San Fernando Watershed, Texas 2D Base Level Engineering Methods and Results

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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 labeled 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 automated techniques to produce estimates of flood hazard boundaries for multiple recurrence intervals. The San Fernando Watershed BLE documented here was designed to use 2-dimensional (2D) modeling efforts with enhancements and calibration to develop products intended to be transitioned into regulatory data development workflows.

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 Coordinated Needs Management Strategy (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 Identification (SID) #29 requires that during Discovery, data must be identified that illustrates potential changes in flood elevation and mapping which 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 should not only be used for CNMS evaluations of Zone A studies but can also be leveraged throughout the Risk MAP program. The large volume of data resulting from a BLE 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.

FEMA Region VI (Region) contracted Compass to perform a BLE analysis for the San Fernando HUC-8 Watershed (12110204) in South Texas to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHA). This report documents the BLE process, products, and results for this watershed. **Figure 1** depicts the San Fernando Watershed footprint in parts of Duval, Jim Wells, Nueces, and Kleberg counties.

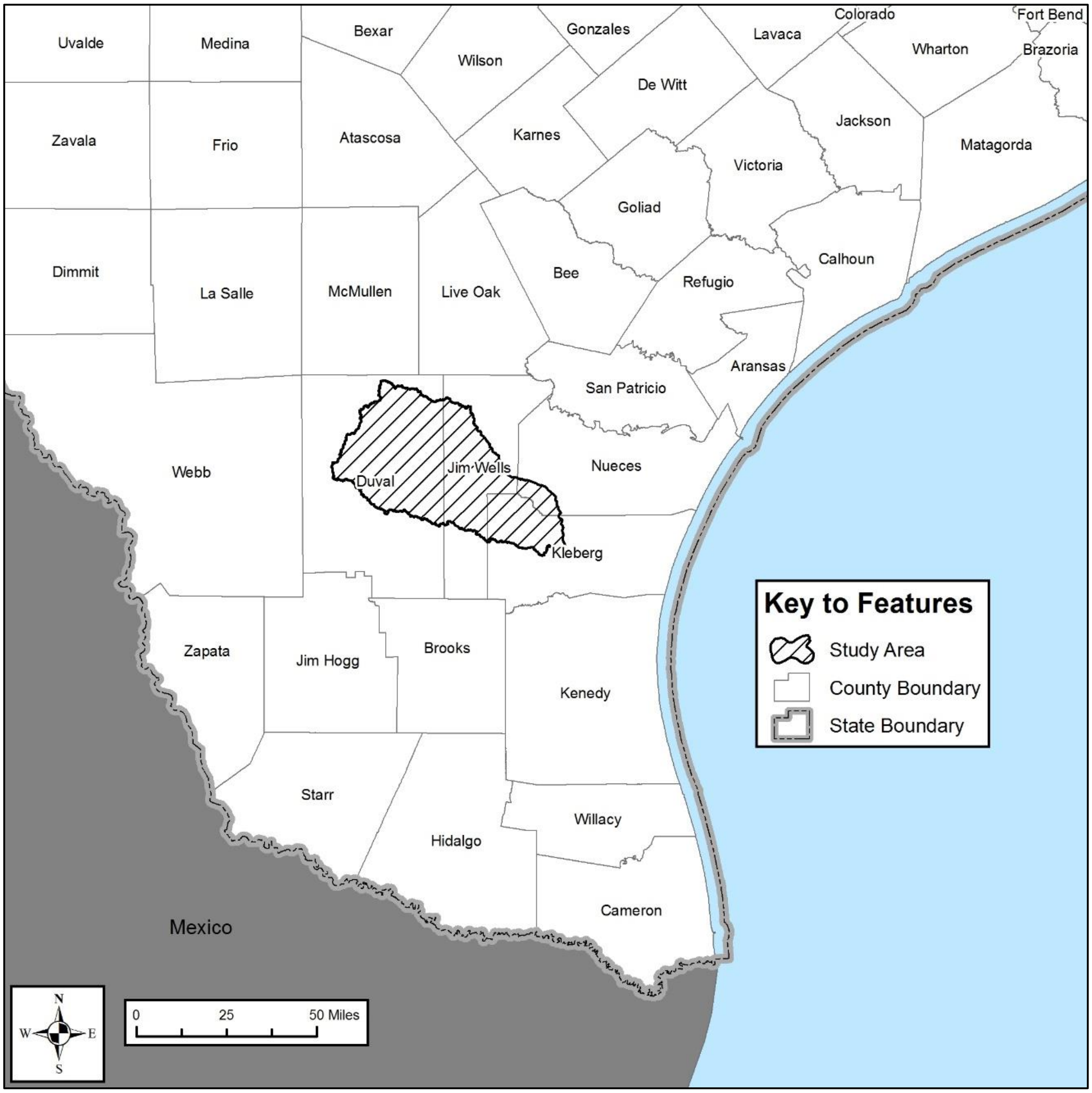

Figure 1: San Fernando Watershed

02 2D BLE Modeling Inputs and Controls

Section 2 presents fundamental components required to execute a 2-dimensional (2D) hydraulic engineering analysis for the San Fernando Watershed. Inputs such as elevation data, hydrology from 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 these Texas 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 San Fernando 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 San Fernando Watershed, was executed using the following steps:

1. Available elevation data for the project area were inventoried and collected and listed in **Table 2**.
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 detailed in 2.1.4.

Documentation regarding leveraged data including coverage, accuracy, acquisition dates, and source contact/agency are presented in the figures, tables, and text within Section 2.1. 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 San Fernando Watershed.

2.1.1 Inventory

An inventory of existing topographic data was conducted for the San Fernando BLE project footprint.

Figure 2 depicts the datasets identified for leveraged 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.

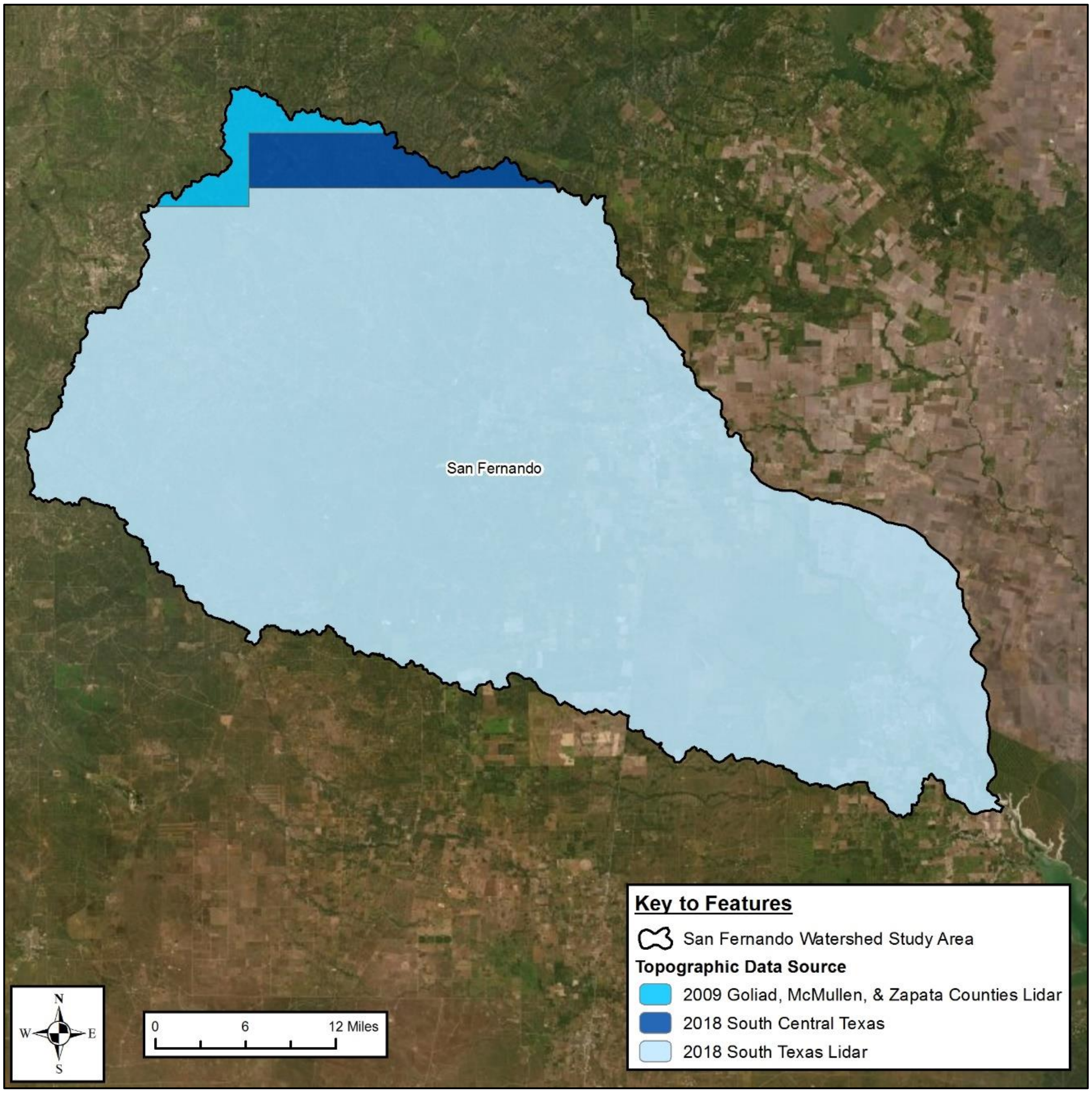

Figure 2: San Fernando Watershed BLE Source Terrain Data

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 1**)
- Date of origination
- Data density and coverage

Table 1 depicts the Risk Map SID 43 vertical accuracy requirements based on flood risk and terrain slope within the floodplain being mapped.

Table 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 depicts the complete list of source elevation data and attributes leveraged for the San Fernando Watershed BLE project. All datasets used for hydraulic analyses and mapping meet the highest specification level defined in **Table 1**. Further explanation of the **Table 2** datasets can be referenced in section 2.1.2.1.

Table 2: Source Topographic Data Available for the San Fernando Watershed

Year	Description	Data Type	RMSE	Source/Owner
2009	2009 TNRIS LiDAR – Goliad, McMullen, and Zapata Counties, Texas	Airborne LiDAR	11.5 cm	TNRIS
2018	2018 USGS South Central Texas LiDAR	Airborne LiDAR	5.9 cm	USGS
2018	2018 USGS South Texas LiDAR	Airborne LiDAR	10 cm	USGS

2.1.2.1 San Fernando Watershed Source Terrain Data

The source elevation data for the San Fernando Watershed are DEMs derived from the 2009 TNRIS LiDAR – Goliad, McMullen, and Zapata Counties, Texas, 2018 USGS South Central Texas LiDAR, and 2018 USGS South Texas LiDAR. Only points classified as “ground” points (i.e., bare earth) were imported from the LiDAR and used for development of the project DEMs. Bare-earth LIDAR data are typically made by filtering non-ground returns (e.g. buildings, vegetation, etc.) from the raw laser returns. Figure 2 depicts the extent of the data defined in **Table 2**. The 2009 TNRIS LiDAR was collected with a nominal pulse spacing of 1 meter. The data was tested to meet 22.5 cm vertical accuracy at 95% confidence level (RMSE * 1.96). The 2018 USGS South Central Texas LiDAR was collected with a nominal pulse spacing of 0.7 meters. The data was tested to meet 11.6 cm vertical accuracy at 95% confidence level (RMSE * 1.96). The 2018 USGS South Texas LiDAR was collected with a nominal pulse spacing of 0.7 meters. The data was tested to meet 19.6 cm vertical accuracy at 95% confidence level (RMSE * 1.96).

2.1.3 Data Development Methodology

The source topographic data were processed for an area covering the San Fernando Watershed and contributing drainage areas for the San Fernando BLE modeling efforts. The topographic data for San Fernando Watershed was projected horizontally, as needed, to North American Datum of 1983 (NAD83), State Plane Coordinate System (SPCS) Texas South in feet (4205). All topographic data were adjusted vertically, as needed, to NAVD88 in feet. Compass 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 San Fernando Watershed BLE analysis were developed and independent assured to meet quality standards of the project. The data were developed using a controlled process, were 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

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 was accomplished through quality control checks 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.

The final DEM data developed for the San Fernando 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 computation times. The 2D mesh for the model was set as evenly spaced cells at 200 feet. The mesh was further refined by placing breaklines along roads, berms, ridges, and other high ground that can influence the flow.

To ensure the entire San Fernando Watershed was represented, an initial 1,000-foot buffer extension was added to the HUC boundary for the model mesh limits. Further refinements of the mesh included incorporating portions of Baffin Bay and Lower Nueces watersheds in order to better capture several interactions between the adjacent watersheds.

After initial mapping review, it was decided the San Fernando watershed and its neighboring HUC8, Baffin Bay, would be better modeled with an updated Mesh border. To simplify the cross-border interactions and inflow areas between the two HUC8 watersheds, the San Fernando 2D mesh was split and the eastern portion merged with the Baffin Bay model, with the western portion being modeled independently. This can be seen in **Figure 3**, with the updated San Fernando mesh in light grey and Baffin Bay East model in dark grey. For more information on the Baffin Bay model and decisions to split that HUC8 into an east and west section for modeling purposes, refer to the *Baffin Bay Watershed, Texas 2D Base Level Engineering Methods and Results* report.

The HEC-RAS 2D computational mesh was created for San Fernando 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 for San Fernando consists of around 495,000 cells and 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 30-second time step was used in the HEC-RAS model, applying the Diffusion Wave (simplified Full Momentum) equations. This timestep was selected to improve unstable courant values that were present at higher timestep intervals.

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 San Fernando basin, three inflow hydrographs from the Baffin Bay East model were used, and excess precipitation applied to the mesh. **Figure 3** shows the 2D computational mesh for the San Fernando basin along with the neighboring Baffin Bay East mesh. **Figure 4** shows the inflow boundary condition locations for the San Fernando basin. **Figure 5** shows the outflow hydrograph locations for San Fernando to Baffin Bay West.

The development of the inflow hydrograph, and excess precipitation hyetographs for the 2D mesh, are described in the following Section 2.2.3.

Outflow boundary conditions (from the computational 2D mesh) were utilized along basin boundaries along with inflow boundary hydrographs. For the outflow into Baffin Bay, unique outflow boundaries were established for obvious riverine outflows, while the remaining boundaries were defined as continuous boundaries to allow drainage from adjacent basins to leave the model area freely. The free flow outfall allows for water along boundaries to be tracked to determine if significant flow is leaving the studied watershed. Without boundary conditions the mesh boundary can act as a wall, forcing water to build up artificially. Normal depth was used for all non-unique outflow boundary conditions using approximate energy grade-line slopes estimated from the LiDAR terrain data.

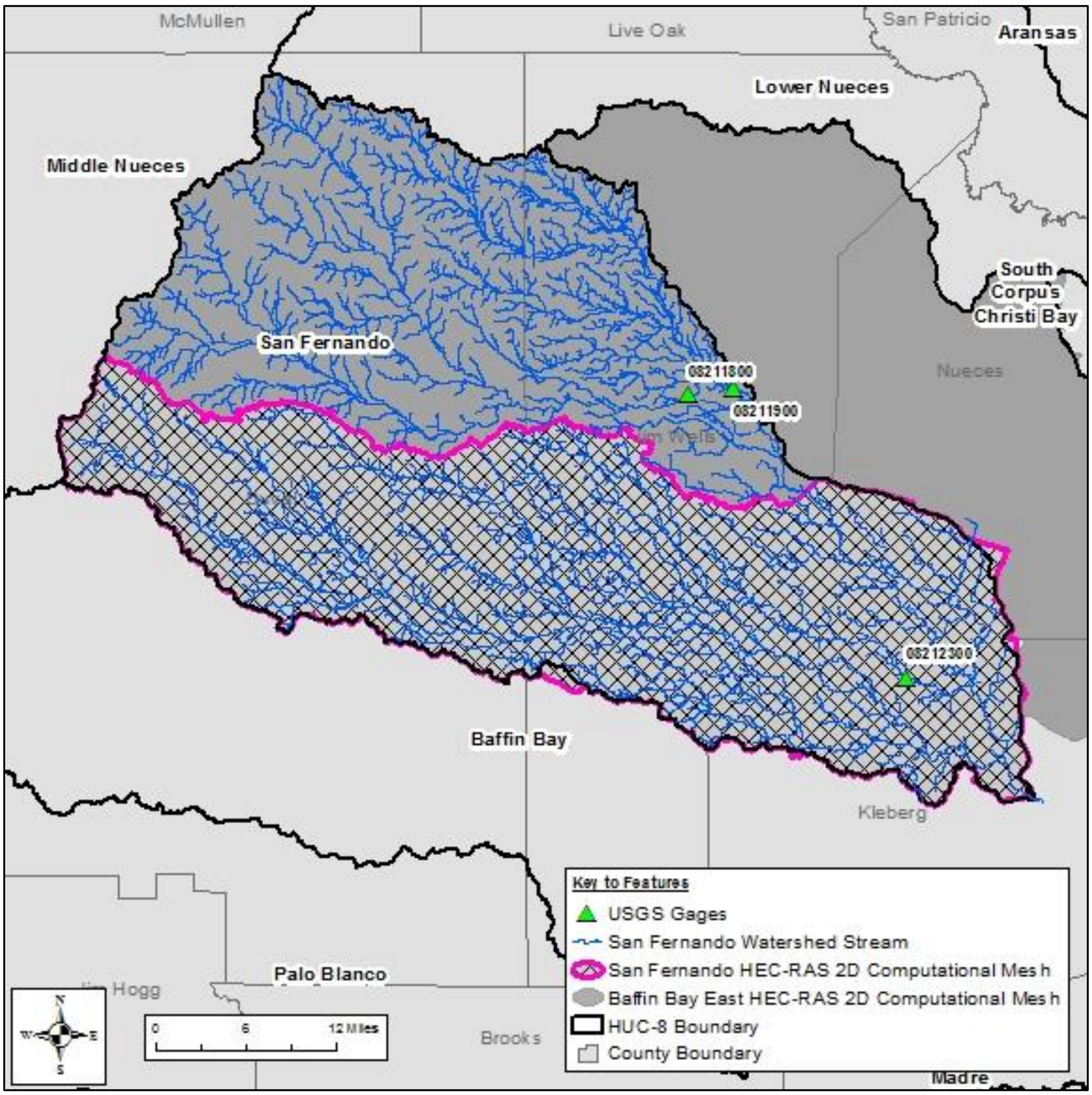

Figure 3: HEC-RAS 2D Computational Mesh and USGS Peak Streamflow Gages

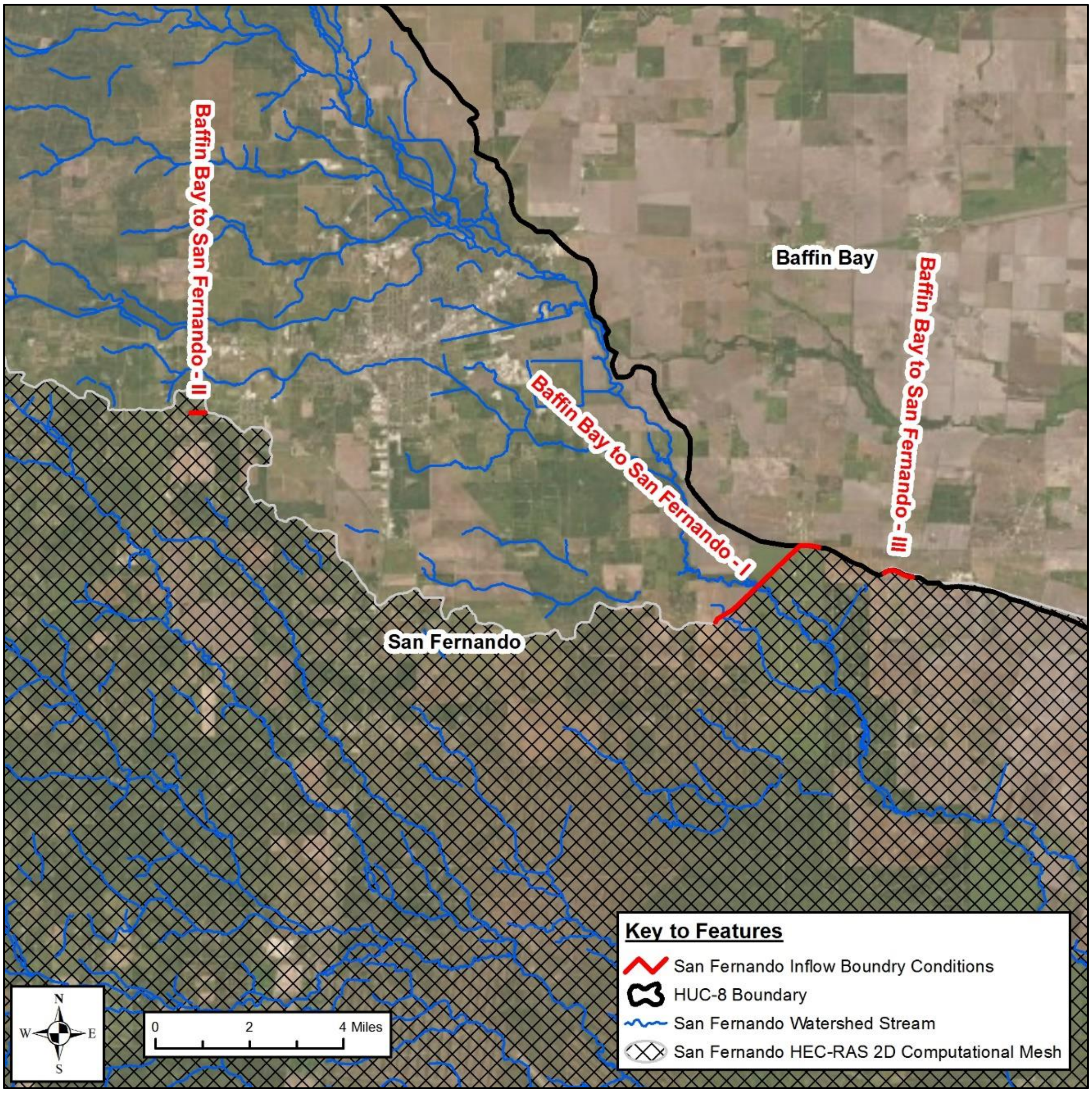

Figure 4: HEC-RAS 2D Computational Mesh and Inflow Boundary Conditions for San Fernando from Baffin Bay East

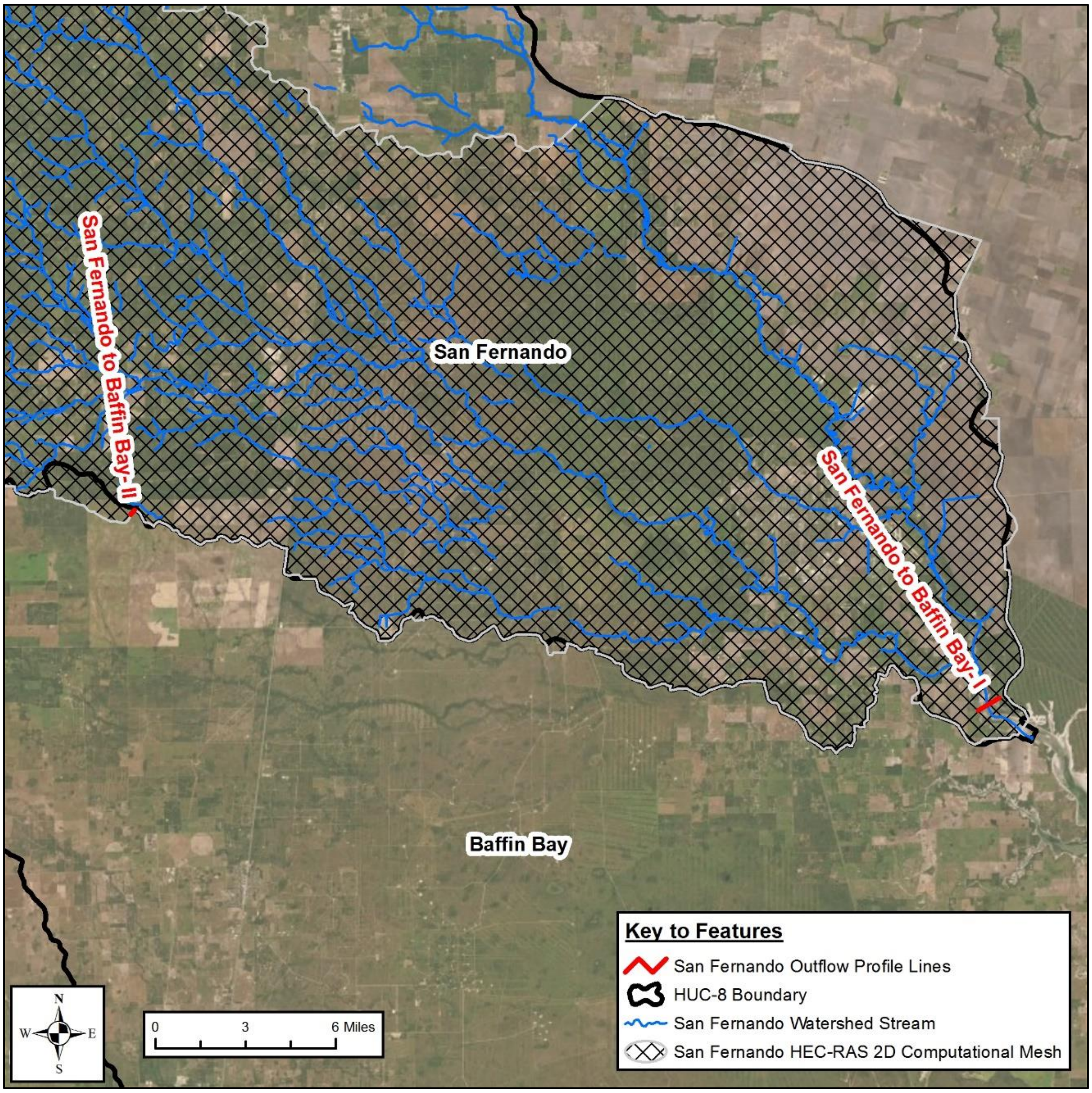

Figure 5: HEC-RAS 2D Computational Mesh and Outflow Profile Lines from San Fernando to Baffin Bay West

2.2.3 Hydrology

Precipitation data for this study were referenced from NOAA's Precipitation Frequency Data Server, and appropriate values for all sub-basin elements were determined considering spatial variation and a representative total for each particular sub-basin. 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 developed using a combination of HEC-HMS rainfall-runoff modeling and USGS peak streamflow gage analyses. USGS streamflow gage data were leveraged to develop the inflow hydrograph and to estimate peak flows for downstream gages within each work area for calibration purposes, as discussed in Section 2.3.1.1. Due to there being no USGS peak streamflow gages with adequate periods of record in the modeled mesh boundary, discharges were validated for Baffin Bay East model and chosen parameters applied to the San Fernando model. Since the watershed boundary mesh was divided, and the official San Fernando boundary has the USGS gages, the gages are included in this report in **Table 3**.

Table 3: USGS Peak Streamflow Gages

Gage ID	Flooding Source and Location	Published Drainage Area (mi^2)	Period of Record
08211800	San Diego Ck at Alice, TX	319	1964-1989
08211900	San Fernando Ck at Alice, TX	507	1962-2020
08212300[1]	Tranquitas Ck at Kingsville, TX	48.5	1965-2020

[1] Missing sufficient peak streamflow data

The HEC-HMS version 4.6 model 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 all sub-basin elements were determined by area-weighted intersection of gridded PFDS data with sub-basins. Excess precipitation for the 2D mesh was developed as described in Section 2.2.3.1.

Annual chance peak flows were calculated at each gage using USGS Bulletin 17B methodology. The 84% confidence interval was used to determine the 1% plus and minus chance events. Calculated discharges for the 1%, 1% plus, and 1% minus events are presented in **Table 4** for each gage utilized in this study.

Table 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)
08211800[1]	San Diego Ck at Alice, TX	22,500	10,740	63,450
08211900[1]	San Fernando Ck at Alice, TX	41,900	23,140	90,180
08212300[2]	Tranquitas Ck at Kingsville, TX	3,347	1,323	36,670

[1] Gages are included in the original San Fernando HUC but not the updated mesh, Validation was done in the Baffin Bay East model

[2] Missing sufficient peak streamflow data

2.2.3.1 Excess Precipitation for 2D Computational Mesh

HEC-HMS version 4.6 was used to apply the SCS Curve Number method to calculate losses and define excess precipitation for each watershed. Temporal distributions of point rainfall totals were defined using 24-hour, SCS Type II storm distributions. The plus and minus standard error for the 1-percent annual chance precipitation depths were determined as the upper and lower 92% 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. It should be noted that the standard errors for the 1% rainfall depth were based on the depth used post-areal reduction.

Curve Numbers were computed by intersecting the National Land Cover Dataset (NLCD) 2016 coverage and NRCS soils data based on the matrix. The CN Matrix was developed from the United States Department of Agriculture (USDA) *Urban Hydrology for Small Watershed Technical Release-55* (1986) procedures. A range of CN values were developed based on Good (minimum), Fair (mean), and Poor (maximum) values obtained from Table 2-2a – 2-2d of the TR-55 document. These matrices were then used to develop Minimum, Median, and Maximum CN values to be input into HEC-HMS, along with the Original CN values shown below. The excess precipitation was obtained from HMS for each CN value and input into the hydraulic model for an iterative validation analysis. The validation process is described more in Section 2.3.1.1. The Validated CN matrix is presented in **Table 5**: Validated Land Use-Soils-CN Matrix for Computing Minimum Curve Numbers

.

Table 5: Validated Land Use-Soils-CN Matrix for Computing Minimum 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	39	61	74	80
22	Developed Low Intensity	54	70	80	85
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	80
82	Cultivated Crops	51	67	76	80

LU_GridCode	NLCD LU Description	Hydrologic Soil Group			
		A	B	C	D
90	Woody Wetlands	49	62	74	85
95	Emergent Herbaceous Wetlands	49	62	74	85

A Curve Number (CN) can be considered a parameter, exhibiting variability that follows some frequency distribution. While Antecedent Runoff Condition (ARC) II CNs were used for a 1% event, the range between ARC I and ARC III for the ARC II CN was assumed to correspond to an 80% confidence interval of the ARC II CN. The CN Loss method assumes a maximum potential retention parameter, S, is inversely related to a CN by S = 1000 / CN – 10; this relationship is based on a median value of S determined from plotting a large number of observations.

Chapter 5 of the NRCS NEH Part 630 provides an example of computing a CN for a watershed based on annual peak gage observations. The example involves computing a CN and corresponding S value for each event, then taking the logarithms of the S values. Further, the logarithm of S is assumed to vary normally, and the mean of the logarithms corresponds to the arithmetic median. Therefore, 10% (S10) and 90% (S90) extremes of log normally distributed S values can be assumed to correspond to ARC III and ARC I condition CN values, respectively. This range represents an 80% confidence interval, corresponding to +/- 1.282 standard deviations from the mean. The following procedure was used to estimate one standard deviation of a given CN (in fact, one standard deviation of the logarithm of S) for the purposes of modeling 1% plus and minus events. First, ARC I (corresponding to S10) and ARC III (corresponding to S90) CN values can be estimated from a 1% CN (ARC II) by:

$$\mathrm{CNI} = 4.2 * \mathrm{CNII} \,/\, (10 - 0.058 * \mathrm{CNII})$$
$$\mathrm{CNIII} = 23 * \mathrm{CNII} \,/\, (10 + 0.13 * \mathrm{CNII})$$

Next, S90 and S10 can be computed by:

$$\mathrm{S10} = 1000 \,/\, \mathrm{CNIII} - 10$$
$$\mathrm{S90} = 1000 \,/\, \mathrm{CNI} - 10$$

The following relationship can then be used to compute one standard deviation of the logarithm of S:

$$\log\,(\mathrm{S10}) = \mathrm{mean}\,(\log\mathrm{S}) + 1.282\ \mathrm{std.dev.}\,(\log\mathrm{S})$$
$$\log\,(\mathrm{S90}) = \mathrm{mean}\,(\log\mathrm{S}) - 1.282\ \mathrm{std.dev.}\,(\log\mathrm{S})$$
$$1\ \mathrm{std.dev.}\,(\log\mathrm{S}) = (\log\mathrm{S10} - \log\mathrm{S90}) \,/\, (1.282 * 2)$$

Therefore, 1% plus and minus S values can be estimated by:

$$\log\,\mathrm{SPlus} = \log\mathrm{S} + [1\ \mathrm{std.dev.}\,(\log\mathrm{S})]$$
$$\log\,\mathrm{SMinus} = \log\mathrm{S} - [1\ \mathrm{std.dev.}\,(\log\mathrm{S})]$$

Finally, 1% plus and minus CNs can be computed by:

$$\mathrm{CNPlus} = 1000 \,/\, (\mathrm{SPlus} + 10)$$

$$CNMinus = 1000 / (SMinus + 10)$$

Since the 1% plus and minus events represent plus and minus one standard deviation of a 1% event, CNs used in a rainfall-runoff simulation for modeling 1% Plus and Minus events were developed, as described above.

Lag Times for sub-basins were determined using the SCS Lag Equation, as well as engineering judgement. **Table 6** below shows the Curve Numbers and Lag Time values used in this study.

Table 6: Rainfall-Runoff Parameters (Curve Number, Lag Time)

Sub-basin Description	CN	CN 1% Minus	CN 1% Plus	Tlag (min)
San Fernando	66.0	50.00	79.03	1,199

NRCS rainfall-runoff methods were used to define excess precipitation applied to the 2D mesh, including Curve Numbers for defining rainfall losses and Lag Time for transforming the runoff temporally. No routing was considered in the rainfall-runoff modeling. NRCS Type II storm distributions were used for defining temporal distributions of point rainfall totals. An Areal Reduction Factor (ARF) of 0.91 was used on all recurrence interval total precipitation depths in order to determine the effective precipitation for the sub-basin representing the 2D mesh. **Table 7**: Precipitation Totals for HEC-RAS 2D Computational Mesh (post ARF)
provides the precipitation totals used for determining excess precipitation.

Table 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
San Fernando	6.08	7.80	9.29	10.96	15.53	8.68	13.23

Figure 6 shows the hyetographs applied to the 2D computational mesh.

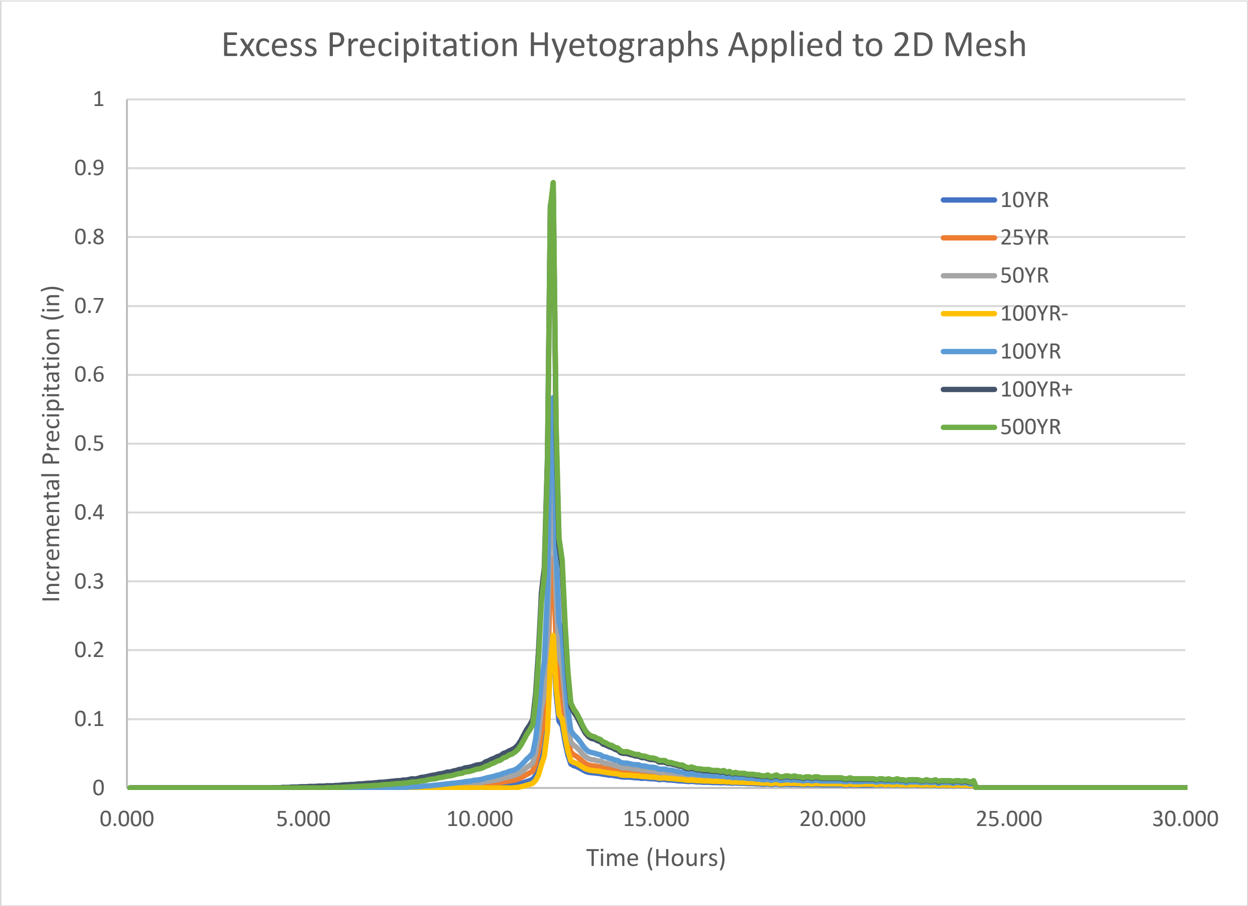

Figure 6: Precipitation Hyetographs (post ARF) applied to the Computational Mesh

2.2.3.2 Rainfall-Runoff Hydrograph Boundary Conditions

Outflow hydrographs shown in **Figure 7** through **Figure 9**, developed from rainfall-runoff modeling, were used as inflow boundary conditions to the San Fernando 2D model. These hydrographs were extracted from the Baffin Bay East computational mesh at locations of a major contributing spill area to San Fernando shown in **Figure 4**. **Figure 10** and **Figure 11** include the outflow hydrographs contributing to the Baffin Bay west model. These hydrographs were computed from the San Fernando computational mesh outflow or spill locations, as seen in **Figure 5**. Models were then adjusted to be within 0.5 feet of the adjoining floodplain water surface elevations. These adjustments include matching slopes for the boundary conditions and overlapping mesh for identifying tie-in locations.

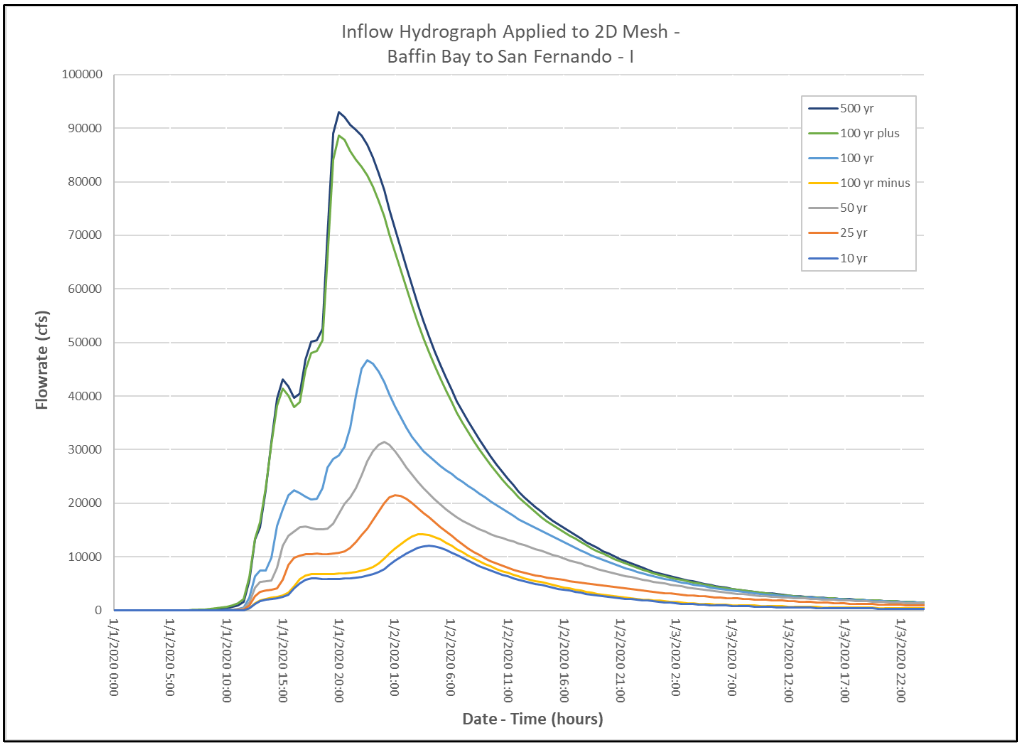

Figure 7: San Fernando Basin Inflow Hydrograph from Baffin Bay East – I

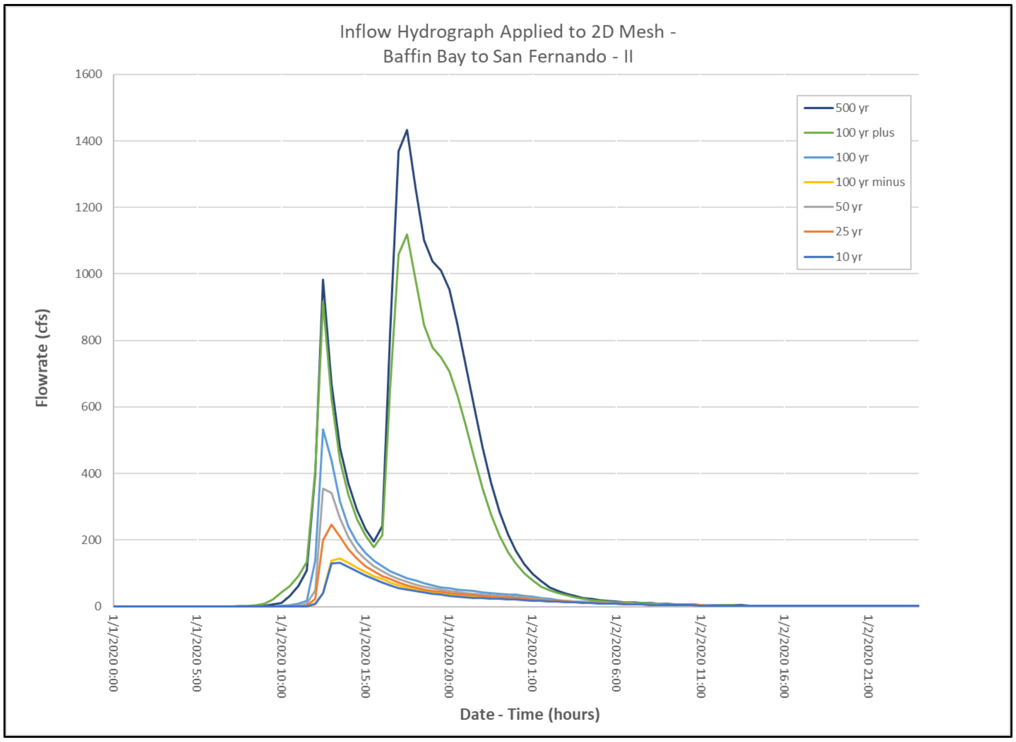

Figure 8: San Fernando Basin Inflow Hydrograph from Baffin Bay East – II

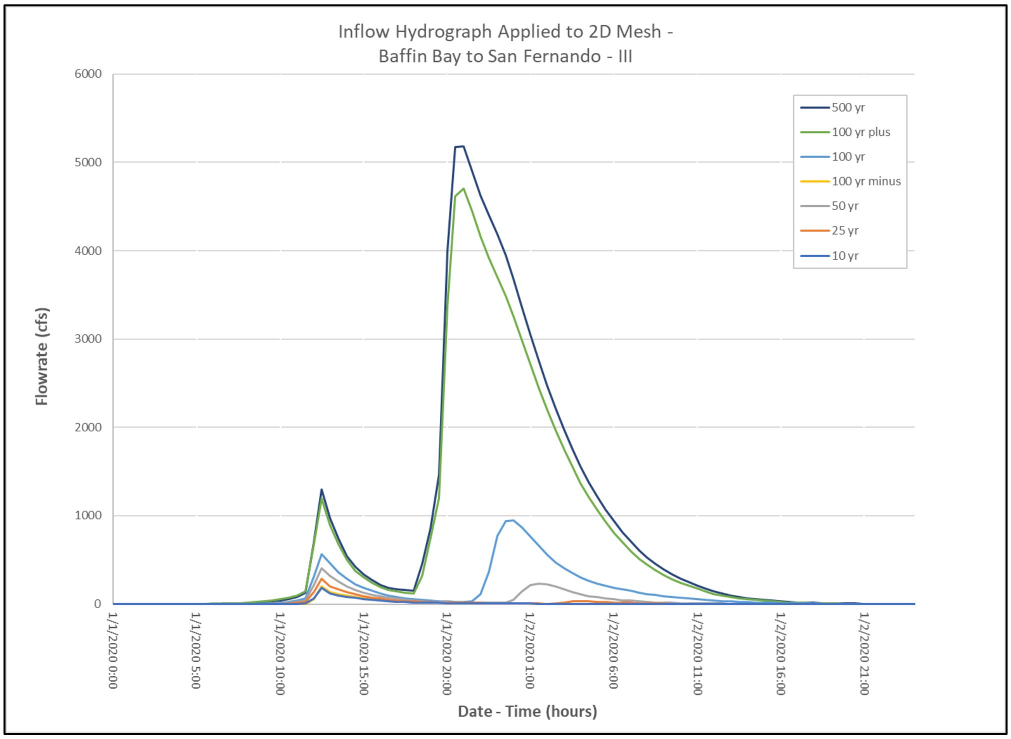

Figure 9: San Fernando Basin Inflow Hydrograph from Baffin Bay East – III

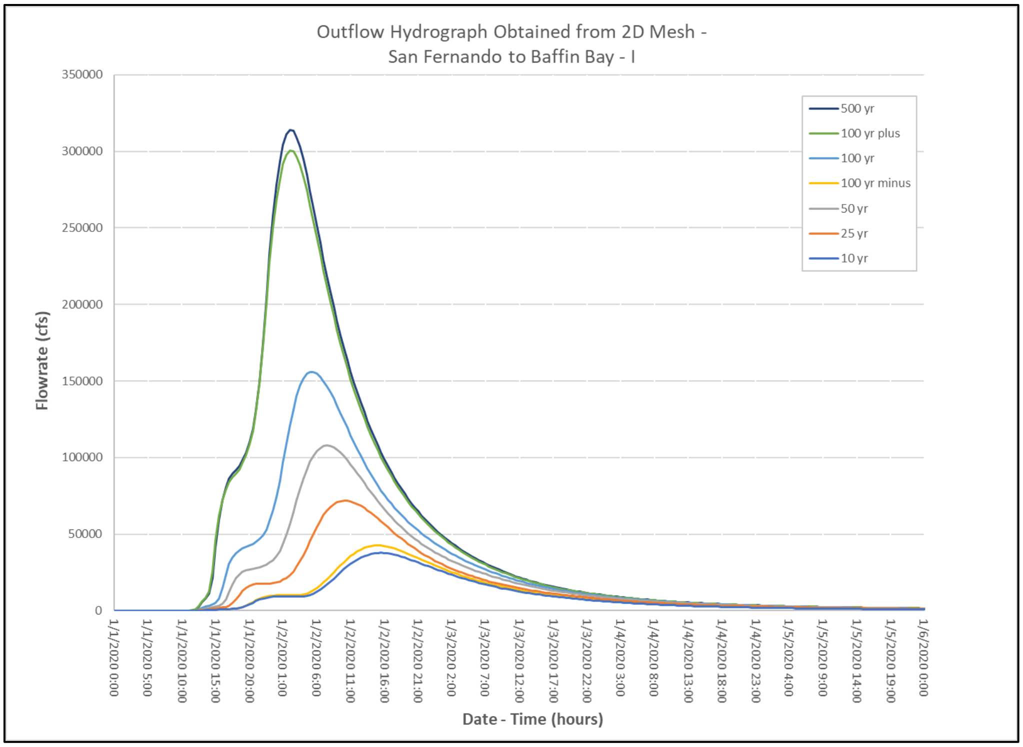

Figure 10: San Fernando Basin Outflow Hydrograph into Baffin Bay West – I

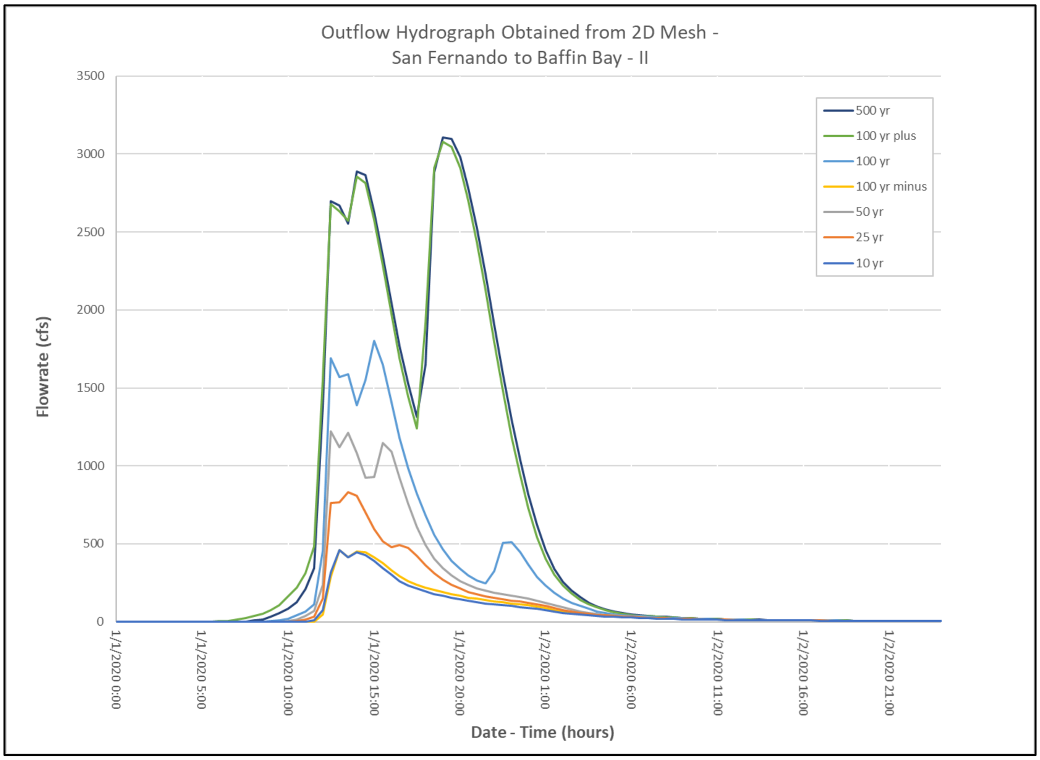

Figure 11: San Fernando Basin Outflow Hydrograph into Baffin Bay West – II

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. In several areas, the channel section land use indicated a Manning's n-value inappropriate conveyance; because of this, a 200-foot buffer zone was created around each stream centerline to create a main channel roughness zone. The channel roughness zone was given a Manning's n value of 0.045 based on the normal values per the HEC-RAS User's Manual. **Table 8**: NLCD 2016-Manning's N Roughness Matrix

below shows a typical land use-roughness matrix used in defining the roughness coverage for the study area.

Table 8: NLCD 2016-Manning's N Roughness Matrix

NLCD Classification	Validated[2]	Minimum	Normal	Maximum	Source
Open Water	**0.025**	0.025	0.03	0.033	Chow 1959
Developed, Open Space	**0.03**[3]	0.01	0.013	0.016	Calenda, et al. 2005
Developed, Low Intensity	**0.038**	0.038	0.05	0.063	Calenda, et al. 2005
Developed, Medium Intensity	**0.056**	0.056	0.075	0.094	Calenda, et al. 2005
Developed, High Intensity	**0.075**	0.075	0.1	0.125	Calenda, et al. 2005
Barren Land	**0.025**	0.025	0.03	0.035	Chow 1959
Deciduous Forest	**0.1**	0.1	0.12	0.16	Chow 1959
Evergreen Forest	**0.1**	0.1	0.12	0.16	Chow 1959
Mixed Forest	**0.1**	0.1	0.12	0.16	Chow 1959
Scrub/Shrub	**0.035**	0.035	0.05	0.07	Chow 1959
Grassland/Herbaceous	**0.025**	0.025	0.03	0.035	Chow 1959
Pasture/Hay	**0.03**	0.03	0.04	0.05	Chow 1959
Cultivated Crops	**0.025**	0.025	0.035	0.045	Chow 1959
Woody Wetlands	**0.08**	0.08	0.1	0.12	Chow 1959
Emergent Herbaceous Wetland	**0.075**	0.075	0.1	0.15	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] Selected values based on validation efforts in neighboring basins values adjusted to accomplish validation goals as described in **Section** Error! Reference source not found.

[3] Aerial imagery shows less developed conditions for Open Space.

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 that were not processed out of the terrain data were modeled by offsetting 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. Another breakline alteration that provided the same effect included V-notch breaklines. 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. An example of the offset breakline approach is shown below.

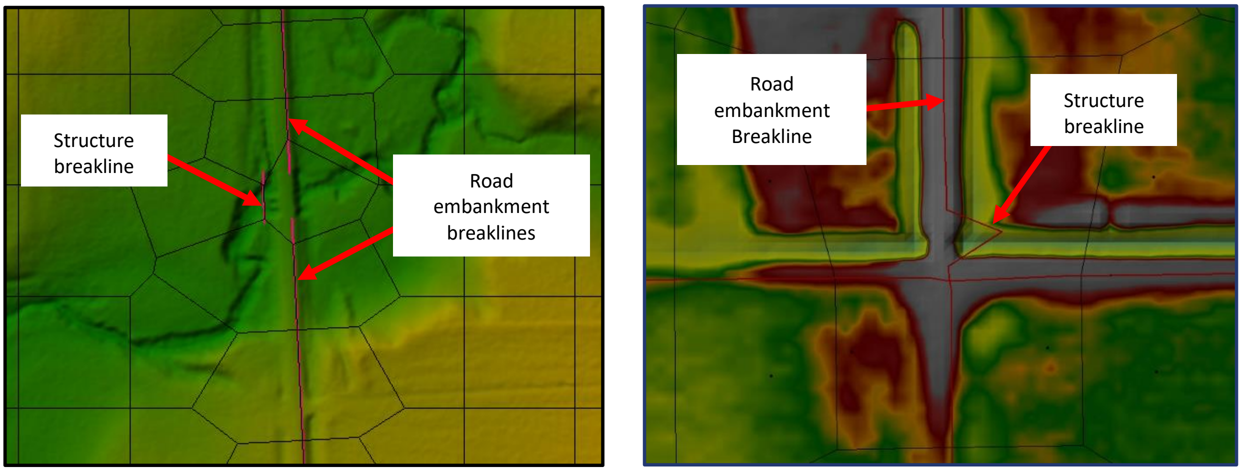

Figure 12: Offset and V-notch Breakline Approach at Bridge Crossing

County, interstate, common name, state recognized, and U.S. roads were incorporated for road breaklines from the U.S. Census Bureau TIGER/Line road layer. The stream centerlines were input as breaklines to ensure cells lined up perpendicular to the stream and to capture stream conveyance. The study area included multiple accredited levee systems. To represent the prominent features, breaklines were utilized for the Nueces-Bishop Levee System sections within the HUC. The San Diego-San Diego Creek System and San Diego Creek System were incorporated into the Baffin Bay East model.

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

2.3 Model Results

After the initial sensitivity and model runs, it was decided to split a portion of the San Fernando HUC and combine it with Baffin Bay East model to limit the number of hydrographs between the two HUC computational meshes. This decision improves future stakeholder use by reducing the number of complex boundary conditions in the model while increasing accuracy of capturing all contributing drainage area.

The 2D BLE results for the study produced an SFHA that compared reasonably well with the effective SFHA in most cases and provides additional estimated SFHA in areas that do not currently have an SFHA mapped. **Table 9**: Effective and Model WSEL Comparison

shows a comparison of some the effective water surface elevation (WSEL) 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 9: Effective and Model WSEL Comparison

Stream	Effective XS Line Station	Effective WSEL (feet)	Model WSEL (feet)	Difference (feet)
Unnamed Creek at Ben Bolt in Jim Wells County (Between Co Rd 461 and US 281)	SS 8320	186.6	186.87	0.27
	SS 13970	192.2	192.76	0.56
Santa Gertrudis Creek	SS 26379.798	34.38	34.36	-0.02
	SS 48872.104	53.33	53.87	0.54
Tranquitas Creek	SS 18700.756	46.81	50.98	4.09
Carretta Creek	SS 12210	54.44	57.22	2.78
North Carretta Creek	SS 2860	48.55	48.78	0.23

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 a Bulletin 17B Analysis of the gage data using PeakFQ.

To determine which factors were significantly impacting the model results, a sensitivity analysis was run to evaluate the impact of several parameters including Manning's roughness values, breaklines, hydrologic losses, initial conditions, and boundary conditions. The Manning's n-values greatly impacted the results and was determined that a channel n-value needed to be set for the watershed. Further discussion of the roughness coefficients can be found in Section 2.2.4. 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.

Initial validation efforts were done within the San Fernando HUC8 boundary. Once it was determined that the computational mesh boundary would need to be revised to limit cross basin interaction areas, the gages were used to validate the neighboring Baffin Bay East hydraulic model shown in **Figure 13.** Manning's N and Curve Number values used in the Baffin Bay East model were mimicked for the San Fernando model.

Results of the flow comparisons are presented in **Table** .

Table 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)**
08211800[2]	San Diego Ck at Alice, TX	209.66	18,923	209.70	22,500
08211900[2]	San Fernando Ck at Alice, TX	180.20	42,011	177.88	41,900
08212300[3]	Tranquitas Ck at Kingsville, TX	62.04	12,802	55.23	3,347

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

[2] Gages are included in the original San Fernando HUC but not the updated mesh. Validation was done in the Baffin Bay East model

[3] Missing sufficient peak streamflow data

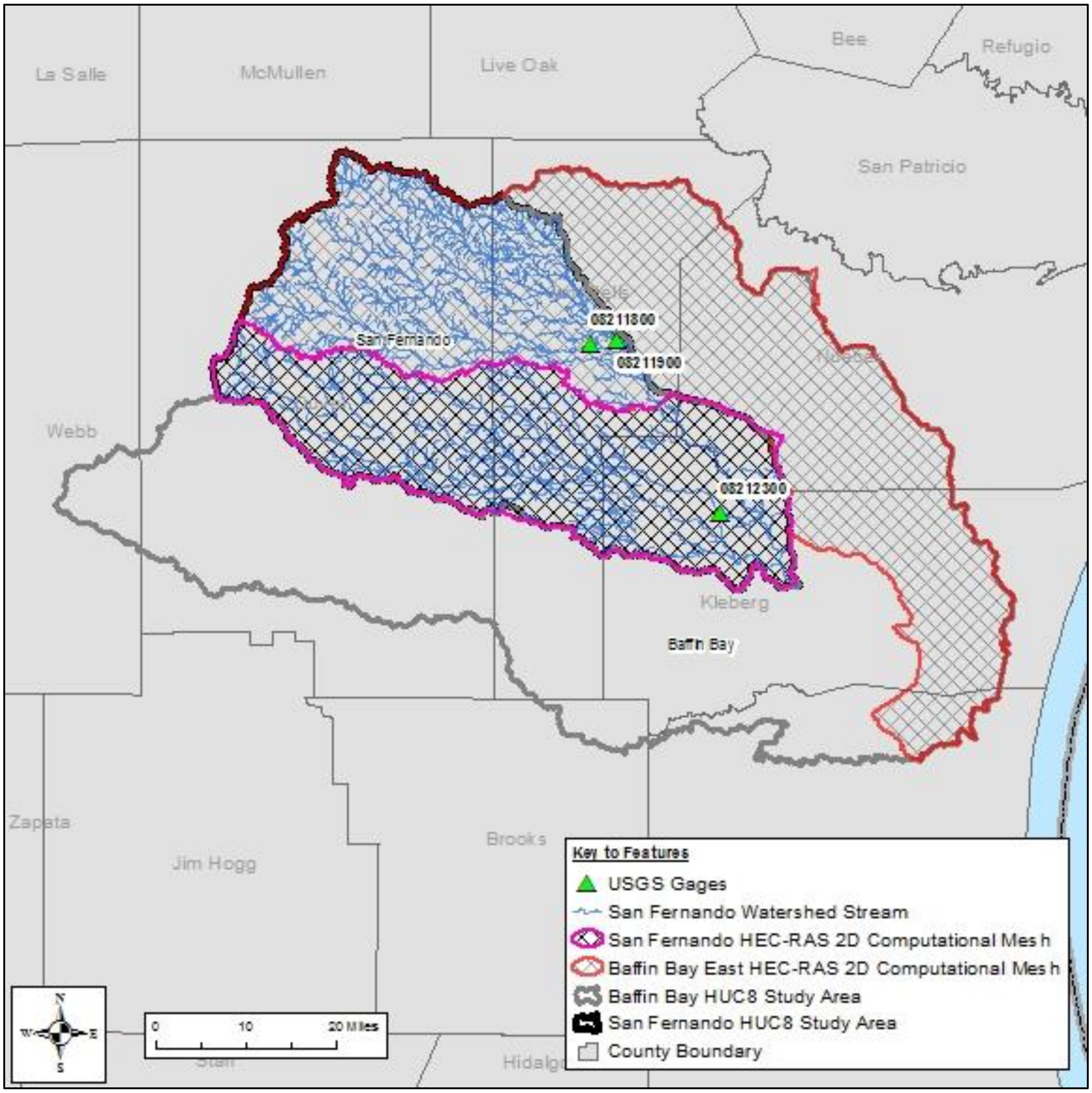

Figure 13: San Fernando and Baffin Bay East Watershed and Computational Mesh

Multiple model iterations were compared to the two gage analyses. When reviewing results of each model iteration, specific WSEL and discharge targets were considered. Resulting water surface elevations and flow values for the 100-year event were compared to the 100-year gage analysis results at the same location.

Roughness values were adjusted by increasing and decreasing all n-values to the maximum and minimum values provided in Section 2.2.4.1. CN values were adjusted to Minimum, Median, and Maximum CN values as discussed in 2.2.3.1. All model iteration setups tested combined parameter options to achieve validated parameters with minimal differences when compared to gage analysis results. To select a model iteration that represented the entire watershed and not just one gage location, results were compared between the two gages. The overall best model iteration that met the targeted alignments for both locations was selected as the validated model iteration and used for final model and mapping products.

Table shows the result comparisons for Station 08211800. The water surface elevation gage analysis results compared reasonably well to most model parameter options with greater variability in the flow values. The validated model compared well with a difference of 0.04ft and flows within 16%.

Table 11: Sensitivity Analysis Results at USGS Gage 08211800

Iteration[1]	Manning's N Zones	Breaklines[1]	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions[2]	Peak Flow (cfs)	Peak Elevation (ft)
1	Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	15,374	209.61
2	N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	12,735	208.50
3	N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	19,952	209.57
4	CN Max; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	15,875	209.60
5	CN Max; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	12,992	209.89
6	CN Max; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	20,662	209.66
7	CN Min; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	14,363	209.33
8	CN Min; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	11,835	209.27

Iteration[1]	Manning's N Zones	Breaklines[1]	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions[2]	Peak Flow (cfs)	Peak Elevation (ft)
9	CN Median; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	15,614	209.68
10	CN Median; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	12,791	209.83
11	CN Median; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	20,311	209.82
12[3]	CN Min; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	18,923	209.66
					Gage Analysis:	22,500	209.70[4]

[1] All iterations included breaklines for roads and centerlines.
[2] Normal depth boundary conditions used except directly next to inflow boundaries in low lying areas due to the some of the flow immediately leaving the model.
[3] Parameters from Iteration 12 were used for the final model, however additional computational mesh was implemented flowing the results of the sensitivity analysis.
[4] Water surface elevation is approximate based on PeakFQ input data.

Table shows the result comparison for Station 08211900. The peak flow data was limited, and water surface elevations were not available for flows that exceeded 26,800 cubic feet per second. Power regression extrapolations for this gage analysis did not yield realistic results and were well over 10 ft higher than effective FIS data. The best model run for Station 08211900 was selected based on flow values that were within 1% of the gage analysis. Water surface elevations were compared based on additional data to provide confidence in model validation. Due to this, iterative model water surface elevations and flows were compared to the effective data and were within 0.3 to 1 ft. When reviewing final validated WSE and flow values, the 50-year flow and WSE compared well to peak stream flow data.

Table 12: Sensitivity Analysis Results at USGS Gage 08211900

Iteration[1]	Manning's N Zones	Breaklines[1]	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions[2]	Peak Flow (cfs)	Peak Elevation (ft)
1	Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	27,038	179.76
2	N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	22,676	179.83
3	N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	38,776	179.60
4	CN Max; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	31,341	180.75
5	CN Max; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	25,862	180.72
6	CN Max; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	44,184	180.43
7	CN Min; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	23,406	179.06
8	CN Min; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	19,574	179.08
9	CN Median; Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	28,996	180.22
10	CN Median; N Max	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	23,761	180.13
11	CN Median; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	40,460	179.85
12[3]	CN Min; N Min	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30 second	Stage Hydrograph and Normal Depth	42,011	180.20
					Gage Analysis:	41,900	177.88[4]

[1] All iterations included breaklines for roads and centerlines.
[2] Normal depth boundary conditions used except directly next to inflow boundaries in low lying areas due to the some of the flow immediately leaving the model.
[3] Parameters from Iteration 12 were used for the final model, however additional computational mesh was implemented flowing the results of the sensitivity analysis.
[4] 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. Gages within the HUC8 watershed were outside the altered San Fernando Mesh. Validated parameters for the Baffin Bay East model were applied to the San Fernando model.

The major interactions and spillage between San Fernando and the Baffin Bay East model watersheds are complex, and it was necessary to perform multiple iterations. USGS HUC8 boundaries between San Fernando and Baffin Bay did not strictly follow ridgelines or high terrain. Due to this, the model boundary needed to be adjusted to limit cross basin interaction areas for more accurate results. As stated in Section 2.2.1, after initial mapping review, it was decided the San Fernando watershed and its neighboring HUC8, Baffin Bay, would be better modeled with an updated Mesh border. To simplify the cross-border interactions and inflow areas between the two HUC8 watersheds, the San Fernando 2D mesh was split and the eastern portion merged with the Baffin Bay model, with the western portion being modeled independently. For more information on the Baffin Bay model and decisions to split that HUC8 into an east and west section for modeling purposes, refer to the *Baffin Bay Watershed, Texas 2D Base Level Engineering Methods and Results* report.

There were a few areas where the San Fernando model spills in and out of the mesh boundary. Most of the spill areas were identified as minor HUC boundary refinements. Normal depth boundary conditions were adjusted slightly in these areas to produce seamless boundaries between San Fernando and the adjoining HUC8s, Lower Nueces, Middle Nueces, and Baffin Bay. In areas where San Fernando spilled into Lower Nueces and Middle Nueces watersheds, the mesh grid was extended to simplify the spill locations. Any identified spills into these watersheds were provided as Area of Mitigation Interest (AOMI) regions.

Two (2) San Fernando flow hydrographs from the model were extracted to be incorporated as inflow boundary conditions for the West Baffin Bay model as part of the Baffin Bay Watershed, TX 2D Base Level Engineering study. This resulted in similar water surface elevations at the boundaries in both models with a seamless floodplain mapped across HUC8 boundaries.

As part of our coordination efforts with the Texas Water Development Board (TWDB), a FEMA CTP partner, we used a mapping clean-up process recommended by the TWDB. The San Fernando HUC8 is located near the coastal region of Texas with several interactions with the coastal HUC8s. The TWDB recommended a threshold for mapping clean-up for this HUC8 which removes 0.33 feet of depth and then 0.33 acres of disconnected areas. Holes within a floodplain are filled up to 0.33 acres as well.

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.

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 San Fernando BLE project, floodplain mapping delineation was completed using connected raster cells at the extent of the CNMS mapped and unmapped features in the project footprint with raster depths greater than 0.33 feet. 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% 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 were aggregated with the larger surrounding polygons to merge them and make the floodplain complete. Mapping polygons were cleaned against the criteria of being larger than 2 acres. For example, if flooding polygons were disconnected from a flooding source and less than two acres, the polygon was removed from the SFHA. Flood polygon less than 2 acres that intersected a flooding source were assessed individually. These edits adhere to traditional and approved floodplain mapping approaches.

In addition to the SFHA, all other flooding associated with the 1% and 0.2% raw results were retained as "on the shelf" data that may be leveraged for future needs and analysis.

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 was 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 San Fernando 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 the study area in the San Fernando Watershed the effective Zone A topographic data source leveraged contours from USGS 24K map products. The topographic data source for the BLE was derived from LiDAR flown for the state of Texas from 2009 to 2018. This elevation data represents a significant improvement from the effective Zone A topographic source for all reaches and were, therefore, set to FAIL this check.

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. It is unknown if regression methods were used in the effective studies, therefore, this element was set to PASS 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 San Fernando Watershed was completed by evaluating percentage of urban change at the HUC-12 level. The majority of the watershed is classified as rural and were set to PASS this assessment minus San Fernando Creek in Kleberg County.

Table presents the summarized results of checks A1 through A3.

Table 13: A1-A3 Validation Results

Assessment Checks	Pass / Fail	Notes
A1 – Topography	Fail	LiDAR significantly better than effective USGS topo source
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. Due to lack of documentation of the original engineering methods in the San Fernando Watershed, check A4 has been marked as FAIL for all 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 San Fernando 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. For this 2D study, the effective A zone boundaries were compiled using the National Flood Hazard Layer and Core Logic effective digital uplift product. These data were dissolved to one continuous A-zone layer, which then had points placed along its perimeter every 200 feet.

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 761.9 total miles of available CNMS features representing the effective Zone A studies were categorized as VALID – BEING STUDIED or UNVERIFIED – BEING STUDIED. Total miles in each of these categories are summarized in **Table** and illustrated in **Figure 14** below.

Table summarizes the validation results based on the individual HUC 12 watersheds within San Fernando Watershed.

Table 14: Aggregated Zone A Validation Results

Validation Status	Status Type	Total Miles
VALID	BEING STUDIED	0.0
UNVERIFIED	BEING STUDIED	761.9

Table 15: HUC 12 Zone A Validation Results

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>90%)	Priority Score
Watershed Name	Watershed Number						
San Fernando	All Streams	46,331	30,207	1,814	3.9%	FAIL	
Amargosa Creek	121102040 402	1,279	1,279	0	0.0%	FAIL	45.1
Animas Creek North	121102040 101	1,050	1,050	0	0.0%	FAIL	25.0
Caesar Grande Water Hole-San Fernando Creek	121102040 407	1,911	1,760	151	7.9%	FAIL	41.3
Carreta Creek	121102040 408	584	535	49	8.4%	FAIL	34.0
Chiltipin Creek	121102040 401	2,887	2,882	5	0.2%	FAIL	30.4
Escondido Creek	121102040 203	2,292	2,092	200	8.7%	FAIL	45.6
Escondido Creek-Santa Gertrudis Creek	121102040 205	1,118	1,080	38	3.4%	FAIL	49.4
Guajillo Creek	121102040 108	1,675	1,510	165	9.9%	FAIL	25.7
Headwaters San Diego Creek	121102040 305	1,514	1,514	0	0.0%	FAIL	25.0
Las Animas Creek	121102040 102	1,046	1,041	5	0.5%	FAIL	25.7
Lattas Creek-San Fernando Creek	121102040 405	1,727	1,617	110	6.4%	FAIL	32.9
Llano Windmill	121102040 307	619	619	0	0.0%	FAIL	25.0
Lower Narciseno Creek	121102040 107	1,440	1,116	324	22.5%	FAIL	24.4
Lower Piedras Pintas Creek	121102040 105	1,135	1,031	104	9.2%	FAIL	26.4
Lower Rosita Creek	121102040 304	1,173	1,173	0	0.0%	FAIL	25.3

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>90%)	Priority Score
Watershed Name	Watershed Number						
Middle Rosita Creek	121102040303	744	737	7	0.9%	FAIL	24.8
Muerto Creek-Chiltipin Creek	121102040403	3,852	3,852	0	0.0%	FAIL	41.5
Muralla Tank-San Diego Creek	121102040309	1,170	1,170	0	0.0%	FAIL	25.2
Nopaleras Creek-Santa Gertrudis Creek	121102040109	2,087	2,015	72	3.4%	FAIL	28.4
Ogados Lake-San Fernando Creek	121102040406	216	171	45	20.8%	FAIL	45.2
Red Windmill-San Diego Creek	121102040306	1,146	1,146	0	0.0%	FAIL	25.0
Resaca de Enmedio-San Fernando Creek	121102040404	1,260	1,260	0	0.0%	FAIL	50.0
Reyes Cemetery	121102040308	493	493	0	0.0%	FAIL	25.0
San Andreas Creek-Santa Gertrudis Creek	121102040202	2,225	1,989	236	10.6%	FAIL	39.8
Santa Gertrudis Creek	121102040103	862	813	49	5.7%	FAIL	28.3
Santa Gertrudis Creek	121102040206	362	362	0	0.0%	FAIL	57.7
Tarancahuas Creek	121102040302	1,228	1,228	0	0.0%	FAIL	25.0
Town of San Diego-San Diego Creek	121102040310	1,090	1,090	0	0.0%	FAIL	38.7
Tranquitas Creek	121102040409	1,527	1,444	83	5.4%	FAIL	46.5

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>90%)	Priority Score
Watershed Name	Watershed Number						
Trinidad Creek-Santa Gertrudis Creek	121102040201	2,618	2,295	323	12.3%	FAIL	42.2
Tulosa Lake	121102040204	223	170	53	23.8%	FAIL	38.1
Upper Narciseno Creek	121102040106	1,262	986	276	21.9%	FAIL	19.5
Upper Piedras Pintas Creek	121102040104	1,233	1,106	127	10.3%	FAIL	22.4
Upper Rosita Creek	121102040301	1,283	1,283	0	0.0%	FAIL	25.0

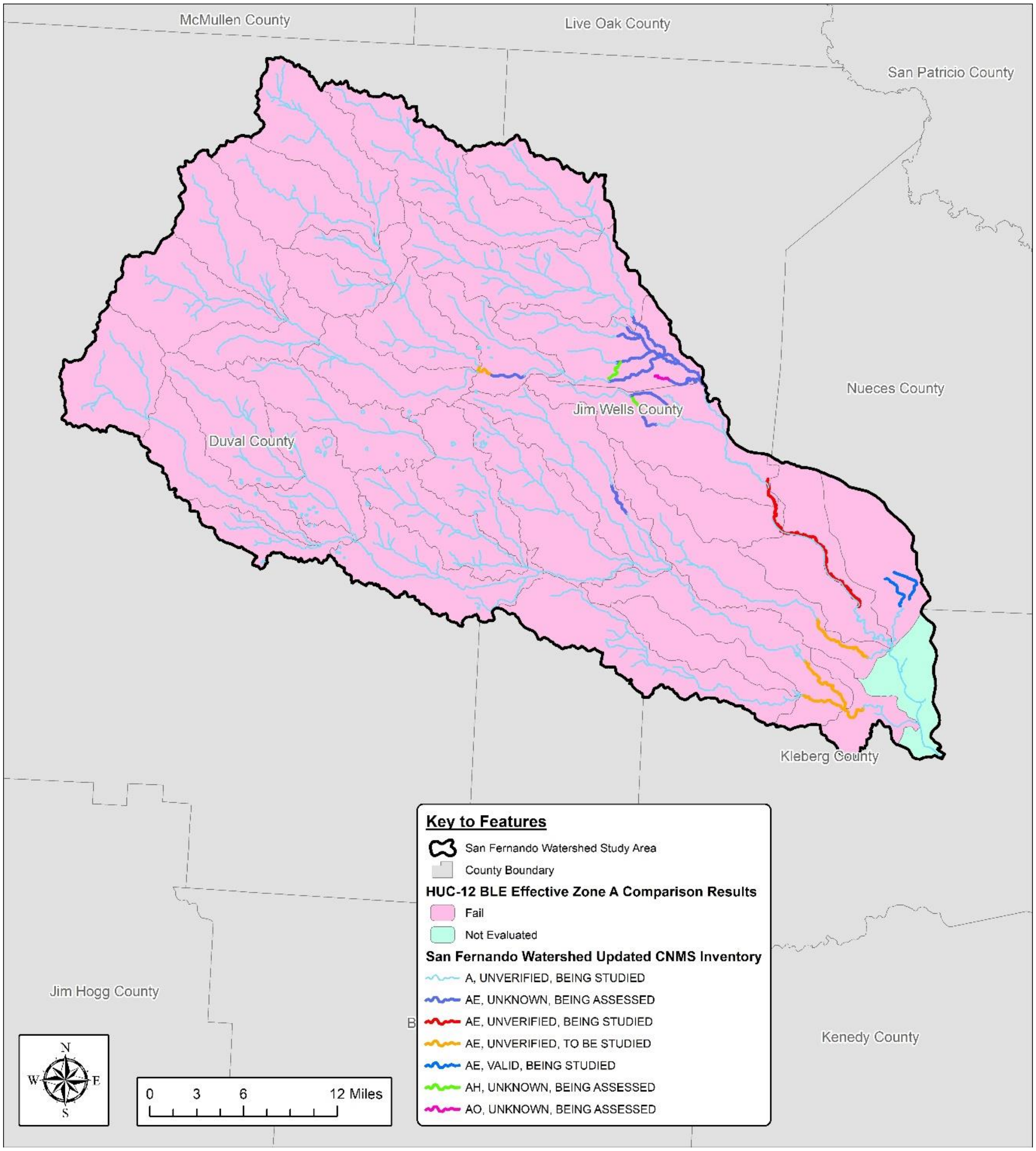

Figure 14: San Fernando Watershed CNMS Validation Results

An overall risk for each HUC-12 watershed was calculated using the National Flood Risk Percentages Dataset and its proportional area. The weighted risk was multiplied by the percentage of points in the watershed that failed the CNMS comparison to effective to determine the priority score.

Figure 15 below shows the range of the San Fernando HUC-12 priority scores which can be used to initiate discussions during the Discovery phase. Santa Gertrudis Creek HUC-12 was determined to have the highest priority score and the most need while Upper Narciseno Creek HUC-12 had the lowest score.

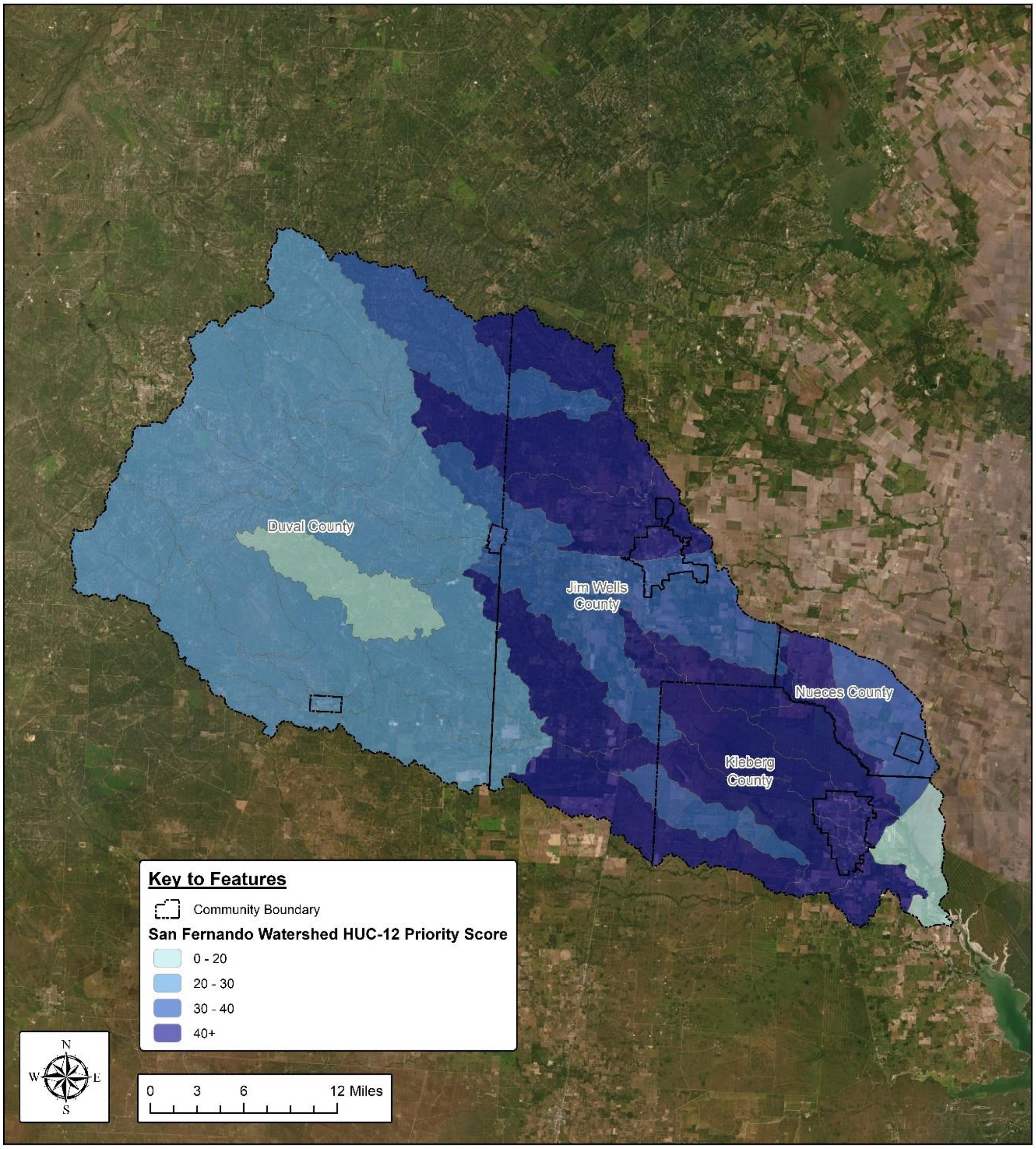

Figure 15: Ranking of San Fernando Watershed HUC-12s

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 5.0 (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 5.0 (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 parish within the project watershed extends for each return period to ensure proper model processing. A summary of results per parish for the 100-year scenarios are shown in **Table** .

Table 16: Hazus 5.0 (SP02) Results for 1-percent-annual-chance (100 year) scenario for San Fernando Watershed, Texas

County	Full Replacement – Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Duval	$94,216,000	$505,077,000	$280,779,000
Jim Wells	$711,423,000	$2,346,649,000	$1,480,319,000
Kleberg	$324,193,000	$2,322,615,000	$1,465,952,000
Nueces	$29,577,000	$315,019,000	$186,003,000
Total	$1,159,409,000	$5,489,360,000	$3,413,053,000

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