Aransas 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. 12100407 – Aransas 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 in Section 2.1.

Precipitation depths for this study were established using National Oceanic and Atmospheric Administration (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	Aransas Stream Miles
CNMS	404.7

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
Unverified	To be Studied	364.1
Valid	NVUE Compliant	40.6

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 Aransas HUC-8 Watershed (12100407) 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 Bee, Live Oak, San Patricio, Aransas, and Refugio Counties, and include the following communities: The Cities of Beeville, Sinton, Taft, and Odem. The study area consists of four HUC-10 basins: Poesta Creek, Lower Aransas River, Upper Aransas River, and Chiltipin Creek. Figure 1.1 shows the location and extent of the Aransas HUC-8 watershed.

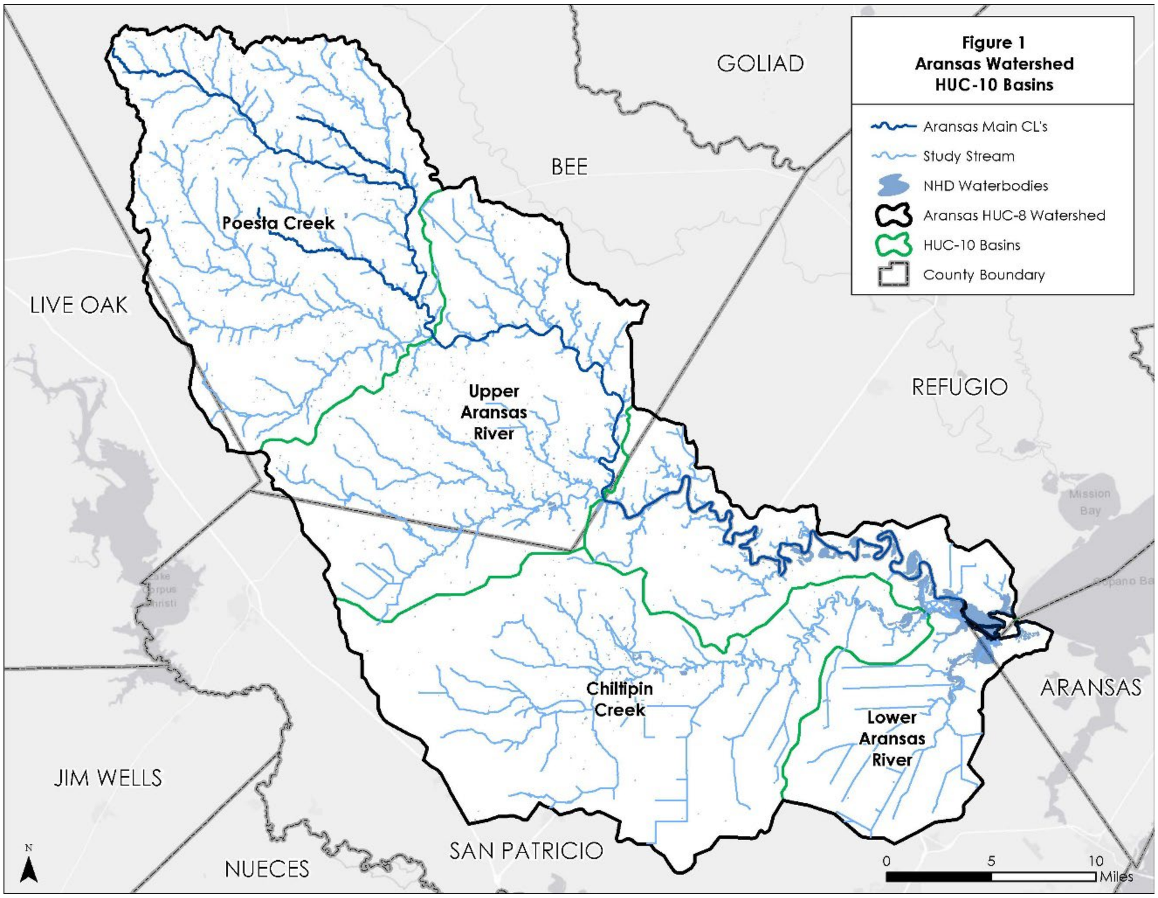

Figure 1.1: Aransas Watershed

02 2D BLE Modeling Inputs and Controls

Section 2 presents fundamental components required to execute a 2-dimensional (2D) hydraulic engineering analysis for the Aransas 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 Aransas 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 Aransas 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 Aransas Watershed.

2.1.1 Inventory

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

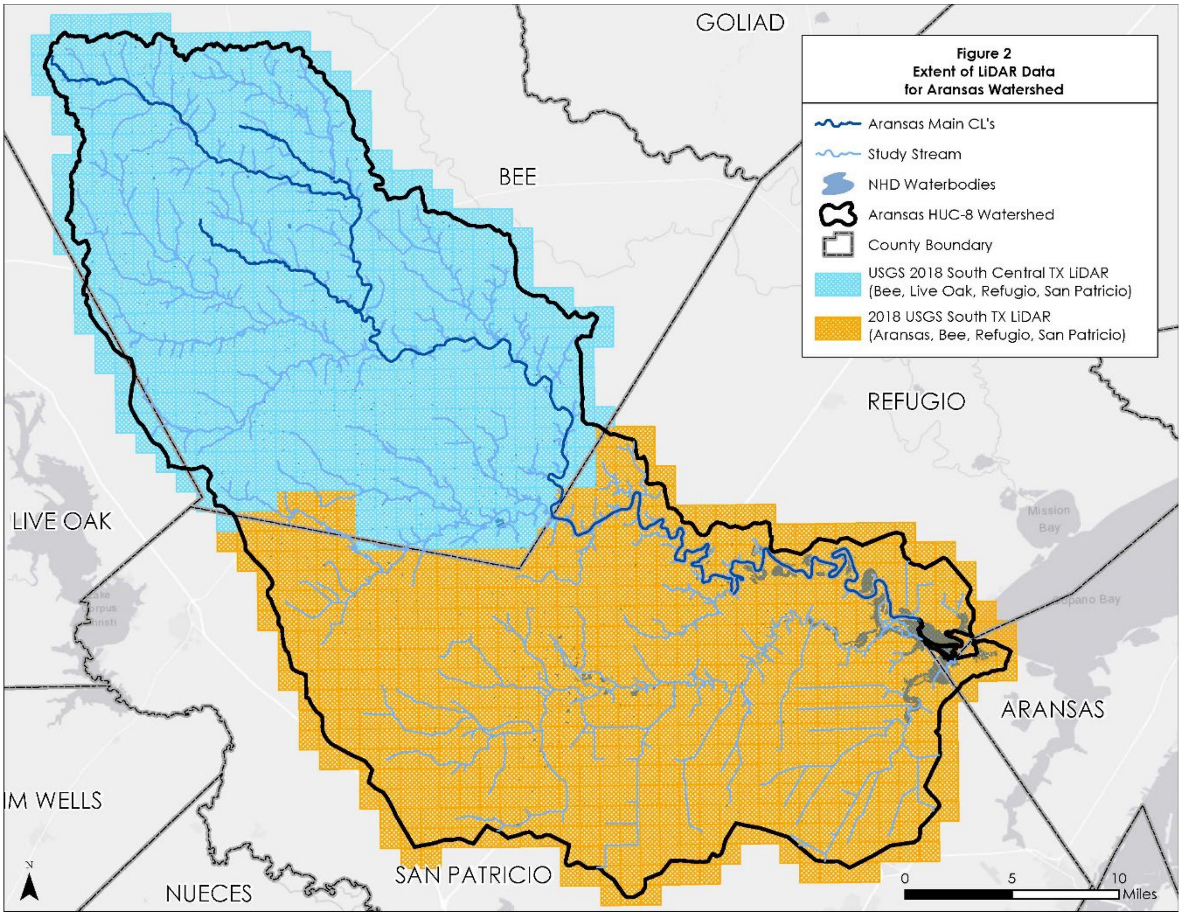

Figure 2.1: Aransas Watershed BLE Source Terrain Data

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 Aransas 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 Aransas Watershed

Year	Description	Data Type	RMSE	Source/Owner
2018	2018 USGS South Central TX LiDAR (Bee, Live Oak, Refugio, San Patricio)	Airborne LiDAR	5.6 cm	USGS
2018	2018 USGS South TX LiDAR (Aransas, Bee, Refugio, San Patricio)	Airborne LiDAR	0.089	USGS

2.1.2.1 Aransas Watershed Source Terrain Data

The source elevation data for the Aransas Watershed are DEMs derived from the 2018 USGS 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 Central TX LiDAR, Bee, Live Oak, Refugio, San Patricio – 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.

2018 USGS South TX LiDAR, Aransas, Bee, Refugio, San Patricio – The 2018 USGS LiDAR was acquired from January 2018 to February 2018 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.

2.1.3 Data Development Methodology

The source topographic data were processed for an area covering the Aransas Watershed and contributing drainage areas for the Aransas BLE modeling efforts. The topographic data for Aransas 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 Aransas 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 Aransas 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 Aransas Watershed were captured, a buffer was added to the HUC boundary.

The HEC-RAS 2D computational mesh was created for the Aransas 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 730,551 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.

2.2.2 Model and Boundary Condition Setup

Using HEC-RAS rain-on-grid modeling requires establishing a 2D computational mesh boundary and applies the excess precipitation directly to the mesh. For the Aransas basin, excess precipitation was applied to the mesh. Figure 2.2 shows the 2D computational mesh for the Aransas basin, along with USGS peak streamflow gages pertinent to the study. The development of the excess precipitation hyetographs for the 2D mesh, are described in Section 2.2.3.

Outflow boundary conditions (from the computational 2D mesh) were utilized along basin boundaries. A stage hydrograph representing a known water surface elevation was used for the boundary conditions along Copano Bay. This was established using NOAA tidal datums for the Texas coast and applying the mean higher high water elevation. The remaining boundaries were defined as continuous normal-depth boundaries for non-unique outflow boundary conditions using approximate energy grade-line slopes estimated from the LiDAR terrain data.

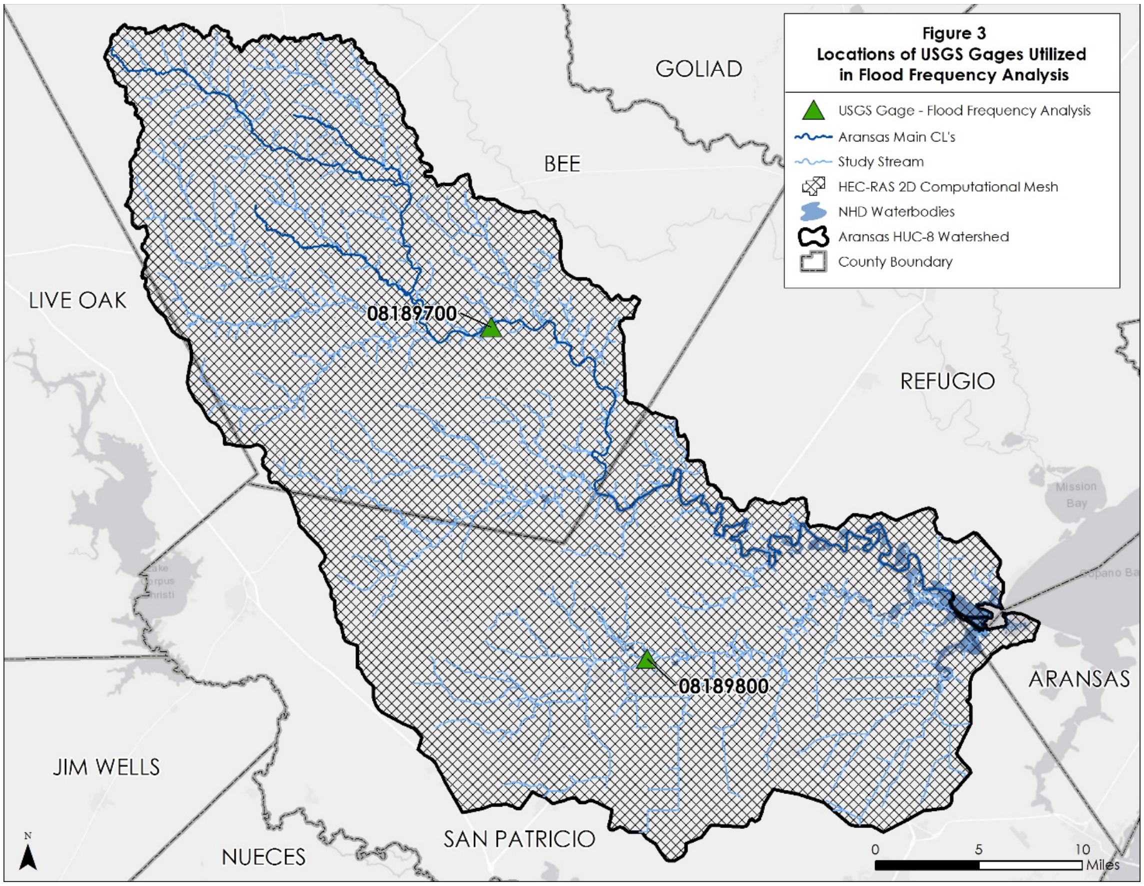

Figure 2.2: HEC-RAS 2D Computational Mesh and USGS Peak Streamflow Gages

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 all sub-basin elements were determined by area-weighted intersection of gridded PFDS data within the study area.

USGS streamflow gage data were leveraged to estimate peak flows for downstream gages within the study 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
08189700	Aransas Rv nr Skidmore, TX	244	1964 – 2016
08189800	Chiltipin Ck at Sinton, TX	139	1971 – 1991

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)
08189700	Aransas River nr Skidmore, TX	71,030	36,090	267,100
08189800	Chiltipin Creek at Sinton, TX	39,850	17,470	223,300

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)
Aransas	74	1,049

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. 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
Aransas	4.23	6.09	7.69	9.49	14.40	6.93	12.11

Figure 2.3 shows the hyetographs applied to the 2D computational mesh.

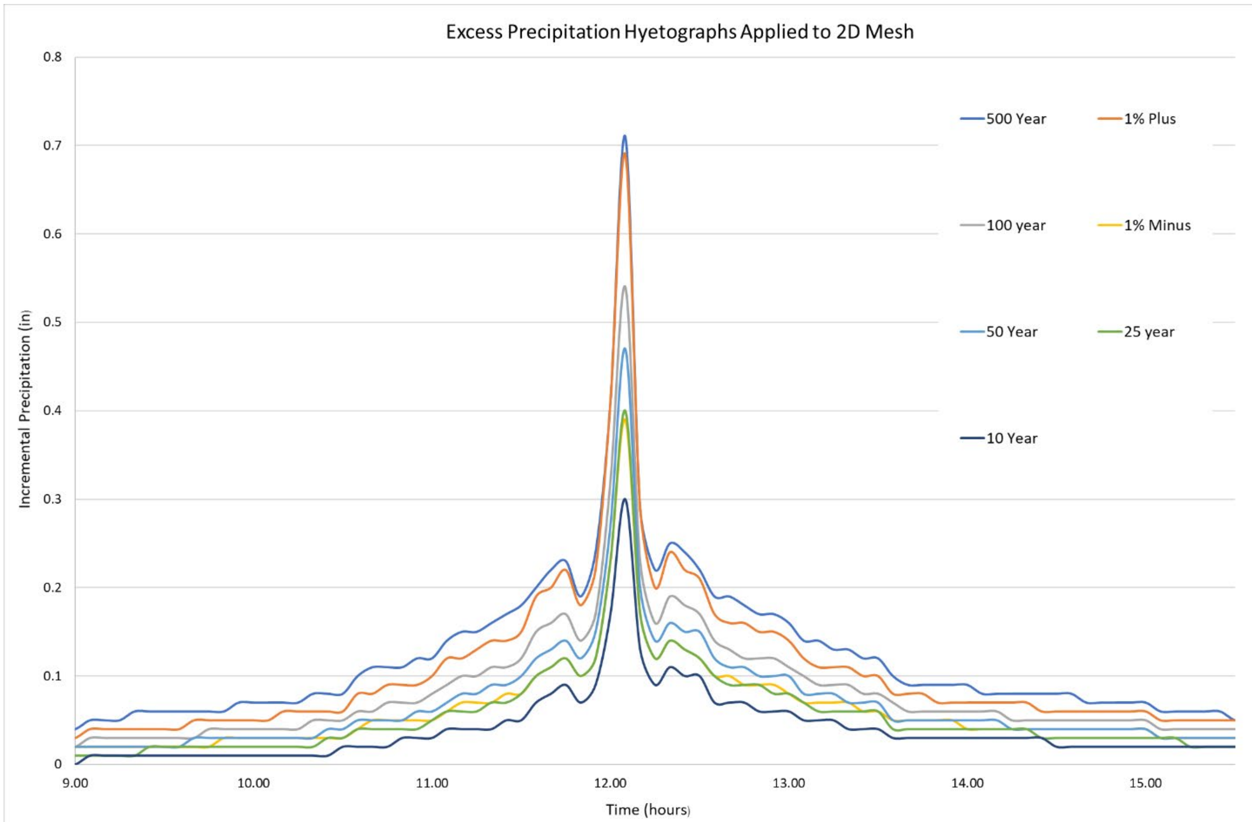

Figure 2.3: Precipitation Hyetographs (post ARF) applied to the Computational Mesh

2.2.3.2 Rainfall-Runoff Hydrograph Boundary Conditions

Inflow Hydrographs were not used in the Aransas 2D BLE Model.

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 20-foot buffer zone was created by automated processes around each stream centerline (mainstem and tributaries) to create a main channel roughness zone. Due to the automated nature of this process, the buffer zone was not varied per stream. The channel roughness zone was given a Manning's n value of 0.030, obtained from the HEC-RAS User's Manual, to ensure the channel 2D cells have 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	0.015	0.025	0.030	0.033	Chow 1959
Developed, Open Space	0.035	0.01	0.013	0.016	Calenda, et al. 2005
Developed, Low Intensity	0.055	0.038	0.050	0.063	Calenda, et al. 2005
Developed, Medium Intensity	0.085	0.056	0.075	0.094	Calenda, et al. 2005
Developed, High Intensity	0.105	0.075	0.100	0.125	Calenda, et al. 2005
Barren Land	0.035	0.025	0.030	0.035	Chow 1959
Deciduous Forest	0.085	0.100	0.120	0.160	Chow 1959
Evergreen Forest	0.085	0.100	0.120	0.160	Chow 1959
Mixed Forest	0.085	0.100	0.120	0.160	Chow 1959
Scrub/Shrub	0.065	0.035	0.050	0.070	Chow 1959
Grassland/Herbaceous	0.035	0.025	0.030	0.035	Chow 1959
Pasture/Hay	0.015	0.030	0.040	0.050	Chow 1959
Cultivated Crops	0.035	0.025	0.035	0.045	Chow 1959
Woody Wetlands	0.085	0.080	0.100	0.120	Chow 1959
Emergent Herbaceous Wetland	0.085	0.075	0.100	0.150	Chow 1959
Main Channel[1]	0.030				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 using ArcGIS were modeled by 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.

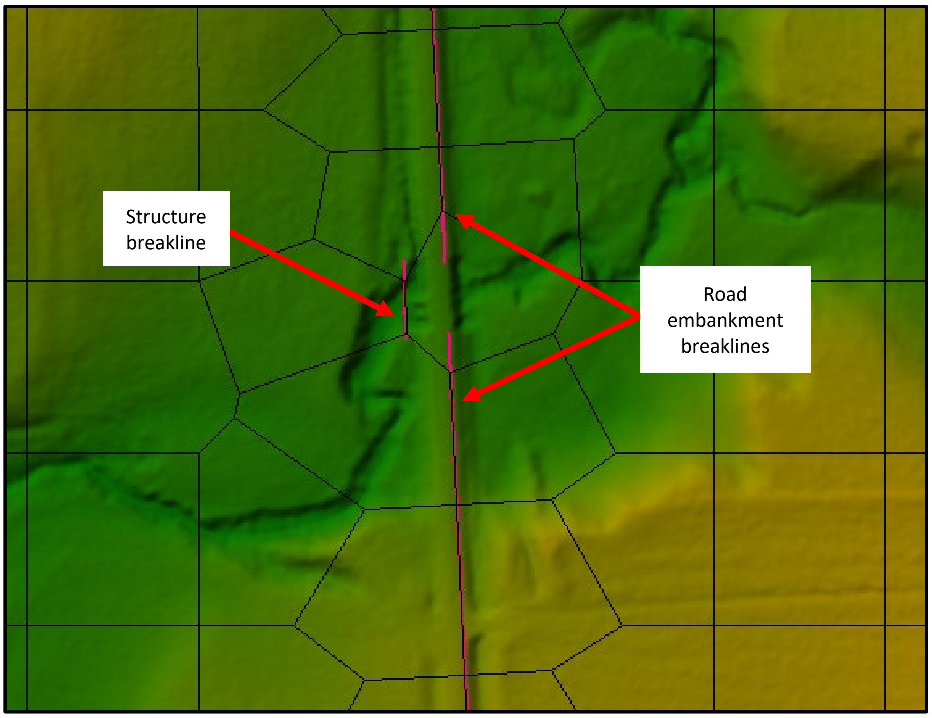

Figure 2.4: Offset Breakline Approach at Bridge Crossing

County, interstate, common name, state recognized, and U.S. roads were incorporated for road breaklines from the ESRI North America Detailed Streets layer. The stream centerlines were input as breaklines to ensure cells lined up perpendicular to the stream and to capture stream conveyance. Berms and dams that were visible in the DEM were incorporated as breaklines. Railroads from the TIGER Railroads layer were also incorporated. No levees were present in the study area.

2.2.4.3 Initial Conditions

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

2.2.5 Special Assumptions

The Aransas watershed required special consideration in the selection of an adequate time step. The initial results using a 1-minute time step, yielded computed Courant numbers greater than 2 at several locations and greater than 5 at sporadic locations. Reducing the time step to 30-seconds significantly reduced instances where the Courant number surpassed a value of 2, and instead yielding courant numbers near a value of 1.

Some locations within the watershed required grid cell sizes smaller (i.e. 50-foot minimum) than the nominal 200-foot cell size generally used throughout the watershed. Refinements in mesh cell sizes were generally made to prevent leakage where terrain features (e.g. roads, berms, centerlines) were in a spatial proximity less than 200-feet. Furthermore, engineering judgement was used to determine adequate mesh cell sizes at special locations with greater topographic complexity.

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 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 as a regulatory product.

Table 2.9: Effective and Model BFE Comparison

Stream	Comparison Point Effective Station	Effective BFE (feet)	Model BFE (feet)	Difference (feet)
Chiltipin Creek	4482	47.6	46.1	1.5
Chiltipin Creek	9008	48.5	49.0	0.5
Peters Swale	2475	70.7	70.7	0
Peters Swale	2737	72.5	71.44	1.06

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 and EMA Analysis of the gage data using PeakFQ 7.2. Results of the flow comparisons are presented in Table 2.10. Priority was given to the Chiltpin River gage. This was due to wider confidence bands on the Aransas River gage as well as location issues of the gage, not allowing for a reasonable comparison to the gage flows.

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)**
Aransas River	08189700	118.50	147,800	112.24	71,030

Flooding Source	USGS Gage Used for Verification	HEC-RAS 5.0.7 (2D)		Reference	
		WSEL (ft)	Discharge (cfs)	WSEL (ft) [1]	Discharge (cfs)
Chiltipin River	08189800	46.08	38,750	33.20	39,850

[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 and Table 2.12 summarizes the results of each run at each of the USGS gages.

Table 2.11: Sensitivity Analysis Results at USGS Gage 08189700

Iteration	Manning's N Zones	Breaklines[1]	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions	Peak Flow (cfs)	Peak Elevation (ft)	Volume[2] (ac-ft)
1	Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	111,100	119.32	119,854
2	Original Land Use with Cultivated Crops=0.025	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	111,100	119.32	119,883
3	Original Land Use with Pasture/Hay=0.03	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	121,050	119.2	120,123
4	Decrease all Manning's N by 0.01	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	137,800	118.87	120,535
5[4]	Decrease all Manning's N by 0.015	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	147,800	118.5	120,746
6	Decrease all Manning's N by 0.02	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	160,550	118.17	120,967
					Gage Analysis:	71,030	112.24[5]	

[1] All iterations included breaklines for roads and centerlines.
[2] Sensitivity Runs were completed to pass the peak flow and elevations, and do not capture the full volume of the hydrograph.
[3] Normal depth boundary conditions used except directly next to inflow boundaries in low lying areas due to some of the flow immediately leaving the model.
[4] Parameters from Iteration 5 were used for the final model, however additional computational mesh was implemented following the results of the sensitivity analysis.

[5] Water surface elevation is approximate based on PeakFQ input data.

Table 2.12: Sensitivity Analysis Results at USGS Gage 08189800

Iteration	Manning's N Zones	Breaklines[1]	Hydrologic Losses	Initial Conditions/ Computational Interval	Boundary Conditions	Peak Flow (cfs)	Peak Elevation (ft)	Volume[2] (ac-ft)
1	Original Land Use	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	22,650	47.68	49,815
2	Original Land Use with Cultivated Crops=0.025	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	24,300	48.43	46,071
3	Original Land Use with Pasture/Hay=0.03	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	27,650	46.89	53,920
4	Decrease all Manning's N by 0.01	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	33,900	46.42	55,901
5[4]	Decrease all Manning's N by 0.015	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	38,750	46.08	57,060
6	Decrease all Manning's N by 0.02	Major Roads w/Centerlines Enforced	Excess Precipitation	Dry / 30sec	Stage Hydrograph, Normal Depth	44,950	45.65	58,372
					Gage Analysis:	39,850	33.20[5]	

[1] All iterations included breaklines for roads and centerlines.
[2] Sensitivity Runs were completed to pass the peak flow and elevations and do not capture the full volume of the hydrograph.
[3] 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.
[4] Parameters from Iteration 5 were used for the final model, however additional computational mesh was implemented flowing the results of the sensitivity analysis.
[5] 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 and throughout the watershed, though sufficient data was available to provide confidence in the results. Within the watershed, there are two distinct terrain types: high ground with distinct channels mainly in the northern half of the watershed and low, flat ground at the southern portion. There exists gage data for only one location within each region (northern and southern). The Aransas River gage is in the northern region, and the Chiltipin Creek gage is in the southern region. As shown in section 2.3.1, while the Chiltipin Creek gage discharges closely resemble the model peak discharge results, the Aransas River gage does not. The difference in terrain may suggest that further refinements in mesh cell size and/or time step may yield better results for the northern region of the watershed.

Basin interflows were investigated but none were found for this HUC.

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 2.5 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.

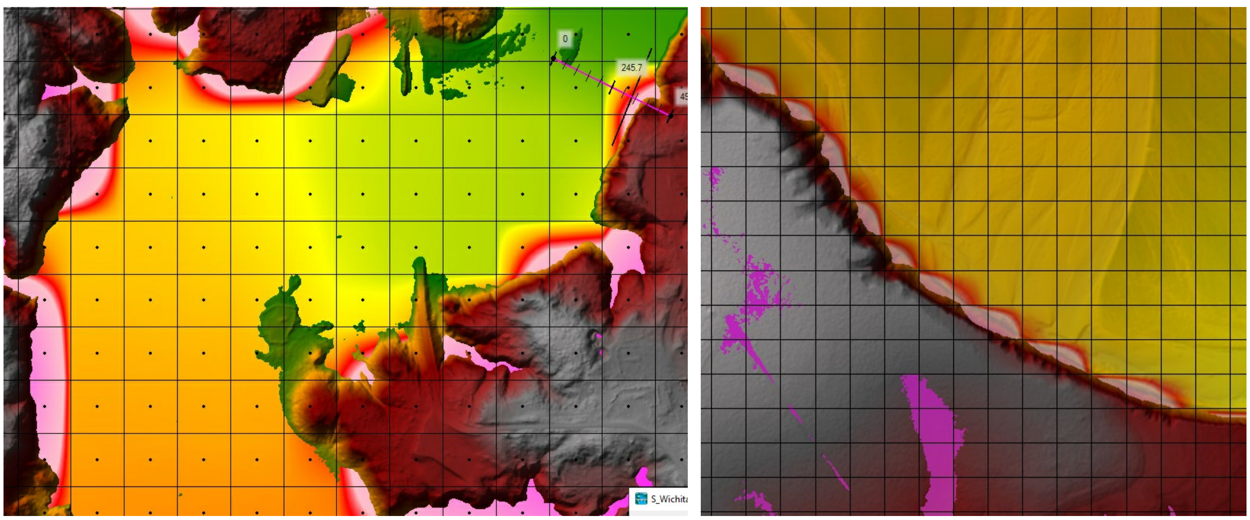

Figure 2.5: Cupping Examples

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. To represent the desired model results and eliminate extraneous disconnected cells, post processing of the depth grids is required. For the purposes of the Aransas 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 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 0.33 acres. For example, if flooding polygons were disconnected from a flooding source and less than 0.33 acres, the polygon was removed from the SFHA. Flood polygon less than 0.33 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 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 Aransas 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. 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 Aransas Watershed was completed by evaluating percentage of urban change at the HUC-12 level. The entire watershed is classified as rural, and all reaches were set to PASS this assessment. Table 3.1 presents the summarized results of checks A1 through A3.

Table 3.1: 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	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 Aransas Watershed, check A4 has been marked as PASS for all HUC 12s.

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 Aransas 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 859 total miles of available CNMS features representing the effective Zone A studies were categorized as shown in Tables 3.2, 3.3 and illustrated in Figure 3.1. Table 3.3 summarizes the validation results based on the individual HUC 12 watersheds within the Aransas Watershed.

Table 3.2: Aggregated Zone A Validation Results

Validation Status	Status Type	Total Miles
ASSESSED	BEING STUDIED	503
UNVERIFIED	TO BE STUDIED	320
VALID	NVUE COMPLIANT	36

Table 3.3: HUC 12 Zone A Validation Results

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	Pass/Fail
Watershed Name	Watershed Number					
All	**All Streams**	**839,715**	**25,811**	**813,904**	**97%**	**Pass**
Aransas River	121004070401	43,451	1,099	42,352	**97%**	**Pass**
Boggy Creek-Aransas River	121004070206	35,260	946	34,314	**97%**	**Pass**
Bullshead Creek	121004070202	36,481	787	35,694	**98%**	**Pass**
Corrigan Hole-Aransas River	121004070205	20,947	237	20,710	**99%**	**Pass**
Headwaters Chiltipin Creek	121004070301	40,032	586	39,446	**99%**	**Pass**
Lower Aransas Creek	121004070106	20,709	355	20,354	**98%**	**Pass**
Lower Papalote Creek	121004070203	48,349	876	47,473	**98%**	**Pass**
Lower Poesta Creek	121004070103	29,039	833	28,206	**97%**	**Pass**
Mud Flats-Aransas River	121004070404	17,099	732	16,367	**96%**	**Pass**
Olmos Creek	121004070105	31,367	484	30,883	**98%**	**Pass**
Peters Swale-Chiltipin Creek	121004070302	32,652	1,060	31,592	**97%**	**Pass**
Plymouth Gas and Oil Field-Lower Chiltipin Creek	121004070305	60,825	2,185	58,640	**96%**	**Pass**
South Fork Moody Creek-Aransas River	121004070402	56,714	1,992	54,722	**96%**	**Pass**
Spring Creek-Aransas River	121004070204	28,615	1,013	27,602	**96%**	**Pass**
Taft Drainage Ditch	121004070403	65,113	3,510	61,603	**95%**	**Pass**
Talpacate Creek	121004070102	27,090	1,251	25,839	**95%**	**Pass**
Town of Sinton-Chiltipin Creek	121004070304	56,924	3,268	53,656	**94%**	**Fail**
Town of St Paul-Chiltipin Creek	121004070303	66,768	1,214	65,554	**98%**	**Pass**
Upper Aransas Creek	121004070104	29,405	791	28,614	**97%**	**Pass**
Upper Papalote Creek	121004070201	55,080	1,109	53,971	**98%**	**Pass**
Upper Poesta Creek	121004070101	37,795	1,483	36,312	**96%**	**Pass**

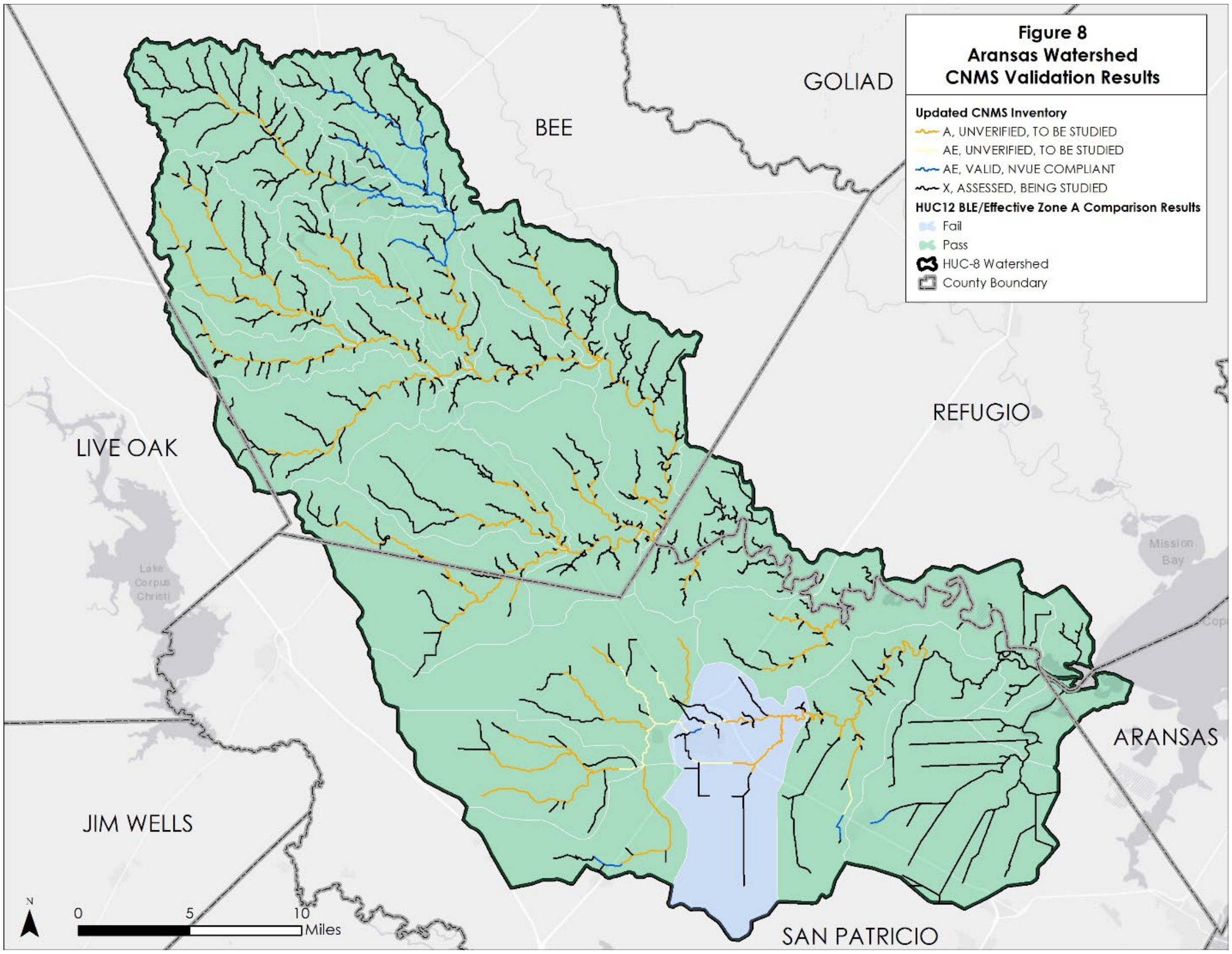

Figure 3.1: Aransas Watershed CNMS Validation Results

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 3.4, 3.5 and 3.6.

Table 3.4: Hazus 4.2 (SP02) Results for 1-percent-annual-chance (100 year) scenario for Aransas Watershed, Texas

County	Full Replacement – Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Bee	197	5,941	2,969
Live Oak	356,352	2,041,720	1,302,840
San Patricio	25	4,688	2,346
Aransas	3,386	33,624	18,455
Refugio	284,827	1,353,678	803,531
Total	**644,787**	**3,439,651**	**2,130,141**

Table 3.5: Hazus 4.2 (SP02) Results for 1-percent-annual-chance (100 year) coastal scenario for Aransas Watershed, Texas

County	Full Replacement – Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Aransas	135	5,424	2,711
Total	**135**	**5,424**	**2,711**

Table 3.6: Hazus 4.2 (SP02) Results for 1-percent-annual-chance (100 year) riverine and coastal scenarios for Aransas Watershed, Texas

County	Full Replacement – Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Aransas	332	11,365	5,680
Bee	356,352	2,041,720	1,302,840
Live Oak	25	4,688	2,346
Refugio	3,386	33,624	18,455
San Patricio	284,827	1,353,678	803,531
Total	**644,922**	**3,445,075**	**2,132,852**

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