Lower San Antonio HUC-8 Watershed, Texas Base Level Engineering (BLE) Results

MAS No. FY20-CTP-FRP-MAST#2 T.O. No. 8

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Executive Summary

The Texas Water Development Board (TWDB) contracted Halff Associates (Halff) to complete a Base Level Engineering (BLE) analysis for the HUC-8 watershed No. 12100303 – Lower San Antonio and including HUC-8 watershed No. 12100404 – West San Antonio Bay in South Central Texas, to support the U.S. Department of Homeland Security's Federal Emergency Management Agency's (FEMA) Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHAs). The BLE process involves using best available data and incorporating automated techniques with standard 2D model development procedures to produce flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals.

The source digital terrain data used for surface model development in support of hydrologic and hydraulic analysis as well as mapping activities were leveraged from various local, State, and Federal partners. Details regarding the different datasets used are provided below in Section 2.1.

Precipitation depths for this study were established using NOAA Atlas 14 rainfall. An average precipitation depth was computed for the study area. The Hydrologic Engineering Center's (HEC) Hydrologic Modeling System (HMS) was used to develop a simplified hydrologic model to compute excess rainfall which was then used in a rain-on-grid, 2D hydraulic model using HEC-RAS. This hydraulic model was used to compute flood depths and peak water surface elevations within the study area.

The stream mile network that was validated for this watershed was compiled using FEMA's Community Needs Management Strategy (CNMS) inventory. CNMS is an inventory of flood hazard studies and flood hazard mapping needs for areas where a study is needed. This data is helpful for community officials in analyzing and depicting flood hazards to enhance the understanding of flood risks. Communities may use this information to make informed decisions on their planning and flood mitigation efforts. Table ES-1.1 lists the stream miles associated with this validation analysis.

Table ES-1.1: Summary of Stream Miles

Source	Lower San Antonio Stream Miles
CNMS	1,782.5

The full inventory of Zone A studies in the watershed were classified in CNMS. Total miles validated in CNMS are summarized in Table ES-1.2.

Table ES-1.2: Aggregated Zone A Validation Results

Validation Status	Status Type	Total Miles
Valid	Being Assessed	45.7
	Being Studied	116.4
Unverified	To be Studied	397.9
	Being Studied	1,028.6
Unknown	Being Studied	193.1
Assessed	Being Studied	0.8

01 Introduction

Recent innovations and efficiencies in floodplain mapping have allowed the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA)to develop a process formerly known as First Order Approximation (FOA), now called Base Level Engineering (BLE), which can be used to address current program challenges, including the validation of Zone A studies and the availability of flood risk data in the early stages of a flood risk project. The BLE process involves using best available data and incorporating automated techniques with standard 2D model development procedures to produce flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals. The cost for developing the data and estimates resulting from the BLE process are lower than standard flood production costs. The BLE results may be used for eventual production of regulatory and non-regulatory products.

As described in Title 42 of the Code of Federal Regulations, Chapter III, Section 4101(e), once every five years, FEMA must evaluate whether the information on Flood Insurance Rate Maps (FIRMs) reflects the current risks in flood-prone areas. FEMA makes this determination of flood hazard data validity by examining flood study attributes and change characteristics, as specified in the Validation Checklist of the CNMS Technical Reference. The CNMS Validation Checklist provides a series of critical and secondary checks to determine the validity of flood hazard areas studied by detailed methods (e.g., Zone AE, AH, or AO). While the critical and secondary elements in CNMS provide a comprehensive method of evaluating the validity of Zone AE studies, a cost-effective approach for evaluating Zone A studies has been lacking.

In addition to the need for Zone A validation guidance, FEMA standards require flood risk data to be provided in the early stages of a flood risk project. FEMA Program Standard SID #29 requires that during Discovery, data must be identified that illustrates potential changes in flood elevation and mapping that may result from the proposed project scope. If available data does not clearly illustrate the likely changes, an analysis is required that estimates the likely changes. This data and any associated analyses should be shared, and results should be discussed with stakeholders.

An important goal of the BLE process is the scalability of the results. Scalability means that the results of a BLE analysis can not only be used for CNMS evaluations of Zone A studies but can also be leveraged throughout the Risk Mapping, Assessment and Planning (Risk MAP) program. The data resulting from a BLE analysis can be updated as needed and used for the eventual production of regulatory and non-regulatory products, outreach and risk communication, and MT-1 processing. Leveraging this data outside the Risk MAP program may also be valuable to external stakeholders.

The TWDB contracted Halff to complete a BLE analysis for the Lower San Antonio HUC-8 Watershed (12100303) and including HUC-8 watershed No. 12100404 – West San Antonio Bay located in South Central Texas to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHA). The study extents include portions of Bexar, Guadalupe, Wilson, Karnes, De Witt, Goliad, Victoria, Refugio, and Aransas Counties, and include the following communities: The Cities of Floresville, Falls, Karnes, Kenedy, Goliad, and Austwell, the Towns of Poth and Runge, and the Communities of Hobson, Ecleto, Gillett, and Tivoli. The study area consists of eight HUC-10 basins: Marcelinas Creek – San Antonio River, Hynes Bay – San Antonio Bay, Ecleto Creek, San Antonio River – Guadalupe River, Hondo Creek – San Antonio River, Kicaster Creek – San Antonio River, Cabeza Creek – San Antonio River, and San Antonio Bay – Espiritu Santo Bay. Figure 1.1 shows the location and extent of the Lower San Antonio HUC-8 watershed.

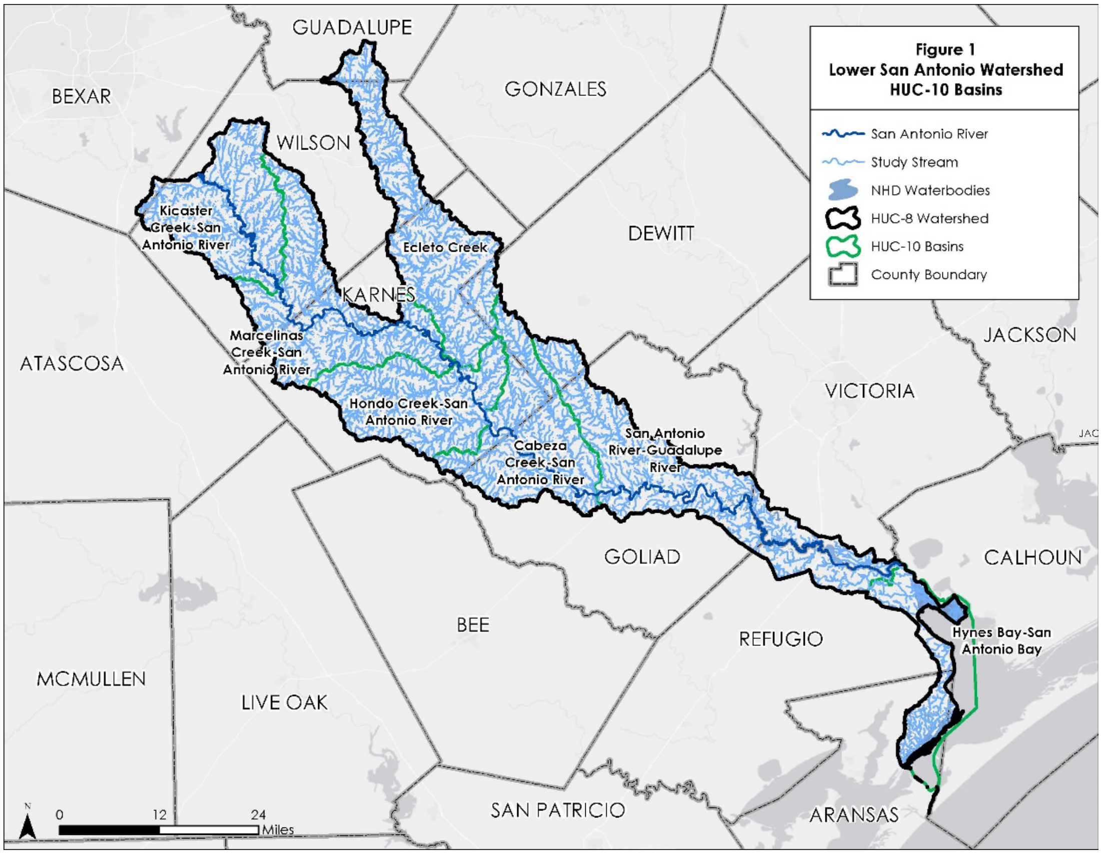

Figure 1.1: Lower San Antonio Watershed

02 2D BLE Modeling Inputs and Controls

Section 2 presents fundamental components required to execute a 2-dimensional (2D) hydraulic engineering analysis for the Lower San Antonio Watershed. Inputs such as elevation data, hydrology for rain-on-grid and inflow hydrographs, and hydraulic analyses and variables are defined herein. HEC-RAS 5.0.7 rain-on-grid utility was applied in the production of the 2D BLE products produced for this watershed.

2.1 Topographic Data

A high-resolution Digital Elevation Model (DEM) is a fundamental component for two-dimensional engineering analyses by providing a detailed representation of the surface for hydraulic routing through the model area. As such, DEMs were developed for the Lower San Antonio BLE project by leveraging available high-resolution gridded elevation data derived from Light Detection and Ranging (LiDAR) collections throughout the entire State of Texas. The 10-foot DEM developed to support the 2D BLE modeling and analysis, within the Lower San Antonio Watershed, was executed using the following steps:

1. Available elevation data for the project area were inventoried and collected.
2. Leveraged elevation data were evaluated and prioritized based on source vertical accuracy, year of collection, and resolution.
3. Seamless DEMs were processed using GIS.
4. Quality was assured using quantitative and qualitative assessment.

Documentation regarding leveraged data including coverage, accuracy, acquisition dates, and source contact/agency are presented in the figures, tables, and text below. All vertical accuracy specifications were obtained from the metadata or survey reports provided with the leverage datasets. All available metadata, survey reports, and other leverage documentation are included in the FEMA Data Capture Technical Reference compliant submittal content for the Lower San Antonio Watershed.

2.1.1 Inventory

An inventory of existing topographic data was conducted for the Lower San Antonio BLE project footprint. Figure 2.1 depicts the datasets identified for leverage across the project area. FEMA, NOAA, USGS, and other State and Federal agencies were queried to build the inventory with the most current and available data sources.

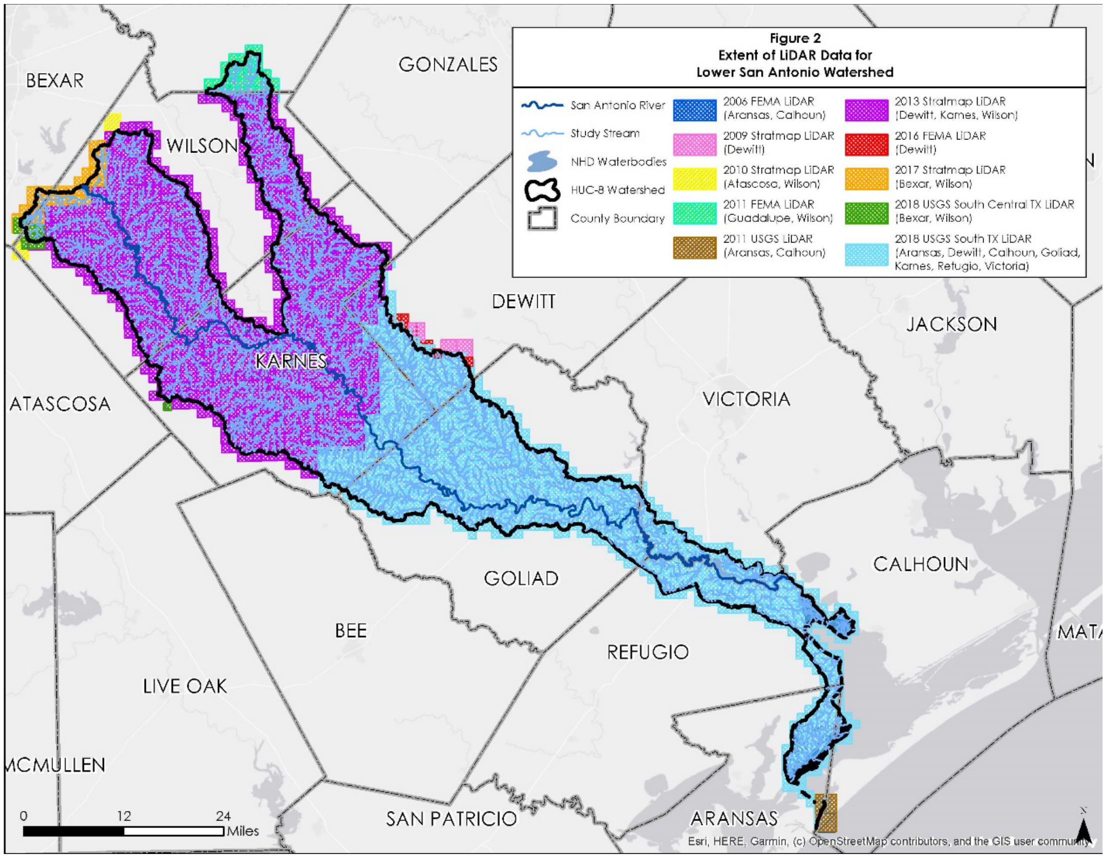

Figure 2.1: Lower San Antonio Watershed BLE Source Terrain Data

2.1.2 Evaluation

A data coverage assessment was conducted to check for data gaps, extent, accuracy, and completeness. A review of related documentation, reports, indexes, and metadata associated with the leveraged datasets ensured each dataset meets FEMA accuracy requirements for topographic data. Decisions to leverage or exclude a dataset (or portion of it), were based generally on the following criteria coupled with engineering judgment:

- Data meet FEMA vertical accuracy standards (Table 2.1)
- Date of origination
- Data density and coverage

Table 2.1 depicts the Risk Map SID #43 vertical accuracy requirements based on flood risk and terrain slope within the floodplain being mapped.

Table 2.1: FEMA Vertical Accuracy Requirements for Leveraged Data

Level of Flood Risk	Typical Slopes	Specification Level	Vertical Accuracy*	LiDAR Nominal Pulse Spacing (NPS)
High (Deciles 1,2,3)	Flattest	Highest	24.5 cm / 36.3 cm	≤ 2 meters
High (Deciles 1,2,3)	Rolling or Hilly	High	49.0 cm / 72.6 cm	≤ 2 meters
High (Deciles 2,3,4,5)	Hilly	Medium	98.0 cm / 145 cm	≤ 3.5 meters
Medium (Deciles 3,4,5,6,7)	Flattest	High	49.0 cm / 72.6 cm	≤ 2 meters
Medium (Deciles 3,4,5,6,7)	Rolling	Medium	98.0 cm / 145 cm	≤ 3.5 meters
Medium (Deciles 3,4,5,6,7)	Hilly	Low	147 cm / 218 cm	≤ 5 meters
Low (Deciles 7,8,9,10)	All	Low	147 cm / 218 cm	≤ 5 meters

***Vertical Accuracy at 95% Confidence Level (FVA or NVA)/(CVA or VVA)**

Table 2.2 depicts the complete list of source elevation data and attributes leveraged for the Lower San Antonio Watershed BLE project. All datasets used for hydraulic analyses and mapping meet the highest specification level defined in Table 2.1. Further explanation of the Table 2.2 datasets can be referenced in Section 2.1.2.1.

Table 2.2: Source Topographic Data Available for the Lower San Antonio Watershed

Year	Description	Data Type	RMSE	Source/Owner
2018	2018 USGS South TX LiDAR (Aransas, Dewitt, Calhoun, Goliad, Karnes, Refugio, Victoria)	Airborne LiDAR	0.089	USGS
2018	2018 USGS South Central TX LiDAR (Bexar, Wilson)	Airborne LiDAR	5.6 cm	USGS
2017	2017 Stratmap LiDAR (Bexar, Wilson)	Airborne LiDAR	6.175 cm	TWDB
2016	2016 FEMA LiDAR (Dewitt)	Airborne LiDAR	0.071 m	FEMA
2013	2013 Stratmap LiDAR (Dewitt, Karnes, Wilson)	Airborne LiDAR	3.428 cm	TWDB
2011	2011 USGS LiDAR (Aransas, Calhoun)	Airborne LiDAR	0.057 m	USGS

Year	Description	Data Type	RMSE	Source/Owner
2011	2011 FEMA LiDAR (Guadalupe, Wilson)	Airborne LiDAR	4.08 cm	FEMA
2010	2010 Stratmap LiDAR (Atascosa, Wilson)	Airborne LiDAR	0.108m	TWDB
2009	2009 Stratmap LiDAR (Dewitt)	Airborne LiDAR	0.288 m	TWDB
2006	2006 FEMA LiDAR (Aransas)	Airborne LiDAR	13.88 cm	FEMA
2006	2006 FEMA LiDAR (Calhoun)	Airborne LiDAR	20.41 cm	FEMA

2.1.2.1 Lower San Antonio Watershed Source Terrain Data

The source elevation data for the Lower San Antonio Watershed are DEMs derived from USGS (2018 and 2011), TWDB (2017, 2013, 2010, and 2009) and FEMA (2016, 2011, and 2006) LiDAR data. Preprocessed Bare-earth, hydro-enforced DEMs from the acquiring entity (via TNRIS) were projected and adjusted as needed into one seamless DEM in Texas State Plane 4204 NAD83, Vertical Feet NAVD88. Bare-earth LIDAR data are typically made by filtering non-ground returns (e.g. buildings, vegetation, etc.) from the processed LiDAR returns. Please see brief descriptions of the lidar sources below.

2018 USGS South TX LiDAR, Aransas, Dewitt, Calhoun, Goliad, Karnes, Refugio, Victoria – The 2018 USGS LiDAR was acquired from January 2018 to February 2019 and was collected with a point spacing of 70 cm. The measured RMSE was documented at 0.089 Non-Vegetative Accuracy. The reported Z (vertical) Accuracy meets the 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA) and was assessed and reported following National Digital Elevation Program (NDEP)/ASRPS Guidelines.

2018 USGS South Central TX LiDAR, Bexar, Wilson – The 2018 USGS LiDAR was acquired in January 2018 and collected with a point spacing of 70 cm. The Non-Vegetated Vertical Accuracy (NVA) was reported as RMSEz = 5.6 cm, equating to +/- 10.9 cm at 95% confidence level which meets project accuracy specifications of the NSSDA.

2017 Stratmap LiDAR Bexar, Wilson, TX – The data for the 2017 Stratmap LiDAR was acquired from December 2016 to December 2017 and collected with a point spacing of 50 cm. The accuracy assessment results found 6.175 cm vertical accuracy at 95% confidence level in bare earth using RMSEz x 1.96 which meets project accuracy specifications.

2016 FEMA LiDAR, Dewitt, TX – The 2016 FEMA LiDAR was collected with a point spacing of 70 cm. The non-vegetated vertical accuracy (RMSE * 1.9600) was calculated at 0.233 feet (0.071) meters, which is well within the FEMA and USGS-NGP requirements of 0.196 meters.

2013 Stratmap LiDAR, Dewitt, Karnes, Wilson, TX – The data for the 2013 Stratmap LiDAR was acquired from April 2013 through October 2013 and collected with a point spacing of 50 cm. The bare earth vertical accuracy statistics results found 3.428 cm RMSEz which meets FEMA/NSSDA specifications.

2011 USGS LiDAR, Aransas, Calhoun, TX – The 2011 USGS LiDAR was acquired between December 2010 and February 2011 and collected with a point spacing of 150 cm. The Fundamental Vertical Accuracy (FVA) of the Classified Bare Earth files for the project area achieved an RMSE of 0.057 meters.

2011 FEMA LiDAR, Guadalupe, Wilson, TX – The 2011 FEMA LiDAR was acquired and processed from November 2010 to September 2011 and collected with a point spacing of 61 cm. Fundamental Vertical Accuracy (FVA) in open terrain was tested and reported at the 95% confidence level, computed as the root mean square error of the checkpoint elevations (RMSEz) x 1.9600 and found as 4.08 cm for open terrain.

2010 Stratmap LiDAR, Atascosa, Wilson, TX – The data for the 2010 Stratmap LiDAR was collected with a point spacing of 50 cm. The accuracy assessment results found the RMSE for the data is 0.108m with vertical accuracy at the 95% confidence level equals RMSEZ x 1.9600, which is under the specification of 0.185m.

2009 Stratmap LiDAR, Dewitt, TX – The data for the 2009 Stratmap LiDAR was collected with a point spacing of 1 m. The accuracy assessment for the flood/soils land cover category of the dataset (RMSE * 1.96) was calculated at 0.288 m.

2006 FEMA LiDAR, Aransas, TX– The data for the 2006 FEMA LiDAR in Aransas County was collected with a point spacing of 140 cm. The accuracy assessment yielded a RMSE of 13.88 cm, well within the 18.5 cm RMSE requirement in open areas.

2006 FEMA LiDAR, Calhoun, TX– The data for the 2006 FEMA LiDAR in Calhoun County was collected with a point spacing of 140 cm. The accuracy assessment yielded a RMSE of 20.41 cm in open areas. Please see report for notes and recommendations. This LiDAR affected minimal areas along the barrier islands and did not affect the overall quality of the study dem used in the BLE analysis.

2.1.3 Data Development Methodology

The source topographic data were processed for an area covering the Lower San Antonio Watershed and contributing drainage areas for the Lower San Antonio BLE modeling efforts. The topographic data for Lower San Antonio Watershed was projected horizontally, as needed, to North American Datum of 1983 (NAD83), State Plane Coordinate System (SPCS) Texas S Central in feet (4204-SPC83). All topographic data were adjusted vertically, as needed, to NAVD88 in feet. Halff used a combination of ArcGIS and other software tools to apply any vertical datum shifts and\or any horizontal projection transformations to the topographic data.

2.1.4 DEM QA/QC

DEMs developed for use in the Lower San Antonio Watershed BLE analysis were developed and independently assured to meet quality standards of the project. The data were developed using a controlled process, evaluated, and assured by a topographic data development team and were evaluated and assured by the engineering team. Quality assurance during the data development process includes, but is not limited to the following QC checks:

- Horizontal Projection Check
- Vertical Datum Check
- Resolution Check
- Format Check
- Seamless Data Check to ensure the DEM files are consistent and seamless along source data edges

The quality control after the development process by the DEM development team included visual observations using hillshade, contouring, color rendering, and/or other visual aids to review and identify potential impactful anomalies within the DEM surface. This QC step included, but were not limited to the following QC checks:

- Seamless Data Check to ensure no voids along the edges and between the prioritized datasets
- NoData Value Check to ensure no null values
- Manual Elevation Check using hillshade rasters to find erroneous elevation issues
- Unit Consistency Check
- Legacy Cell Value Anomalies

Quality assurance conducted after the seamless DEM development conducted by the engineering team included visual or automated assessments to identify potentially impactful anomalies or slope changes that may adversely impact hydraulic computations.

The final DEM data developed for the Lower San Antonio Watershed are assured to meet FEMA standards and present a representative surface developed from leveraged elevation data for the purposes of this BLE project.

2.2 2D BLE Methods

The following sections describe the 2D computational mesh and program setting considerations, followed by discussion and tabulation of hydrologic and hydraulic engineering methods and model inputs.

2.2.1 2D Computational Mesh and Settings

The HEC-RAS 2D computational mesh defines the extents of the 2D flow and can affect the accuracy of the 2D calculations. A denser mesh may provide more accurate results, but it can dramatically increase model run times. The 2D mesh for the model was set as evenly spaced cells at approximately 200 feet. The mesh was refined by placing breaklines along roads, berms, ridges, and other high ground that can impede flow as well as stream centerlines to allow flow conveyance.

To ensure all adjacent inflows into the Lower San Antonio Watershed were captured, a 1000-foot buffer was added to upper portion of the HUC boundary, and a 1-mile buffer was added to the lower portion of the HUC boundary. A smaller buffer was necessary in the upper portion to account for inflow from Cibolo HUC which runs through the middle of the upper portion of Lower San Antonio.

The HEC-RAS 2D computational mesh was created for the Lower San Antonio Watershed based on HUC boundaries using ArcGIS toolsets, such as smoothing and simplification routines; ultimately, significantly reducing the need for manual edits to mesh cells within HEC-RAS that happen to generate errors. The 2D mesh consists of 618,381 cells in the upper model and 747,772 cells in the lower model, with a 200-foot nominal mesh cell size. There are factors that could result in either larger or smaller cell sizes including proximity to the edge of the 2D mesh or the presence of breaklines. A 1-minute time step was used in the HEC-RAS model, applying the Diffusion Wave (simplified Full Momentum) equations.

2.2.2 Model and Boundary Condition Setup

Using HEC-RAS rain-on-grid modeling requires establishing a 2D computational mesh boundary, and often requires defining inflow boundary conditions in addition to excess precipitation applied to the mesh. For the Lower San Antonio basin, inflow hydrographs from Upper San Antonio and Cibolo HUCs were used, along with excess precipitation applied to the mesh. Figure 2.2 shows the 2D computational mesh for the Lower San Antonio basin, along with USGS peak streamflow gages pertinent to the study. Figure 2.3, Figure 2.4, and Figure 2.5 show the inflow boundary condition locations for the Upper San Antonio and Cibolo basins.

The development of the inflow hydrographs, and excess precipitation hyetographs for the 2D mesh, is described in Section 2.2.3.

Stage hydrographs representing a known water surface elevation were used for the boundary conditions along San Antonio Bay and Mesquite Bay. The remaining boundaries were defined as continuous boundaries to allow drainage from adjacent basins to leave the model area freely. Normal depth was used for non-unique outflow boundary conditions using approximate energy grade-line slopes estimated from the LiDAR terrain data.

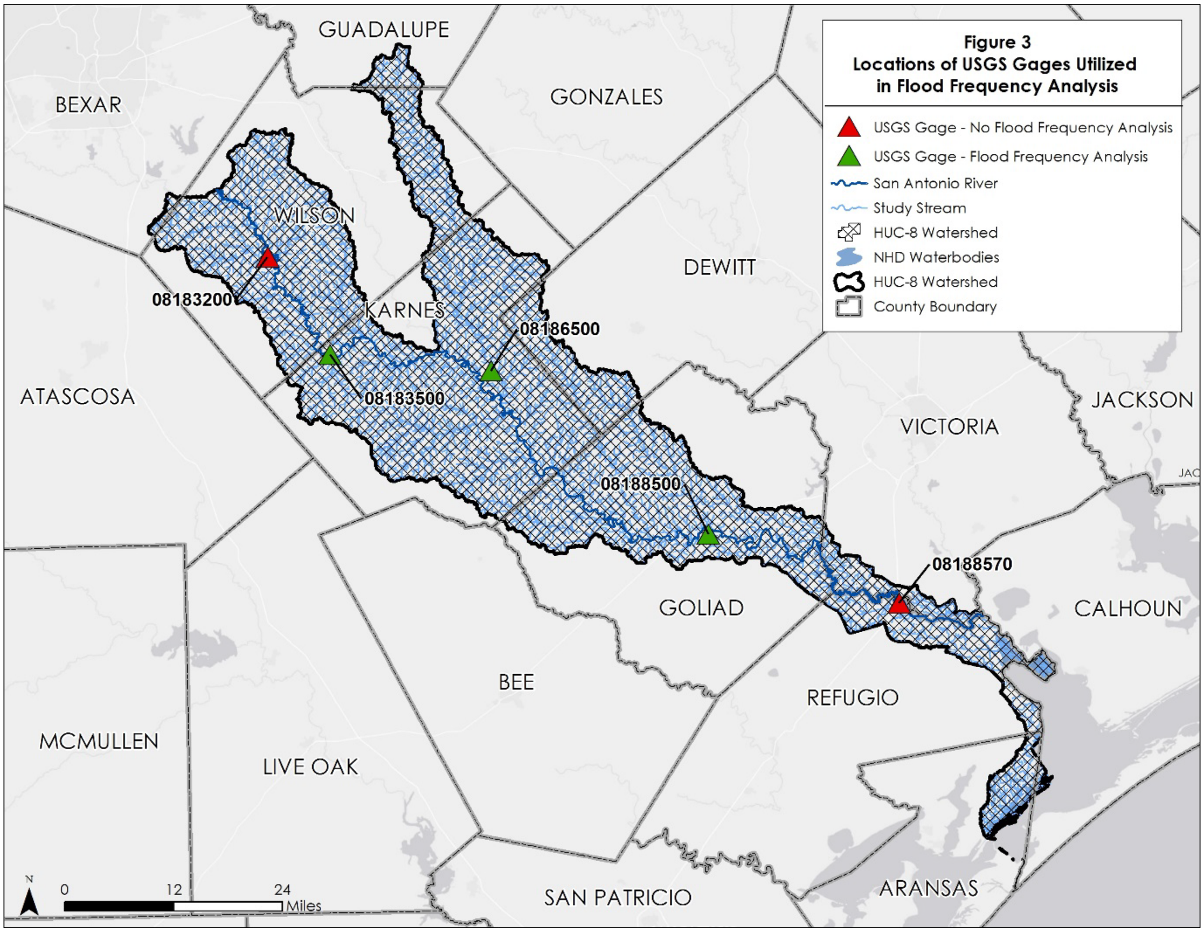

Figure 2.2: HEC-RAS 2D Computational Mesh and USGS Peak Streamflow Gages

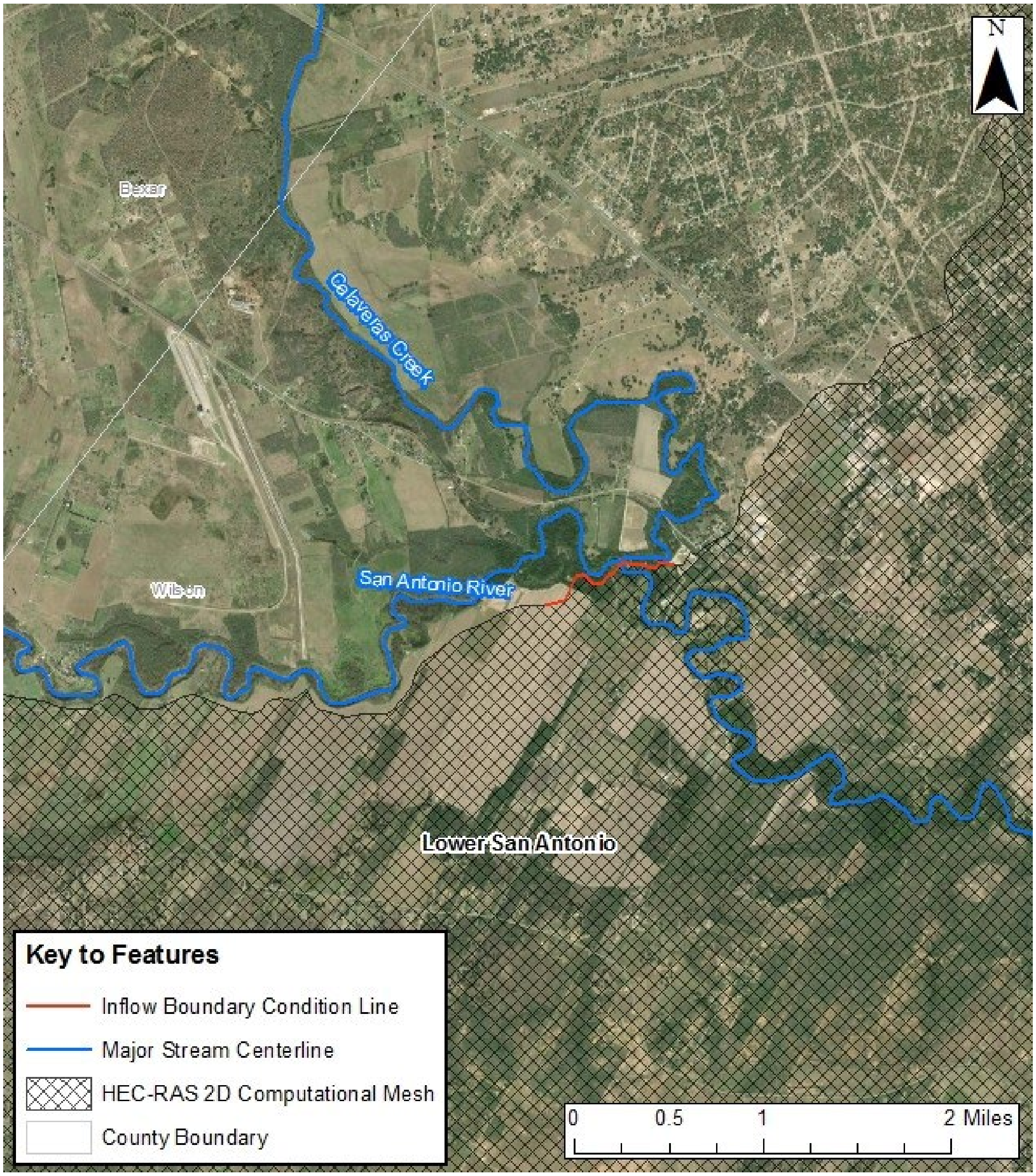

Figure 2.3: HEC-RAS 2D Computational Mesh and Inflow Boundary Conditions for Upper San Antonio HUC – San Antonio River

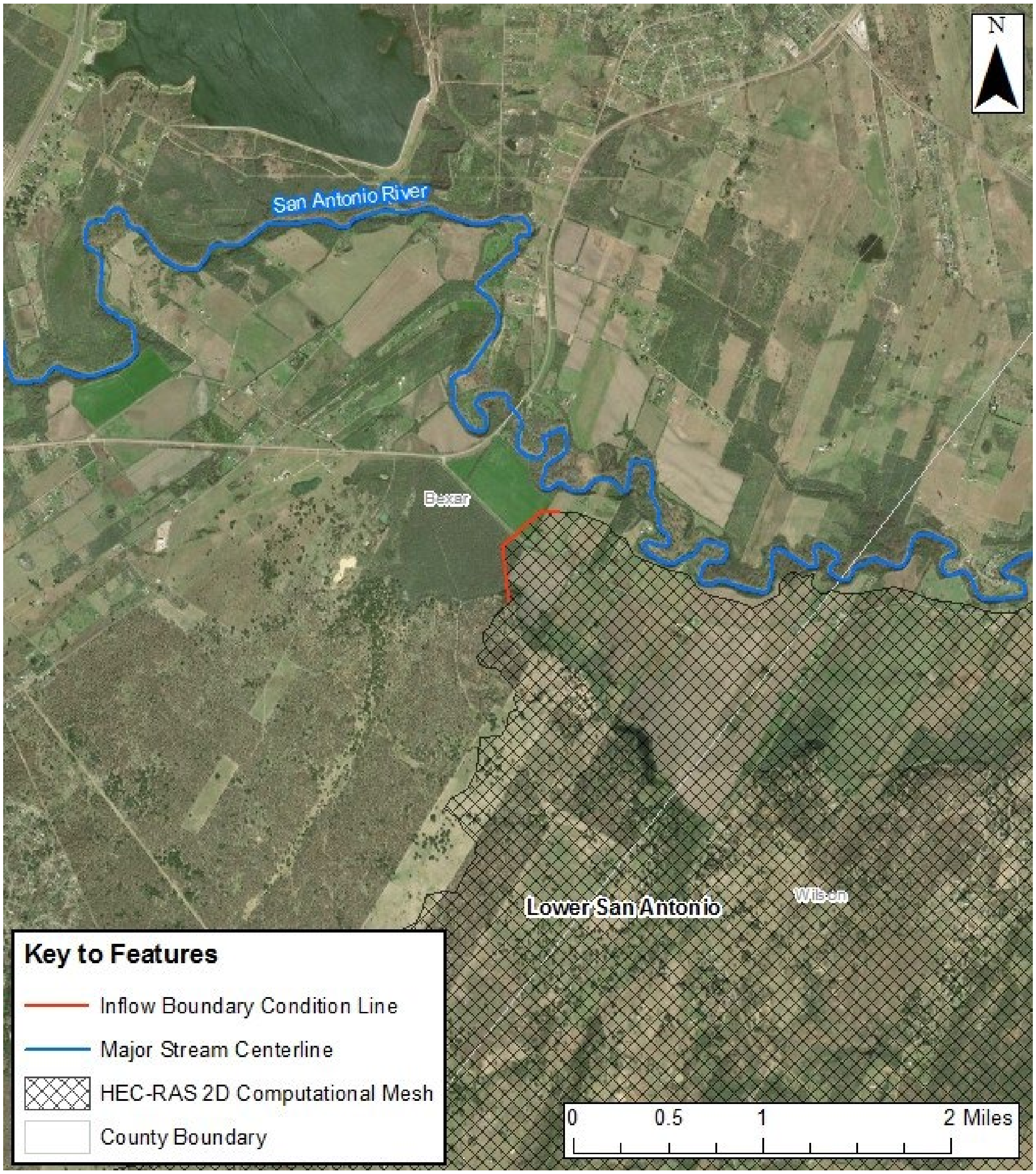

Figure 2.4: HEC-RAS 2D Computational Mesh and Inflow Boundary Conditions for Upper San Antonio HUC – San Antonio River Spill

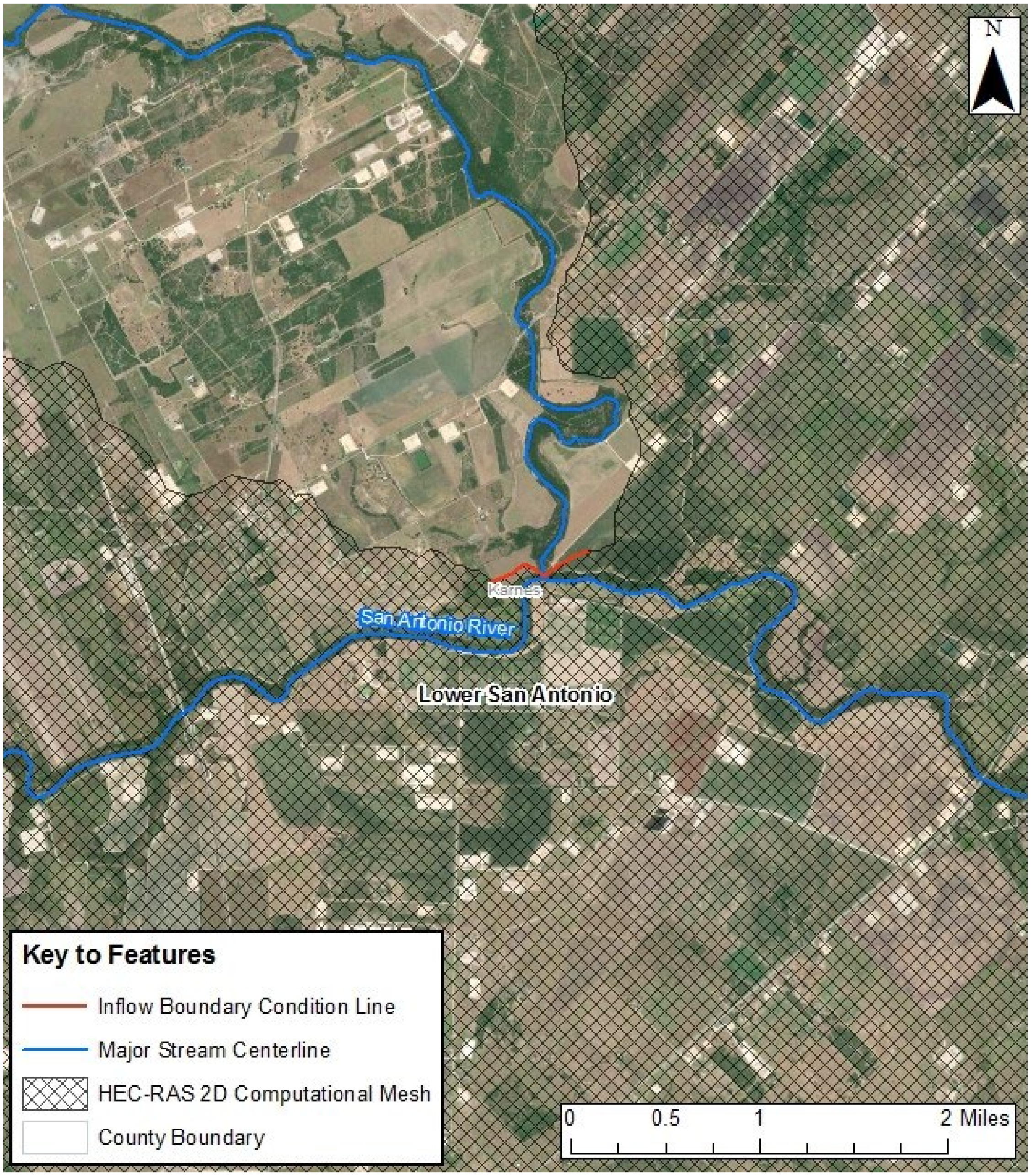

Figure 2.5: HEC-RAS 2D Computational Mesh and Inflow Boundary Conditions for Cibolo HUC – Cibolo Creek

2.2.3 Hydrology

HEC-HMS, Version 4.3, was used solely for the development of excess precipitation hyetographs which were applied to the 2D mesh. Precipitation frequency data published in NOAA Atlas 14, Volume 11 Version 2.0 (NOAA, 2018) were used for this study. These data were obtained from NOAA's Precipitation Frequency Data Server (PFDS) (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html). The 10-, 4-, 2-, 1-, and 0.2-percent annual chance 24-hour precipitation depths for the watershed were determined by area-weighted intersection of gridded PFDS data within the study area. Excess precipitation for the 2D mesh was developed as described in Section 2.2.3.1.

Inflow hydrograph boundary conditions to the 2D mesh were derived from upstream models for Upper San Antonio HUC and Cibolo HUC.

USGS streamflow gage data were leveraged to estimate peak flows for downstream gages within each work area for calibration purposes, as discussed in Section 2.3.1.1. The gages utilized for this study are presented in Table 2.3.

Table 2.3: USGS Peak Streamflow Gages

Gage ID	Flooding Source and Location	Published Drainage Area (mi^2)	Period of Record
08183500	San Antonio Rv nr Falls City, TX	2,113	1913-2020
08186500	Ecleto Ck nr Runge, TX	239	1903-2020
08188500	San Antonio Rv at Goliad, TX	3,921	1924-2020

Annual chance peak flows were calculated at each gage using USGS Bulletin 17B methodology. Calculated discharges for the 1%, 1% plus, and 1% minus events used for comparison of flow validation within the upper and lower confidence intervals are presented in Table 2.4 for each gage utilized in this study.

Table 2.4: USGS Peak Streamflow Gage Analysis Results

Gage ID	Flooding Source and Location	1% Peak Q (cfs)	1%- Peak Q (cfs)	1%+ Peak Q (cfs)
08183500	San Antonio Rv nr Falls City, TX	57,900	37,450	153,600
08186500	Ecleto Ck nr Runge, TX	34,740	21,480	66,960
08188500	San Antonio Rv at Goliad, TX	61,240	47,070	84,910

2.2.3.1 Excess Precipitation for 2D Computational Mesh

HEC-HMS, Version 4.3, was used to apply the SCS Curve Number method to calculate losses and define excess precipitation for the study watershed. Temporal distributions of point rainfall totals were defined using frequency storm distributions. The plus and minus standard error for the 1-percent annual chance precipitation depths were determined as the upper and lower 84% confidence limits on the nominal 1-percent depth, assuming a normal distribution of the logarithms for the precipitation depths.

In addition to recurrence interval precipitation estimates, NOAA Atlas 14 provides 90% confidence intervals of reported precipitation values. On a normal distribution curve, 90% confidence intervals (i.e.

the upper and lower 95% confidence limits) correspond to +/- 1.645 standard deviations. The 1% plus and minus events are defined to be one standard deviation above and below the 1% event.

Curve Numbers were computed by intersecting the National Land Cover Dataset (NLCD) 2016 coverage and NRCS soils data based on the matrix presented in Table 2.5.

Table 2.5: Land Use-Soils-CN Matrix for Computing Initial Curve Numbers

LU_GridCode	NLCD LU Description	Hydrologic Soil Group			
		A	B	C	D
11	Open Water	99	99	99	99
21	Developed Open Space	49	69	79	84
22	Developed Low Intensity	61	75	83	87
23	Developed Medium Intensity	81	88	91	93
24	Developed High Intensity	89	92	94	95
31	Barren Land	39	61	74	80
41	Deciduous Forest	30	55	70	77
42	Evergreen Forest	30	55	70	77
43	Mixed Forest	30	55	70	77
52	Shrub Scrub	30	48	65	73
71	Herbaceous	49	62	74	85
81	Hay Pasture	39	61	74	84
82	Cultivated Crops	51	67	76	80
90	Woody Wetlands	72	80	87	93
95	Emergent Herbaceous Wetlands	72	80	87	93

The time of concentration for the study area was approximated as the square root of the drainage area, then multiplied by 0.6 to compute the lag time. The lag time does not impact the excess rainfall hyetograph, so it was not necessary to compute a more accurate basin travel time. The table below shows the curve numbers and lag time values used in this study.

Table 2.6: Rainfall-Runoff Parameters (Curve Number, Lag Time)

Sub-basin Description	CN	Tlag (min)
Upper – Lower San Antonio	71	1,063
Lower – Lower San Antonio	70	940

NRCS rainfall-runoff methods were used to define excess precipitation applied to the 2D mesh, including curve numbers for defining rainfall losses and lag times for transforming the runoff temporally. No routing was considered in the rainfall-runoff modeling. Frequency storm distributions were used for defining temporal distributions of point rainfall totals. Areal reduction was applied using TP40 curves and an assumption of storm area equivalent to approximately one half of the total study area. Table 2.7 provides the precipitation totals used for determining excess precipitation.

Table 2.7: Precipitation Totals for HEC-RAS 2D Computational Mesh (post ARF)

Sub-basin Description	Percent Annual Chance Precipitation Total (in)						
	10	4	2	1	0.2	1% Minus	1% Plus
Upper – Lower San Antonio	5.70	7.33	8.74	10.38	15.12	8.24	13.76
Lower – Lower San Antonio	6.35	8.17	9.74	11.56	16.39	9.25	13.88

Figures 2.6 and 2.7 show the hyetographs applied to the 2D computational mesh.

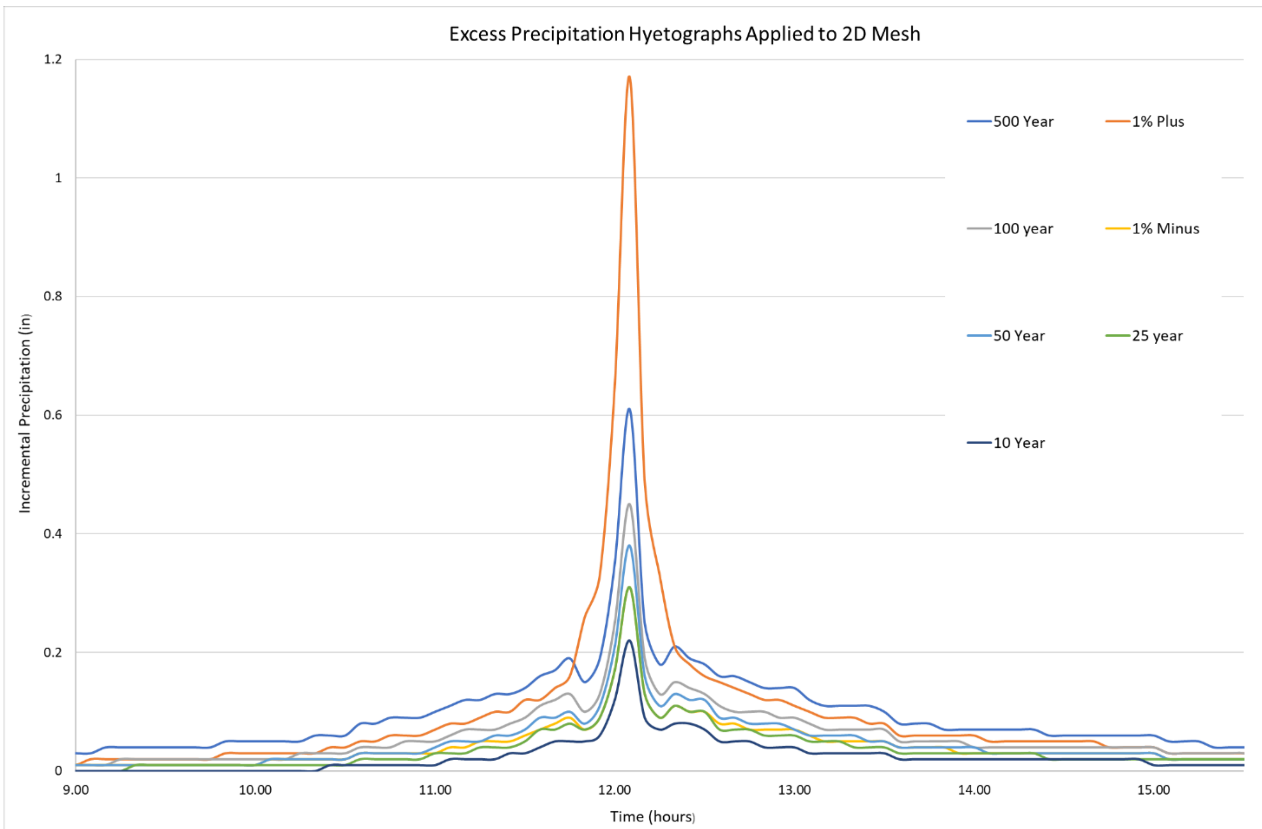

Figure 2.6: Precipitation Hyetographs (post ARF) Applied to the Computational Mesh in the Upper Portion of the HUC

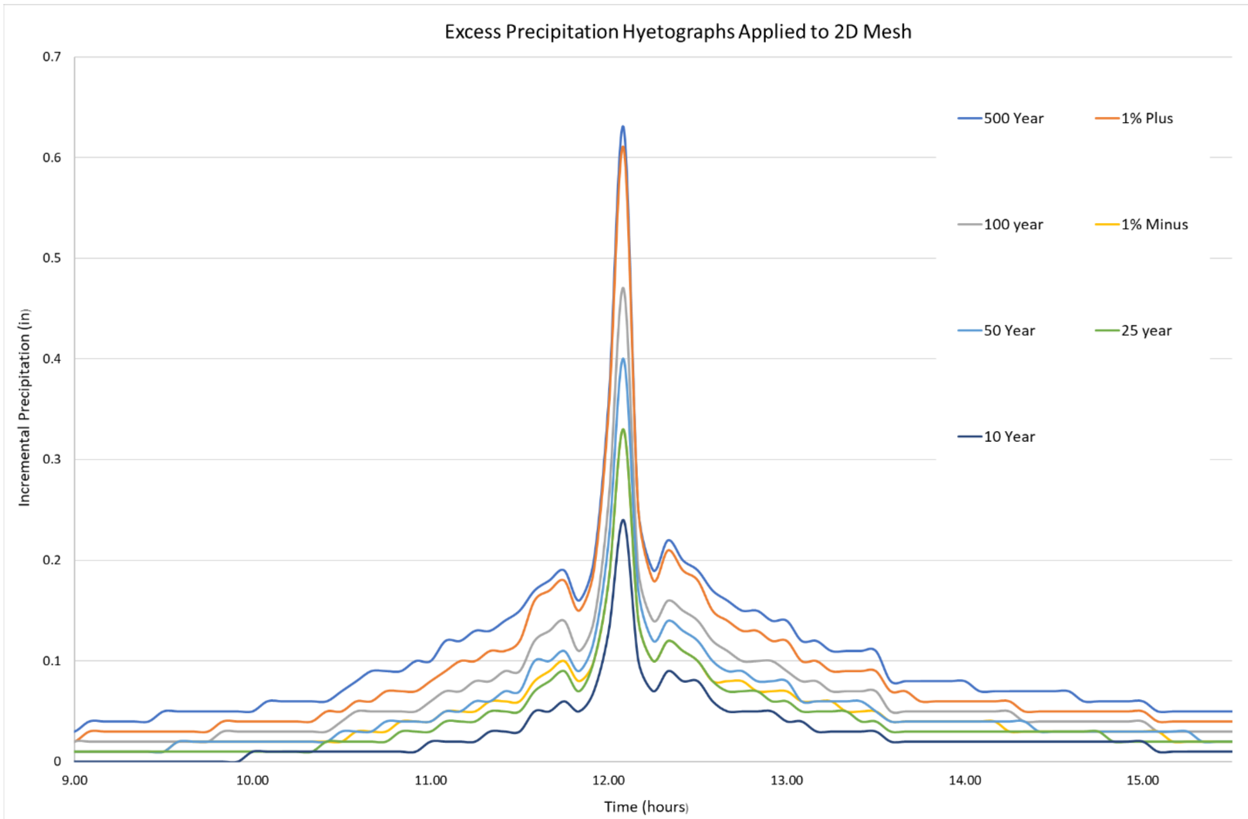

Figure 2.7: Precipitation Hyetographs (post ARF) Applied to the Computational Mesh in the Lower Portion of the HUC

2.2.3.2 Rainfall-Runoff Hydrograph Boundary Conditions

The Lower San Antonio models have additional contributing drainage area outside of the extents of the HUC boundary that was accounted for with the addition of inflow hydrographs, used as boundary conditions to the 2D computational mesh. The following figures show the inflow hydrographs for each contributing flooding source applied to the 2D computational mesh. Figures 2.8 and 2.9 include the Upper San Antonio drainage area contributing inflow hydrograph to Lower San Antonio. Figure 2.10 includes the Cibolo drainage area contributing inflow hydrograph Lower San Antonio.

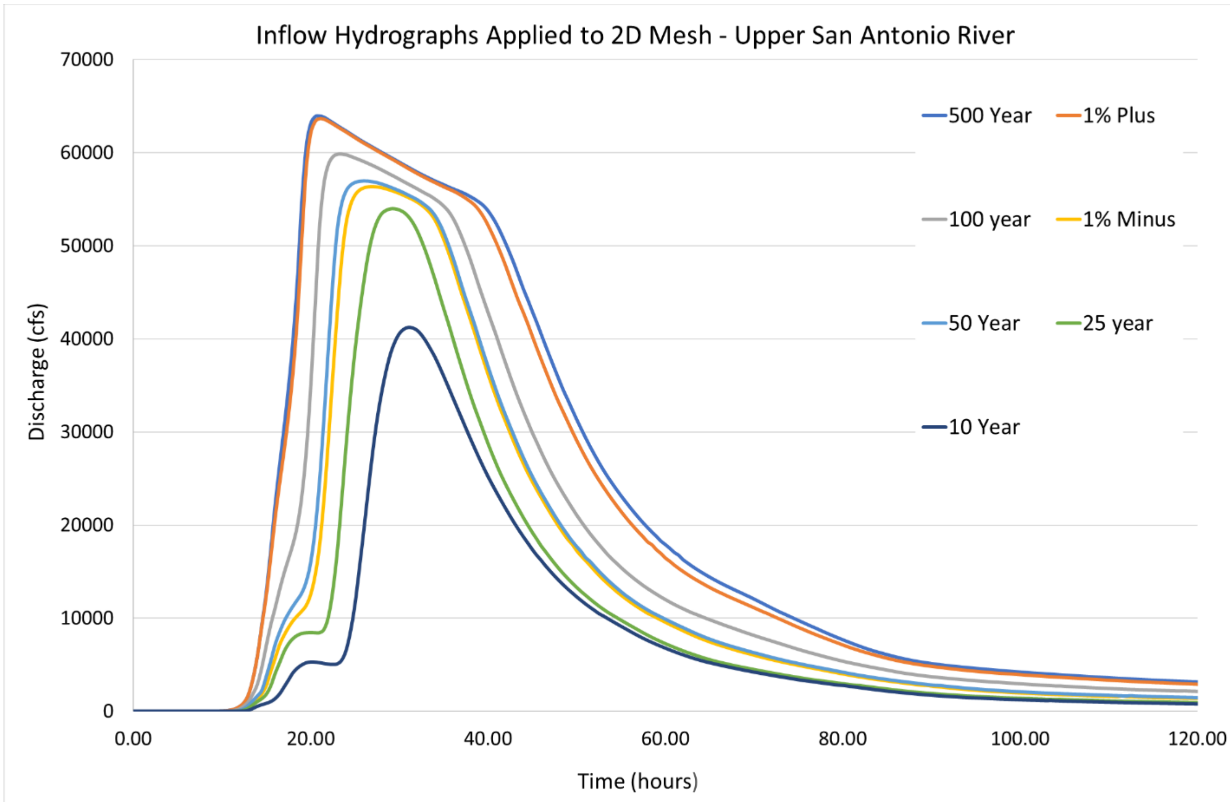

Figure 2.8: Upper San Antonio Basin – San Antonio River Contributing Drainage Area Inflow Hydrographs

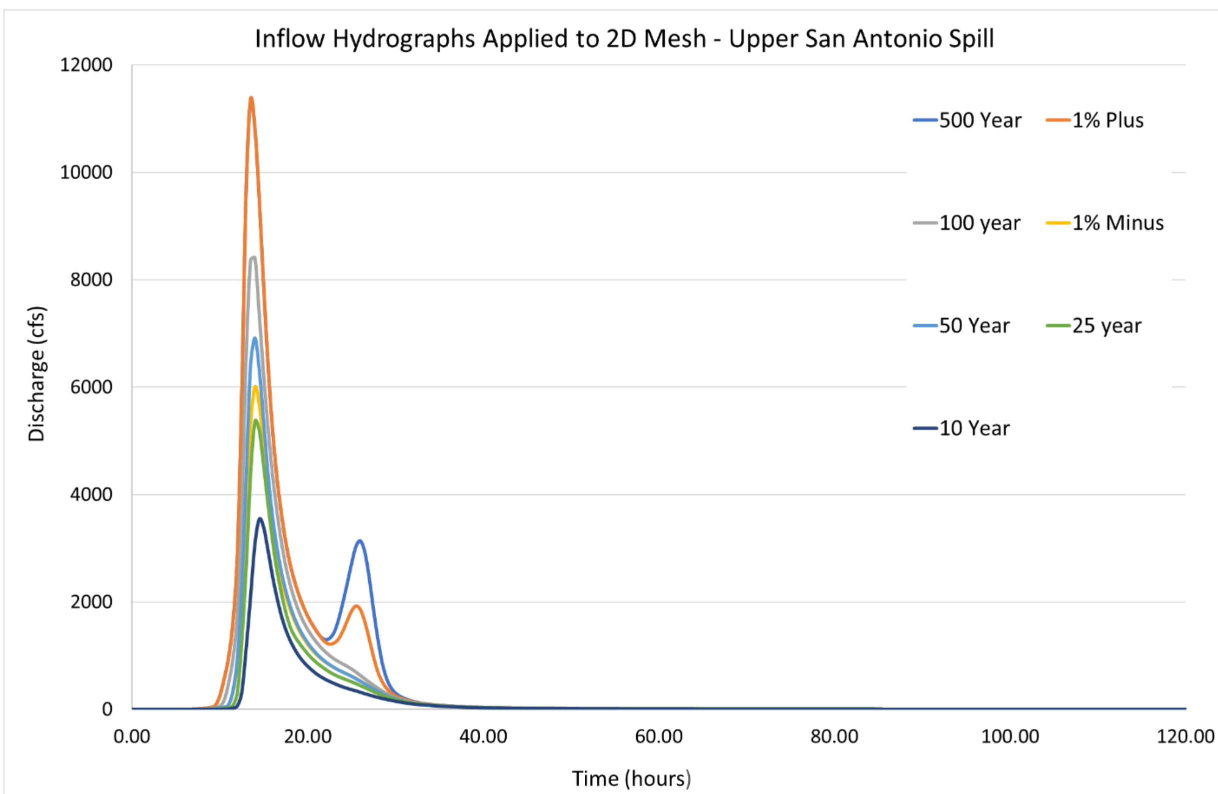

Figure 2.9: Upper San Antonio Basin – San Antonio River Spill Contributing Drainage Area Inflow Hydrographs

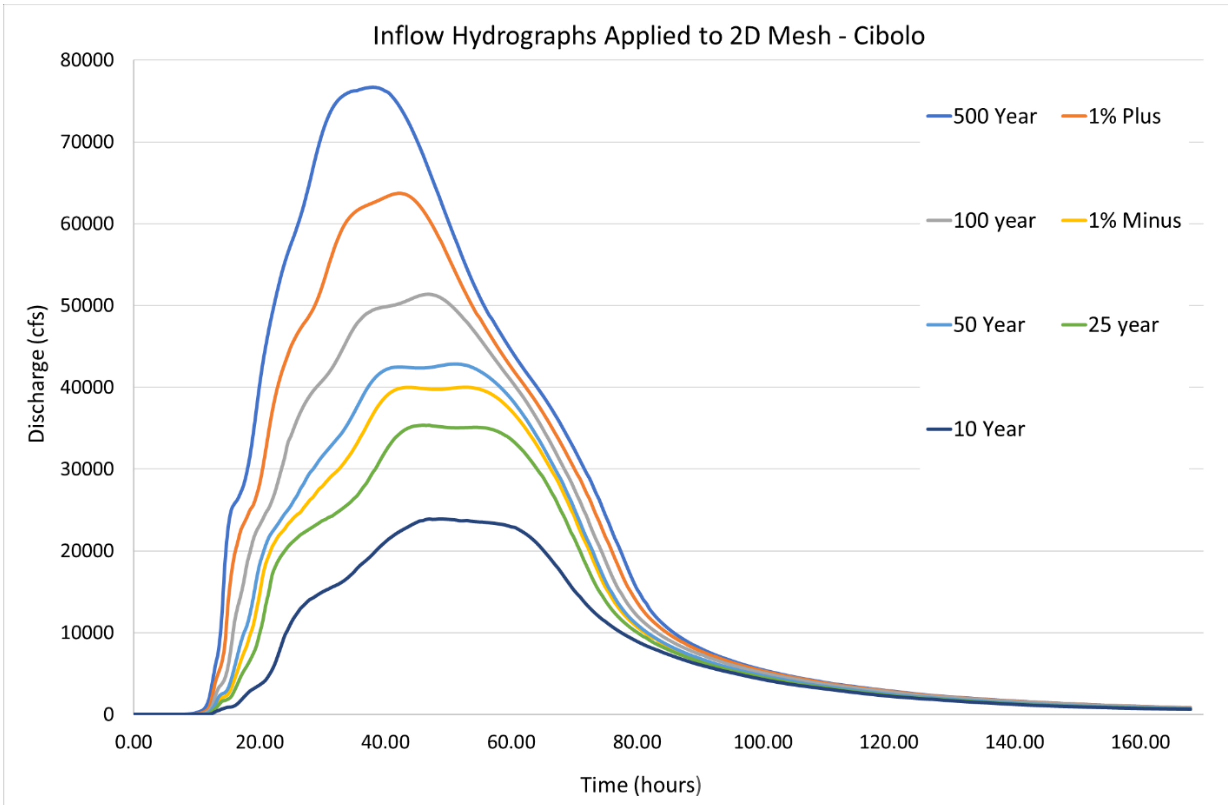

Figure 2.10: Cibolo Basin – Cibolo Creek Contributing Drainage Area Inflow Hydrographs

2.2.4 Hydraulics

This section describes the remaining hydraulic modeling considerations, including implementation of Manning's roughness, breaklines, and hydraulic structures within the 2D computational mesh.

2.2.4.1 Roughness Coefficients

A Manning's N roughness coverage was developed for the 2D computational mesh using typical values for roughness for given NLCD land classifications. A buffer zone was created around each stream centerline to create a main channel roughness zone. Different channel buffers were used for main stem channels and tributaries. The buffers used were 60 feet and 20 feet, respectively. A channel roughness value of 0.045, taken from the HEC-RAS User's Manual, was applied throughout the buffer to ensure that the 2D cells through the channel area had appropriate conveyance. The table below shows a typical land use-roughness matrix used in defining the roughness coverage for the study area.

Table 2.8: NLCD 2016-Manning's N Roughness Matrix

NLCD Classification	Manning's N	Minimum	Normal	Maximum	Source
Open Water	0.030	0.025	0.030	0.033	Chow 1959
Developed, Open Space	0.050	0.010	0.013	0.016	Calenda, et al. 2005
Developed, Low Intensity	0.070	0.038	0.050	0.063	Calenda, et al. 2005
Developed, Medium Intensity	0.100	0.056	0.075	0.094	Calenda, et al. 2005
Developed, High Intensity	0.120	0.075	0.100	0.125	Calenda, et al. 2005
Barren Land	0.050	0.025	0.030	0.035	Chow 1959
Deciduous Forest	0.100	0.100	0.120	0.160	Chow 1959
Evergreen Forest	0.100	0.100	0.120	0.160	Chow 1959
Mixed Forest	0.100	0.100	0.120	0.160	Chow 1959
Scrub/Shrub	0.070	0.035	0.050	0.070	Chow 1959
Grassland/Herbaceous	0.050	0.025	0.030	0.035	Chow 1959
Pasture/Hay	0.050	0.030	0.040	0.050	Chow 1959
Cultivated Crops	0.050	0.025	0.035	0.045	Chow 1959
Woody Wetlands	0.100	0.080	0.100	0.120	Chow 1959
Emergent Herbaceous Wetland	0.100	0.075	0.100	0.150	Chow 1959
Main Channel[1]	0.045				HEC-RAS User's Manual

[1] Clean, winding, some pools and shoals, some weeds and stones, lower stages, more ineffective slopes, and sections

2.2.4.2 Breaklines

Breaklines align grid cell faces and were used within the 2D mesh area to define prominent features including, road embankments and hydraulic structures as well as stream centerlines. Road embankments were identified in ArcGIS and imported into HEC-RAS as breaklines to ensure that water was not routed past roads until it was deep enough to overtop the road. Similarly, bridge/culvert crossings were modeled by burning channels through the embankment in the DEM to prevent unnecessary impoundment of water. This approach was used for most hydraulic structures because it could be implemented in ArcGIS on a large scale with much less effort than alternative methods.

Bridge/culvert crossings that were not processed out of the terrain data were modeled adding v-notches, u-notches, or offset breaklines adjacent to the road embankment to align grid cells around the embankment and allow water to be routed across the embankment without creating artificial backwater. An example of the offset breakline approach is shown below.

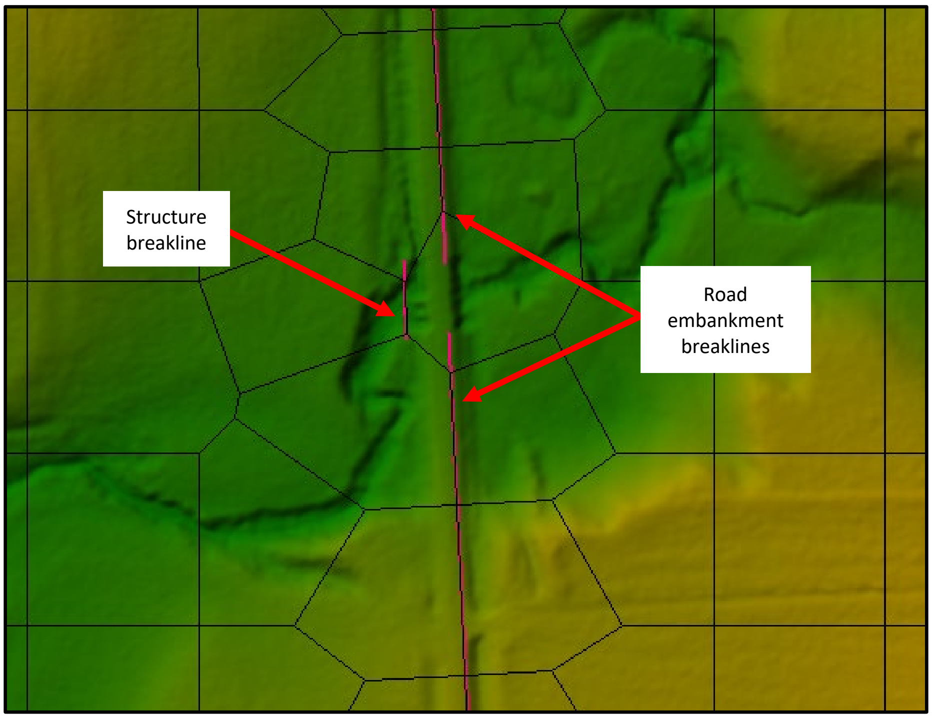

Figure 2.11 : Offset Breakline Approach at Bridge Crossing

County, interstate, common name, state recognized, and U.S. roads were incorporated for road breaklines from the ESRI North America Detailed Streets layer. Several private dams and embankments were added as breaklines to better represent flow patterns. The stream centerlines were input as breaklines to ensure cells lined up perpendicular to the stream and to capture stream conveyance. Stream centerlines were simplified to speed up editing and run times in HEC-RAS. Levees from the National Levee Inventory, railroads from the TIGER Railroads layer, and irrigation canals located from local water control districts, municipalities, and counties, were also incorporated.

2.2.4.3 Initial Conditions

Initial conditions were not used in the Lower San Antonio 2D BLE model.

2.2.5 Special Assumptions

Due to the large size of the Lower San Antonio HUC, the HUC8 was split into two RAS model representing the upper and lower portions of the study HUC. The models were split approximately 1,000 ft downstream of the San Antonio River – Ecleto Creek confluence. There were some differences in the upper and lower models such as buffer size and necessary boundary conditions, but computational parameters, nominal mesh cell size, and land use n-values remained constant between the two models. Figure 2.12 below shows the two model boundaries with respective buffers used in the RAS models.

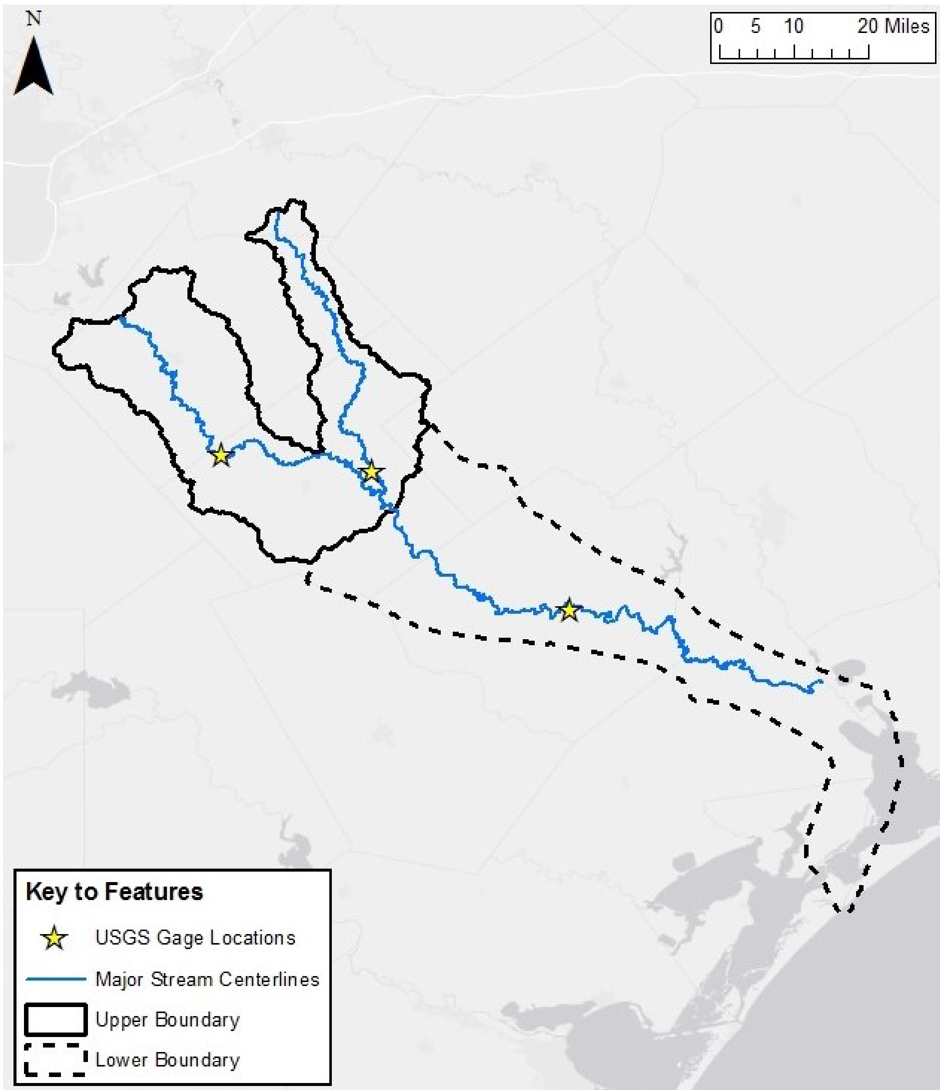

Figure 2.12 : Lower San Antonio Model Boundaries

The upper portion of the watershed received inflow from the Upper San Antonio Watershed and Cibolo Watershed. Initially, inflow was only modeled where the San Antonio River and Cibolo Creek enter the Lower San Antonio Watershed, respectively. After initial runs were completed, an area in the northwest part of the HUC was found to have flow spilling in from the Upper San Antonio Watershed at a different location. This inflow was added for subsequent runs.

2.3 Model Results

The 2D BLE results for the study produced flood risk mapping which compared reasonably well with the effective SFHA in most cases. The 2D BLE flood risk mapping extends the traditional SFHA due to the nature of the watershed wide approach of rain-on-mesh methodology. Additionally, the application of rain-on-mesh modeling allowed for the identification of localized flood risk beyond the extents of the traditional SFHA. Table 2.9 shows a comparison of some the effective BFE data with the model results. While the results provide context for flood risk communication as part of the Discovery process, and are scalable, the results require further analysis to be used for regulatory purposes. The validity of the 2D BLE results should be verified through community work map meetings before being applied to a regulatory product.

Table 2.9: Effective and Model BFE Comparison

Stream	Comparison Point Effective Station	Effective BFE (feet)	Model BFE (feet)	Difference (feet)
San Antonio River	1053473	412.81	412.22	-0.59
San Antonio River	1012160	398.94	399.16	0.22
San Antonio River	1004737	394.49	395.10	0.61
San Antonio River	995301	391.60	390.71	-0.89
San Antonio River	989914	389.65	388.87	-0.78
San Antonio River	978110	382.85	381.90	-0.95
San Antonio River	936091	369.70	369.77	0.07
San Antonio River	891006	345.83	344.97	-0.86
San Antonio River	853895	333.41	333.23	-0.18
San Antonio River	801718	308.55	307.48	-1.07
San Antonio River	784094	299.15	298.70	-0.45
San Antonio River	773149	291.64	291.53	-0.11
San Antonio River	732555	270.73	272.67	1.94
San Antonio River	699369	259.21	257.07	-2.14
San Antonio River	627153	231.18	223.73	-7.45
Ecleto Creek	42314	251.75	254.83	3.08
Ecleto Creek	10433	228.37	229.70	1.33
Escondido Creek	88870	321.00	322.82	1.82
Escondido Creek	68338	285.57	288.33	2.76
Escondido Creek	45534	257.23	258.94	1.71
Escondido Creek	16180	228.47	230.19	1.72
Marcelinas Creek	81369	365.40	366.70	1.30
Marcelinas Creek	57590	337.31	339.31	2.00
Marcelinas Creek	48189	324.76	326.50	1.74
Marcelinas Creek	23636	302.51	305.01	2.50
Poth Creek	39763	426.00	425.89	-0.11
Poth Creek	32033	390.27	388.51	-1.76
Poth Creek	15877	348.33	347.66	-0.67
East Branch	9789	442.27	440.51	-1.76
Stream 1	6722	384.28	380.89	-3.39

Stream	Comparison Point Effective Station	Effective BFE (feet)	Model BFE (feet)	Difference (feet)
Stream 2	2521	391.64	391.58	-0.06
Pajarito Creek	21982	415.47	415.22	-0.25
Lodi Branch	26733	466.81	465.82	-0.99
Lodi Branch	9222	399.04	401.93	2.89
San Antonio River	606096	229.76	225.17	-4.59
San Antonio River	582550	218.86	215.51	-3.36
San Antonio River	565140	212.09	207.89	-4.20
San Antonio River	543876	404.50	401.76	-2.74
San Antonio River	543876	404.50	401.76	-2.74
San Antonio River	531444	195.21	195.55	0.34
San Antonio River	515376	183.73	184.83	1.10
San Antonio River	495104	169.52	169.54	0.02
San Antonio River	467613	163.15	163.09	-0.06
San Antonio River	451901	156.13	155.54	-0.59
San Antonio River	414401	149.56	149.22	-0.34
San Antonio River	390524	147.62	147.77	0.15
San Antonio River	368707	143.67	142.45	-1.22
San Antonio River	358168	141.37	139.27	-2.10
San Antonio River	344580	135.32	132.00	-3.32
San Antonio River	331650	128.91	131.30	2.39
San Antonio River	302085	111.99	111.91	-0.08
San Antonio River	283276	103.85	104.54	0.69
San Antonio River	268702	100.14	100.51	0.37
San Antonio River	256803	93.48	96.46	2.98
San Antonio River	231398	81.62	85.79	4.17
Maddox Branch	13944	199.46	199.68	0.22
Maddox Branch	8989	154.52	157.16	2.64
Maddox Branch	5036	128.93	140.95	12.02
Maddox Branch	205	112.53	140.94	28.41
Ojo de Agua Creek	38016	306.94	309.87	2.93
Ojo de Agua Creek	37991	306.53	309.72	3.19
Ojo de Agua Creek	37924	306.40	309.44	3.04
Ojo de Agua Creek	16125	240.84	244.33	3.49
Ojo de Agua Creek	2518	206.83	223.29	16.46
Southwest City Drain	6682	186.30	186.48	0.18
Southwest City Drain	4721	143.09	145.87	2.78
Southwest City Drain	358	113.49	144.61	31.12
Sparrow Branch	10776	198.53	199.50	0.97
Sparrow Branch	6172	173.62	174.74	1.12
Sparrow Branch	163	111.54	144.48	32.94

2.3.1.1 Calibration & Sensitivity Analysis

Known USGS gages within the model area with more than 20-years of flow record were used for calibration and validation of the 1% annual chance event. Peak flows within the model were compared with Bulletin 17B Analyses and EMA Analyses of the gage data using PeakFQ, Version 7.2. Results of the flow comparisons are presented in Table 2.10.

Table 2.10: 1% Annual Chance Reasonability Comparisons

Flooding Source	USGS Gage Used for Verification	HEC-RAS 5.0.7 (2D)		Reference	
		WSEL (ft)	Discharge (cfs)	WSEL (ft) [1]	Discharge (cfs)
San Antonio River	08183500	318.97	58,840	321.69	57,900
Ecleto Creek	08186500	247.40	36,643	246.59	34,740
San Antonio River	08188500	142.59	82,092	143.36	61,240

[1] Water surface elevation is approximate based on PeakFQ input data and adjusted to NAVD 88 Datum.

To determine which factors were significantly impacting the model results, a sensitivity analysis was run to evaluate the impact of five parameters including Manning's roughness values, breaklines, hydrologic losses, initial conditions, and boundary conditions. Further discussion of the roughness coefficients can be found in Section 2.2.4.1. It was determined that enforced breaklines at major roads and centerlines were needed and are discussed further in Section 2.2.4.2. No changes were made to the precipitation. Table 2.11, Table 2.12 and Table 2.13 summarizes the results of each run at each of the USGS gages.

Table 2.11: Sensitivity Analysis Results at USGS Gage 08183500

Iteration	Manning's N Zones	Breaklines	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions	Peak Flow (cfs)	Peak Elevation (ft)
1	Original Land Use	None	Excess Precipitation	Dry / 1 min	Normal Depth	59,033	318.66
2[1]	Original Land Use	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	58,840	318.97
3	Land Use with Woody Wetland 0.12	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	62,404	319.10
4	Land Use with Woody Wetland 0.12 and Deciduous, Evergreen, Mixed Forest 0.16	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	62,397	319.07
5	Land Use with Woody Wetland 0.12, Emergent Herbaceous Wetland 0.15 and Deciduous, Evergreen, Mixed Forest 0.16	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	62,398	319.09

Iteration	Manning's N Zones	Breaklines	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions	Peak Flow (cfs)	Peak Elevation (ft)
6	Land Use with Woody Wetland 0.08, Emergent Herbaceous Wetland 0.075, and Pasture/Hay 0.04	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	59,367	318.80
					Gage Analysis:	57,900	321.69[2]

[1] Parameters from Iteration 2 were used for the final model, however additional computational mesh was implemented following the results of the sensitivity analysis.
[2] Water surface elevation is approximate based on PeakFQ input data.

Table 2.12: Sensitivity Analysis Results at USGS Gage 08186500

Iteration	Manning's N Zones	Breaklines	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions	Peak Flow (cfs)	Peak Elevation (ft)
1	Original Land Use	None	Excess Precipitation	Dry / 1 min	Normal Depth	43,608	246.83
2[1]	Original Land Use	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	36,643	247.40
3	Land Use with Woody Wetland 0.12	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	39,839	246.67
4	Land Use with Woody Wetland 0.12 and Deciduous, Evergreen, Mixed Forest 0.16	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	39,838	246.67
5	Land Use with Woody Wetland 0.12, Emergent Herbaceous Wetland 0.15 and Deciduous, Evergreen, Mixed Forest 0.16	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	39,838	246.68
6	Land Use with Woody Wetland 0.08, Emergent Herbaceous Wetland 0.075, and Hay/Pasture 0.04	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Normal Depth	40,242	246.98
					Gage Analysis:	34,740	246.59[2]

[1] Parameters from Iteration 2 were used for the final model, however additional computational mesh was implemented flowing the results of the sensitivity analysis.
[2] Water surface elevation is approximate based on PeakFQ input data.

Table 2.13: Sensitivity Analysis Results at USGS Gage 08188500

Iteration	Manning's N Zones	Breaklines	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions[1]	Peak Flow (cfs)	Peak Elevation (ft)
1	Original Land Use	None	Excess Precipitation	Dry / 1 min	Stage Hydrograph and Normal Depth	82,590	141.60
2[2]	Original Land Use	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Stage Hydrograph and Normal Depth	82,092	142.59
3	Land Use with Woody Wetland 0.08 (-.02), emergent wetland 0.075 (-0.025), Pasture/hay 0.04 (-0.01)	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Stage Hydrograph and Normal Depth	82,490	141.91
4	Land Use with Woody Wetland 0.12, Emergent Herbaceous Wetland 0.15 (+0.05) and Deciduous, Evergreen, Mixed Forest 0.16	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Stage Hydrograph and Normal Depth	81,152	144.38
5	Land Use with Woody Wetland 0.12 and Deciduous, Evergreen, Mixed Forest 0.16 (+.06)	Major Roads w/Centerlines Enforced - Simplified	Excess Precipitation	Dry / 1 min	Stage Hydrograph and Normal Depth	81,313	144.13

Iteration	Manning's N Zones	Breaklines	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions[1]	Peak Flow (cfs)	Peak Elevation (ft)
					Gage Analysis:	61,240	143.363

[1] Normal depth boundary conditions used except at outfalls to bays where stage hydrographs representing known water surface elevations were used.
[2] Parameters from Iteration 2 were used for the final model.
[3] Water surface elevation is approximate based on PeakFQ input data.

2.4 Challenges

Major challenges included a lack of peak streamflow records at the outlet, though sufficient data was available to provide confidence in the results. Please note that although the flows at USGS Gage 08188500 are approximately 20,000 cfs higher than the estimated Gage Analysis flow, it is also 20,000 cfs lower than the 100-year FIS values for the same location (104,690 cfs). Because of the large difference between the two comparison flows, they could not both be satisfied. As such, the final result, which is halfway between the FIS flows and the gage analysis flow, is considered an acceptable result.

Structures have not been added to the BLE model despite evidence of cross structures which allow the streams to convey water through numerous structures. In these locations, the model may be overestimating the water surface elevation upstream of the road until the road is overtopped and underestimating the water surface elevation downstream of the road.

HEC-RAS, Version 5.0.7 has a known error in the rain on mesh interpolation of flood depths between adjacent cells in the overbank area. This error produces artificially higher depths of flooding on the flood fringe referred to as cupping. Since this is a known issue in HEC-RAS and HEC is working on a solution, effort to remove these errors from the flood extents was not performed. Figure 2-13 below provides an example of cupping for reference. Once a solution is provided by HEC, it may be possible to update mapping to reduce and/or remove the cupping effects on the fringe of the floodplains.

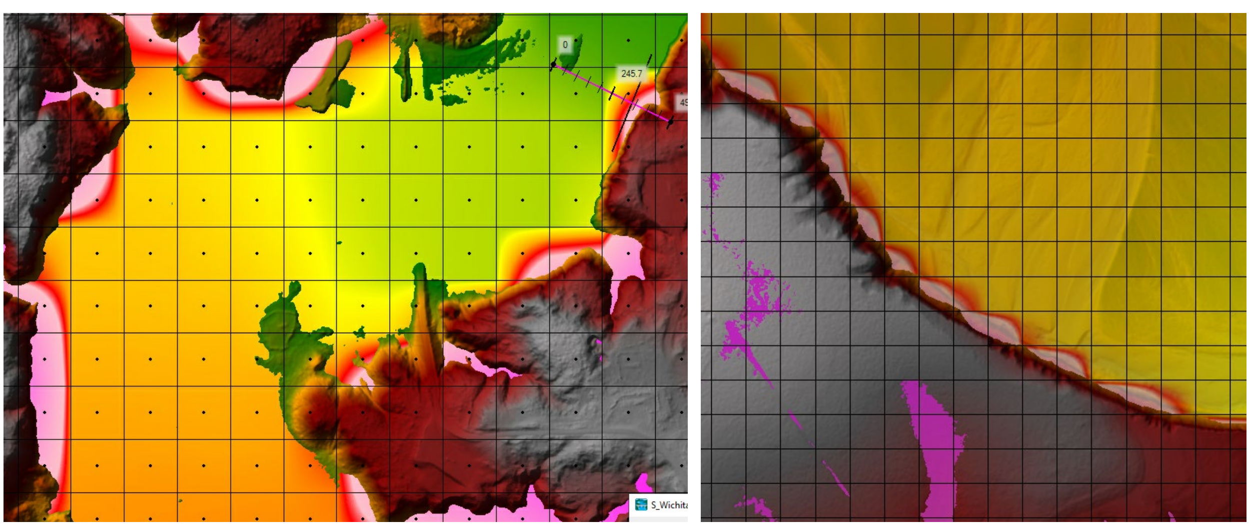

Figure 2-13: Cupping Examples

2.5 Recommendations

This study provides significant information useful for flood identification and communication among those affected. The study is highly scalable, and stakeholder input and further analysis would enhance the product and inform implementation of regulatory flood hazard areas. In addition, the validity of the 2D BLE results should be verified through community work map meetings before being applied as a regulatory product.

03 Floodplain Mapping and Effective Zone A Validation

The following sections provide a synopsis of how raw modeled depths were translated into SFHAs. In addition to developing a new SFHA, the BLE model data was leveraged to validate the effective zone A studies within the project footprint. The results of the validation effort can be found below in section 3.2.

3.1 Special Flood Hazard Area

3.1.1 Model Outputs

The floodplains are derived from the raw modeled depth grids using the maximum value. These depth grids are exported from HEC-RAS as TIFF format rasters with an interpolated rendering that slope values at the center and along the faces/edges of the computational mesh cells. Using GIS, the TIFF rasters are post processed into 1% SFHA and 0.2% shaded X polygons.

3.1.2 Methodology

The use of 2D modeling methods results in water surface elevation values at every cell in the model's computational mesh. In order to represent the desired model results and eliminate extraneous disconnected cells, post processing of the depth grids is required. For the purposes of the Lower San Antonio BLE study, floodplain mapping delineation was completed using connected raster cells at the extent of the CNMS mapped and unmapped features in the project footprint. Converting the raster data to polygon features enabled an intersection of modeled results to the CNMS and effective zones to create the SFHA and 0.2-percent shaded X features. Because the new mapping, based on gridded engineering, retains the blocky shape of a raster, a simplification process was applied using GIS to smooth the boundaries. These processes remove unnecessary points, bends, and angles while preserving the natural shape of the polygon. Furthermore, small voids, or "holes" inside of the floodplain footprint were aggregated with the larger surrounding polygons to merge them and make the floodplain complete. In alignment with the TWDB's 2D BLE Guidelines (May 2022) floodplain polygons were cleaned against the criteria provided below in Table 3.1 which provides thresholds for mapping removal based on depth and area of flood risk.

Table 3.1: Mapping Threshold Matrix

Area (ac)	Depth (ft)
< 0.33	-
0.33 - 0.5	< 0.33
0.5 - 1.0	< 0.25
1.0 - 2.0	<0.1

For example, if flooding polygons were disconnected from a flooding source and less than two acres in area and 0.1 feet of depth, the polygon was removed from the SFHA. These edits align to the mapping standards adopted by the TWDB and those required by FEMA.

In addition to the SFHA, all other flooding associated with the 1- and 0.2-percent raw results were retained as "on the shelf" data that may be leveraged for future needs and analysis. This information is available in the included Supplemental Data associated with this study.

3.1.3 Flood Hazard Area Layer

Special Flood Hazard Areas, as noted above, were developed to the extent of the CNMS features or up to 1 square mile drainage area and effective zone A study locations. The Regional CNMS database, National

Flood Hazard Layer, and paper inventory were used as reference data to ensure extent of the BLE results represents appropriate flooding extent.

The 0.2% flood areas were produced using the same methods as the 1% SFHA. After both layers were developed, a union of the two products was performed to develop the deliverable format EBFE_FLD_HAZ_AR.

3.2 Validation of Effective Zone A SFHA

The following summarizes the results of the CNMS validation assessments for the effective Zone A studies in the Lower San Antonio Watershed.

3.2.1 Initial Assessment A1 – Significant Topography Update Check

The significant topography update check determines whether a topographic data source is available that is significantly better than what was used for the effective Zone A modeling and mapping. For this study area, the best available lidar data was used. Recent quality lidar provided coverage for the entire study area, therefore this check is set to PASS.

3.2.2 Initial Assessment A2 – Check for Significant Hydrology Changes

The significant hydrology changes check determines whether new regression equations have become available from the USGS since the date of the effective Zone A study. If newer regression equations exist for the area of interest, then an engineer must determine whether these regression equations would significantly affect the 1-percent-annual-chance flow. Due to the size of the watershed, some sections of the project area are model back while others were not (previously). This element was set to PASS / FAIL for all reaches within the study area.

3.2.3 Initial Assessment A3 – Check for Significant Development

The significant development check, using the National Urban Change Indicator (NUCI) dataset, assesses increased urbanization in the watershed of the BLE. If the percentage of urban area within the HUC-12 watershed containing the effective Zone A study is 15 percent or more and has increased by 50 percent or more since the effective analysis, the study would fail this check. The check for significant development in the watershed was completed by evaluating percentage of urban change at the HUC-12 level. The majority of this watershed is classified as rural with same pockets of suburban development. All reaches were set to PASS this assessment after a spatial analysis.

Table 3.2 presents the summarized results of checks A1 through A3.

Table 3.2: A1-A3 Validation Results

Assessment Checks	Pass / Fail	Notes
A1 – Topography	Pass	LiDAR significantly better than effective USGS topo source/Effective mapping leveraged LiDAR data.
A2 – Hydrology	Pass	Effective hydrology methods are unknown
A3- Development	Pass/Fail	Less than 15% of study area is under urban cover/>50% increase in urban area in an urban HUC-12

3.2.4 Validation Check A4 – Check of Studies Backed by Technical Data

Zone A studies that pass all initial assessment checks described above may be categorized as "Valid" in the CNMS Inventory only if the effective Zone A study is supported by modeling or sound engineering judgment and all regulatory products are in agreement. If the effective Zone A study passes all initial assessment checks, but is not supported by modeling, or if the original engineering method used is unsupported or undocumented, a comparison of the BLE results and effective Zone A's is performed. While this 2D analysis is backed by technical data, some of the original modeling is lacking documentation. This watershed has varied PASS and FAIL reaches.

3.2.5 Validation Check A5 – Comparison of BLE and Effective Zone A

The effective Zone A comparison was performed at the full extent of the Lower San Antonio Watershed. The validation of the effective Zone A boundaries using 2D flood hazard products differ from the standard 1D methods due to the lack of cross sections and their use with standard FBS methodology. A test point was created around the perimeter of the floodplain area every 100'.

For each test point, a 75-foot buffer was created. Using this buffer, the minimum and maximum values of the DEM were extracted, as a proxy for the effective base flood elevation. The minimum value of the 1% minus raster, and the maximum value of the 1% plus raster are also extracted. These 1% plus maximum and 1% minus minimum values are products of the new 2D BLE study and act as the vertical tolerance. The test point passes if the DEM maximum value is less than or equal to the 1% plus maximum value and the DEM minimum value is greater than or equal to the 1% minus minimum value. This can be visualized as a short 75-foot radius cylinder, with a height of 1% plus maximum – 1% minus minimum. This test verifies that at least one point from the ground surface (i.e. proxy BFE) falls both vertically and horizontally within this range.

3.2.6 Validation Results

All 3,700 total miles of available CNMS features representing the effective Zone A studies were categorized as shown in Table 3.3, 3.4 and illustrated in Figure 3.1. Table 3.4 summarizes the validation results based on the individual HUC 12 watersheds within the Lower San Antonio watershed.

Table 3.3: Aggregated Zone A Validation Results

Validation Status	Status Type	Total Miles
ASSESSED	BEING STUDIED	2,212
UNKNOWN	BEING STUDIED	169
UNVERIFIED	BEING STUDIED	899
UNVERIFIED	TO BE STUDIED	348
VALID	BEING ASSESSED	40
VALID	BEING STUDIED	102

Table 3.4: HUC 12 Zone A Validation Results

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	Pass/Fail
Watershed Name	Watershed Number					
All	**All Streams**	**2,196,308**	**3,099**	**2,193,209**	**100%**	**Pass**
Cadena Creek-San Antonio River	121003030604	63,933	31	63,902	**100%**	Pass
Camp Ranch-San Antonio River	121003030105	38,840	50	38,790	**100%**	Pass
Charco Creek-San Antonio River	121003030503	29,594	13	29,581	**100%**	Pass
Chicken Creek	121003030502	16,110	9	16,101	**100%**	Pass
Conquista Creek	121003030201	45,606	94	45,512	**100%**	Pass
Doe Branch-Escondido Creek	121003030402	68,201	259	67,942	**100%**	Pass
Dry Ecleto Creek-Ecleto Creek	121003030304	106,034	172	105,862	**100%**	Pass
Escondido Creek-San Antonio River	121003030403	45,670	98	45,572	**100%**	Pass
Guadalupe River-South Guadalupe River	121003030608	53,745	36	53,709	**100%**	Pass
Headwaters Ecleto Creek	121003030301	74,592	98	74,494	**100%**	Pass
Headwaters Escondido Creek	121003030401	67,626	130	67,496	**100%**	Pass
Hines Lake-San Antonio River	121003030607	31,663	27	31,636	**100%**	Pass
Hondo Creek	121003030405	46,414	66	46,348	**100%**	Pass
Hord Creek	121003030504	43,603	47	43,556	**100%**	Pass
Hynes Bay-San Antonio Bay	121004040000	182,166	298	181,868	**100%**	Pass
Kicaster Creek	121003030102	52,924	36	52,888	**100%**	Pass
Lake Slough-San Antonio River	121003030205	82,290	158	82,132	**100%**	Pass
Lookout Hill-San Antonio River	121003030206	70,074	162	69,912	**100%**	Pass
Lott Lake-San Antonio River	121003030606	36,754	23	36,731	**100%**	Pass
Lower Cabeza Creek	121003030507	28,429	15	28,414	**100%**	Pass
Lower Manahuilla Creek	121003030603	51,831	28	51,803	**100%**	Pass

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	Pass/Fail
Watershed Name	Watershed Number					
Lower Marcelinas Creek	121003030204	66,358	86	66,272	**100%**	Pass
McTennel Creek-Ecleto Creek	121003030305	52,141	57	52,084	**100%**	Pass
Middle Manahuilla Creek	121003030602	41,865	16	41,849	**100%**	Pass
Ojo de Agua Creek-San Antonio River	121003030404	39,871	170	39,701	**100%**	Pass
Olmos Creek	121003030106	21,836	38	21,798	**100%**	Pass
Pajarito Creek-San Antonio River	121003030103	67,070	122	66,948	**100%**	Pass
Picosa Creek	121003030104	79,482	96	79,386	**100%**	Pass
Porter Oil Field-San Antonio River	121003030501	22,074	8	22,066	**100%**	Pass
Portis Draw-San Antonio River	121003030605	49,867	26	49,841	**100%**	Pass
Pridgeon Creek-Ecleto Creek	121003030303	79,080	90	78,990	**100%**	Pass
Salt Creek-Ecleto Creek	121003030306	44,150	49	44,101	**100%**	Pass
Sandpit Creek-San Antonio River	121003030101	77,174	186	76,988	**100%**	Pass
Scared Dog Creek-San Antonio River	121003030202	85,678	122	85,556	**100%**	Pass
Steel Branch-Ecleto Creek	121003030302	74,808	80	74,728	**100%**	Pass
Town of Riverdale-San Antonio River	121003030505	18,140	7	18,133	**100%**	Pass
Upper Cabeza Creek	121003030506	47,459	40	47,419	**100%**	Pass
Upper Manahuilla Creek	121003030601	31,058	16	31,042	**100%**	Pass
Upper Marcelinas Creek	121003030203	62,098	40	62,058	**100%**	Pass

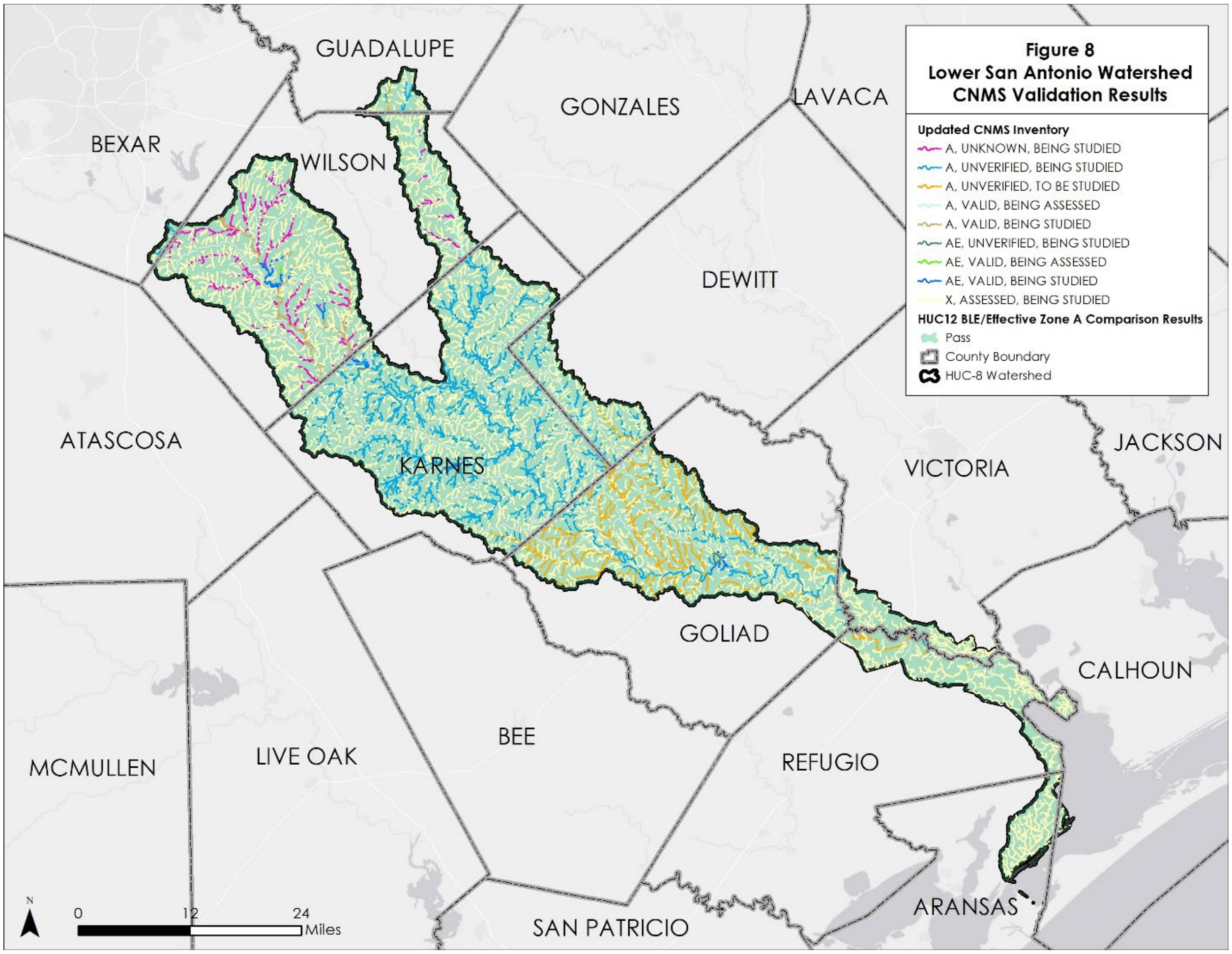

Figure 3.1: Lower San Antonio Watershed CNMS Validation Results

3.3 Flood Risk Analysis

A flood risk analysis was performed for this project. The updated 1-percent annual chance depth grid was used to calculate the potential flood losses. The loss results are stored in the S_FRAC_AR spatial file within the FRD geodatabase. All results are reported in whole dollar values.

Hazus version 4.2 (SP02) was used for the basic and refined loss analysis.

The losses are reported via census blocks. It is important to note that Hazus version 4.2 (SP02) uses dasymetric census blocks. Dasymetric mapping removes undeveloped areas (such as areas covered by other bodies of water, wetlands, or forests) from the census blocks, changing their shape and reducing their size in these areas. For more information on dasymetric data visit FEMA's Media Library for the Hazus-MH Data Inventories: Dasymetric vs. Homogenous, or Hazus 3.0 Dasymetric Data Overview.

Hazus analysis was performed by county within the project watershed extends for each return period to ensure proper model processing. A summary of results per county for the 100-year scenarios are shown in Table 3.5.

Table 3.5: Hazus 4.2 (SP02) Results for 1-percent-annual-chance (100 year) scenario for Lower San Antonio Watershed, Texas (in 1000s)

County	Full Replacement – Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Aransas	1,766	5,681	4,804
Bexar	621	5,471	2,966
DeWitt	1,720	70,491	42,121
Goliad	54,577	470,167	281,416
Guadalupe	5,052	66,855	39,308
Karnes	152,951	1,160,236	728,177
Refugio	29,303	112,683	77,725
Victoria	2,337	13,452	8,685
Wilson	166,806	2,431,376	1,352,831
Total	**415,133**	**4,336,412**	**2,538,033**

04 References

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