Elm Fork Trinity Watershed, TX
Base Level Engineering (BLE) Results

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APPROVALS

This document requires the approval of the following persons:

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CLIENT DISTRIBUTION

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FEMA's MIP	Region VI	See path above
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Executive Summary

FEMA Region 6 contracted Compass to complete a Base Level Engineering (BLE) analysis for Area K – North Central (TX), to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHAs). Area K includes the Elm Fork Trinity HUC-8 and Parker County in the Lower West Fork Trinity HUC-8. This report is focused on the Elm Fork Trinity HUC-8 of Area K. This BLE study will provide significant data for several Texas counties previously lacking modernized flood models.

The BLE process involves using best available data and incorporating automated techniques with traditional model development procedures to produce regulatory-quality flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals.

The source digital terrain data used for surface model development in support of hydrologic and hydraulic analysis as well as mapping activities were leveraged from various local, State, and Federal partners. Details regarding the different datasets used are provided below in Section 1.1.

Flood discharges for this study were calculated using both the United States Geological Survey (USGS) regression equations and gage analysis, where stream gages with sufficient record exist. Regression equations were obtained from the USGS Scientific Investigations Report (SIR) 2009-5087, *Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment Based, PRESS-Minimized, Residual-Adjusted Approach* (2009).

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) program version 5.0.7 was used to compute water surface elevations on a stream by stream basis. All hydraulic models were computed using 1-D steady state analysis.

The stream mile network that was validated for these watersheds 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 lists the Zone A stream miles associated with this validation analysis.

Table ES-1: Summary of Stream Miles

Source	Elm Fork Trinity Stream Miles
CNMS	1,148.2

The full inventory of Zone A studies in the watershed were classified in CNMS. Total miles validated in CNMS are summarized in Table ES-2 and illustrated in Figure ES-1 below.

Table ES-2: Zone A Validation Results

Validation Status	Status Type	Total Miles
VALID	BEING STUDIED	412.0
VALID	NVUE COMPLIANT	4.9
UNVERIFIED	BEING STUDIED	726.7
UNKNOWN	BEING STUDIED	4.6

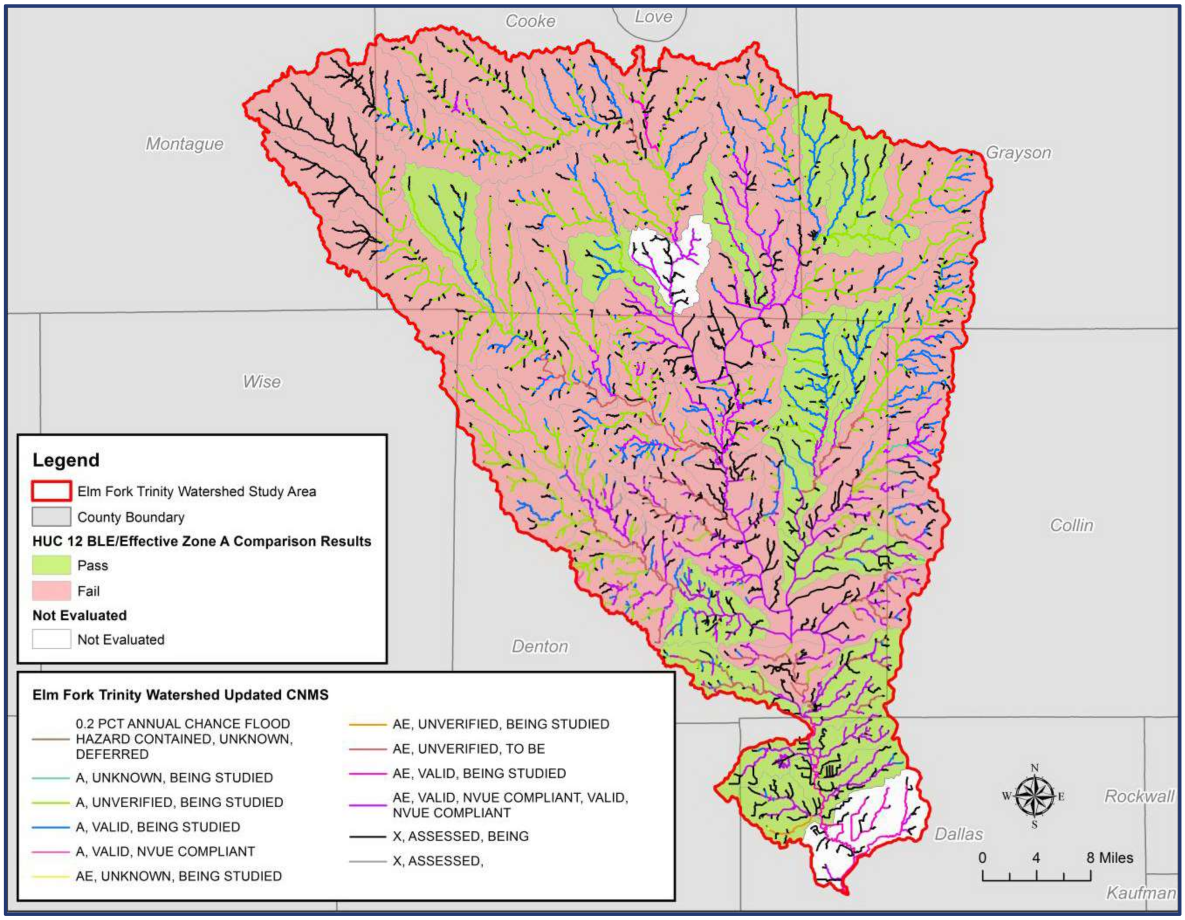

Figure ES-1: Area K CNMS Validation Results

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 ES-2 below shows the range of the Elm Fork Trinity HUC-8 priority scores which can be used to initiate discussions during the Discovery phase.

North Hickory Creek HUC-12 was determined to have the highest priority score and the most need while both Cottonwood Branch-Hackberry Creek and Indian Creek-Elm Fork Trinity River HUC-12s had the lowest scores.

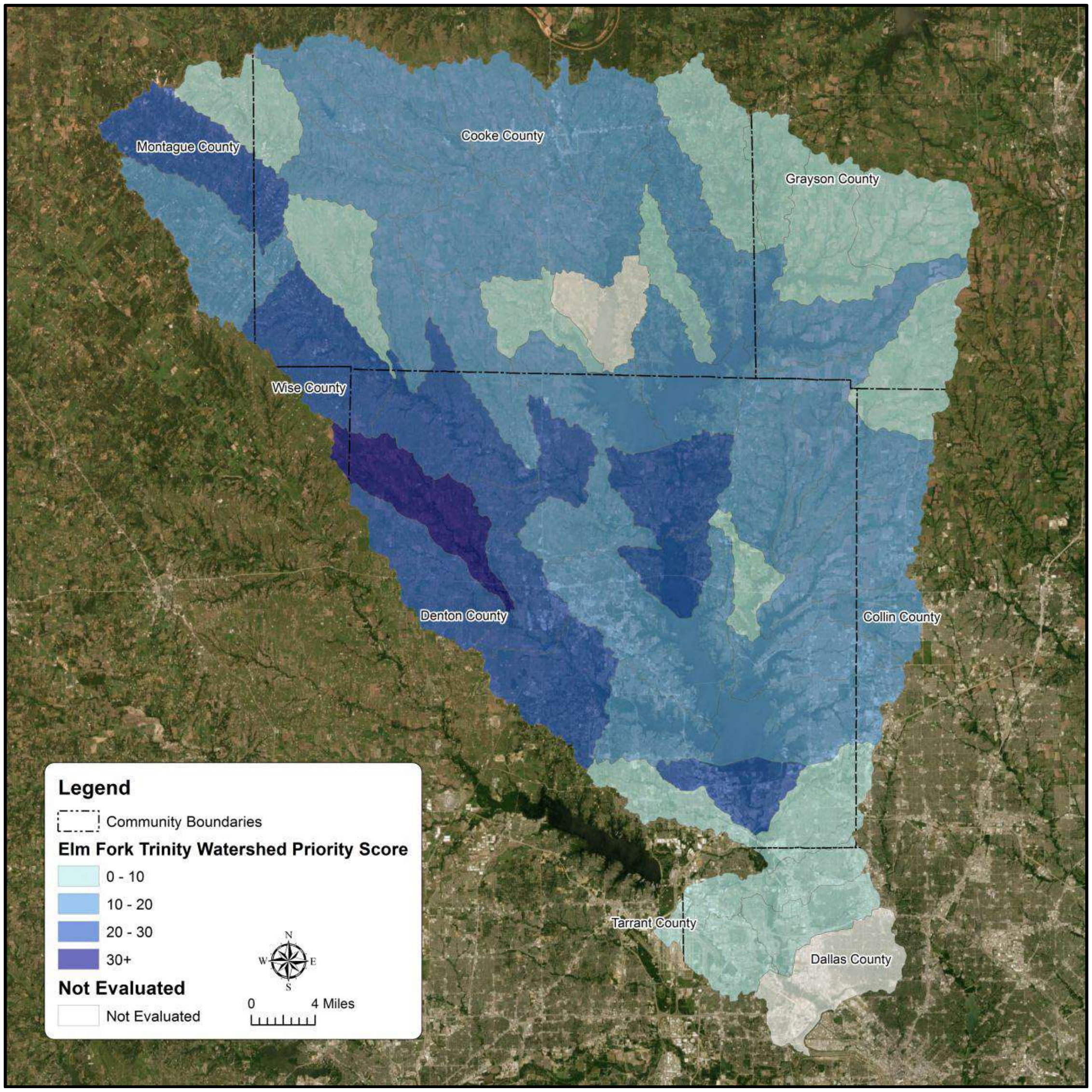

Figure ES-2: Ranking of Elm Fork Trinity HUC-12s

Base Level Engineering (BLE) Methodology

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 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 traditional model development procedures to produce regulatory quality 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 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 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 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.

FEMA Region 6 contracted Compass to complete a BLE analysis for the Elm Fork Trinity Watershed in North 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 Collin, Cooke, Dallas, Denton, Grayson, Montague, Tarrant and Wise Counties, and include the following communities: the Cities of Aubrey, Callisburg, Carrollton, Celina, Collinsville, Coppell, Corinth, Dallas, Denton, Farmers Branch, Frisco, Gainesville, Grapevine, Hackberry, Hebron, Highland Village, Irving, Krugerville, Krum, Lake Dallas, Lewisville, Lindsay, McKinney, Muenster, Oak Pointe, Pilot Point, Plano, Saint Jo, Sanger, The Colony, University Park, Valley View, and Whitesboro and the Towns of Addison, Argyle, Bartonville, Copper Canyon, Cross Roads, Dorchester, Double Oak, Flower Mound, Gunter, Hickory Creek, Lakewood Village, Lincoln Park, Little Elm, Northlake, Oak Ridge, Ponder, Prosper, Providence Village, Shady Shores, and Tioga. The study area consists of ten

HUC-10 basins: Blocker Creek-Clear Creek, Buck Creek-Isle du Bois Creek, Culp Branch-Elm Fork Trinity River, Duck Creek-Clear Creek, Elm Fork Trinity River – Little Elm Reservoir, Headwaters Elm Fork Trinity River, Hickory Creek – Little Elm Reservoir, Indian Creek-Isle du Bois Creek, Little Elm Creek – Little Elm Reservoir, and Timber Creek – Elm Fork Trinity River. Figure 1 shows the orientation of the Elm Fork Trinity HUC-10 basins with respect to the counties.

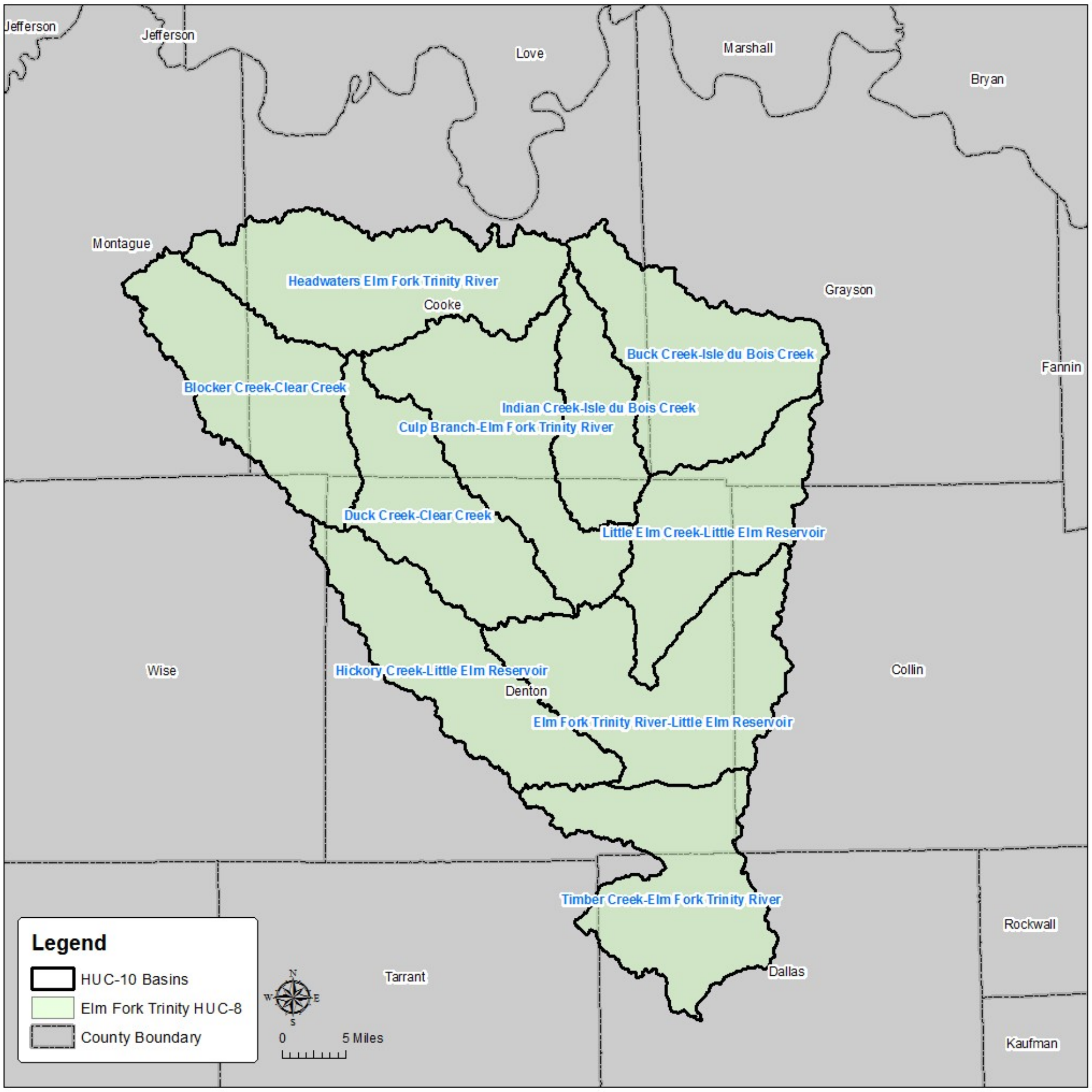

Figure 1: Elm Fork Trinity HUC-10 Basins

AECOM studied approximately 2,630 miles of stream reaches within the Elm Fork Trinity Watershed with a minimum drainage area tolerance of one square mile outside of population centers and half a square mile inside population centers. The selection and extent of stream reaches studied were based upon the number of stream miles with a minimum drainage area of one square mile (or half a square mile, where appropriate) and not the number of effective Zone A stream miles. Study reaches were extended above this threshold as appropriate to ensure all effective Zone A flood areas received an updated analysis. Topographic data from multiple sources were used to determine the hydrologic and hydraulic characteristics of the watershed. The following sections summarize the BLE process and discuss the results along with their recommended use.

1.1 Topographic Data

Topographic data from multiple sources were used to determine the hydrologic and hydraulic characteristics of the watershed. Topographic data were obtained from the Texas Natural Resources Information System (TNRIS), and the United States Geological Survey (USGS).

All available metadata, survey reports, and other leverage documentation are available with the source dataset. Figure 2 shows the extents of the source Digital Terrain Model (DTM) data used for the Elm Fork Trinity Watershed.

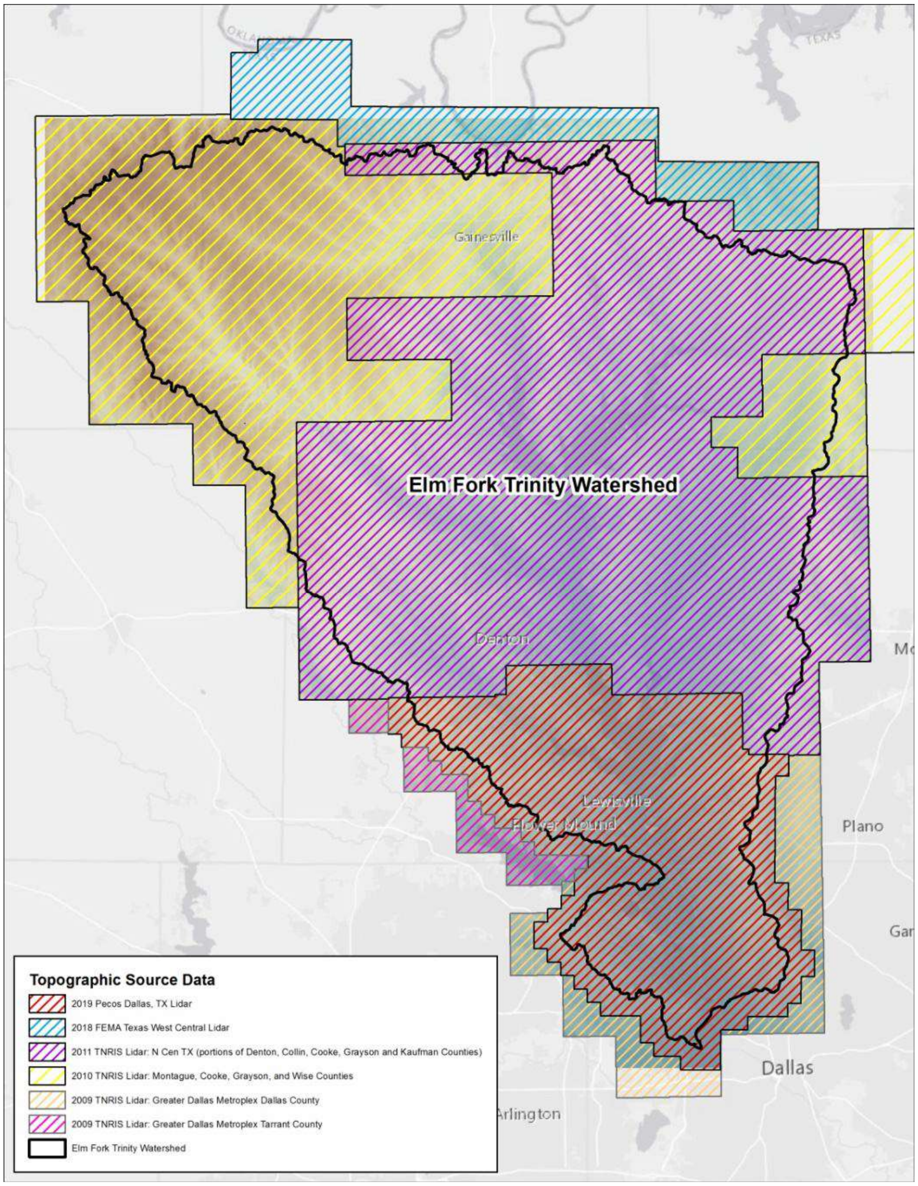

Figure 2: Extent of LiDAR Data for Elm Fork Trinity Watershed

1.1.1 Source Terrain Data

Six topographic datasets were used in the development of the BLE hydraulic models. Details on each dataset are outlined below.

1.1.1.1 2019 Pecos Dallas, TX LiDAR

The 2019 Pecos Dallas, TX Light Detection and Ranging (LiDAR) was acquired from the USGS. Digital Aerial Solutions, LLC (DAS) was tasked to collect and process LiDAR derived elevation dataset for the 140G0219F0014-TX_Pecos_Dallas_2018. The area encompasses approximately 9,557 square miles. Aerial LiDAR data was collected utilizing a Leica ALS80. The ALS80 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the 140G0219F0014-TX_Pecos_Dallas_2018 QL2 LiDAR survey has an Aggregate Nominal Pulse (ANPS) spacing of (QL2 0.71 meters), and includes up to 2 discrete returns per pulse, along with intensity values for each return.

LiDAR datasets were post processed to generate elevation point cloud swaths for each flight line. Deliverables include the point cloud swaths, tiled point clouds classified by land cover type, breaklines to support hydro-flattening of digital elevation models (DEM), intensity tiles, and bare-earth DEM tiles. The point cloud deliverables are stored in the LAS version 1.4, point data record format 6. The tiling scheme for tiled deliverables is a 1,500-meter x 1,500-meter grid. Tile number is the appropriate cell number values found in the USNG index. All deliverables were generated in conformance with the USGS National Geospatial Program Guidelines and Base Specifications, Version 1.3.

The Root Mean Square Error (RMSE)z reported for the dataset was 12.9 cm at the 95% confidence level which meets project accuracy specifications of the National Standard for Spatial Data Accuracy (NSSDA).

1.1.1.2 2018 FEMA Texas West Central LiDAR

The primary purpose of this project is to support the 3DEP mission and the FEMA Risk Mapping, Assessment and Planning (MAP) program for the Texas West Central 2018 D18 Project Area.

The LiDAR data were processed and classified according to project specifications. Detailed breaklines and bare-earth DEMs were produced for the project area. Data was formatted according to tiles with each tile covering an area of 1,500-meters by 1,500-meters. A total of 50,901 tiles were produced for the project encompassing an area of approximately 42,557 square miles. Airborne Imaging, AXIS, Eagle, LEG and Precision Aerial Reconnaissance completed LiDAR data acquisition and data calibration for the project area.

The project area falls within the New Mexico counties of Chaves, Lea and Roosevelt; Oklahoma counties of Bryan, Choctaw, Cotton, Crane, Jackson, Jefferson, Love, Marshall and Tillman; and Texas counties of Andrews, Baylor, Borden, Brown, Clay, Cochran, Coke, Coleman, Concho, Cooke, Crosby, Dawson, Delta, Dickens, Ector, Fannin, Fisher, Gaines, Garza, Glasscock, Grayson, Haskell, Hockley, Hopkins, Howard, Hunt, Irion, Kent, King, Knox, Lamar, Lubbock, Lynn, Martin, Midland, Mitchell, Montague, Nolan, Reagan, Runnels, Scurry, Sterling, Stonewall, Taylor, Terry, Tom Green, Upton, Wichita, Wilbarger, Winkler, Wise and Yoakum.

The LiDAR aerial acquisition was conducted from February 1, 2018 thru May 27, 2018. Re-flights were collected on November 5, 2018.

The RMSEz reported for the dataset was 9.1 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

1.1.1.3 2011 TNRIS LiDAR: N Cen TX (portions of Denton, Collin, Cooke, Grayson and Kaufman Counties)

This LiDAR collection within the Upper Trinity River Basin covers portions of Denton, Collin, Cooke, Grayson, and Kaufman counties in north Texas. The project area for this task order consists of 2,373 square miles in the State of Texas. The raw LiDAR data was collected between January 21, 2011 and April 1, 2011. The LiDAR data produced for this project adheres to the ASPRS and NSSDA accuracy standards, as referenced in the Texas Water Development Board (TWDB) Purchase Order No. 580-11-0916. The RMSEz reported for the dataset was 11.8 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

1.1.1.4 2010 TNRIS LiDAR: Montague, Cooke, Grayson, and Wise Counties

This project comprises areas in Cooke, Montague, Wise, and Grayson County Texas. The project design of the LiDAR data acquisition was developed to support a nominal post spacing of 4pts/meter. Data was acquired by Surdex Inc. and The Atlantic Group under sub-contract to Surdex from May 20 through August 4, 2010. LiDAR data collection was performed with a Cessna 375 aircraft, utilizing a Leica ALS50-II MPiA sensor and utilizing a Optech Sensor collecting multiple return x, y, and z data as well as intensity data. The boresight of the LiDAR was processed against the ground control consisted of 163 LiDAR ground survey points and 2 airborne GPS base station at the operation airport. The RMSEz reported for the dataset was 9.25 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

1.1.1.5 2009 TNRIS LiDAR: Greater Dallas Metroplex Tarrant County

The 2009 TNRIS LiDAR: Greater Dallas Metroplex Tarrant County project area spans 322 tiles covering 1,061 square miles and supports the National Flood Insurance Program in the development of accurate flood zone maps as well as the USGS's efforts in maintaining its National Elevation Data. The sensor used to acquire the data was the Leica ALS-50. The RMSEz reported for the dataset was 7.8 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

1.1.1.6 2009 TNRIS LiDAR: Greater Dallas Metroplex Dallas County

This LiDAR collection covers Dallas County, Texas and surrounding areas. Data was flown by Sanborn March-April of 2009 with third party quality assurance/quality control performed by Dewberry. Data was collected with the intention of aiding the National Flood Insurance Program in the development of accurate flood zone maps in addition to the the USGS's efforts in maintaining National Elevation Data. The LiDAR project consists of 1,974 square miles. The LiDAR data was flowing using a Leica ALS-50 sensor. The LiDAR was collected to meet the 1.4 meter nominal point resolution and therefore maintained sufficient density throughout the project area. The RMSEz reported for the dataset was 20.8 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

1.1.2 Terrain Data Processing

The LiDAR data were processed in Environmental System Research Institute (ESRI) ArcGIS software to create a composite DTM dataset for the project area. The outputs from the processing described below were used during the hydrology, hydraulics, floodplain mapping and CNMS processes and validations.

The Watershed Information System (WISE) software platform was utilized in order to create a digital surface model for the Elm Fork Trinity Watershed project area. This module allows source data from a variety of sources to be prioritized based on level of accuracy or preference of the user. The 2019 Pecos Dallas, TX LiDAR dataset was prioritized as the best data source for the Elm Fork Trinity Watershed followed by the 2018 FEMA Texas West Central LiDAR, 2011 TNRIS LiDAR: N Cen TX (portions of Denton, Collin, Cooke, Grayson and Kaufman Counties), 2010 TNRIS LiDAR: Montague, Cooke, Grayson, and Wise Counties, 2009 TNRIS LiDAR: Greater Dallas Metroplex Tarrant County, and lastly the 2009 TNRIS LiDAR: Greater Dallas Metroplex Dallas County.

The 10-foot DEMs created from the LiDAR datasets described above were compiled in order of vertical accuracy into a mosaic dataset using ArcMap. From this mosaic, a tile index was created for the project area and the mosaic was clipped into 40,000-foot tiles, converted to asciis and imported into Wise Terrain Analyst (WTA). Visual inspection of the 10-foot DEMs was performed to ensure no voids and/or artifacts were present. The DEM surface model was affirmed to be suitable for hydraulic takeoffs and supporting other hydraulic analyses.

Stream centerlines were manually digitized using the 10-foot DEMs as a source for horizontal alignment and vertical elevation. These stream centerlines are created for use in the hydraulic analysis-and hydro-enforcement of the 50-foot DEMs. Several routines were then used to take localized elevations from the source topographic data and apply them to the streams. This gave the stream vertices elevation information along the Z axis. The resulting elevations ensure that the streams are lower in elevation than any overbank sumps. A separate routine was then used to ensure that the elevations of these vertices descend in height down to an outfall. The final streams file is then “burned” into the 50-foot DEMs to force flow through structures while preventing it from “jumping” out of the channel banks.

After the DEM was imported, an additional 50-foot DEM was created from the same mosaic and tile index used for the 10-foot DEM. This 50-foot DEM was used for hydro enforcement of the project area. Proprietary software was used to identify natural sinks, peaks and flat areas in the 50-foot DEM surface. Elevations of the cells in the DEM were algorithmically calculated and the best path to route flow was determined without filling sinks in the DEM. Once all calculations were completed, the flow was checked confirming that all drainage flowed downstream correctly and routed to outside of the project area.

In addition to the quantitative assessment of the source digital terrain, a qualitative visual inspection of the composite DEM was performed using a hillshade derived from the 10-foot DEM. The visual inspection indicated no unusual or non-terrestrial features were observed in the composite DEM assuring the surface files used for hydrologic and hydraulic analyses and floodplain mapping activities are sufficient for BLE analysis.

1.2 Hydrology

Flood discharges for this study were calculated using both the USGS regression equations and gage analysis, where stream gages with sufficient record exist. Regression equations obtained from the USGS Scientific Investigations Report (SIR) 2009-5087, *Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment Based, PRESS-Minimized, Residual-Adjusted Approach* (2009) contain the most recent regression equations for Texas.

The Watershed Information System (WISE) software was used to delineate drainage basins in shapefile format using the 50-foot DEM. WISE was also used to calculate the main-channel slope for each basin. The basin shapefile attribution was automated by WISE with drainage area, main-channel slope, precipitation, and OmegaEM.

Table 1 shows the published equations used in this study. In these equations, Q_i represents peak streamflow for i-recurrence interval (annual chance exceedance (a.c.e.)) in cubic feet per second (cfs), P represents mean annual precipitation in inches, S represents dimensionless main-channel slope, Ω represents the OmegaEM parameter, and A represents cumulative drainage area in square miles.

Table 1: Summary of Regression Equations in Texas (SIR 2009-5087)

Recurrence Interval	Equation[1]
$Q_{10\%}$	$PREC^{1.203}S^{0.403} * 10^{[0.908*\Omega + 13.62 - 11.97*CONTDA\wedge(-0.0289)]}$
$Q_{4\%}$	$PREC^{1.140}S^{0.446} * 10^{[0.945*\Omega + 11.79 - 9.819*CONTDA\wedge(-0.0374)]}$
$Q_{2\%}$	$PREC^{1.105}S^{0.476} * 10^{[0.961*\Omega + 11.17 - 8.997*CONTDA\wedge(-0..0424)]}$
$Q_{1\%}$	$PREC^{1.071}S^{0.507} * 10^{[0.969*\Omega + 10.82 - 8.448*CONTDA\wedge(-0.0467)]}$
$Q_{0.2\%}$	$PREC^{0.988}S^{0.569} * 10^{[0.976*\Omega + 10.40 - 7.605*CONTDA\wedge(-0.0554)]}$

Variables:

Q_i, peak flow for i recurrence interval (a.c.e.), in cubic feet per second;
PREC, mean annual precipitation, in inches;
S, Main-channel slope (dimensionless);
Ω, OmegaEM parameter;
CONTDA, Contributing Drainage Area in square miles;

Discharges for the 1-percent plus and 1-percent minus a.c.e. were calculated as well. These values were computed as $Q_{1\%+/-} = Q_{1\%} \times (10^{\pm 0.30})$ where 0.30 is the residual standard error in $\log_{10}$-unit of cubic feet per second for the $Q_{1\%}$ equation (Table 3 in SIR 2009-5087). In other words, these values were computed by multiplying the $Q_{1\%}$ discharges by 1.995 and 0.501 respectively, which account for the log10 format residual standard error of 0.30 associated with the $Q_{1\%}$ regression equation.

The mean annual precipitation values were determined based on a shapefile coverage obtained from the TWDB and is available for download at the following location: https://www.twdb.texas.gov/mapping/gisdata.asp

The annual precipitation values reflect data for the climatological period 1981-2010 as recorded by the Natural Resources Conservation Service (NRCS).

Main-channel slope was calculated in WISE. An automated routine determined the longest flowpath from upstream of a reach to the outlet of the sub-basin of interest. Two points along the channel, one at 0 percent and the other at 100 percent of the channel length, determined the endpoints of the segment used in the main-channel slope calculation. The elevations for those endpoints were based on the 10-foot DEM developed from the LiDAR.

From SIR 2009-5087, the OmegaEM parameter is a generalized terrain and climate index that expresses relative differences in peak-streamflow potential. A shapefile was developed and populated with OmegaEM values based on Figure 2 in SIR 2009-5087. This shapefile was used to determine Omega EM values on a sub-basin basis. For sub-basins spanning more than one OmegaEM grid, the sub-basin's centroid determined its OmegaEM parameter.

Drainage area for each sub-basin was determined based on automated basin delineations performed by WISE. Basin break points were set by the user with a sub-basin target size of one square mile. This criterion was adjusted for the main stem of the Elm Fork Trinity River to avoid excessive and unnecessary discharge breaks. Break points were also set immediately upstream of stream confluences. Cumulative drainage area was determined based on these automated delineations performed by WISE in combination with a stream connectivity routine that defined the stream reach segments with upstream and downstream neighbors.

The sub-basin shapefile was attributed with the computed discharges, and those discharges were incorporated into the HEC-RAS 5.0.7 models using an automated routine in WISE. Discharges, as well as water surface elevation results, were associated with the hydraulic cross sections prior to generation of floodplain boundaries and grid mapping. Those results are available in GIS format as part of this BLE submittal package. Final discharges can be found in the Vector and raster GIS data, file geodatabase dataset (SUBBASINS) on the eBFE viewer and in the SUBBASINS.shp file on FEMA's Mapping Information Platform (MIP) in the hydraulics task.

1.2.1 Stream Gage Analysis

Figure 3 shows the location of the thirteen (13) USGS stream gages in the Elm Fork Trinity Watershed that were analyzed in developing discharges. Flood frequency analyses (FFA) were performed for these gages using PeakFQ version 7.3 (gage details provided in **Error! Reference source not found.**), according to Bulletin 17C (Expected Moments Algorithm) guidelines.

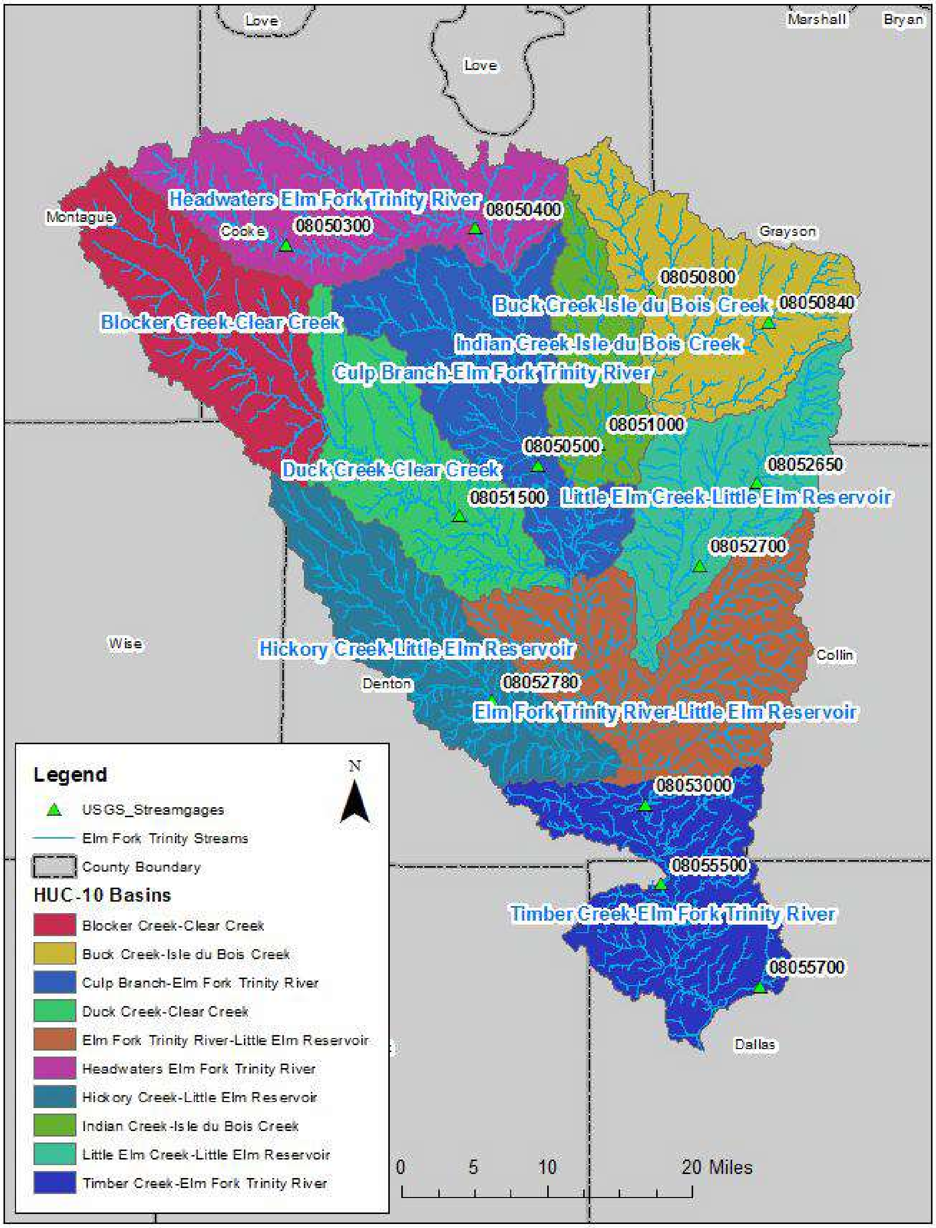

Figure 3: Locations of USGS Gages Utilized in Flood Frequency Analyses

Table 2: USGS Stream Gages in Elm Fork Trinity Watershed

Gage ID	Flooding Source and Location	Computed Drainage Area (mi.^{2})	Published Drainage Area (mi.^{2})	Period of Record
08050300	Elm Fork Trinity River nr Muenster, TX	46	46	1957-1973
08050400	Elm Fork Trinity River at Gainesville, TX	174	174	1986-2020
08050500	Elm Fork Trinity River near Sanger, TX	381	381	1949-1983
08053000	Elm Fork Trinity River near Lewisville, TX	1,673	1,673	1950-2020
08055500	Elm Fork Trinity River near Carrollton, TX	2,459	2,459	1908-2020
08055700	Bachman Branch at Dallas, TX	9.4	10.0	1962-1979
08051500	Clear Creek near Sanger, TX	294.4	295	1949-2020
08052780	Hickory Creek at Denton, TX	127.7	129	1986-2020
08051000	Isle du Bois Creek near Pilot Point, TX	265.4	266	1949-1984
08052700	Little Elm Creek near Aubrey, TX	71.6	75.5	1957-2020
08052650	Little Elm Creek near Celina, TX	42.0	46.7	1966-1976
08050840	Range Creek nr Collinsville, TX	29.9	29.2	1993-2020
08050800	Timber Creek near Collinsville, TX	38.8	38.8	1986-2020

With the FFA results, discharges for the reaches between gages were calculated using the following equation.

$$Q_{ungaged} = Q_{USgage} \times 10^{(((\log(DAungage)-\log(DAUSgage))*(\log(QDSgage)-\log(QUSgage))/(\log(DADSgage)-\log(DAUSgaged)))}$$

Following the FFA analysis and after discussion with U.S. Corps of Engineers (Fort Worth District), it was determined that the flows from the Interagency Flood Risk Management (InFRM) Watershed Hydrology Assessment (WHA) study on the Trinity River Basin should be used.

Flows for all events were incorporated from the InFRM report, however the 1-percent plus and 1-percent minus flows were not included in the InFRM Report. These flows were calculated using the methodology listed in Bulletin 17B. Using the 2-year flows from the InFRM report resulted in unreasonable results in the 1-percent plus, therefore a 2-year flow was calculated using a log-log extrapolation in order to calculate the 1-percent plus and 1-percent minus.

For Elm Fork Trinity River tributaries with gages, stream gage analysis was incorporated in the development of the final discharges.

1.2.2 InFRM Trinity River Basin WHA Trinity River Basin Flows

As mentioned above, the Elm Fork Trinity River mainstem utilized flows from the USACE InFRM Trinity River Watershed WHA report. The following table shows the flow locations used from the report and the computed 1-percent discharge.

Table 3: InFRM Trinity River Basin Study – Mainstem Discharges

Flooding Source and Location	Drainage Area (mi.^{2})	1% Discharge (cfs)
Elm Fork Trinity River above Brushy Elm Creek	67.4	24,100
Elm Fork Trinity River below Brushy Elm Creek	92.9	27,500
Elm Fork Trinity River below Dry Elm Creek	137	45,600
Elm Fk Trinity Rv at Gainesville, TX USGS gage	177.2	60,400
Elm Fork Trinity River below Pecan Creek	216.8	64,200
Elm Fork Trinity above Ray Roberts Lake	265	64,100
Ray Roberts Lake Inflow	692.6	216,400
Ray Roberts Lake Outflow (Elm Fork at Greenbelt nr Pilot Point USGS gage)	692.6	7,000
Elm Fork Trinity River above Clear Creek	36.9	17,200
Elm Fork Trinity River below Clear Creek	388.1	62,100
Lewisville Lake Inflow	968.2	157,800
Lewisville Lake Outflow (Elm Fork nr Lewisville USGS Gage)	968.2	26,500
Elm Fork Trinity River above Indian Creek	21.4	26,500
Elm Fork Trinity River below Indian Creek	37.5	26,500
Elm Fork Trinity River below Timber Creek	61.5	26,500
Elm Fork Trinity River above Denton Creek	79.9	27,400
Elm Fork Trinity River near Carrollton USGS gage	104.2	37,100
Elm Fork Trinity at Interstate 635	143.4	43,300
Elm Fork Trinity River above Hackleberry Creek	143.4	42,100
Elm Fork Trinity Rv at Spur 348 in Irving, TX USGS gage	180.4	45,100
Elm Fork Trinity River above Bachman Branch	202.6	41,600
Elm Fork Trinity River below Bachman Branch (at Frasier USGS Gage)	216.7	42,600
Elm Fork Trinity River above the West Fork Trinity River	222.8	41,800

1.3 Hydraulics

The hydraulic approach for this BLE analysis of the Elm Fork Trinity Watershed consisted of using the terrain model described in Section 1.1 in combination with the hydrologic outputs from Section 1.2 to establish water surface elevations using 1-D steady state analysis. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) program version 5.0.7 was chosen as the computer model to compute water surface elevations on a stream by stream basis. The WISE software was used to establish model stream orientation, generate initial hydraulic cross section layout and stationing, assign n-values to cross sections, and develop all input files for the HEC-RAS program. ESRI's ArcMap program was used to review and refine cross-section layout orientation.

First pass cross-section layout was performed using an automated routine in WISE that varies cross section spacing based on the cumulative drainage area at the cross section location. A first draft model was created based on this initial cross-section layout, and draft boundaries were developed. Next, a second pass inspection for cross-section placement and alignment occurred. Significant refinement occurred during this step. To improve the hydraulic models, additional cross-sections were added as needed to better define the BLE floodplain boundary. Cross-sections were extended in locations where overtopping occurred. Orientation of cross-sections was refined to improve on the perpendicular orientation to flow. Additional cross-sections were added at floodplain constrictions and at downstream portions of tributaries to ensure a proper tie-in with receiving streams. Cross-sections were adjusted to remove sections that intersected hydraulic crossings in the floodplain. For some of the largest studied streams, cross-sections were laid out manually in order to have more reasonable spacing and better capture the constrictions in the floodplain.

Cross-sections were not drawn on top of roadways or railroads but were placed at the upstream and downstream face of major roads and railroads. Ineffective flow stations were placed in the hydraulic models as appropriate to account for flow constrictions and other locations deemed by the engineer to be ineffective at conveying flow downstream.

Cross-sections were drawn on dam crests for dams with well-defined spillways in order to better represent ponded water upstream of the structures. In so doing, it was assumed that the vast majority of the flow during a flood event would pass the spillway and that the hydraulic model would reasonably estimate flow across the spillway as represented in the hydraulic cross-section. The elevations used in the modeling were checked against effective Zone A boundaries, and the results were deemed reasonable.

The relationship between cumulative drainage area and assigned channel geometry is shown in Table 4. These default values for dimensions and spacing were subject to change based on engineering judgment.

Table 4: Cross-Section Default Parameters

Drainage area (upper limit)	XS Spacing	Channel Top Width	Channel Bottom Width	Channel Depth
1	300	7	6	0.8
2	300	8	7	0.8
4	300	11	10	0.8
8	400	12	11	0.8
10	500	13	12	0.8
15	500	18	13	0.8

Drainage area (upper limit)	XS Spacing	Channel Top Width	Channel Bottom Width	Channel Depth
20	500	19	14	0.8
25	500	20	15	0.8
30	500	21	16	0.8
40	500	25	17	0.8
50	600	28	18	0.8
75	600	30	19	1
100	750	33	20	1
150	750	36	21	1
250	1000	38	22	2
500	1500	40	23	2
1000	2500	100	50	3
2000	2500	150	75	3
5000	2500	200	100	3

In typical BLE projects, Manning's roughness coefficients (n-values) are determined using the 2016 National Land Cover Data (NLCD) dataset in combination with n-values from Chow (1959) and Calenda et al. (2005). For this watershed, the n-values for the developed areas indicated an underestimation of the roughness coefficients when compared to the aerial imagery and were adjusted accordingly. The association between the n-values and the NLCD Classification is shown in Table 5. Manning's n-value takeoffs are performed by WISE (default values taken from the "Normal" column). N-values within channel banks are constrained by the automated routine to a range of 0.030 to 0.070. Then, overbank and channel n-values are manually adjusted in certain locations based on engineering judgment.

Table 5: Manning's "n" Roughness Based on 2016 NLCD Classification (Moore, 2011)

NLCD Classification	Selected Manning's N	Minimum	Normal	Maximum	Source
Open Water	0.033	0.025	0.03	0.033	Chow 1959
Developed, Open Space	0.04	0.01	0.013	0.016	Calenda et al. 2005
Developed, Low Intensity	0.08	0.038	0.05	0.063	Calenda et al. 2005
Developed, Medium Intensity	0.1	0.056	0.075	0.094	Calenda et al. 2005
Developed, High Intensity	0.15	0.075	0.1	0.125	Calenda et al. 2005
Barren Land	0.025	0.025	0.03	0.035	Chow 1959
Deciduous Forest	0.16	0.1	0.12	0.16	Chow 1959
Evergreen Forest	0.16	0.1	0.12	0.16	Chow 1959
Mixed Forest	0.16	0.1	0.12	0.16	Chow 1959
Scrub/Shrub	0.1	0.035	0.05	0.1	Chow 1959
Grassland/Herbaceous	0.035	0.025	0.03	0.035	Chow 1959
Pasture/Hay	0.03	0.03	0.04	0.05	Chow 1959
Cultivated Crops	0.035	0.025	0.035	0.045	Chow 1959
Woody Wetlands	0.12	0.08	0.1	0.12	Chow 1959
Emergent Herbaceous Wetland	0.07	0.07	0.1	0.15	Chow 1959

The boundary condition used for the majority of the study streams was normal depth with a default value of 0.005 ft/ft. For streams with large drainage areas (generally greater than 8 square miles), the normal depth slope was calculated based on the channel inverts of the downstream cross sections.

In cases where streams tie in to a lake, a normal depth slope was calculated based on the channel inverts of the downstream cross sections (typically between 0.0001 and 0.001 ft/ft). Several HUC-10s within this watershed are located in urban areas with storm drain systems, which are unaccounted for in the BLE models. Implications of these systems may considerably affect risk.

1.4 Quality Control

Following the initial hydraulic model analysis in each watershed, the resulting flood hazard area delineations were reviewed for areas where the results were not ideal.

QC results indicated that some of the models should be extended to cover the scope of effective flood hazard data. Those streams were extended farther upstream to match the extents of the effective SFHA data.

Typical revisions resulting from reasonability checks included adding cross-sections, adjusting orientation of cross-sections, trimming cross-sections and reduction of the default “V” angle of cross-sections. Examples of default “V” angled cross-sections are shown in Figure 4. It is estimated that 75 percent of cross-sections were adjusted in some work areas while other areas did not require as much editing. Other examples of manual editing included the addition of cross-sections at confluence areas (see Figure 5 below), modifications to improve perpendicular orientation at the channel, adjustment of discharge breaks to better represent flow addition points, revisions to cross sections at dams, additional cross-sections bounding major hydraulic structures, and revisions to n-values.

A major component of the QC process was an automated check that identified locations where the 1-percent a.c.e profile was crossed by any other frequency profile. Significant effort was made to reasonably resolve all of these instances. Another automated check identified locations where there was a drawdown of greater than 0.5 foot on the 1-percent a.c.e. water surface profile. This check is particularly useful for identifying errors in the model such as a channel that is too wide, a poorly placed cross-section, or a need for additional cross-sections. Again, significant effort was made to reasonably resolve these drawdown situations.

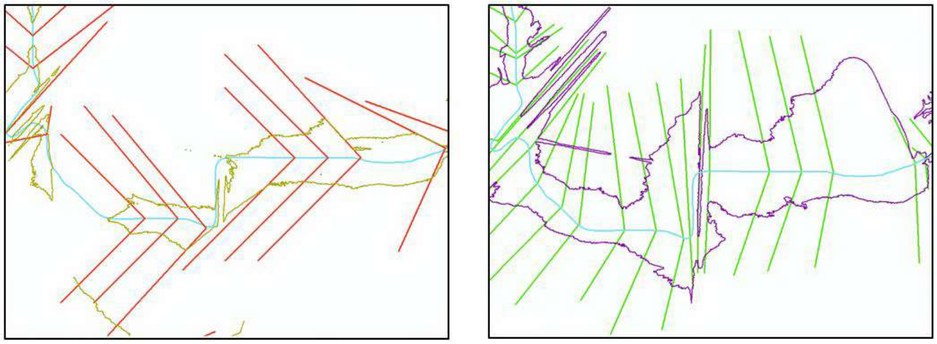

Figure 4: Default "V" angle cross-sections automated by WISE (left). Manually edited cross-sections to more accurately capture terrain (right). Resulting flood boundaries shown in gold (left) or purple (right) for clarity.

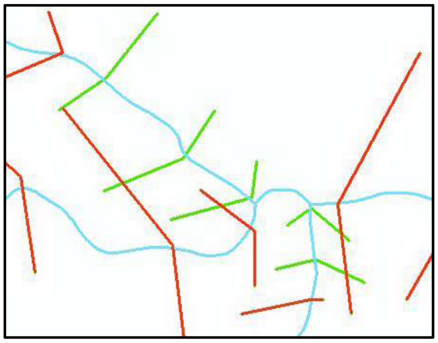

Figure 5: Manually added cross-sections (green) to improve accuracy of tie-ins at confluences.

1.5 Floodplain Delineation (10%, 1% and 0.2% events)

The 1-percent and 0.2-percent boundaries were mapped using a routine that develops water surface elevation grids based on the 10-foot cell size DEM developed from the LiDAR dataset used for this project (see Section 1.1). This product was converted to a polygon for cleaning. The cleaning routine involved manual inspection of the polygons to identify and remove areas of disconnected flooding. In general, all polygons greater than 5,000 square feet are investigated, but all polygons, including those less than 5,000 square feet that intersect the stream lines were included in the final output. This investigation was aided by the ground DEM and aerial imagery. Manual adjustments to the polygons were made to account for spillways on dams which could not be accurately modeled using HEC-RAS as well as disconnected areas along the flooding source that should reasonably be connected.

Following the removal of disconnected flooding areas and other boundary adjustments, the small islands in the floodplain were filled. In general, islands less than 2 acres were inspected and filled.

Once the island filling process was complete, the water surface raster mapping routine was run and set to conform to the polygon boundary. This ensures that the water surface raster and the floodplain boundary are consistent with each other. The depth raster product was created at the end of the process by performing a raster subtraction with the water surface elevation raster and the ground DEM.

Challenges

The Elm Fork Trinity Watershed is located in north Central Texas, northeast of the City of Dallas. In some of the wide and flat floodplains, small tributaries run parallel to large streams. Parallel streams with shared floodplains were modeled by moving the combined discharge upstream to the cross-section that begins the shared floodplain.

The Elm Fork Trinity River flows through the Lewisville Lake and Ray Roberts Lake reservoir. In addition to the discharges, the USACE InFRM study does include recommended frequency pool elevations for several reservoirs. Elevations for both reservoirs were incorporated into the Elm Fork Trinity River HEC-RAS model as known water surface elevations. A 1-percent water surface elevation of 645.5 feet was used for Ray Roberts Lake and a 1-percent water surface elevation of 537.8 feet was used for Lewisville Lake.

Towards the downstream end of the mainstem model, Elm Fork Trinity River encounters the following accredited levee systems: Valwood North, Valwood South, Valley Ranch, Denton Creek, and Carrollton-Elm Fork Trinity River. For these accredited levee systems, cross-sections were trimmed to the levee crest as the levee was assumed to provide containment.

A significant effort was made to achieve proper 1-percent water surface elevation tie-ins at stream confluences. Cross-sections were manually added on the downstream end of nearly every stream, some of which traverse the receiving stream; so that the water surface elevation of the tributary would be lower than that of the receiving stream.

There are dams of varying sizes throughout the watershed. Discharges calculated with the regression equations do not take into account the impact of these structures. There may be need for further investigation, particularly for those dams designed for flood control, when upgrading these models for detailed studies.

There are a few containment issues across the study area. In some areas the 0.2-percent flows overtopped cross sections. For these situations, additional investigation is recommended when upgrading these models for detailed study.

Toward the lower portion of this watershed, the Denton HUC-8 BLE flows into the Elm Fork Trinity River. When the Denton HUC-8 BLE data was pulled in, there is a gap between it and the Elm Fork Trinity River. In order to cover this gap within the Denton HUC-8 boundary, this area from the Elm Fork Trinity HUC-8 BLE study was included and therefore extends outside of the Elm Fork Trinity HUC-8 boundary. An AoMI point has been added to the spatial files explaining this and for consideration of a future study to revise the rasters and tie-in at this confluence.

In the Elm Fork Trinity Watershed, some areas were flat which results in a few cross sections being overtopped. For example, various types of cross section layouts were tried for streams like Cottonwood Branch Tr 4, Cottonwood Branch Tr 4_1, Lynchburg Creek, but still some of the cross sections remain overtopped. These streams require further study.

In Blocker Creek Watershed, the area upstream of the confluence of Bingham Creek and UNT 012 in BCR proved difficult to model due to the flat terrain. Bingham Creek is the larger stream and has a well-defined channel, but UNT 012 in BCR runs parallel without a defined channel and spills over into Bingham Creek. The cross section on UNT 012 in BCR had to be heavily curved upstream because a shared floodplain could not be used on the smaller creek.

In Buck Creek Watershed, UNT 072 in Buck Cr Watershed could not be mapped properly due to the flat terrain and lack of a defined channel. The cross sections were trimmed to the basin boundary and set to the highest point in the area, but many of the cross sections are still overtopping, particularly on the 0.2-percent annual chance event.

In Duck Creek Watershed, Moores Branch has an overflow on the north side of the stream into the main channel (Clear Creek) between cross sections 18121 and 17051. This occurs significantly on 0.2-percent annual chance event and to a lesser extent on 1-percent annual chance event. Moores Branch does directly tie into Clear Creek at the end of its reach, so this overflow does not have significant effect on Clear Creek mapping.

In Culp Branch Watershed, there is a low-lying area to the north of the stream path of UNT 013 in Culp Branch Watershed, which adds difficulties to model water surface elevations due to the relatively flat terrain. UNT 012 in Culp Branch Watershed passes through an area with irregular elevations downstream of a dam. This area with modeling challenges may need further detailed study. At the confluence of Bray Branch, Bray Branch Tributary 10 and Bray Branch Tributary 9; Bray Branch Tributary 9 doesn't meet the criteria to include in this study. To be consistent with the effective stream names, Bray Branch Tributary 10 was modeled as a separate stream utilizing the known water surface elevation of Bray Branch. A similar approach was used for model UNT 005 in CBW where it meets with the Pecan Creek South Tributary 1 and Pecan Creek South Tributary No. 1.

In Little Elm Creek Watershed, there is an issue with the tie in of Pecan Creek into Little Elm Creek starting at Little Elm Creek cross section 52706. Pecan Creek runs parallel to Little Elm Creek and has a low-lying ridge separating it from Little Elm Creek, but spills over in several locations. The water surface elevation of Little Elm Creek is relatively flat here as the stream approaches Lake Lewisville.

In Hickory Creek Watershed, Stream DF2 Trib 1 streamline is located outside of the SFHA area. Further study is needed, to confirm this is the correct approach to this tributary. Tie ins were no achieved for Hickory Cr, South Hickory Cr, and North Hickory Cr. The rasters were manually adjusted to fix these differences.

In Indian Creek Watershed, multiple streams contain overflow and require further study. These streams include Indian Creek East, UNT 48 in Indian Creek Watershed, and UNT 74 in Indian Cr Watershed.

Results and Recommendations

The BLE results for this study produced a SFHA that compares favorably with the effective SFHA. These boundaries provide an estimated SFHA in areas that have not been previously studied and therefore do not currently have an SFHA mapped. These results provide context for flood risk communication as part of the Discovery process, and should be verified through community work map meetings before being applied to a regulatory product.

A map showing the BLE results is included as Appendix A.

3.1 CNMS Validation of Effective Zone A SFHA

The inventory of Zone A studies (1,143.3 miles) in the Elm Fork Trinity Watershed were classified in CNMS with validation status of "UNVERIFIED" (726.7 miles), "UNKNOWN" (4.6 miles) or "VALID" (412.0 miles), and with status type of "BEING STUDIED." The following is a summary of the results of the CNMS validation assessment for the effective Zone A studies in the study area. Initial assessment checks A1-A3 were evaluated for the CNMS inventory of Zone A studies.

INITIAL ASSESSMENT A1 – SIGNIFICANT TOPOGRAPHY UPDATE CHECK

This check involves determining whether a topographic data source is available that is significantly better than what was used for the effective Zone A modeling and mapping. There are 22 reaches spread throughout the HUC-8 that were updated by a LOMR that used LiDAR for the effective study. These reaches pass this check. For all other reaches within this watershed the LiDAR sources utilized in this BLE study are considered significant improvements from the effective zone A topographic sources and, therefore, fail this check.

INITIAL ASSESSMENT A2 – CHECK FOR SIGNIFICANT HYDROLOGY CHANGES

This check involves first determining if regression equations were used for the effective study. Next, it must be determined 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.

For all Zone A streams in this watershed except for 3 reaches, updated as part of LOMR 14-06-0033P, regression equations were not known to be used for any effective studies and, therefore, pass this assessment check. LOMR 14-06-0033P used the current regression equations and, therefore, also pass this assessment check.

INITIAL ASSESSMENT A3 – CHECK FOR SIGNIFICANT DEVELOPMENT

This check involves using the National Urban Change Indicator (NUCI) dataset to assess increased urbanization in the watershed of the Zone A study. If the percentage of urban area within the HUC-12 watershed containing the effective Zone A study is 15% or more, and has increased by 50% 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. The check for significant development in this watershed was completed by evaluating percentage of urban change at the HUC-12 level.

The majority of the watershed does not meet the minimum urban threshold, so the majority of reaches pass this check. The southern portion of the watershed is an urbanized area. So, further assessment was done to determine if there had been a significant increase in urbanization since the effective analysis in these areas. Among these reaches, if the effective hydrology was completed before 2005, significant urbanization had occurred since the effective and the reach fails this check. Those where the effective hydrology was completed after 2005 did not experience a significant increase in urbanization since the effective analysis and, therefore, pass this check.

All of the initial assessment results are shown in Table 6.

Table 6: Zone A Initial Assessment Results

Assessment Check	Pass / Fail	Notes
A1 – Topography	Pass/Fail	LiDAR was used in the effective study / LiDAR sources available are considered significant improvements from the effective zone A topographic sources.
A2 – Hydrology	Pass	Regression equations are not known used in effective study OR No new equations were published since effective analysis
A3 – Development	Pass/Fail	Watershed does not meet urban threshold OR Watershed has not had a significant increase in urban area/Urban watershed has experienced significant increase in urban area

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.

All LOMR studies and Zone A studies in Cooke County are supported by technical data and pass this check. The remainder of the watershed is not model-backed nor supported by any documentation of methodology used and, therefore, fail this check.

VALIDATION CHECK A5 – COMPARISON OF BLE AND EFFECTIVE ZONE A

The BLE /effective Zone A comparison method leverages the existing Floodplain Boundary Standard (FBS) certification procedures described in FEMA SID 113, but with a slight modification. This modified FBS comparison approach uses the 1-percent plus and 1-percent minus flood profiles and horizontal and vertical tolerances described in FEMA's Automated Engineering guidance document dated May 2016. For the comparison of BLE and effective Zone A in the Texas study area, the following vertical and horizontal tolerances were used to conduct the modified FBS procedure. One point was placed every 200 feet along the floodplain boundaries for comparison.

- Vertical Tolerance: +/- 10 feet (one-half contour interval of assumed effective topographic source).
- Horizontal Tolerance: +/- 75 feet (standard horizontal tolerance for BLE comparison testing).

Comparison results for these streams were grouped at the HUC-12 level and are summarized in Table 7 to better understand the general health of the HUC-12 watershed, but the validation check was performed at the stream level. Streams where the percentage of passing FBS sample points is greater than or equal to 85% are marked as "Pass", otherwise marked as "Fail".

Table 7: BLE Comparison Results

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>85%)	Priority Score
Watershed Name	Watershed Number						
Elm Fork Trinity Watershed	All Streams	61,156	12,970	48,186	79%	FAIL	
Bear Creek-Buck Creek	120301030206	1,847	508	1,339	72%	FAIL	12.6
Bingham Creek	120301030503	232	38	194	84%	FAIL	13.1
Blocker Creek	120301030504	1,679	210	1,469	87%	PASS	9.9
Brushy Elm Creek	120301030103	1,279	298	981	77%	FAIL	16.1
Buck Creek-Clear Creek	120301030602	1,649	409	1,240	75%	FAIL	22.2
Buck Creek-Timber Creek	120301030201	2,684	465	2,219	83%	FAIL	8.7
Cottonwood Branch-Hackberry	120301031006	28	0	28	100%	PASS	0.0

Cottonwood Branch-Lewisville	120301030905	204	22	182	89%	PASS	10.6
Culp Branch-Elm Fork Trinity	120301030406	1,417	336	1,081	76%	FAIL	21.0
Doe Branch-Lewisville Lake	120301030903	1,533	266	1,267	83%	FAIL	15.6
Dry Elm Creek-Elm Fork Trinity	120301030104	2,169	534	1,635	75%	FAIL	16.1
Dye Creek-Clear Creek	120301030501	402	129	273	68%	FAIL	25.7
Farmers Branch-Elm Fork	120301031005	381	39	342	90%	PASS	9.0
Flat Creek	120301030601	1,382	297	1,085	79%	FAIL	17.0
Gibbons Branch-Elm Fork	120301030101	1,035	169	866	84%	FAIL	9.2
Grapevine Creek-Elm Fork	120301031004	117	5	112	96%	PASS	4.1
Headwaters Jordan Creek	120301030202	782	96	686	88%	PASS	6.5
Headwaters Little Elm Creek	120301030701	3,687	674	3,013	82%	FAIL	9.4
Indian Creek-Elm Fork Trinity	120301031003	8	0	8	100%	PASS	0.0
Jordan Creek-Isle du Bois Creek	120301030205	524	160	364	69%	FAIL	14.5
Little Duck Creek-Duck Creek	120301030603	1,599	345	1,254	78%	FAIL	18.5
Little Elm Creek	120301030703	2,010	393	1,617	80%	FAIL	17.6
Long Branch-Elm Fork Trinity	120301030102	1,847	406	1,441	78%	FAIL	15.6
Lower Hickory Creek	120301030805	372	49	323	87%	PASS	13.2
Lower Indian Creek	120301030302	70	15	55	79%	FAIL	10.7
Lower Range Creek	120301030204	1,640	237	1,403	86%	PASS	7.9
Lower Spring Creek	120301030402	861	97	764	89%	PASS	9.1
Middle Hickory Creek	120301030804	1,934	598	1,336	69%	FAIL	24.9
Milam Creek-Clear Creek	120301030605	1,214	224	990	82%	FAIL	16.7
Montague Creek-Elm Fork	120301030106	2,651	508	2,143	81%	FAIL	14.0
Moores Branch-Clear Creek	120301030604	1,374	392	982	71%	FAIL	26.5
Mustang Creek	120301030702	1,205	155	1,050	87%	PASS	10.1
North Hickory Creek	120301030801	1,718	759	959	56%	FAIL	37.5
Panther Creek-Lewisville Lake	120301030904	867	167	700	81%	FAIL	18.3
Pecan Creek	120301030704	2,234	266	1,968	88%	PASS	10.9
Pecan Creek-Lewisville Lake	120301030902	621	112	509	82%	FAIL	16.5
Pond Creek-Elm Fork Trinity	120301030405	527	103	424	80%	FAIL	18.1
Prairie Creek-Elm Fork Trinity	120301031001	127	33	94	74%	FAIL	27.2
Running Branch-Little Elm	120301030705	216	24	192	89%	PASS	10.0
Scott Creek-Elm Fork Trinity	120301030403	2,253	564	1,689	75%	FAIL	18.2
South Hickory Creek	120301030802	1,982	563	1,419	72%	FAIL	25.5
Stewart Creek-Lewisville Lake	120301030906	207	37	170	82%	FAIL	14.6
Timber Branch-Lewisville Lake	120301030901	130	32	98	75%	FAIL	22.2
Timber Creek	120301031002	121	12	109	90%	PASS	8.8
Upper Hickory Creek	120301030803	1,080	318	762	71%	FAIL	26.1
Upper Indian Creek	120301030301	403	62	341	85%	PASS	10.9
Upper Range Creek	120301030203	1,928	373	1,555	81%	FAIL	9.7
Upper Spring Creek	120301030401	2,283	430	1,853	81%	FAIL	15.1
Walnut Branch-Isle du Bois	120301030304	285	64	221	78%	FAIL	15.7
Wheeler Creek-Pecan Creek	120301030105	1,631	258	1,373	84%	FAIL	11.0
Whites Creek-Clear Creek	120301030505	2,327	645	1,682	72%	FAIL	22.6

Willawalla Creek-Clear Creek	120301030502	354	69	285	81%	FAIL	15.6
Wolf Creek	120301030303	46	5	41	89%	PASS	5.4

VALIDATION RESULTS

Based on the validation assessments and BLE comparison results described above, the CNMS inventory of Zone A studies in the Elm Fork Trinity Watershed has been updated as summarized in Table 8 and illustrated in Figure 6 below.

Table 8: Zone A Validation Results

Validation Status	Status Type	Total Miles
VALID	BEING STUDIED	412.0
VALID	NVUE COMPLIANT	4.9
UNVERIFIED	BEING STUDIED	726.7
UNKNOWN	BEING STUDIED	4.6

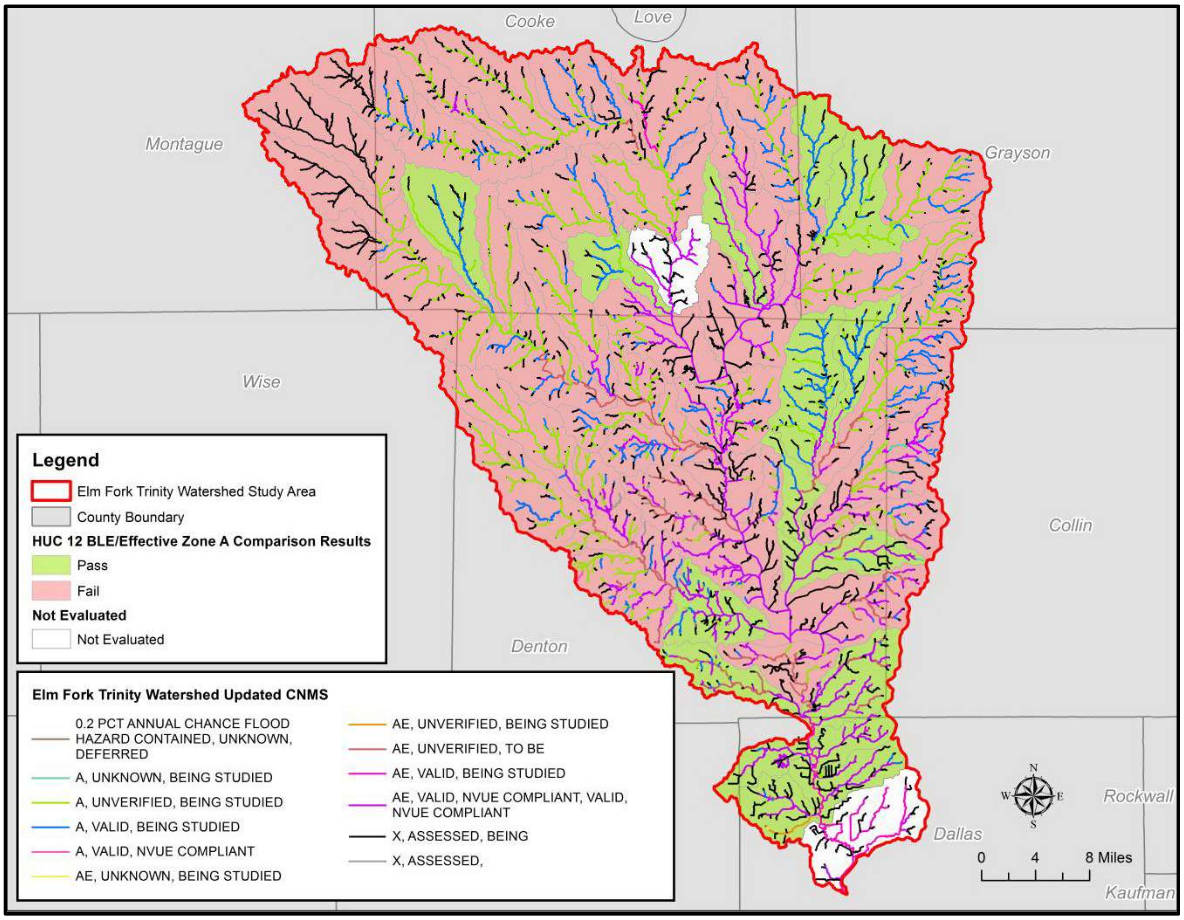

Figure 6: Elm Fork Trinity Watershed CNMS Validation Results

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 7 below shows the range of the HUC-12 priority scores which can be used to initiate discussions during the Discovery phase.

North Hickory Creek HUC-12 was determined to have the highest priority score and the most need while both Cottonwood Branch-Hackberry Creek and Indian Creek-Elm Fork Trinity River HUC-12s had the lowest scores.

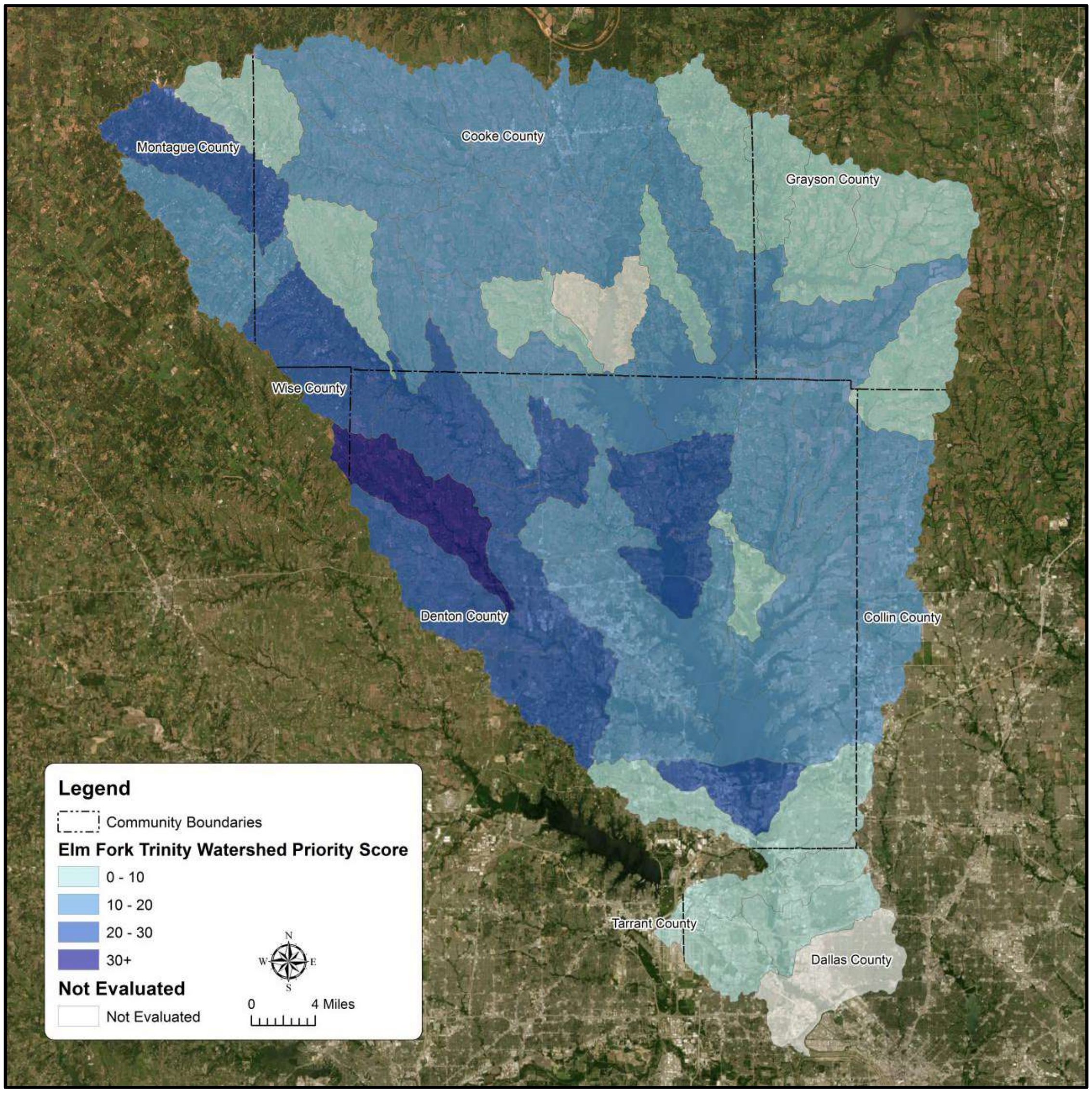

Figure 7: Ranking of Elm Fork Trinity Watershed HUC-12s

3.2 Flood Risk Analysis

A flood risk analysis was performed for this project. The updated 1-percent a.c.e. and 0.2-percent a.c.e. depth grids were 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 (SP03) 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 (SP03) 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 extents for each return period to ensure proper model processing. A summary of results for the 1-percent a.c.e. scenarios are shown in Table 9.

Table 9: Hazus 4.2 (SP03) Results for 1-percent-annual-chance (100 year) scenario

County	Full Replacement - Total Loss	Dollar Exposure (Replacement Value) - Buildings	Dollar Exposure (Replacement Value) - Contents
Collin	69,884,000	9,066,172,000	5,684,857,000
Cooke	193,482,000	4,723,462,000	3,345,373,000
Dallas	1,720,466,000	46,285,757,000	33,759,706,000
Denton	1,460,386,000	66,290,291,000	37,820,256,000
Grayson	11,999,000	910,385,000	537,906,000
Montague	1,864,000	176,941,000	97,619,000
Tarrant	4,373,000	250,214,000	262,919,000
Wise	104,000	50,277,000	29,760,000

References

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Appendix A BLE Map