El Paso County, TX: 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. Although the cost for developing the data and estimates resulting from the BLE process should be lower than standard flood production costs, the El Paso 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.

In an effort to increase and enhance the flood risk products in Texas, FEMA Region VI contracted the Compass PTS JV to perform BLE for El Paso County. This report documents the BLE process, products, and results for this watershed. Figure 1 depicts the El Paso County footprint. Figure 2 depicts the El Paso County HEC-RAS 2D model areas.

Figure 1: El Paso County BLE

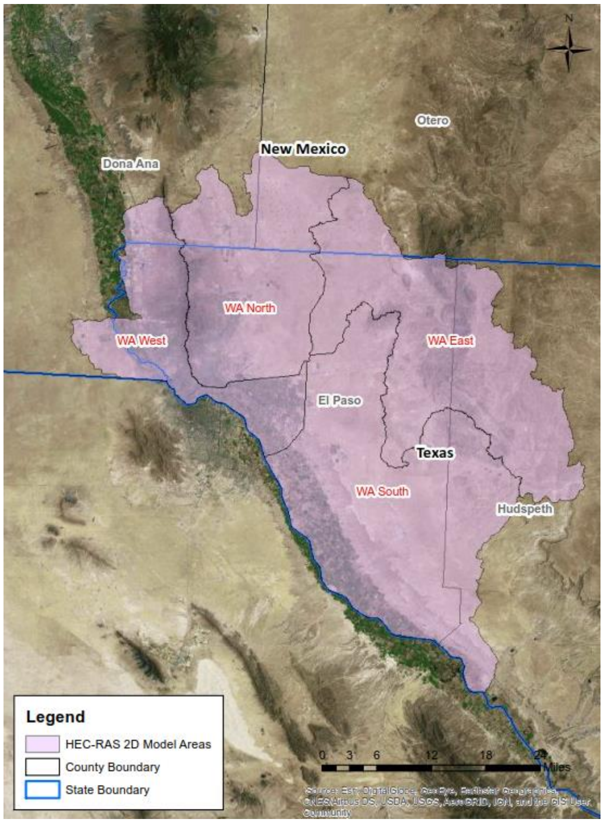

Figure 2: El Paso County HEC-RAS 2D Model Areas

02 2D BLE Modeling Inputs and Controls

Section 2 presents fundamental components required to execute a 2-dimensional (2D) hydraulic engineering analysis for El Paso County. Inputs such as elevation data, hydrology from rain-on-grid and inflow hydrographs, and hydraulic analyses and variables are defined herein.

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 El Paso 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 5 foot DEM developed to support the 2D BLE modeling and analysis, within El Paso County, was executed using the following steps:

1. Available elevation data for the project area were inventoried and collected.
2. Leverage 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 leverage 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 El Paso County.

2.1.1 Inventory

An inventory of existing topographic data was conducted for the El Paso BLE project footprint. Figure 3 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.

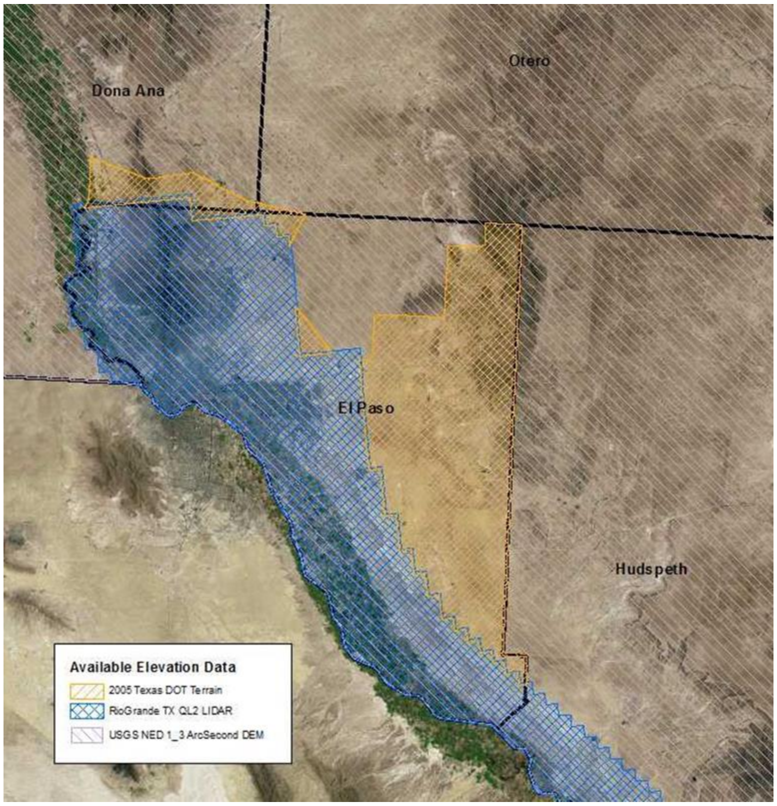

Figure 3: El Paso BLE Source Terrain

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 leverage 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

Level of Flood Risk	Typical Slopes	Specification Level	Vertical Accuracy*	LiDAR Nominal Pulse Spacing (NPS)
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 El Paso 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 El Paso County

Year	Description	Data Type	RMSE	Source/Owner
2015	Rio Grande TX QL2 LiDAR	Airborne LiDAR	5.3 cm	USGS
2005	TxDOT Photogrammetry	DEM from Contours	83.5 cm	TxDOT
2013	NED 10 meter	DEMs		USGS

2.1.2.1 El Paso County Source Terrain Data

The primary source elevation data for El Paso County are DEMs derived from the Rio Grande QL2 LiDAR collection. 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. Table 2 lists the source data used to compile the engineering DEM for El Paso County. Figure 3 depicts the extent of the data defined in Table 2 while **Error! Reference source not found.** shows the DEM used to conduct this analysis.

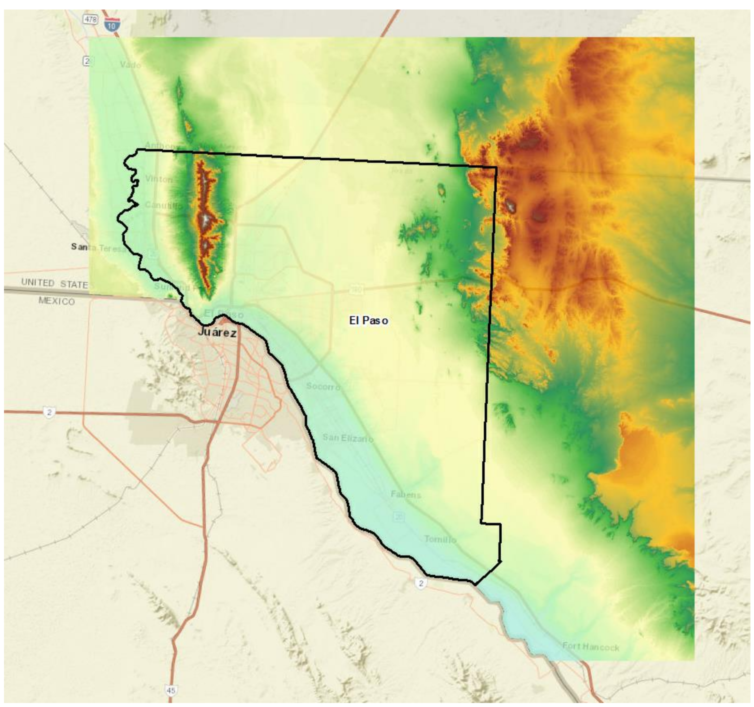

Figure 4: El Paso County BLE DEM

2.1.2.1.1 2015 Rio Grande Texas QL2 LiDAR

The FEMA Region 6 TX - Rio Grande and Fort Whitman Watershed QL2 LiDAR project called for the Planning, Acquisition, processing and derivative products of LIDAR data to be collected at a nominal pulse spacing (NPS) of 0.7 meter. Project specifications are based on the U.S. Geological Survey National Geospatial Program Base LIDAR Specification, Version 1. The data was developed based on a horizontal projection/datum of NAD83, UTM Zone 13, Meters and vertical datum of NAVD1988 (GEOID12A), Meters. LiDAR data was delivered in RAW flight line swath format, processed to create Classified LAS 1.2 Files formatted to 6 individual 1500m x 1500m tiles for the pilot (995 individual 1500m x 1500m tiles), and corresponding Intensity Images and Bare Earth DEMs tiled to the same 1500m x 1500m schema, and Breaklines in Esri shapefile format. The geographical extent includes Rio Grande and Fort Whitman Watershed in Texas, covering approximately 754 square miles.

2.1.2.1.2 2005 TXDOT Photogrammetry

2005 Texas DOT Terrain was acquired in Fall 2004 with a publication date of March 3, 2005. The vertical accuracy reported for the 2005 Texas DOT Terrain is 2.7406 feet at the 95% confidence level.

2.1.2.1.3 2013 USGS NED 10m

The National Elevation Dataset (NED), a product of the USGS, is a seamless gridded dataset representing the best available raster elevation data available to the USGS for the conterminous United States, Alaska, Hawaii, and territorial islands. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. The NED serves the El Paso County topographic data development by filling in as best available data where there are gaps in the data sets listed above. The NED extent for El Paso County Texas is represented in Figure 3.

2.1.3 Data Development Methodology

The source topographic data were processed for an area covering the El Paso County and contributing drainage areas for the El Paso BLE modeling efforts. The topographic data for El Paso was projected horizontally, as needed, to North American Datum of 1983 (NAD83), State Plane Coordinate System (SPCS) Texas Central in feet (4203-SPC83). 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 El Paso 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

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.

The final DEM data developed for El Paso are assured to meet FEMA standards and present a representative surface developed from leverage 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. For this study, HEC-RAS 5.0.3 (RAS 5) was used for hydraulic calculations.

2.2.1 2D Computational Mesh and Settings

The RAS 5 2D computational mesh was created for El Paso County using ArcGIS toolsets, such as smoothing and simplification routines, ultimately significantly reducing the need for manual edits to mesh cells within RAS 5 that happen to generate errors. The 2D mesh for the El Paso County was divided into four work areas totaling 731,585 cells and a 250 foot nominal mesh cell size. Smaller cell sizes were utilized near boundary condition lines to ensure water surface elevation tie-ins to downstream work areas. Computational time steps were 15-seconds in the RAS 5 model, applying the Diffusion Wave (simplified Full Momentum) equations.

2.2.2 Model and Boundary Condition Setup

Using RAS 5 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 El Paso County, inflow hydrographs were used to transfer flows from upstream work areas to downstream work areas. In addition to the inflow hydrographs (where applicable), excess precipitation is applied to the 2D mesh for each RAS 5 model area. Figure 5 below shows the 2D computational mesh for this project, along with locations where inflow hydrographs were applied.

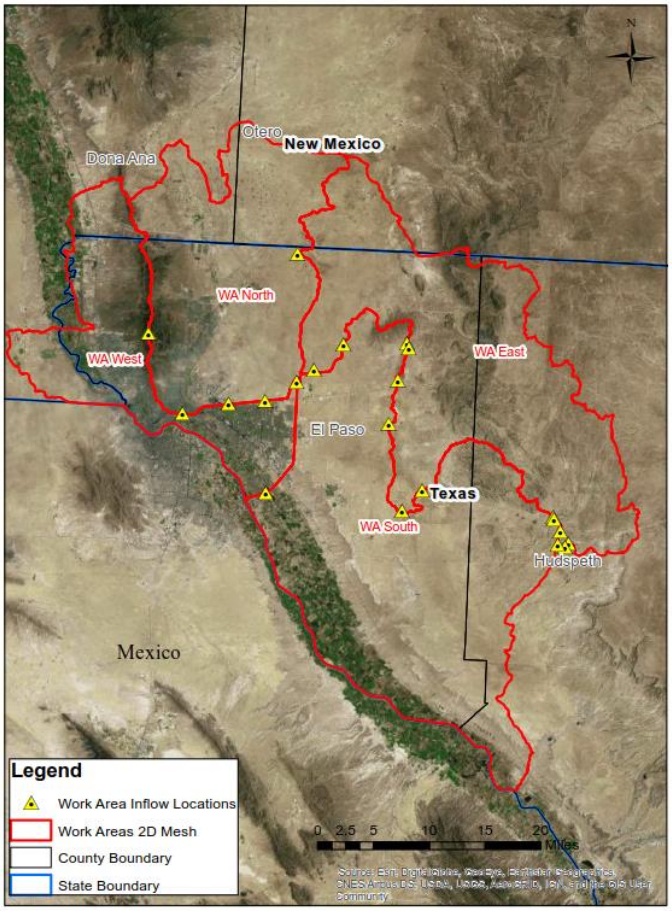

Figure 5: RAS 5 2D Mesh and Inflow Boundary Conditions

The development of inflow hydrographs and 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 work area boundaries without an inflow boundary condition. 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. Normal depth was used for all outflow boundary conditions using approximate energy grade-line slopes estimated from the LiDAR terrain data.

2.2.3 Hydrology

Precipitation data for this study were taken from a combination of extrapolated National Oceanic and Atmospheric Association's (NOAA) Precipitation Frequency Data Server and depth-duration frequency data provided by the City of El Paso Drainage Design Manual. Appropriate values for all sub-basin elements were determined considering spatial variation and a representative total for each particular sub-basin. Inflow hydrograph boundary conditions to the 2D mesh were transferred from upstream work areas to downstream work areas. In addition, there were no USGS streamflow gages within the model areas, therefore, no gage analyses were performed for the models.

2.2.3.1 Excess Precipitation for 2D Computational Mesh

HEC-HMS version 4.1 was used to apply the SCS Curve Number method to calculate losses and define excess precipitation for each model work area. Temporal distributions of point rainfall totals were defined using 24-hour, SCS Type II storm distributions. The 1% plus and minus storm event precipitation values were found by using a 68% confidence interval on the baseline 1% event. Table 3**Error! Reference source not found.** shows the precipitation total depths (without an areal reduction factor (ARF) applied) for the sub-basin elements representing drainage areas to (and within) the 2D computational mesh.

Table 3: Precipitation Totals for Sub-basin Elements of Inflow Drainage Areas to 2D Mesh (no ARF)

Model Area	Percent Annual Chance Precipitation Total (in)						
	10	4	2	1	0.2	1% Minus	1% Plus
East	2.58	3.20	3.66	4.15	5.43	3.76	4.55
North	2.29	2.81	3.21	3.66	4.72	3.33	4.00
West	2.37	2.99	3.52	4.11	5.79	3.73	4.50
South	2.40	3.03	3.40	3.90	5.00	3.54	4.27

An areal reduction factor (ARF) is generally defined as the ratio of the mean precipitation depth over a watershed resulting from a storm to the maximum point depth of the storm. ARF's range from 0.0 to 1.0, and vary according to storm characteristics such as watershed size, shape, and geographic location. For this study, areal reduction factors were calculated for each contributing HUC-12 watershed in El Paso County and then grouped and averaged for each of the four work areas. The grouping of the HUC-12 watersheds into the four work areas was based on geographic location and precipitation values. Table 4**Error! Reference source not found.** summarizes the average ARFs for each modeled work area. However, it was determined that areal reduction factors would not be used for this study. Based on models results, the averaged areal reduction factors were considered too general for this BLE study and would not be appropriate for the smaller flowpaths within the work areas. Areal reduction factors will be considered for future detailed study.

Table 4: Summary of Averaged Areal Reduction Factors

Model Area	Area (mi^2)	Averaged Areal Reduction Factor (ARF)
East	453.5	0.7986
North	333.2	0.7564
West	219.1	0.7941
South	577.3	0.7487

Initial Curve Numbers (i.e., prior to calibration) were computed by intersecting the National Land Cover Dataset (NLCD) 2011 coverage and NRCS soils data based on the matrix presented in Table 5.

Table 5: Landuse-Soils-CN Matrix for Computing Initial Curve Numbers

Land Use (LU) GridCode	NLCD LU Description	Hydrologic Soil Group			
		A	B	C	D
11	Open Water	98	98	98	98
21	Developed Open Space	49	69	79	84
22	Developed Low Intensity	61	75	83	87
23	Developed Medium Intensity	77	85	90	92
24	Developed High Intensity	89	92	94	95
31	Barren Land	68	79	86	89
41	Deciduous Forest	36	60	73	79
42	Evergreen Forest	36	60	73	79
43	Mixed Forest	36	60	73	79
52	Shrub Scrub	55	72	81	86
71	Herbaceous	49	62	74	85
81	Hay Pasture	39	61	74	84
82	Cultivated Crops	64	75	82	85
90	Woody Wetlands	30	55	70	77
95	Emergent Herbaceous Wetlands	30	55	70	77

Antecedent Runoff Condition (ARC) II Curve Numbers (CN's) were used for all baseline recurrence interval storm events, while ARC III CN's were used for the 1% plus event and ARC I CN's were used for the 1% minus event. Table 6 provides the initial CNs used for determining excess precipitation.

Table 6: Curve Numbers Input into HMS Models

Model Area	Initial CN's ARC II	1% Plus CN's ARC III	1% Minus CN's ARC I
East	75	85	61
North	71	83	56
West	81	89	69
South	71	83	56

The following figures show the final excess precipitation hyetographs applied to the 2D computational mesh.

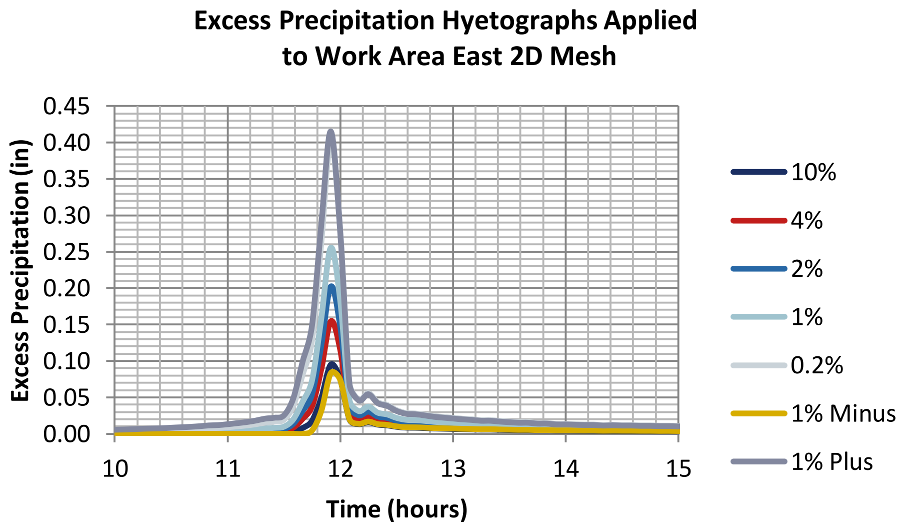

Figure 6: Excess Precipitation Hyetographs (post ARF) Applied to the 2D Mesh – WA East

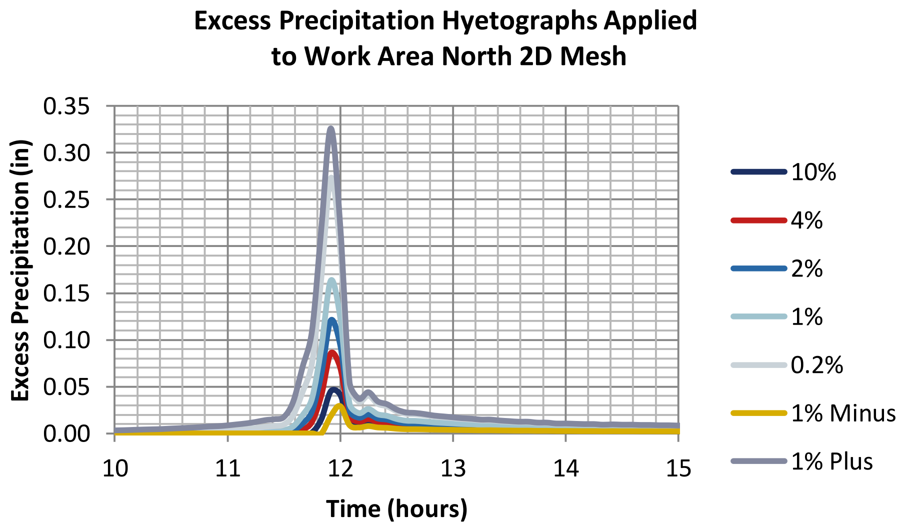

Figure 7: Excess Precipitation Hyetographs (post ARF) Applied to the 2D Mesh –WA North

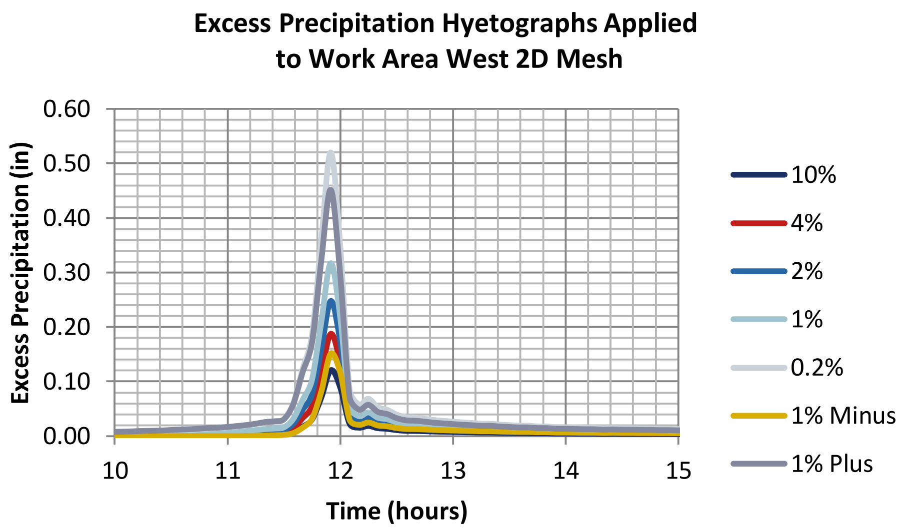

Figure 8: Excess Precipitation Hyetographs (post ARF) Applied to the 2D Mesh - WA West

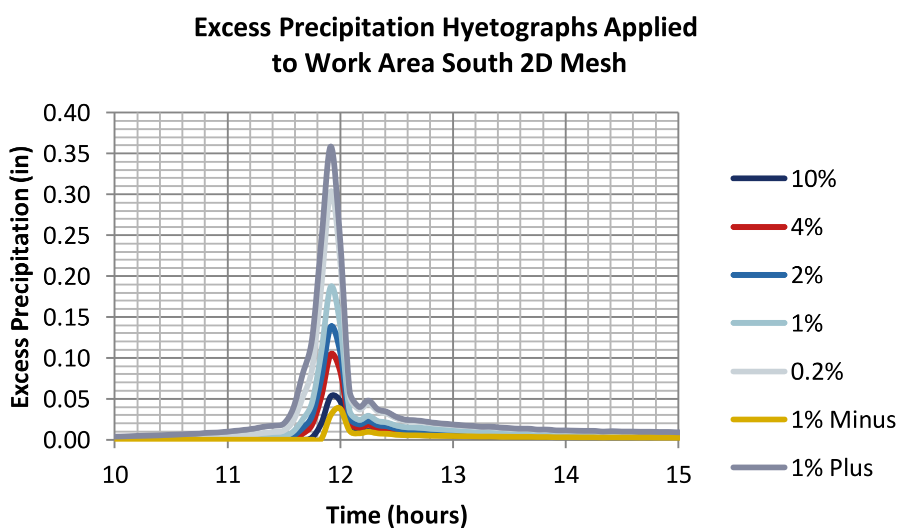

Figure 9: Excess Precipitation Hyetographs (post ARF) Applied to the 2D Mesh – WA South

The following figure shows the 1% annual chance inflow hydrographs applied to the model area for each contributing boundary condition applied to the 2D computational mesh. Inflow hydrographs with insignificant peak flows below 250 cfs or continuous boundaries rather than obvious riverine outflows have not been included in the following figure. Inflow hydrographs were also applied to all model areas for the other modeled recurrence intervals.

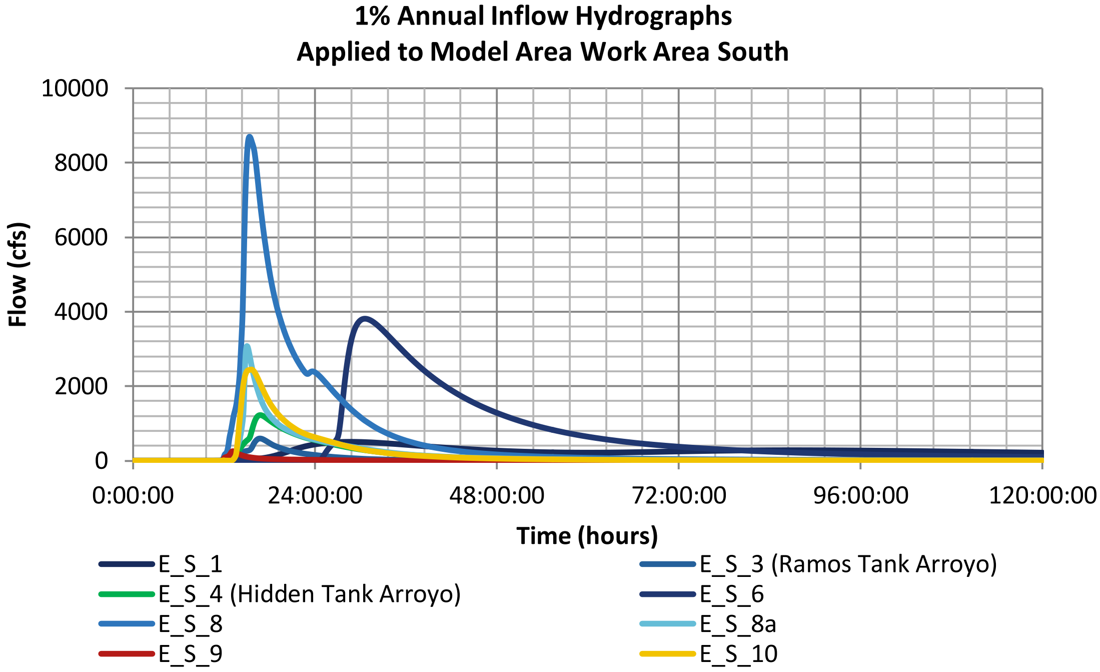

Figure 10: 1% Annual Chance Contributing Drainage Area Inflow Hydrographs applied to WA South

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

Manning's n roughness coverage was developed for the 2D computational mesh using typical values for roughness for given NLCD land classifications. The table below shows a typical landuse-roughness matrix used in defining the roughness coverage for the study area.

Table 7: NLCD 2011-Manning's N Roughness Matrix

NLCD Classification	Minimum	Normal	Maximum	Source
Open Water	0.025	0.03	0.033	Chow 1959
Developed, Open Space	0.01	0.013	0.016	Calenda, et al. 2005
Developed, Low Intensity	0.038	0.05	0.063	Calenda, et al. 2005
Developed, Medium Intensity	0.056	0.075	0.094	Calenda, et al. 2005
Developed, High Intensity	0.075	0.1	0.125	Calenda, et al. 2005
Barren Land	0.025	0.03	0.035	Chow 1959
Deciduous Forest	0.1	0.12	0.16	Chow 1959
Evergreen Forest	0.1	0.12	0.16	Chow 1959
Mixed Forest	0.1	0.12	0.16	Chow 1959
Scrub/Shrub	0.035	0.05	0.07	Chow 1959
Grassland/Herbaceous	0.025	0.03	0.035	Chow 1959

NLCD Classification	Minimum	Normal	Maximum	Source
Pasture/Hay	0.03	0.04	0.05	Chow 1959
Cultivated Crops	0.025	0.035	0.045	Chow 1959
Woody Wetlands	0.08	0.1	0.12	Chow 1959
Emergent Herbaceous Wetland	0.075	0.1	0.15	Chow 1959

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. Road embankments were defined in GIS and imported into RAS 5 as breaklines to ensure that water was not routed past roads without passing through a structure 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. This approach was used for most hydraulic structures because it could be implemented in GIS on a large scale with much less effort than alternative methods. An example of the offset breakline approach is shown below.

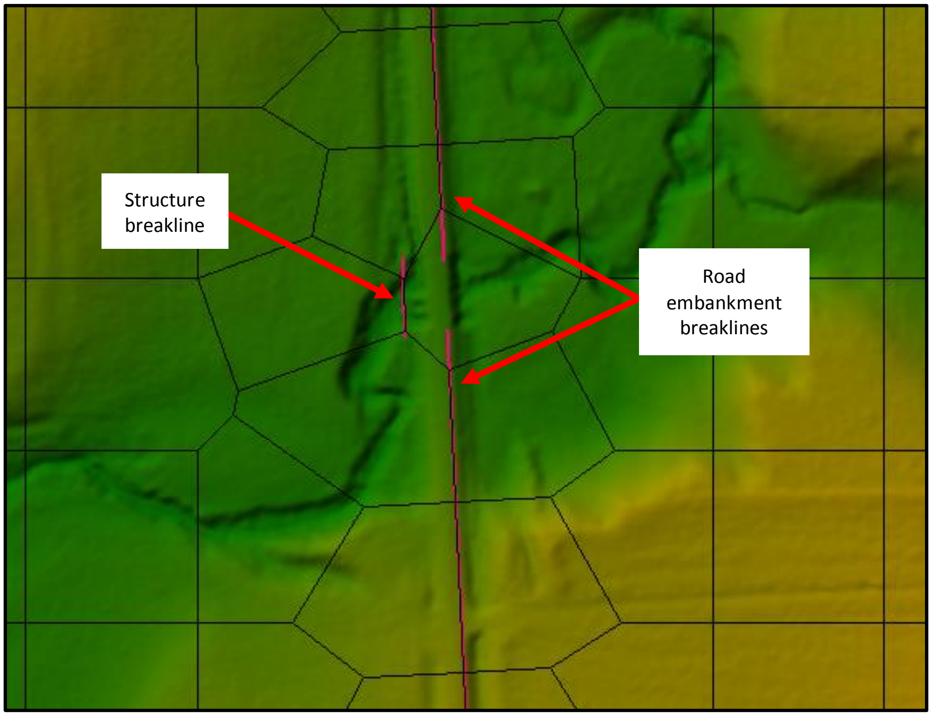

Figure 11: Offset Breakline Approach at Bridge Crossing

2.2.5 Model Results

The 2D BLE results for the study produced a Special Flood Hazard Area (SFHA) that was reasonable, but generally thinner than the effective CoreLogic data. In comparison to the FLO-2D model created by JE Fuller, the 2D BLE results produced a SFHA that compared well to that model. In addition, the 2D BLE results provide additional estimated SFHA in areas that have not been studied. 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.

2.2.5.1 Calibration

Due to the lack of peak streamflow record, calculated discharges were not able to be calibrated to historic data. However, results were compared with the effective data and the JE fuller FLO-2D model results throughout the modeling process.

2.3 Challenges

Major challenges included a lack of peak streamflow record, though sufficient data was available to provide confidence in the results. Most of the gages in the El Paso County have limited period of records. The terrain datasets available for El Paso County presented a challenge. For areas where only the NED data was available, the terrain data was not considered accurate enough to be included in the study. In addition, the transitions between the different terrain datasets required smoothing in order to effectively model runoff for any given area contributing to a downstream area. The smoothing process required using GIS tools to interpolate the terrain between datasets resulting in a better floodplain mapping transition between datasets as shown below in Figure 14.

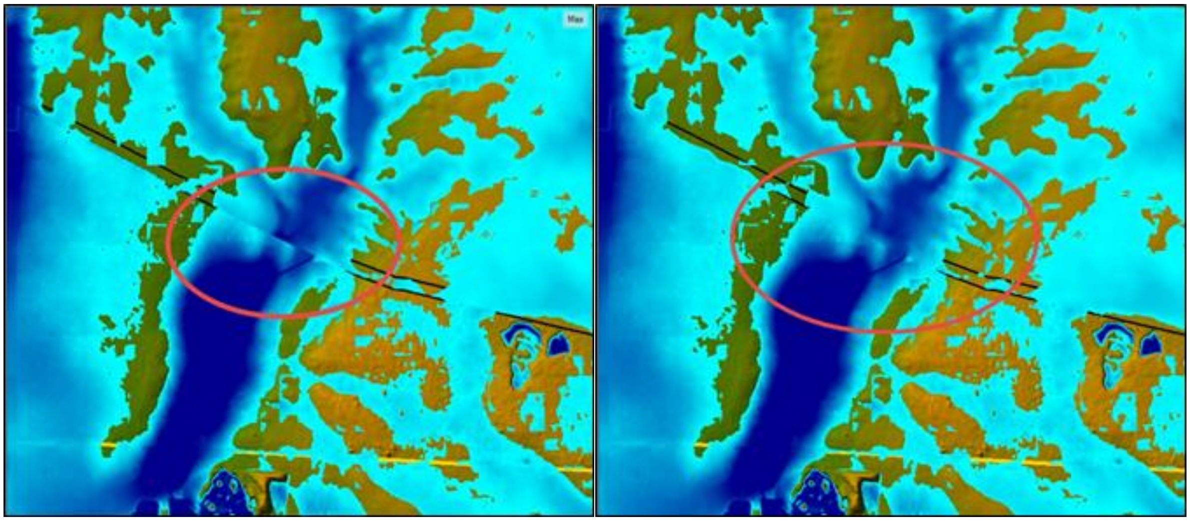

Figure 12: Mapping on Original Terrain Dataset (left) and on Smoothed Terrain Dataset (right)

Another challenge included tie-ins between work areas. Inflow hydrographs were used to transfer flow from upstream work areas to downstream work areas. However, adjustments to the normal depths, work area boundaries, and cell sizes were made to ensure that there were consistent water surface elevations between work areas.

2.4 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 could enhance end products and the transformation to regulatory flood hazard areas. Some suggestions for model refinement include adding further detail to structures in the study area, updating and refining precipitation data, and updating terrain data where available. Additionally, the results presented in this report and the accompanying FEMA data capture technical reference format flood hazard results should be presented and further evaluated through Flood Risk Review meetings before being mapped as special flood hazard area.

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 El Paso 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. 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. 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 El Paso County.

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 El Paso County the effective Zone A topographic data source is unknown, but most likely would have leveraged contours from USGS 24K map products. The topographic data source for the majority of the BLE study area was derived from LiDAR flown for FEMA Region VI in 2014. This elevation data leveraged in the BLE represents a significant improvement from the assumed effective Zone A topographic source and, therefore, approximately 68% of the assessed miles failed 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. The effective approximate hydrology methods are unknown for all effective A Zones except for a reach updated as part of a Letter of Map Revision (LOMR). The reach studied as part of the LOMR did not use regression equations. This resulted in all assessed reaches passing this check.

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. Although the NUCI data provide year-to-year changes in urbanization, the NLCD also is needed to establish a baseline of urban land cover for this analysis. Approximately 84% of the assessed miles fall inside watersheds still classified as rural, so these reaches passed this check. The remainder of the assessed miles are in urban watersheds that have experience greater than a 50% increase in urban area since the effective analysis and, therefore, fail this check.

Table 8 presents the summarized results of checks A1 through A3.

Table 8: A1-A3 Validation Results

Assessment Checks	Pass / Fail	Notes
A1 – Topography	Pass/Fail	No new topo/2015 FEMA R6 LiDAR significantly better than assumed effective USGS topo source.
A2 – Hydrology	Pass	Effective hydro methods unknown. One LOMR reach did not use regression.
A3- Development	Pass/Fail	Less than 15% of study area is under urban cover/>50% increase in urban area.

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 the non-technical engineering methods used in the effective El Paso County studies, check A4 has been marked as failing in CNMS with the exception of the LOMR reach. The LOMR reach is model-backed and passes this check.

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 El Paso County. 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 a combination of data from the National Flood Hazard Layer and the CoreLogic digital uplift product. These data were dissolved to one continuous A-zone layer, which then had points placed along its perimeter every 250 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 act as the vertical tolerance. The point passes if the DEM minimum value is less than or equal to the 1% plus maximum value and the DEM maximum 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 there is 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

Based on 517.2 total miles of available CNMS features representing the effective zone A studies, 491.0 stream miles were categorized as UNVERIFIED, and 26.2 miles categorized as VALID. Total miles in each of these categories are summarized in Table 9 and illustrated in Figure 13 below.

Table 10 summarizes the validation results based on the individual HUC 12 watersheds within El Paso County.

Table 9: Aggregated Zone A Validation Results

Validation Status	Total Miles
VALID	491.0
UNVERIFIED	26.2

Table 10: 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						
El Paso County	All Streams	10,572	5,084	5,693	54%	Fail	
Anthony Wash	130301020802	204	63	141	69%	Fail	27.5
Anthony Wash-Rio Grande	130301020803	22	22	0	0%	Fail	-
Ascarate Lake-Rio Grande	130401000104	515	205	310	60%	Fail	24.4
Avispa Canyon-Rio Grande	130301020804	1141	386	755	66%	Fail	30.0

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>90%)	Priority Score
Watershed Name	Watershed Number						
Borrego Draw-Cottonwood Lake	130401000405	25	17	8	32%	Fail	54.4
City of Santa Teresa	130301020902	2	2	0	0%	Fail	-
Coronodo Hills- Rio Grande	130301020906	620	93	527	85%	Fail	18.5
Coyote Tank	130401000202	159	112	47	30%	Fail	34.7
Daugherty Lateral-Rio Grande	130401000204	632	248	384	61%	Fail	31.4
East Tularosa Valley	130500032105	56	25	31	55%	Fail	24.2
Eighteen Tank	130500032103	319	208	111	35%	Fail	40.8
Franklin Drain-Rio Grande	130401000203	726	469	257	35%	Fail	45.6
Guadalupe Lateral-Rio Grande	130401000406	1422	743	679	48%	Fail	33.4
Hackberry Canyon	130500032102	405	170	235	58%	Fail	34.2
Island Spur Drain-Rio Grande	130401000305	307	154	153	50%	Fail	28.4
La Union-Rio Grande	130301020904	58	40	18	31%	Fail	66.2
Lake Tank	130401000404	318	214	104	33%	Fail	53.8
Mckelligon Canyon	130401000103	380	211	169	44%	Fail	39.9
Mulberry Dam-Rio Grande	130301020905	359	66	293	82%	Fail	7.6
Phoneline Canyon-Fourmile Draw	130401000303	329	149	180	55%	Fail	36.2
Powwow Canyon	130401000302	694	355	339	49%	Fail	43.2
Quirlce Lake	130500032207	242	121	121	50%	Fail	45.0
Ramos Tank	130401000201	302	161	141	47%	Fail	46.8
Rattlesnake Tanks	130401000101	573	274	299	52%	Fail	42.5
San Felipe Arroyo	130401000304	411	164	247	60%	Fail	32.1
West Tularosa Valley	130500032106	15	9	6	40%	Fail	-
Young Lateral-Rio Grande	130401000507	336	198	138	41%	Fail	39.3

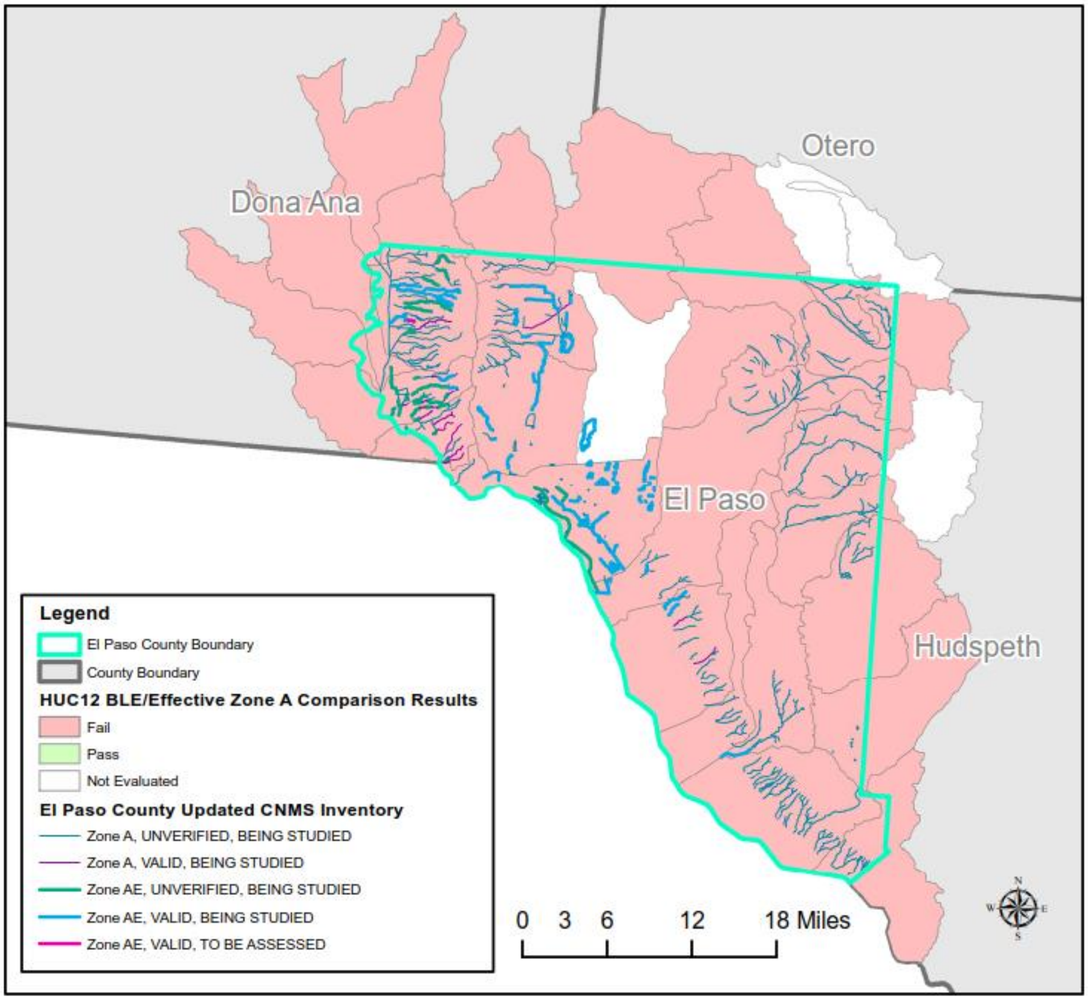

Figure 13: El Paso County CNMS Validation Results

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 14 below shows the range of the El Paso County priority scores. La Union-Rio Grande HUC-12 was determined to have the highest priority score and the most need while Mulberry Dam- Rio Grande HUC-12 has the lowest score. The CNMS comparison and priority scores for the McElroy Well, Monument Tank, New Tank, Coyote Tank (NM), City of Santa Teresa, Anthony Wash-Grande, and West Tularosa Valley HUC-12s were not calculated due to limited FBS points within these watersheds.

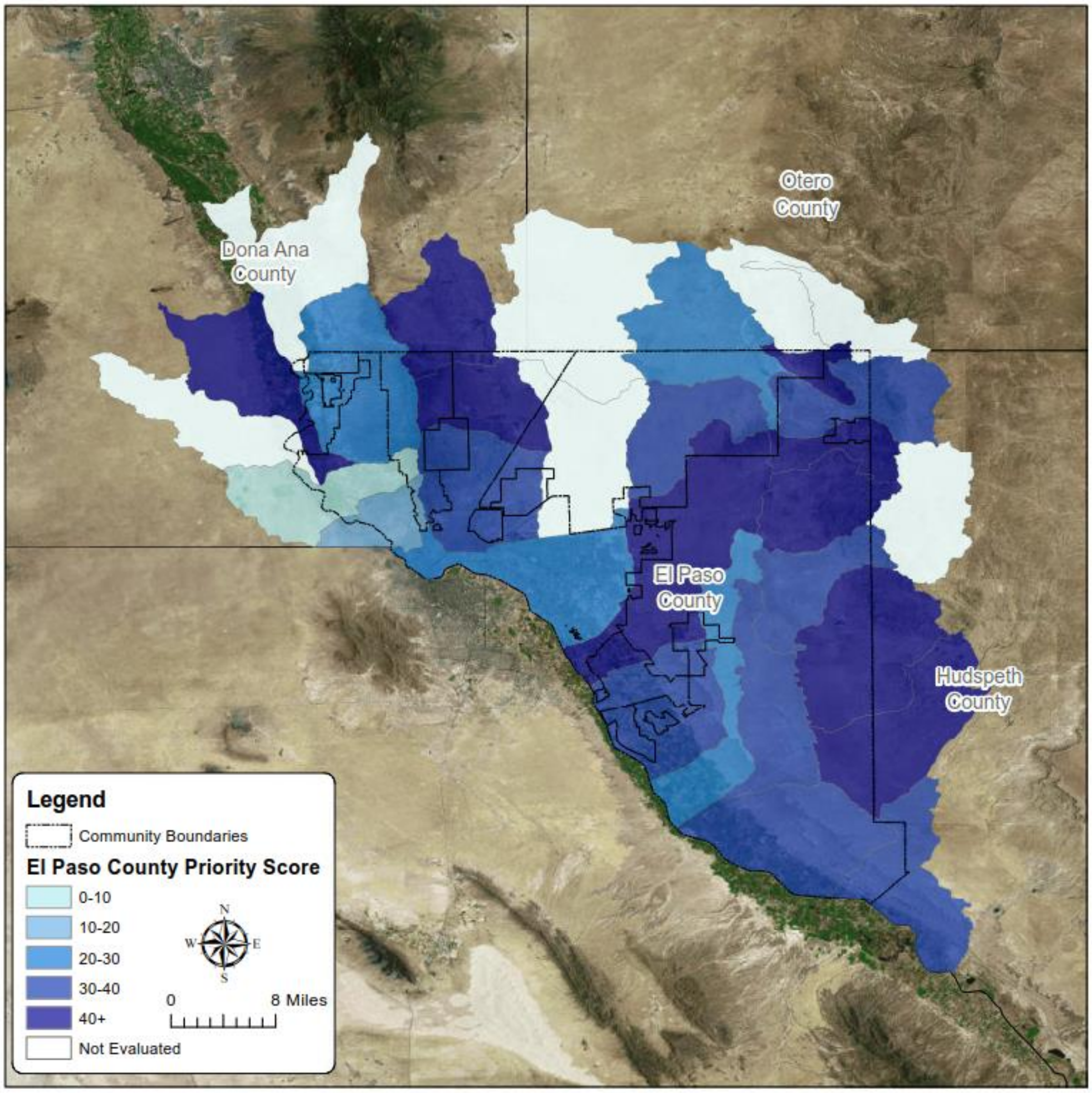

Figure 14: Ranking of El Paso County HUC-12s

3.3 Flood Risk Analysis

A flood risk analysis was performed for this project. The updated 1-percent annual chance grid (known as the 'refined' grid) was used to perform the flood risk analysis to produce the flood losses. The refined grid loss results are stored in the L_RA_Results table.

Hazus version 4.0 was used for the basic and refined loss analysis.

The losses are reported via census blocks. It is important to note that Hazus version 4.0 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.

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Appendix A BLE Map