Final Report: Hunt County FIF - Countywide Drainage Study

Texas Water Development Board Contract #40027

Prepared for:

Texas Water Development Board

Prepared by:

Freese and Nichols, Inc.

Jorge Gallosa, P.E., CFM

Ryan Edwards, EIT

Hunt County

Brian Toole

David Jones

August 2024

This page is intentionally blank.

Final Report: Hunt County FIF - Countywide Drainage Study

Texas Water Development Board Contract #40027

By:

Freese and Nichols, Inc.

Jorge Gallosa, P.E., CFM

Ryan Edwards, EIT

Hunt County

Brian Toole

David Jones

August 2024

This project was funded in part by Hunt County and by the Texas Water Development Board through a Category 1 Flood Infrastructure Fund (FIF) Grant.

Engineering Seal

This report documents the work of the following Licensed Texas Engineers:

STATE OF TEXAS
JORGE LUIS GALLOSA JR.
135560
LICENSED
PROFESSIONAL ENGINEER

08/07/2024

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

Table of Contents

List of Figures

List of Tables

Executive Summary

Hunt County (County) has been experiencing rapid development over the past decade, leading to increases in stormwater runoff, residential flooding reports, and flood related needs outpacing drainage infrastructure improvements. This trend is expected to continue for years to come, prompting County officials to develop plans and establish policies that will help them manage and minimize flooding risks. The County was awarded financial assistance from the Texas Flood Infrastructure Fund (FIF) to develop a Countywide Drainage Study (CDS). The FIF is managed by the Texas Water Development Board (TWDB), and it was created to assist in the financing of drainage, flood mitigation and flood control projects. The County hired Freese and Nichols, Inc. (FNI) to assist with the development of the CDS.

The primary goals of the CDS are: 1) identifying areas of greatest flood risk, 2) analyzing alternatives to reduce flooding risks, and 3) developing flood mitigation projects that may be included in the Texas State Flood Plan and become eligible for future State funding opportunities. In addition, the CDS includes public outreach efforts and an effort to aid communities that do not participate in the National Flood Insurance Program (NFIP) in adopting proper floodplain ordinances.

The CDS study area includes drainage basins that cover the entirety of Hunt County. The majority of the CDS study area is within the Sabine River Basin, with smaller portions within the Lower Red-Sulphur-Cypress and Trinity River Basins. The major river systems in this area include the South Fork Sabine River, Cowleech Fork Sabine River, South Sulphur River, and Middle Sulphur River. Most of the County drains to Lake Tawakoni, while the northeast section of the County drains to Jim Chapman Lake, the southwest corner drains to Lake Fork, and the northwest corner drains to Lavon Lake.

Areas of greatest flood risk were identified using a series of 2D "Rain-on-Mesh" (ROM) models developed with the United States Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS). The ROM models served as planning tools to assess flooding hazard risks countywide. Two site visits were also conducted with County Commissioners and County staff to gather their insights on flood-related issues. Their hands-on involvement was critical to develop an understanding of the challenges faced on the ground and to gather information for the screening assessment. Final selection of the most critical sites was also done in collaboration with County Commissioners and County staff. Their local and historical knowledge was invaluable to select the sites of greatest significance to Hunt County. The selected sites are listed in Table ES-1 and their general location is shown in Figure ES-1.

The ROM models were refined to conduct a detailed alternatives analysis for each selected site. Several conceptual solutions were developed and tested with the goal of minimizing flood risk. The hydraulic performance and feasibility of each alternative was evaluated within the context of "*Exhibit C - Technical Guidelines for Regional Flood Planning*" (TWDB, 2021). A feasible alternative should result in a quantifiable reduction in flood risk, must be permittable, constructable, and implementable, and must have no negative impacts on neighboring areas.

A comparative assessment of pre- and post-project conditions for the 1% annual chance flood (100-year recurrence interval) was performed for each alternative. Hydraulic results were

compared to determine compliance with the no negative impact requirements. If negative impacts were identified, the solution was modified until all requirements were met or until no negative impacts could be demonstrated based on professional engineering judgment. According to modeling results, all six sites would experience flooding conditions during the 100-year flood event, but they are also susceptible to flooding during more frequent smaller storms. The most common causes of flooding are undersized cross-drainage infrastructure, lack of proper drainage pathways, and excessively low roadway elevation profiles. Significant roadway overtopping is observed at all sites. Model results indicate that these existing roads are susceptible to flooding depths of up to 3' in the 2-year flood event and 6' in the 100-year flood event.

In general, the proposed solutions entail a combination of improvements such as constructing bridges and culverts, channel improvements, raising road elevations, and minor channel grading (Table ES-1). It is expected that these improvements will significantly improve local drainage conditions and reduce flooding risks. Roadway overtopping would be practically eliminated for all sites at least up to the 10-year flood event. The estimated construction costs for these improvements range from approximately $3.3 million to $14.4 million.

In line with the County's vision for the CDS – *to leverage the opportunity to address drainage problems at a county scale with funding support from the State* – the proposed conceptual solutions were submitted as Flood Mitigation Projects (FMP) to the corresponding Regional Flood Planning Group (RFPG) for inclusion in the Sabine or Lower Red-Sulphur-Cypress Regional Flood Plan (RFP). Inclusion in the RFP makes these projects eligible for future funding opportunities through the State Flood Planning process.

Although these FMPs may bring significant flood reduction benefits in their project areas, it is recognized that Countywide flooding risks are still significant and there is a need to continue evaluating flood mitigation measures for other flood prone areas. Thus, Hunt County will continue participating in the State Flood Planning process as it represents a potential long-term mechanism to reduce flooding risks with financial assistance from the State. As such, the County submitted a Phase II CDS to the Sabine RFPG for potential inclusion as a Flood Management Evaluation (FME) in the Sabine Amended RFP. This FME is intended to continue the detailed alternative analysis efforts for other flood prone areas and develop additional FMPs that may be included in future State Flood Plans.

The CDS also includes public outreach efforts, an effort to aid non-NFIP communities in adopting proper floodplain ordinances, and a Dam Assessment of Wolfe City Reservoirs 1 and 2. Public outreach efforts included multiple public meetings and the creation of a project website that provided options to receive community feedback and allowed citizens to report additional known areas of flooding. Moreover, 5 communities were identified that do not enforce floodplain management standards that are at least equivalent to NFIP minimum standards. Hunt County made efforts to aid these non-NFIP communities in adopting proper floodplain ordinances, but the ultimate adoption of floodplain ordinances will be at the discretion of each local entity. The Dam Assessment Technical Memorandum is attached in Appendix F.

Table ES-1. Selected Sites for Alternatives Analysis and Proposed Project Summary.

Site Name	Proposed Project	Pre-Project LOS	Post-Project LOS	Opinion of Probable Construction Cost (Sep 2020 dollars)
CR 1051	350' and 400' span bridges, raise road, channel improvements	< 2-yr	10-yr	$8,197,000
CR 2400	1500' span bridge, raise road, channel improvements	< 2-yr	10-yr	$14,437,000
CR 2706	300' and 400' span bridges, 2-10'x6' culverts, raise road, channel improvements	< 2-yr	10-yr	$9,126,000
CR 3101	200' and 500' span bridges, raise road, channel improvements	< 2-yr	10-yr	$9,217,000
CR 4105	200' span bridge, raise road, channel improvements	< 2-yr	10-yr	$4,285,000
CR 4106	2-100' span bridges, raise road, channel improvements	< 2-yr	100-yr	$3,344,000

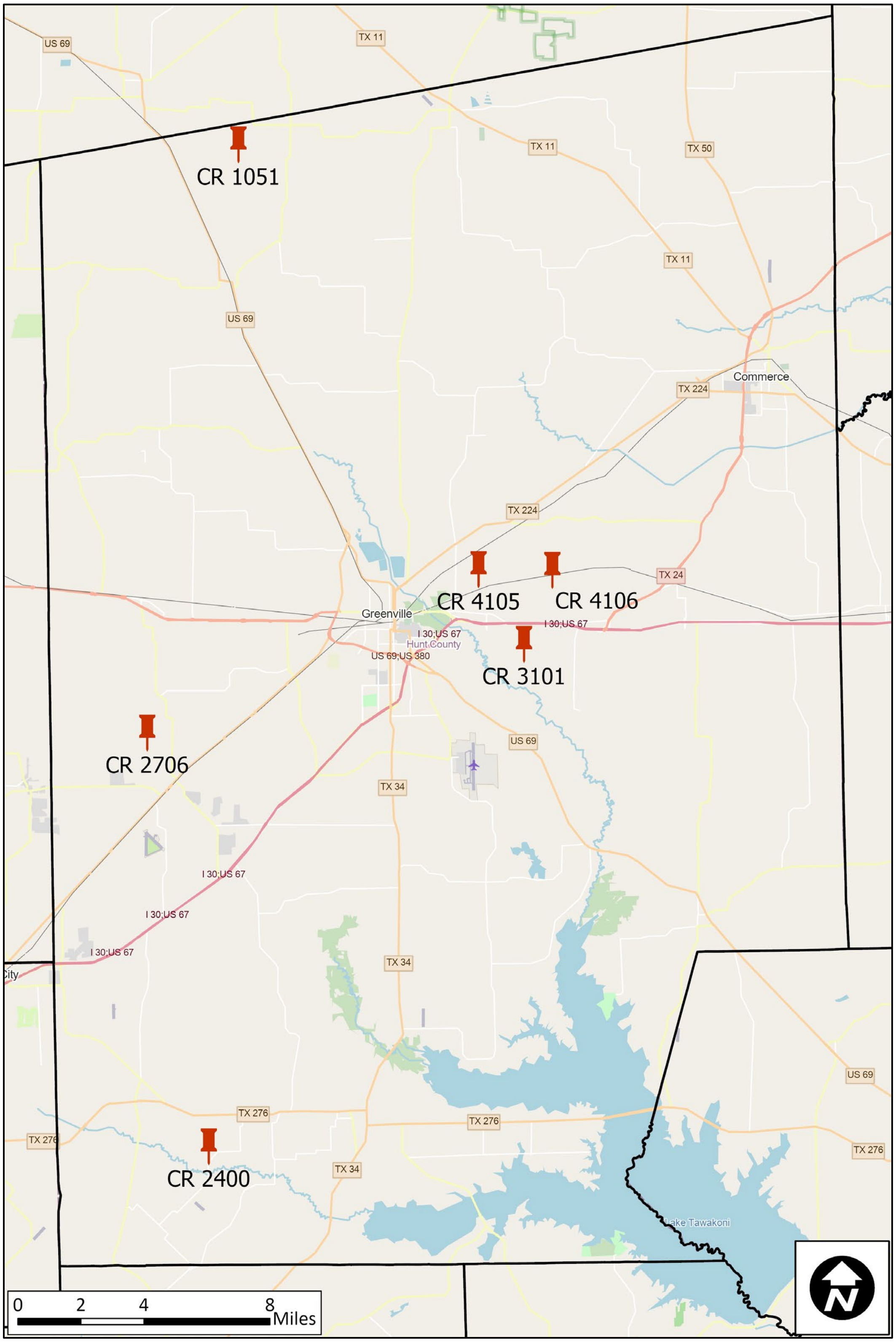


Figure ES-1. General location of selected sites to develop Flood Mitigation Projects.

1 Introduction

1.1 Project Area – General Description

Hunt County is in northeast Texas, just east of the Dallas/Fort Worth Metroplex. Greenville, the county seat, is located about 50 miles northeast of Dallas. The Hunt County population was 99,956 as of the 2020 Census. The County is growing quickly, with a 16.1% increase in population from 2010 to 2020. The largest cities in the County are Greenville (pop. 28,149), Royse City (pop. 13,532), and Commerce (pop. 9,091) (U.S. Census Bureau, 2023).

Most of the County lies within the Sabine River Basin (Region 4), while the northeast section falls within the Lower Red-Sulphur-Cypress River Basin (Region 2) and a small northwest corner falls within the Trinity River Basin (Region 3). Additional details regarding watersheds analyzed as part of the CDS are presented in Section 2.3.1. Table 2-2 provides a list of the HUC-10 basins that were fully or partially included in the study area.

1.2 Hunt County Situational Context

Rapid population growth is continuing to place significant pressure on Hunt County officials to properly balance development needs with responsible floodplain management. Reclaiming valuable land for development and being development friendly is a commonly desired goal for many communities. However, this goal must be balanced with protecting natural areas and protecting existing and future communities from increased flood risk. There is a need to better identify current and future flood risk in Hunt County.

Hunt County has taken steps toward responsible floodplain management and has engaged in important collaboration efforts. The County is currently an active participant of the NFIP and has floodplain management policies in place to regulate development in the floodplain. Some of their polices are considered “higher standards”, as they exceed the minimum NFIP standards for floodplain regulation. Additional studies to identify the most effective changes in policies and standards will prevent or minimize increases in flood risk.

Although the County is actively involved in floodplain management and regulation, County officials recognize that there are widespread flooding risks within Hunt County, primarily along its main thoroughfares and population centers. Although FEMA flood insurance rate maps are available for significant portions of the County, these are primarily based on approximate methods (Zone A) and/or may be outdated. Therefore, there is a significant need for performing engineering studies to properly quantify flooding risks using improved data sources and taking advantage of the most recent advances in hydrologic and hydraulic modeling. These studies are crucial to analyze and develop local and countywide mitigation solutions that can be turned into future projects. A more detailed assessment of the most critical flood risk areas results in the development of the most effective mitigation projects.

However, financing flood mitigation studies and projects is a significant struggle for many communities. Typically, stormwater project needs far outweigh the communities’ local funding capacity of their Capital Improvement Programs. This gap often limits their ability to take proactive measures to reduce flood risk. There is an evident need for funding assistance from

State and Federal sources to help communities address their most pressing flood mitigation challenges. A practical flood risk reduction strategy must include financing for project implementation.

1.3 Countywide Drainage Study Vision and Goals

The vision and goals for the Hunt County CDS were developed jointly by the Hunt County Commissioners Court, the County's Development Services Staff, and FNI. The vision and goals were established during the Project Kickoff Meeting on October 12, 2022. FNI prepared a memorandum capturing the vision and goals as discussed during the work session, which is included as part of this report in Appendix E.

1.4 Scope of Work

The CDS scope of work was organized into eight major tasks, as listed below. This report documents the methodology, main analysis assumptions, results and recommendations pertaining to the hydrologic and hydraulic analyses.

- Task 1: Project Management
- Task 2: Coordination and Collaboration Work Sessions
- Task 3: Data Collection
- Task 4: Screening Assessment
- Task 5: Targeted Hydrologic and Hydraulic Modeling and Alternatives Analysis
- Task 6: Dam Assessment – Wolfe City Reservoir (Appendix F)
- Task 7: Countywide Drainage Study (CDS) – Technical Report
- Task 8: Public Outreach

1.5 Previous Studies

No previous flood related studies or H&H models were used in the preparation of this CDS. The areas that were selected for detailed study (see Section 3 - Alternatives Analysis) have not been previously studied in detail for the locations of the proposed projects.

2 Screening Assessment

The goal of the screening assessment was to identify flood prone areas within the County. The screening assessment was conducted using a series of H&H models (Section 2.3). In addition to the desktop H&H analysis, field reconnaissance was conducted in the form of site visits, where critical information was gathered from locations identified by County personnel as a high priority for the study.

2.1 Data Collection

The following data resources were requested from the County or obtained from freely available online sources. If available, the resources were used to help aid the Screening Assessment and selection of priority sites for the Alternatives Analysis.

Table 2-1. Data Collection for Screening Assessment.

Data Resource	Data Collected
GIS data	LiDAR, land use, streamlines, municipal boundaries, roadways, railroads, buildings, aerial imagery
Previous plans and studies from partnering cities and other related authorities	No existing plans or studies were used for the study area.
Existing hydrologic and hydraulic models	No existing plans or studies were used for the study area.
Site Visits	See Section 2.2
Microsoft building footprints	Acquired with GIS data

2.2 Site Visits

Two site visits were conducted to gather information to help inform the screening assessment. The overall goal of the site selection process was to focus the screening assessment on locations of significance to Hunt County and ensure the process would be meaningful to the County. Each of the four County Commissioners and County staff provided a list of sites within their precinct with previous flood related issues that they wanted to be analyzed in the screening assessment. FNI staff were joined by Hunt County Development staff and County Commissioners from their respective precincts. The County staff provided local knowledge and insights of flood related issues, including information about the frequency and severity of flooding at certain locations. This information was critical to develop an understanding of the challenges faced on the ground. This information, along with photos and measurements of drainage infrastructure, helped to validate the H&H modeling results.

The site visits for all four Precincts were conducted in November 2022, where a total of 27 potential project areas were visited. Figure 2-1 shows the locations of the data points collected at the various sites. Figures Figure 2-2 through Figure 2-5 provide some examples of existing conditions of drainage infrastructure and road crossings observed during the site visits.

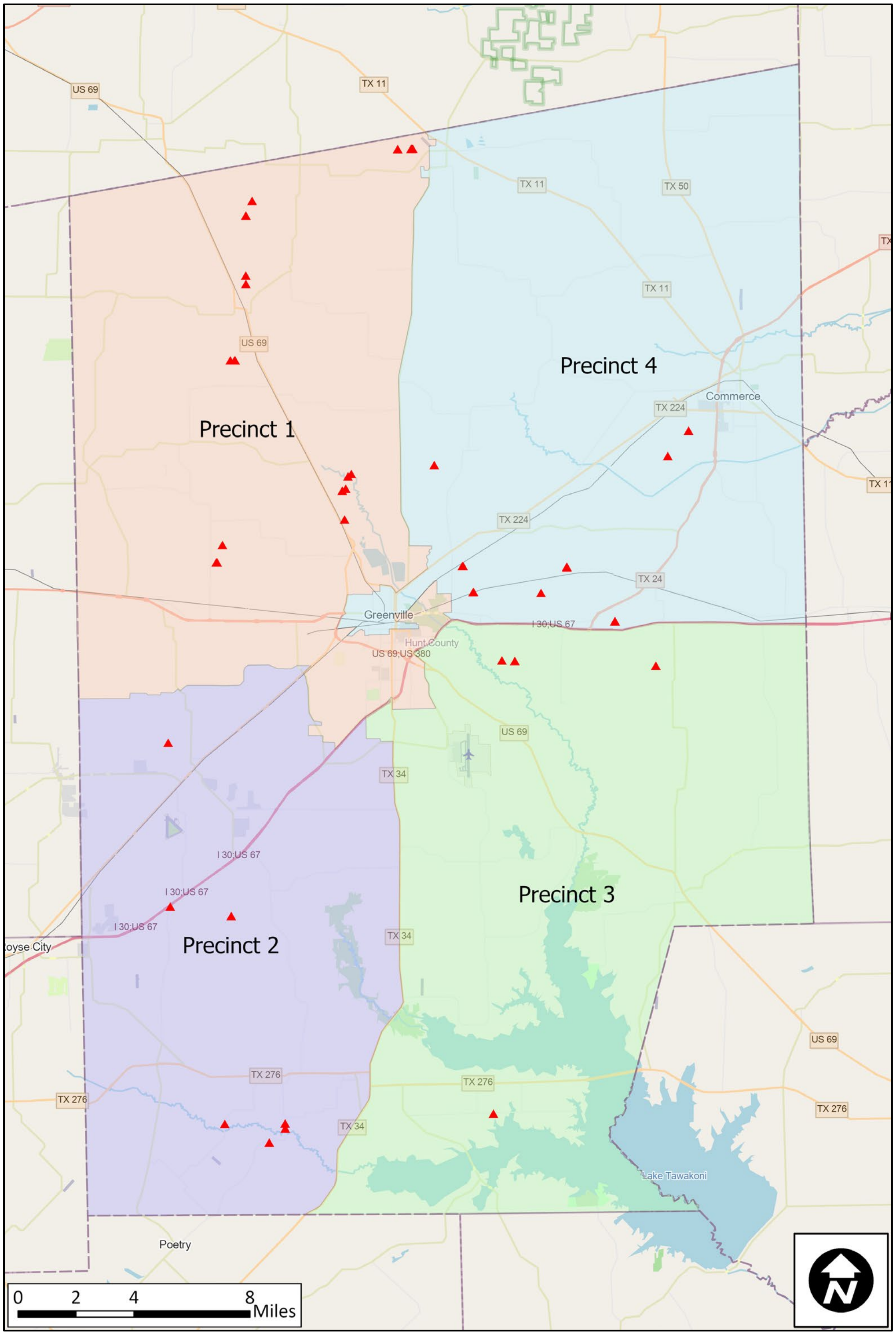


Figure 2-1. Site Visit Locations.

Figure 2-2. View from existing 40' span bridge for CR 1051.

Figure 2-3. Crossing for CR 2400 (flooded during site visit).

Figure 2-4. View from existing 40' span bridge for CR 3101.

Figure 2-5. 2-7' tank car culverts at CR 4106.

2.3 Methodology

The main tool used to identify flood prone areas was a series of "Rain-on-Mesh" (ROM) hydraulic models. The ROM models were developed using the United States Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS) version 6.3.1. This modeling software has the capability to simulate a flood event by applying a rainfall hyetograph directly to a 2D area. The model considers infiltration using the SCS (Soil Conservation Service) Curve Number method. Excess rainfall is then dynamically routed along the surface to simulate runoff as it travels to the open channel systems.

The ROM approach was used to efficiently provide a high-level identification of the worst flood prone areas in the County. This approach allows study resources, and more detailed analysis, to be focused on the highest priority risks. Model results obtained from this analysis provided information about roadway flooding/overtopping, structure flooding, and other drainage concerns. Additional details regarding the ROM methodology are provided below.

2.3.1 Model and Boundary Condition Setup

The project area for the screening assessment covers a total of 1,282 square miles. It consists of six separate model areas representing the drainage areas covering the limits of Hunt County, along with some additional catchment areas that extend into surrounding counties. In general, the six model areas capture the portions of the County that drain to Lake Tawakoni, Jim Chapman Lake, Lake Fork, and Lavon Lake. The project area was divided this way to simplify model development and shorten run times. Table 2-2 shows the associated HUC 10 watersheds for each model area, and Figure 2-6 shows the six model areas in relation to Hunt County. Some model areas were delineated by hand using engineering judgment to only include portions of HUC 10 watersheds. This was done to focus the model areas on the Hunt County limits without omitting any drainage areas contributing to the project study area.

Table 2-2. Screening Assessment 2D Model Areas.

Model Name	HUC 10(s)	HUC 10 Name(s)	Area (sq. miles)
Lake Fork Creek - Case Lake	1201000301*	Lake Fork Creek - Case Lake	92.56
Greenville - Cowleech Fork Sabine River	1201000101	Town of Greenville - Cowleech Fork Sabine River	188.60
Indian Creek - Pilot Grove Creek	1203010601*	Indian Creek - Pilot Grove Creek	53.04
Royse City - South Fork Sabine River	1201000103	Royse City - South Fork Sabine River	159.39
Spring Creek - Sulphur River	1114030101* 1114030102*	Spring Creek - South Sulphur River Middle Sulphur River - South Sulphur River	373.24
West Caddo Creek - Lake Tawakoni	1201000102 1201000104	West Caddo Creek Lake Tawakoni	463.37

*Indicates only a portion of the HUC 10 is included in the model area and/or the model boundaries were manually delineated or altered. Reported area values in the table will not match official reported HUC 10 watershed area values.

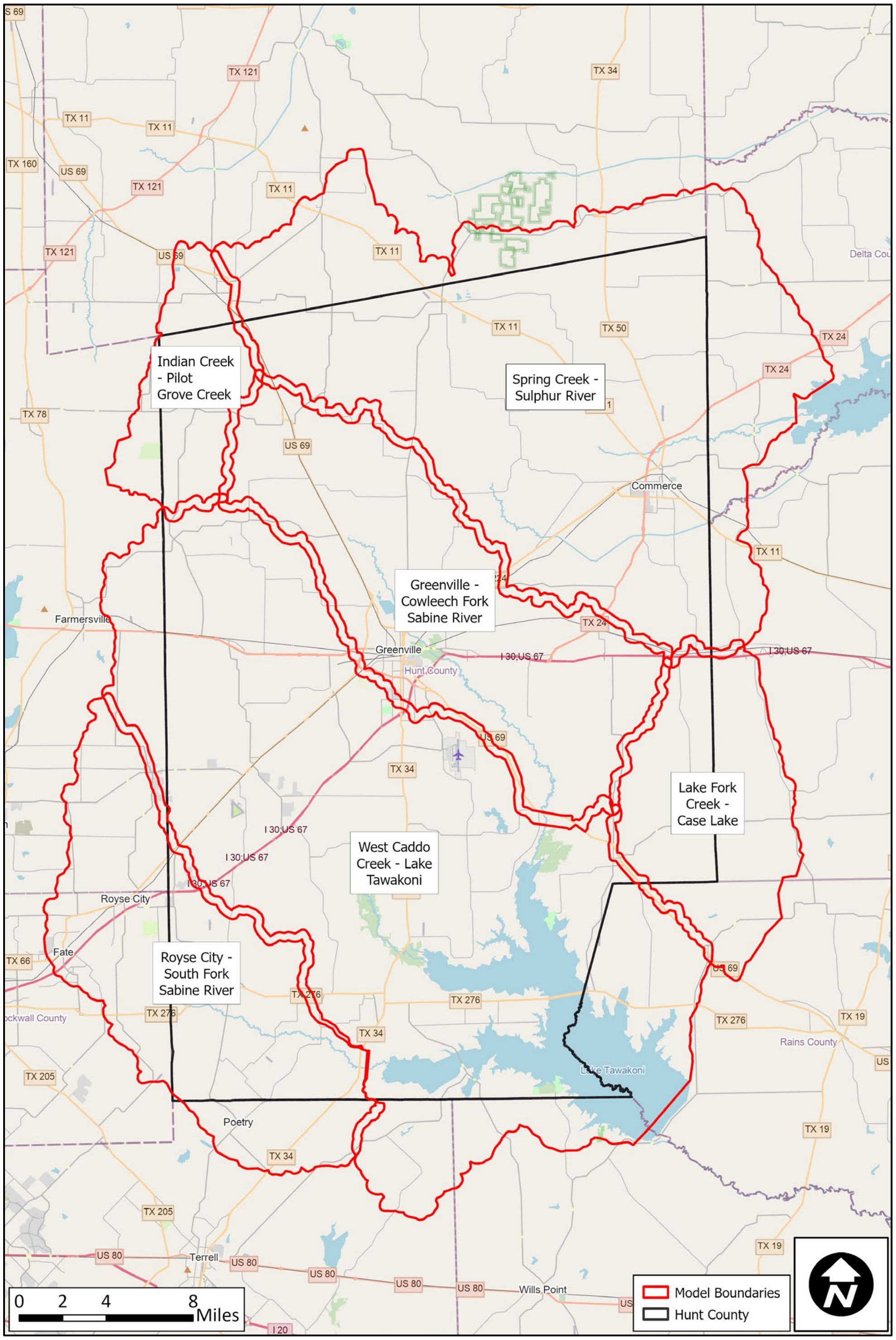


Figure 2-6. Screening Assessment 2D Model Areas.

The ROM models require two main components: 1) a 2D computational mesh, and 2) inflow hydrology. 1000-foot buffers were added to each model boundary to establish the 2D computational mesh boundaries. This caused the model areas to overlap. Due to this overlap, the sum of the model areas presented in Table 2-2 and the total project area will differ but does not affect the model results.

Inflow hydrology can be applied through various methods in HEC-RAS 2D modeling, but hydrology methods were limited to only precipitation time-series for the screening assessment. Section 2.3.4 describes the development of the precipitation data applied to each model. Precipitation, rather than excess precipitation, was applied directly to the 2D mesh because hydrologic losses can be accounted for entirely within HEC-RAS version 6.3.1. Boundary conditions were applied to each model where a transfer of flow (inflow or outflow) may occur.

For the screening assessment, all models except for West Caddo Creek - Lake Tawakoni bordered watershed divides until the outlet. Because of this, all water entering these models was from precipitation. A normal depth boundary condition was utilized along all basin outflows based on an approximate energy grade-line slope of 0.5%. This option was considered the best approach since it is not dependent on any other hydrologic or hydraulic input and allows to identify any localized impacts. Normal depth was also able to be applied near watershed divides because of the 1000-foot buffer.

The West Caddo Creek - Lake Tawakoni model included inflows from other models, such as the Greenville - Cowleech Fork Sabine River and Royse City - South Fork Sabine River models fed into this model. The outfall was based on a spillway rating curve for Lake Tawakoni (Freese & Nichols, Inc., 2005). The discharge curve was based on the ogee spillway for Iron Bridge Dam.

2.3.2 2D Computational Mesh and Settings

The HEC-RAS 2D computational mesh defines both the extent and level of detail of 2D hydraulic results. The base mesh for each model was developed using 200’x200’ cells, providing a balance between mesh detail and model performance. The mesh was also refined through addition of “breaklines” along roadways, railroads, reservoirs, and other topographically significant features. The mesh for each model area was developed in a manner that allows for automatic regeneration of the mesh by future users, without the need for manual cell edits. Each model uses a 30-second computational timestep and applies the Diffusion Wave equation set. All other computational settings were kept at their default values.

2.3.3 Terrain

The terrain surface was created with LiDAR data obtained from the Texas Natural Resources Information System (TNRIS). Most of the study area is covered by LiDAR captured in 2020 with 50 cm resolution, or in 2019 with 70 cm resolution. Small gaps in coverage were filled with LiDAR collected from 2013-2017, with 50 cm or 70 cm resolutions. Bathymetry for Lake Tawakoni was obtained from a 2009 survey (TWDB, 2012). Figure 2-7 shows the availability of LiDAR coverage used for the screening assessment. The LiDAR datasets were processed in GIS and combined into a single terrain surface raster with a 1-meter resolution to be used as an input in the ROM models. Figure 2-8 shows the final terrain surface used in the screening assessment.

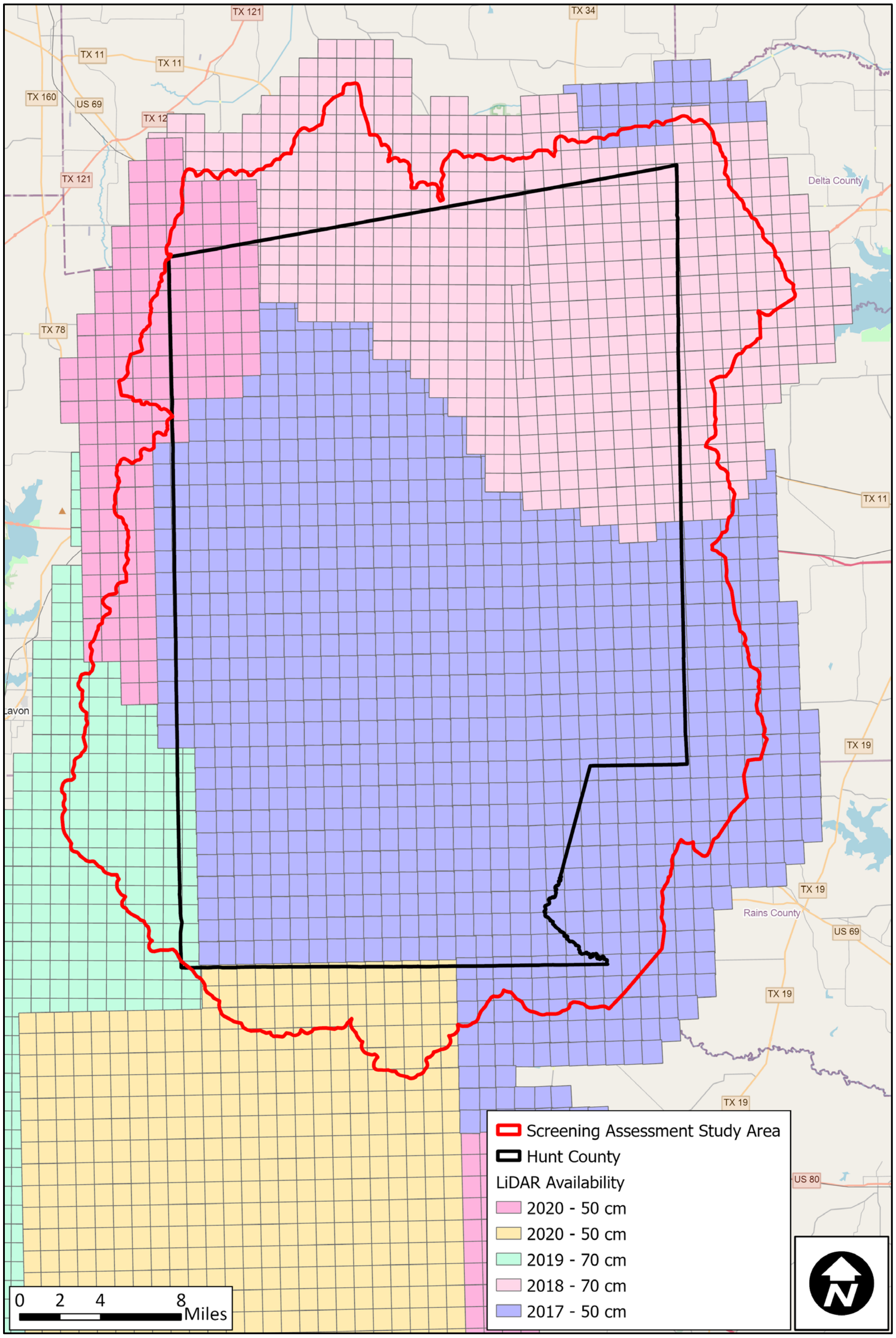


Figure 2-7. LiDAR Availability for Screening Assessment.

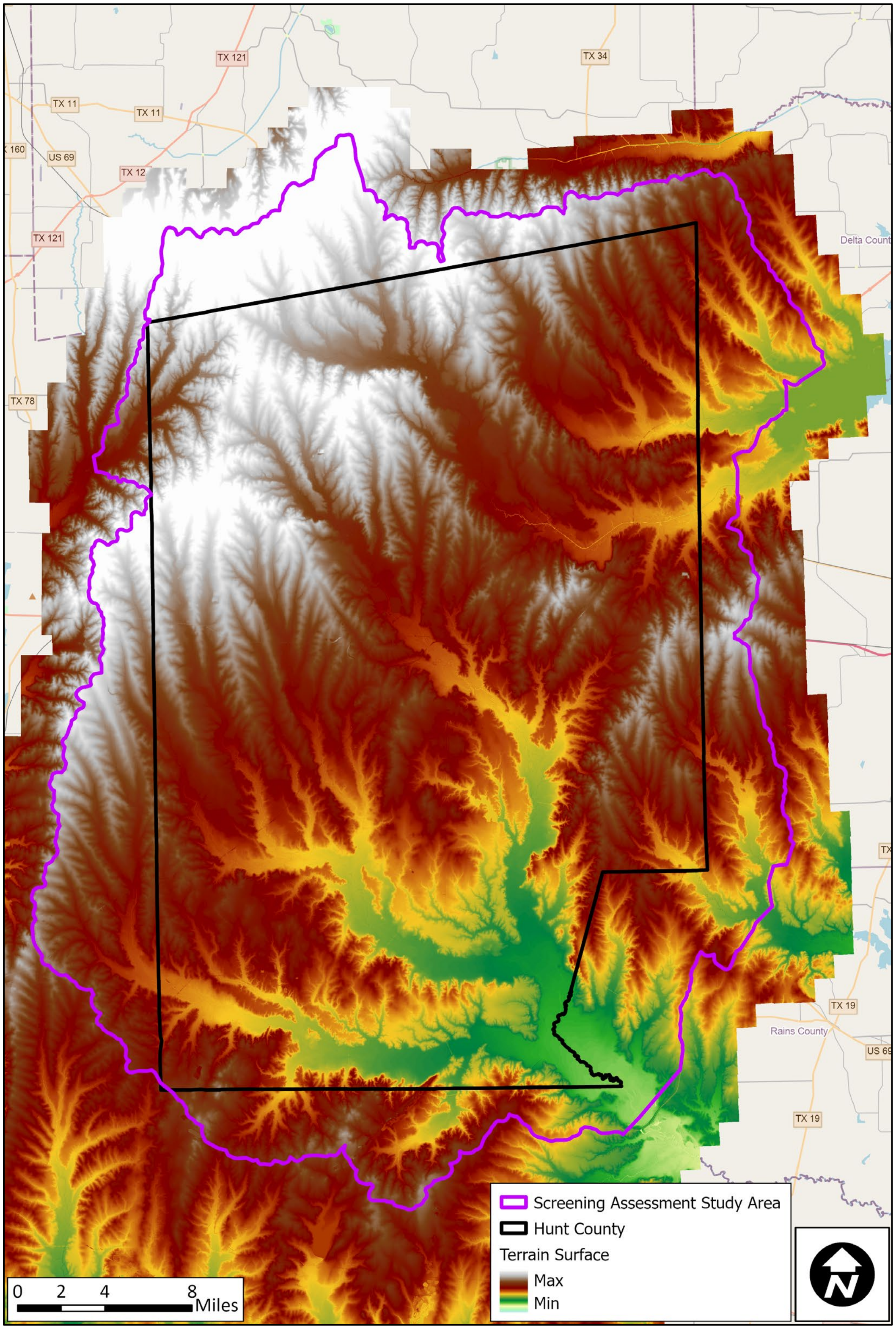


Figure 2-8. Terrain Surface for Screening Assessment.

2.3.4 Hydrology

Precipitation

Precipitation data for the screening assessment was derived from NOAA Atlas 14, Volume 11 Version 2.0 precipitation data, which was obtained from NOAA's Precipitation Frequency Data Server. Average precipitation depths for the screening assessment study area were calculated using a custom GIS tool that calculates spatially weighted average precipitation depths from NOAA Atlas 14 precipitation raster files when given an area-of-interest. The average NOAA Atlas 14 precipitation-frequency depths for the study area were converted to a precipitation time-series dataset within a simplified HEC-HMS v4.9 model. Frequency storms were created within HEC-HMS for the 2-, 10-, 50-, and 100-year 24-hour return periods. Table 2-3 shows the rainfall depths used to develop the frequency storms in HEC-HMS. A precipitation time-series was then extracted from the HEC-HMS model and utilized in the HEC-RAS 2D simulations.

Table 2-3. NOAA Atlas 14 Precipitation Depths (inches)

Duration	2-year event	10-year event	50-year event	100-year event
5 min	0.51	0.70	0.90	0.98
15 min	1.01	1.39	1.78	1.95
1 hr	1.85	2.54	3.27	3.58
2 hr	2.31	3.25	4.29	4.75
3 hr	2.59	3.71	4.97	5.54
6 hr	3.11	4.53	6.17	6.93
12 hr	3.67	5.39	7.40	8.34
24 hr	4.29	6.31	8.66	9.75

Infiltration Losses

Infiltration losses were calculated using the SCS Curve Number method. This method uses a combination of land use and soil type to characterize the amount of infiltration. Current land use data was obtained from the North Central Texas Council of Governments (NCTCOG, 2015) and the National Land Cover Dataset (Dewitz, 2021) and is shown in Figure 2-9 and Figure 2-10. NLCD data was only used for infiltration when NCTCOG data was unavailable. Land use was intersected with soil data from the Natural Resources Conservation Service's (NRCS) Soil Survey Geographic database (SSURGO). Based on land use and soil data, curve numbers were assigned using guidance from Technical Release 55 (TR-55). The abstraction ratio was assumed to be 0.2. No minimum infiltration rate was used.

2.3.5 Hydraulics

Roughness Coefficients

A Manning's n roughness layer was developed for the 2D mesh by applying typical values associated with NLCD land use classifications. A 2-year simulation was run to further refine the roughness coefficients for rivers/streams. Cells with a depth greater than 2 ft were assigned a Manning's n value of 0.04. Any land without a land use classification was also assigned an n value of 0.04. Table 2-4 documents the roughness coefficients assigned for each land use classification.

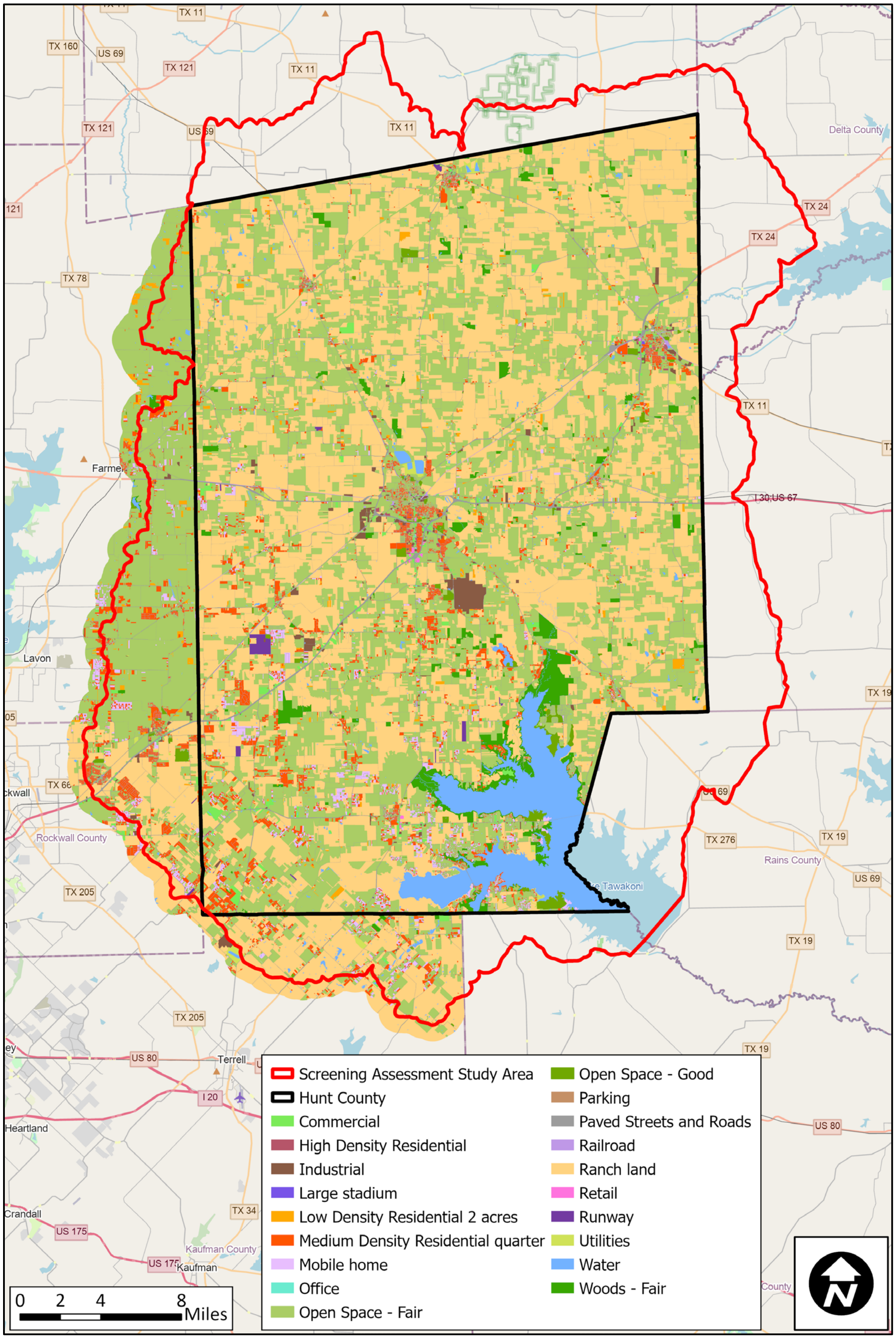


Figure 2-9. NCTCOG 2015 Land Use for Screening Assessment.

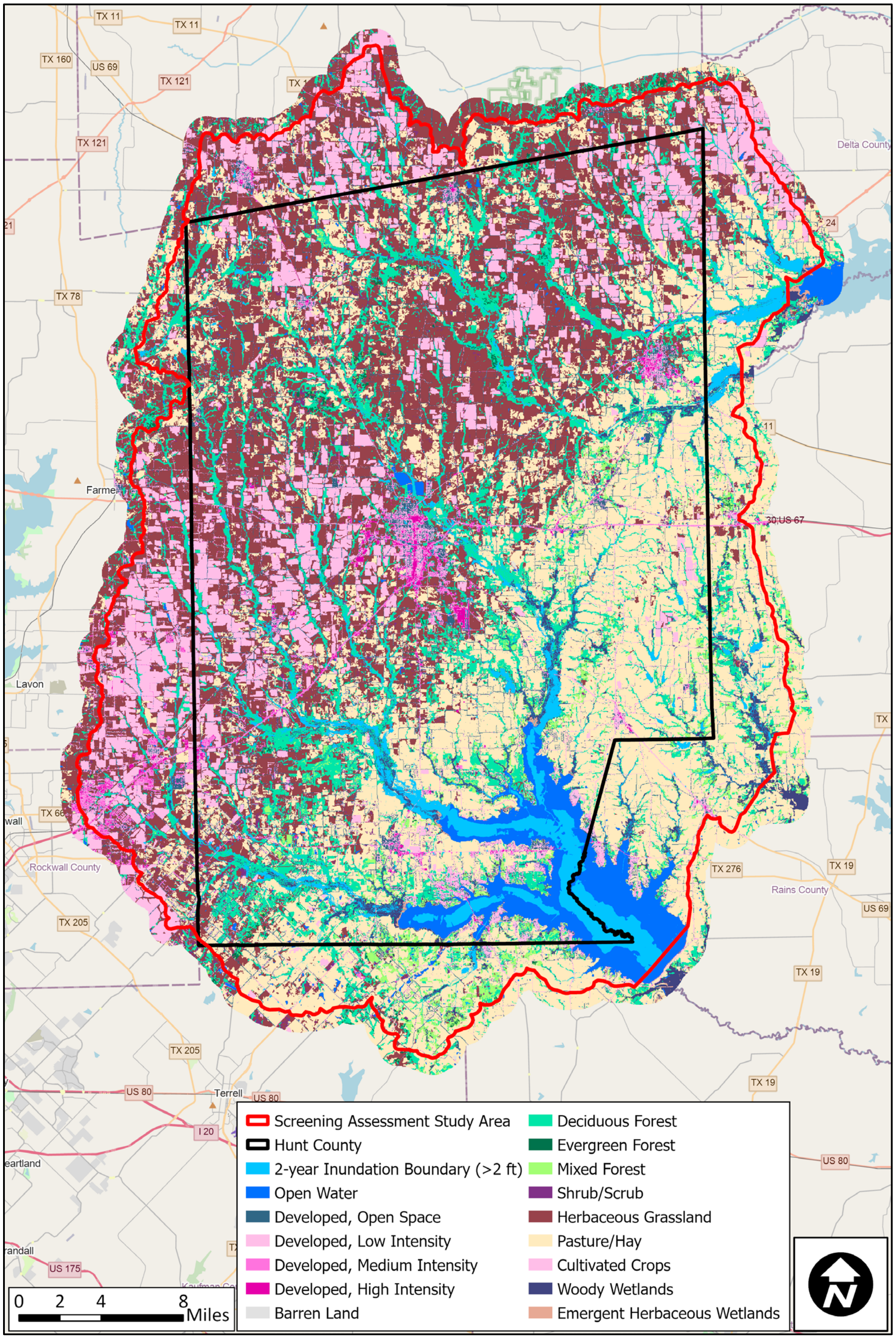


Figure 2-10. NLCD/2-year Inundation Boundary (>2 ft) Land Use for Screening Assessment.

Table 2-4. Manning's N Roughness Values by Land Use Classification.

NLCD Land Use Classification	Manning's n
Open Water	0.035
Developed, Open Space	0.04
Developed, Low Intensity	0.08
Developed, Medium Intensity	0.12
Developed, High Intensity	0.15
Barren Land Rock-Sand-Clay	0.035
Deciduous Forest	0.15
Evergreen Forest	0.1
Mixed Forest	0.12
Shrub-Scrub	0.08
Grassland-Herbaceous	0.04
Pasture-Hay	0.04
Cultivated Crops	0.04
Woody Wetlands	0.1
Emergent Herbaceous Wetlands	0.07

Hydraulic Structures

Breaklines were used within the 2D mesh to align cell faces along roadway and railroad embankments, NRCS dams and other reservoir embankments, and other hydraulically significant features. Roadway centerlines and railroads were initially identified within ArcGIS and then imported into HEC-RAS as breaklines. A breakline was added to every dam in the Texas Commission on Environmental Quality (TCEQ) inventory within the model boundaries.

Terrain Modifications

Terrain modifications within HEC-RAS were used where the initial terrain model insufficiently represented the ground surface or conveyance area. For example, when roadway embankments did not accurately show bridge or culvert openings, a terrain modification was incorporated to represent conveyance through the roadway similar to the existing drainage structure. To maintain a stable and efficient 2D model, terrain modifications were used to allow flow to pass through these openings, rather than using storage area/2D flow area (SA/2D) connections with culverts or bridge data. The terrain modification dimensions were estimated based on information collected during site visits, adjacent ground characteristics, aerial imagery, and Google Street View.

2.4 Screening Assessment Results

Hydraulic results for the 2-, 10-, 50-, and 100-year storm events were analyzed for the entire County. The 2-year storm was used to identify road crossings that frequently experience high flooding depths. The larger storm events were then used to identify the existing level of service (LOS) of each site. The analysis was primarily focused on the site visit locations discussed in Section 2.1. Figure 2-11 shows the mapped 100-year maximum flood depth results from the screening assessment models, along with site visit locations.

In addition to site visit locations, an analysis was performed using the Microsoft Building Footprints structure inventory covering the entire County and the results from the screening assessment. This analysis identified areas with the highest density of structures affected by 2-year and 100-year flood events. Figure 2-12 shows a heat map of modeled structural flooding based upon these results. Potential sites were then screened at a high level for the feasibility of potential alternative projects.

Next, an initial list of priority sites was developed by FNI to present to County personnel. Sites with modeled road inundation during both the 2-year and 100-year storm events were given a higher priority ranking, while sites with inundation only during the 100-year storm event were given a lower priority ranking. These initial results were then shared with the County as part of the site selection process, which is described in the following section.

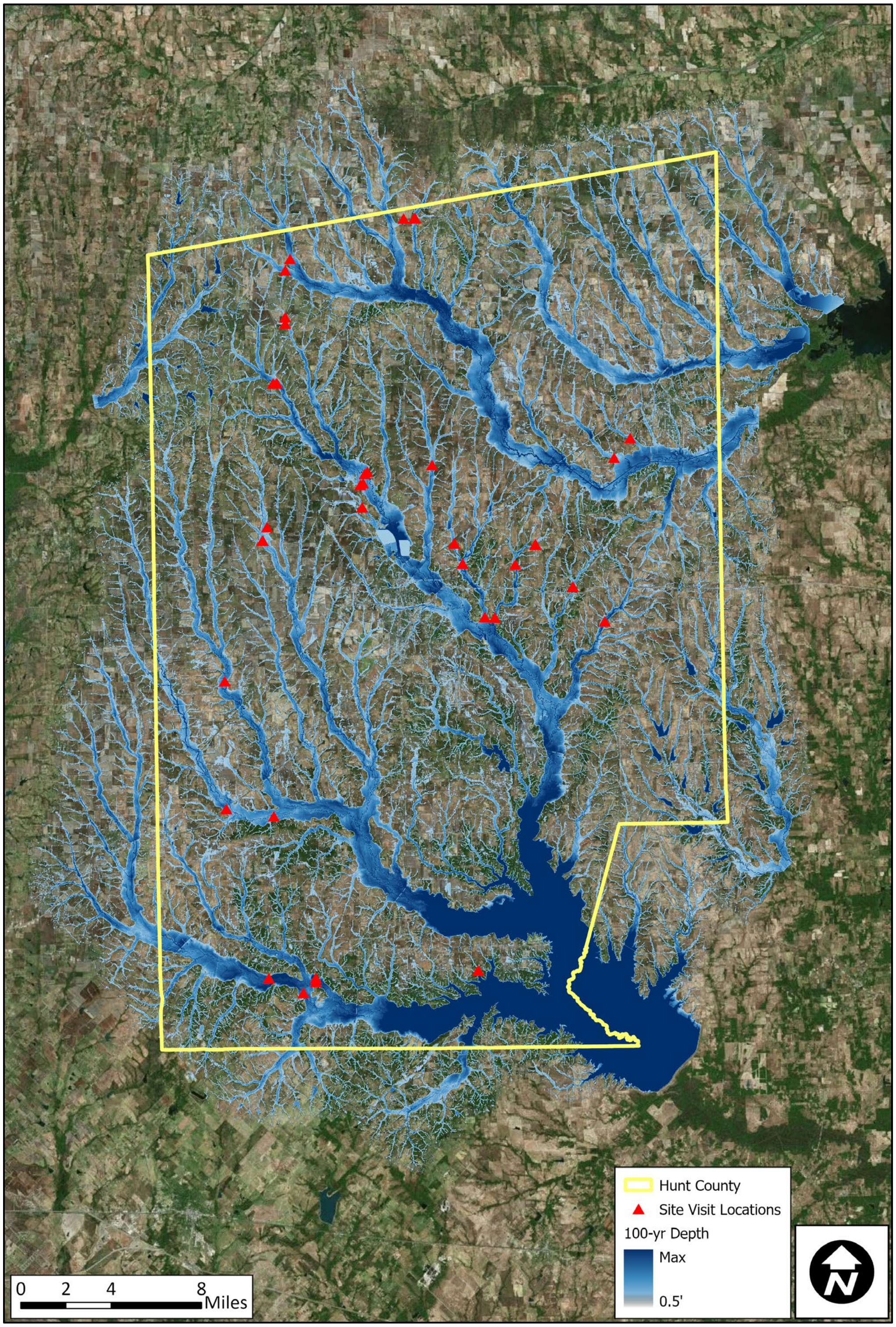


Figure 2-11. Combined 100-year storm event maximum floodwater depths.

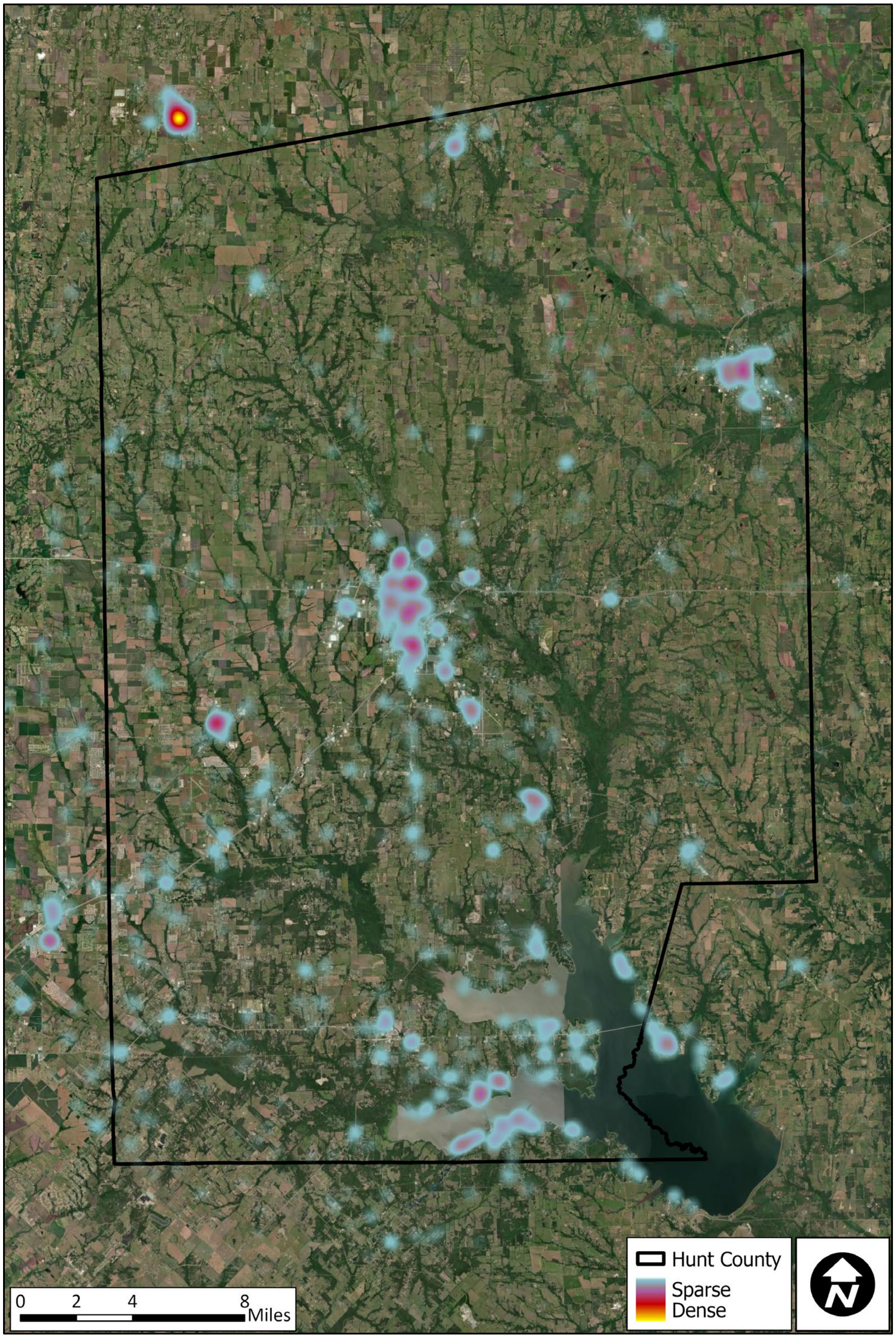


Figure 2-12. Heat map of modeled structural flooding in Hunt County.

2.5 Site Selection for Alternative Analysis

The initial screening assessment results, including a list of priority site locations, were presented to the Hunt County Commissioners Court meeting on January 10. Information such as maximum road inundation depths, water surface elevations (WSE), width of roadway inundation, nearby structures, roadway cross-section plots, flow visualization examples, and other relevant information on specific flood related issues were assessed to determine these priority site locations. Figure 2-13 and Figure 2-14 provide examples of the types of model results and visualization tools that were utilized in the selection process. Based on this information, the County confirmed the list of sites that would be modeled in greater detail in the Alternatives Analysis. The conceptual solutions to be developed for these sites were ultimately submitted as FMPs to the appropriate RFPG for inclusion in the Regional Flood Plan. These final selected sites are listed in Table 2-5.

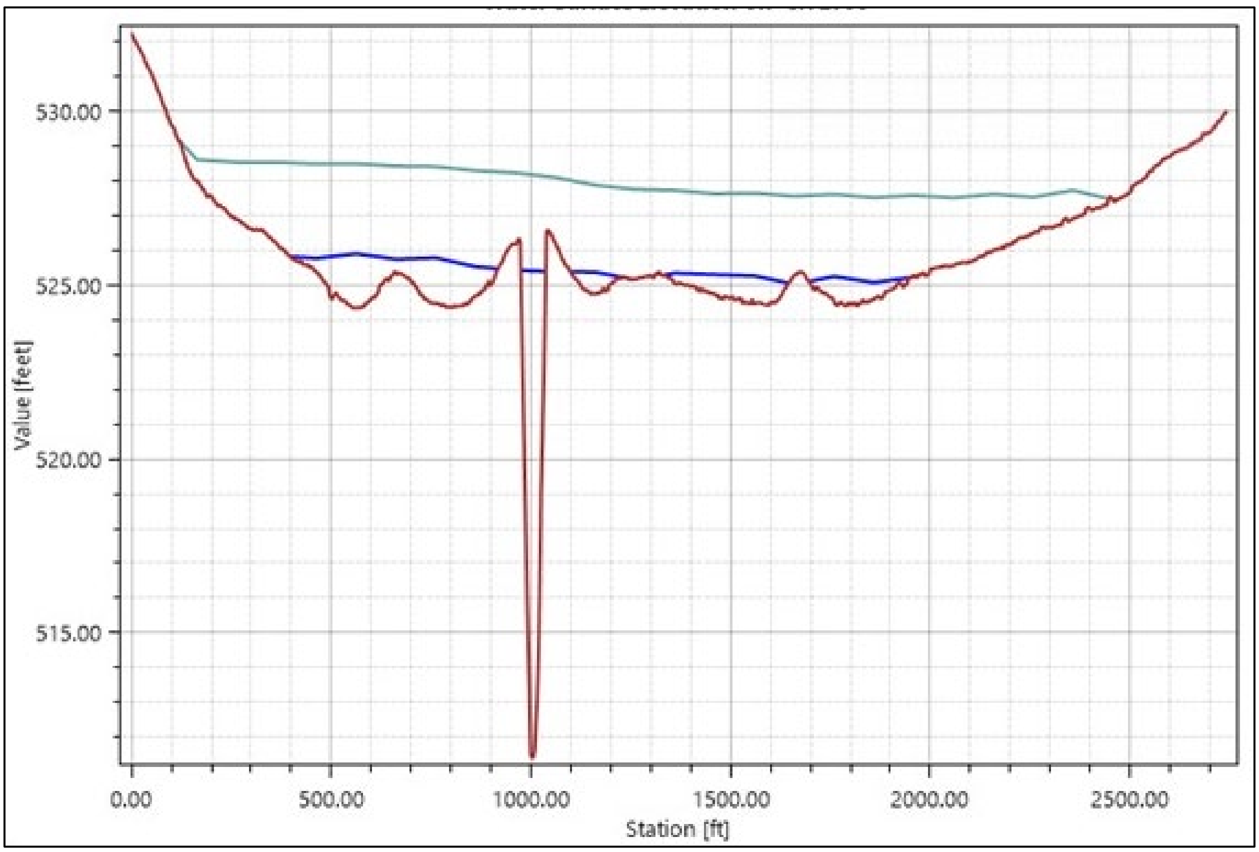


Figure 2-13. CR 2706 existing Water Surface Elevation profile for the 2-year and 100-year events.

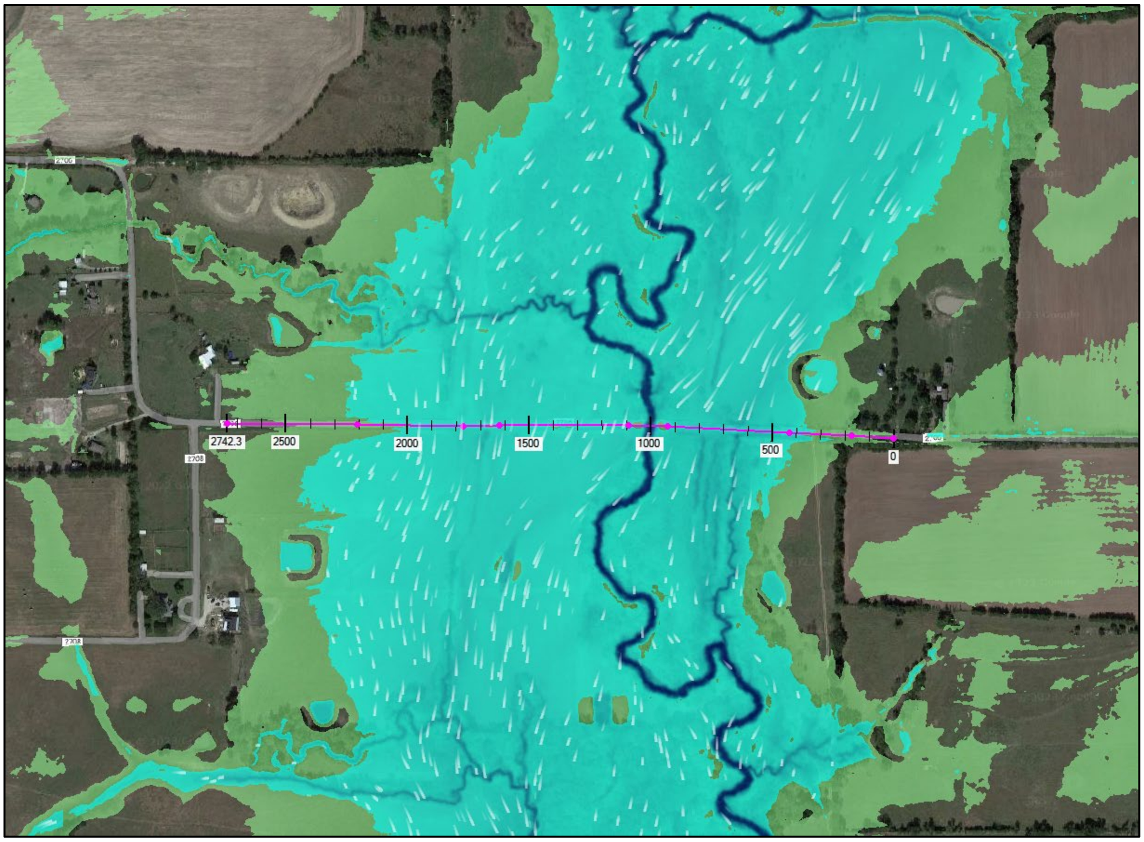


Figure 2-14. CR 2706 existing maximum flood depth extents for the 2-year (blue) and 100-year (green) storm events.

Table 2-5. Final sites selected for Alternative Analysis.

Site Name	Precinct	Model	Region
CR 1051	1	Spring Creek - Sulphur River	Lower Red-Sulphur-Cypress
CR 2400	2	Royse City - South Fork Sabine River	Sabine
CR 2706	2	West Caddo Creek - Lake Tawakoni	Sabine
CR 3101	3	Greenville - Cowleech Fork Sabine River	Sabine
CR 4105	4	Greenville - Cowleech Fork Sabine River	Sabine
CR 4106	4	Greenville - Cowleech Fork Sabine River	Sabine

3 Alternatives Analysis

The 2D HEC-RAS models developed under the screening assessment task (Section 2) were refined to conduct a detailed alternatives analysis for each of the six selected sites. Conceptual solutions were developed and tested with the goal of minimizing flood risk. The methods and assumptions adopted in the alternatives analysis are consistent with TWDB requirements as established on "*Exhibit C - Technical Guidelines for Regional Flood Planning*" (TWDB, 2021).

The hydraulic performance and feasibility of each alternative was evaluated within the context of *Exhibit C*. The recommended conceptual projects must meet all TWDB requirements for inclusion in the Regional Flood Plans (RFPs) as Flood Mitigation Projects (FMPs). In general, FMPs should result in a quantifiable reduction in flood risk, must be permittable, constructable, and implementable, and must have no negative impacts on neighboring areas. The TWDB also recommends that, at a minimum, FMPs should mitigate flood events associated with the 1% annual chance storm event (100-year recurrence interval). However, if this LOS is not feasible, the FMP may still be included in the RFP with proper documentation of the reasons for its infeasibility.

The proposed alternatives for each site include different combinations of installing bridges, installing culverts, raising the road elevation, adding upstream and downstream channel grading, and adding side ditch grading. These improvements increase the LOS from <2-years to at least 10-years for each FMP. Although the roadways for most FMPs are still inundated during the 50- and 100-year storm events, a significant reduction in flood depth and duration of flooding is achieved for each road. However, it should be apparent that there is a residual flood risk for these roads, as they may overtop for storm events larger than the design storm. To help reduce flooding risks during larger storms, it is recommended that the County should consider including roadway safety signage and other safety components.

An Opinion of Probable Construction Cost (OPCC) was developed for each alternative and details are provided in Appendix A. TWDB-required *Exhibit C* tables are included in Appendix B.

3.1 No Negative Impact Assessment

Each identified FMP must demonstrate that no negative impacts on a neighboring area would result from its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The no negative assessment shall be based on the 100-year storm event. The following requirements, per *Exhibit C*, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.
4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (subbasins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to 2D overland analysis.

If negative impacts are identified, mitigation measures may be utilized to alleviate such impacts. Alternatively, the Regional Flood Planning Groups (RFPGs) have flexibility to consider and accept additional "negative impact" for requirements one through five based on engineering professional judgment and analysis given any affected communities are informed and accept the impacts. This should be well-documented and consistent across the entire region. Flexibility regarding negative impact remains subject to TWDB review.

A comparative assessment of pre- and post-project conditions for the 100-year storm event was performed for each alternative under existing hydrologic conditions. Floodplain boundary extents, water surface elevations, and peak discharge results were compared at pertinent locations to determine if the recommended FMP conforms to the no negative impact requirements. This comparative assessment was performed for the entire zone of influence of the FMP. If negative impacts were identified, the alternative was modified until all requirements were met or until no negative impacts could be demonstrated based on professional engineering judgment.

Impacts greater than 0.35 were allowed within the county right-of-way and within any proposed grading. The county right-of-way was estimated to be at the bounding 2D hydraulic cell adjacent to the proposed roadway. Any proposed grading is assumed to occur within a proposed drainage easement.

3.2 Benefit-Cost Analysis (BCA)

A benefit-cost analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The result is a benefit-cost ratio (BCR), which is calculated by dividing the project's total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost-effectiveness" of a project. A project is generally considered to be cost effective when the BCR is one or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (FEMA, 2009). However, a BCR greater than one is not a requirement for inclusion in the Texas RFP. The RFPG can decide to recommend a project with a lower BCR with appropriate justification.

A BCA was performed for each alternative, and the spreadsheets used to develop these values are provided in Appendix C. BCRs were developed using a TWDB benefit-cost analysis input tool in conjugation with the FEMA BCA Toolkit 6.0. The process makes several assumptions, including a 7% discount rate and an annual inflation of 2% (AECOM, 2022).

Parameters used to quantify benefits were taken directly from model results and applied to the BCA spreadsheet. Roadway overtopping durations were determined using the 2D HEC-RAS models. The depths and durations obtained from these unsteady models are considered planning level estimates. The impacts from 2-, 10-, 50-, and 100-year 24-hour synthetic storm events as described in Section 2.3.4 were considered for all alternatives.

3.3 Model Refinements

Enhanced versions of the HEC-RAS screening assessment models were created to improve the level of detail at the six selected sites. The perimeter of the respective base screening assessment model (Section 2.3.1) was reduced in size to the immediate contributing drainage area of each site. Inflow boundary conditions were established with hydrologic inflows from the screening assessment results. Normal depth boundary conditions were established for other boundaries with a similar methodology as in the Screening Assessment. These boundaries were set so that they were sufficiently far from the crossings of interest. The cell size for the 2D mesh was reduced from 200'x200' to 100'x100', and the computation interval was reduced from a 30-second timestep to a 10-second timestep. The reduced model boundary size allowed for much faster run times, even with the reduced cell size and computation interval.

Existing and proposed drainage infrastructure at the selected sites was modeled as bridges/culverts using SA/2D connections rather than terrain modifications. This adjustment provides a more accurate representation of the structure's flow capacity. Terrain modifications were still used to allow flow to pass through existing smaller culverts or openings in the contributing drainage area that were not captured in the terrain surface. Proposed channel and grading improvements were modeled as terrain modifications. In some cases, modifications were made to the land use and infiltration layers based on information received from the County or aerial imagery. These modifications were adopted for a more accurate representation of infiltration losses and Manning's roughness coefficients of the surrounding areas.

3.4 County Road 1051

CR 1051 is located within Precinct 1, about 10 miles north of the City of Celeste. CR 1051 connects to U.S. Highway 69 to the west. The site crosses the South Sulphur River within the Spring Creek - Sulphur River model in the Lower Red-Sulphur-Cypress River Basin (Region 2). The existing drainage infrastructure for CR 1051 includes an approximately 40' span bridge at the western crossing and a culvert at the eastern crossing. The minimum road elevation over the crossing is approximately 620.2'. Existing drainage infrastructure is significantly undersized for the 2-year storm event (Table 3-1). The nearby roads crossing the South Sulphur River also appear to flood for the 2-year storm event. Therefore, improving this crossing will significantly improve the connectivity across the river.

Several potential alternatives were determined for this site using an iterative process. Alternative 1 included a 400' span bridge on the western crossing and a 250' span on the eastern crossing. Alternative 2 increased the eastern crossing span to 350' to reduce the WSEs. The proposed alternative (Alternative 3) swapped the span lengths for the two crossings to reduce WSE rises and is described in the next section.

3.4.1 Proposed Alternative

The proposed alternative (Alternative 3) for CR 1051 includes installing a 350' span bridge on the western crossing and a 400' span bridge on the eastern crossing, raising the road elevation, and adding side ditch grading. The road was raised by approximately 1-5' along a stretch of road spanning 1400', not including bridge span. This increased the road elevation to a minimum of 625.3'. The road was also raised by an additional 4' around the bridges to facilitate drift clearance. Side ditch grading for both bridges on the upstream side of CR 1051 was added to increase conveyance on the upstream side. Figure 3-1 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $8,197,000 (Appendix A).

A 10-year LOS is achieved with the proposed improvements. Table 3-1 provides a comparison between existing and proposed conditions for CR 1051. Figure 3-2 shows a comparison between the existing and proposed 10-year WSEs over the roadway and 10-year floodplain extents. While the roadway is still inundated during the 50-year and 100-year storm events, a significant reduction in roadway inundation depth and duration of flooding is achieved (Table 3-1). The BCR for this alternative is 0.1 (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project does not meet all no negative impacts requirements as established in *Exhibit C* (Section 3.1). However, there are no habitable structures within the 100-year floodplain and impacted area for this site (Figure 3-3). Therefore, the proposed project is considered to have no negative impacts based on professional engineering judgment (see Appendix D).

Table 3-1. Existing vs. Proposed Conditions for CR 1051.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1]	3	4	5	5	-	-	0.5	1
Duration of flooding over roadway (hrs)[2]	17	18	22	23	-	-	1	1.5

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

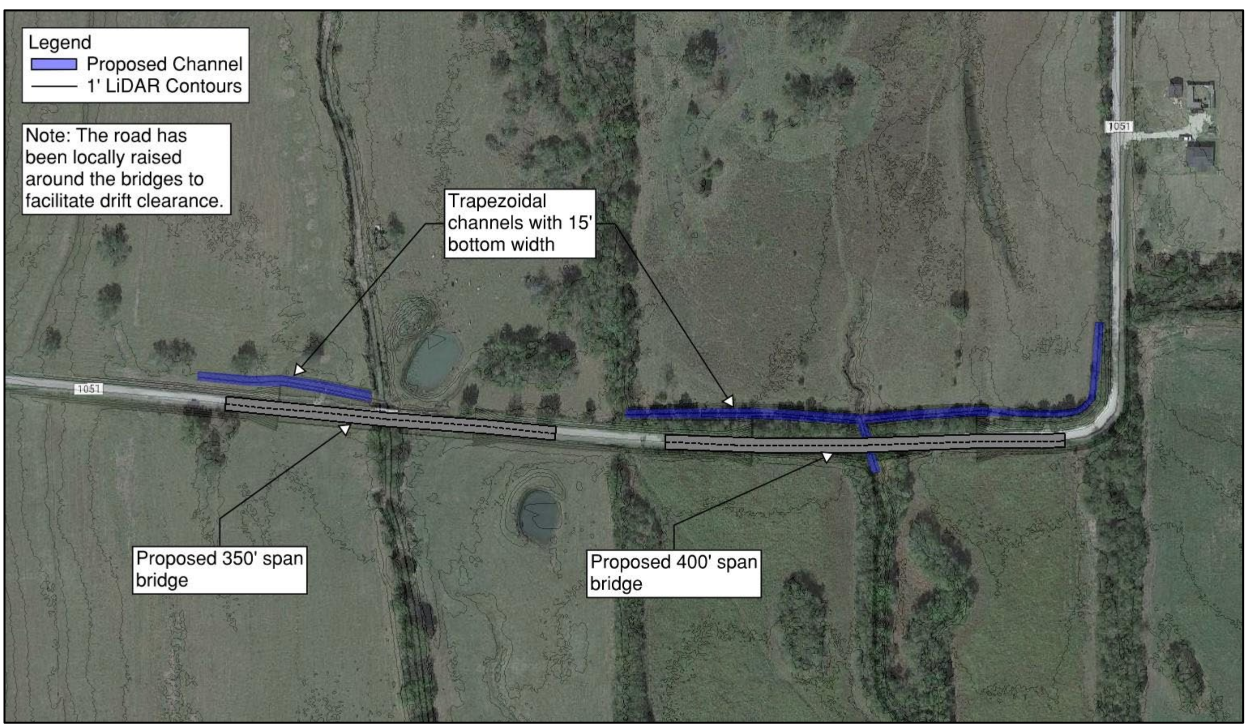


Figure 3-1. Proposed improvements: CR 1051.

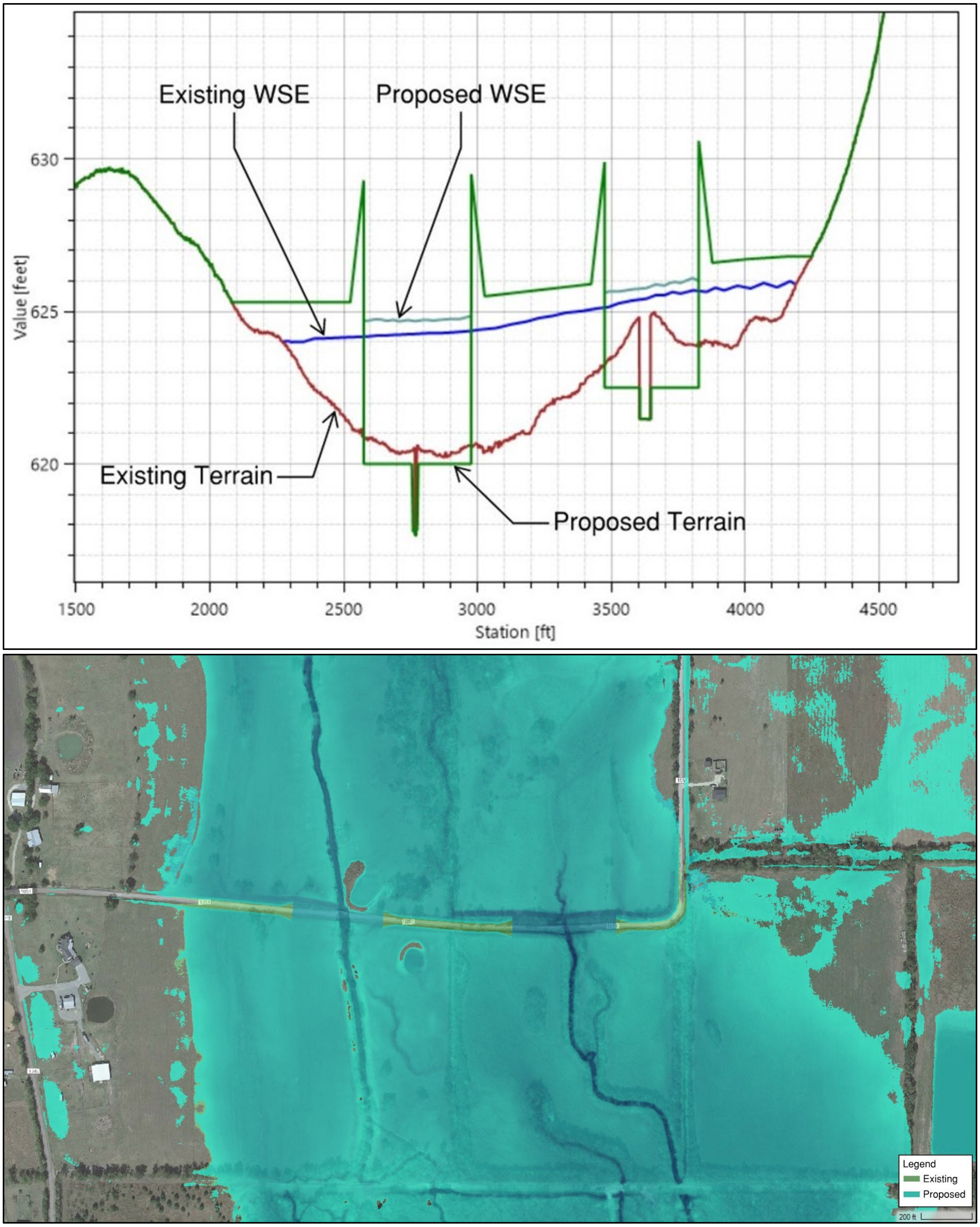


Figure 3-2. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: CR 1051.

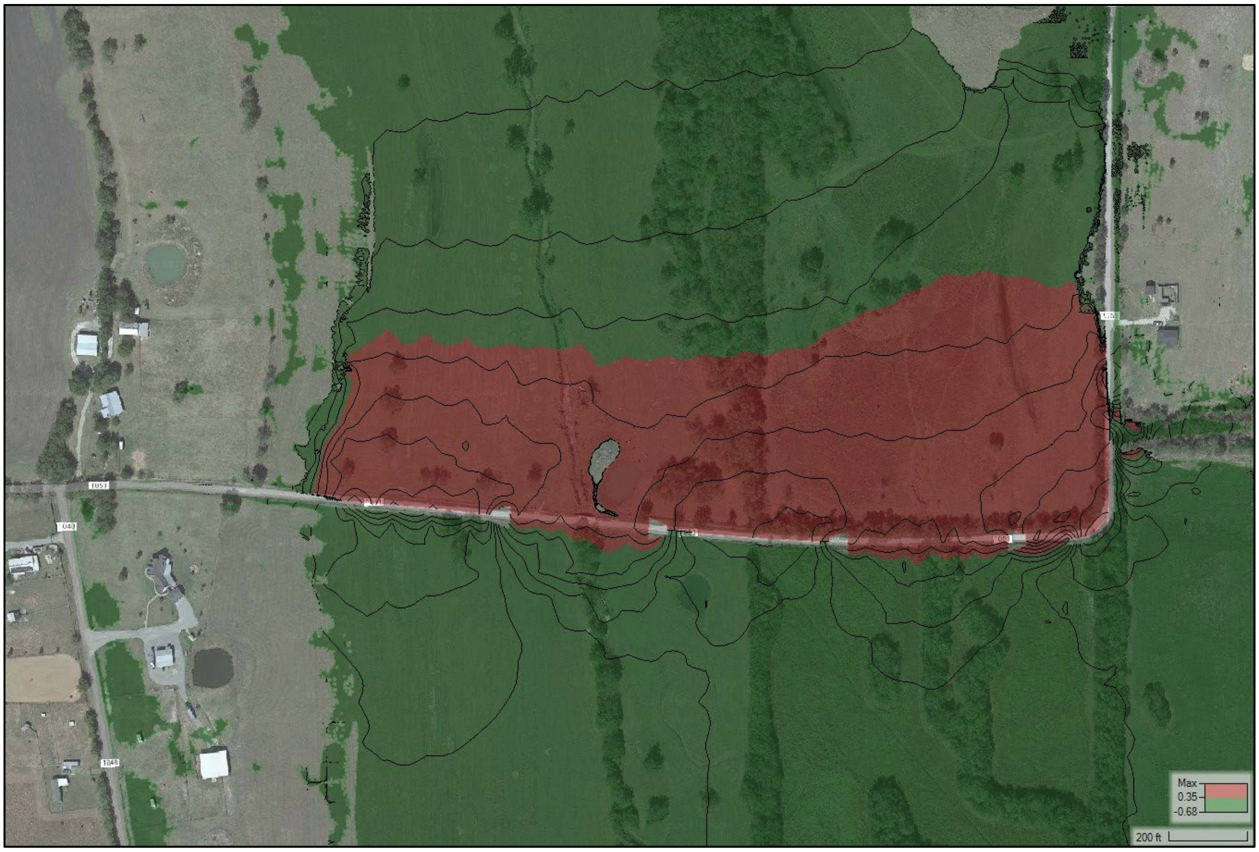


Figure 3-3. Change in 100-yr WSE (ft) (Proposed minus Existing): CR 1051.

3.5 County Road 2400

CR 2400 is located within Precinct 2, about 5 miles southwest of the City of Quinlan. The site crosses the South Fork Sabine River within the Royse City - South Fork Sabine River model in the Sabine River Basin (Region 4). The existing drainage infrastructure for CR 2400 includes an approximately 60’ span bridge. The minimum road elevation over the crossing is approximately 462.1’. Existing drainage infrastructure is significantly undersized for the 2-year storm event (Table 3-2). CR 2400 commonly floods from small magnitude storms (< 2-year storm events) and was flooded during the site visit (Figure 2-3). When CR 2400 and the adjacent roads flood, the area south of CR 2400 is disconnected from FM-1565 to the west and TX-276 to the north. If improved to a 10-year LOS, CR 2400 would greatly improve the connectivity between this southern area and the larger roads.

Several potential alternatives were determined for this site using an iterative process. Alternative 1 included a 300’ span bridge on the northern crossing and a 600’ span bridge on the southern (existing) crossing. Alternative 2 increased the northern crossing span to 550’ to reduce WSE impacts for one of the structures on the northern side, but a WSE rise of over 0.035’ was still present. The proposed Alternative (Alternative 3) then connected the two crossings together, which resulted in no net negative impacts.

3.5.1 Proposed Alternative

The proposed alternative (Alternative 3) for CR 2400 includes installing a 1500' span bridge, raising the road elevation, adding downstream channel grading, and adding side ditch grading. The road was raised by approximately 1-3' along a stretch of road spanning 1700', not including the bridge span. This increased the road elevation to a minimum of 466.8'. The road was also raised by an additional 4' around the bridges to facilitate drift clearance. Downstream grading was added at the northern section to connect to an existing pilot channel to improve the conveyance. Figure 3-4 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $14,437,000 (Appendix A).

A 10-year LOS is achieved with the proposed improvements.
Table 3-2 provides a comparison between existing and proposed conditions for the CR 2400 site. Figure 3-5 shows a comparison between the existing and proposed 10-year WSE over the roadway and 10-year floodplain extents. While the roadway is still inundated for a small amount of time during the 50-year and 100-year storm events, there is a significant reduction in maximum flood depth and duration of flooding (Table 3-2). The BCR for this alternative is 0.7. (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project meets all no negative impacts requirements as established in *Exhibit C* (Section 3.1). All 100-year WSE rises greater than 0.35' are contained within the CR 2400 right-of-way and do not affect any residential structures (Figure 3-6).

Table 3-2. Existing vs. Proposed Conditions for CR 2400.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1]	3	4	5.5	6	-	-	1	1.5
Duration of flooding over roadway (hrs)[2]	36	37	40	41	-	-	8	11
Residential structures in floodplain	0	1	2	2	0	1	2	2

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

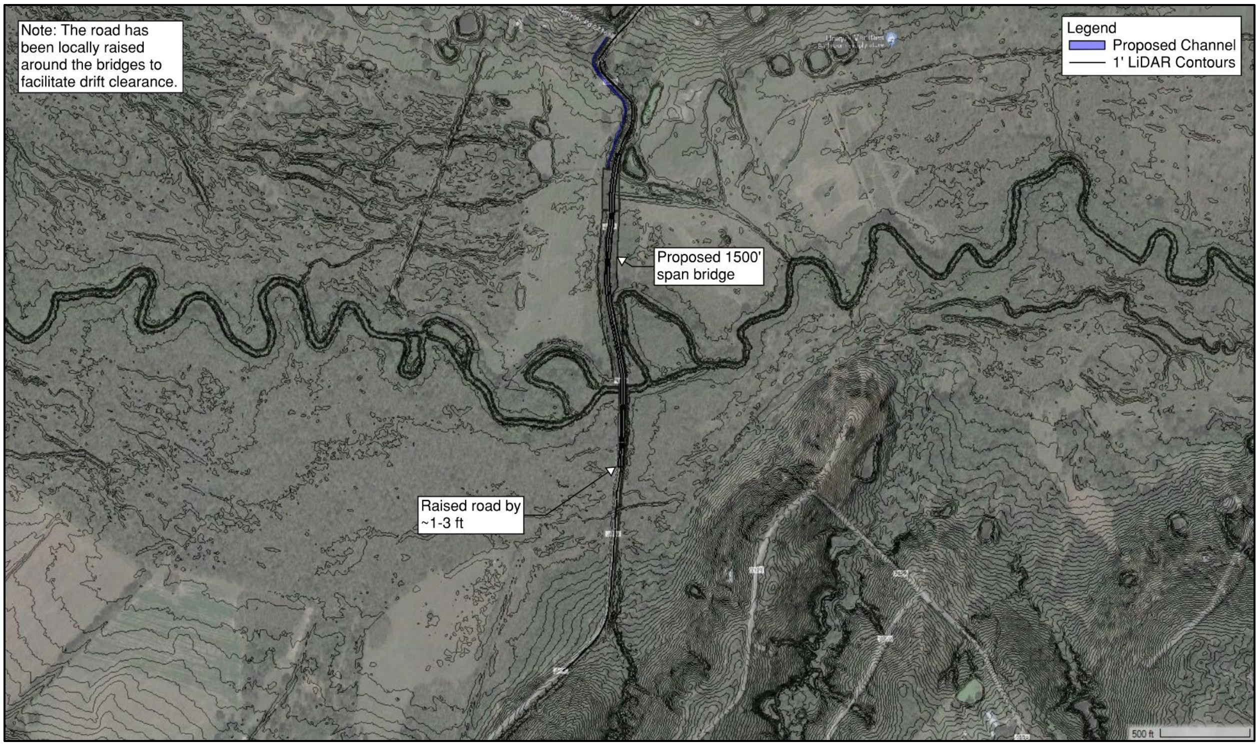


Figure 3-4. Proposed improvements: CR 2400.

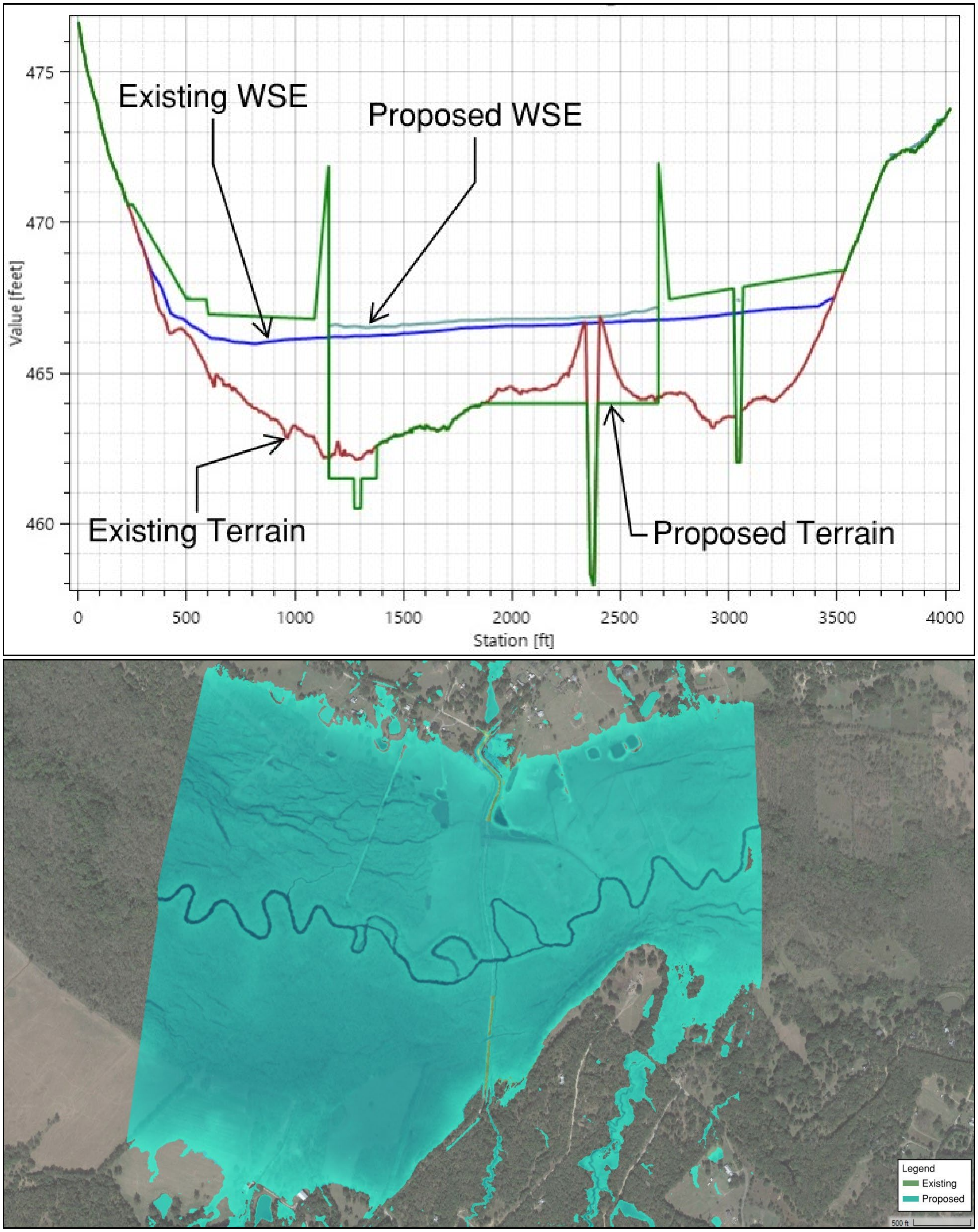


Figure 3-5. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: CR 2400.

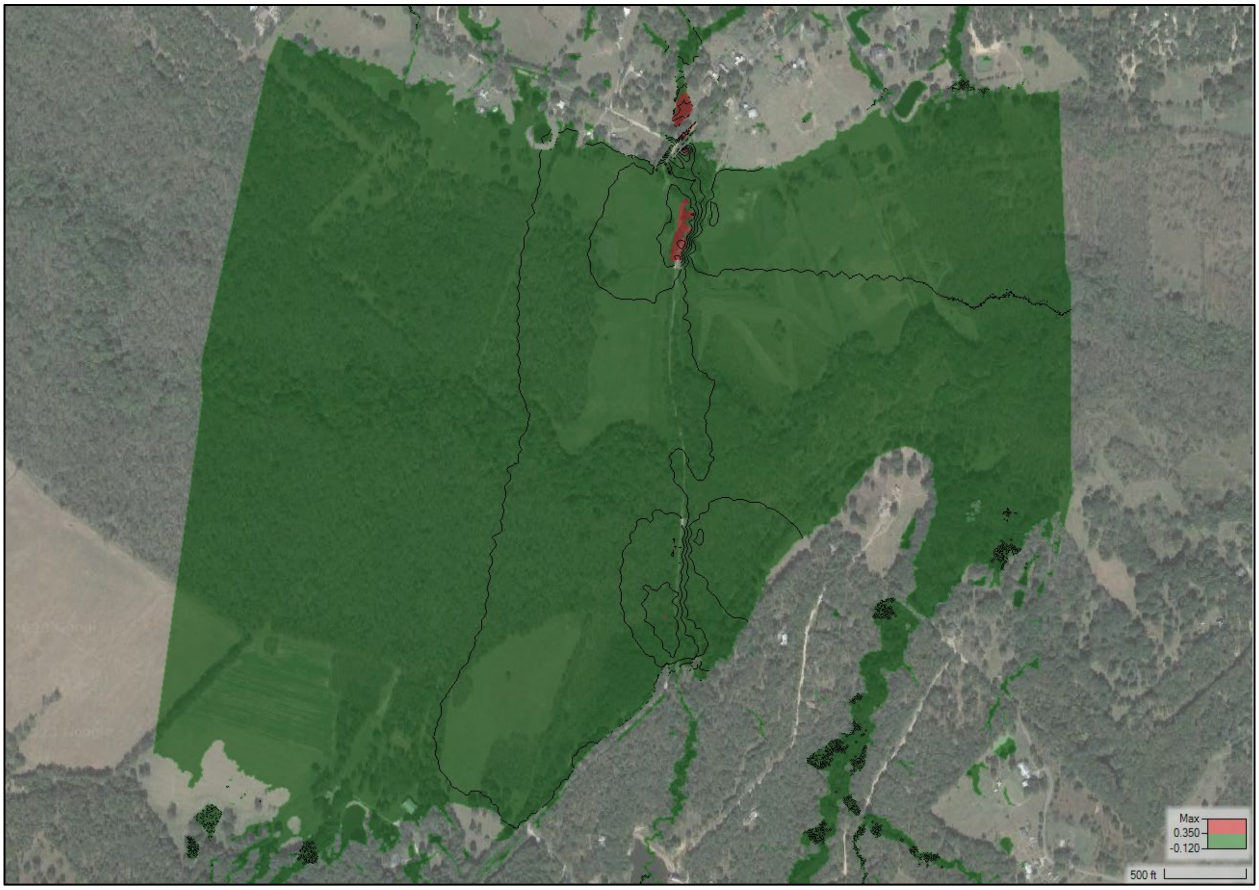


Figure 3-6. Change in 100-yr WSE (ft) (Proposed minus Existing): CR 2400.

3.6 County Road 2706

County Road 2706 is located within Precinct 2, about 2 miles northwest of the City of Caddo Mills. The site is located within the West Caddo Creek - Lake Tawakoni model in the Sabine River Basin (Region 4). The existing drainage infrastructure for CR 2706 includes an approximately 50' span bridge. The minimum road elevation over the crossing is approximately 524.3'. Existing drainage infrastructure is undersized for the 2-year storm event (Table 3-3). When CR 2706 and the adjacent roads flood during a 2-year storm event, the City of Caddo Mills and the Caddo Mills Independent School District are disconnected from the area to the west. As a result, the area to the west needs to re-route to FM-36 and TX-66. If improved to a 10-year LOS, this would significantly improve the connectivity between the regions.

Several potential alternatives were determined for this site using an iterative process. Alternative 1 included a 50' wide bridge-class culvert to the west and a 400' span bridge to the east (at the existing bridge location). Alternative 2 included a 150' span bridge on the western crossing to reduce the WSE impacts. However, both alternatives would add a non-residential structure to the 100-year floodplain. To avoid adding this structure to the floodplain, the western crossing was expanded and two 10'x6' culverts were added on the eastern side for Alternative 3.

3.6.1 Proposed Alternative

The proposed alternative (Alternative 3) for CR 2706 includes installing a 300' span bridge on the western crossing, a 400' span bridge on the eastern crossing, and two 10'x6' culverts, raising the road elevation, adding upstream and downstream channel grading, and adding side ditch grading. The road was raised by approximately 1-3' along a stretch of road spanning 1100', not including the bridge span. This increased the road elevation to a minimum of 526.7'. The road was also raised by an additional 4' around the bridges to facilitate drift clearance.

Although there is not an existing bridge or channel on the western side, the western 300' bridge was added due to the large amount of flow that is conveyed across the western side of the road in existing conditions. Side ditch grading was also added on the western upstream side of CR 2706 to increase conveyance through the crossings. 2 - 10'x6' culverts are proposed to allow drainage from the eastern upstream area to connect to the existing channel east of the bridge. There does not appear to be an existing culvert at this point. Figure 3-7 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $9,126,000 (Appendix A).

A 10-year LOS is achieved with the proposed improvements. Table 3-3 provides a comparison between existing and proposed conditions for the CR 2706 site. Figure 3-8 provides a comparison between existing and proposed 10-year WSE over the roadway and 10-year floodplain extents. The roadway is still inundated for the 50-year and 100-year events, but modeled results show depths of 1' or less for this alternative (Table 3-3). The BCR for this alternative is 0.8 (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project meets all no negative impacts requirements as established in *Exhibit C* (Section 3.1). All 100-year WSE rises greater than 0.35' are contained within the CR 2706 right-of-way and do not affect any residential structures (Figure 3-9).

Table 3-3. Existing vs. Proposed Conditions for CR 2706.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1]	1.5	2.5	3.5	4	-	-	0.5	1
Duration of flooding over roadway (hrs)[2]	16	19	21	22	-	-	8	10.5

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

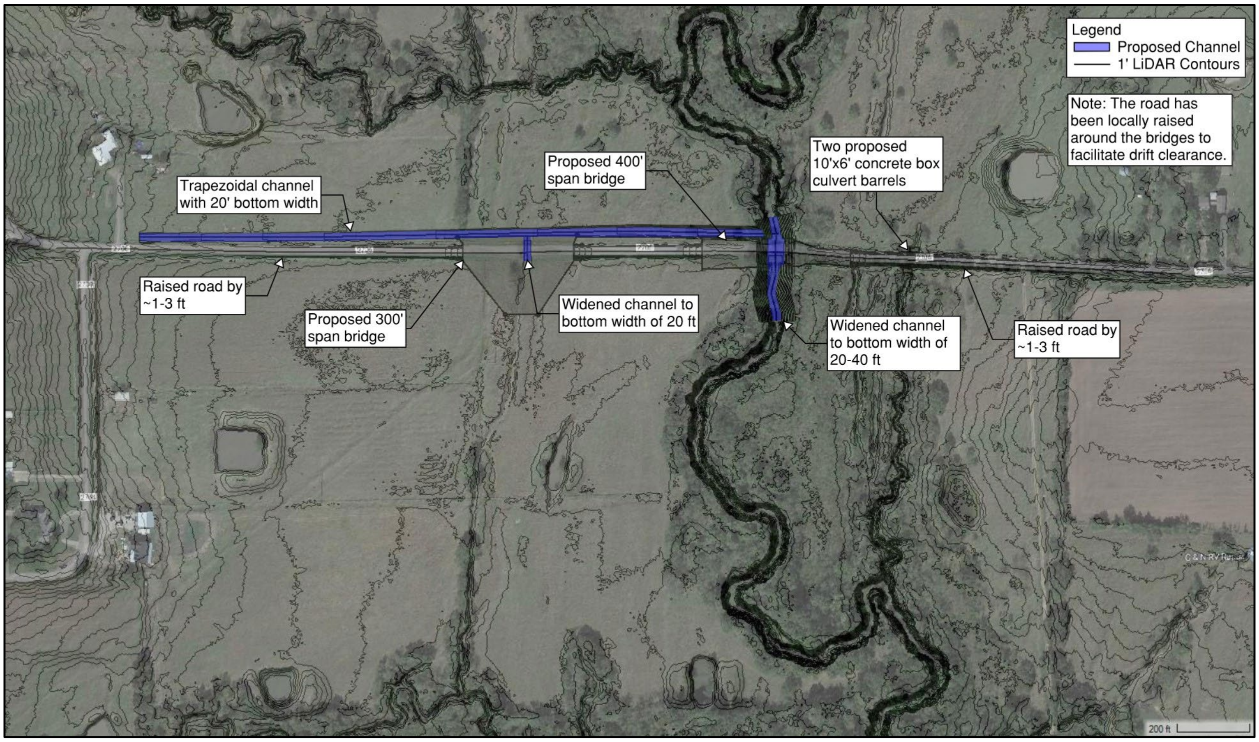


Figure 3-7. Proposed improvements: CR 2706.

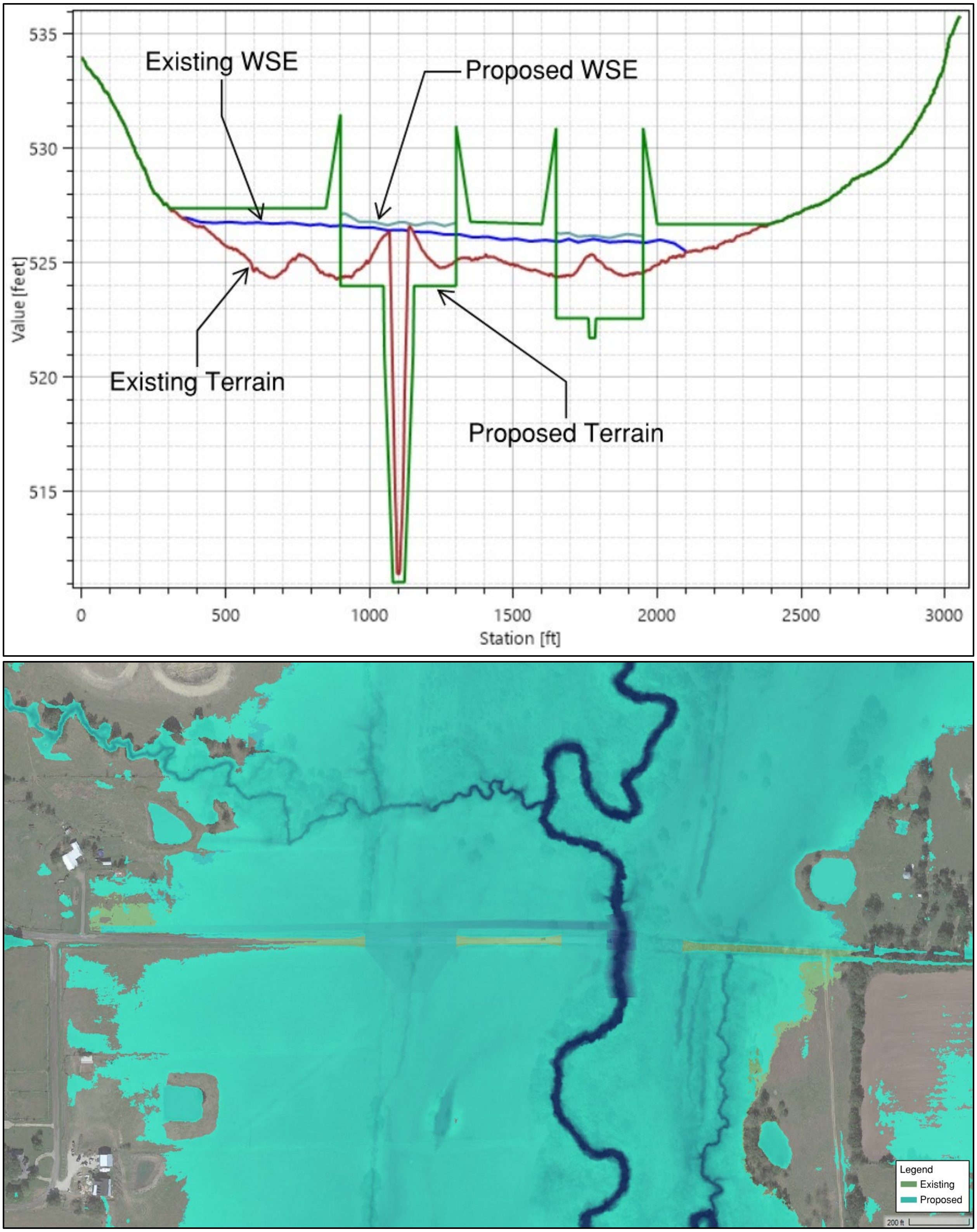


Figure 3-8. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: CR 2706.

Figure 3-9. Change in 100-yr WSE (ft) (Proposed minus Existing): CR 2706.

3.7 County Road 3101

CR 3101 is located within Precinct 3, approximately 5 miles east of the City of Greenville. The site is located within the Greenville - Cowleech Fork Sabine River model in the Sabine River Basin (Region 4). The existing drainage infrastructure for CR 3101 includes an approximately 40’ span western bridge, an approximately 50’ span eastern bridge, and a 3’ culvert. The minimum road elevations are approximately 486.1’ for the western crossing and 485.7’ for the eastern crossing. Existing drainage infrastructure is undersized for the 2-year storm event (Table 3-4). When CR 3101 floods it causes traffic and the nearby residents to have to re-route to I-30 to the north. If improved to a 10-year LOS, CR 3101 would be able to provide better relief to I-30 and the nearby residents when a storm occurs.

Several potential alternatives were determined for this site using an iterative process. Alternative 1 included a 400’ span bridge on the western crossing and a 200’ span bridge on the western crossing. The western bridge was widened to a 500’ span for Alternative 2 (the proposed alternative) in order to reduce WSE impacts.

3.7.1 Proposed Alternative

The proposed alternative (Alternative 2) for CR 3101 includes installing a 500’ span bridge on the western crossing and a 200’ span bridge on the eastern crossing, raising the road elevation, adding side ditch grading, and adding rock rip-rap armoring. The road was raised by approximately 1-3’ along a stretch of road spanning 1100’, not including the bridge span. This increased the road elevation to a minimum of 489.3’ for each crossing. The road was also raised by an additional 4’ around the bridges to facilitate drift clearance. For the western crossing, side ditch grading is proposed to increase conveyance and rock rip rap armoring is proposed due to the angle of the incoming stream. Figure 3-10 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $9,217,000 (Appendix A).

A 10-year LOS is achieved for both crossings with the proposed improvements. Table 3-4 provides a comparison between existing and proposed conditions for the CR 3101 site. Figure 3-11 and Figure 3-12 provide a comparison between existing and proposed 10-year WSEs over the roadway and 10-year floodplain extents. While the roadway is still inundated for the 50-year and 100-year storm events, there is a significant reduction in maximum flood depth and duration of flooding. The BCR for this alternative is 0.4 (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project meets all no negative impacts requirements as established in *Exhibit C* (Section 3.1). All 100-year WSE rises greater than 0.35’ are contained within the CR 3101 right-of-way and do not affect any residential structures (Figure 3-13 and Figure 3-14).

Table 3-4. Existing vs. Proposed Conditions for CR 3101.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1] - Western	1	2	3	3.5	-	-	1	1.5
Duration of flooding over roadway (hrs)[2] - Western	9	12	14	14.5	-	-	4	5
Max depth over roadway (ft)[1] - Eastern	1.5	3	4.5	5	-	-	0.5	0.5
Duration of flooding over roadway (hrs)[2] - Eastern	8	12	14	15	-	-	6	8

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

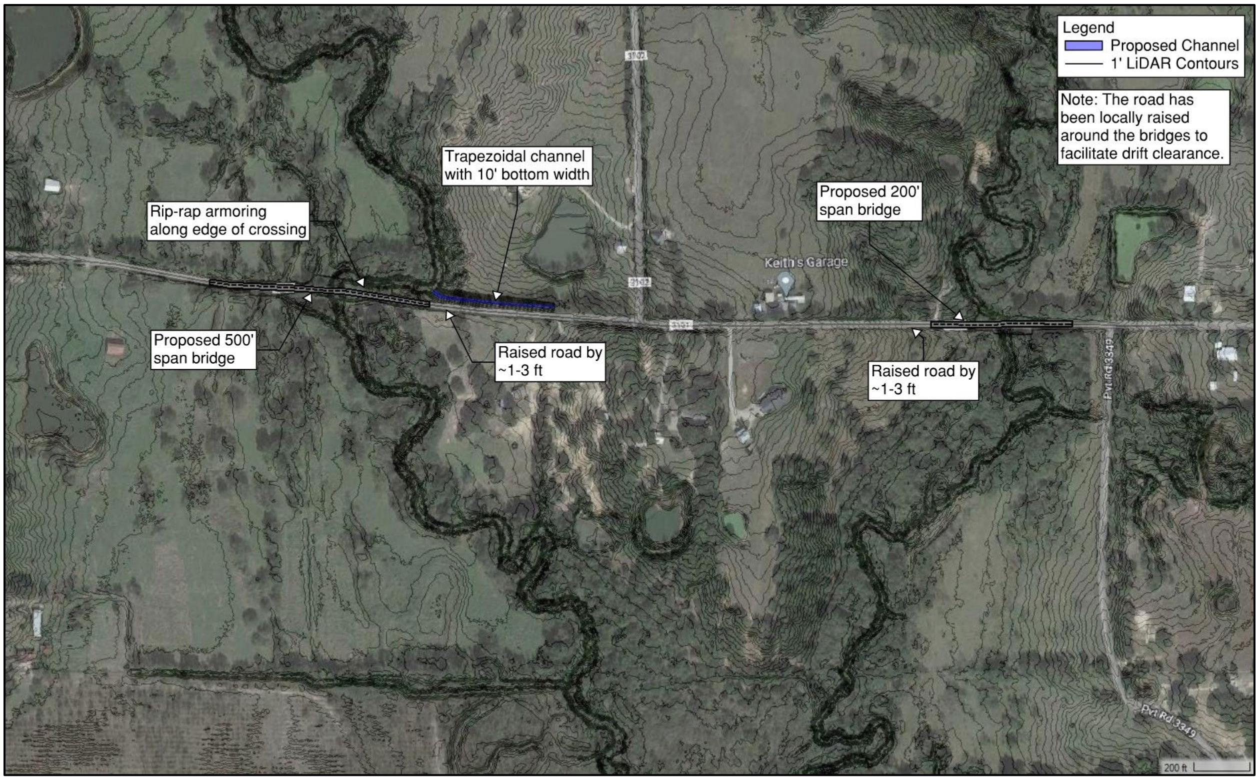
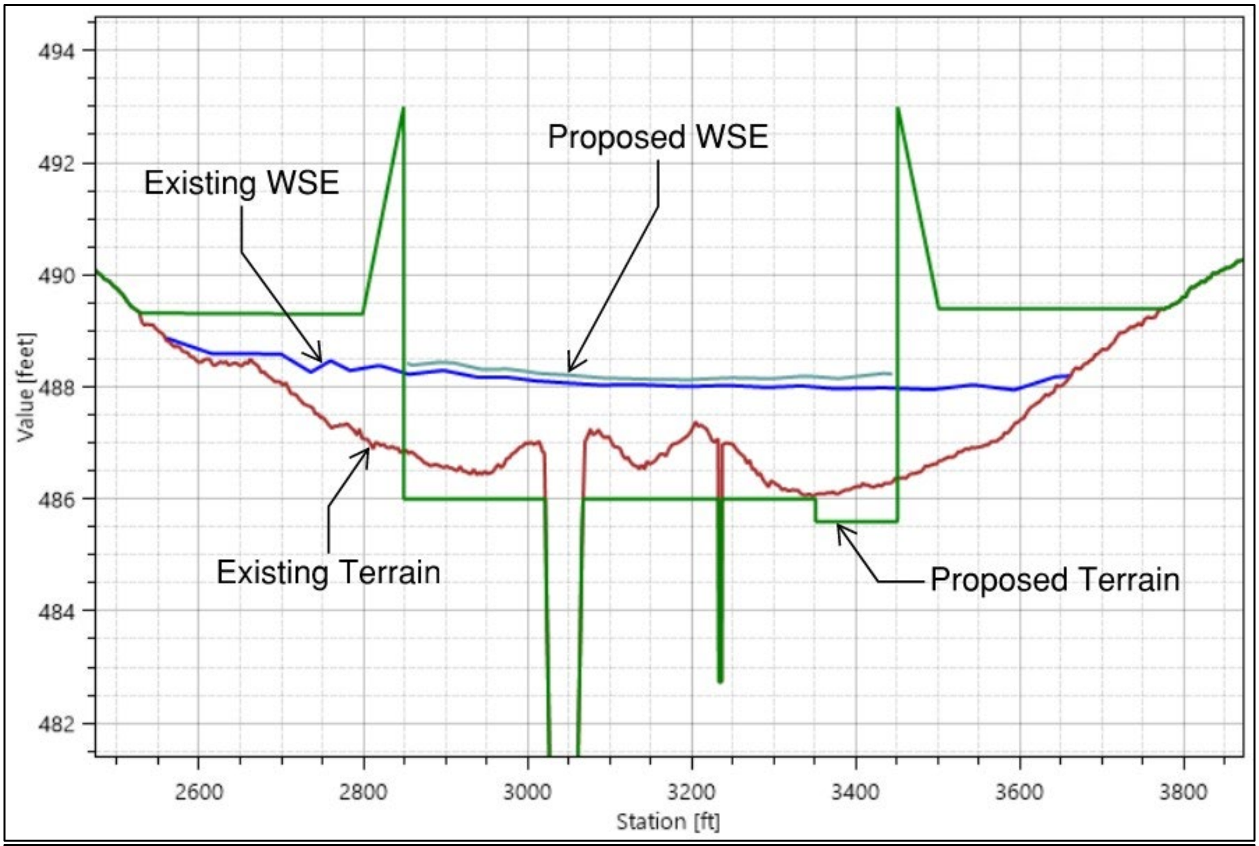


Figure 3-10. Proposed improvements: CR 3101.



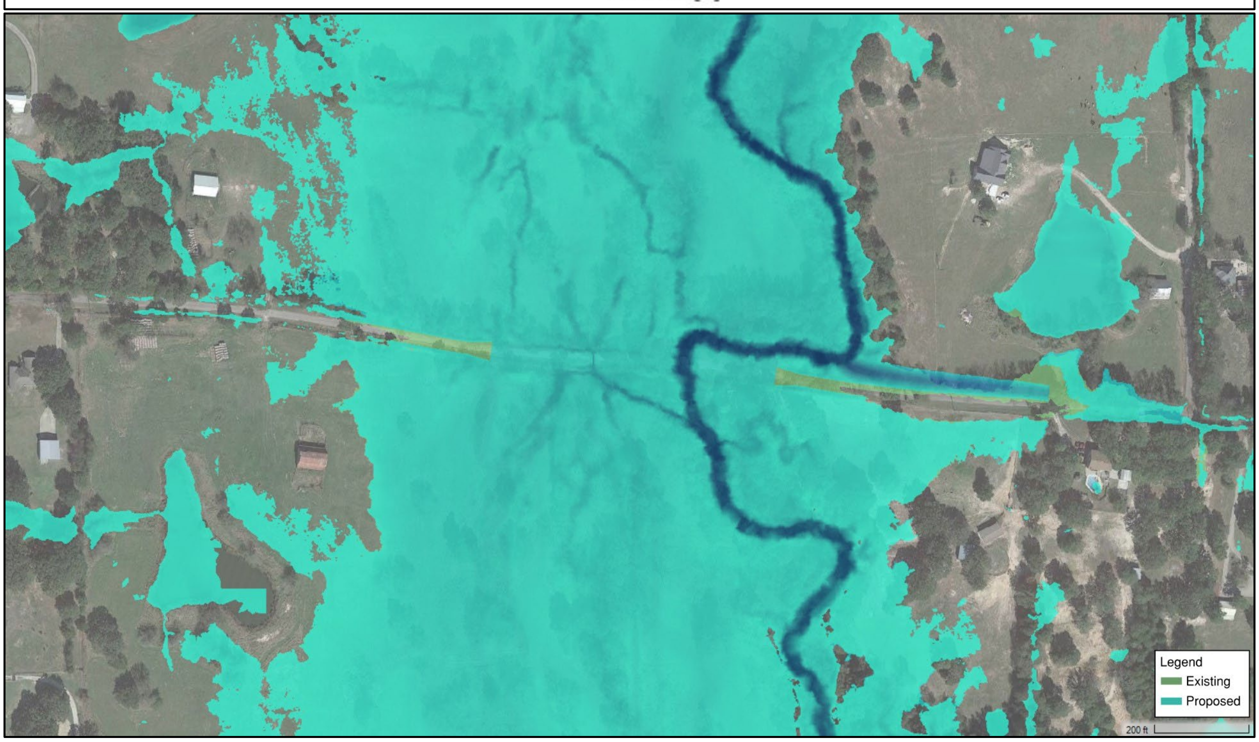
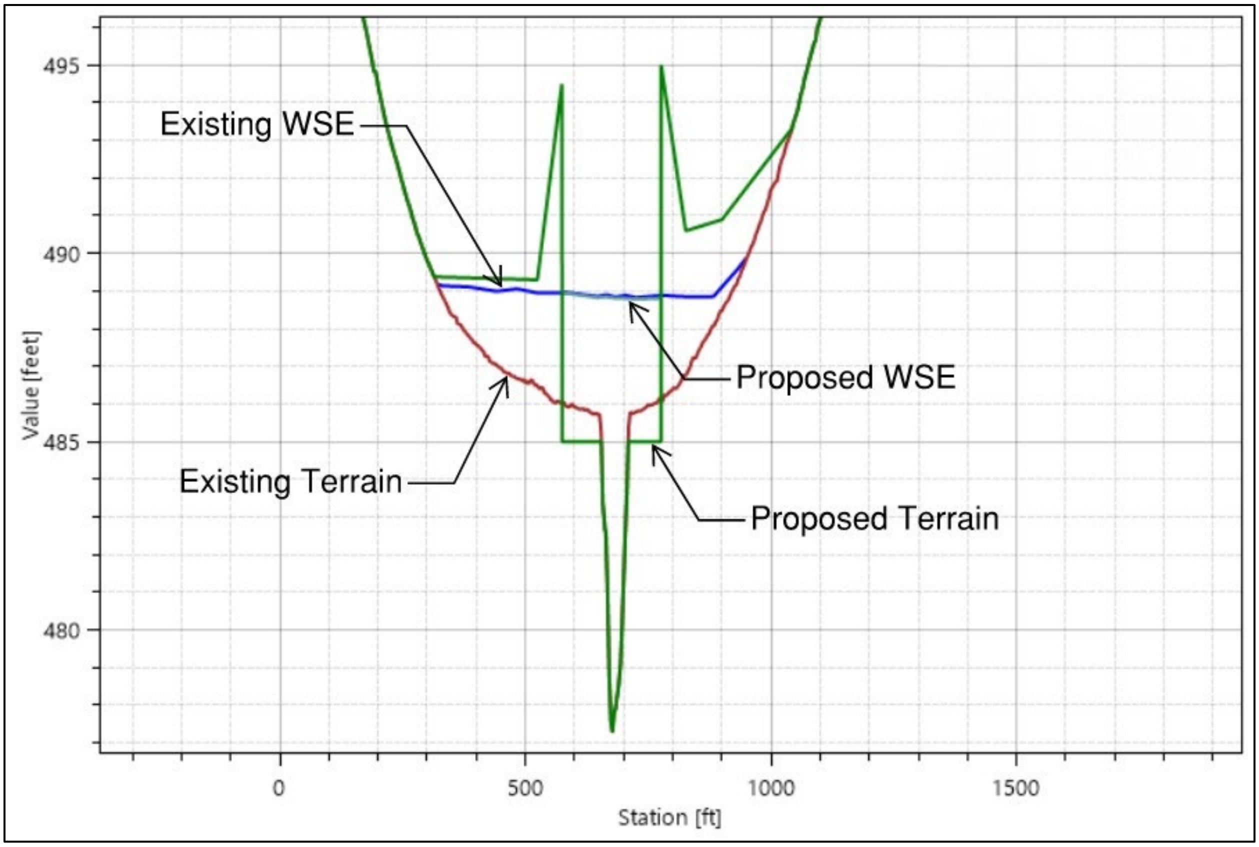


Figure 3-11. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: Western Crossing of CR 3101.



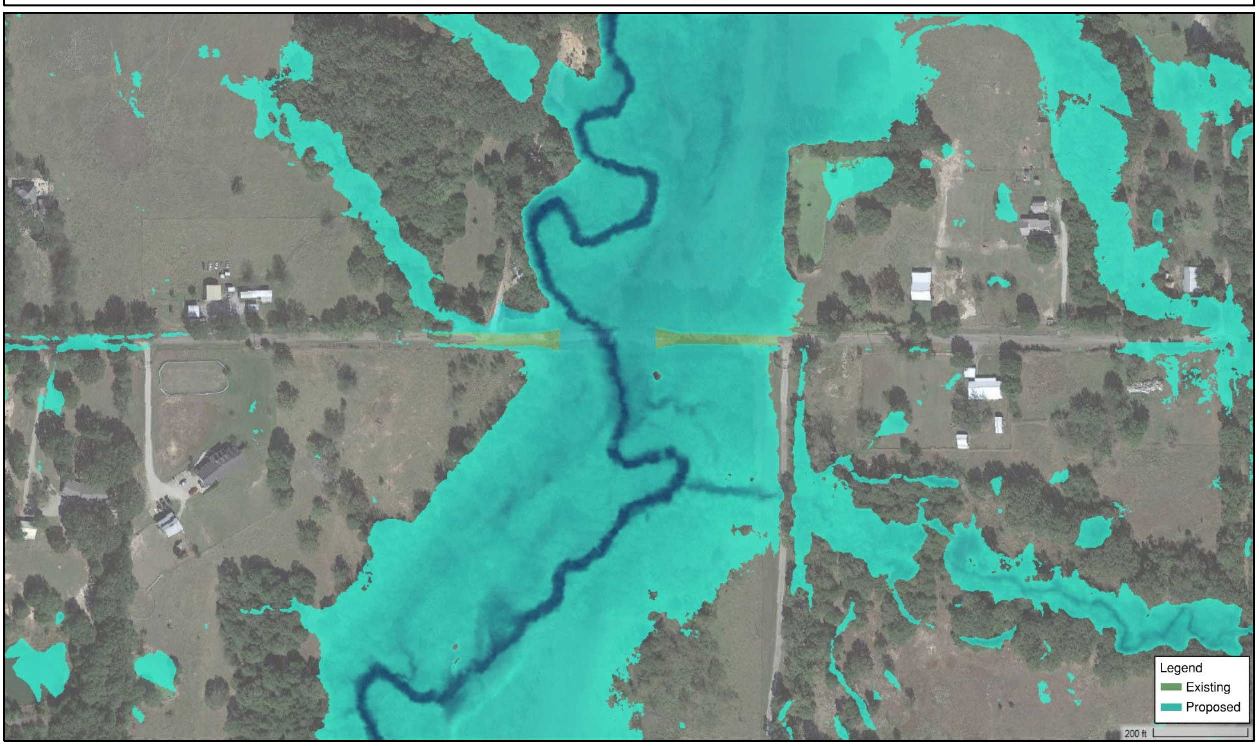


Figure 3-12. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: Eastern Crossing of CR 3101.

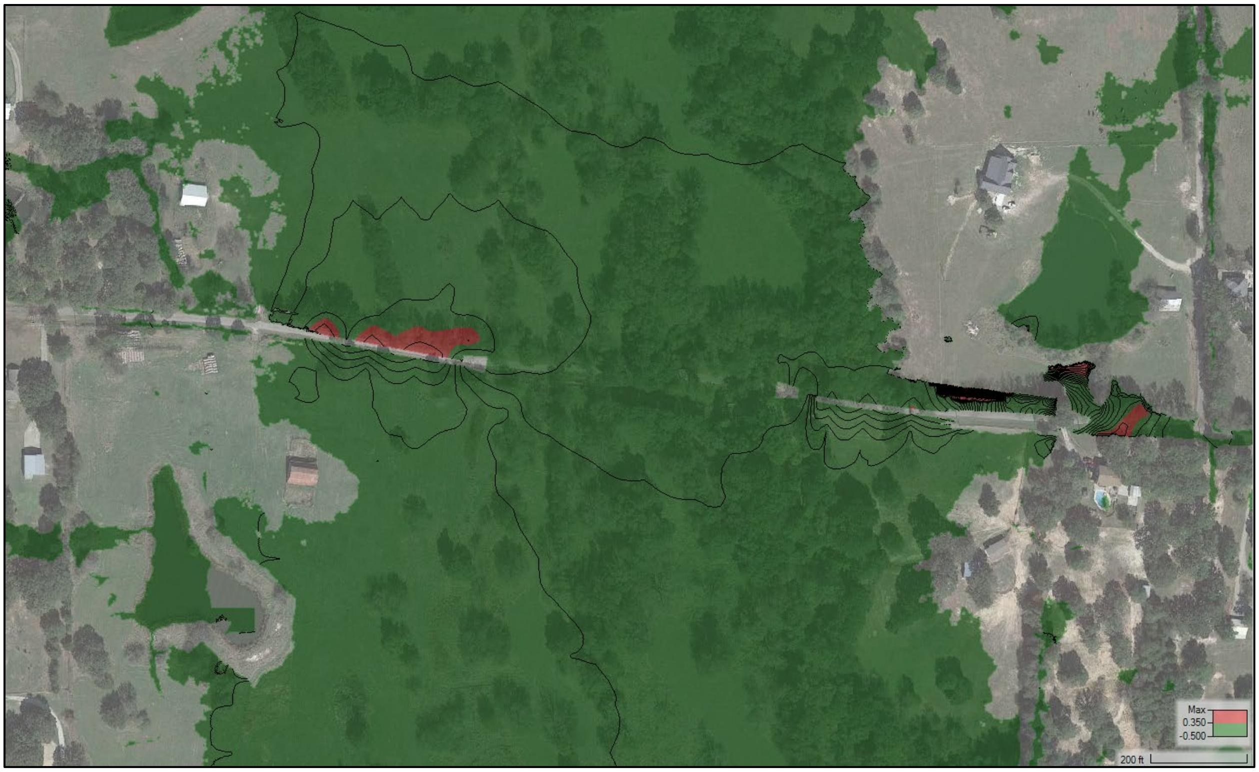


Figure 3-13. Change in 100-yr WSE (ft) (Proposed minus Existing): Western Crossing of CR 3101.

Figure 3-14. Change in 100-yr WSE (ft) (Proposed minus Existing): Eastern Crossing of CR 3101.

3.8 County Road 4105

CR 4105 is located within Precinct 4, approximately 5 miles northeast of the City of Greenville. The site is located within the Greenville - Cowleech Fork Sabine River model in the Sabine River Basin (Region 4). The existing drainage infrastructure for CR 4105 includes two 3' culverts. The minimum road elevation is approximately 507.8'. Existing drainage infrastructure is undersized for the 2-year event. CR 4105 is close to Greenville and provides relief to TX-224. When the road floods, this relief and the connection between FM 2736 and FM 118 is lost. Therefore, improving the road to a 10-year LOS would improve the connectivity between Greenville and the west.

Several potential alternatives were determined for this site using an iterative process. Alternatives 1 and 2 for this site both included a 200' span bridge, but Alternative 1 raised the road approximately 1' higher than Alternative 2. However, Alternative 2 is proposed as it results in smaller WSE rises than Alternative 1.

3.8.1 Proposed Alternative

The proposed alternative (Alternative 2) for CR 4105 includes installing a 200' span bridge, raising the road elevation, and adding side ditch grading. The road was raised by approximately 1-5' along a stretch of road spanning 900', not including the bridge span. This increased the road elevation to a minimum of 511.0’. The road was also raised by an additional 4’ around the bridge to facilitate drift clearance. Side ditch grading was added for the western side of the crossing which transitions into a channel that goes through the crossing. Figure 3-15 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $4,285,000 (Appendix A).

A 10-year LOS is achieved for both crossings with the proposed improvements. Table 3-5 provides a comparison between existing and proposed conditions for the CR 4105 site. Figure 3-16 provides a comparison between existing and proposed 10-year WSEs over the roadway and 10-year floodplain extents. While the roadway is still inundated for the 50-year and 100-year storm events, there is a significant reduction in maximum flood depth and duration of flooding. The BCR for this alternative is 0.3 (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project meets all no negative impacts requirements as established in *Exhibit C* (Section 3.1). This is because all 100-year WSE rises (including at structures) are less than 0.35’ (Figure 3-17). A small hill (assumed to be removed) just downstream of the proposed bridge is shown on Figure 3-17 to have a rise greater than 0.35’ only because it is higher than the existing WSE.

Table 3-5. Existing vs. Proposed Conditions for CR 4105.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1]	1	3	4.5	5	-	-	1.5	2
Duration of flooding over roadway (hrs)[2]	4	8.5	10	12	-	-	4.5	5.5
Residential structures in floodplain	0	1	1	1	0	1	1	1

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

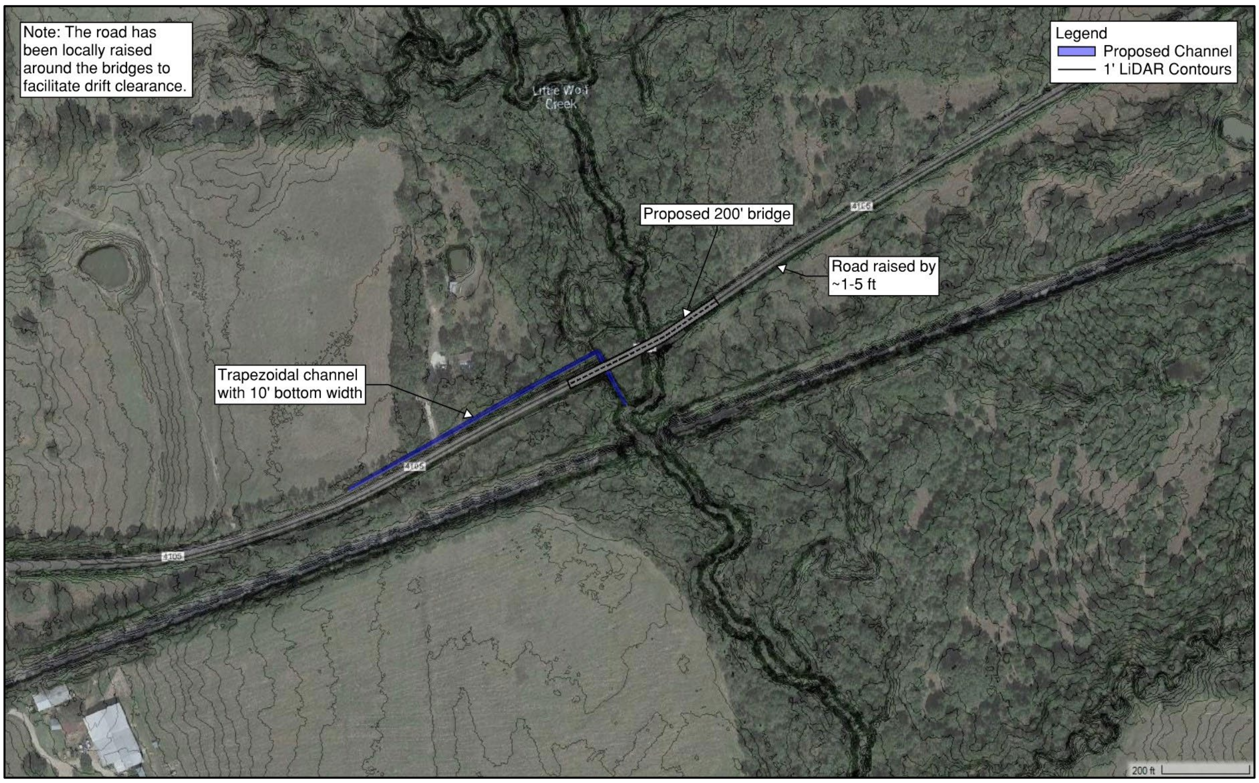


Figure 3-15. Proposed improvements: CR 4105.

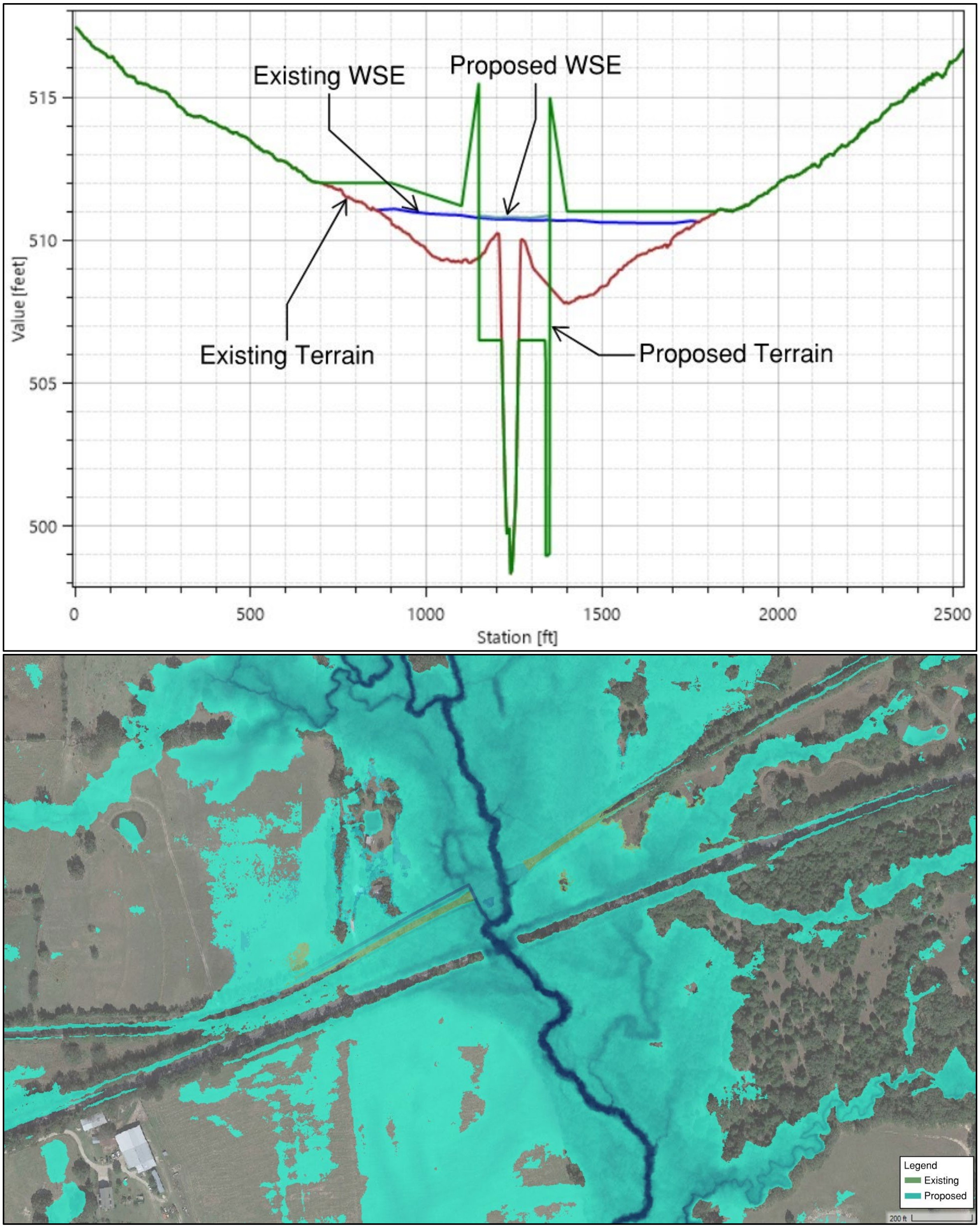


Figure 3-16. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: CR 4105.

Figure 3-17. Change in 100-yr WSE (ft) (Proposed minus Existing): CR 4105.

3.9 County Road 4106

CR 4106 is located within Precinct 4, approximately 5 miles east of the City of Greenville. The site is located within the Greenville - Cowleech Fork Sabine River model in the Sabine River Basin (Region 4). The existing drainage infrastructure for CR 4106 includes two 7' tanker culverts. The minimum road elevation is approximately 524.2'. Existing drainage infrastructure is undersized for the 2-year event (Table 3-6). CR 4106 is also close to Greenville and provides relief to I-30. When CR 4106 is flooded, the connection between I-30 and SH-24 is lost. Therefore, improving the road to a 100-year LOS would greatly improve the connectivity between Greenville and the west.

Several potential alternatives were determined for this site using an iterative process. Alternative 1 included a 70' span western bridge and an 80' span eastern bridge, but resulted in WSE rises that were too high. Alternative 2 included a 120' span for both bridges and Alternative 3 included a 100' span for both bridges. Both Alternative 2 and Alternative 3 met the necessary WSE rise requirements, but Alternative 3 is proposed as it is the more economical option.

3.9.1 Proposed Alternative

The proposed alternative (Alternative 3) for CR 4106 includes installing two 100' span bridges, raising the road elevation, and adding channel grading under the bridges. The road was raised by approximately 1-3' along a stretch of road spanning 700', not including the bridge span. This increased the road elevation to a minimum of 527.9' for each crossing. The road was also raised by an additional 4' around the bridges to facilitate drift clearance. Two bridges are proposed for this alternative to allow the two existing flow paths to remain at the same locations as the existing conditions. Figure 3-18 shows a summary of the proposed improvements. The estimated total capital cost for this alternative is $3,344,000 (Appendix A).

A 100-year LOS is achieved for both crossings with the proposed improvements. Table 3-6 provides a comparison between existing and proposed conditions for the CR 4106 site. Figure 3-19 provides a comparison between existing and proposed 10-year WSEs over the roadway and shows the 10-year floodplain extents. The BCR for this alternative is 0.5 (Appendix C).

Based on the comparative assessment performed for this alternative, the proposed project meets all no negative impacts requirements as established in *Exhibit C* (Section 3.1). All 100-year WSE rises greater than 0.35' are contained within the CR 4106 right-of-way and do not affect any residential structures (Figure 3-20).

Table 3-6. Existing vs. Proposed Conditions for CR 4106.

Flood Condition	Existing				Proposed			
	2-yr	10-yr	50-yr	100-yr	2-yr	10-yr	50-yr	100-yr
Max depth over roadway (ft)[1]	2	3	3.5	4	-	-	-	-
Duration of flooding over roadway (hrs)[2]	8	12	14.5	16	-	-	-	-
Residential structures in floodplain	2	2	2	3	2	2	2	3

[1]Rounded to the nearest 0.5 ft
[2]Rounded to the nearest 0.5 hours

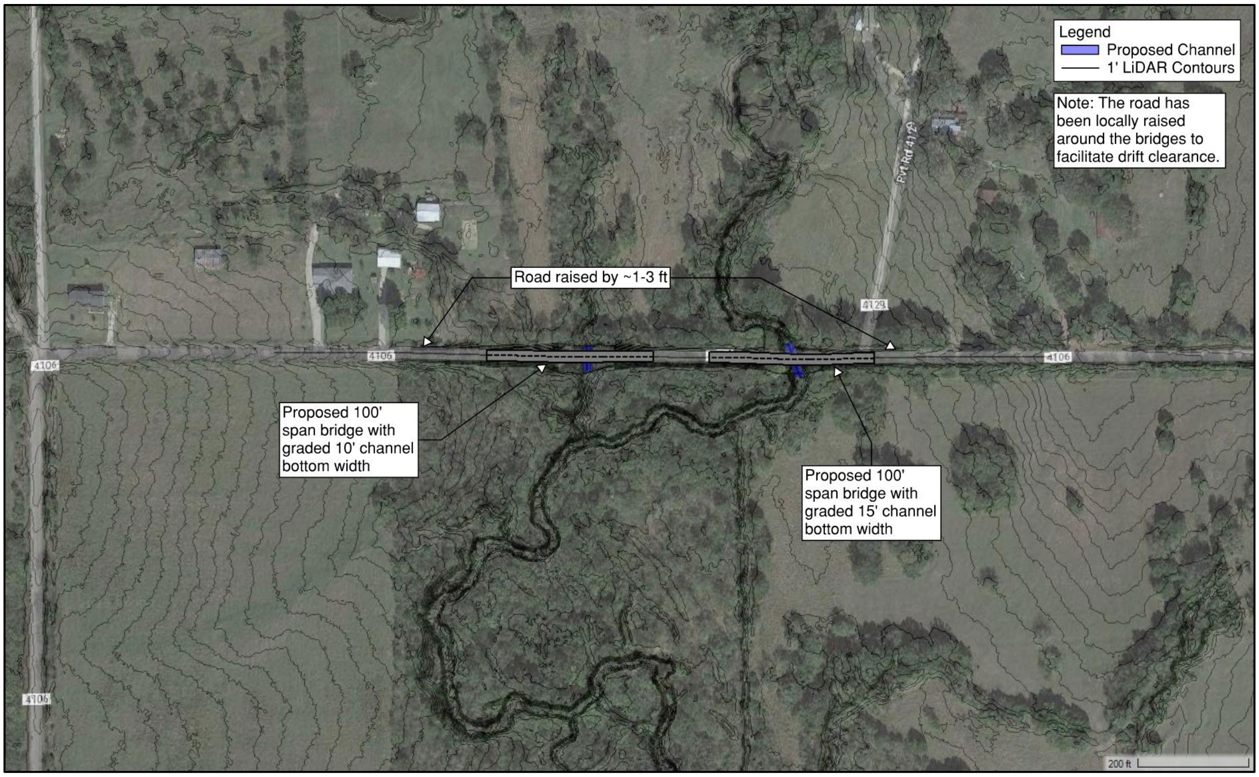


Figure 3-18. Proposed improvements: CR 4106.

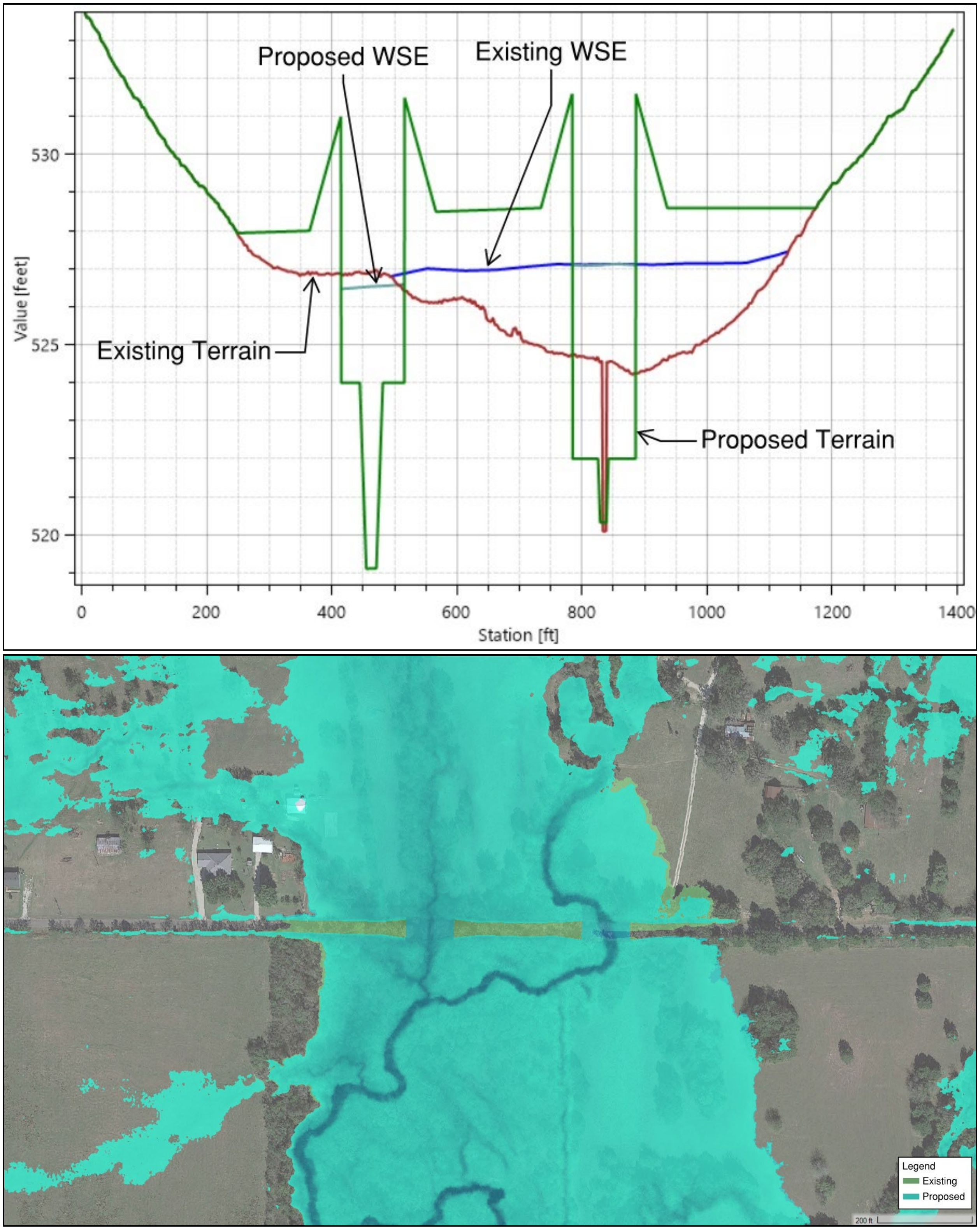


Figure 3-19. WSE profile (top) and maximum flood depth extent (bottom) for a 10-yr storm event: CR 4106.

Figure 3-20. Change in 100-yr WSE (ft) (Proposed minus Existing): CR 4106.

3.10 Funding Sources and Financing Strategies

Communities, counties, and entities with flood-related authority or responsibility across the state utilize a variety of funding sources for their flood management efforts, including local, state, and federal sources. As indicated in Section 1.3, the Hunt County Commissioners Court adopted the vision of leveraging the opportunity to address current and future drainage problems at a county scale with funding support from the State. As such, all projects analyzed as part of this study meet the TWDB requirements for inclusion as FMPs in the Regional Flood Plans and eventually the Texas State Flood Plan. The County will primarily pursue funding opportunities provided by the TWDB through the Flood Infrastructure Fund (FIF), which provides financial assistance in the form of low or no interest loans and grants (cost match varies) to eligible political subdivisions for flood control, flood mitigation, and drainage projects. After the first State Flood Plan is adopted, only projects included in the most recently adopted state plan will be eligible for funding from the FIF. The County will also conduct future drainage studies to create new FMPs that may be included in subsequent State Flood Plans cycles.

4 Public Outreach

The Hunt County CDS included public outreach efforts to engage and inform the community, and to obtain their feedback. These efforts included a project website and a series of public meetings over the course of the study.

4.1 Project Website

A project website was created to share the study's purpose, progress, main results, and upcoming activities. Multiple project documents and public meeting presentations associated with this study have been uploaded to the website. Figure 4-1 shows the website's home page, which can be accessed at: https://freese.mysocialpinpoint.com/huntcountyfif

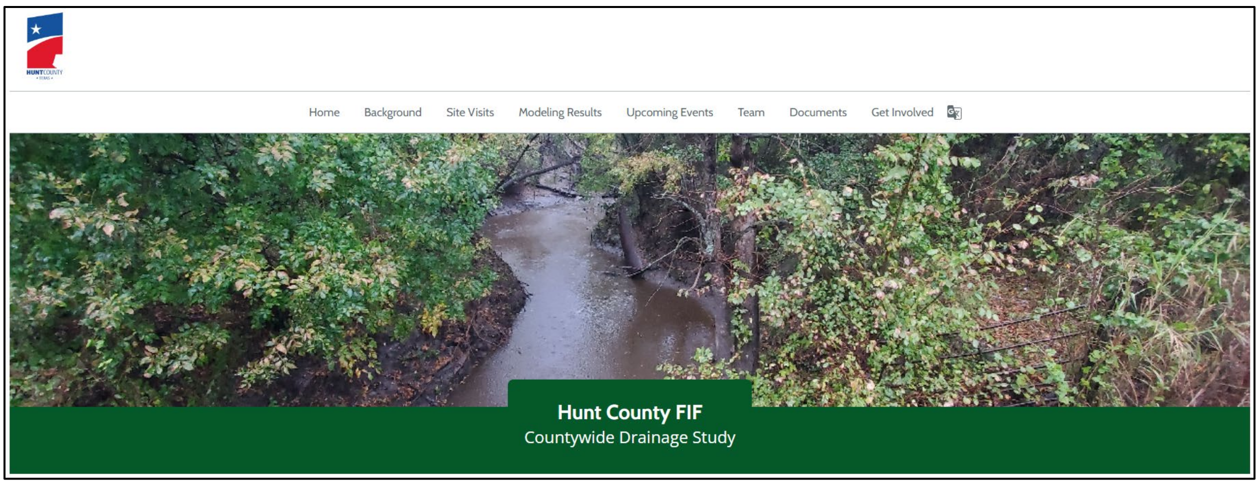


Figure 4-1. Hunt County CDS Website Home Page.

The Hunt CDS project website also provides options for receiving community feedback and allows citizens to report additional known areas of flooding. The "Get Involved" tab provides an interactive map option that citizens can use to provide report flooding or make other comments for a specific location in Hunt County (Figure 4-2). This feature also allows the user to upload photos to supplement their comments. There is also a survey on the "Get Involved" tab which allows citizens to submit comments on as well.

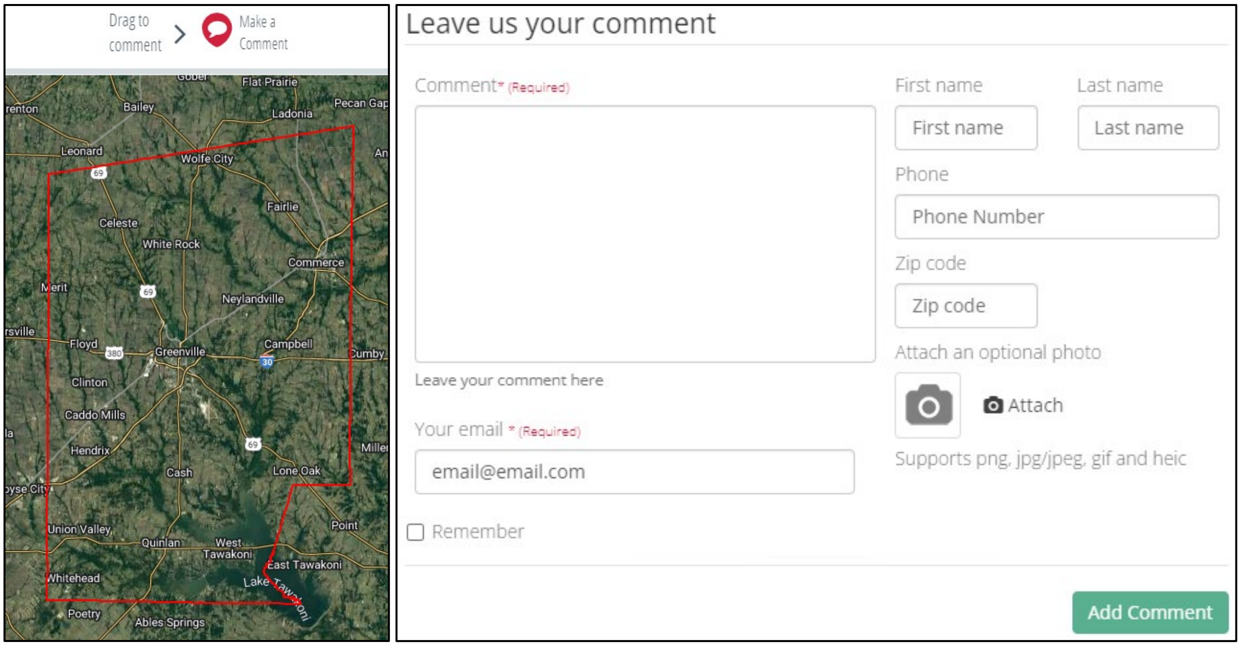


Figure 4-2. Hunt County CDS Interactive Map.

4.2 Public Meetings

Table 4-1 summarizes the project meetings that were held throughout the development of the CDS. These meetings were fundamental as they kept the County, TWDB, and the community continually involved in this planning effort.

In addition to the project technical workshops and progress meetings, two public meetings were held over the course of the study. The first public meeting was held on January 10, 2023, and the second on September 12, 2023. These public meetings were conducted as part of the regular Hunt County Commissioners Court meetings.

Table 4-1. Project Meetings Summary.

Meeting	Date	Description
Project Kickoff with TWDB	Oct 12, 2022	Team introductions, reviewed roles, scope, schedule, project report review periods, public meeting requirements, vision and goals, and contract details.
Site Visits	Nov 14-15, 2022	Visited top flooding spots in each precinct identified by County commissioners and staff, took measurements and photos, and discussed preliminary ranking of project sites.
Commissioner's Court Project Progress Meeting #1	Jan 10, 2023	Presented screening assessment results and 6 selected sites to be studied for alternatives analysis and provided project schedule update.
Commissioner's Court Project Progress Meeting #2	Sep 12, 2023	Presented alternative analysis results for 6 sites, introduced project website and public involvement survey/interactive map, and provided project schedule update.
Wolfe City Dam Field Visit	Jan 25, 2024	Conducted a field visit with County staff to assess the current condition of Wolfe City Reservoirs 1 and 2.

5 Floodplain Ordinances for Non-NFIP Communities

The CDS also included an effort to identify communities within the study area that currently do not enforce floodplain management standards that are at least equivalent to National Flood Insurance Program (NFIP) minimum standards. According to the Lower Red-Sulphur-Cypress and Sabine Amended Regional Flood Plans, the following 5 non-NFIP communities are within Hunt County:

- City of Hawk Cove
- City of Lone Oak
- City of Wolfe City
- Town of Campbell
- Town of Neylandville

Efforts were conducted to aid these non-NFIP communities in drafting and adopting floodplain ordinances that meet the NFIP minimum standards. Appendix G includes the email correspondence that was sent to these communities.

6 Conclusions

The Hunt County CDS was developed with the primary goals of: 1) identifying areas of greatest flood risk, 2) analyzing alternatives to reduce flooding risks, and 3) developing flood mitigation projects that may be included in the Texas State Flood Plan and become eligible for future State funding opportunities. In addition, the CDS included an effort to aid non-NFIP communities in drafting and adopting proper floodplain ordinances.

The areas of greatest flood risk were identified using a series of H&H models that served as planning tools to assess flood hazard risks for private properties and public infrastructure countywide. A combination of model results and site visit information was evaluated to create a list of priority sites that were grouped according to their flooding potential. Final screening and selection of the most critical sites was done in collaboration with County Commissioners and County staff. Their local and historical knowledge was invaluable to select the sites of greatest significance to Hunt County. The proposed projects for the selected sites are listed in Table 6-1.

According to model results, all six sites would experience flooding conditions during the 100-year flood event, but they are also susceptible to flooding from more frequent storms like the 2-year flood event. The most common causes of flooding are undersized cross-drainage infrastructure, lack of proper drainage pathways, and excessively low roadway elevation profiles. Significant roadway overtopping is observed at all sites. Existing conditions model results indicate that these roads are susceptible to flooding depths of up to 3’ in the 2-year flood event and up to 6’ in the 100-year flood event.

Refined versions of the screening assessment models were created to perform detailed alternative analysis for the selected sites. Multiple conceptual solutions were developed and tested with the goal of minimizing flood risk. In general, the proposed solutions entail a combination of improvements such as replacing undersized drainage infrastructure, construction of new bridges, channel improvements, raising road elevations, and minor channel grading. It is expected that these improvements will significantly improve local drainage conditions and reduce flooding risks. Roadway overtopping would be practically eliminated up to the 10-year flood event for all sites and up to the 100-year flood event for CR 4106.

Additionally, 5 communities were identified that do not enforce floodplain management standards that are at least equivalent to NFIP minimum standards. Hunt County made efforts to aid these non-NFIP Communities in drafting and adopting proper floodplain ordinances, but the ultimate adoption of floodplain ordinances will be at the discretion of each local entity.

In line with the County’s vision for the CDS, the selected conceptual alternatives were submitted as FMPs to the corresponding RFPG for inclusion in the Lower Red-Sulphur-Cypress and Sabine RFPs. Inclusion in the RFP makes these FMPs eligible for funding opportunities through the State Flood Planning process.

Although these FMPs may bring significant flood reduction benefits in their project areas, it is recognized that Countywide flooding risks are still significant and there is a need to continue evaluating flood mitigation measures for other flood prone areas. Therefore, Hunt County will continue participating in the State Flood Planning process as it represents a potential long-term mechanism to reduce flooding risks with financial assistance from the State. As such, the County submitted a Phase II CDS to the Sabine RFPG to be included as a Flood Management Evaluation (FME) in the Sabine Amended RFP. This FME is intended to continue the detailed alternative analysis efforts for other flood prone areas and develop additional FMPs that may be included in future State Flood Plans.

Table 6-1. Proposed Alternatives Summary.

Site Name	Proposed Project	Pre-Project LOS	Post-Project LOS	Opinion of Probable Construction Cost (Sep 2020 dollars)
CR 1051	350’ and 400’ span bridges, raise road, channel improvements	< 2-yr	10-yr	$8,197,000
CR 2400	1500’ span bridge, raise road, channel improvements	< 2-yr	10-yr	$14,437,000
CR 2706	300’ and 400’ span bridges, 2-10’x6’ culverts, raise road, channel improvements	< 2-yr	10-yr	$9,126,000
CR 3101	200’ and 500’ span bridges, raise road, channel improvements	< 2-yr	10-yr	$9,217,000
CR 4105	200’ span bridge, raise road, channel improvements	< 2-yr	10-yr	$4,285,000
CR 4106	2-100’ span bridges, raise road, channel improvements	< 2-yr	100-yr	$3,344,000

7 References

AECOM. (2022, April). *TWDB State Flood Plan BCA Input Tool.* Retrieved from Texas Water Development Board: https://www.twdb.texas.gov/flood/planning/planningdocu/2023/index.asp

Dewitz, J. (2021). National Land Cover Database (NLCD) 2019 Products. U.S. Geological Survey.

FEMA. (2009, June). Final BCA Reference Guide. Retrieved from https://www.fema.gov/sites/default/files/2020-04/fema_bca_reference-guide.pdf

Freese & Nichols, Inc. (2005). Iron Bridge Dam and Lake Fork Dam Breach Analysis.

North Central Texas Countil of Governments. (2015). Regional Data - Geographic Information Systems (GIS).

Region 2 Regional Flood Planning Group. (2023). Region 2 - 2023 Lower Red-Sulphur-Cypress Amended Regional Flood Plan.

Region 4 Regional Flood Planning Group. (2023). Region 4 - 2023 Sabine Amended Regional Flood Plan.

Texas Water Development Board. (2012). Volumetric and Sedimentation Survey of Lake Tawakoni. June – August 2009 Survey.

Texas Water Development Board. (2021). Exhibit C: Technical Guidelines for Regional Flood Planning.

Texas Water Development Board. (2021). Exhibit D: Data Submittal Guidelines for Regional Flood Planning.

U.S. Army Corps of Engineers Hydrologic Engineering Center. (2018). Hydrologic Engineering Center (HEC) River Analysis System (RAS) Hydraulic Reference Manual Version 6.3.1. Davis, CA.

U.S. Army Corps of Engineers Hydrologic Engineering Center. (2021). *Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS) 4.9.* Davis, CA.

U.S. Census Bureau. (2023). U.S. Census Bureau QuickFacts. https://www.census.gov/quickfacts/

U.S. Department of Agriculture Natural Resource Conservation Service. (1986). *Technical Release 55: Urban Hydrology for Small Watersheds.* Washington, D.C.

U.S. Department of Agriculture Natural Resources Conservation Service. (n.d.). Soil Survey Geographic (SSURGO) Database. Retrieved from https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

U.S. Department of Commerce. (2017, April). *"NOAA Atlas 14 Point Precipitation Frequency Estimates: TX"*. Retrieved from Hydrometeorologic Design Studies Center: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=tx

8 Appendix A

OPINION OF PROBABLE CONSTRUCTION COSTS (OPCC)

9 Appendix B

TWDB REQUIRED EXHIBIT C TABLES

10 Appendix C

BENEFIT COST ANALYSIS

11 Appendix D

NO NEGATIVE IMPACT EVALUATIONS

12 Appendix E

CDS VISION AND GOALS MEMORANDUM

13 Appendix F

DAM ASSESSMENT – WOLFE CITY RESERVOIRS

14 Appendix G

WRITTEN CORRESPONDENCE TO NON-NFIP COMMUNITIES
FLOOD ORDER TEMPLATES PROVIDED

15 Appendix H

DIGITAL DATA