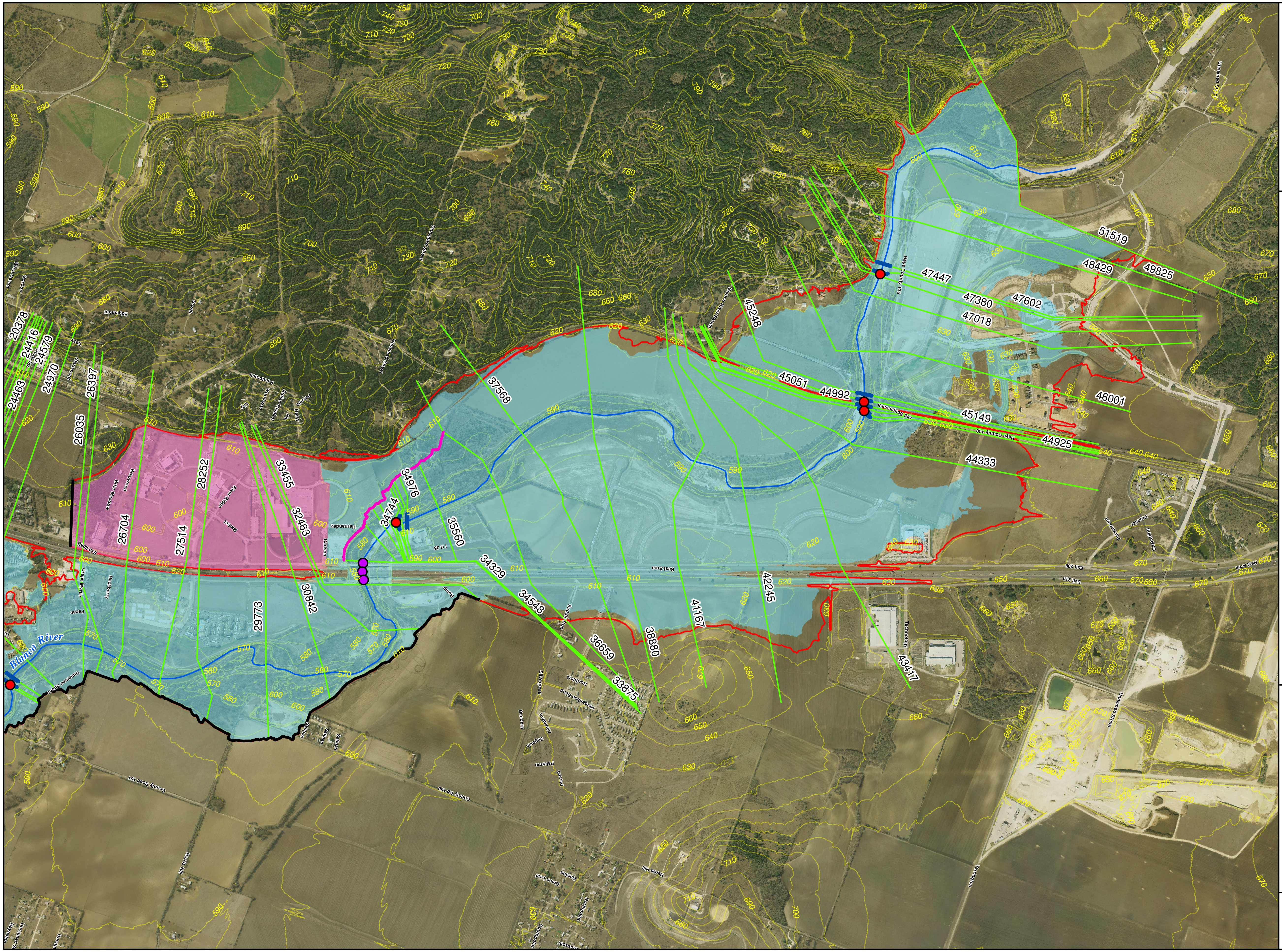
INDEX

San Marcos / Blanco River 0.2% and 1% ACE Floodplains

N
W E
S

0 2,500 5,000 10,000
Feet

HALFF



US Army Corps of Engineers

GBRA Interim Feasibility Study - Phase 2 Blanco Unsteady Modeling

Key to Features

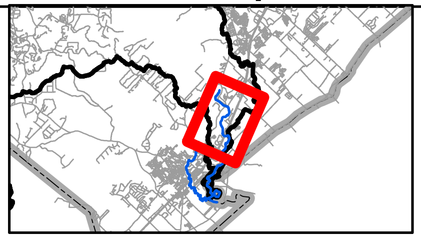
- RAS XS Cutlines
- Stream Centerline
- Limit of Study
- Halff Surveyed Structures
- Non-Surveyed Structures
- Surveyed XS
- Natural Overflow
- 10 ft contours
- 0.2% ACE Floodplain

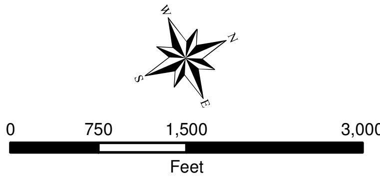
1% ACE Floodplain

- Detailed
- Shallow

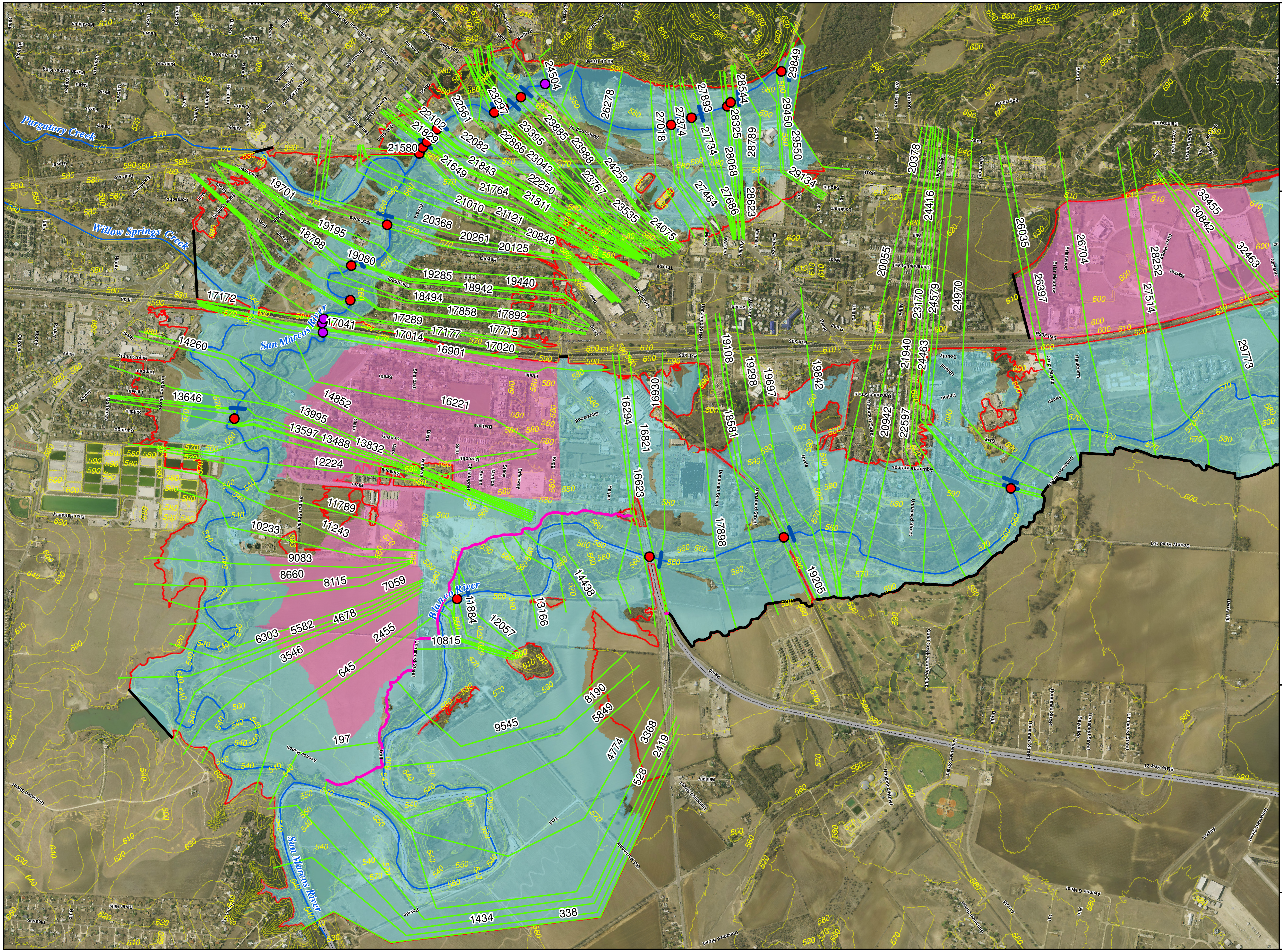
PANEL SMRBR1

San Marcos / Blanco River 0.2% and 1% ACE Floodplains





HALFF



US Army Corps of Engineers

GBRA Interim Feasibility Study - Phase 2 Blanco Unsteady Modeling

Key to Features

- RAS XS Cutlines
- Stream Centerline
- Limit of Study
- Halff Surveyed Structures
- Non-Surveyed Structures
- Surveyed XS
- Natural Overflow
- 10 ft contours
- 0.2% ACE Floodplain
- 1% ACE Floodplain
  - Detailed
  - Shallow

PANEL SMRBR2

San Marcos / Blanco River 0.2% and 1% ACE Floodplains

0 750 1,500 3,000

Feet

HALFF

Appendix C

Quality Assurance

HALFF

Detailed Analysis
Hydraulics QM Checklist

Stream Name: Blanco and San Marcos

Level of Study: ☐ Zone AE with Floodway ☐ Zone AE ☐ Enhanced Approximate

Flood Events: ☒ 50% ☒ 10% ☒ 4% ☒ 2% ☒ 1% ☒ 0.2%

Modeler's Name: Caleb Bolin

Reviewer's Name: Angela Wright

QM Folder Path: W:\Citrix\28000s\28411E\QAQC\Hydraulics

[All submitted QM Data should be able to be found in the QM Folder.]

SUBMITTED ITEMS:

[Data submitted for each checkpoint should be carried through each subsequent checkpoint.]

HEC-RAS Project File Path:
W:\Citrix\28000s\28411E\QAQC\Hydraulics\HEC-RAS\SM
ArcMAP Project File Path:
N:\28000s\28411E\QAQC\Hydraulics\MXD's\Blanco_Unsteady_QAQC.mxd

Checkpoint I: Cross Section Layout
- ☒ GeoRAS geodatabase
- ☒ Study stream centerlines
- ☒ Topographic data
- ☒ Imagery
- ☒ Q3 or current floodplains
- ☐ Watershed location
- ☐ Any previous study work maps
- ☐ Road network for names

Checkpoint II: RAS Geometry
- ☒ Flowpaths
- ☒ Channel bank points
- ☒ Field survey data ______
- ☒ Bridge record plans ______
- ☒ Stationing assumptions and calculations ______
- ☒ Manning's n-values assumptions ______

Checkpoint III: HEC-RAS Model
- ☒ Preliminary floodplain runs
- ☒ Discharge points locations
- ☒ N-values shapefile
- ☐ Check RAS output ______
- ☒ N-value table ______
- ☐ Any record plans needed ______
- ☒ Descriptions of assumptions ______
- ☒ Descriptions of special situations ______

Checkpoint IV: Floodway Model ☐ Included ☒ Not included
- ☐ Floodway points
- ☐ Floodway lines

I. CROSS SECTION LAYOUT:

Modeler's Initials:	CB	Date Submitted:	7/8/2015
Reviewer's Initials:	ALW	Date Reviewed:	7/15/2015
Modeler's Initials:	CB	Date Responded:	7/20/2015

STATISTICAL DATA:

HEC-RAS Multiple Profile Plan Name:

______

TECHNICAL REVIEW:

- ☐ Cross sections extend beyond the assumed limits of all floodplains
- ☐ Cross sections are contained within the drainage area basins
- ☐ Cross sections extend to the limits of the drainage area basins, if spilling
- ☐ Cross sections are reasonably perpendicular to flow
- ☐ The location of the 4 bridge cross sections is reasonable
- ☐ The spacing between cross sections is reasonable
- ☐ Transitions, constrictions, and expansions on the floodplain are reasonable

REVIEW COMMENTS:

1. Blanco XS 43230 – 33455 – XS should be shortened to not include the area east of I-35 or blocked obstructions should be used. The ineffective areas allow water to get in this area and be used a storage when it is not available
2. Blanco XS 26397 – 20055- XS should be shortened to not include the west side of I-35 or blocked out similar to comment #1. I would suggest shortened XS. They also cross a railroad and water can typically not cross railroad embankments
3. Take a look at the current effective FEMA maps. Your cross sections are crossing almost every BFE at the confluence. What you thought was perpendicular to the channel the previous modeler did not. Double check your assumptions. If this was ever used for regulatory reasons you could be changing some BFE's by your cross section alignment.
4. Should the San Marcos XS be extended to the lateral structure in the downstream portion of Reach 1 to account for the shallow flow and storage in the AH flood zone.
5. San Marcos cross sections that have areas of ineffective flow in the overbanks due to long cross sections may need to be reevaluated and shortened or a block obstruction used. This could be over estimating the storage in the cross sections.
6. XS in GeoRAS layer labeled 30179 San Marcos is not in the model. Remove from GeoRAS layer.

RESPONSE TO COMMENTS:

1. At the crest elevation of I-35 it does appear that flow may extend to the east side at these XS for very high flows. Blocks on the east side were placed or adjusted to the crest elevation of I-35.
2. Agree. Went with blocked obstruction to save time.
3. Noted. We agree that our analysis is appropriate for this study.
4. Cross-sections are in containment in this area.
5. Blocked Obs and Perm Ineffectives were used in this area.
6. XS removed from GeoRAS

II. RAS GEOMETRY:

Modeler's Initials:	CB	Date Submitted:	7/8/2015
Reviewer's Initials:	ALW	Date Reviewed:	7/15/2015
Modeler's Initials:	CB	Date Responded:	7/20/2015

TECHNICAL REVIEW:

- ☐ Top of bank at reasonable locations
- ☐ Bridge geometry corresponds to surveys or record plans
- ☐ Bridge geometry assumptions documented
- ☐ Bridge skew utilized appropriately
- ☐ Contraction and expansion coefficients are reasonable
- ☐ Use of ineffective flow areas is reasonable
- ☒ Manning's n-values are reasonable
- ☐ Survey is incorporated into all cross sections properly
- ☒ Flow paths are reasonable
- ☒ Flow paths are located at the centroid of flow based on preliminary mapping
- ☒ Reach lengths across junctions are appropriate
- ☐ No crossing profiles
- ☐ Profile of flowline is reasonable

REVIEW COMMENTS:

1. Add notes and descriptions to everything
2. Add notes to cross sections explaining blocked obstructions
3. XS 13802 - Manning's N value of 0.6 should probably be 0.06
4. Lots of places were horizontal manning's n-values do not align with the bank station
5. Maybe comment 5 will fix this but your weighted manning's n for the channel on XS 19842 is 0.1. That is very high for the channel. Also at XS 49825. There is an area of weighted manning's n values of 0.025 between XS 34877 to 36216. Is this correct?
6. Junction length and reach lengths don't seem right at the junction. Double check all.
7. Blanco River Lateral Structure 36215 – DFIRM shows this area as a split flow region. I think the long cross sections from XS 30842 downstream to 20378 are over estimating storage by not being a separate split flow model.
8. Blanco XS 45093 Bridge – Piers need to be extended to the top of the bridge. Ineffective area is inside the bridge opening and should be moved out. Piers look different in field survey. HTab curve is a bit jagged. You may need to recalculate and use a lower maximum headwater to get better curves in your range of flows.
9. Blanco XS 44960 Post Rd – I think this is a bridge and not culverts. A 33 ft span on a box culvert is something I have not seen before. I also would model this as a bridge with piers because you have natural ground on the bottom of the channel and not concrete. There are also no wingwall on this structure.
10. Add a description to any ineffective areas that are set to permanent. Example XS 35660. If this is supposed to be representing a building in the floodplain then I think you should use a blocked obstruction instead. The ineffective area will count as storage in your unsteady model.
11. Culvert 34799 Private Drive – I could not find pictures or field notes for this. I looked into the hydraulic jump you referenced on the QC email. I would suggest removing the culverts and modeling the private drive as an inline structure. The unsteady model is causing the jump when it tries to put some flow through the culvert. I did a quick test and this seemed to fix the crazy jumps you are seeing. The minimum flows in the model are always well above the road and the culvert will most likely be maxed out at all times. Open the Stage and Flow Hydrograph for 34779. The headwater is out of the HTAB curve. If you keep the culverts you will have to fix this.

12. Bridge 33676 I-35 – What is the dip in the low chord. I didn't see this is in field pictures but I don't think it had all of the bridge either. Only 10 piers are shown in the downstream bridge and 11 are shown in the upstream
13. Culvert 24444 –8.667 feet is too specific. Round to whole numbers for culverts. Culverts are usually constructed with typical shapes.
14. Bridge 16737 Hwy 80 – Ineffective area is inside the bridge opening.
15. San Marcos – 19013 Bridge – The headwater is outside of the HTAB curve. Double check your HTAB curve and all other assumptions.
16. San Marcos 17875 Ped Bridge is also outside of the HTAB curve

RESPONSE TO COMMENTS:

1. Notes and hydraulic notebook have been updated.
2. Notes have been added.
3. N-value corrected.
4. N-Values adjusted to bank stations
5. 0.1 n-values corrected and 0.025 n-values updated to appropriate values.
6. Junction lengths were updated and override downstream reach length of upstream XS.
7. This area may be modeled in the future with a 2D model. For now we are just taking flow out with the weir and placing it back in downstream where is comes back in normally. Area west of I-35 was blocked out in XS downstream of I-35.
8. Adjusted ineffective areas and top of piers. Checked pier locations vs. survey and they appear to be correct. Pier widths were estimated from aerial photos. Aerial photos and field notes confirm that widths vary accordingly.
9. Post Rd. changed to a bridge.
10. Descriptions added.
11. Culvert switched to inline structure.
12. The dip in low chord is reflected on the I-35 plan sheets. The 11th pier on the downstream side is blocked by natural embankment on the right. The bridge abutment is sort of cut into the natural embankment downstream.
13. These dimensions were hand measured in the field. This particular culvert is old and could have non-standard dimensions. Rounded to nearest tenth.
14. Adjusted right ineffective area at downstream XS.
15. We are getting reasonable results and will further investigate.
16. We are getting reasonable results and will further investigate.

III. HEC-RAS MODEL REVIEW:

Modeler's Initials: CB   Date Submitted: 7/8/2015
Reviewer's Initials: ALW   Date Reviewed: 7/15/2015
Modeler's Initials: CB   Date Responded: 7/22/2015

TECHNICAL REVIEW:

- ☒ Discharge locations are appropriate and reasonable
- ☒ Discharge values agree with hydrology
- ☒ Discharge values are rounded appropriately
- ☒ Starting boundary conditions are reasonable
- ☒ Cross section geometry extends beyond the limits of all floodplains
- ☒ Manning's n values are reasonable
- ☒ Contraction and expansion coefficients are appropriate
- ☒ Ineffective flow top widths
- ☒ Bridge and culvert layouts are complete and correctly placed
- ☒ Special feature (weir, overflow, split flow) layouts are complete and correctly placed
- ☒ Profiles are smooth and do not cross
- ☒ Left and right flow paths are appropriate for preliminary floodplains
- ☒ No ineffective areas inside the channel banks unless necessary
- ☒ No permanent ineffective areas (unless using unsteady RAS)
- ☒ Critical water surface elevations have been resolved
- ☒ Entrance loss coefficients are appropriate
- ☐ Check-RAS has been run
- ☒ Errors, warnings, and special notes have been addressed

REVIEW COMMENTS:

1. Has or will the model be calibrated to the recent storm events?
2. I don't have your report but you should add a note about the selection of the 6,000 cfs base flow
3. Flow on XS 21010 is not referencing the DSS and is only a table.
4. Flow from 14260 to 13995 – This is a diversion flow. Where is the diversion from?

RESPONSE TO COMMENTS:

1. When we get a hydrograph of the 2015 flood we will run it through the model.
2. Lowered initial flow to minimum required to stabilize the model. This value will be adjusted for other frequencies Flow hydrograph switched back to DSS.
3. Flow now references the DSS.
4. This is not a diversion. It is the inflow from Willow Springs Creek. The confluence with San Marcos River is just upstream of Cape Rd.

QM CHECKLIST APPROVAL:

This Detailed Analysis Hydraulics QM Review is in compliance with the contract requirements and all task checkpoints are complete. The independent QM Team has reviewed the hydraulic analysis, presented review comments to the Production Team Task Leader, and discussed any problems or issues. The Task Leader, QM Team Manager, and Project Manager have signed the QM Checklist to confirm that all comments are received, addressed, and documented appropriately.

Task Leader	05 AUG 2015 Date
QM Team Manager	8/5/2015 Date
Project Manager	8/5/2015 Date

Appendix D

Digital Data

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