



North Central Texas
Council of Governments

Integrating Transportation and Stormwater Infrastructure

Hydraulic Modeling for the Upper Clear Fork Trinity River Watershed

June 2026



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Integrating Transportation and Stormwater Infrastructure (TSI) HEC-RAS Modeling for the Upper Clear Fork Trinity River Watershed

U.S. Army Corps of Engineers

1. Executive Summary

This report presents an enhanced two-dimensional (2D) hydraulic model of the Upper Clear Fork Trinity Watershed, based on the Base Level Engineering (BLE) Study from the Texas Water Development Board (TWDB). Using the refined Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) derived runoff results, the model estimates flood depths and peak water surface elevations across the integrating Transportation and Stormwater Infrastructure (TSI) study area.

Enhancements to the BLE model include the addition of 78 structures, comprised of 56 bridges, 19 culverts, and 3 Natural Resource Conservation Service (NRCS) dams, with as-built data or standard assumptions, refined computational meshes at crossings, updated terrain from the latest topographic data, and conversion of rain-on-grid inputs to boundary-applied inflow hydrographs. Various simulation plans cover existing (2020) and future (2070) land use conditions across a range of recurrence intervals (2- to 500-year).

The enhanced model provides a tool for flood assessment, hydraulic analysis, and evaluating potential impacts of future development within the watershed.

2. HEC-RAS Methodology

2.1. Original Model

The BLE study for the Lower West Fork Trinity Watershed (HUC-08: 12030102) obtained from TWDB was used as the basis for the enhanced hydraulic model. The 2023 study includes the development of 2D hydraulic models for seven Hydrologic Unit Code (HUC) -10 watersheds within the Lower West Fork Trinity Watershed. The BLE Upper Clear Fork Trinity River watershed model (HUC-10s: 1203010202 and 1203010203 above Lake Benbrook) served as the starting point for the hydraulic modeling developed for this project.

Precipitation depths for this analysis were derived from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall data. HEC-HMS was used to develop a simplified

hydrologic model to generate rainfall-runoff estimates, which were then applied in a rain-on-grid 2D hydraulic simulation using the Hydrologic Engineering Center – River Analysis System (HEC-RAS) model. The hydraulic model was used to estimate flood depths and peak water surface elevations across the study area.

2.2. Enhanced Model

Several modifications were implemented to the original BLE hydraulic model to more accurately represent existing conditions and to evaluate potential impacts of future development within the study area. The primary modifications included changes in the terrain, addition of structures, and the conversion of the rain-on-grid approach to inflow hydrographs. The following chapters provide additional details on each of the modifications done in the hydraulics model.

2.2.1 Structures Data

Bridges and culverts were added to the BLE model at major crossings to more accurately represent hydraulic conditions, including velocity, water surface elevation (WSE), and flow rate at those locations. A total of 78 structures were added, including 56 bridges, 19 culverts, and 3 NRCS dams. The SA/2D Connections representing Benbrook Lake and Lake Weatherford were modified to separate the principal spillway from the auxiliary spillway at each dam.

As-built data was used as inputs for these structures when available. If as-built information was not provided or if data was missing from the document, the following assumptions and procedures were applied:

- No as-built information provided: Major bridge parameters, including total length, number of piers, and width, were obtained using the Texas Department of Transportation (TxDOT) Open Data Portal.
- Missing bridge dimensions: If bridge dimensions (span lengths, widths, or heights) were not provided, measurement tools were applied directly to the document using the sheet scale.
- Unknown elevation datum: In cases where elevations were reported in an undetermined datum—such as some as-builts setting the channel bottom to zero—an offset was applied to align the roadway elevation from the Light Detection and Ranging (LiDAR) data with the converted elevation in the current datum. Additionally, for structures with as-built documentation dated prior to 1987, a conversion from the National Geodetic Vertical Datum of 1929 (NGVD 29) to the North American Vertical Datum of 1988 (NAVD 88) was adopted. The conversion factor, typically ranging from 0.0 to 0.2 feet, was selected based on the specific crossing location.

Table 1 lists the added structures and **Figure 1** shows their locations within the Upper Clear Fork Trinity River watershed. The TxDOT IDs used for the National Bridge Inventory (NBI) are listed for the applicable crossings.

Table 1: List of SA/2D Connections

TxDOT ID	Type	Feature Crossed	Facility Carried
022200AA0110001	Bridge	Bear Creek	Ben Day Murrin Rd
022200133001008	Bridge	Bear Creek	FM 1187
021840008006064	Bridge	Bear Creek	US Highway 377
n/a	Culvert	Belknap Branch	Zion Hill Rd
021840AA0266002	Bridge	Burgess Creek	Airport Rd
021840V00005001	Bridge	Burgess Creek	Annetta Centerpoint Rd
021840316301001	Culvert	Clear Fork Trinity River Trib 1	Lone Star Rd
021840AA0385002	Bridge	Clear Fork Trinity River Trib 2	Jenkins Rd
021840160101011	Bridge	Clear Fork Trinity River	Azle Highway
021840AA0337001	Bridge	Clear Fork Trinity River	Crown Rd
021840AA0159001	Bridge	Clear Fork Trinity River	Erwin Rd
021840000809293	Bridge	Clear Fork Trinity River	FM 5
021840031302029	Bridge	Clear Fork Trinity River	FM 51
021840117902011	Bridge	Clear Fork Trinity River	FM 920
n/a	Culvert	Clear Fork Trinity River	Friendship Rd
021840000803275	Bridge	Clear Fork Trinity River	Interstate Highway 20
021840AA0265001	Bridge	Clear Fork Trinity River	Kelly Rd
021840J00105001	Bridge	Clear Fork Trinity River	Kings Gate Rd
021840B00422001	Bridge	Clear Fork Trinity River	Lake Dr
021840AA0189001	Bridge	Clear Fork Trinity River	Old Agnes Rd
021840AA0405001	Bridge	Clear Fork Trinity River	Old Annetta Rd
021840AA0196001	Bridge	Clear Fork Trinity River	Sarra Ln
021840AA0386001	Bridge	Clear Fork Trinity River	Underwood Rd
021840AA0196001	Bridge	Clear Fork Trinity River	Upper Denton Rd
022200008007050	Bridge	Clear Fork Trinity River	US Highway 377
021840008006029	Culvert	Dickeys Branch	US Highway 377
021840AA0227001	Bridge	Dobbs Branch	Friendship Rd
022200008007033	Bridge	Dutch Branch	Benbrook Blvd
021840AA0222002	Bridge	Gourdneck Creek	Dry Creek Rd
021840117902006	Culvert	Gourdneck Creek	FM 920
021840AA0189002	Bridge	Gourdneck Creek	Old Agnes Rd
021840243501002	Culvert	Gourdneck Creek	Zion Hill Rd
n/a	Culvert	Mustang Creek Trib 1	FM 2331
n/a	Culvert	Mustang Creek Trib 3	Sky Rd
022200133001009	Bridge	Mustang Creek	FM 1187
021270241702002	Bridge	Mustang Creek	FM 2331
n/a	Culvert	Patton Branch	FM 51
021270211802002	Culvert	Rock Creek Trib 1	FM 1902

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TxDOT ID	Type	Feature Crossed	Facility Carried
021270AA0125002	Bridge	Rock Creek Trib 2	County Road 915
n/a	Culvert	Rock Creek Trib 4	County Road 920
022200050402539	Culvert	Rock Creek Trib 5	Chisholm Trail Pkwy
022200133001011	Culvert	Rock Creek Trib 5	FM 1187
022200211801001	Culvert	Rock Creek Trib 5	Old Granbury Rd
022200050402523	Culvert	Rock Creek Trib 6	Chisholm Trail Pkwy (in TxDOT GIS shows Chisholm Trail bridge)
021270050405495	Bridge	Rock Creek	County Road 1015
n/a	Bridge	Rock Creek	County Road 913
021270AA0125001	Bridge	Rock Creek	County Road 915
021270AA0192001	Bridge	Rock Creek	County Road 920
022200133001010	Bridge	Rock Creek	FM 1187
021840AA0409001	Bridge	South Bear Creek	Goforth Rd
021840008006063	Bridge	South Bear Creek	US Highway 377
021840146901004	Bridge	South Fork Trinity River	FM 5
021840146901003	Bridge	South Fork Trinity River	FM 5
021840J00020003	Bridge	Squaw Creek	Ranch House Rd
021840B00080001	Bridge	Town Creek	Bowie Dr
021840AA0375001	Bridge	Town Creek	Center Point Rd
021840117903052	Bridge	Town Creek	Denton St
021840B00255001	Bridge	Town Creek	Elm St
021840B00295001, 021840B00295003	Bridge	Town Creek	Franklin Ln
021840031407048, 021840031407049	Bridge*	Town Creek	Interstate Highway 20
021840031302008	Bridge	Town Creek	Main St
021840AA9283001	Bridge	Town Creek	Ric Williamson Memorial Hwy
021840000803200, 021840000803201	Bridge*	Town Creek	State Highway 180
021840AA0374001	Bridge	Underwood Branch	Center Point Rd
021840031407041	Culvert	Underwood Branch	Interstate Highway 20
021840AA0340001	Bridge	Willow Creek	Bankhead Hwy
021840AA0226001	Bridge	Willow Creek	Ben Day Murrin Rd
n/a	Culvert	Willow Creek	De la Cruz St
021840031302038	Bridge	Willow Creek	FM 51
021840AA0181001	Bridge	Willow Creek	Harwell Lake Rd
021840031407231, 021840031407232, 021840031407043, 021840031407044	Bridge*	Willow Creek	Interstate Highway 20
021840B00570001	Culvert	Willow Creek	Old Dicey Rd

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TxDOT ID	Type	Feature Crossed	Facility Carried
021840000803406, 021840000803407	Bridge*	Willow Creek	State Highway 180
021840AA0252001	Bridge	Willow Creek	Upper Denton Rd
021840243501001	Culvert	Willow Creek	Zion Hill Rd

* Given the short distance between the two bridges and their similar structural profiles, the bridges were modeled as a single structure to more accurately represent hydraulic conditions and prevent stability issues.

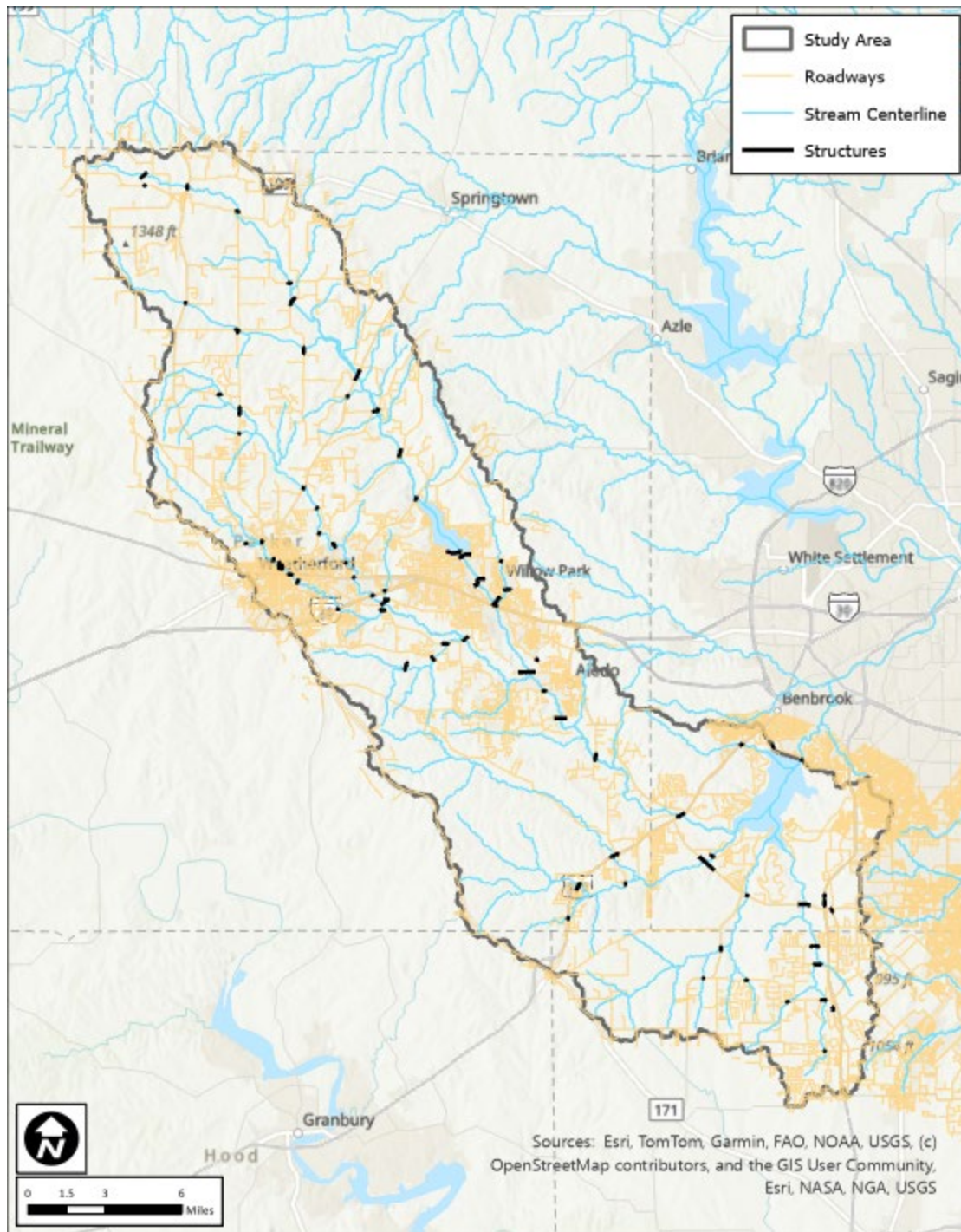


Figure 1: Locations of 2D Structures

2.2.2 2D Mesh

At each bridge location, the computational mesh was refined to ensure that a minimum of two cells spanned the full length of each bridge structure. For culverts, the mesh configuration was developed to include all culvert barrels within a single computational cell upstream and a single cell downstream except for cases where the mesh was too fine. These refinements were achieved by adjusting the near spacing, near repeats, and far spacing of the 2D mesh connections.

Breaklines were modified to accommodate the structures and associated mesh cells. To prevent interference with the mesh around the structures, the breaklines representing the stream and roadway were shortened in the vicinity of each structure, ensuring that the mesh configuration at these locations adhered to the strategy described in the previous paragraph. Once these adjustments were made, the modifications were implemented by enforcing all breaklines.

2.2.3 Unsteady Flow Data

The HEC-HMS version 4.11 model developed for this watershed was used to provide inflows for the 2D HEC-RAS model for this watershed. This replaced the rain-on-grid approach from the BLE model. Documentation of this model is provided in the “HEC-HMS Modeling for the Upper Clear Fork Trinity River Watershed” report.

In addition to the five original BLE plans corresponding to the 2-, 10-, 50-, 100-, and 500-year storms, five plans representing 2020 existing conditions and five plans representing 2070 future conditions were developed for the same recurrence intervals. All additional plans utilize the same geometric configuration, with variations only in the assigned unsteady flow data.

2.2.4 Terrain and Manning’s Number Layer Updates

The BLE terrain was updated by Freese and Nichols (FNI) to incorporate lake bathymetry data and terrain modification for culverts. FNI stitched together the BLE terrain and surfaces generated from the TWDB bathymetric survey of Lake Weatherford dated August 2008 and the TWDB bathymetric survey of Benbrook Lake dated January 1998. Terrain modifications were applied to approximate smaller culverts not modeled as Storage Area/2D Flow Area (SA/2D) connections, adjust culvert inverts to match flowlines, and improve stability of crossings.

The Manning’s roughness layer was updated by FNI to better reflect current land cover conditions, as the source BLE land cover was a post-processed version of the National Land Cover Dataset (NLCD) that did not increase the model resolution. FNI processed the source NLCD and added delineations of the roadway network based on the 2019 North Central Texas Council of Governments (NCTCOG) roads dataset and the channel. The roads were defined using buffers based upon NCTCOG road type (shown in **Table 2**). The channel was defined based on a semi-automated process that combines 10-year depths with a 25-foot buffer of the BLE stream centerlines. **Table 3** lists the Manning’s n values adopted for each land cover area present in the enhanced model.

Table 2: NCTCOG Road Type and Buffer Width Applied

Road Type	Buffer (ft)
Access Ramp	8
Connecting Road*	n/a
Driveway	5
Major Arterial	18
Minor Arterial	12
Other	5
Primary Highway	30
Private Road	5
Secondary Highway	20
Service Road	8
Trail	5
*Generally covered by highway buffers	

Table 3: Manning's n Values by Land Cover

Land Cover	n
Grassland-Herbaceous	0.03
Deciduous Forest	0.12
Shrub-Scrub	0.06
Developed, Open Space	0.04
Cultivated Crops	0.04
Pasture-Hay	0.04
Open Water	0.03
Developed, High Intensity	0.12
Developed, Medium Intensity	0.08
Developed, Low Intensity	0.06
Emergent Herbaceous Wetlands	0.08
Woody Wetlands	0.1
Mixed Forest	0.12
Barren Land Rock-Sand-Clay	0.03
Evergreen Forest	0.12
Channel	0.04
Roads	0.02

3. Results and Conclusions

Existing flood risk within the Upper Clear Fork Trinity River watershed is distributed across many locations. When evaluated against National Structure Inventory (NSI) building data and the road network dataset, the 100-year 2020 flood event affects 370 structures (WSE above NSI ground elevation) and 18.3 miles of road (depth greater than 6 inches). This is shown in **Figure 2**.

With the future increases in impervious surface area in the Upper Clear Fork Trinity River watershed, flood risk increases. The 100-year 2070 flood event affects 1,217 structures (WSE above NSI ground elevation) and 22.2 miles of road (depth greater than 6 inches). This is shown in **Figure 3**. The increase in 100-year flood elevations from the 2020 to 2070 existing storm events is shown in **Figure 4**.

During the model development process, FNI evaluated the placement of inflow locations downstream of the existing NRCS dams within the watershed, which simulated the result of having none of these structures in place. In that evaluation, the 100-year 2020 condition showed a relative increase of about 1% flow rate per NRCS dam on the Upper Clear Fork above Benbrook. This highlights the potential for distributed storage to work, but also the reliance of current flood risk levels on maintenance of this volume for flood protection.

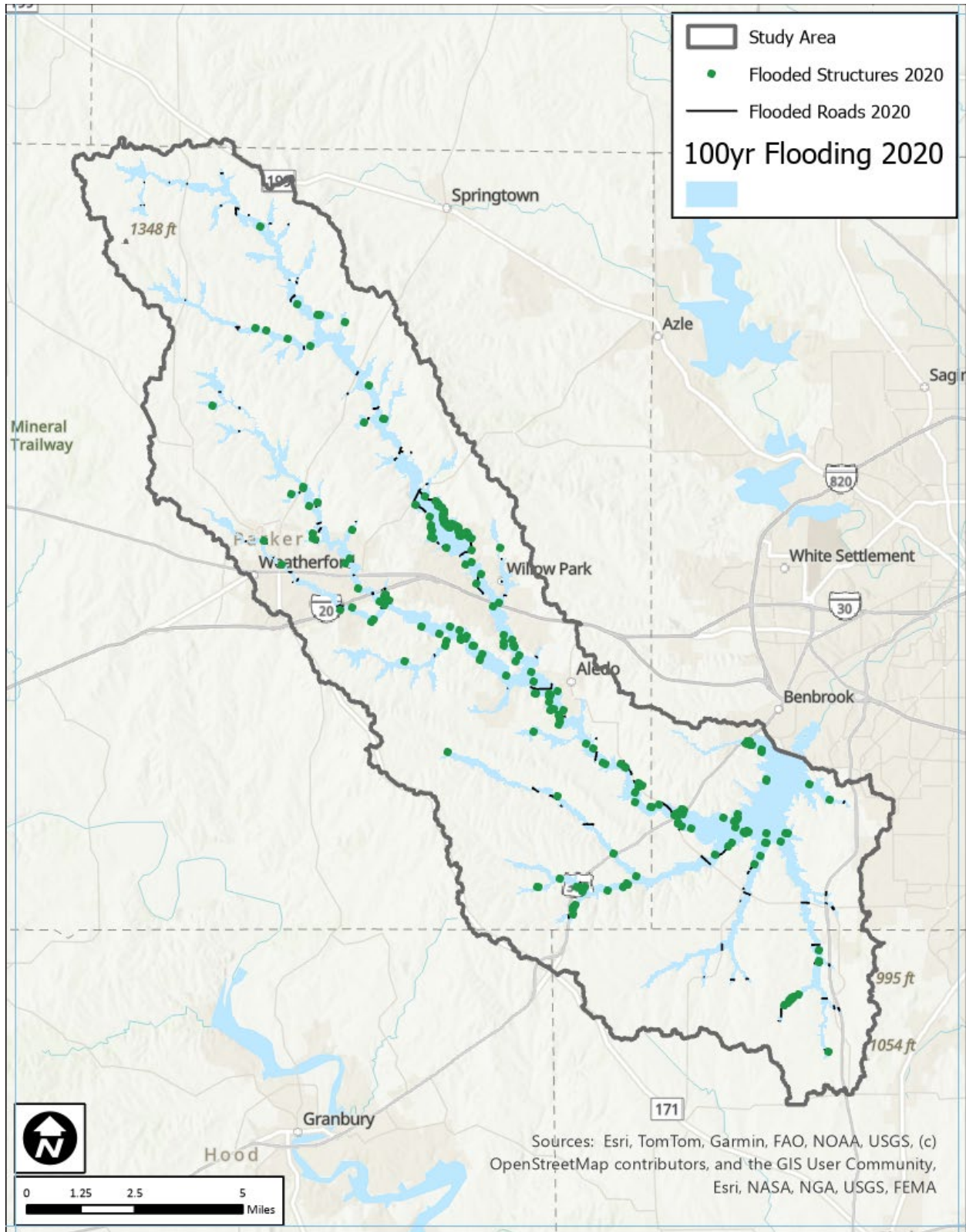


Figure 2: Existing Conditions, 100-year Flooding in 2020

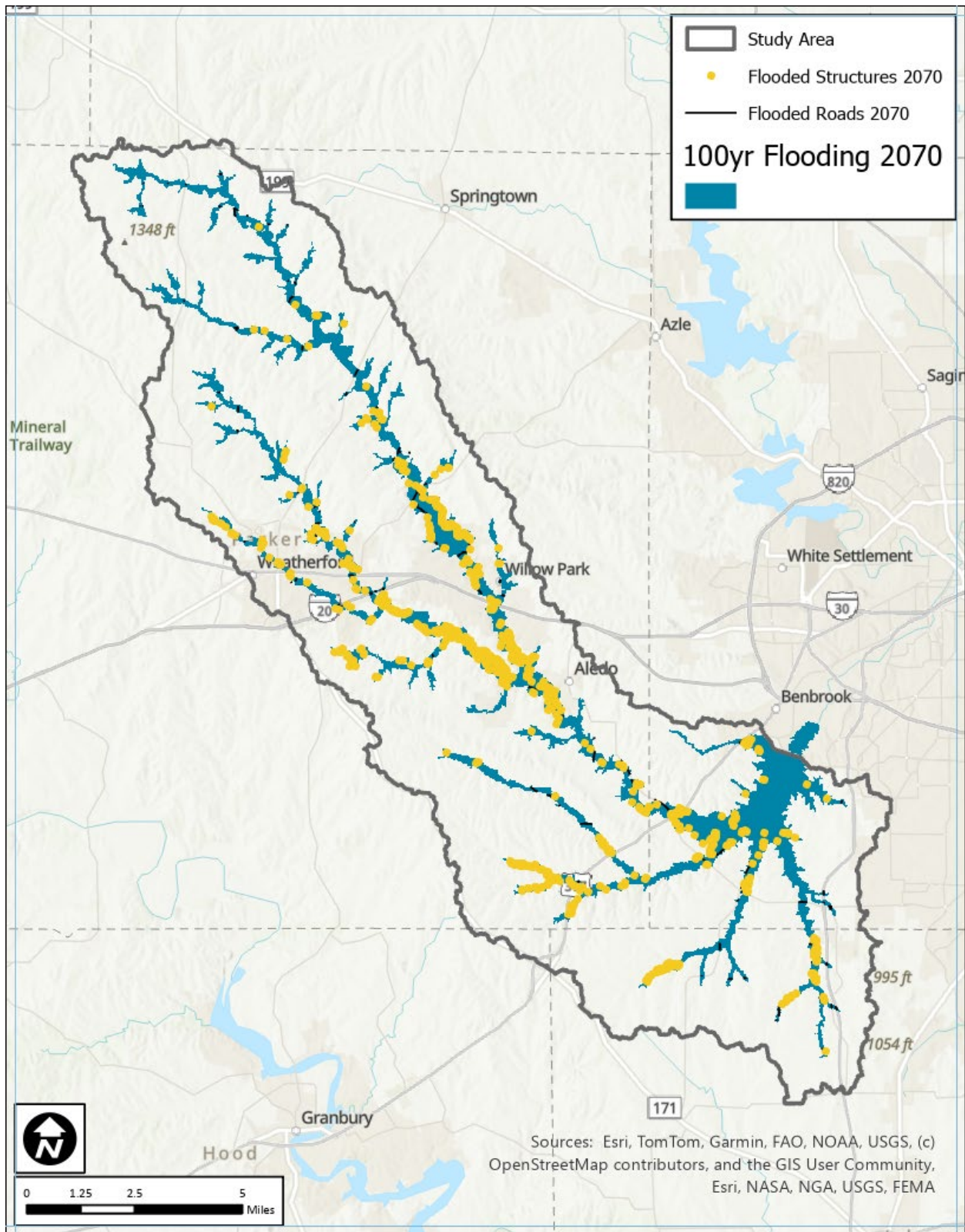


Figure 3: Existing Conditions, 100-year Flooding in 2070

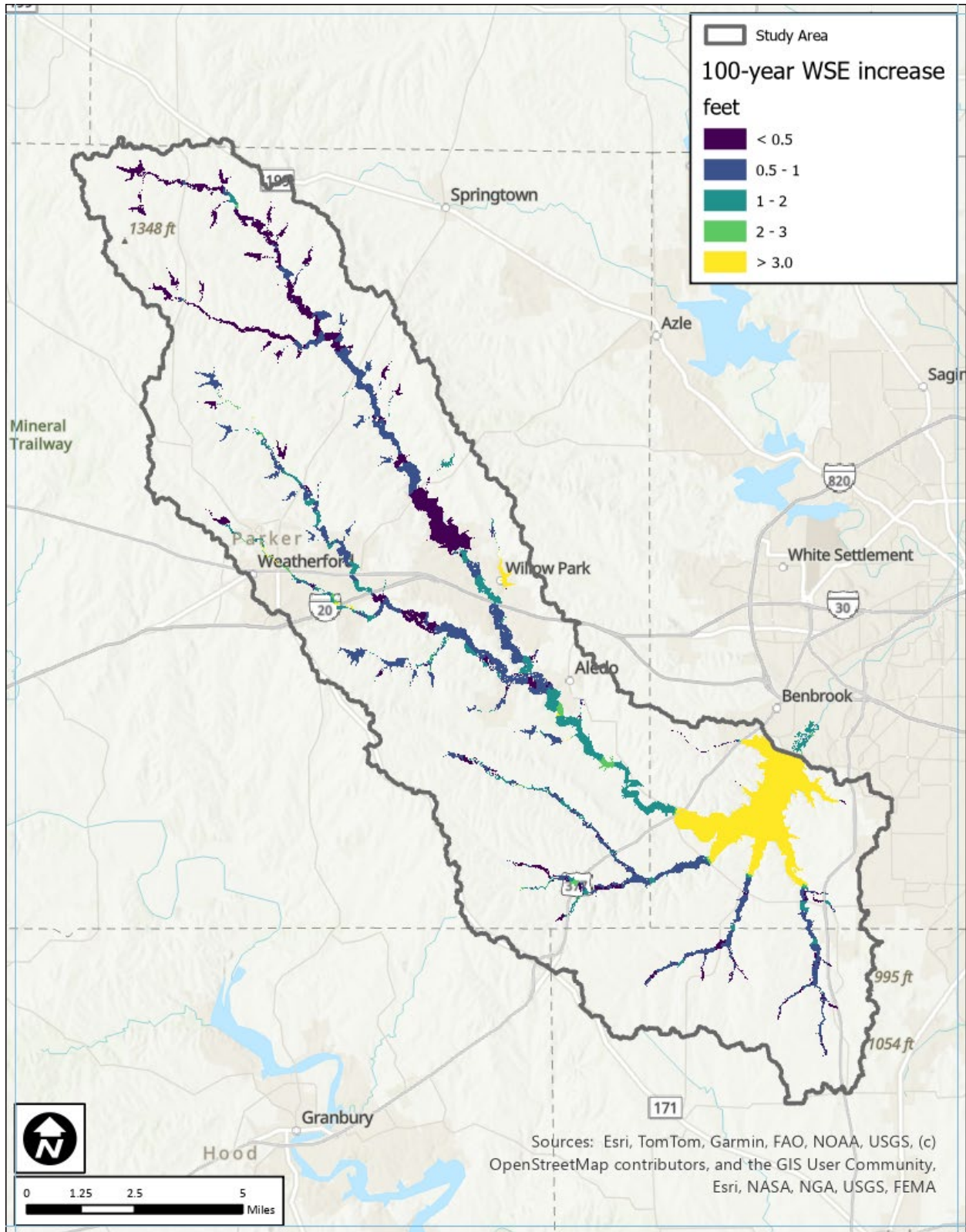


Figure 4: Increase in 100-year flood elevations from 2020 to 2070 without TSI projects

4. References

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