# Upper West 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

| Name | Title/Organization | Location |
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# Executive Summary

Texas Water Development Board (TWDB) contracted AECOM to complete a Base Level Engineering (BLE) analysis for the Upper West Fork Trinity Hydrologic Unit Code (HUC) 8 in North Central Texas, to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHAs). 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 | Upper West Fork Trinity Stream Miles |
|---|---|
| CNMS | 891.2 |

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 | 318.5 |
| UNVERIFIED | BEING STUDIED | 572.6 |

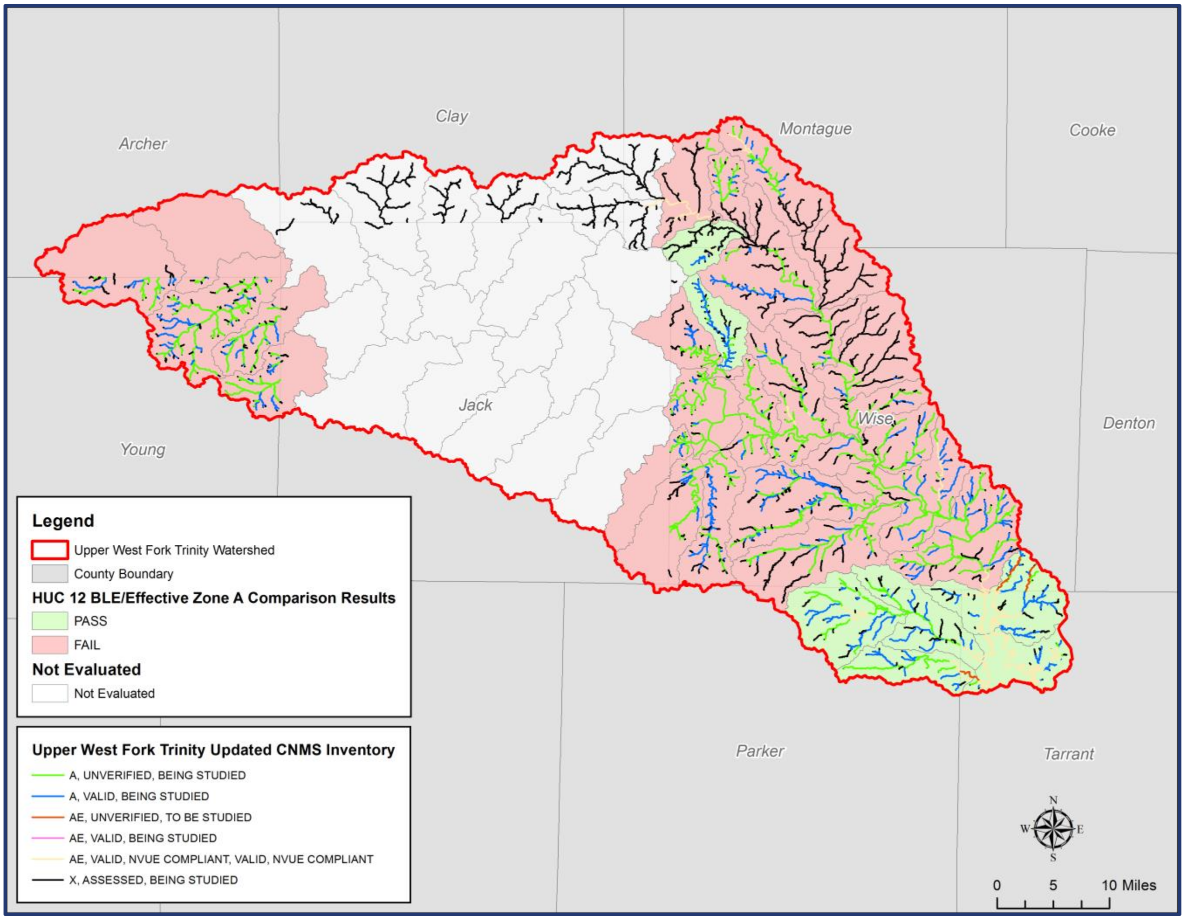


**Figure ES-1: Upper West Fork Trinity Watershed CNMS Validation Results**

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

Chicken Creek-Big Sandy Creek HUC-12 was determined to have the highest priority score and the most need while Indian Creek-Eagle Mountain Lake HUC-12 had the lowest scores.

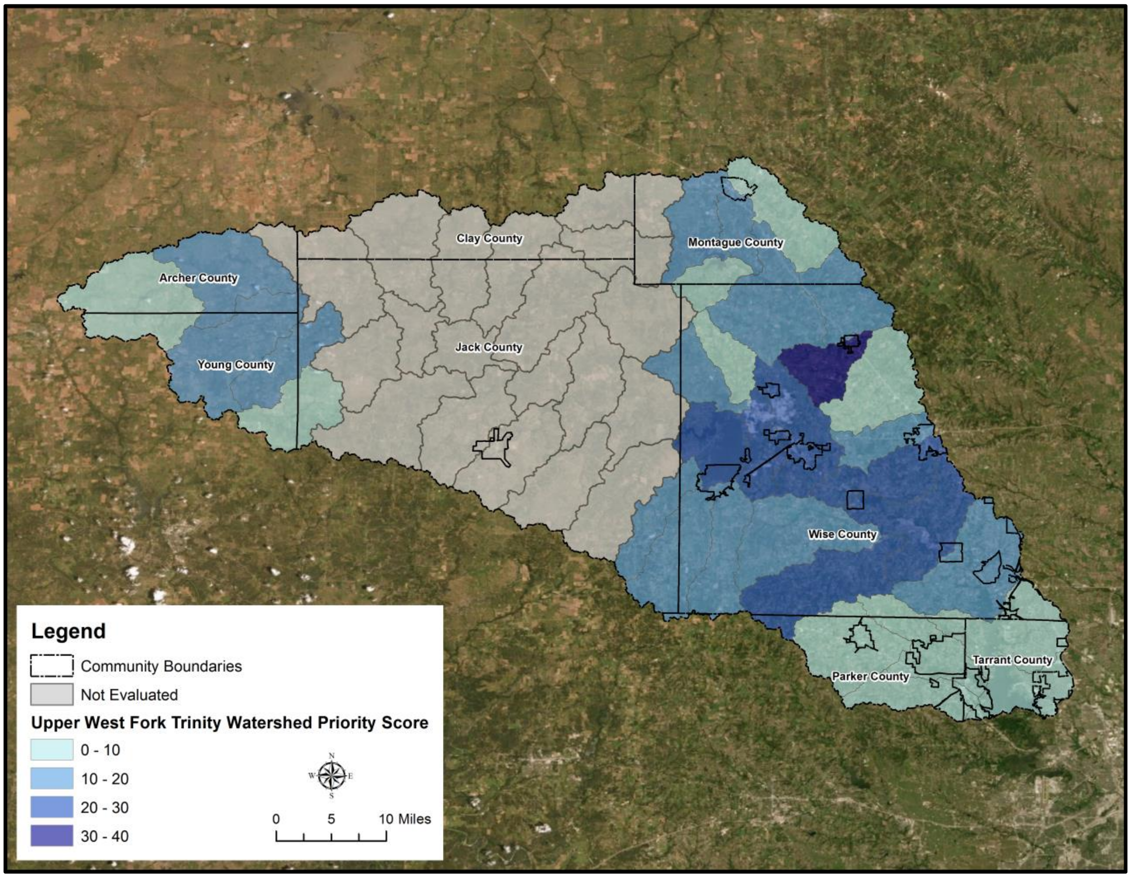


**Figure ES-2: Ranking of Upper West Fork Trinity Watershed HUC-12s**

# 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 Mapping, Assessment and Planning (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.

TWDB contracted AECOM to complete a BLE analysis for the Upper West 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 Clay, Montague, Parker, Tarrant, Wise, and Young County and include the following communities: the Cities of Alvord, Aurora, Azle, Bowie, Boyd, Bridgeport, Chico, Decatur, Forth Worth, Lake Bridgeport, New Fairview, Newark, Paradise, Pelican Bay, Reno, Rhome, Runaway Bay, Sanctuary, and Springtown. Archer and Jack County were previously studied and were not included in this study. The study area consists of portions of 5 HUC-10 basins: Cameron Creek-West Fork Trinity River, Big Cleveland Creek-West Fork Trinity River, Lake Bridgeport-West Fork Trinity River, Big Sandy Creek, and West Fork Trinity River-Eagle Mountain Lake. Figure 1 shows the orientation of the Upper West Fork Trinity HUC-10 basins with respect to the county boundaries.

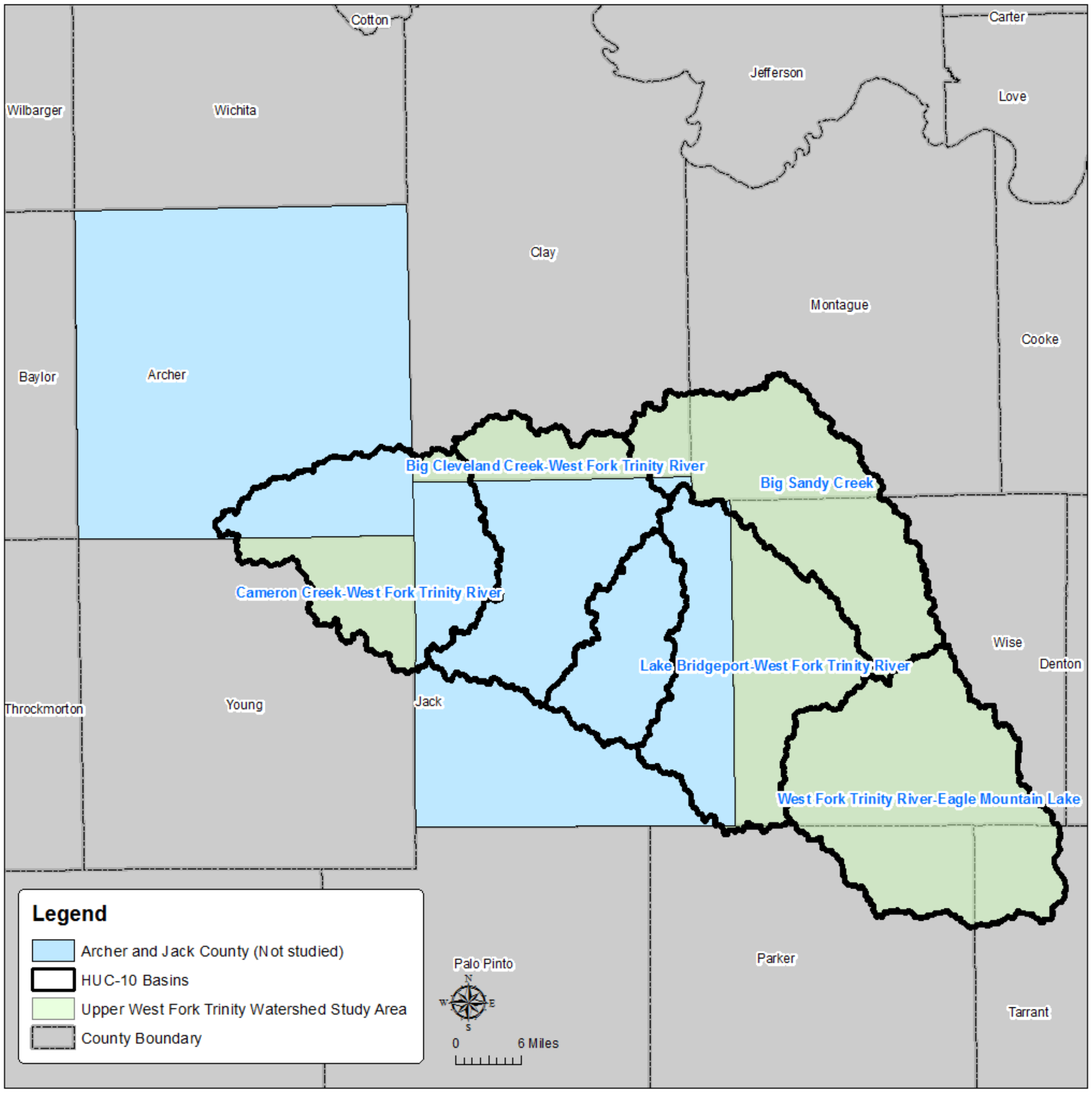


**Figure 1: Upper West Fork Trinity Watershed HUC-10 Basins**

AECOM studied approximately 1,405 miles of stream reaches within the Upper West 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 Upper West Fork Trinity Watershed.

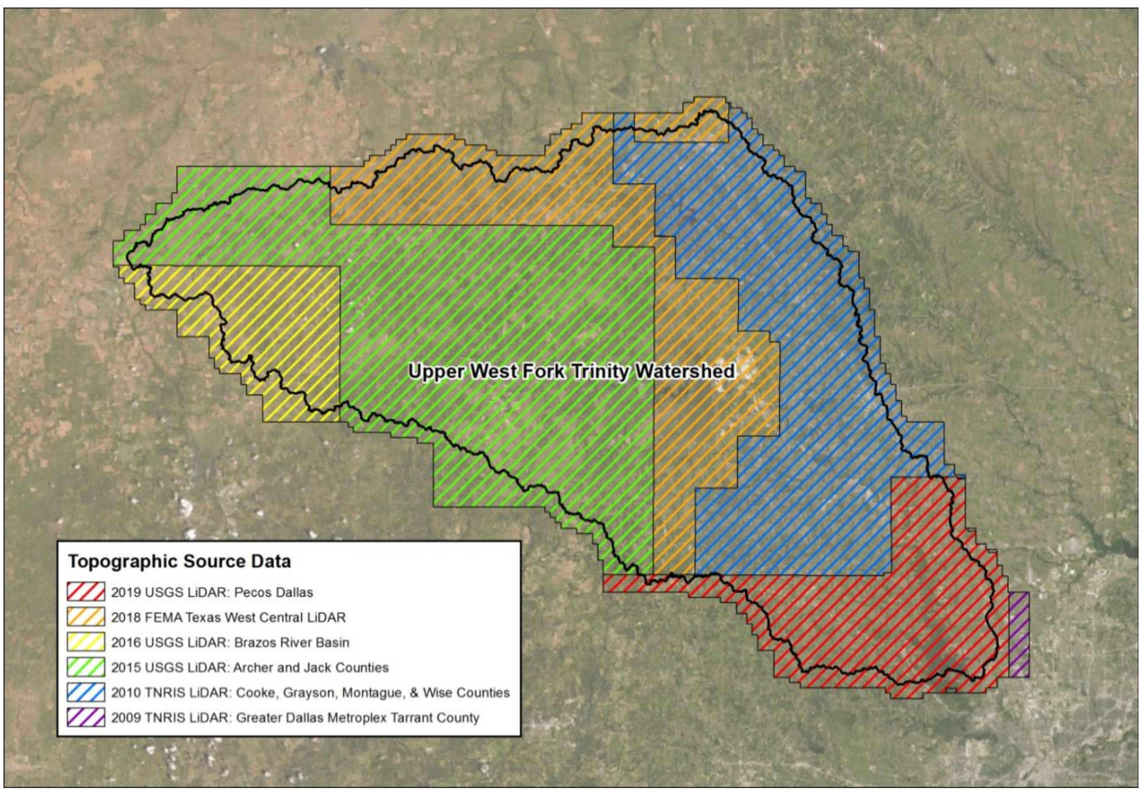


**Figure 2: Extent of LiDAR Data for Upper West Fork Trinity Watershed**

### 1.1.1 Source Terrain Data

Six topographic datasets were used in the development of the BLE hydraulic models. Table 1 depicts the complete list of source elevation data leveraged for the Upper West Fork Trinity Watershed. All datasets used for hydraulic analyses and mapping meet the highest specification level defined by FEMA vertical accuracy requirements. The following datasets were evaluated and prioritized as best available and details on each dataset are outlined in the subsections below.

**Table 1: LiDAR Topographic Data Available for Upper West Fork Trinity**

| Year | Description | Source/Owner | Accuracy[1] | Approximate Footprint (Sq.Mi.)[2] |
|---|---|---|---|---|
| 2019 | 2019 Pecos Dallas, TX LiDAR | USGS | 12.9 cm | 316 |
| 2018 | 2018 FEMA Texas West Central LiDAR | FEMA | 9.1 cm | 440 |
| 2016 | 2016 USGS LiDAR: Brazos River Basin | USGS / FEMA | 18.8 cm | 177 |
| 2015 | FEMA Region 6: Archer and Jack Counties, TX QL2 LiDAR | FEMA | 10.6 cm | 825 |
| 2010 | 2010 TNRIS LiDAR: Montague, Cooke, Grayson, and Wise Counties | TNRIS/TWDB | 9.25 cm | 568 |
| 2009 | 2009 TNRIS LiDAR: Greater Dallas Metroplex Tarrant County | TNRIS/TWDB | 7.5 cm | 14 |

[1]RMSEz reported at the 95% confidence level

[2]Size of LiDAR DEM footprint utilized for BLE study

#### 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 a 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 National Geospatial Program index. All deliverables were generated in conformance with the U.S. Geological Survey 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 MAP program for the TX 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-meter x 1,500-meter. 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, the Oklahoma counties of Bryan, Choctaw, Cotton, Crane, Jackson, Jefferson, Love, Marshall and Tillman, and the 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 2016 USGS LiDAR: Brazos River Basin

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy LiDAR technology for the Brazos portion of the Texas Red River FEMA Region 6 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-meter x 1,500-meter. A total of 15,254 tiles were produced for the project encompassing an area of approximately 12,660 square miles. LEG completed LiDAR data acquisition and data calibration for the project area.

The project area addressed by this report falls within the Brazos Basin, TX, which includes the counties of Archer, Baylor, Bell, Bosque, Brown, Callahan, Coleman, Comanche, Coryell, Dickens, Eastland, Erath, Fisher, Hamilton, Jack, Jones, King, Knox, Lampasas, McLennan, Mills, Palo Pinto, Runnels, Shackelford, Stephens, Stonewall, Taylor, Throckmorton, and Young.

The LiDAR aerial acquisition was conducted from November 17, 2016 and May 28, 2018.

The RMSEz reported for the dataset was 18.8 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

#### 1.1.1.4 2015 FEMA Region 6 - Archer and Jack Counties, TX QL2 LiDAR

The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy LiDAR technology for the FEMA Region 6 Archer and Jack Counties, TX QL2 LiDAR Project Area.

The LiDAR data were processed to a bare-earth DTM. 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-meter x 1,500-meter. A total of 2,252 tiles were produced for the project encompassing an area of approximately 1,671 square miles. Precision Aerial Reconnaissance (PAR) completed LiDAR data acquisition and data calibration for the project area.

The project area addressed by this report falls within the Texas counties of Archer and Jack.

The LiDAR aerial acquisition was conducted from January 4, 2015 to March 12, 2015.

The RMSEz reported for the dataset was 10.6 cm at the 95% confidence level which meets project accuracy specifications of the NSSDA.

#### 1.1.1.5 2010 TNRIS LiDAR: Cooke, Grayson, Montague, 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 4 points per 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 an 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.

#### 1.1.1.6 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.

### 1.1.2 Terrain Data Processing

A qualitative visual inspection of the composite DEM was performed, and no indications of 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. A small, triangular data gap was detected in between source LiDAR-derived datasets, however, and it was decided that this would be best filled by using a nearest neighbor interpolation of the closest LiDAR points. The result matched well with existing topographical maps. Because the gap was so small, no backup source data was necessary.

The Watershed Information System (WISE) software platform was used in order to create a digital surface model for the Upper West Fork Trinity Watershed project area. This module, in conjunction with ArcGIS, 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 Upper West Fork Trinity Watershed, followed by the 2018 FEMA Texas West Central LiDAR, the 2016 USGS LiDAR: Brazos River Basin, the 2015 FEMA Region 6 - Archer and Jack Counties, TX QL2 LiDAR, the 2010 TNRIS LiDAR: Montague, Cooke, Grayson, and Wise Counties, and lastly the 2009 TNRIS LiDAR: Greater Dallas Metroplex Tarrant County.

These LiDAR datasets, described more thoroughly in Section 2.2 above, were compiled in order of vertical accuracy into a mosaic dataset using ArcMap. From this mosaic, a seamless 10-foot bare earth DEM was exported. Visual inspection of the 10-foot DEM 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. A tile index was created for the project area, and the exported DEM was clipped into 40,000-foot tiles, converted to ascii files and imported into Wise Terrain Analyst (WTA).

Stream centerlines were created from the 10-foot DEM using proprietary software that is used to identify natural sinks, peaks and flat areas. 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. A rigorous visual QC was performed to ensure proper stream alignment through dams and culverts and to ensure the stream lines represented the stream bed channel correctly. Manual adjustment was applied where necessary as well as ensuring the stream did not jump a channel bank and flow into a neighboring stream. In open water areas, a more generalized line was used to flow through the middle of the water body.

These stream centerlines were then merged with those from two other sources: existing verified study streams from Archer and Jack Counties, and major streams (greater than 0.9 square miles of drainage area) that had been manually corrected from ArcHydro. The merged stream lines were then used as the basis for the hydraulic analysis and the hydro-enforcement of the 50-foot DEM. Several routines were subsequently used to take localized elevations from the source topographic data and apply them to the streams. This transferred vertical elevation information to each of the stream lines' vertices. The resulting elevations ensured that the streams were 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 was then "burned" into the 50-foot DEM to force flow through structures while preventing it from jumping out of the channel banks. This 50-foot DEM was used for hydro enforcement of the project area. Similar processes were performed to automate and manually route the flow through the 50-foot DEM to the outfall of the project area.

## 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 utilized 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). Bulletin 17C guidelines were utilized to perform a Flood Frequency Analysis (FFA) for the gages within the Upper West Fork Trinity watershed, and consideration was given to an on-going detailed hydrologic analysis by the U.S. Army Corps of Engineers (USACE) Fort Worth District of the Trinity River basin (see below for further discussion).

### 1.2.1 Regression Analysis

The 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 2 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 2: Summary of Regression Equations in Texas (SIR 2009-5087)**

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

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 $\log_{10}$ 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. 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.

### 1.2.2 Stream Gage Analysis

Figure 3 shows the location of the (5) USGS stream gages in the Upper West Fork Trinity River watershed that were utilized in developing discharges for the Upper West Fork Trinity mainstem (see Table 3 for details related to each gage). Flood frequency analyses (FFA) were performed in Peak FQ Version 7.3 for these gages, according to Bulletin 17C guidelines.

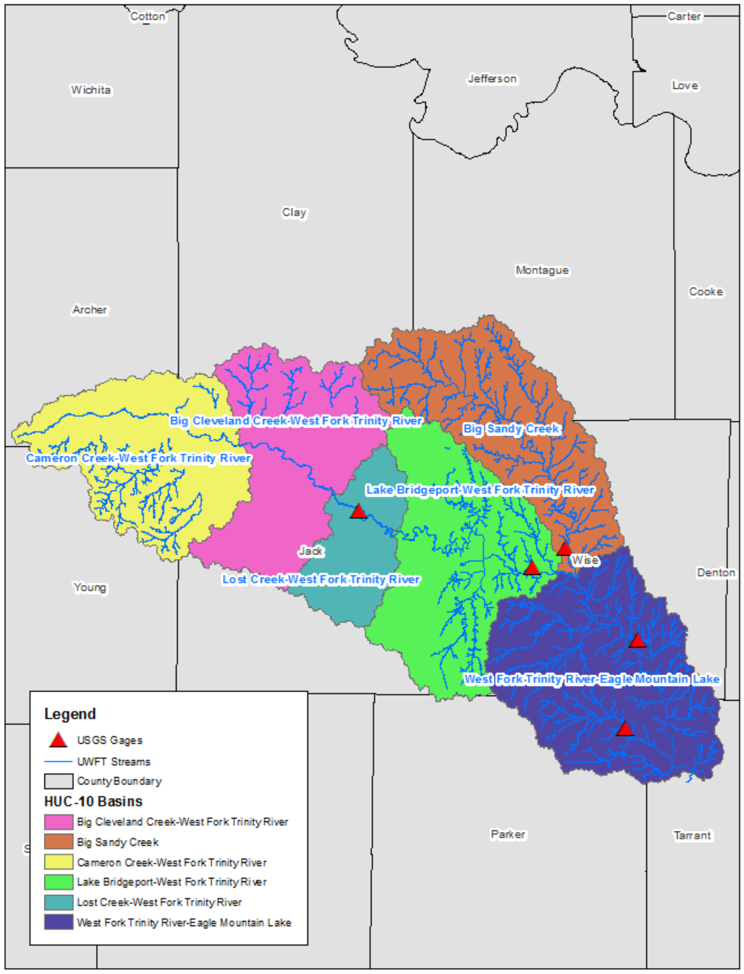


**Figure 3: Locations of USGS Gages Utilized in Flood Frequency Analyses**

**Table 3: USGS Stream Gages in Upper West Fork Trinity Watershed**

| Gage ID | Flooding Source and Location | Computed Drainage Area (mi.$^2$) | Published Drainage Area (mi.$^2$) | Period of Record |
|---|---|---|---|---|
| 08044000 | Big Sandy Creek nr Bridgeport, TX | 333 | 333 | 1956-2020 |
| 08043500 | W Fk Trinity Rv at Bridgeport, TX | 1,147 | 1,147 | 1908-1932 |
| 08044500 | W Fk Trinity Rv nr Boyd, TX | 1,725 | 1,725 | 1948-2019 |
| 08042800 | W Fk Trinity Rv nr Jacksboro, TX | 683 | 683 | 1915-1973 |
| 08044800 | Walnut Ck at Reno, TX | 62.4 | 75.6 | 1993-2020 |

After discussion with USACE Fort Worth District and the Tarrant Regional Water District, it was suggested to utilize flows from the Interagency Flood Risk Management (InFRM) study on the Trinity River Basin for the West Fork Trinity River mainstem. The flows utilized for this study were obtained from the September 2020 draft report due to the timing of this study. A newer version of this report is available as of July 2021 which has updates to the reported mainstem peak flows that were considered too minor to significantly impact the mainstem BLE modeling results.

However, stream gage analysis was incorporated in the development of the final discharges for the Big Sandy Creek and Walnut Creek tributaries. The flood flow frequency data from these gages were weighted with the regression developed discharges using the procedures described in SIR 2009-5087. Gage adjusted discharges were held constant if the adjustment resulted in flows decreasing the downstream direction. Gage variances were used for each storm event to develop the weighted discharges.

For Big Sandy Cr, the period of record used for the gage analysis excludes records prior to 1956. These records were not affected by diversion/regulation and do not reflect current conditions. For the West Fork Trinity Rv near Jacksboro, TX gage, an upper limit of 27,000 cfs was used in PeakFQ to represent the years with missing gage records. Records after 1973 were not used for the Jacksboro gage due to regulation. For the Big Sandy Creek and Walnut Creek gage analysis, a confidence interval of 0.84. However, for the W Fork Trinity Rv gage analysis, a confidence interval of 0.95 was used for comparison with the InFRM flows. Stream gage analysis worksheets are available as a part of this BLE submittal package.

### 1.2.3 InFRM Trinity River Basin Watershed Hydrology Assessment for Trinity River - Basin Flows

As mentioned above, the West Fork Trinity River mainstem utilized flows from the USACE InFRM Trinity River Watershed Hydrology Assessment Draft Report (September 2020). The following table shows the flow locations used from the report and the computed 1% discharge.

**Table 4: InFRM Trinity River Basin Study – Mainstem Discharges**

| Flooding Source and Location | Drainage Area (mi.$^2$) | 1% Discharge (cfs) |
|---|---|---|
| Upper West Fork Trinity below Beans Creek | 874.6 | 62,900 |
| Bridgeport Reservoir Inflow | 1,095.7 | 132,300 |
| Bridgeport Reservoir Outflow | 1,095.7 | 22,200 |
| Upper West Fork Trinity above Dry Creek | 1,136.2 | 22,200 |
| Upper West Fork Trinity above Big Sandy Creek | 1,169.5 | 28,000 |
| Upper West Fork Trinity below Big Sandy Creek | 1,523.5 | 49,300 |
| Upper West Fork Trinity near Boyd, TX | 1,710.8 | 55,100 |
| Eagle Mountain Reservoir Inflow | 1,956.6 | 102,700 |
| Eagle Mountain Reservoir Outflow | 1,956.6 | 29,000 |

Flows for the other events were also incorporated from the InFRM report. However the 1% plus and 1% minus flows were not included in the InFRM Report. The 1% plus and minus 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% plus, therefore a 2-year flow was estimated using a log-log best-fit equation and then applied to the 1% plus and minus methodology.

## 1.3 Hydraulics

The hydraulic approach for this BLE analysis of the Upper West 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 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 5. These default values for dimensions and spacing were subject to change based on engineering judgment.

**Table 5: Cross-Section Default Parameters**

| Drainage area (upper limit) (sq. mi) | XS Spacing (ft) | Channel Top Width (ft) | Channel Bottom Width (ft) | Channel Depth (ft) |
|---|---|---|---|---|
| 1 | 300 | 6 | 5 | 0.8 |
| 2 | 300 | 7 | 6 | 0.8 |
| 4 | 300 | 10 | 8 | 0.8 |
| 8 | 400 | 12 | 11 | 0.8 |
| 10 | 500 | 13 | 12 | 0.8 |
| 15 | 500 | 18 | 13 | 0.8 |
| 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 6. 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 6: 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.

### 1.3.1 InFRM Trinity River Basin Study Reservoir Elevations

Coordination with the Tarrant Regional Water District and USACE was initiated for discharges and reservoir elevations, particularly for the Bridgeport Reservoir. The InFRM Watershed Hydrology Assessment for the Trinity River Basin provided recommended frequency pool elevations for large reservoirs/dams. The pool elevations were incorporated into the HEC-RAS model as known WSELs. The 1% plus and minus pool elevations were not provided in the report, but were calculated based on a discharge interpolation. Table 7 below shows the water surface elevations incorporated at each location for the Upper West Fork Trinity HEC-RAS model.

**Table 7: InFRM Trinity River Basin - Reservoir Elevations**

| Reservoir | Drainage Area (sq. mi) | 10% | 4% | 2% | 1% | 0.2% | 1% minus | 1% plus |
|---|---|---|---|---|---|---|---|---|
| Bridgeport Reservoir | 1095.7 | 839.5' | 842.2' | 845.5' | 848.8' | 855.6' | 846.3' | 851.9' |
| Eagle Mountain Reservoir | 1956.6 | 651.3' | 654' | 656.5' | 659.5' | 666' | 656.9' | 663.8' |

### 1.3.2 Jack and Archer County Tie-ins

A BLE analysis was previously conducted for Jack and Archer Counties as part of a separate BLE study. That study has since been incorporated largely into the effective mapping for Jack and Archer Counties. Several streams in this UWFT study area (outside of Jack and Archer Counties) continue upstream or downstream into Jack and Archer Counties. Cross-sections from the Jack and Archer studies were incorporated into this BLE study at the county boundary and known water surface elevations were applied to the HEC-RAS model to ensure a proper tie-in at the county boundary. In some instances, a scoped stream was not studied in Jack and Archer County. For those streams, the model study was extended downstream into Jack or Archer County in order to tie-in to the effective mapping.

## 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.

Quality Control (QC) review 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.

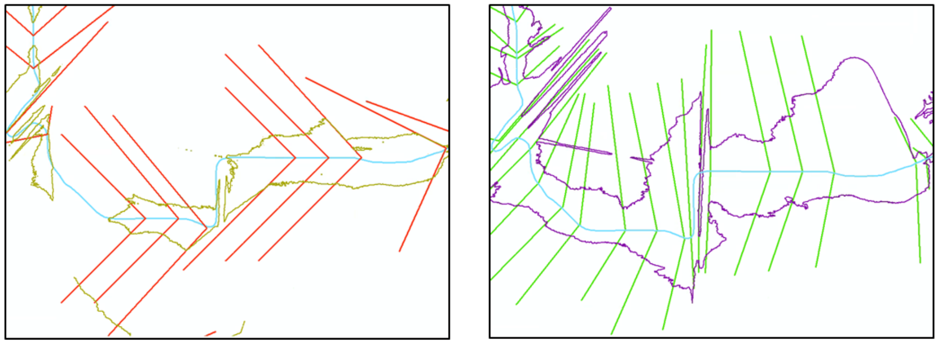

**Figure 4: Default "V" angle cross-sections automated by WISE (left). Manually edited cross-sections to more accurately capture terrain (right). Resulting flood boundaries shown in gold (left) or purple (right) for clarity.**

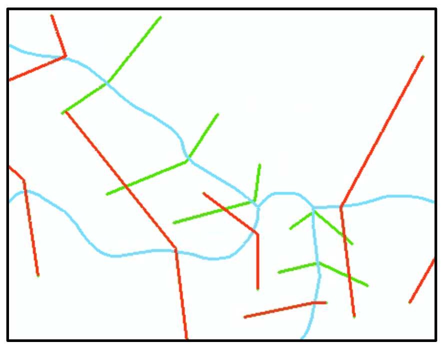

**Figure 5: Manually added cross-sections (green) to improve accuracy of tie-ins at confluences.**

## 1.5 One-percent Special Flood Hazard Area Delineation

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

There are a handful of dams throughout the watershed of different sizes. Flow differences from these structures were not considered with the calculated regression equations used. There are also three levees located in the watershed, the Wise Lake Levees, Garrett Creek Levees, and Salt Creek Lake Levee. All of these levees are non-accredited and do not meet the 44 CFR Part 65.10. BLE mapping reflects a natural valley floodplain approach, and therefore flood impacts of the levees were not considered. There may be need for further investigation in areas that include these structures, particularly the dams designed for flood control.

There are several containment issues in the West Fork Trinity-Eagle Mountain Lake watershed. Many of the issues occurred in areas where multiple streams converged in low lying areas were containment could not easily be obtained. All streams where overtopping errors occur should be considered for detailed study. These streams are discussed further in the following paragraphs.

The outflow of Salt Creek and Garret Creek should also be considered for detailed study. The two streams both have large flows, between 20,000-30,000cfs during the 100-yr event, and run almost parallel to each other. Salt Creek in this area has been confined to a small undersized ditch that does not contain the 100-yr event. This has caused most of the flow to shift to Garrett Creek. Since the flows are high and the floodplains are shared, this area is recommended for detailed study.

There are a few additional areas with shared floodplains including South Fork Rush Creek and North Fork Rush Creek, UNT 109 and Salt Creek, and UNT 180 and UNT 034. In these areas two streams run parallel to each other and share a floodplain, causing issues with mapping. These areas are recommended for detailed study.

There are also some streams where cross sections are overtopping because the stream is confined to one side of a road or within a confined ditch. These streams, including UNT 166, UNT 003, UNT 178, UNT 049 could spill over into adjacent low-lying areas are recommended for detailed study.

A few additional streams in the work area are not contained and tend to flow into adjacent low-lying areas including areas of Browder Creek, UNT 098 wants to flow into Walnut Cr, and UNT 044 wants to flow into UNT 045. Similarly, there are streams with adjacent low-lying areas like pools and ponds. These streams including UNT 264, UNT 230, UNT 190, and UNT 196 should be studied further to determine how much flow is contained within these ponds.

There were no discernable containment issues across the Big Sandy Creek watershed. UNT 203, however, was a unique scenario that had cross section vertices set on top of road US Highway 380 as opposed to typical ground terrain in an effort to contain flows. UNT 203 for the Waggoner Branch watershed is recommended for further detailed study.

Along Big Sandy Creek there are several confluences with the main stem that have shared floodplains where streams run in parallel to each other. The confluence of Big Sandy Creek and Waggoner Branch poses a unique scenario in which the Waggoner Branch tributary takes the place of Big Sandy Creek as the mainstem based on previous NFHL data. The Big Sandy Creek and Waggoner Branch streams also run parallel to each other with 100-yr flows exceeding 40,000cfs. Consequently these streams are recommended for detailed study.

There were a few additional locations with shared floodplains including Briar Branch and UNT 178, Brushy Creek and UNT 156, Big Sandy Creek and Sandy Creek, Big Sandy Creek and Turkey Creek, and Big Sandy Creek and Jones Creek. These locations have been modeled as shared floodplain locations with a significant portion of these streams running parallel.

The Briar Branch and UNT 178 location had an issue pertaining to mapping and it is recommended this area be upgraded for detailed study. UNT 079 was also a location that had issues mapping and may benefit from detailed study.

In the Big Sandy Creek watershed, these streams bordered Jack County: UNT 020, UNT 214, South Creek, UNT 212, UNT 023, Kiel Creek and UNT 047. Tying into the downstream cross section for these streams however was not possible due to resulting differences in water surface elevation between Jack County BLE and Big Sandy Creek BLE models exceeding 0.5ft and overtopping issues when attempting to tie in. These discrepancies were likely due to difference in terrain data cell size between the Jack County BLE study and the Big Sandy Creek BLE study. Consequently, these streams were restudied and incorporated within the scope of the Big Sandy Creek Watershed basin BLE study efforts. Cross sections were adopted from the Jack County BLE models and adjusted or added to as needed for overtopping scenarios or hydraulic structures.

In the Cameron Creek watershed, there were some streams that are overtopping and flow was unable to be contained. These streams include UNT 100, UNT 090, UNT 089, UNT 164, UNT 065, UNT 166, UNT 083, UNT 162, and UNT 188. These streams are recommended for detailed study.

In the Big Cleveland Creek watershed, some cross sections on North Fork Crooked Creek were overtopped and flow was unable to be contained. This stream is recommended for detailed study.

In the Lake Bridgeport watershed, there were some streams that are overtopping and flow was unable to be contained. These streams include Barton Branch, Boons Creek, Dry Creek, Ramsey Creek, UNT 338, UNT 332, UNT 280, UNT 276, UNT 174, UNT 176, UNT 215, UNT 126, UNT 202, UNT 285, UNT 320, and Village Creek. Several of these streams are adjacent to the quarries in the watershed. In particular, Dry Creek, Village Creek, UNT 126, and UNT 133 were difficult to model due to their proximity to the quarries. Additional detailed study is recommended for the streams near the quarry area.

For the Upper West Fork Trinity mainstem, an upstream tie-in with the Jack/Archer County study and effective study was not achieved. The upstream study did not consider the effects from the downstream reservoir (Lake Bridgeport) and appeared to underestimate the water surface elevations at that study's downstream boundary.

# 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 (891.2 miles) in the Upper West Fork Trinity Watershed were classified in CNMS with validation status of “UNVERIFIED” (572.6 miles) or “VALID” (318.5 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. For the study area in the Upper West Fork Trinity Watershed, the effective Zone A topographic data leveraged was based primarily upon USGS Topographic maps. The LiDAR sources discussed in Section 1.1 are a significant improvement from the effective Zone A topographic source and, therefore, nearly the entire effective Zone A inventory fails this check. There are three reaches within the HUC-8 watershed that that were updated via a LOMR study that did utilize LiDAR data for the effective study that pass 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.

Regression equations were not used for any effective Zone A study areas located in the Upper West Fork Trinity Watershed and, therefore, all reaches 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 entire study area is still classified as rural, so all reaches pass this check.

All of the initial assessment results are shown in Table 8.

**Table 8: Zone A Initial Assessment Results**

| Assessment Check | Pass / Fail | Notes |
|---|---|---|
| A1 – Topography | Pass/Fail | LiDAR used in effective study/LiDAR sources available are a significant improvement from effective topography |
| A2 – Hydrology | Pass | Regression equations not used in effective study |
| A3 – Development | Pass | HUC-12 watershed does not meet urban threshold |

### 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. Almost all Zone A studies within the Upper West Fork Trinity Watershed are old studies not known to be model-backed studies and, therefore, fail this check. There are four effective Zone A reaches within the entire watershed that were updated via a LOMR that are known to be model-backed that pass 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 9 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 9: BLE Comparison Results**

| HUC-12 Watershed | | Total FBS points | Fail | Pass | %Pass | BLE Comparison Pass? (>85%) | Priority Score |
|---|---|---|---|---|---|---|---|
| Watershed Name | Watershed Number | | | | | | |
| Upper West Fork Trinity Watershed | All Streams | 44,157 | 9,304 | 34,853 | 79% | FAIL | |
| Ash Creek | 120301010609 | 1,590 | 180 | 1,410 | 89% | PASS | 9.5 |
| Big Creek-Lake Bridgeport | 120301010405 | 1,032 | 188 | 844 | 82% | FAIL | 14.6 |
| Blue Creek-Eagle Mountain | 120301010605 | 3,832 | 717 | 3,115 | 81% | FAIL | 15.4 |
| Boons Creek | 120301010407 | 1,041 | 173 | 868 | 83% | FAIL | 14.8 |
| Briar Branch-Big Sandy Creek | 120301010510 | 500 | 138 | 362 | 72% | FAIL | 8.1 |
| Brier Creek-Lake Amon G | 120301010503 | 118 | 26 | 92 | 78% | FAIL | 14.1 |
| Chicken Creek-Big Sandy Creek | 120301010509 | 574 | 330 | 244 | 43% | FAIL | 33.2 |
| Cowskin Creek-Big Sandy Creek | 120301010505 | 275 | 24 | 251 | 91% | PASS | 7.0 |
| Dead Horse Creek-Brushy | 120301010103 | 3,330 | 803 | 2,527 | 76% | FAIL | 12.1 |
| Dosier Creek-Eagle Mountain | 120301010610 | 357 | 31 | 326 | 91% | PASS | 8.3 |
| Dry Creek-West Fork Trinity | 120301010411 | 2,055 | 656 | 1,399 | 68% | FAIL | 23.8 |
| Garrett Creek | 120301010602 | 2,617 | 483 | 2,134 | 82% | FAIL | 16.6 |
| Indian Creek-Eagle Mountain | 120301010606 | 1,436 | 83 | 1,353 | 94% | PASS | 5.3 |
| Jasper Creek | 120301010406 | 483 | 93 | 390 | 81% | FAIL | 11.8 |
| Lake Bridgeport | 120301010409 | 1,923 | 628 | 1,295 | 67% | FAIL | 26.1 |
| Lower Brushy Creek | 120301010507 | 32 | 21 | 11 | 34% | FAIL | 16.4 |
| Lower Walnut Creek | 120301010608 | 1,694 | 239 | 1,455 | 86% | PASS | 9.5 |
| Martin Branch-West Fork | 120301010601 | 1,922 | 582 | 1,340 | 70% | FAIL | 26.4 |
| Oak Creek-Jones Creek | 120301010504 | 769 | 156 | 613 | 80% | FAIL | 14.5 |
| Plum Creek | 120301010104 | 1,483 | 325 | 1,158 | 78% | FAIL | 11.0 |
| Prickly Pear Branch-West Fork | 120301010102 | 94 | 25 | 69 | 73% | FAIL | 14.5 |
| Pringle Creek-Big Sandy Creek | 120301010508 | 1,811 | 346 | 1,465 | 81% | FAIL | 12.2 |
| Salt Creek | 120301010603 | 1,822 | 561 | 1,261 | 69% | FAIL | 25.3 |
| South Fork Trinity River-West | 120301010101 | 1,057 | 193 | 864 | 82% | FAIL | 7.3 |
| Upper Brushy Creek | 120301010506 | 849 | 127 | 722 | 85% | FAIL | 8.5 |
| Upper Cameron Creek | 120301010105 | 1,288 | 248 | 1,040 | 81% | FAIL | 9.6 |
| Upper Walnut Creek | 120301010607 | 2,477 | 295 | 2,182 | 88% | PASS | 9.2 |
| Venchoner Creek | 120301010404 | 1,105 | 116 | 989 | 90% | PASS | 8.4 |
| Village Creek-West Fork Trinity | 120301010410 | 1,368 | 427 | 941 | 69% | FAIL | 26.2 |
| Waggoner Branch-Big Sandy | 120301010511 | 878 | 203 | 675 | 77% | FAIL | 16.7 |
| Walnut Creek-West Fork | 120301010604 | 2,517 | 591 | 1,926 | 77% | FAIL | 20.6 |
| Willow Creek | 120301010408 | 1,828 | 296 | 1,532 | 84% | FAIL | 14.7 |

## VALIDATION RESULTS

Based on the validation assessments and BLE comparison results described above, the CNMS inventory of Zone A studies in the Upper West Fork Trinity Watershed has been updated as summarized in Table 10 and illustrated in Figure 6 below.

**Table 10: Zone A Validation Results**

| Validation Status | Status Type | Total Miles |
|---|---|---|
| VALID | BEING STUDIED | 318.5 |
| UNVERIFIED | BEING STUDIED | 572.6 |

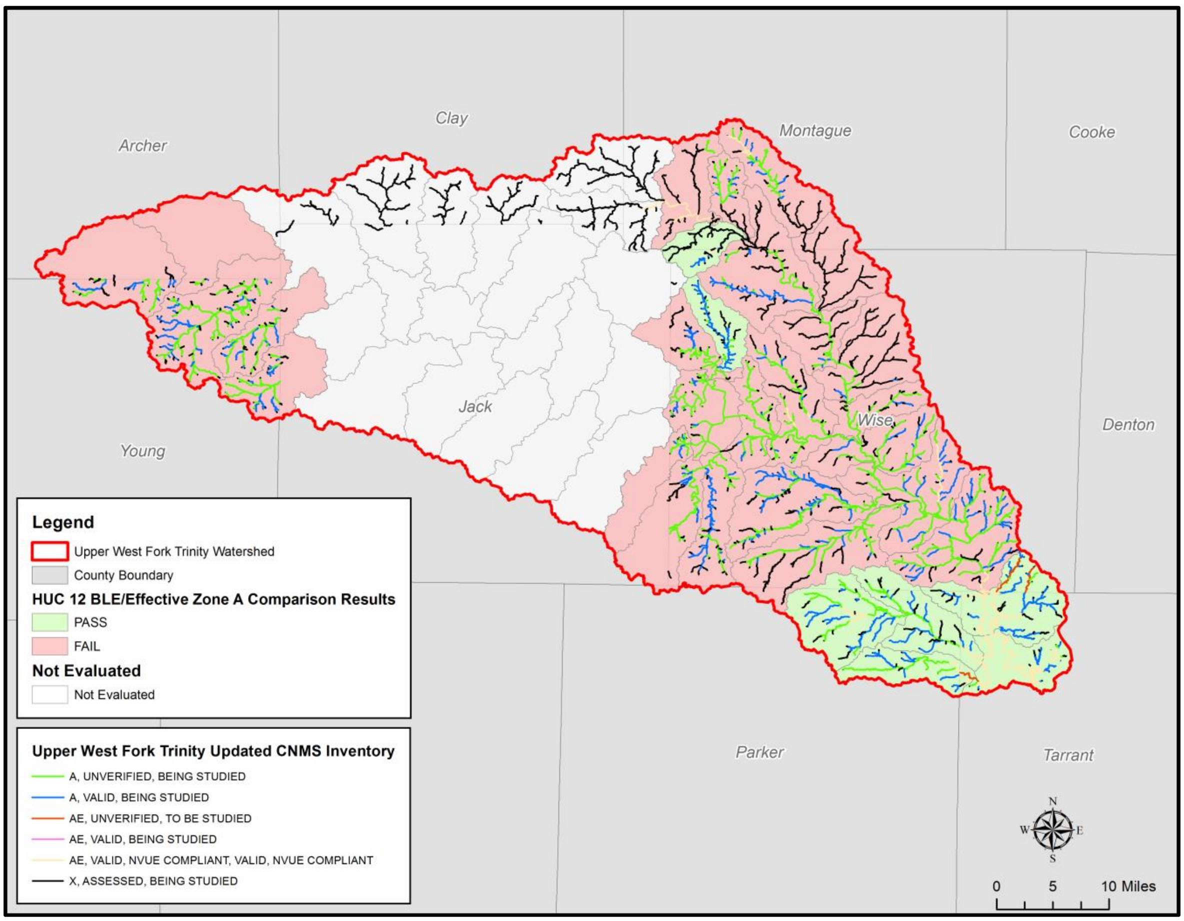


**Figure 6: Upper West Fork Trinity Watershed CNMS Validation Results**

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.

Chicken Creek-Big Sandy Creek HUC-12 was determined to have the highest priority score and the most need while Indian Creek-Eagle Mountain Lake HUC-12 had the lowest scores.

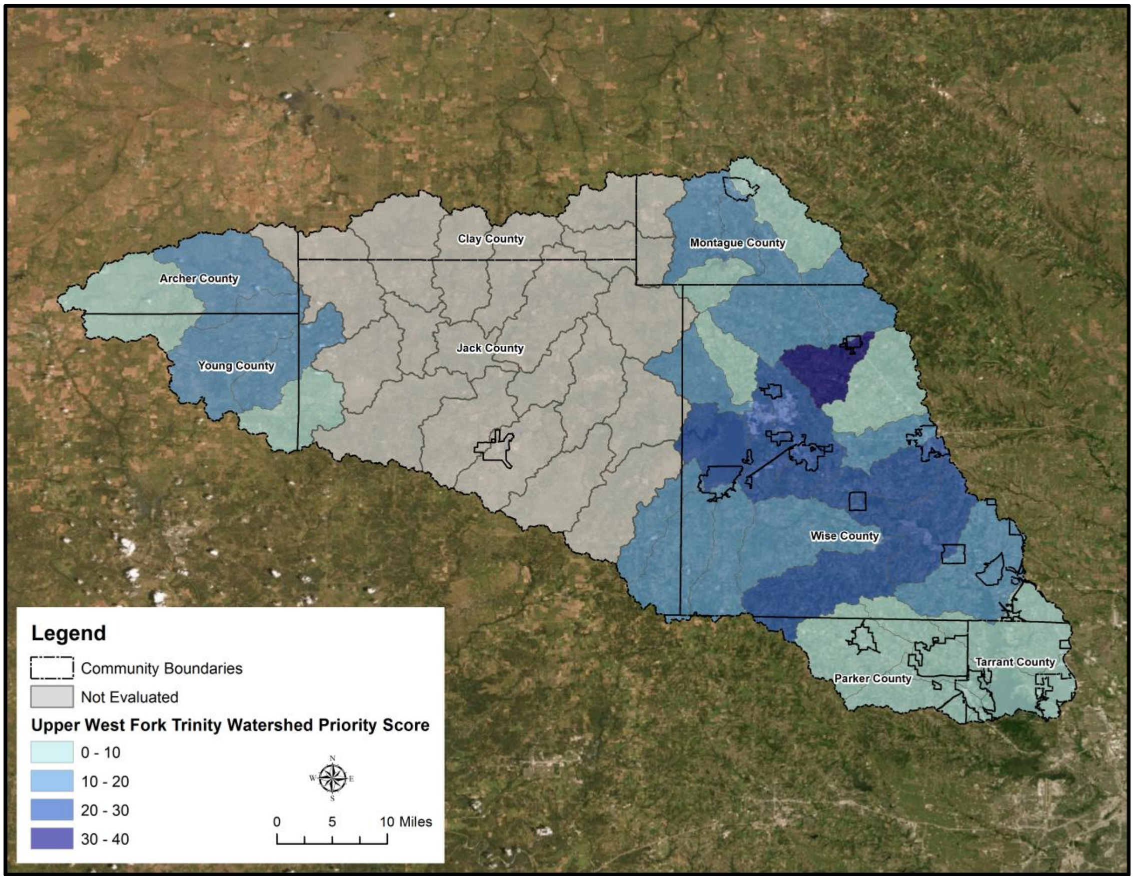


**Figure 7: Ranking of Upper West Fork Trinity Watershed HUC-12s**

## 3.2 Flood Risk Analysis

A flood risk analysis was performed for this project. The updated 1% annual chance and 0.2% annual chance 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 11.

**Table 11: Hazus 4.2 (SP02) Results for 1-percent-annual-chance (100 year) scenario**

| County | Full Replacement - Total Loss | Dollar Exposure (Replacement Value) - Buildings | Dollar Exposure (Replacement Value) - Contents |
|---|---|---|---|
| Archer | 3,000 | 2,000 | 1,000 |
| Clay | 934,000 | 507,000 | 263,000 |
| Jack | 24,000 | 14,000 | 6,000 |
| Montague | 52,582,000 | 21,806,000 | 13,318,000 |
| Parker | 68,693,000 | 21,930,000 | 18,497,000 |
| Tarrant | 118,826,000 | 43,067,000 | 34,222,000 |
| Wise | 225,460,000 | 79,524,000 | 67,282,000 |
| Young | 339,000 | 165,000 | 98,000 |

# References

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# Appendix A BLE Map