APPENDIX H
Hydraulic Study and Water Quality Memorandum

WATER QUALITY TECHNICAL MEMORANDUM

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From: Mrs. Laura Larsen, P.E. and Ms. Nora Jans, LEED AP

Date: June 21, 2023

Subject: **San Joaquin County Messick Bridge Replacement Project Water Quality Technical Memorandum**

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1 Introduction

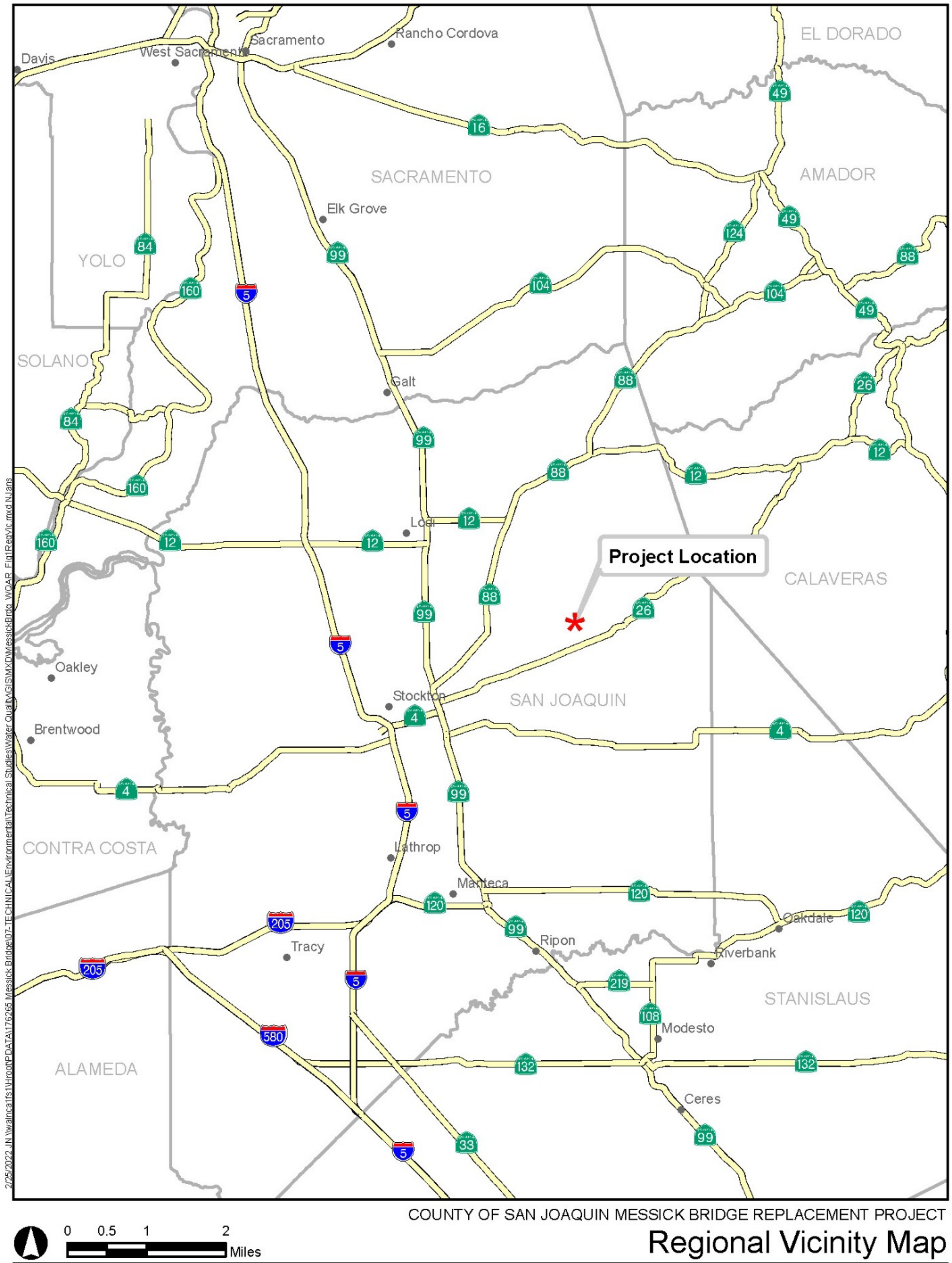
The County of San Joaquin (County) requests California Department of Transportation (Caltrans) District 10's approval for its proposed Messick Bridge Replacement Project in San Joaquin County.

1.1. Purpose and Need

The existing Messick Road Bridge is over 90 years old and does not meet current bridge design and seismic safety standards. Structural and functional deficiencies have been identified for the bridge, such as section loss in substructure, decay in substructure, intolerable deck geometry, and insufficient bridge and approach railings. There is currently a weight restriction for this structure, which is posted at each approach. The proposed project would construct a new bridge meeting current engineering standards to enhance the safety of motorists and bicyclists in the project area.

1.1.1. Project Description

The County of San Joaquin proposes to replace the existing Messick Road Bridge (29C-274) that crosses Mosher Creek with a new bridge structure. The replacement bridge structure would be approximately 55 feet, four inches long and 29 feet, six inches wide. The new structure would maintain a one 10-foot lane of traffic in each east-west direction and would incorporate three-foot shoulders within County right-of-way. The project would not be capacity-increasing (maintaining a two-lane configuration) and no proposed permanent right-of-way acquisition is anticipated. The profile of the proposed bridge would match the existing configuration to reduce impact to the structure approach areas. The number of spans associated with the bridge would be reduced from the current three-span configuration to a single span. The proposed structure type is a cast-in-place voided slab and would be supported by abutments at each bank of the creek founded on Cast in Steel Shell (CISS) or Cast in Drilled Hole (CIDH) piles. Wing walls would be constructed adjacent to the abutments and rock slope protection would be placed along the exterior of each wing wall. A new metal beam guard rail is proposed at all tie-in points to the bridge barriers to meet current American Association of State Highway and Transportation Officials (AASHTO) and Caltrans standards. Figure 1 shows a regional vicinity map of the project location. Figure 2 is a project vicinity map of the project location. Figure 3 is a site plan for the project.

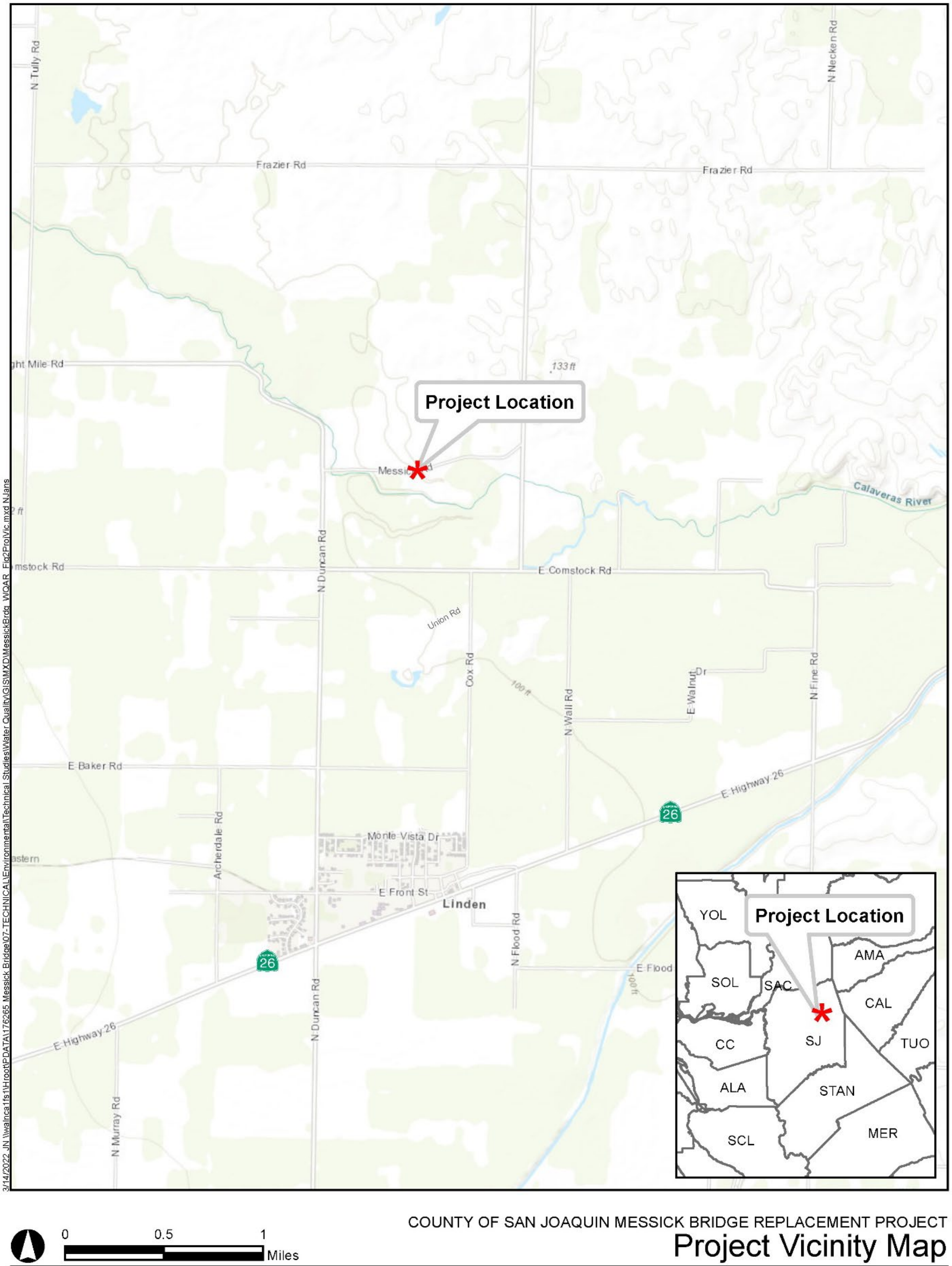


COUNTY OF SAN JOAQUIN MESSICK BRIDGE REPLACEMENT PROJECT

Regional Vicinity Map

Source: ESRI, California Department of Transportation

Figure 1



COUNTY OF SAN JOAQUIN MESSICK BRIDGE REPLACEMENT PROJECT

Project Vicinity Map

Source: ESRI, California Department of Transportation

Figure 2

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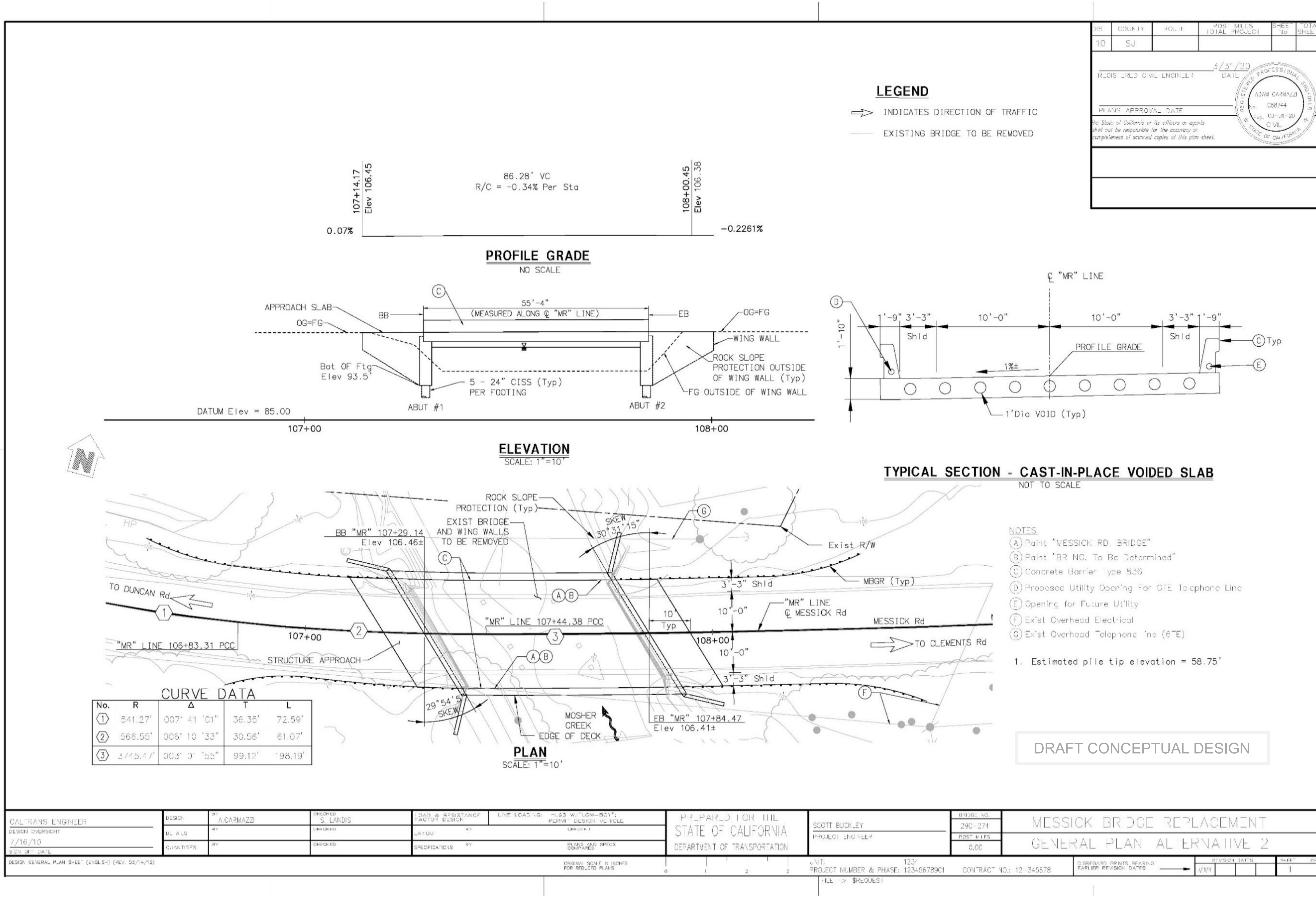

No.	R	Δ	T	L
1	541.27'	007°41'01"	36.35'	72.59'
2	566.55'	006°10'33"	30.56'	61.07'
3	3745.47'	003°01'55"	99.12'	198.19'

Project Site Plan
Figure 3

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2 General Conditions

2.1. Existing Drainage Conditions and Facilities

The existing topography within the proposed project boundary gently slopes to the west, with approximately two feet of elevation change. The proposed project sheet flows directly to Mosher Creek, which is a natural tree-lined creek that flows under Messick Road Bridge.

2.2. Regional and Local Hydrology

The proposed project is located in the Bear Creek Watershed, which is located within the Central Valley Regional Water Quality Control Board's (RWQCB) jurisdiction. Runoff in the region flows from the Bear Mountains east of the proposed project towards San Francisco Bay and the Pacific Ocean. The proposed project discharges directly to Mosher Creek. Mosher Creek flows under the Messick Bridge northwest and then southwest for approximately 17 miles when it confluences with Mosher Slough. Mosher Slough is approximately three miles long until it confluences with Bear Creek, which becomes Disappointment Slough. After flowing north then south, Disappointment Slough flows into Stockton Deep Water Channel, which confluences downstream with San Joaquin River. The San Joaquin River flows toward the west for about 26 miles through the Sacramento San Joaquin Delta and into Suisun Bay. Suisun Bay eventually confluences with Carquinez Strait, which becomes San Pablo Bay, Central San Francisco Bay, and outlets into the Pacific Ocean. The Stockton Metropolitan Airport weather station (Stockton KSCK) is located approximately 14 miles southwest of the proposed project, and the available data indicates that an average of 13.6 inches have been recorded over the past 72 years (U.S. Department of Commerce National Oceanic and Atmospheric Administration).

2.3. Floodplains

The Federal Emergency Management Agency (FEMA) identifies that the proposed project location is in a Zone AE area, which depicts areas subject to inundation by the 1-percent-annual-chance-flood event determined by detailed methods (FEMA, 2009). The proposed project will impact or encroach on the 100-year floodplain or floodway.

2.4. Groundwater Resources

The California Department of Water Resources Sustainable Groundwater Management Act map shows that the proposed project is located within the San Joaquin Valley – Eastern San Joaquin Groundwater Basin 5-022.01 (2018). Data from a water well in the vicinity of the proposed project (0.16 miles northeast of the proposed project) indicates that groundwater depth is approximately 163 feet (2013). In addition, the construction of foundation structures may require dewatering, which will be determined during the final design phase (Plans, Specifications and Estimates [PS&E]).

2.5. Soils/Erosion Potential

The Soil Erodibility Factor (K factor) for the proposed project is 0.28 according to Natural Resources Conservation Service (NRCS) soil survey data. Generally, this equates to a medium potential for erosion within the proposed project area and characterized by particles resistant to detachment. However, this is a planning-level tool (i.e., it has a low accuracy rate for local site conditions), so a detailed site-specific survey will be required for the final design phase (PS&E) analysis.

2.6. Water Quality/Clean Water Act Requirements

2.6.1. Overview

The Clean Water Act (CWA), as amended by the Water Quality Act of 1987, is the major federal legislation governing water quality, which was enacted "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Important sections of the CWA include:

- Sections 303 and 304 – provide for water quality standards, criteria, and guidelines; and
- Section 402 – establishes the National Pollutant Discharge Elimination System (NPDES), a permitting system for the discharge of any pollutant (except for dredge or fill material) into waters of the United States. This permitting program is administered by the California RWQCBs.

The permits associated with these sections of the CWA typically include additional site-specific requirements. The desktop survey indicated that no permits are anticipated under the CWA to develop this site.

2.6.2. Beneficial Uses and Water Quality Objectives

The RWQCB is responsible for the protection of beneficial uses of water resources within its jurisdiction and uses planning, permitting, and enforcement authorities to meet this responsibility. Every water body within the jurisdiction of the Central Valley RWQCB is designated a set of beneficial uses that are protected by appropriate water quality objectives and identified in the Central Valley RWQCB's *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region Fifth Edition Revised May 2018 (with Approved Amendments) in the Sacramento River Basin and the San Joaquin River Basin* (Basin Plan). Per the Basin Plan, the proposed project is located in the Mosher River portion of the Mokelumne River Watershed (Camanche Reservoir to Delta area). Furthermore, the Basin Plan notes that all groundwaters in the Central Valley RWQCB jurisdiction are considered suitable for certain beneficial uses. The table below summarizes the beneficial uses of the groundwater and surface waterbodies as designated by the Basin Plan.

Beneficial Use Type	Groundwater Beneficial Uses	Camanche Reservoir to Delta Beneficial Uses
Municipal and Domestic Supply (MUN) – Includes uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.	✓	-
Agricultural Supply (AGR) – Includes uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.	✓	✓
Industrial Service Supply (IND) – Includes uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.	✓	-
Industrial Process Supply (PROC) – Includes uses of water for industrial activities that depend primarily on water quality.	✓	-
Water Contact Recreation (REC-1) – Includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.	-	✓

Beneficial Use Type	Groundwater Beneficial Uses	Camanche Reservoir to Delta Beneficial Uses
Non-contact Water Recreation (REC-2) – Includes uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.	-	✓
Warm Freshwater Habitat (WARM) – Includes uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	-	✓
Cold Freshwater Habitat (COLD) – Includes uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	-	✓
Migration of Aquatic Organisms (MIGR) – Includes uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.	-	✓
Spawning, Reproduction, and/or Early Development (SPWN) – Includes uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.	-	✓
Wildlife Habitat (WILD) – Includes uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.	-	✓

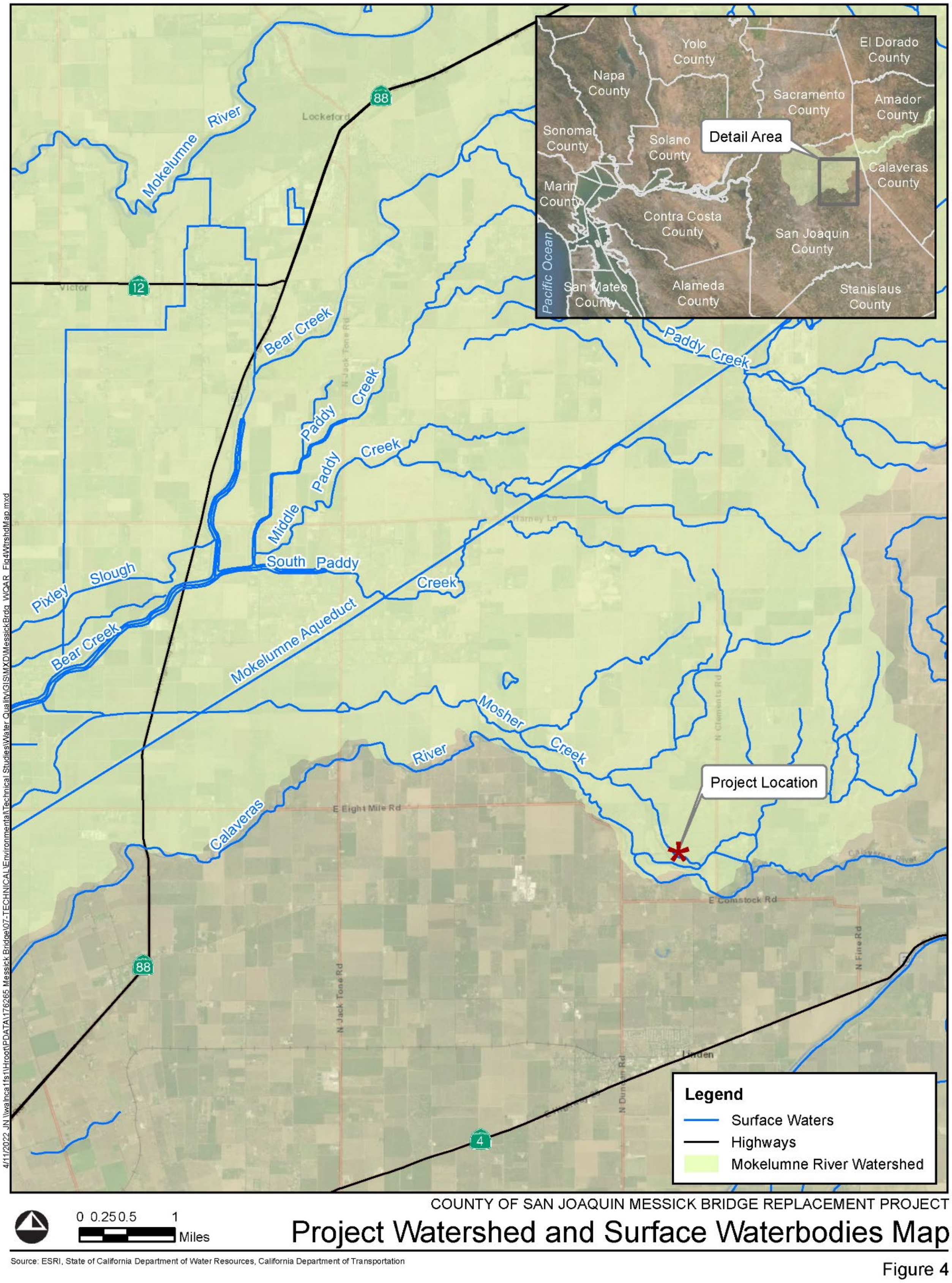
2.6.3. Impaired Waterbodies

Section 303 of the CWA requires that the state adopt water quality objectives for surface waters. The Basin Plan contains water quality objectives that are considered necessary to protect the specific beneficial uses it identifies for surface waters. Section 303(d) of the CWA specifically requires the state to develop a list of impaired water bodies and Total Maximum Daily Loads (TMDLs), which are plans to determine the maximum allowable pollutant load that a water body can receive and continue to meet the designated beneficial uses. The following table summarizes the receiving water bodies that the proposed project will discharge to and their impairments (303(d) List and TMDL Constituents), from its initial discharge to a receiving water body and following the flow downstream to the Pacific Ocean.

Water Body Name	303(d) List Constituent	TMDL Constituent
Mosher Creek	None	Pyrethroid Pesticides
Mosher Slough	Chlorpyrifos, Diazinon, Mercury, and Organic Enrichment/Low Dissolved Oxygen	Indicator Bacteria and Pyrethroid Pesticides
Bear Creek	Copper, Diazinon, Indicator Bacteria, and Low Dissolved Oxygen	Pyrethroid Pesticides
Disappointment Slough	None	Pyrethroid Pesticides
Stockton Deep Water Channel	None	Pyrethroid Pesticides
San Joaquin River	None	Diazinon, Chlorpyrifos, and Pyrethroid Pesticides

Water Body Name	303(d) List Constituent	TMDL Constituent
Sacramento San Joaquin Delta	Chlordane, Dichlorodiphenyltrichloroethane (DDT), Dieldrin, Dioxin Compounds (including 2,3,7,8-TCDD), Furan Compounds, Invasive Species, Mercury, and Selenium	Diazinon, Chlorpyrifos, Pyrethroid Pesticides, Methylmercury, Polychlorinated biphenyls (PCBs), and PCBs (dioxin-like)
Suisun Bay	Chlordane, DDT, Dieldrin, Dioxin Compounds (including 2,3,7,8-TCDD), Furan Compounds, Invasive Species, and Selenium	Mercury, PCBs, and PCBs (dioxin-like)
Carquinez Strait	Chlordane, DDT, Dieldrin, Dioxin Compounds (including 2,3,7,8-TCDD), Furan Compounds, Invasive Species, and Selenium	Mercury, PCBs, and PCBs (dioxin-like)
San Pablo Bay/San Francisco Bay, North	Chlordane, DDT, Dieldrin, Dioxin Compounds (including 2,3,7,8-TCDD), Furan Compounds, and Invasive Species	Selenium, Mercury, PCBs, and PCBs (dioxin-like)
San Francisco Bay, Central	Chlordane, DDT, Dieldrin, Dioxin Compounds (including 2,3,7,8-TCDD), Furan Compounds, Invasive Species, Selenium, and Trash	Mercury, PCBs, and PCBs (dioxin-like)

Figure 4 shows the location of the proposed project within the Mosher Creek portion of the Mokelumne River Watershed, and Figure 5 shows the proposed project location within the regional watershed.



COUNTY OF SAN JOAQUIN MESSICK BRIDGE REPLACEMENT PROJECT

Project Watershed and Surface Waterbodies Map

Source: ESRI, State of California Department of Water Resources, California Department of Transportation

Figure 4

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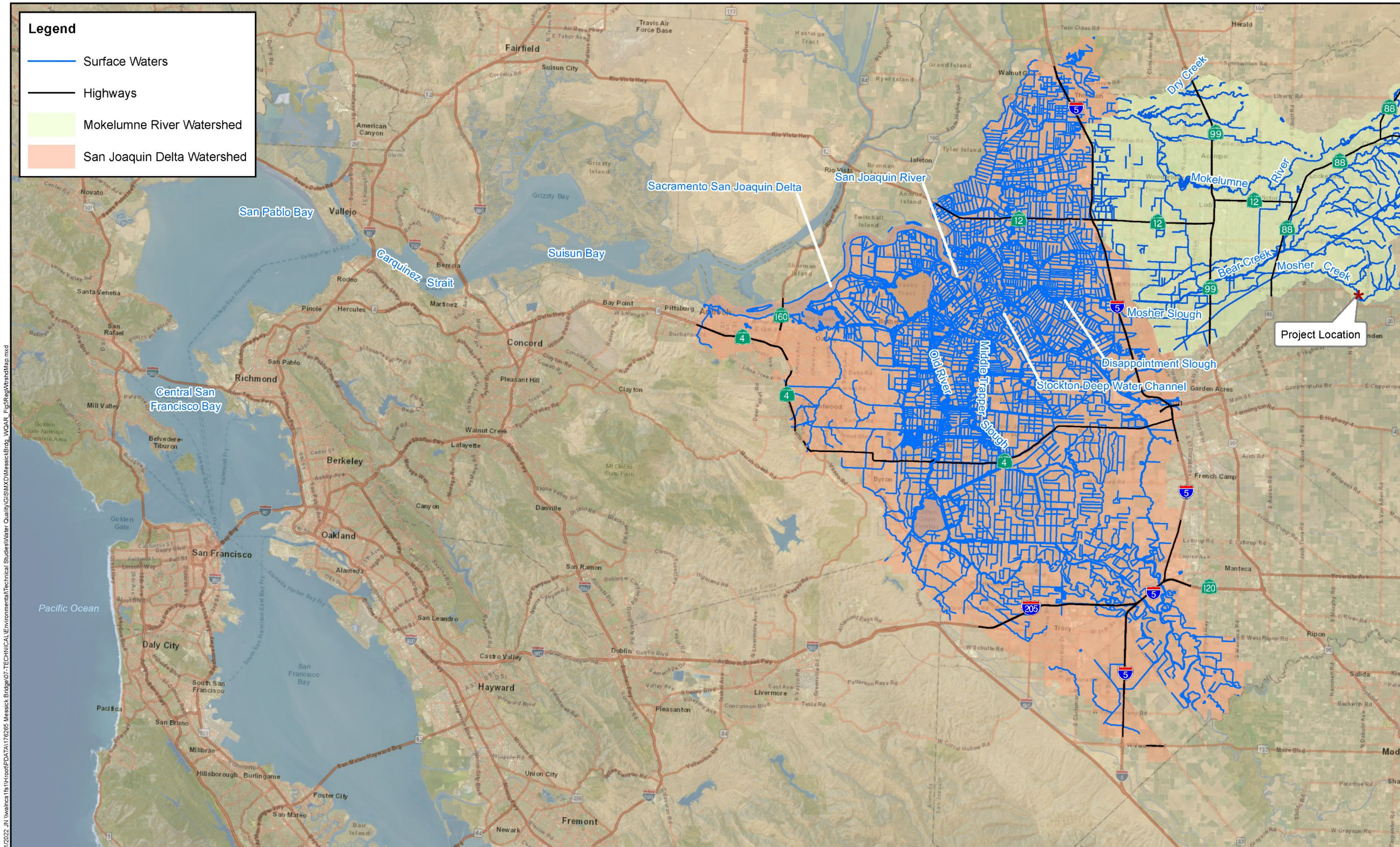

4/11/2022 JN \\walnca1fs1\Hroot\PDATA\176265 Messick Bridge\07-TECHNICAL\Environmental\Technical Studies\Water Quality\GIS\MXD\MessickBridg_WQAR_Fig5RegWtrshdMap.mxd

0 5 10 20 Miles

Source: ESRI, California Department of Transportation, California Department of Water Resources

COUNTY OF SAN JOAQUIN MESSICK BRIDGE REPLACEMENT PROJECT

Regional Watershed and Surface Waterbodies Map

Figure 5

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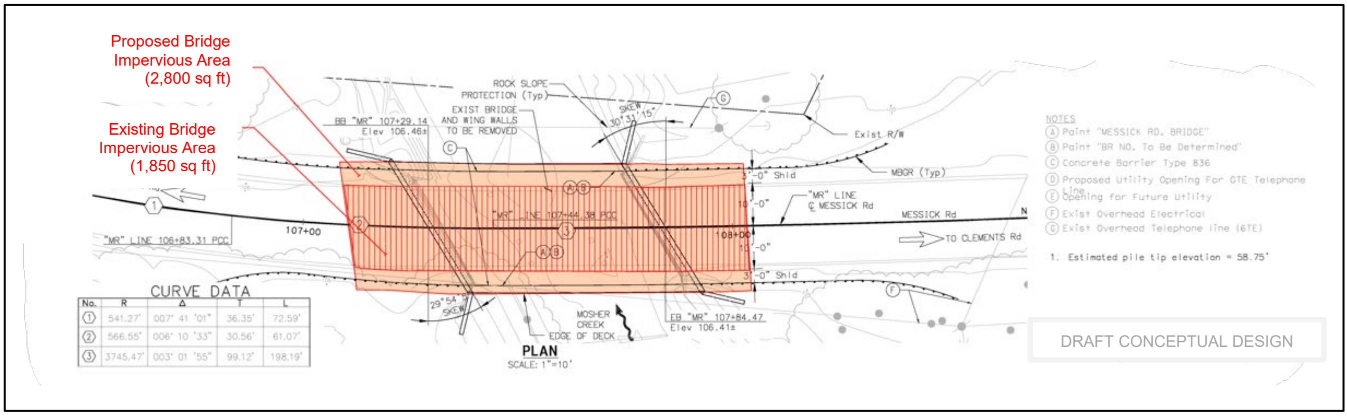
2.7. NPDES Permit

2.7.1. NPDES Municipal Permit Requirements

The proposed project must conform to all applicable water quality regulations and/or permit requirements of the SWRCB and any applicable local RWQCB. It is located within the County's jurisdiction, and the existing total impervious surface area is approximately 1,850 square feet (0.04 acres). The estimated proposed impervious surface is 2,800 square feet (0.06 acres), resulting in approximately 950 square feet (0.02 acres) of new impervious surface. Figure 6 shows the impervious areas of the existing (hatched area) and proposed (hatched and non-hatched areas) bridges.



Impervious Area Calculation
Figure 6

The County is a co-permittee along with the City of Stockton in the Central Valley RWQCB's Region-wide MS4 Permit (Order Numbers R5-2016-0040 and R5-2016-0040-003). The San Joaquin County 2009 National Pollutant Discharge Elimination System Municipal Stormwater Program Stormwater Management Plan's (SWMP) Planning and Land Development Program requires priority projects within the Stockton Urbanized Area to implement low impact development (LID) strategies on streets and road projects for any paved surface equal to or greater than one acre of impervious area. In addition, the Multi-Agency Post-Construction Stormwater Standards Manual applies to the cities of Lathrop, Lodi, Manteca, Patterson, and Tracy, and Phase II San Joaquin County areas. Since the proposed project is located outside of the Stockton Urbanized Area and Phase II portions of San Joaquin County, the SWMP and the Multi-Agency Post-Construction Stormwater Standards Manual requirements do not apply to the proposed project.

2.7.2. Construction General Permit

The *General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities* (Construction General Permit and/or CGP), Order 2009-0009-DWQ, requires coverage for any construction project disturbing more than one acre of land, for any size parcel that is part of a larger common plan of development, or for any site that the Central Valley RWQCB requires coverage. Although the current CGP has expired, it has been administratively extended until the new order has been approved. The CGP generally requires the following:

1. Assessment of the Site Risk (Risk Level 1, 2, 3, from low risk to high risk)
2. Enrollment under the CGP through the SWRCB
3. Development and implementation of a Storm Water Pollution Prevention Plan (SWPPP)

4. Sampling of stormwater and potential sampling of receiving water (depending on project risk)
5. Reporting requirements

Based on the information currently available, the disturbed soil area is estimated to be less than one acre (0.06 acres), therefore the proposed project would not require CGP coverage or the preparation of a SWPPP.

3 Impact Analysis

3.1. Potential Impacts to Water Quality

Since the proposed project is a bridge replacement project, the expected pollutants of concern that will impact water quality are suspended solids/sediment, nutrients, heavy metals, pathogens, oil and grease, toxic organic compounds, and trash and debris. To avoid and minimize impacts, minimal temporary construction BMPs will be implemented during construction where feasible. The proposed project will impact or encroach on a "high risk" area for flooding (Zone AE) as defined by the U.S. Department of Homeland Security's Federal Emergency Management Agency.

3.1.1. Temporary Impacts during Construction

During construction, the proposed project's total DSA is estimated to be less than one acre (0.06 acres), and therefore, the proposed project is not subject to the Construction General Permit requirements and not required to prepare a SWPPP. The *Messick Bridge Replacement Project Natural Environment Study* (NES) identified the following temporary construction impacts (Caltrans, 2023):

- Any vegetation along the embankments may need to be cleared or trimmed (approximately 0.03 acres) when the abutments are replaced, and riprap is placed along the embankments.
- Pile driving will be required to install the proposed bridge abutments, which will require driving and operating heavy equipment in Mosher Creek during construction, and potentially crushing existing aquatic vegetation. In addition, the existing piers will be removed during the demolition phase.
- Since construction is expected to occur during the dry period of the Mosher Creek annual hydrologic cycle, direct impacts to water quality and fish migration are not expected to occur. However, indirect impacts to fish during construction (i.e., hydroacoustic noise and vibration) would not occur since Mosher Creek will be dry.

A diversion of Mosher Creek is anticipated to occur during construction of the proposed project. In the event that groundwater and any other non-stormwater dewatering activities are necessary, these activities are subject to the requirements of the RWQCB. A separate permit will be required for dewatering activities. In addition, a dewatering plan will need to be prepared, and a Temporary Construction Easement may be required.

The proposed project will require regulatory permits from the U.S. Army Corps of Engineers (Section 404), the Central Valley RWQCB (Sections 401 and 402), and the California Department of Fish and Wildlife (1602 Streambed Alteration Agreement) for the required work within Mosher Creek. The table below shows the jurisdictional areas that the temporary construction activities are anticipated to occur for each regulatory agency.

Jurisdictional Impact Area Type	Jurisdictional Impact Area (acres)
U.S. Army Corps of Engineers/RWQCB Non-Wetland Waters of the U.S.	0.084
U.S. Army Corps of Engineers/RWQCB Wetland Waters of the U.S.	0.001
California Department of Fish and Wildlife Vegetated Jurisdictional Streambed	0.074
California Department of Fish and Wildlife Non-Vegetated Jurisdictional Streambed	0.022
California Department of Fish and Wildlife Associated Riparian	0.026
Total	**0.207**

3.1.2. Permanent Impacts during Operation and Maintenance

It is expected that the proposed project's new replacement bridge will be built within the existing County right-of-way. The proposed project will result in an impervious area of 2,800 square feet (0.06 acres), which will result in an increase in pollutants. The NES identified the following permanent operation and maintenance impacts (Caltrans, 2023):

- Direct impact due to the placement of permanent riprap (approximately 0.03 acres) in the creek, along its embankments, and along the bridge abutments.
- Proposed bridge has a wider footprint (29.6 feet wide, which is approximately 7.6 feet wider than the existing bridge) that is reasonably expected to result in a larger shaded area underneath and a reduction in the quantity of in-stream vegetation under the proposed bridge. However, any shade-related loss of existing vegetation would be much less than the additional area that is shaded by the wider bridge, as most of the creek below and around the proposed expanded area is currently bare.
- Permanent impacts are expected to approximately 0.013 acres of non-wetland Waters of the U.S., 0.003 acres of wetland Waters of the U.S., and 0.017 acres of California Department of Fish and Wildlife streambed.

Since the proposed project is in a rural location and not subject to NPDES municipal permit requirements, preparation of a Storm Water Quality Control Criteria Plan is not required and the increase in pollutants is considered minimal. If U.S. Army Corps of Engineers, Central Valley RWQCB, and California Department of Fish and Wildlife permits identify post-construction requirements, then they will be implemented.

3.2. Impact Assessment Methodology

Since the proposed project consists of replacing an existing bridge, the thresholds for the Construction General Permit (disturbed soil area) and NPDES municipal permit (rural location) are not met. If these requirements are implemented as required and as presented in the Avoidance and Minimization Measures in Section 4, then no adverse water quality impacts would occur during long-term operation of the proposed project.

4 Avoidance and Minimization Measures

As a result of the construction and operation of the proposed project, temporary and permanent impacts to the existing infrastructure and downstream waterbodies are anticipated. To address these impacts, avoidance and minimization measures are designated to ensure that these impacts are minimized. The following sections describe the BMPs that are applicable to the proposed project and the Avoidance and Minimization Measures identified for the proposed project.

4.1. Best Management Practices

4.1.1. Post-Construction BMPs and Runoff Reduction Measures

Post construction (structural and non-structural) BMPs and runoff reduction measures applicable to the proposed project may include, but are not limited to the following:

- Implement minimum BMPs as applicable to the proposed project
- Preservation of existing flow patterns
- U.S. Army Corps of Engineers, Central Valley RWQCB, and California Department of Fish and Wildlife permits post-construction requirements (if applicable)

4.1.2. Temporary Construction BMPs

Temporary construction BMPs applicable to the proposed project may include, but are not limited to the following:

- Implement minimum BMPs as applicable to the proposed project
- Site Management BMPs
- Erosion Control BMPs
- Sediment Control BMPs

4.2. Regulatory Requirement Summary

The table below summarizes the regulatory requirements that must be met to construct this proposed project.

Regulatory Number	Regulatory Requirement	Avoidance and Minimization Measures to Address Requirement
WQ-1	U.S. Army Corps of Engineers, Central Valley Regional Water Quality Control Board, and California Department of Fish and Wildlife	U.S. Army Corps of Engineers Section 404, Central Valley Regional Water Quality Control Board Sections 401 and 402, and California Department of Fish and Wildlife 1602 Streambed Alteration Agreement permits will be required for this proposed project. Any required Best Management Practices noted in these permits will be implemented as requested.

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5 References

California Department of Transportation (Caltrans), *Messick Bridge Replacement Project Natural Environment Study (NES), including a Delineation of State and Federal Jurisdictional Waters*, San Joaquin County, California, San Joaquin County-District 10-Bridge #29C-274, Federal-Aid Project #: 5929(254), February 2023.

California Department of Water Resources, Sustainable Groundwater Management Program Groundwater Data website, accessed at https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions on February 23, 2022.

California State Water Resources Control Board, *National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities*, Order Number 2009-0009-DWQ, NPDES Number CAS000002, September 2, 2009, and latest Google Earth K Factor and LS Factor data files.

California Regional Water Quality Control Board, Central Valley Region, *National Pollutant Discharge Elimination System Permit and Waste Discharge Requirements General Permit for Discharges from Municipal Separate Storm Sewer Systems*, June 23, 2016.

California Regional Water Quality Control Board, Central Valley Region, *The Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region, Fifth Edition, the Sacramento River Basin and the San Joaquin River Basin (8)*, Revised May 2018).

Cities of Lathrop, Lodi, Manteca, Patterson, Tracy, and County of San Joaquin, *Post-Construction Stormwater Standards Manual,* (Revised Draft), June 11, 2015.

City of Stockton, National Pollutant Discharge Elimination System Municipal Stormwater Program Stormwater Management Plan, April 2009, accessed at http://www.stocktonca.gov/files/sw_swmp.pdf on February 15, 2022.

City of Stockton and County of San Joaquin, *Stormwater Quality Control Criteria Plan*, August 2020, Revised April 27, 2021, and accessed at http://www.sjwater.org/Portals/0/assets/docs/010621-Full-City-Stockton-County-San-Joaquin-SWQCCP-August-2020-REV.pdf?ver=r-QnY0gmVh4-pZBt7otrKQ%3d%3d on February 16, 2022.

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DESIGN HYDRAULIC STUDY

MESSICK ROAD BRIDGE AT MOSHER CREEK

Bridge Number 29C0274

SAN JOAQUIN COUNTY, CALIFORNIA

AVILA & ASSOCIATES

~DRAFT~

Design Hydraulic Study

MESSICK ROAD BRIDGE AT MOSHER CREEK

San Joaquin County, California

Bridge #29C0274

May 17, 2023

PREPARED FOR:

THE SAN JOAQUIN COUNTY DEPARTMENT OF PUBLIC WORKS

Prepared by:

AVILA AND ASSOCIATES

CONSULTING ENGINEERS, INC.

Catherine M.C. Avila, P.E

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EXECUTIVE SUMMARY

The Messick Road Bridge (bridge) at Mosher Creek in San Joaquin County (County) is proposed for replacement by the County in 2026. The proposed bridge will be a single-span cast-in-place prestressed voided concrete slab bridge. The bridge will be 29.5 feet wide and will accommodate 2 travel lanes with 3-feet wide shoulders as shown on the attached General Plan (Appendix A). The bridge will be supported by reinforced concrete abutments on 24-inch diameter cast-in-steel-shell (CISS) piles or cast-in-drilled hole (CIDH) piles.

Mosher Creek flows northwesterly through the project site through the northern part of San Joaquin County. The discharges used for the bridge hydraulic analysis are shown in Table 1.

Table 1. Discharge and water surface elevation for bridge design

	Design	Base	Flood of Record
Frequency (years)	50	100	≈ 90
Discharge (cubic feet per second)	520	755	636
Water Surface Elevation at Upstream Face of Bridge (in feet)	104.38	104.94	104.9
Freeboard at Upstream Face (in feet)*	0.69	0.13	0.2
*Based on a minimum soffit elevation of 105.07 at the upstream face.			
Water Surface Elevation at Downstream Face of Bridge (in feet)	104.37	104.90	104.8
Freeboard at Downstream Face (in feet)**	0.08	-0.45	-0.35
**Based on a minimum soffit elevation of 104.45 at the downstream face.			

This study used hydraulic modeling based on a HEC-RAS[1] version 6.3 model to estimate the water surface elevation (WSE) for the existing and proposed bridge. Results indicate that after construction of the proposed bridge, the WSE is lowered upstream from the bridge approximately 0.04 feet and increased approximately 0.02 feet downstream for the 100-yr discharge. The proposed minimum soffit elevation, WSE, and resulting freeboard at the upstream and downstream faces of the bridge for both the 50-yr and 100-yr discharges are shown in Table 1. The available freeboards shown in Table 1 are lower than freeboards recommended in HDM criteria.

Mosher Creek through the project area is within an existing FEMA floodway which prohibits any increase in WSE. This analysis is based on 35% preliminary plans. The 0.02 feet increase in WSE downstream from the bridge will be eliminated at the 65% phase of design by either changing the bridge length, changing the grading of the channel through the bridge, or a combination of both. The proposed Messick Road profile and cross slope will also be revised so that the minimum soffit elevation will be 105.1 to eliminate the negative freeboard available on the downstream side with the 100-yr discharge. In the final design, the bridge geometrics and grading will be designed to cause no rise in WSE, and pass the 100-yr design storm without

[1] US Army Corps of Engineers Hydraulic Engineering Center River Analysis System which backwater hydraulic model designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

going under pressure flow. The final hydraulic report will reflect these changes to the design and the scour and Rock Slope Protection will be updated.

The proposed bridge will improve the hydraulics due to the removal of two existing piers from the channel reducing the risk for debris capture.

This report follows the California Department of Transportation (Caltrans) Final Hydraulic Report Format and has been prepared in accordance with the Caltrans Local Assistance Program Guidelines (Caltrans 2020) and Memos to Designers 16-1 [2].

GENERAL

This design hydraulic study has been prepared for the sole purpose of meeting the requirements of the Caltrans "Local Assistance Program Guidelines." Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than for which Avila and Associates Consulting Engineers, Inc. (Avila and Associates) intended and without their written authorization is not endorsed or encouraged and is at the sole risk of the entity reusing the information.

Avila and Associates was retained to complete the hydraulic analysis of the existing Messick Road Bridge over Mosher Creek in San Joaquin County. The location of this project is shown in Figure 1. The following scope of work has been completed to develop this report:

1. Obtain backup information and field review.
2. Obtain discharge information.
3. Create HEC-RAS model and perform hydraulic analysis.
4. Estimate scour, channel bed degradation, and bank protection parameters.
5. Prepare draft report for comment.
6. Prepare final report.

The existing bridge is located within the northern part of San Joaquin County approximately 10 miles northeast from Stockton as shown in Figure 1. The existing bridge was constructed in 1931. The existing structure is approximately 51-feet long and is a 3-span timber girder with timber plank deck bridge supported by concrete abutments on unknown footings and timber pier bents. It has a sufficiency rating as of 2015 of 48.7 and is Functionally Obsolete. The San Joaquin County Department of Public Works proposes to replace the existing bridge using Highway Bridge Program (HBP) funds.

[2] Caltrans Memo to Designers 16-1 December 2017 (http://www.dot.ca.gov/des/techpubs/manuals/bridge-memo-to-designer/page/section-16/MTD_16-1-attach1.pdf)

Figure 1. Bridge location map

Figure 2. Detail of bridge location

The datum elevation used for this study is NAVD-88[3]. The proposed bridge will be located along the same alignment as the existing bridge. It will be 59.75-feet long and will be a single-span cast-in-place prestressed voided concrete slab bridge supported by reinforced concrete abutments on 24-inch diameter CISS or CIDH piles. The bridge will be 29.5-feet wide and will accommodate 2 travel lanes and 3-feet wide shoulders as shown in Figure 3 and the attached General Plan (See Appendix A).

[3] Verification to be included in the Final Report.

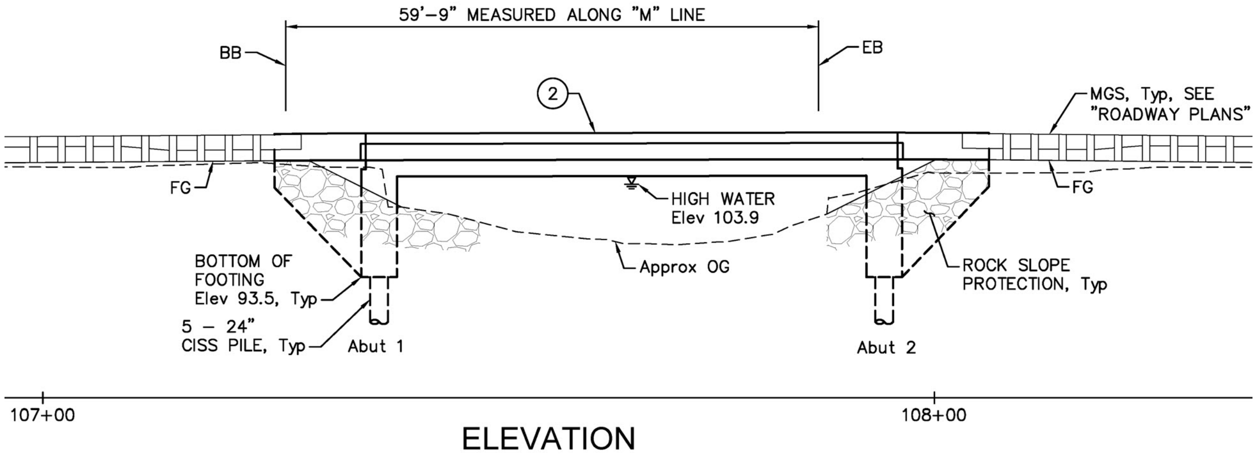

Figure 3. Proposed bridge profile view

BRIDGE HISTORY

Avila and Associates reviewed the pertinent bridge maintenance records for the existing bridge and the adjacent bridges on Mosher Creek to determine the typical impacts to bridges along this reach. Details of the bridge are shown in Table 2.

Table 2. Bridge information from maintenance records

	Clements Road over Branch Mosher Creek	Clements Road over Branch Mosher Creek	Messick Road at Mosher Creek (Project)	Tully Road over Mosher Creek
Bridge Number	29C0214	29C0215	29C0274	29C0275
Bridge Length (ft)	105.6	51.8	50.9	68
Span Lengths (ft)	4 @ 26	1 @ 1.476, 1 @ 20, 1 @ 14.76	16.4 / 16.8 / 17.2	1 @ 19.33, 1 @ 26, 1 @ 19.33
Bridge Type	Reinforced Concrete (RC) slab on RC (5) pile bents and RC diaphragm abutments.	Continuous RC slab on RC 4-column bents and RC diaphragm abutments with monolithic wingwalls. All founded on 45-ton CIDH piles.	Simple span timber girders (18 – Spans 1 and 3, 19 – Span 2) with a timber plank deck on reinforced concrete abutments.	Continuous RC slab on RC 5-column bents and RC diaphragm abutments with monolithic wingwalls. All founded on CIDH piles.
Debris	2001[4], 2003[5]		N/A	2013[6]

[4] Cattle fence upstream and downstream of bridge has accumulated substantial amounts of vegetation and debris.
[5] Same as 2001.

Challenges				
Cross Sections Available for	1977, 1995, 2001, 2011[7]	1977, 2001, 2011[8]	1995, 2005, 2011	1995, 2001. 2011[9]
NBIS Item 113 (scour) code	5	5	U	5
ELI Flag 361 Condition State	N/A	N/A	N/A	2
ELI Flag 252/6000 (Pile-CIDH/Scour) Condition State[10]	N/A	N/A	N/A	2
Pier Type	Reinforced Concrete Pile Bents	RC 4-column bents	Timber pier bents.	RC 5-column bents
Year Built	1969	1969	1931	1989
Year Widened	N/A	N/A	N/A	N/A
Scour Challenges	None Noted	None Noted	2003[11], 2003[12], 2005[13], 2007[14], 2010[15]	2001[16], 2003[17], 2005[18], 2007[19], 2011[20], 2013[21], 2015[22], 2017[23]

[6] Log shown on Pier in photos.
[7] Notes channel aggraded.
[8] No changes noted.
[9] No significant changes noted
[10] In 2015 after change in element inspection methodology.
[11] No scour or undermining was noted.
[12] The Item 113 code, Scour Critical Bridges is U for this structure. This bridge has an unknown foundation and has not yet been evaluated for scour.
[13] This structure has an unknown foundation that has not been evaluated for scour. The scour risk cannot be determined. This structure should be monitored for scour related problems during flood events.
[14] Same as 2005.
[15] Based on field inspection dated 08/16/2010, the channel was dry, and none of the footings for Abutment 1, Bent 2, Bent 3 or Abutment 4 are visible. The condition of the scour does not compromise the integrity of the structure. Therefore, the County is planning to perform annual inspection to monitor both abutments and bents for potential scour damages.
[16] 1991 bridge report mentioned the footing of column 3 at Pier 2 is exposed ~ 6 inches in depth. The channel bed has degraded approximately 2 ft since the last investigation of 12/12/89.
[17] Column 2 at Bent 3 is exposed ~ 2m.
[18] CIDH pile at column 3 Bent 2 is exposed ~0.1m and column 2 Bent 3 exposed ~0.2m
[19] CIDH pile at column 3 Bent 2 is exposed ~4" and column 2 Bent 3 exposed ~8"
[20] Pier 2: Pile 3 exposed 50 mm, Pile 4 exposed 100mm. Pier 3, Pile 4 exposed 200mm
[21] Pier 3, Pile 4 is exposed up to 200 mm.
[22] Same as 2013
[23] Same as 2015.

DISCHARGE

Mosher Creek was included in a FEMA Flood Insurance Study (FIS) for San Joaquin County (FEMA, 2016). According to the FIS, the 50-yr discharge at the bridge is 520 cfs and the 100-yr discharge is 755 cfs. The discharges used for this analysis are shown in Table 3.

Table 3. Discharges used for analysis (cfs)

	Design	Base
Frequency (years)	50	100
Discharge (cubic feet per second)	520	755

See Appendix B for excerpts from the FEMA FIS.

HEC-RAS ANALYSIS

Hydraulic parameters (water surface elevations and velocity) were obtained from the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 6.3 model based on: 1) survey information provided by San Joaquin County, 2) LiDAR data obtained from California Department of Water Resources (DWR), and 3) field investigation by Avila and Associates on June 23, 2014.

Initial analyses of Mosher Creek downstream from the bridge using a 1D HEC-RAS model based on the topographic survey provided by the County indicated that the design discharges were not contained by the channel. The LiDAR data obtained from DWR was used to extend the cross sections for containment; however, there were some areas where the flows would not be contained. To obtain more realistic results, a 2D flow area was created for the downstream area and a combination 1D/2D analysis was performed. The 2D flow area and cross sections used for the HEC-RAS model are shown in Figure 4 and Figure 5.

For the 2D flow area, a 30-ft x 30-ft grid was analyzed using the SWE-ELM (full momentum) equation set. A simulation time of 25 hours 15 minutes was selected using a computation interval of 0.1 second.

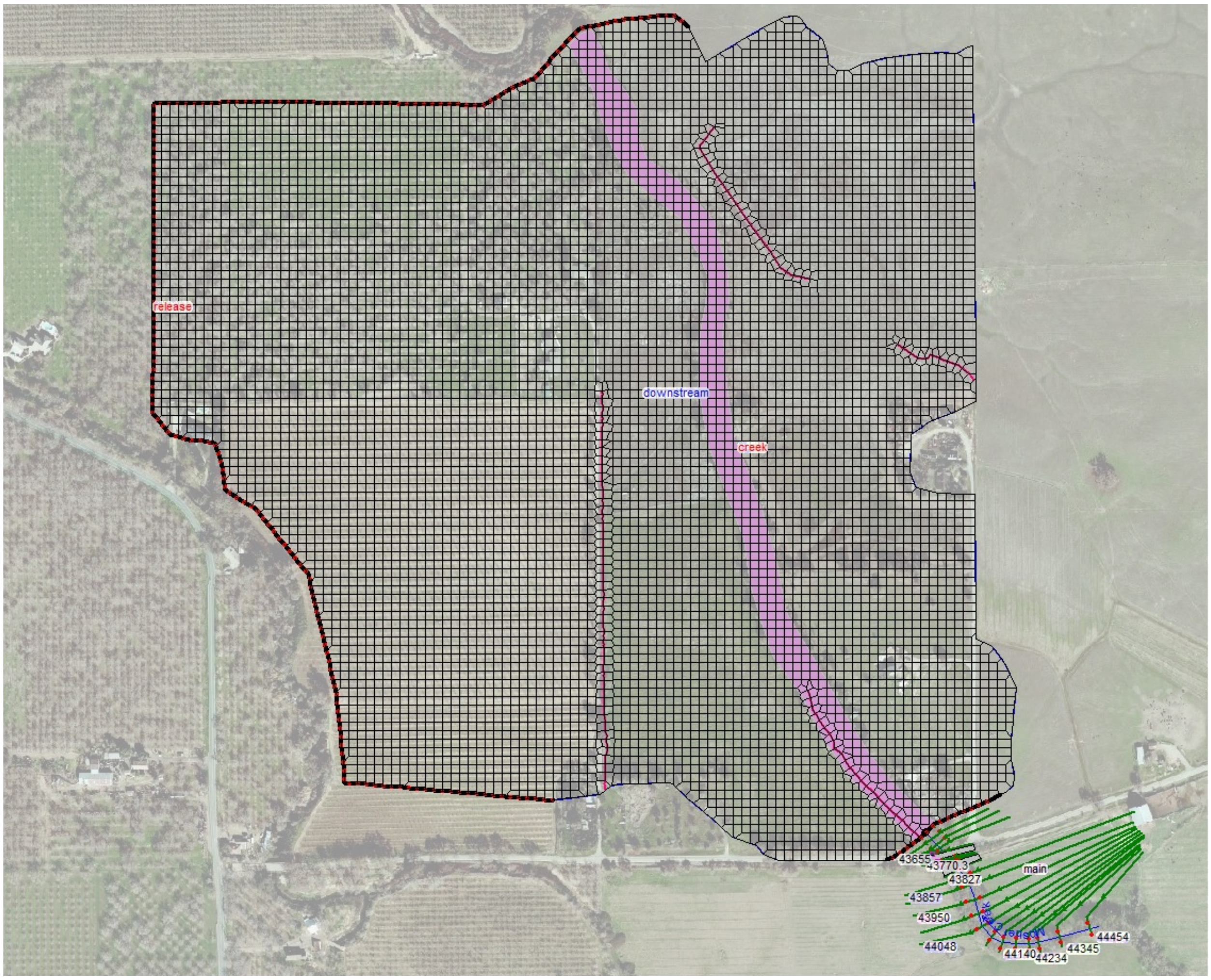

Figure 4. Plan View of the combination 1D/2D HEC-RAS model

Figure 5. Close up of 1D portion of the HEC-RAS model

Existing Condition

The Manning "n" values of 0.045 for the channel and 0.060 for the overbanks were used in the model and are consistent with the FIS and the field review by Avila and Associates as shown in Figure 6. There is an existing low water crossing just upstream from the bridge also shown in Figure 6.

Figure 6. Looking upstream from the bridge. The channel is clear and the overbank areas are vegetated contributing to a higher n-value. Existing low water crossing also shown.

The existing bridge was input into the model as a 3-span bridge with a minimum soffit elevation of 104.5 feet as shown in Figure 7. The existing low water crossing was modeled as a bridge with two 36-in diameter culverts as shown in Figure 8. The topographic survey indicates that one of the culverts is completely silted in on the upstream end as shown in Figure 8.

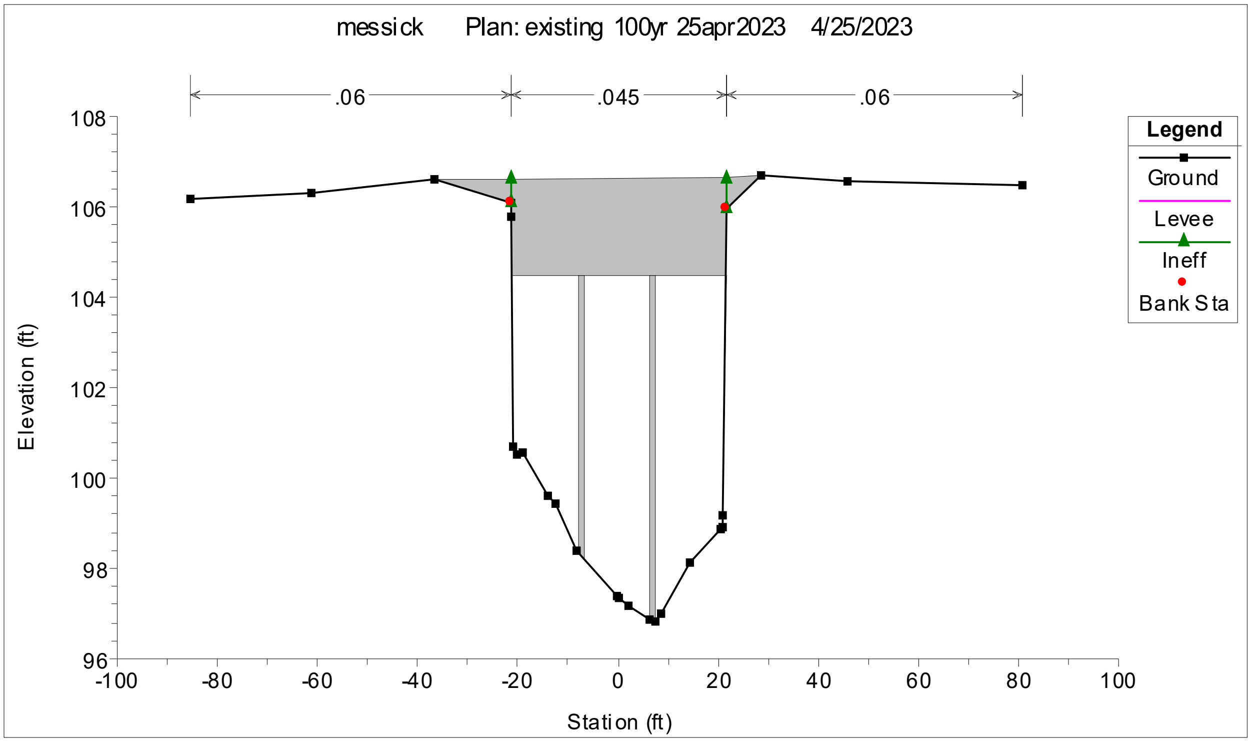

Figure 7. HEC-RAS cross section for the upstream existing condition

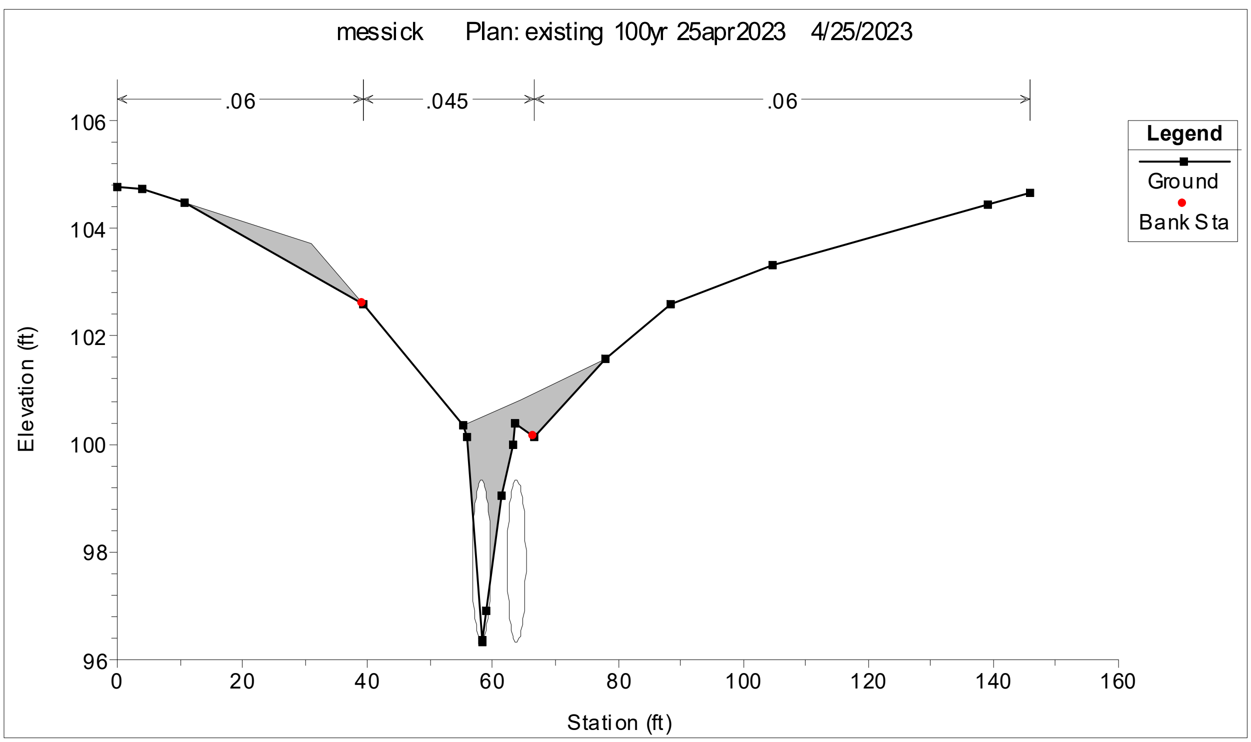

Figure 8. HEC-RAS cross section for the existing low water crossing (upstream side)

Starting Water Surface Elevation

A downstream water surface boundary condition line was created along the edge of the 2D flow area (shown as a heavy line in Figure 4) and an assumed friction slope of 0.0015 ft/ft was used for the analysis. The most downstream cross section in the 1D portion of the model (RS 43655) was connected to the 2D flow area. After each analysis, the water surface elevation (WSE) along the upstream edge of the 2D flow area along the connection was compared to the WSE at RS 43655 to make sure they matched.

Unsteady Flow Analysis

Because unsteady flow analyses were performed, synthetic hydrographs were developed with peaks that matched the peak 50-yr and 100-yr discharges taken from the FIS. The synthetic hydrographs were patterned after a SCS 24-hr Type I rainfall distribution using a 5-minute interval as shown in Figure 9. These hydrographs were used as the upstream boundary flow condition in the 1D/2D analyses.

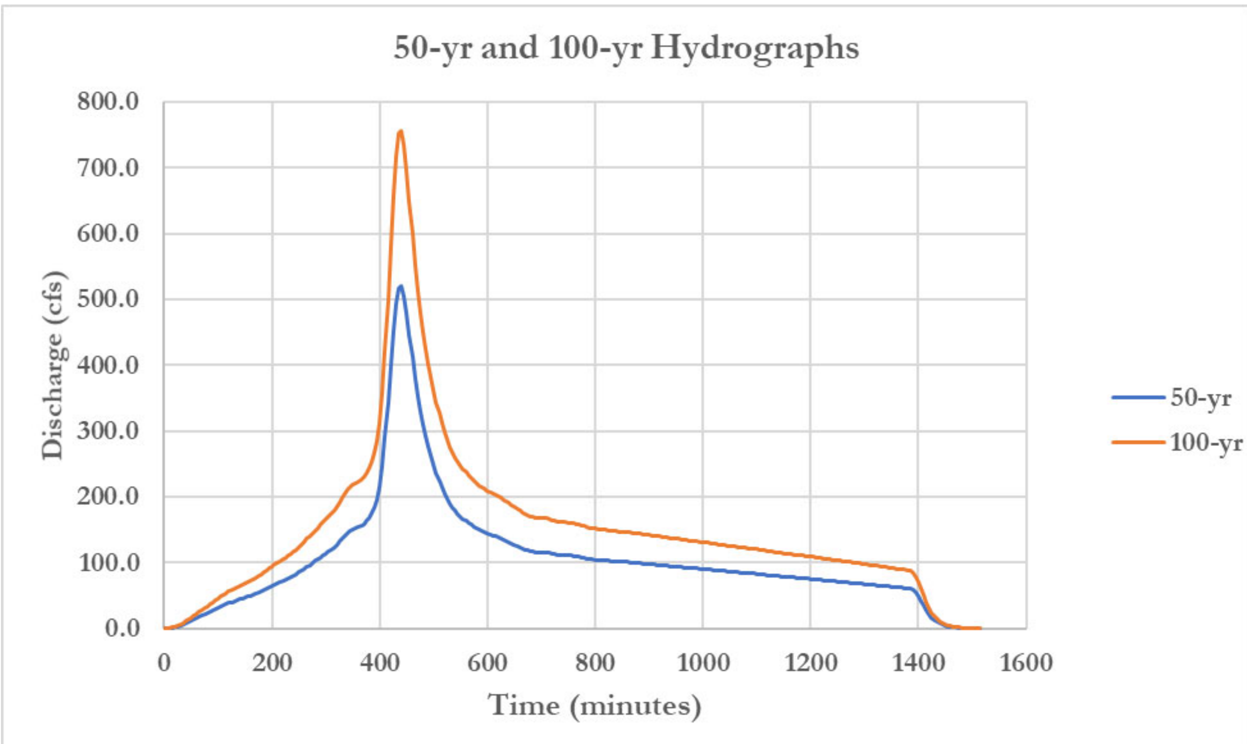

Figure 9. Hydrographs used for the unsteady flow analyses

Proposed Condition Model

Three proposed alternatives were first investigated for the proposed replacement bridge. The details of this investigation and the hydraulic results of the alternatives analysis were documented in the Preliminary Hydraulic Report for the project which is included in Appendix C.

The HEC-RAS model was re-run for the preferred proposed condition by replacing the existing bridge with the proposed bridge. The proposed bridge was modeled as a single span bridge as shown in Figure 10. The cross slope of the roadway and bridge deck will be superelevated as shown in Figure 11. The minimum soffit elevation on the upstream side will be 105.07 and the minimum soffit elevation on the downstream side will be 104.45. The proposed bridge will be approximately 9.5 feet wider than the existing bridge as shown in Figure 12.

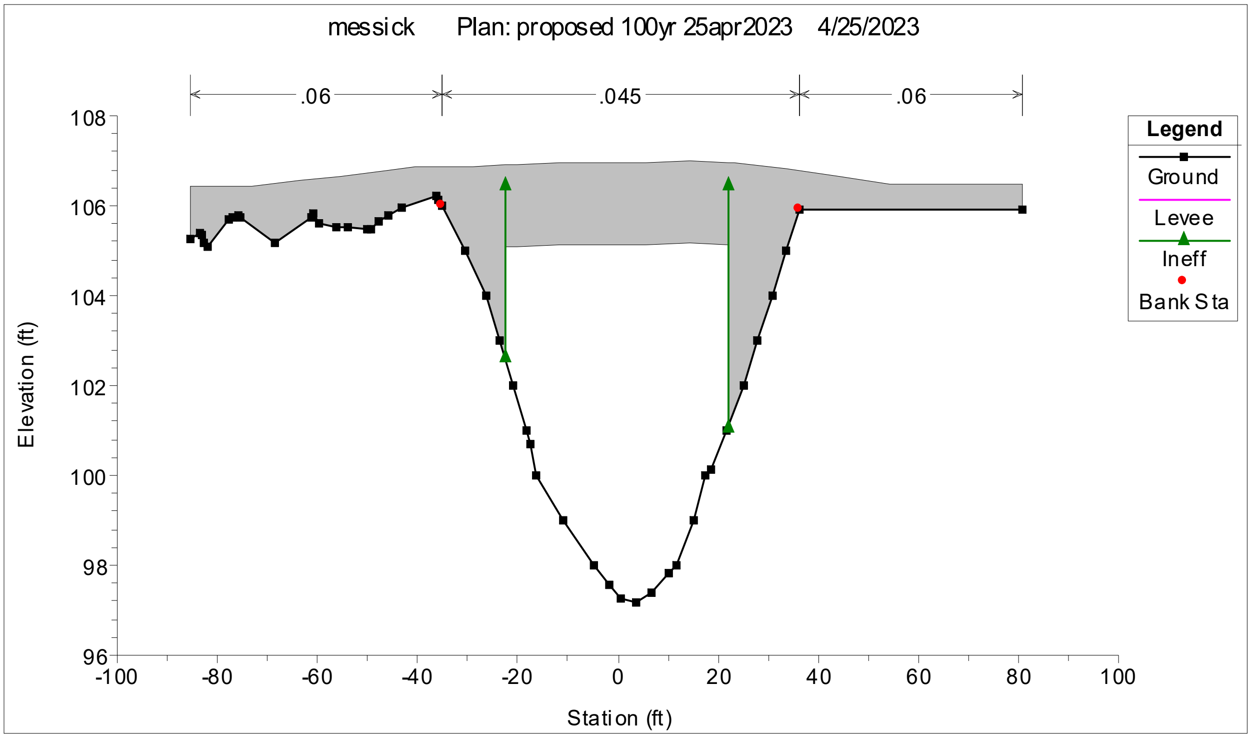

Figure 10. HEC-RAS cross section of proposed bridge

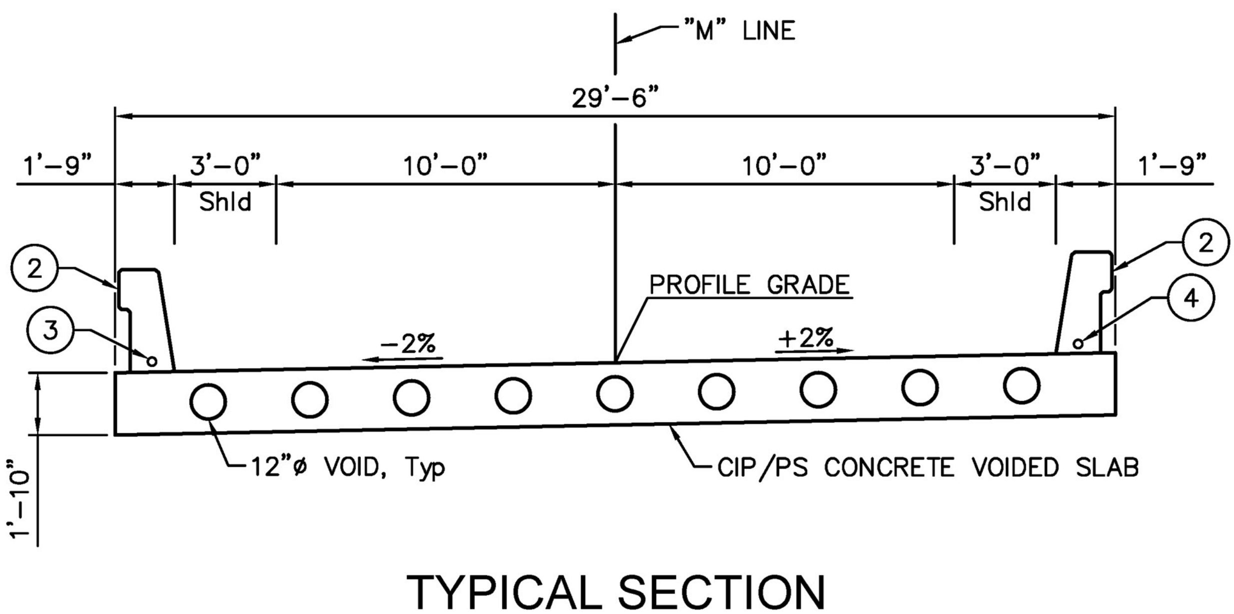

Figure 11. Typical section of the proposed bridge deck (upstream face is on the right side)

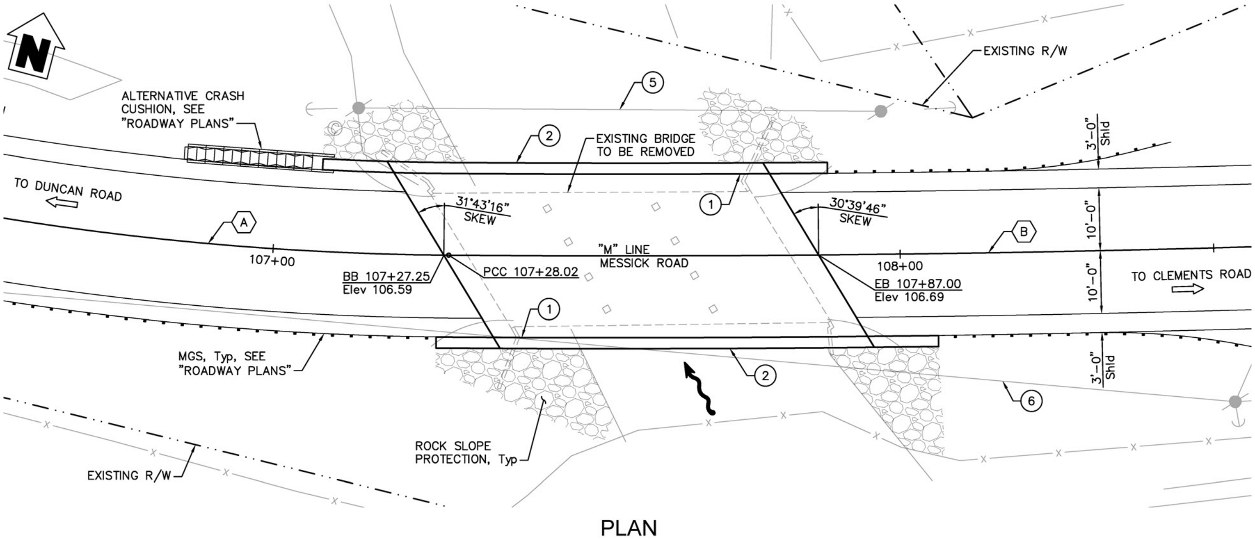

Figure 12. Plan view of the proposed bridge

Figure 13 shows a comparison of the maximum 50-yr WSE's between the existing and proposed conditions. Figure 14 is the same comparison zoomed into the bridge area. As can be seen, the WSE is lowered slightly (approximately 0.02 feet) upstream from the bridge and increased slightly (approximately 0.02 feet) downstream.

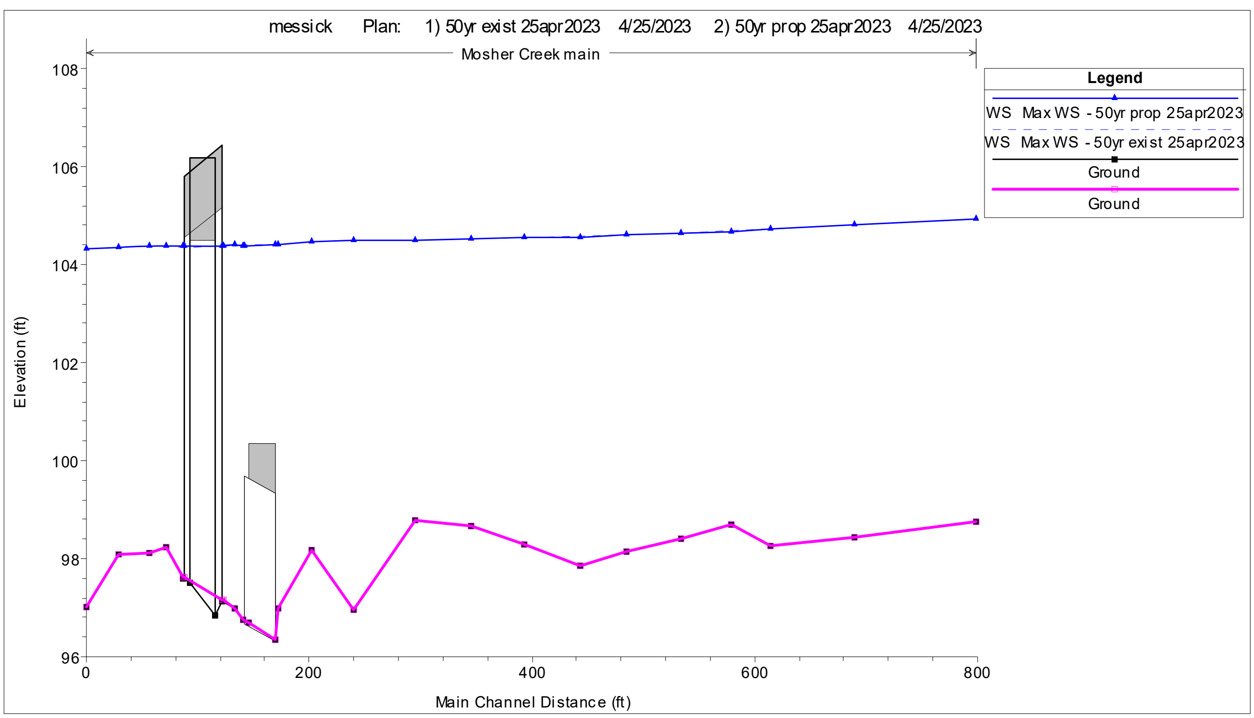

Figure 13. 50-yr WSE profile comparison between existing and proposed conditions

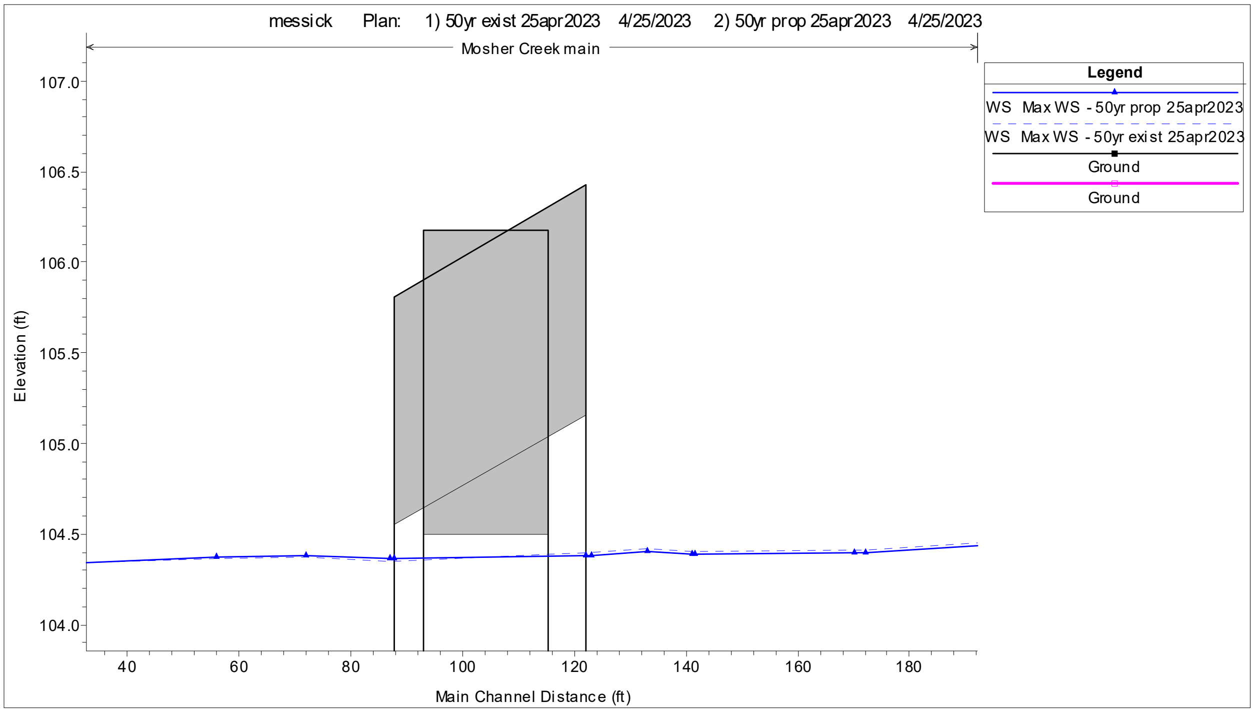

Figure 14. Same as Figure 13 zoomed into the bridge area

Figure 15 shows a comparison of the maximum 100-yr WSE's between the existing and proposed conditions. Figure 16 is the same comparison zoomed into the bridge area. As can be seen, the WSE is lowered slightly (approximately 0.04 feet) upstream from the bridge and increased slightly (approximately 0.02 feet) downstream.

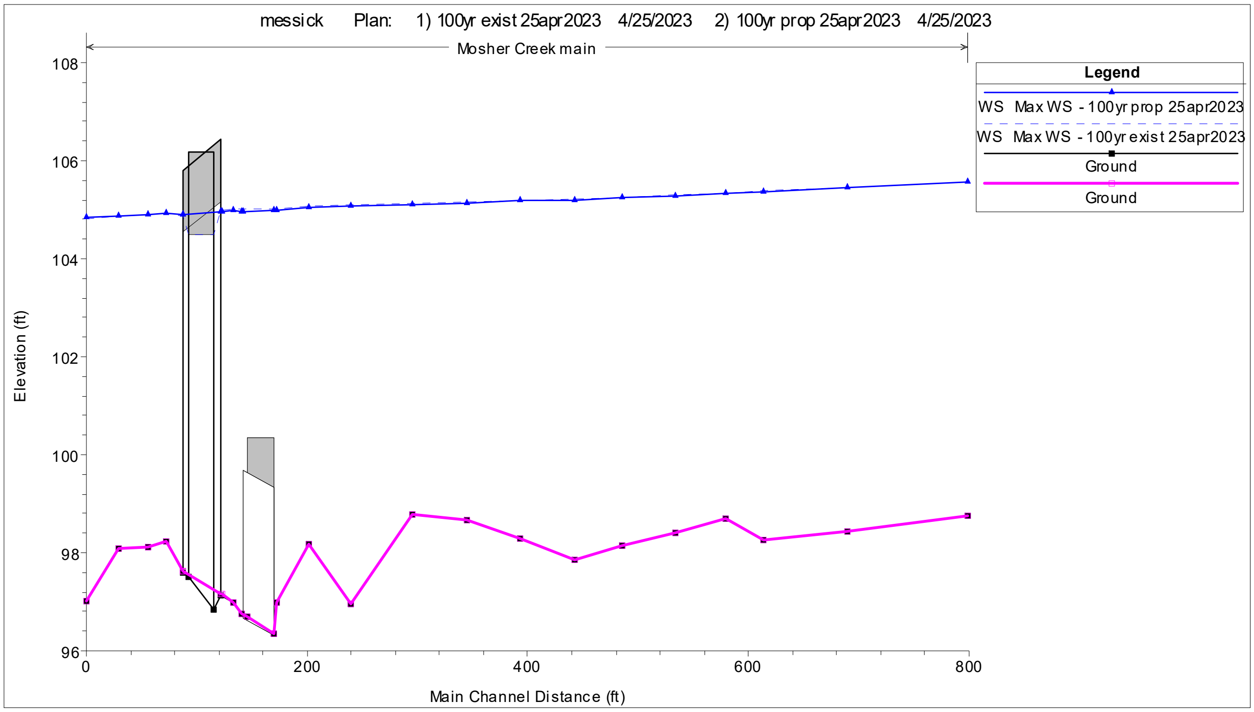

Figure 15. 100-yr WSE profile comparison between existing and proposed conditions

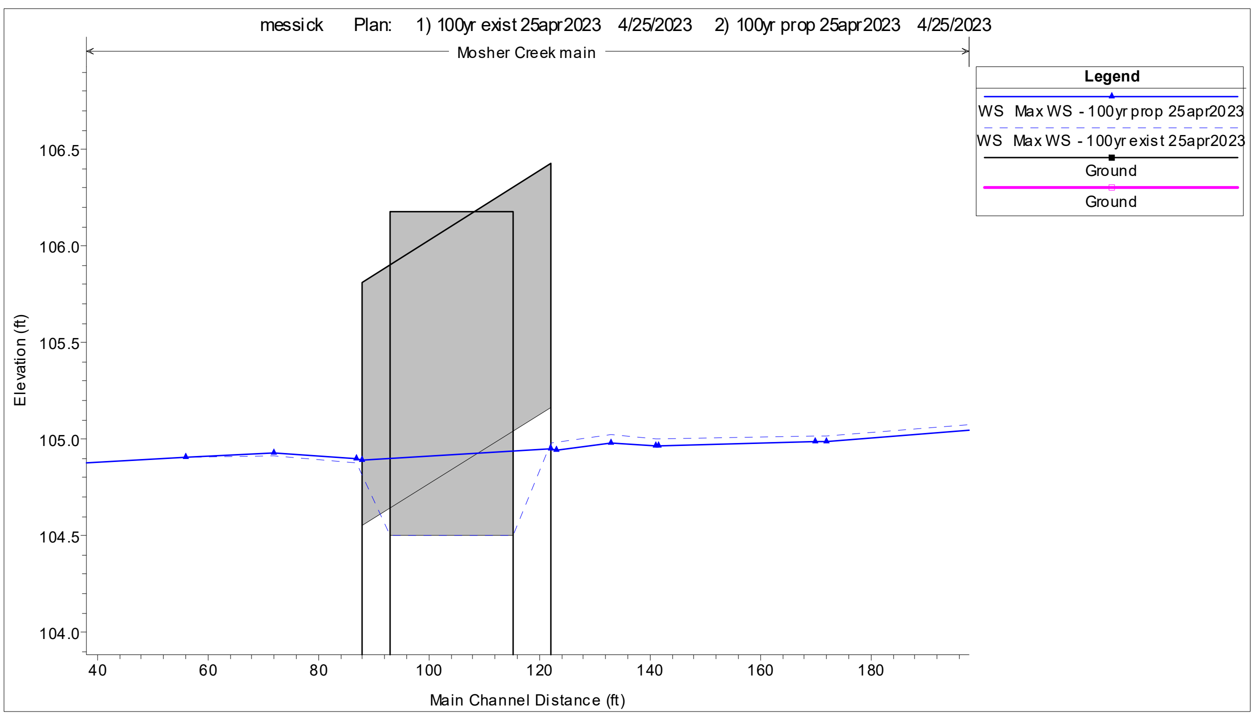

Figure 16. Same as Figure 15 zoomed into the bridge area

Table 4. 50-yr and 100-yr WSE comparisons between existing and proposed conditions

River Station	50-year			100-year		
	Existing	Proposed	Difference	Existing	Proposed	Difference
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
44454	104.92	104.91	-0.01	105.57	105.56	-0.01
44345	104.81	104.8	-0.01	105.46	105.45	-0.01
44269	104.73	104.72	-0.01	105.38	105.36	-0.02
44234	104.69	104.68	-0.01	105.34	105.32	-0.02
44189	104.65	104.63	-0.02	105.29	105.27	-0.02
44140	104.61	104.6	-0.01	105.26	105.24	-0.02
44098	104.57	104.56	-0.01	105.22	105.2	-0.02
44048	104.56	104.55	-0.01	105.2	105.17	-0.03
44000	104.53	104.52	-0.01	105.17	105.14	-0.03
43950	104.51	104.49	-0.02	105.13	105.11	-0.02
43895	104.49	104.48	-0.01	105.11	105.08	-0.03
43857	104.47	104.46	-0.01	105.08	105.06	-0.02
43827	104.41	104.39	-0.02	105.02	104.99	-0.03
Upstream face of low water crossing						
43796	104.41	104.39	-0.02	105.01	104.96	-0.05
43788	104.42	104.4	-0.02	105.02	104.98	-0.04
43777	104.39	104.38	-0.01	104.98	104.94	-0.04
Upstream face of bridge						
43742	104.35	104.37	0.02	104.88	104.9	0.02
43727	104.37	104.38	0.01	104.92	104.93	0.01
43711	104.37	104.37	0.00	104.91	104.91	0.00
43684	104.33	104.34	0.01	104.86	104.86	0.00
43655	104.31	104.31	0.00	104.82	104.83	0.01

See Appendix D for complete HEC-RAS results. See Appendix E for Overtopping and Flood of Record analysis.

HYDRAULIC CRITERIA AND DEBRIS

Chapter 820 of the Caltrans Highway Design Manual (HDM) delineates the hydraulic design criteria for bridges (Caltrans 2020). The basic HDM rule for hydraulic design is that bridges should be designed to pass the Q_{50} with sufficient freeboard and convey the Q_{100} without freeboard. Exceptions may be granted if the bridge designer can provide sufficient evidence that less freeboard is needed. The HDM notes that 2 feet of freeboard over the Q_{50} is often assumed to be appropriate for preliminary bridge designs but leaves the recommendation for freeboard to the judgment of the hydraulic engineer based primarily upon the debris anticipated at the bridge. The freeboard above the 50-year discharge controls the bridge design and more than zero feet of freeboard above the 100-year discharge is an additional benefit to the bridge.

The proposed minimum soffit elevation, maximum WSE, and available freeboard for the 50-yr and 100-yr discharges at the upstream and downstream face of the proposed bridge is shown in Table 5. The HDM criteria for preliminary design are not met. The proposed Messick Road profile and cross slope will also be revised so that the minimum soffit elevation will be 105.1 to eliminate the negative freeboard available on the downstream side with the 100-yr discharge. In the final design, the bridge geometrics and grading will be designed to cause no rise in WSE, and pass the 100-yr design storm without going under pressure flow. The final hydraulic report will reflect these changes to the design.

Table 5. Minimum soffit elevation, maximum WSE, and available freeboard for the 50-year and 100-year events at the upstream and downstream face of the bridge.

	Upstream		**Downstream**	
	50-year	100-year	50-year	100-year
Minimum Soffit Elevation (ft)	105.07	105.07	104.45	104.45
Water Surface Elevation (ft)	104.38	104.94	104.37	104.90
Freeboard (ft)	0.69	0.13	0.08	-0.45

Avila and Associates researched the available Bridge Maintenance Reports for the existing bridge to determine if floating debris catches on the bridge. There were no instances reported of debris captured by the bridge in the reports. The elimination of two piers from the channel will improve the hydraulics of the channel and will reduce the potential for capturing debris.

SCOUR

Degradation

Avila and Associates reviewed the available channel cross-sections to compare the oldest recorded condition in 1995 with the most recent cross sections taken in 2011. During this 16-year span of time, the channel lowered approximately 1 foot between 1995 and 2005, as shown in Figure 17. This lowering is within the margin of error for these measurements. Therefore, the historical cross sections were compared for the bridges upstream (29C0214 and 29C0215) and downstream (29C0275) on Mosher Creek. As shown in Figure 18 and Figure 19, the channel has been stable upstream of the project bridge from 1977 to 2011. However, as shown in Figure 20, the channel has lowered approximately 2 feet in 16 years at the bridge downstream on Mosher Creek. The cross sections at bridge 29C0275 are limited in detail and this bridge has a history of local pier scour; thus, the channel lowering may be the result of the local pier scour. Without additional historical cross sections at the project bridge, or downstream bridge, a conservative estimate of future degradation is 2 feet during the anticipated 75-year life of the proposed bridge.

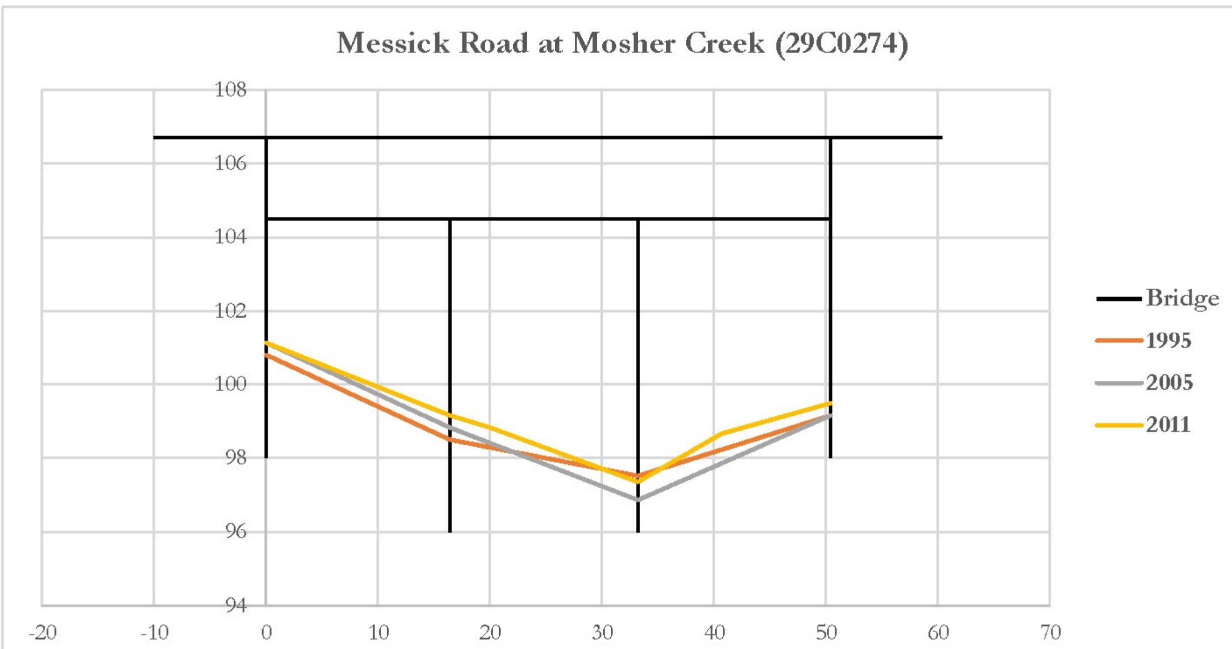

Figure 17. Cross sections taken at the project bridge over time (from Caltrans Maintenance Reports)

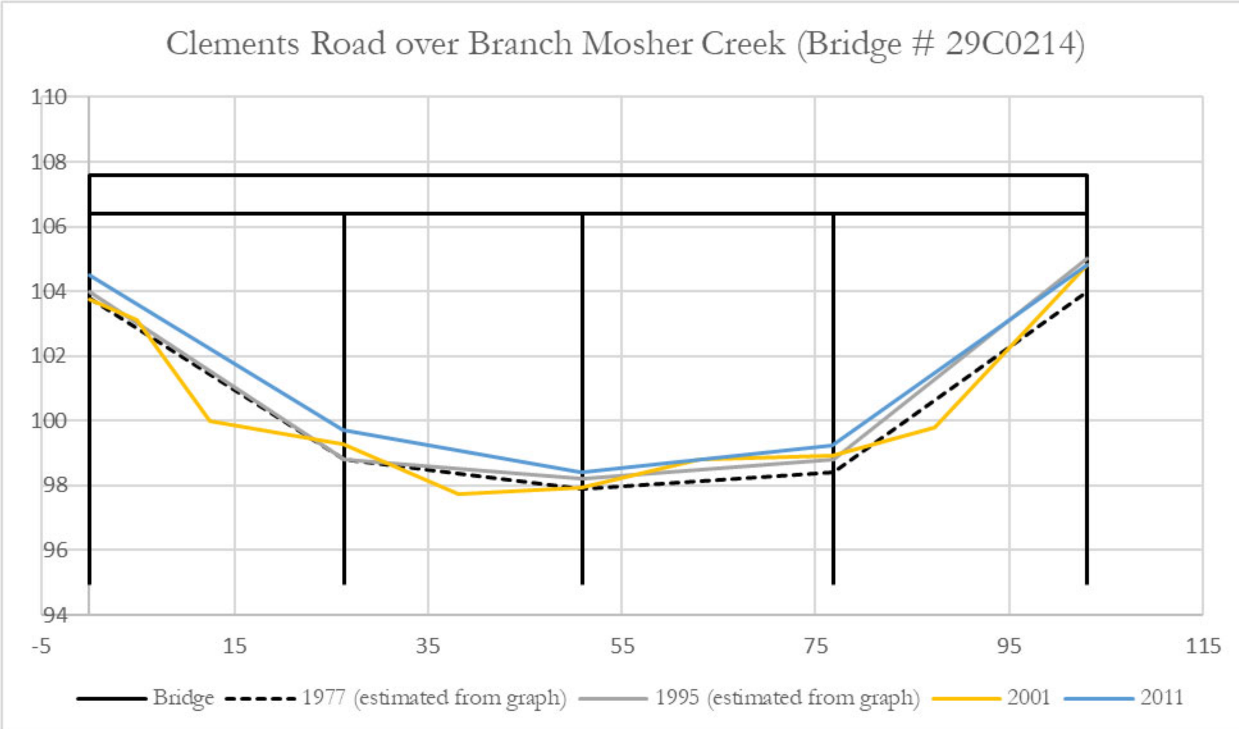

Figure 18. Cross sections taken at the upstream bridge over time (from Caltrans Maintenance Reports)

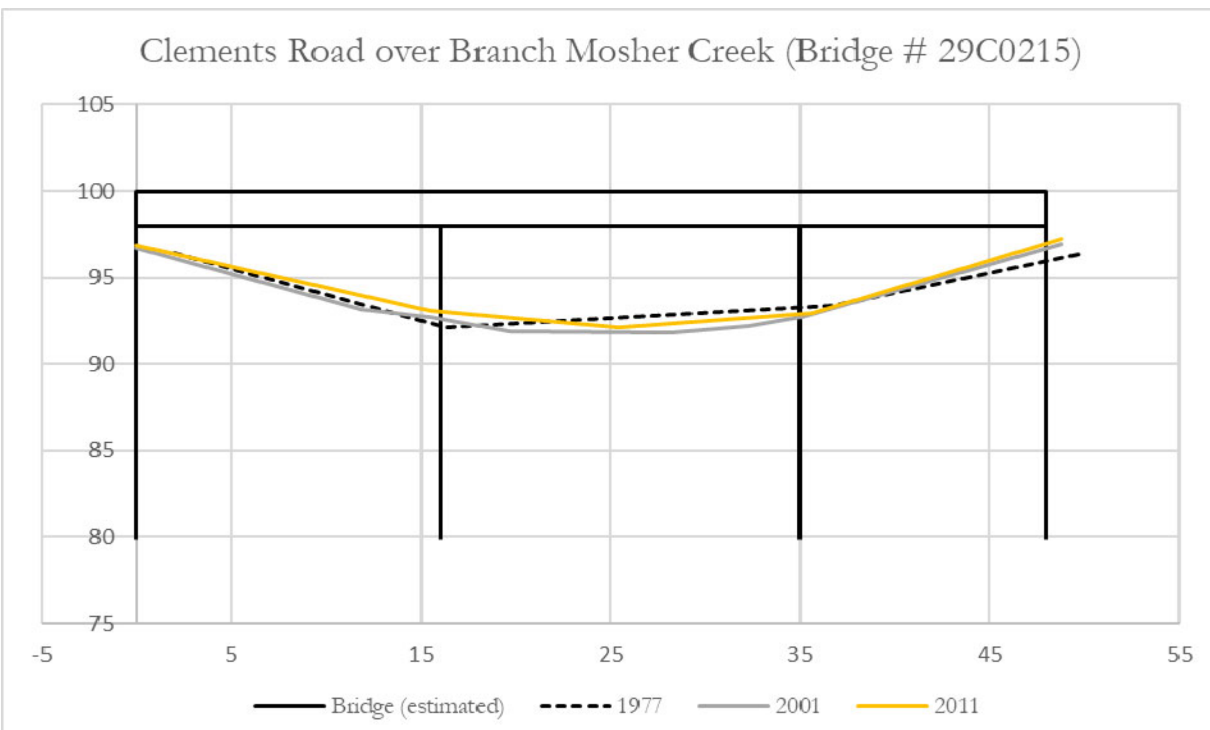

Figure 19. Cross sections taken at the upstream bridge over time (from Caltrans Maintenance Reports)

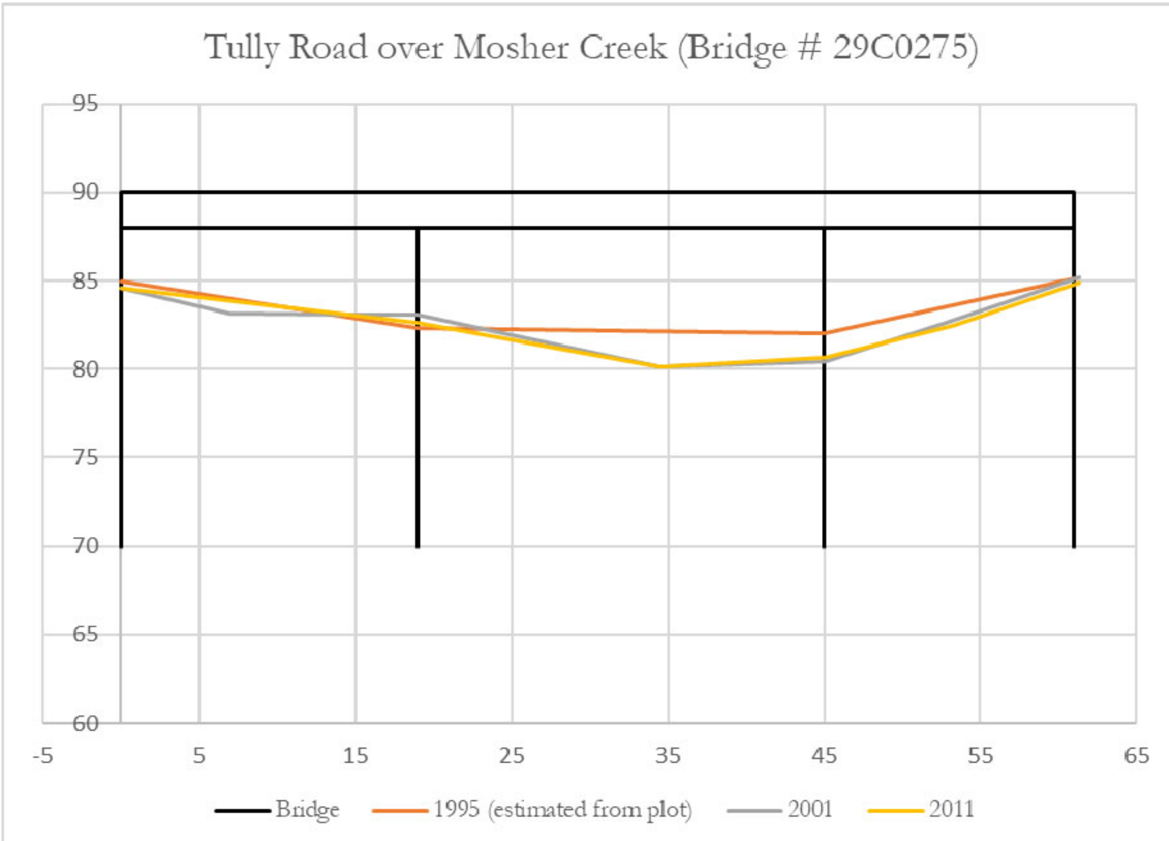

Figure 20. Cross sections taken at the downstream bridge over time (from Caltrans Maintenance Reports)

All scour calculations were completed following the methodology outlined in HEC-18 (Arneson, 2012). Scour calculations were preformed using the 100-year hydraulic results.

Contraction Scour

The proposed bridge does not constrict the channel. Thus, no contraction scour is anticipated.

Abutment Scour

Abutment scour was calculated using the equations from NCHRP 24-20 for Condition A (abutments near the main channel). Preliminary calculations for the proposed bridge alternatives resulted in abutment scour depths of 4 feet. With the current bridge configuration, the calculated abutment scour depth is 1 ft. The bridge length and grading will be updated in the 65 % plans to remove any increase in the water surface elevation, which might change the theoretical scour depths. Therefore, the recommended abutment scour depth for preliminary design is 4 ft.

These equations are inclusive of contraction scour, thus additional contraction scour should not be added. Unless it is determined the channel cannot migrate laterally, thalweg migration to the abutment could occur. Therefore, the abutment scour elevation should be determined from the channel thalweg of 97 ft.

Total Scour

According to the Draft Foundation Report (Crawford, 2020), there is no scour resistant material at the project site. The total scour depths and elevations at the Messick Road Bridge over Mosher Creek are provided in Table 6, assuming a channel thalweg of 97 ft. The scour summary table is provided in Table 7.

Table 6. Total scour depths and elevations assuming a thalweg elevation of 97 ft.

Support	A1	A2
Degradation Depth (ft)	2	2
Contraction Scour Depth (ft)	0	0
Abutment Scour Depth (ft)	4	4
Total Scour Depth (ft)	6	6
Total Scour Elevation (ft)	91	91

Table 7. Scour Summary Table.

Long Term & Short-Term Scour Depths			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short Term (Local) Scour Depth (ft)
A1	2	0	4
A2	2	0	4

See Appendix F for detailed scour calculations.

ROCK SLOPE PROTECTION

Riprap size was calculated using the FHWA Hydraulic Engineering Circular No. 23 (HEC 23) guidelines for RSP (Lagasse, 2009). The riprap revetment design guidelines outlined in HEC 23 are based on flume studies performed by Stephen Maynord in 1989 and 1990 and were published in the U.S. Army Corp of Engineers (USACE) Engineering Manual (EM) 1601 in 1991. The rock slope protection was designed using the HEC-RAS results for the 100-year discharge for both side slopes of 1.5:1 and 2:1.

As shown in Table 8 below, the preliminary necessary RSP size is Class I, which is 20 lb. rock with a D_{50} of 6 inches. The RSP should be 12 inches thick (the greater of 1.5 times the D_{50} or the D_{100}). The RSP size calculations will be updated using the model results of the 65 % design plans.

Table 8. Preliminary rock slope protection sizing for cross sections near the bridge.

	1.5:1 Side Slopes				2:1 Side Slopes			
Cross-Section	**43777**	**43770.3 BR U**	**43770.3 BR D**	**43742**	**43777**	**43770.3 BR U**	**43770.3 BR D**	**43742**
Class (based on size)	I	I	I	I	I	I	I	I
D50 (in)	6	6	6	6	6	6	6	6
Weight (lbs)	20	20	20	20	20	20	20	20
Thickness (in)	12	12	12	12	12	12	12	12

The rock slope protection should extend up the banks to the 50-year design water surface elevation of 104.38 plus 2 feet of freeboard or elevation 106.38 ft. The RSP should be keyed into the channel the total scour depth or depth to erosion resistant material or utilize a mounded toe as shown in Figure 21.

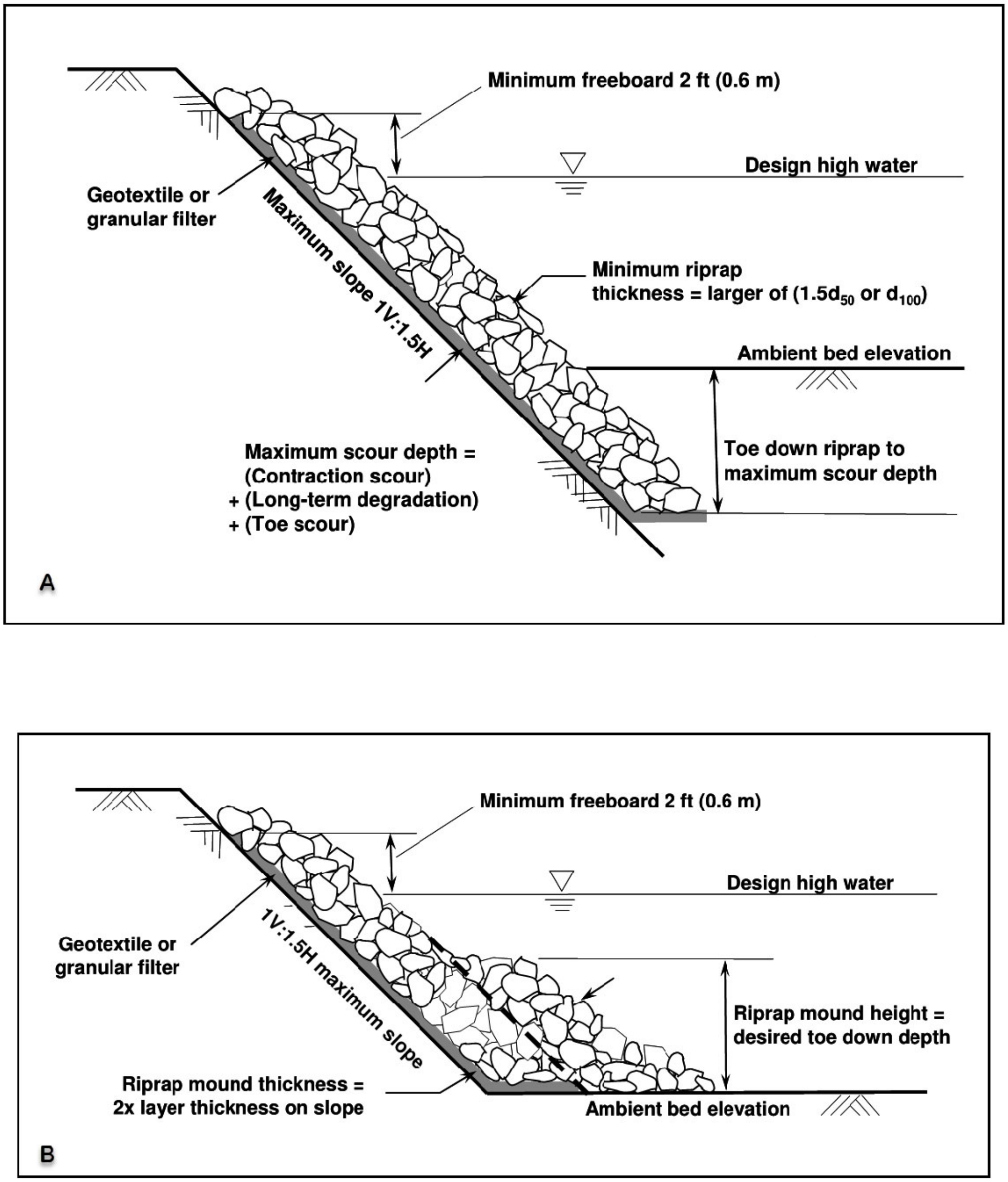

Figure 21. Bank RSP freeboard and termination options: A) key down to the scour depth and B) Mounded Toe

Details of the Rock Protection Sizing are provided in Appendix G.

SUMMARY TABLES

The following Hydrologic Summary Table is provided for your use for placement on the Foundation Plan:

Drainage Area: Indeterminate	Design	Base	Flood of Record
Frequency (Years)	50	100	≈ 90
Discharge (Cubic feet per second)	520	755	636
Water Surface (elevation in feet at upstream face of Bridge)	104.38	104.94	104.9
Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the County and interested or affected parties should make their own investigation.			

The following Scour Data Table is provided for placement on the Foundation Plan, assuming a thalweg elevation of 97 ft:

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
A1	95	4
A2	95	4

Location Hydraulic Study and Floodplain Evaluation Report:

The Floodplain Evaluation Report as outlined in 23 CFR 650 Subpart A, Section 650.111(b)(c)(d) will be included in Appendices H and I.

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APPENDICES

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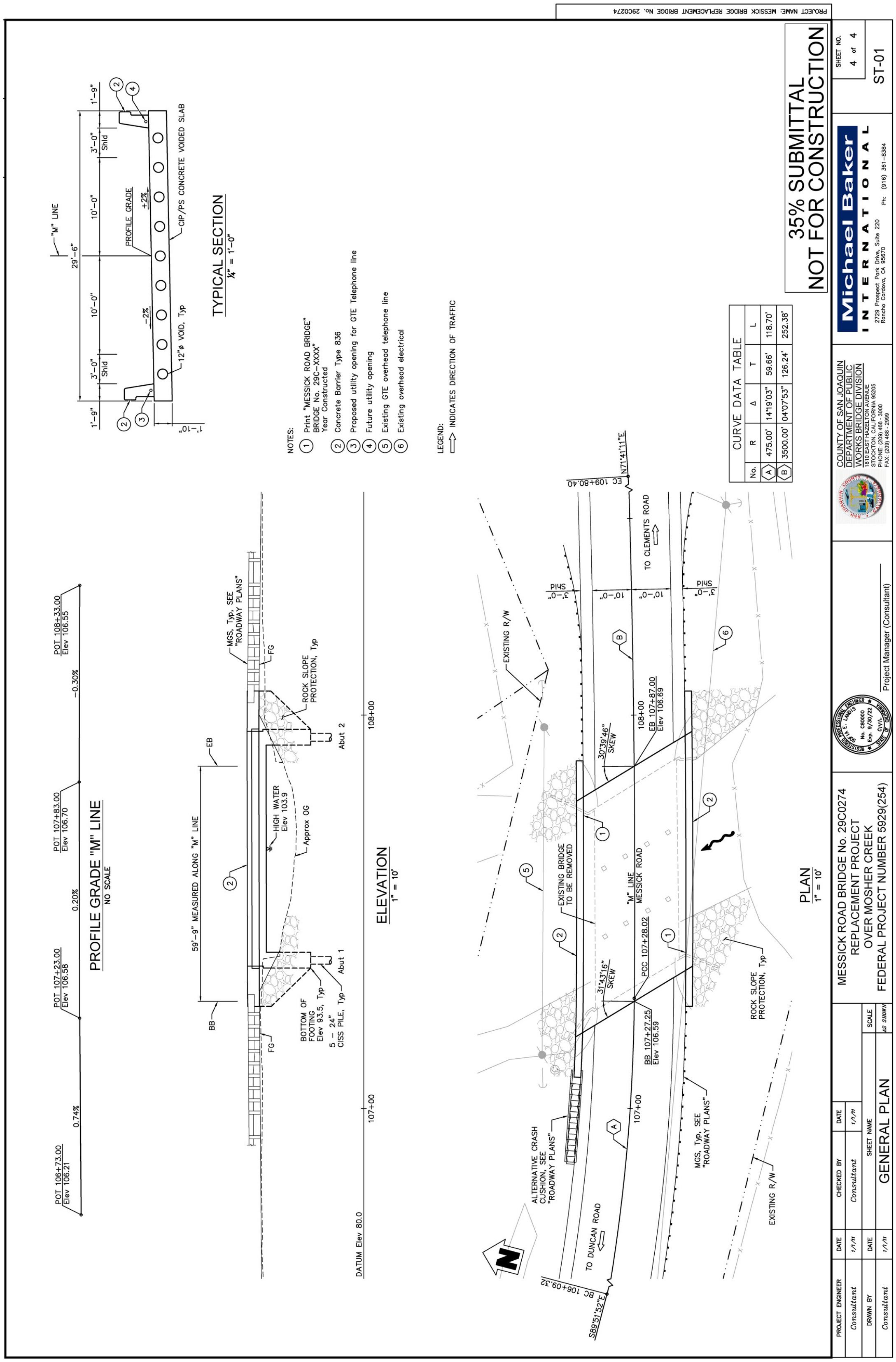
APPENDIX A – GENERAL PLAN



APPENDIX B – DISCHARGES

From FIS

Table 10: Summary of Discharges (continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharges (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Mosher Creek	Jack Tone Road	7.1	*	*	*	721	*
Mosher Creek	Clements Road	3.0	150	*	520	755	1,245
North Fork South Littlejohns Creek[8,12]	Terminus (French Camp Slough)	321.9	730	*	815	955	1,520
North Fork South Littlejohns Creek[8,12]	State Highway 99	234.1	730	*	935	965	1,550
North Fork South Littlejohns Creek[8,12]	Austin Road	232.0	730	*	940	1,025	1,100
North Fork South Littlejohns Creek[8,12]	Kaiser Road	230.0	730	*	820	1,115	1,315
North Fork South Littlejohns Creek[8,12]	Atchison, Topeka & Santa Fe Railway	226.7	720	*	775	960	1,625
North Fork South Littlejohns Creek[8,12]	Source (bifurcation, North and South Forks)	226.0	720	*	775	780	785

APPENDIX C – PRELIMINARY HYDRAULIC REPORT

PRELIMINARY DESIGN HYDRAULIC STUDY

MESSICK ROAD BRIDGE AT MOSHER CREEK

Bridge Number 29C0274

SAN JOAQUIN COUNTY, CALIFORNIA

AVILA & ASSOCIATES

~DRAFT~

Preliminary Design Hydraulic Study

MESSICK ROAD BRIDGE AT MOSHER CREEK

San Joaquin County, California

Bridge #29C0274

SEPTEMBER 18, 2021

PREPARED FOR:

THE SAN JOAQUIN COUNTY DEPARTMENT OF PUBLIC WORKS

Prepared by:

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CONSULTING ENGINEERS, INC.

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Note, only Appendix A of the Preliminary Hydraulic Report is included in this appendix as the other appendices are the same as in the Final Hydraulic Report.

EXECUTIVE SUMMARY

The Messick Road Bridge (bridge) at Mosher Creek in San Joaquin County (County) is proposed for replacement by the County in 2023. There are three alternatives for the proposed bridge. Alternative 1 will be a single-span prestressed, pre-cast concrete slab girder, Type SIV 36 and Alternative 2 will be a single span voided slab Type IV bridge. Alternative 1 will be supported by 7 ft wide footings with seven 24-inch Cast-In-Steel-Shell piles at the abutments and Alternative 2 will be supported by five 24-inch cast in drilled hole piles at the abutments. Alternative 3 is a three-cell box culvert with wingwalls as shown on the attached General Plan (Appendix A).

Mosher Creek flows northwesterly through the project site through the northern part of San Joaquin County. The discharges used for the bridge hydraulic analysis are shown in Table 1.

Table 1. Discharge and water surface elevation for bridge design

	Design	**Base**	**Flood of Record**
Frequency (years)	50	100	(to be included in final report)
Discharge (cubic feet per second)	520	755	
Alt 1 & 2 Water Surface (elevation in feet at upstream face of Bridge)	103.9	104.5	
Alt 3 Water Surface (elevation in feet at upstream face of Bridge)	104.0	104.5	

This study used hydraulic modeling based on a HEC-RAS[1] version 5.0.7 model to estimate the water surface elevation (WSE) for the existing and proposed bridge. Results indicate that after construction of the either alternative, the WSE is lowered up to 0.4 feet both upstream and downstream from the bridge for the 50-yr discharge and lowered up to 0.5 feet upstream and downstream, for the 100-yr discharge. The proposed soffit elevations and minimum freeboard for each alternative are presented in Table 7. The available freeboard is lower than the recommended freeboard in the HDM criteria.

Table 2. Soffit elevations and available freeboard for the 50-year and 100-year event.

	Alternative 1 and 2		Alternative 3	
	50-year	100-year	50-year	100-year
Minimum Soffit Elevation (ft)	105.2	105.2	105.9	105.9
Water Surface Elevation (ft)	103.9	104.5	104.0	104.5
Freeboard (ft)	1.3	0.7	1.9	1.4

[1] US Army Corps of Engineers Hydraulic Engineering Center River Analysis System which backwater hydraulic model designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

The proposed Alternative 1 and 2 bridges will improve the hydraulics due to the removal of two piers from the channel.

This report follows the California Department of Transportation (Caltrans) Final Hydraulic Report Format and has been prepared in accordance with the Caltrans Local Assistance Program Guidelines (Caltrans 2020) and Memos to Designers 16-1 [2].

GENERAL

This design hydraulic study has been prepared for the sole purpose of meeting the requirements of the Caltrans "Local Assistance Program Guidelines." Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than for which Avila and Associates Consulting Engineers, Inc. (Avila and Associates) intended and without their written authorization is not endorsed or encouraged and is at the sole risk of the entity reusing the information.

Avila and Associates was retained to complete the hydraulic analysis of the existing Messick Road Bridge over Mosher Creek in San Joaquin County. The location of this project is shown in Figure 1. The following scope of work has been completed to develop this report:

1. Obtain backup information and field review.
2. Obtain discharge information.
3. Create HEC-RAS model and perform hydraulic analysis.
4. Estimate scour, channel bed degradation, and bank protection parameters.
5. Prepare draft report for comment.
6. Prepare final report.

The existing bridge is located within the northern part of San Joaquin County approximately 10 miles northeast from Stockton as shown in Figure 1. The existing bridge was constructed in 1931. The existing structure is approximately 51-feet long and is a 3-span timber girder with timber plank deck bridge supported by concrete abutments on unknown footings and timber pier bents. It has a sufficiency rating as of 2015 of 48.7 and is Functionally Obsolete. The San Joaquin County Department of Public Works proposes to replace the existing bridge using Highway Bridge Program (HBP) funds.

[2] Caltrans Memo to Designers 16-1 December 2017 (http://www.dot.ca.gov/des/techpubs/manuals/bridge-memo-to-designer/page/section-16/MTD_16-1-attach1.pdf)

Figure 1. Bridge location map

Figure 2. Detail of bridge location

The datum elevation used for this study is NAVD-88[3]. The proposed bridge will be located along the same alignment as the existing bridge. Alternatives 1 and 2 will be approximately 55.3-feet long and Alternative 1 (Figure 3) will be a single-span prestressed, pre-cast concrete slab girder, and Alternative 2 (Figure 4) will be a single span voided slab bridge. Alternative 1 will be supported by 7 ft wide footings with seven 24-inch Cast-In-Steel-Shell piles at the abutments and Alternative 2 will be supported by five 24-inch cast in drilled hole piles at the abutments. Alternative 3 (Figure 5) is a three-cell box culvert with wingwalls. All alternatives will be 29 ft wide and will accommodate 2 travel lanes as shown in the attached General Plan (See Appendix A).

[3] Verification to be included in the Final Report

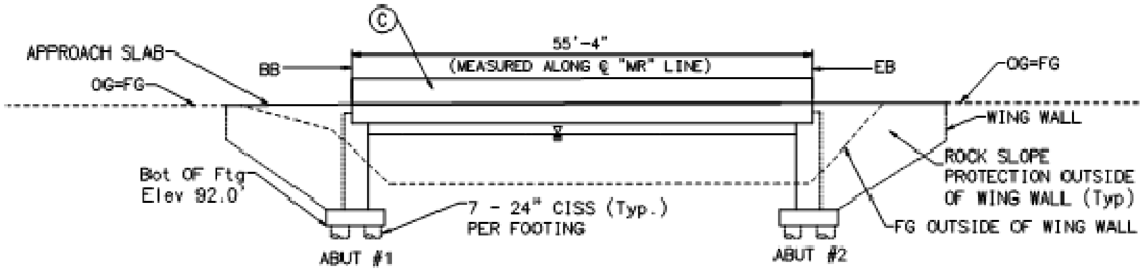

Figure 3. Proposed Alternative 1 bridge profile view

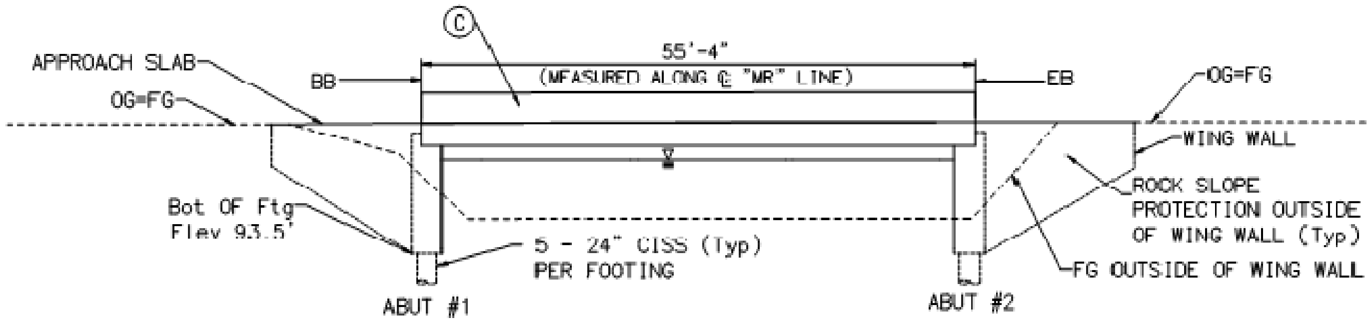

Figure 4. Proposed Alternative 2 bridge profile view

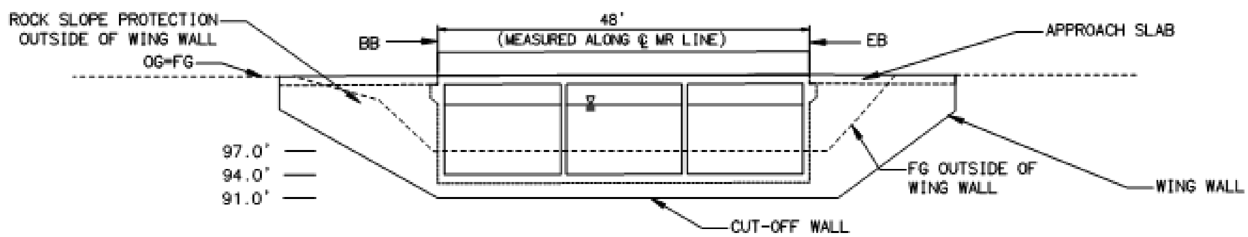

Figure 5. Proposed Alternative 3 bridge profile view

BRIDGE HISTORY

Avila and Associates reviewed the pertinent bridge maintenance records for the existing bridge and the adjacent bridges on Mosher Creek to determine the typical impacts to bridges along this reach. Details of the bridge are shown in Table 3.

Table 3. Bridge information from maintenance records

	Clements Road over Branch Mosher Creek	Clements Road over Branch Mosher Creek	Messick Road at Mosher Creek (Project)	Tully Road over Mosher Creek
Bridge Number	29C0214	29C0215	29C0274	29C0275
Bridge Length (ft)	105.6	51.8	50.9	68
Span Lengths (ft)	4 @ 26	1 @ 1.476, 1 @ 20, 1 @ 14.76	16.4 / 16.8 / 17.2	1 @ 19.33, 1 @ 26, 1 @ 19.33
Bridge Type	Reinforced Concrete (RC) slab on RC (5) pile bents and RC diaphragm abutments.	Continuous RC slab on RC 4-column bents and RC diaphragm abutments with monolithic wingwalls. All founded on 45-ton CIDH piles.	Simple span timber girders (18 – Spans 1 and 3, 19 – Span 2) with a timber plank deck on reinforced concrete abutments.	Continuous RC slab on RC 5-column bents and RC diaphragm abutments with monolithic wingwalls. All founded on CIDH piles.
Debris Challenges	2001[4], 2003[5]		N/A	2013[6]
Cross Sections Available for	1977, 1995, 2001, 2011[7]	1977, 2001, 2011[8]	1995, 2005, 2011	1995, 2001. 2011[9]
NBIS Item 113 (scour) code	5	5	U	5
ELI Flag 361 Condition State	N/A	N/A	N/A	2
ELI Flag 252/6000 (Pile-CIDH/Scour)	N/A	N/A	N/A	2

[4] Cattle fence upstream and downstream of bridge has accumulated substantial amounts of vegetation and debris.
[5] Same as 2001.
[6] Log shown on Pier in photos.
[7] Notes channel aggraded.
[8] No changes noted.
[9] No significant changes noted

Condition State[10]				
Pier Type	Reinforced Concrete Pile Bents	RC 4-column bents	Timber pier bents.	RC 5-column bents
Year Built	1969	1969	1931	1989
Year Widened	N/A	N/A	N/A	N/A
Scour Challenges	None Noted	None Noted	2003[11], 2003[12], 2005[13], 2007[14], 2010[15]	2001[16], 2003[17], 2005[18], 2007[19], 2011[20], 2013[21], 2015[22], 2017[23]

DISCHARGE

Mosher Creek was included in a FEMA Flood Insurance Study (FIS) for San Joaquin County (FEMA, 2016). According to the FIS, the 50-yr discharge at the bridge is 520 cfs and the 100-yr discharge is 755 cfs. The discharges used for this analysis are shown in Table 4.

Table 4. Discharges used for analysis (cfs)

	Design	Base
Frequency (years)	50	100
Discharge (cubic feet per second)	520	755

See Appendix B for excerpts from the FEMA FIS.

[10] In 2015 after change in element inspection methodology.
[11] No scour or undermining was noted.
[12] The Item 113 code, Scour Critical Bridges is U for this structure. This bridge has an unknown foundation and has not yet been evaluated for scour.
[13] This structure has an unknown foundation that has not been evaluated for scour. The scour risk cannot be determined. This structure should be monitored for scour related problems during flood events.
[14] Same as 2005.
[15] Based on field inspection dated 08/16/2010, the channel was dry, and none of the footings for Abutment 1, Bent 2, Bent 3 or Abutment 4 are visible. The condition of the scour does not compromise the integrity of the structure. Therefore, the County is planning to perform annual inspection to monitor both abutments and bents for potential scour damages.
[16] 1991 bridge report mentioned the footing of column 3 at Pier 2 is exposed ~ 6 inches in depth. The channel bed has degraded approximately 2 ft since the last investigation of 12/12/89.
[17] Column 2 at Bent 3 is exposed ~ 2m.
[18] CIDH pile at column 3 Bent 2 is exposed ~0.1m and column 2 Bent 3 exposed ~0.2m
[19] CIDH pile at column 3 Bent 2 is exposed ~4" and column 2 Bent 3 exposed ~8"
[20] Pier 2: Pile 3 exposed 50 mm, Pile 4 exposed 100mm. Pier 3, Pile 4 exposed 200mm
[21] Pier 3, Pile 4 is exposed up to 200 mm.
[22] Same as 2013
[23] Same as 2015.

HEC-RAS ANALYSIS

Hydraulic parameters (water surface elevations and velocity) were obtained from the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 5.0.4 model based on: 1) survey information provided by San Joaquin County, 2) LiDAR data obtained from California Department of Water Resources (DWR), and 3) field investigation by Avila and Associates on June 23, 2014.

Initial analyses of Mosher Creek downstream from the bridge using a 1D HEC-RAS model based on the topographic survey provided by the County indicated that the design discharges were not contained by the channel. The LiDAR data obtained from DWR was used to extend the cross sections for containment; however, there were some areas where the flows would not be contained. To obtain more realistic results, a 2D flow area was created for the downstream area and a combination 1D/2D analysis was performed. The 2D flow area and cross sections used for the HEC-RAS model are shown in Figure 6 and Figure 7.

For the 2D flow area, a 30-ft x 30-ft grid was analyzed using the diffusion wave method. A simulation time of 25 hours 15 minutes was selected using a computation interval of 1 second.

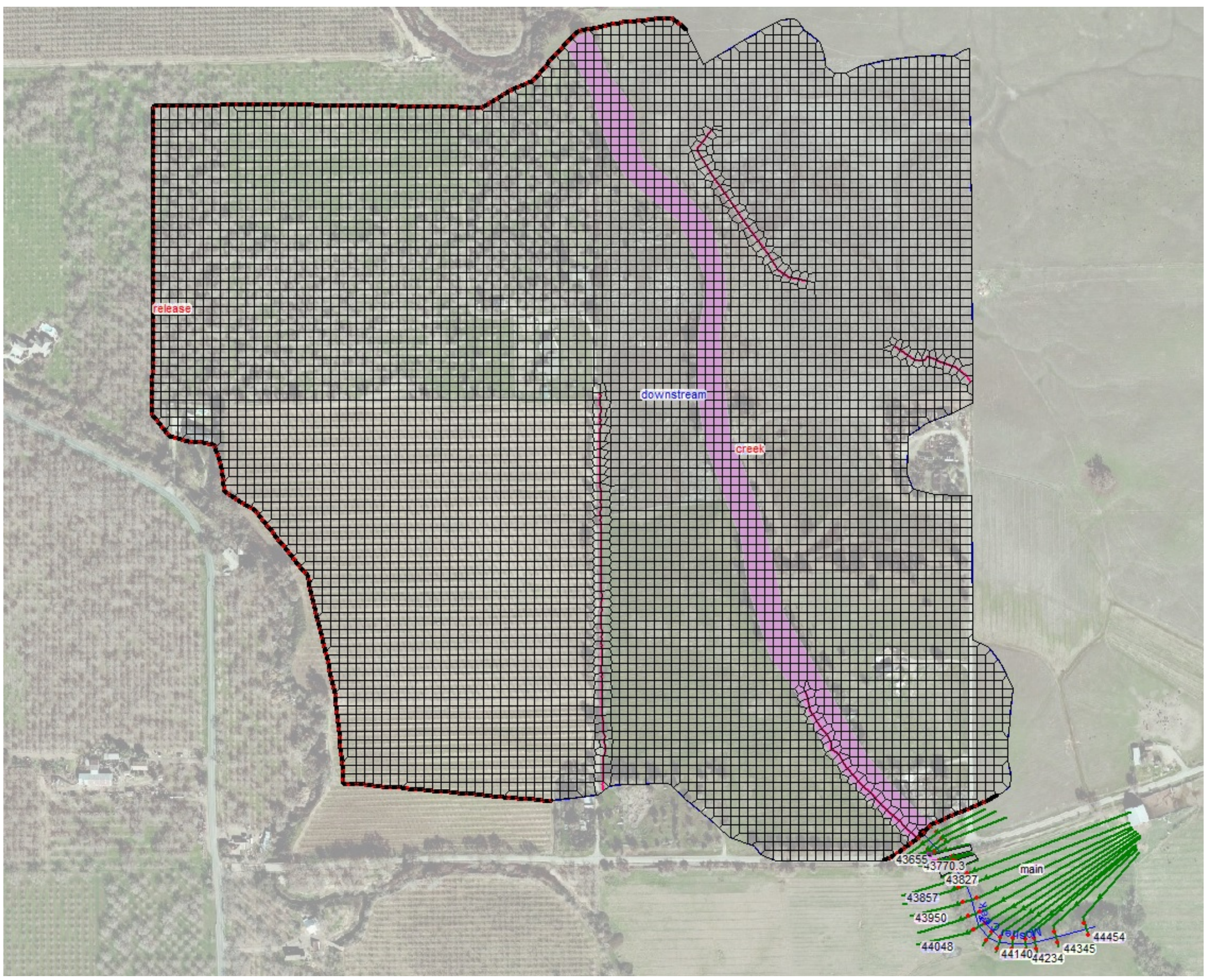

Figure 6. Plan View of the combination 1D/2D HEC-RAS model

AVILA & ASSOCIATES

Figure 7. Close up of 1D portion of the HEC-RAS model

Existing Condition

The Manning "n" values of 0.045 for the channel and 0.060 for the overbanks were used in the model and are consistent with the FIS and the field review by Avila and Associates as shown in Figure 8. There is an existing low water crossing just upstream from the bridge also shown in Figure 8.

Figure 8. Looking upstream from the bridge. The channel is clear and the overbank areas are vegetated contributing to a higher n-value. Existing low water crossing also shown.

The existing bridge was input into the model as a 3-span bridge with a minimum soffit elevation of 104.5 feet as shown in Figure 9. The existing low water crossing was modeled as a bridge with two 36-in diameter culverts as shown in Figure 10. The topographic survey indicates that one of the culverts is completely silted in on the upstream end as shown in Figure 10.

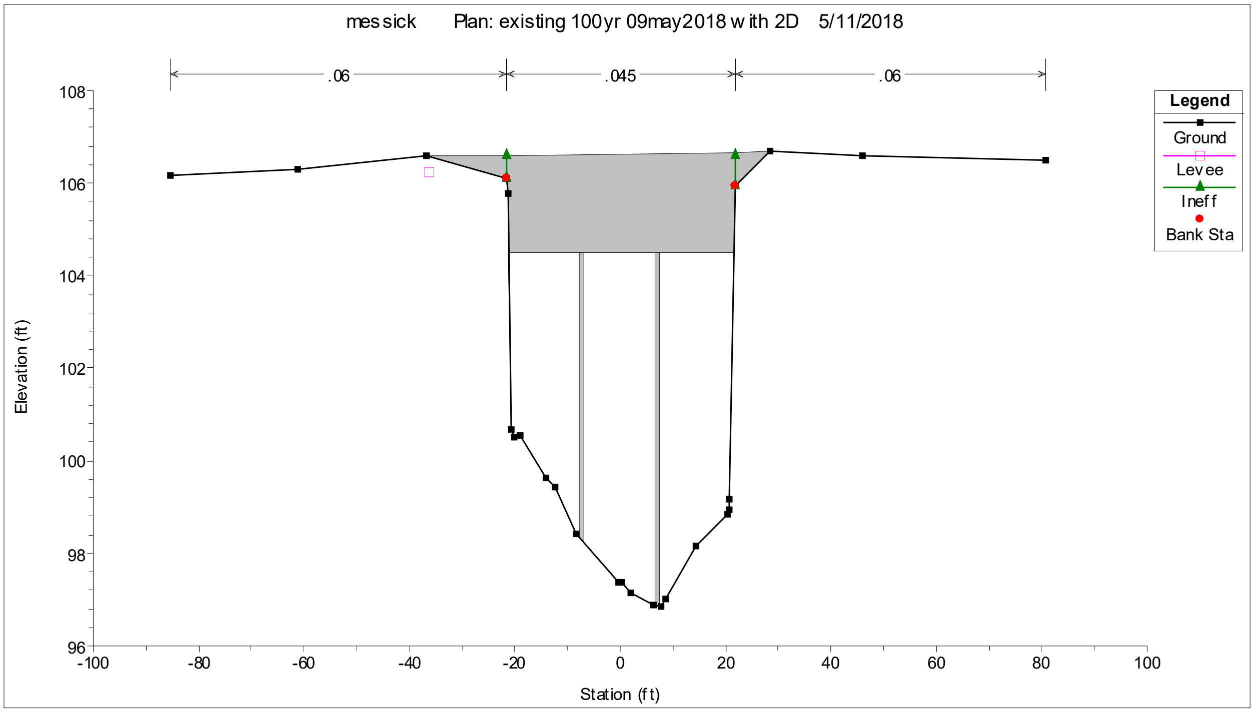

Figure 9. HEC-RAS cross section for the upstream existing condition

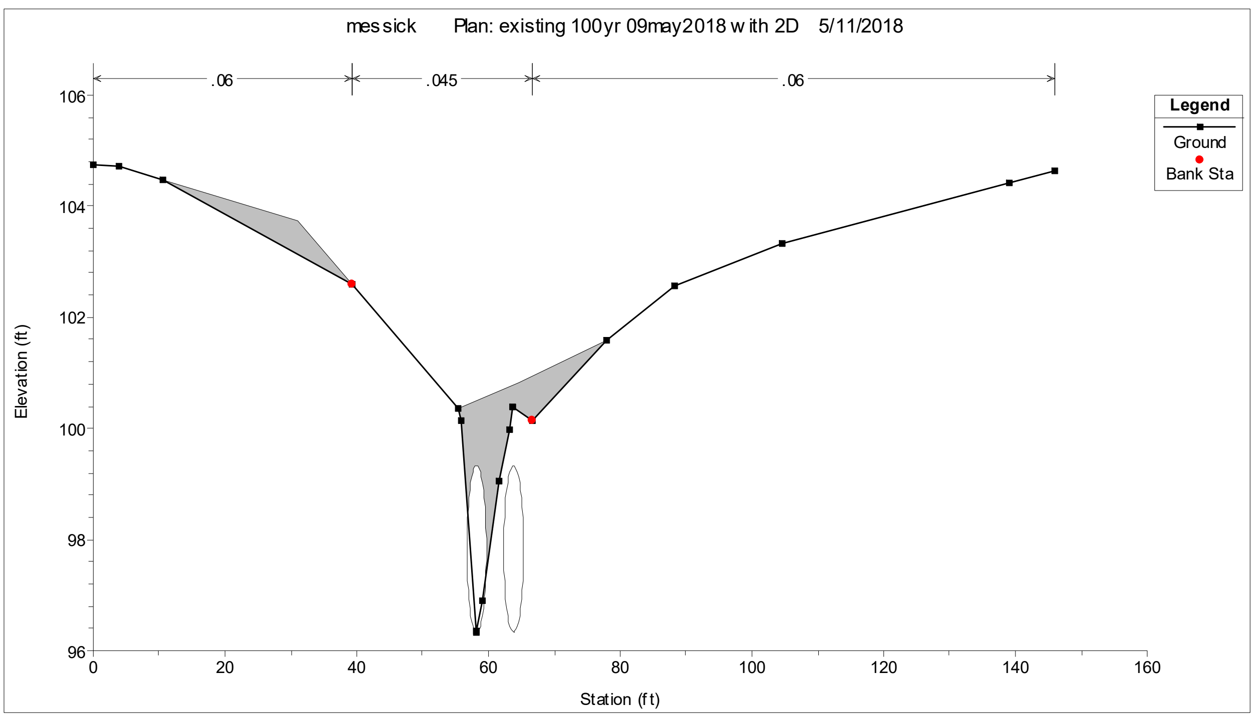

Figure 10. HEC-RAS cross section for the existing low water crossing (upstream side)

Starting Water Surface Elevation

A downstream water surface boundary condition line was created along the edge of the 2D flow area (shown as a heavy line in Figure 6) and an assumed friction slope of 0.0015 ft/ft was used for the analysis. The most downstream cross section in the 1D portion of the model (RS 43655) was connected to the 2D flow area. After each analysis, the water surface elevation (WSE) along the upstream edge of the 2D flow area along the connection was compared to the WSE at RS 43655 to make sure they matched.

Unsteady Flow Analysis

Because unsteady flow analyses were performed, synthetic hydrographs were developed with peaks that matched the peak 50-yr and 100-yr discharges taken from the FIS. The synthetic hydrographs were patterned after a SCS 24-hr Type I rainfall distribution using a 5-minute interval as shown in Figure 11. These hydrographs were used as the upstream boundary flow condition in the 1D/2D analyses.

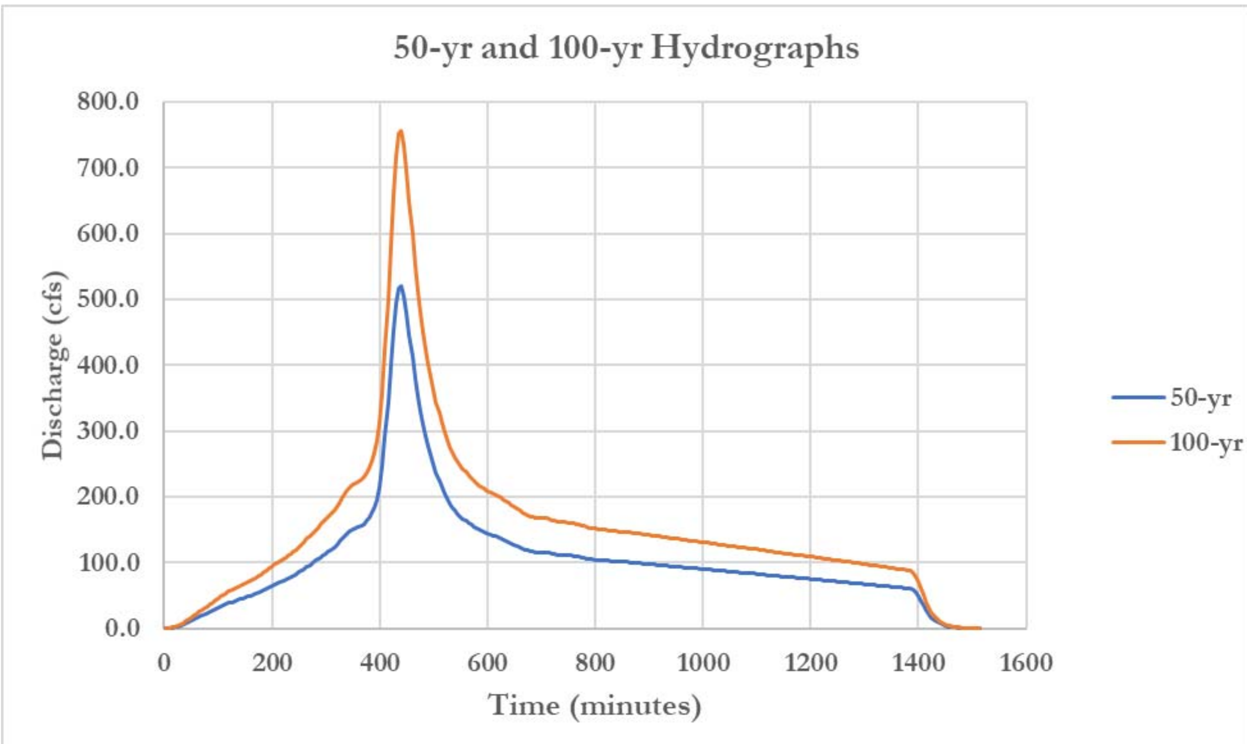

Figure 11. Hydrographs used for the unsteady flow analyses

Proposed Condition Model

The HEC-RAS model was re-run for the proposed condition by replacing the existing bridge with the proposed bridge alternatives. The proposed bridge for Alternatives 1 and 2 was modeled as a single span bridge with minimum soffit elevation of 105.2 as shown in Figure 12. While Alternative 3 is a three-box culvert, it was modeled as a three-span bridge using the culvert dimensions with a minimum soffit elevation of 105.9 ft. This allows for the existing ground to be used through the culvert opening as shown in Figure 13. All of the proposed bridge alternatives will be approximately 9 feet wider than the existing bridge as shown in Figure 14, Figure 15, and Figure 16.

The preliminary modeling does not incorporate any grading that may be proposed later in design. Once a grading plan has been completed for the preferred alternative, the model will need to be updated, and the hydraulics evaluated, for the proposed grading.

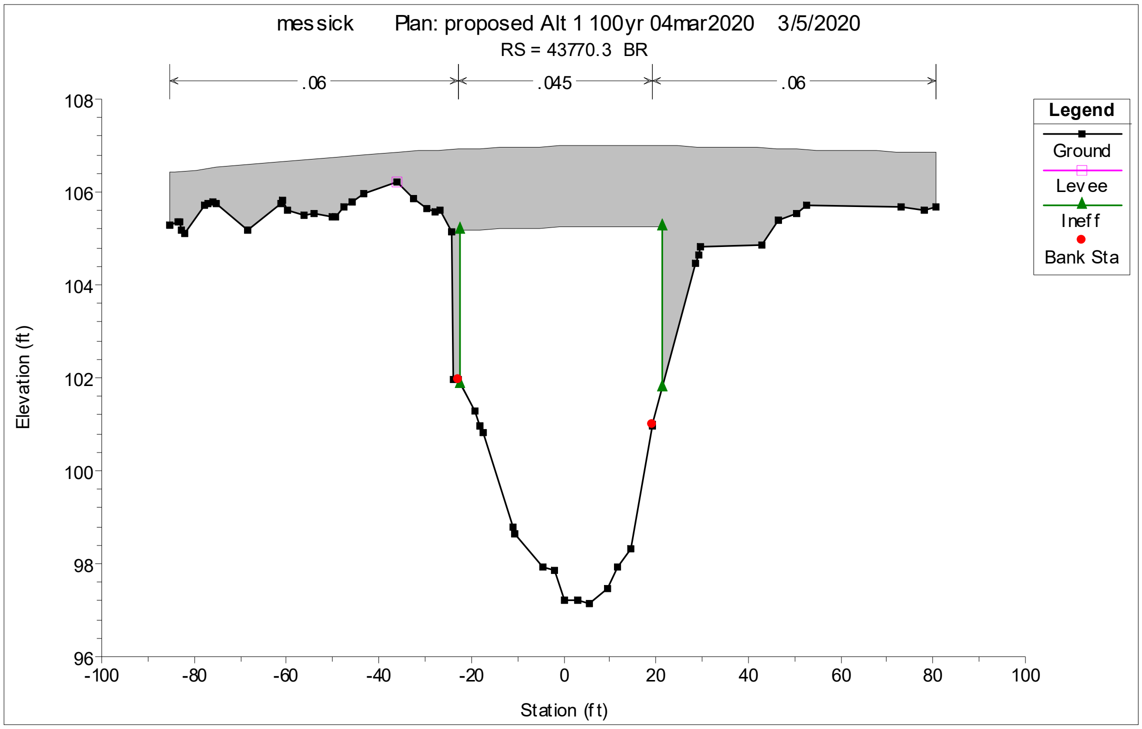

Figure 12. HEC-RAS cross section of proposed Alternatives 1 and 2 bridge

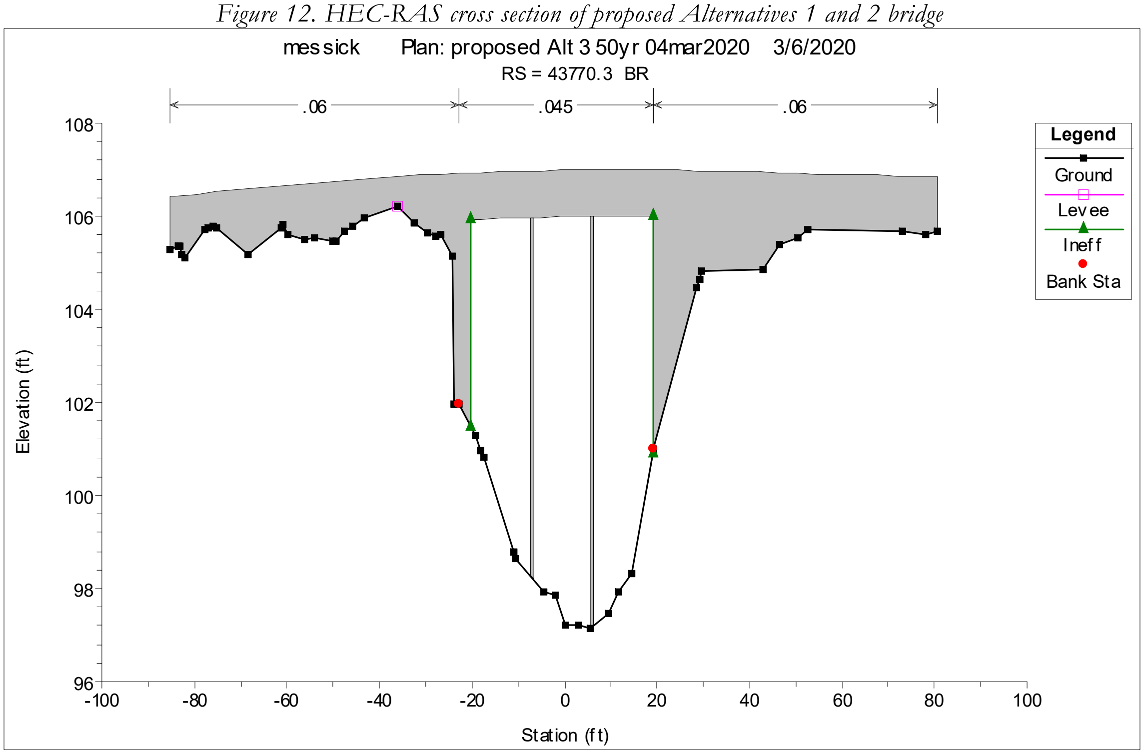

Figure 13. HEC-RAS cross section of proposed Alternatives 3 bridge

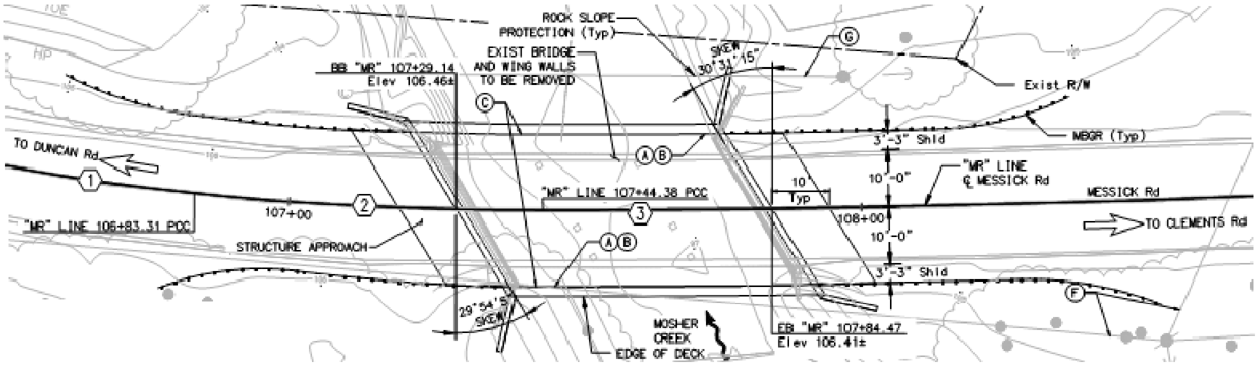

Figure 14. Plan view of proposed Alternative 1 bridge

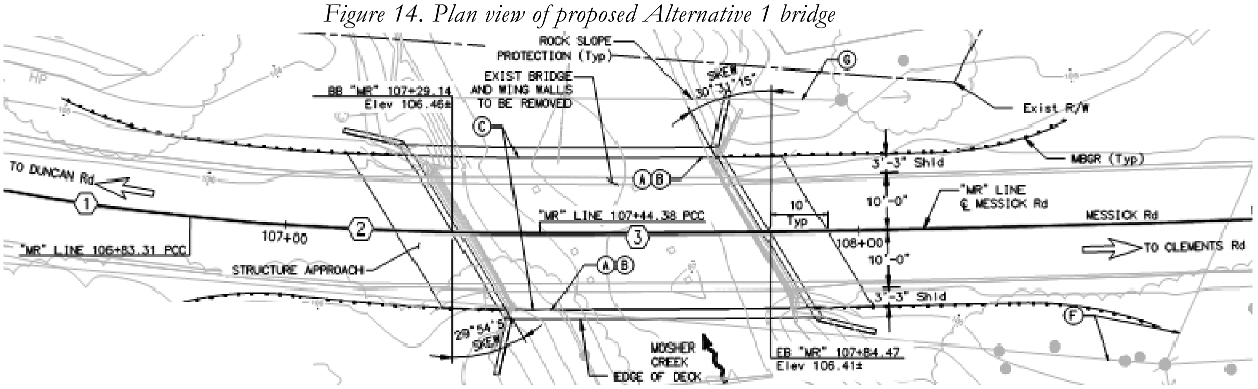

Figure 15. Plan view of proposed Alternative 2 bridge

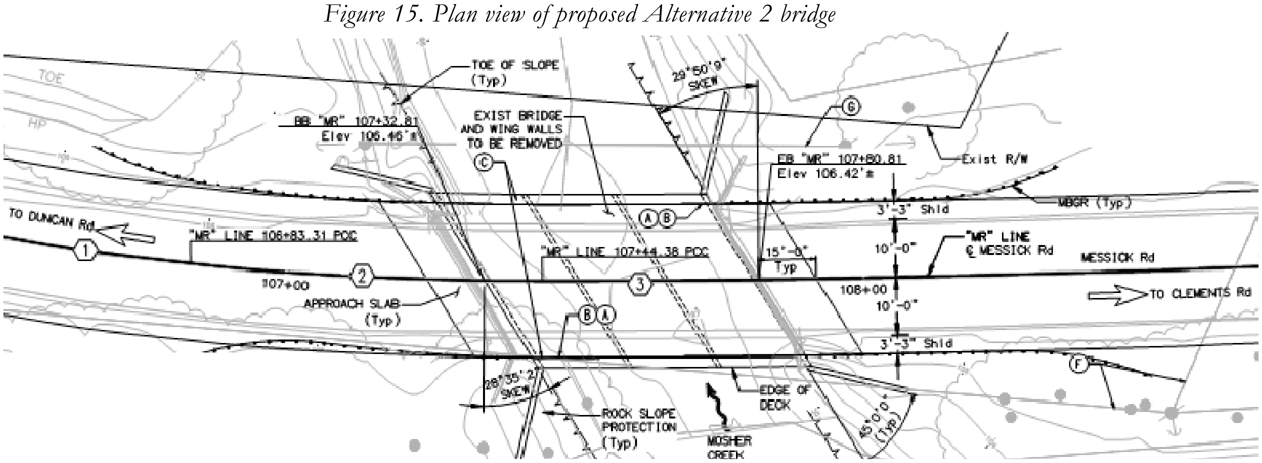

Figure 16. Plan view of proposed Alternative 3 bridge

Figure 17, Figure 18, and Table 6 shows a comparison of the existing to the proposed WSE profiles for the 50-yr and 100-yr discharges. As can be seen, the WSE is lowered up to 0.4 feet both upstream and downstream from the bridge for the 50-yr discharge and lowered up to 0.5 feet upstream and downstream, for the 100-yr discharge.

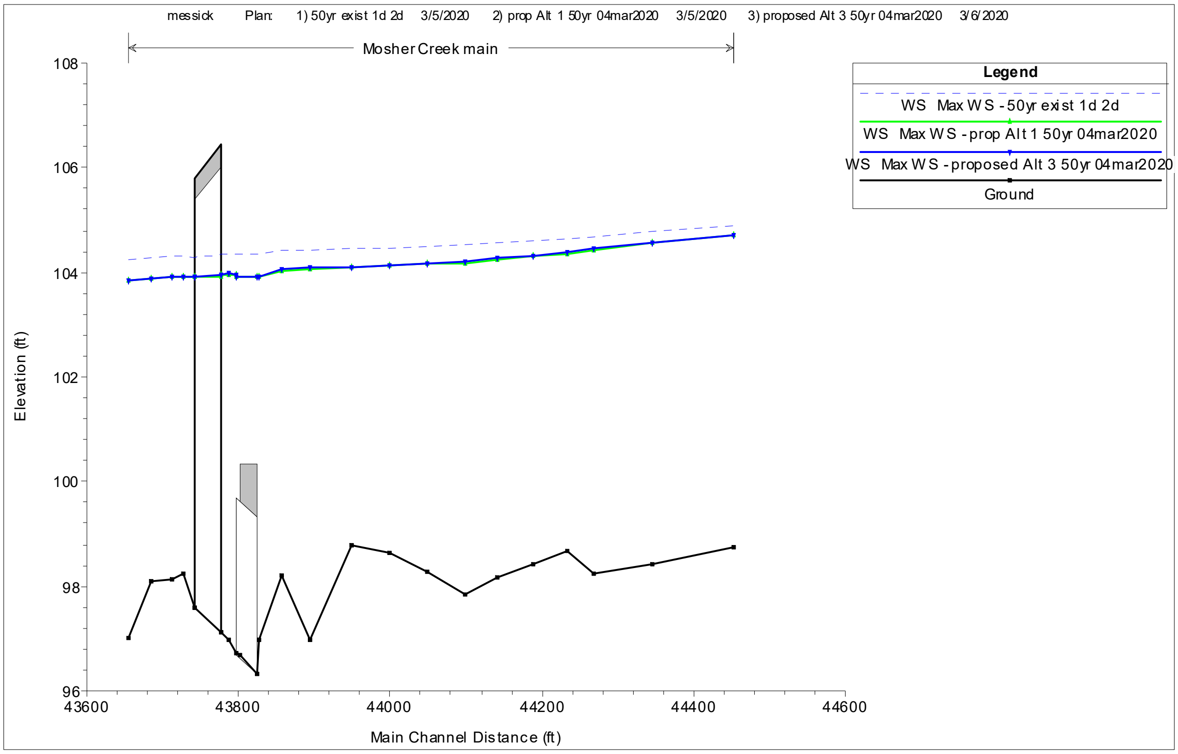

Figure 17. Water surface elevation profile comparison of existing to proposed for the 50-yr discharge

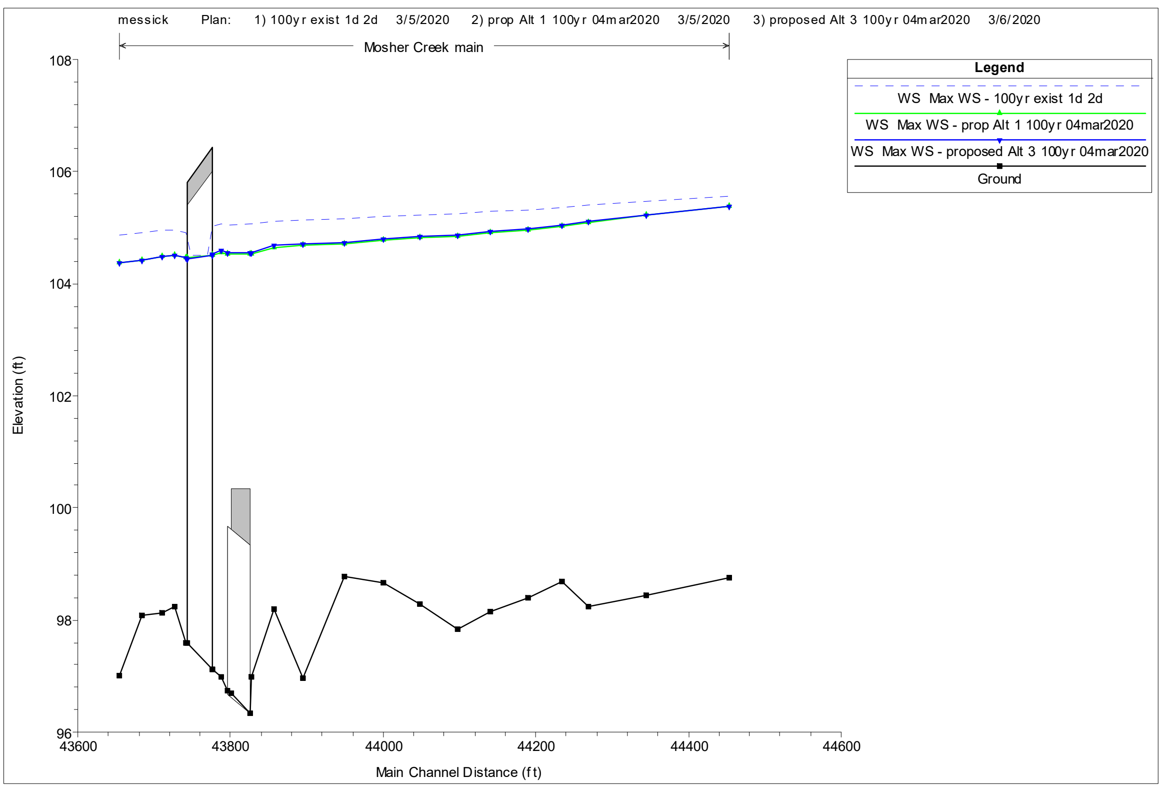

Figure 18. Water surface elevation profile comparison of existing to proposed for the 100-yr discharge

Table 5. Water Surface Elevation (WSE) comparison existing to proposed condition 50-yr discharges

River Station	Alt 1 & 2 50-year			Alt 3 50-year		
	Existing	Proposed	Difference	Existing	Proposed	Difference
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
44454	104.89	104.7	-0.19	104.89	104.71	-0.18
44345	104.77	104.55	-0.22	104.77	104.56	-0.21
44269	104.69	104.43	-0.26	104.69	104.44	-0.25
44234	104.64	104.36	-0.28	104.64	104.37	-0.27
44189	104.59	104.3	-0.29	104.59	104.31	-0.28
44140	104.56	104.25	-0.31	104.56	104.26	-0.3
44098	104.52	104.18	-0.34	104.52	104.19	-0.33
44048	104.5	104.16	-0.34	104.5	104.18	-0.32
44000	104.47	104.12	-0.35	104.47	104.14	-0.33
43950	104.44	104.08	-0.36	104.44	104.1	-0.34
43895	104.43	104.07	-0.36	104.43	104.08	-0.35
43857	104.41	104.04	-0.37	104.41	104.05	-0.36
43827	104.34	103.91	-0.43	104.34	103.93	-0.41
Upstream face of low water crossing			0			0
43796	104.34	103.94	-0.4	104.34	103.97	-0.37
43788	104.36	103.97	-0.39	104.36	103.99	-0.37
43777	104.33	103.94	-0.39	104.33	103.95	-0.38
Upstream face of bridge			0			0
43742	104.29	103.91	-0.38	104.29	103.9	-0.39
43727	104.31	103.93	-0.38	104.31	103.93	-0.38
43711	104.3	103.92	-0.38	104.3	103.91	-0.39
43684	104.27	103.87	-0.4	104.27	103.87	-0.4
43655	104.24	103.83	-0.41	104.24	103.83	-0.41

Table 6. Water Surface Elevation (WSE) comparison existing to proposed condition 100-yr discharges

River Station	Alt 1 & 2 100-year			Alt 3 100-year		
	Existing	Proposed	Difference	Existing	Proposed	Difference
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
44454	105.57	105.37	-0.2	105.57	105.38	-0.19
44345	105.47	105.22	-0.25	105.47	105.23	-0.24
44269	105.39	105.1	-0.29	105.39	105.11	-0.28
44234	105.36	105.03	-0.33	105.36	105.05	-0.31
44189	105.31	104.96	-0.35	105.31	104.98	-0.33
44140	105.28	104.91	-0.37	105.28	104.93	-0.35
44098	105.25	104.84	-0.41	105.25	104.87	-0.38
44048	105.23	104.81	-0.42	105.23	104.84	-0.39
44000	105.2	104.77	-0.43	105.2	104.79	-0.41
43950	105.17	104.72	-0.45	105.17	104.74	-0.43
43895	105.15	104.69	-0.46	105.15	104.72	-0.43
43857	105.12	104.65	-0.47	105.12	104.68	-0.44
43827	105.06	104.53	-0.53	105.06	104.56	-0.5
Upstream face of low water crossing						
43796	105.04	104.53	-0.51	105.04	104.56	-0.48
43788	105.06	104.56	-0.5	105.06	104.59	-0.47
43777	105.02	104.51	-0.51	105.02	104.53	-0.49
Upstream face of bridge						
43742	104.92	104.47	-0.45	104.92	104.46	-0.46
43727	104.96	104.5	-0.46	104.96	104.5	-0.46
43711	104.95	104.49	-0.46	104.95	104.48	-0.47
43684	104.9	104.42	-0.48	104.9	104.42	-0.48
43655	104.87	104.37	-0.5	104.87	104.37	-0.5

See Appendix C for complete HEC-RAS results. See Appendix D for Overtopping analysis.

HYDRAULIC CRITERIA AND DEBRIS

Chapter 820 of the Caltrans Highway Design Manual (HDM) delineates the hydraulic design criteria for bridges (Caltrans 2020). The basic HDM rule for hydraulic design is that bridges should be designed to pass the Q_{50} with sufficient freeboard and convey the Q_{100} without freeboard. Exceptions may be granted if the bridge designer can provide sufficient evidence that less freeboard is needed. The HDM notes that 2 feet of freeboard over the Q_{50} is often assumed to be appropriate for preliminary bridge designs but leaves the recommendation for freeboard to the judgment of the hydraulic engineer based primarily upon the debris anticipated at the bridge. The freeboard above the 50-year discharge controls the bridge design and more than zero feet of freeboard above the 100-year discharge is an additional benefit to the bridge.

The proposed soffit elevations and minimum freeboard for each alternative are presented in Table 7. The HDM criteria for preliminary design is not met.

Table 7. Soffit elevations and available freeboard for the 50-year and 100-year event.

	Alternative 1 and 2		Alternative 3	
	50-year	100-year	50-year	100-year
Minimum Soffit Elevation (ft)	105.2	105.2	105.9	105.9
Water Surface Elevation (ft)	103.9	104.5	104.0	104.5
Freeboard (ft)	1.3	0.7	1.9	1.4

Avila and Associates researched the available Bridge Maintenance Reports for the existing bridge to determine if floating debris catches on the bridge. There were no instances reported of debris captured by the bridge in the reports. The elimination of two piers from the channel will improve the hydraulics of the channel and will reduce the potential for capturing debris.

SCOUR

Degradation

Avila and Associates reviewed the available channel cross-sections to compare the oldest recorded condition in 1995 with the most recent cross sections taken in 2011. During this 16-year span of time, the channel lowered approximately 1 foot between 1995 and 2005, as shown in Figure 19. This lowering is within the margin of error for these measurements. Therefore, the historical cross sections were compared for the bridges upstream (29C0214 and 29C0215) and downstream (29C0275) on Mosher Creek. As shown in Figure 20 and Figure 21, the channel has been stable upstream of the project bridge from 1977 to 2011. However, as shown in Figure 22, the channel has lowered approximately 2 feet in 16 years at the bridge downstream on Mosher Creek. The cross sections at bridge 29C0275 are limited in detail and this bridge has a history of local pier scour; thus, the channel lowering may be the result of the local pier scour. Without additional historical cross sections at the project bridge, or downstream bridge, a conservative estimate of future degradation is 2 feet during the anticipated 75-year life of the proposed bridge.

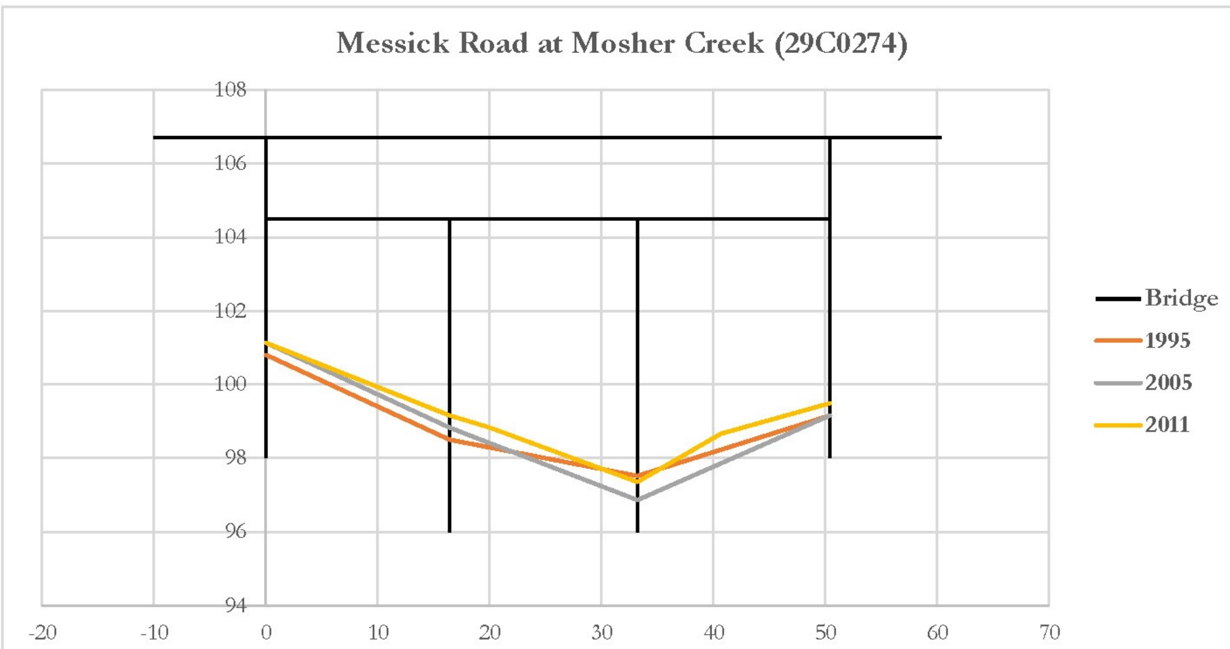

Figure 19. Cross sections taken at the project bridge over time (from Caltrans Maintenance Reports)

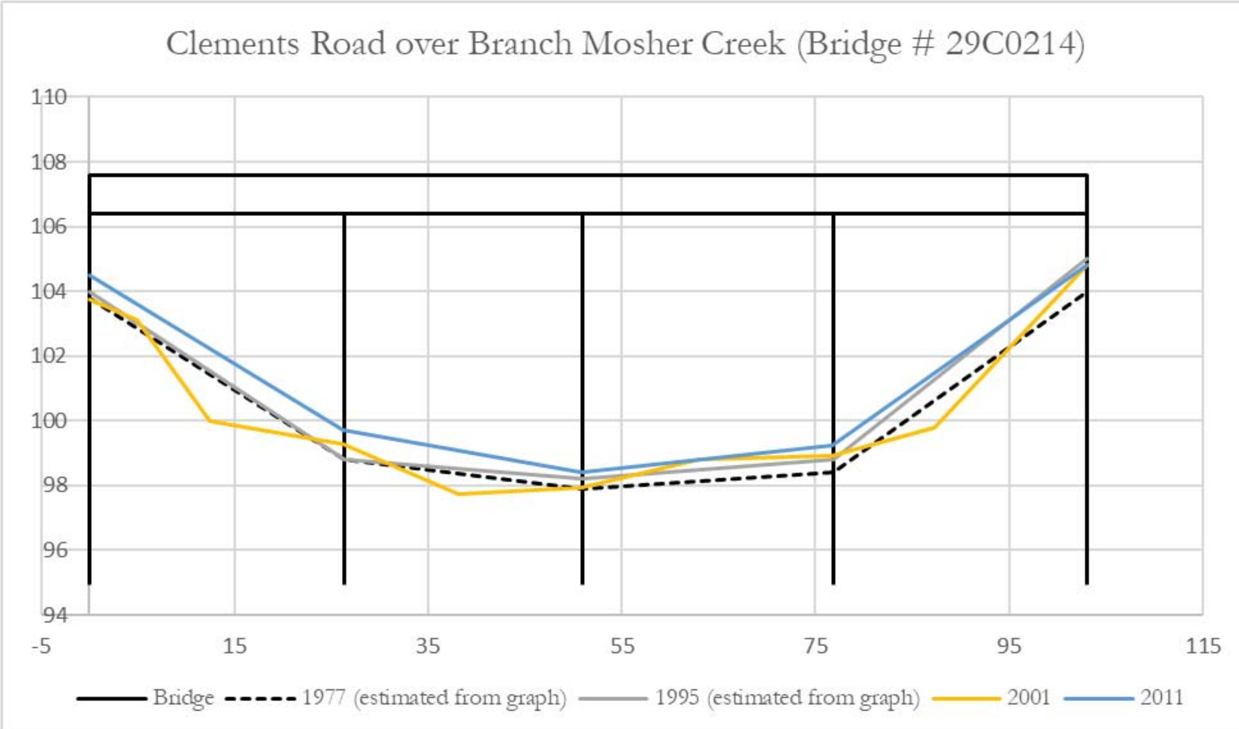

Figure 20. Cross sections taken at the upstream bridge over time (from Caltrans Maintenance Reports)

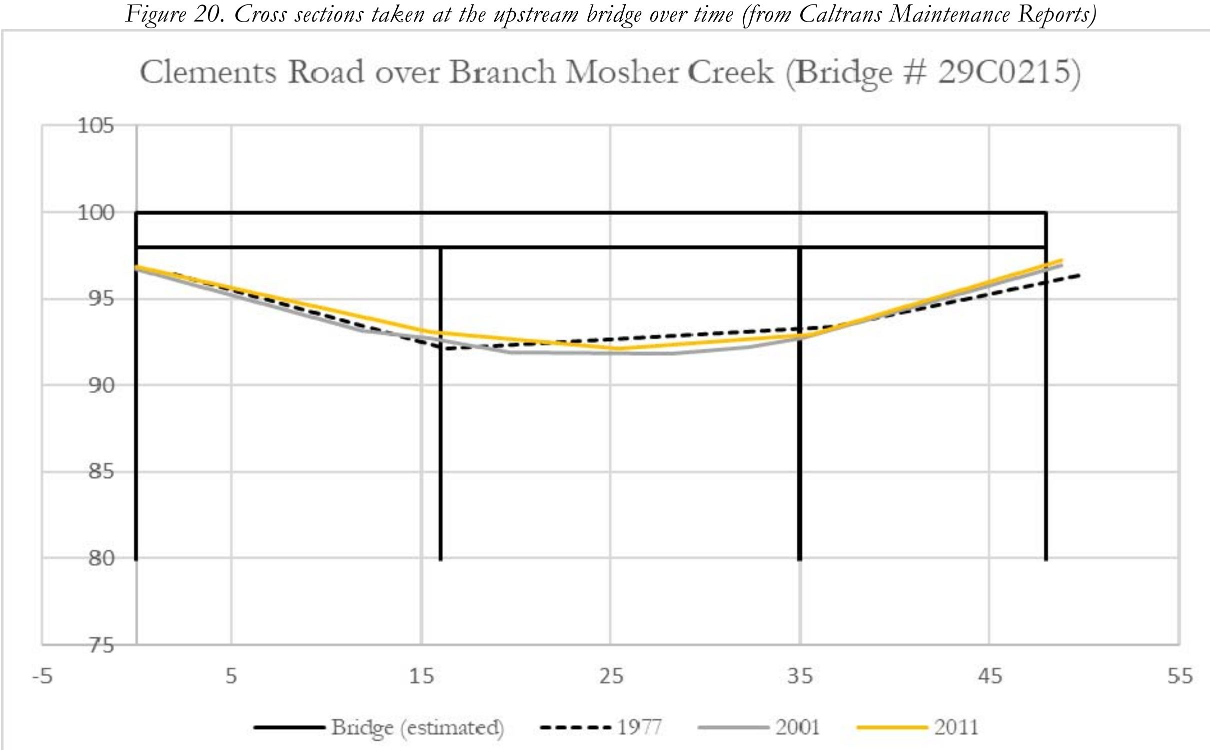

Figure 21. Cross sections taken at the upstream bridge over time (from Caltrans Maintenance Reports)

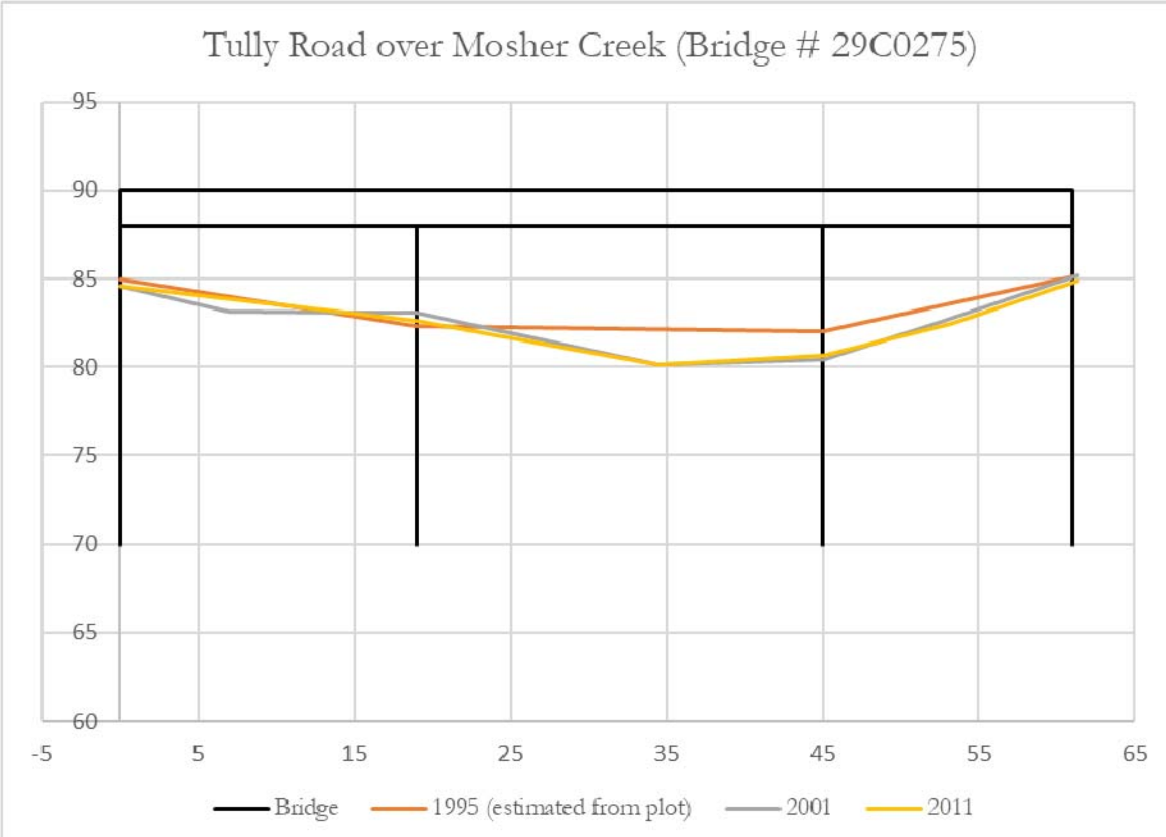

Figure 22. Cross sections taken at the downstream bridge over time (from Caltrans Maintenance Reports)

All scour calculations were completed following the methodology outlined in HEC-18 (Arneson, 2012). Scour calculations were preformed using the 100-year hydraulic results for the Alternative 1 model. Since, Alternative 2 is the same hydraulically as Alternative 1, these results apply to both alternatives. Alternative 3 is a concrete lined three cell reinforced concrete box culvert. Thus, bridge scour is not estimated for Alternative 3.

Contraction Scour

The proposed bridge does not constrict the channel. Thus, no contraction scour is anticipated.

Abutment Scour

Abutment scour was calculated using the equations from NCHRP 24-20 for Condition A (abutments near the main channel) for both Alternatives and Condition C for Alternative 2 (abutments fills washout and the abutments act as piers in the channel). Both calculations resulted in an estimated 4 feet of scour. Abutment scour Condition C will be calculated for Alternative 1, if it is the chosen alternative.

These equations are inclusive of contraction scour, thus additional contraction scour should not be added. Unless it is determined the channel cannot migrate laterally, thalweg migration to the abutment could occur. Therefore, the abutment scour elevation should be determined from the channel thalweg of 97 ft.

Total Scour

According to the Draft Foundation Report (Crawford, 2020), there is no scour resistant material at the project site. The total scour depths and elevations at the Messick Road Bridge over Mosher Creek are provided in Table 8, assuming a channel thalweg of 97 ft. The scour summary table is provided in Table 9.

Table 8. Total scour depths and elevations for Alternatives 1 and 2 assuming a thalweg elevation of 97 ft.

Support	A1	A2
Degradation Depth (ft)	2	2
Contraction Scour Depth (ft)	0	0
Abutment Scour Depth (ft)	4	4
Total Scour Depth (ft)	6	6
Total Scour Elevation (ft)	91	91

Table 9. Scour Summary Table for Alternatives 1 and 2.

Long Term & Short-Term Scour Depths			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short Term (Local) Scour Depth (ft)
A1	2	0	4
A2	2	0	4

See Appendix E for detailed scour calculations.

SUMMARY TABLES

The following Hydrologic Summary Table is provided for your use for placement on the Foundation Plan:

Drainage Area: Indeterminate

	Design	Base	Flood of Record
Frequency (Years)	50	100	(to be included in final report)
Discharge (Cubic feet per second)	520	755	
Alt 1 & 2 Water Surface (elevation in feet at upstream face of Bridge)	103.9	104.5	
Alt 3 Water Surface (elevation in feet at upstream face of Bridge)	104.0	104.5	

The following Scour Data Table is provided for placement on the Foundation Plan of Alternatives 1 and 2, assuming a thalweg elevation of 97 ft:

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
A1	95	4
A2	95	4

The following Scour Data Table is provided for placement on the Foundation Plan of Alternatives 3, assuming a thalweg elevation of 97 ft:

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
A1	95	n/a*
A2	95	n/a*

*Alternative 3 is a concrete lined three-box culvert. Thus, local bridge scour was not estimated.

Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the County and interested or affected parties should make their own investigation.

Location Hydraulic Study and Floodplain Evaluation Report:

The Floodplain Evaluation Report as outlined in 23 CFR 650 Subpart A, Section 650.111(b)(c)(d) will be included in Appendices G and H.

REFERENCES

Arneson, L.A., Zevenbergen, L.W., Lagasse, P.F., and Clopper, P.E. 2012. *Evaluating Scour at Bridges. Fifth Edition.* Hydraulic Engineering Circular No. 18. Federal Highway Administration Publication No. FHWA HIF-12-003, Washington, D.C. April.

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50-yr Existing and Proposed

HEC-RAS River: Mosher Creek Reach: main Profile: Max WS

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
main	44454	Max WS	50yr exist 25apr2023	492.98	98.75	104.92		105.02	0.000911	2.61	225.14	302.71	0.22
main	44454	Max WS	50yr prop 25apr2023	494.36	98.75	104.91		105.02	0.000923	2.62	223.94	300.35	0.22
main	44345	Max WS	50yr exist 25apr2023	484.32	98.44	104.81		104.92	0.000964	2.68	219.11	367.39	0.22
main	44345	Max WS	50yr prop 25apr2023	486.05	98.44	104.80		104.91	0.000979	2.70	217.48	362.99	0.22
main	44269	Max WS	50yr exist 25apr2023	479.89	98.25	104.73		104.85	0.001047	2.78	212.75	403.33	0.23
main	44269	Max WS	50yr prop 25apr2023	481.39	98.25	104.72		104.84	0.001065	2.80	210.79	396.41	0.23
main	44234	Max WS	50yr exist 25apr2023	478.95	98.69	104.69		104.81	0.001217	2.84	209.87	425.07	0.24
main	44234	Max WS	50yr prop 25apr2023	479.66	98.69	104.68		104.80	0.001236	2.86	207.89	419.86	0.24
main	44189	Max WS	50yr exist 25apr2023	477.74	98.41	104.65		104.76	0.001062	2.73	215.27	442.92	0.23
main	44189	Max WS	50yr prop 25apr2023	478.62	98.41	104.63		104.75	0.001078	2.75	213.25	437.56	0.23
main	44140	Max WS	50yr exist 25apr2023	476.92	98.16	104.61		104.71	0.000864	2.53	239.12	447.09	0.21
main	44140	Max WS	50yr prop 25apr2023	477.95	98.16	104.60		104.70	0.000879	2.54	236.83	441.17	0.21
main	44098	Max WS	50yr exist 25apr2023	476.17	97.84	104.57		104.67	0.000894	2.64	244.18	471.26	0.21
main	44098	Max WS	50yr prop 25apr2023	477.08	97.84	104.56		104.66	0.000911	2.66	241.70	459.07	0.21
main	44048	Max WS	50yr exist 25apr2023	475.95	98.28	104.56		104.63	0.000613	2.13	275.65	581.02	0.18
main	44048	Max WS	50yr prop 25apr2023	476.91	98.28	104.55		104.61	0.000625	2.14	273.29	566.65	0.18
main	44000	Max WS	50yr exist 25apr2023	475.83	98.66	104.53		104.60	0.000567	2.11	277.64	514.23	0.17
main	44000	Max WS	50yr prop 25apr2023	476.86	98.66	104.52		104.58	0.000577	2.12	275.51	503.62	0.17
main	43950	Max WS	50yr exist 25apr2023	475.89	98.78	104.51		104.57	0.000562	2.06	270.85	479.60	0.17
main	43950	Max WS	50yr prop 25apr2023	476.85	98.78	104.49		104.56	0.000571	2.08	269.06	470.32	0.17
main	43895	Max WS	50yr exist 25apr2023	475.85	96.97	104.49		104.54	0.000356	1.78	294.33	486.43	0.14
main	43895	Max WS	50yr prop 25apr2023	476.90	96.97	104.48		104.53	0.000361	1.79	292.80	477.62	0.14
main	43857	Max WS	50yr exist 25apr2023	475.81	98.19	104.47		104.53	0.000422	1.86	272.34	384.36	0.15
main	43857	Max WS	50yr prop 25apr2023	476.86	98.19	104.46		104.51	0.000428	1.87	271.12	365.02	0.15
main	43827	Max WS	50yr exist 25apr2023	475.77	96.98	104.41		104.51	0.001947	3.90	225.54	104.93	0.27
main	43827	Max WS	50yr prop 25apr2023	476.81	96.98	104.39		104.49	0.001782	3.72	223.85	103.92	0.26
main	43825			Culvert									
main	43796	Max WS	50yr exist 25apr2023	475.78	96.74	104.41		104.47	0.000469	2.45	292.42	84.33	0.17
main	43796	Max WS	50yr prop 25apr2023	476.84	96.74	104.39		104.46	0.000472	2.45	292.46	84.11	0.17
main	43788	Max WS	50yr exist 25apr2023	475.81	96.99	104.42		104.46	0.000360	1.64	291.15	78.82	0.14
main	43788	Max WS	50yr prop 25apr2023	476.80	96.99	104.40		104.44	0.000366	1.64	291.63	78.64	0.14

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HEC-RAS River: Mosher Creek Reach: main Profile: Max WS (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
main	43777	Max WS	50yr exist 25apr2023	475.73	97.13	104.39	99.96	104.46	0.000374	2.00	241.26	52.64	0.15
main	43777	Max WS	50yr prop 25apr2023	476.80	97.16	104.38	100.09	104.44	0.000377	1.95	244.04	59.84	0.15
main	43770.3			Bridge									
main	43742	Max WS	50yr exist 25apr2023	475.77	97.60	104.35		104.42	0.000378	2.12	232.07	43.34	0.15
main	43742	Max WS	50yr prop 25apr2023	476.80	97.62	104.37		104.42	0.000368	1.94	246.27	62.30	0.15
main	43727	Max WS	50yr exist 25apr2023	475.74	98.24	104.37		104.41	0.000335	1.63	292.67	68.06	0.13
main	43727	Max WS	50yr prop 25apr2023	476.83	98.24	104.38		104.42	0.000248	1.53	311.35	70.78	0.12
main	43711	Max WS	50yr exist 25apr2023	475.75	98.12	104.37		104.41	0.000349	1.66	286.07	122.61	0.14
main	43711	Max WS	50yr prop 25apr2023	476.81	98.12	104.37		104.41	0.000349	1.67	286.33	123.04	0.14
main	43684	Max WS	50yr exist 25apr2023	475.72	98.09	104.33		104.40	0.000618	2.01	236.87	158.46	0.18
main	43684	Max WS	50yr prop 25apr2023	476.79	98.09	104.34		104.40	0.000619	2.01	237.12	159.63	0.18
main	43655	Max WS	50yr exist 25apr2023	475.70	97.00	104.31	100.37	104.38	0.000633	2.10	226.75	77.07	0.18
main	43655	Max WS	50yr prop 25apr2023	476.77	97.00	104.31	100.37	104.38	0.000634	2.10	226.98	81.62	0.18

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100-year Existing and Proposed

HEC-RAS River: Mosher Creek Reach: main Profile: Max WS

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
main	44454	Max WS	100yr exist 25apr2023	698.75	98.75	105.57		105.69	0.000975	2.90	327.79	339.89	0.23
main	44454	Max WS	100yr prop 25apr2023	700.32	98.75	105.56		105.67	0.000993	2.92	325.51	339.80	0.23
main	44345	Max WS	100yr exist 25apr2023	689.27	98.44	105.46		105.58	0.001009	2.95	331.59	431.97	0.23
main	44345	Max WS	100yr prop 25apr2023	690.89	98.44	105.45		105.56	0.001031	2.97	328.63	431.88	0.23
main	44269	Max WS	100yr exist 25apr2023	682.06	98.25	105.38		105.50	0.001058	3.00	332.44	499.11	0.23
main	44269	Max WS	100yr prop 25apr2023	684.84	98.25	105.36		105.48	0.001089	3.03	328.85	499.01	0.24
main	44234	Max WS	100yr exist 25apr2023	678.55	98.69	105.34		105.46	0.001187	3.02	322.29	524.97	0.24
main	44234	Max WS	100yr prop 25apr2023	681.28	98.69	105.32		105.44	0.001226	3.05	318.66	524.23	0.25
main	44189	Max WS	100yr exist 25apr2023	675.47	98.41	105.29		105.41	0.001074	2.95	322.48	561.68	0.23
main	44189	Max WS	100yr prop 25apr2023	678.42	98.41	105.27		105.39	0.001110	2.99	318.63	557.99	0.24
main	44140	Max WS	100yr exist 25apr2023	674.24	98.16	105.26		105.36	0.000878	2.72	357.89	589.69	0.21
main	44140	Max WS	100yr prop 25apr2023	677.12	98.16	105.24		105.34	0.000909	2.76	353.49	589.19	0.22
main	44098	Max WS	100yr exist 25apr2023	673.16	97.84	105.22		105.32	0.000893	2.80	369.80	616.03	0.21
main	44098	Max WS	100yr prop 25apr2023	675.69	97.84	105.20		105.30	0.000926	2.84	364.73	615.90	0.22
main	44048	Max WS	100yr exist 25apr2023	672.96	98.28	105.20		105.28	0.000631	2.36	392.07	780.52	0.19
main	44048	Max WS	100yr prop 25apr2023	675.39	98.28	105.17		105.25	0.000652	2.39	387.14	780.15	0.19
main	44000	Max WS	100yr exist 25apr2023	672.95	98.66	105.17		105.25	0.000618	2.39	378.17	743.50	0.18
main	44000	Max WS	100yr prop 25apr2023	675.12	98.66	105.14		105.22	0.000638	2.42	373.75	742.11	0.19
main	43950	Max WS	100yr exist 25apr2023	672.97	98.78	105.13		105.21	0.000656	2.37	356.33	711.42	0.19
main	43950	Max WS	100yr prop 25apr2023	675.26	98.78	105.11		105.19	0.000677	2.40	352.35	706.35	0.19
main	43895	Max WS	100yr exist 25apr2023	673.14	96.97	105.11		105.18	0.000456	2.16	361.82	723.63	0.16
main	43895	Max WS	100yr prop 25apr2023	675.33	96.97	105.08		105.15	0.000469	2.18	358.49	716.80	0.16
main	43857	Max WS	100yr exist 25apr2023	673.14	98.19	105.08		105.16	0.000543	2.27	325.36	685.31	0.17
main	43857	Max WS	100yr prop 25apr2023	675.44	98.19	105.06		105.13	0.000558	2.29	322.76	678.27	0.18
main	43827	Max WS	100yr exist 25apr2023	673.13	96.98	105.02		105.14	0.002301	4.50	295.23	124.70	0.30
main	43827	Max WS	100yr prop 25apr2023	675.44	96.98	104.99		105.11	0.002398	4.58	291.35	124.06	0.31
main	43825			Culvert									
main	43796	Max WS	100yr exist 25apr2023	673.13	96.74	105.01		105.10	0.000641	3.03	345.56	95.35	0.20
main	43796	Max WS	100yr prop 25apr2023	675.44	96.74	104.96		105.07	0.000655	3.06	343.16	94.09	0.20
main	43788	Max WS	100yr exist 25apr2023	673.12	96.99	105.02		105.09	0.000489	2.03	333.79	85.76	0.16
main	43788	Max WS	100yr prop 25apr2023	675.43	96.99	104.98		105.05	0.000503	2.04	332.52	85.32	0.17

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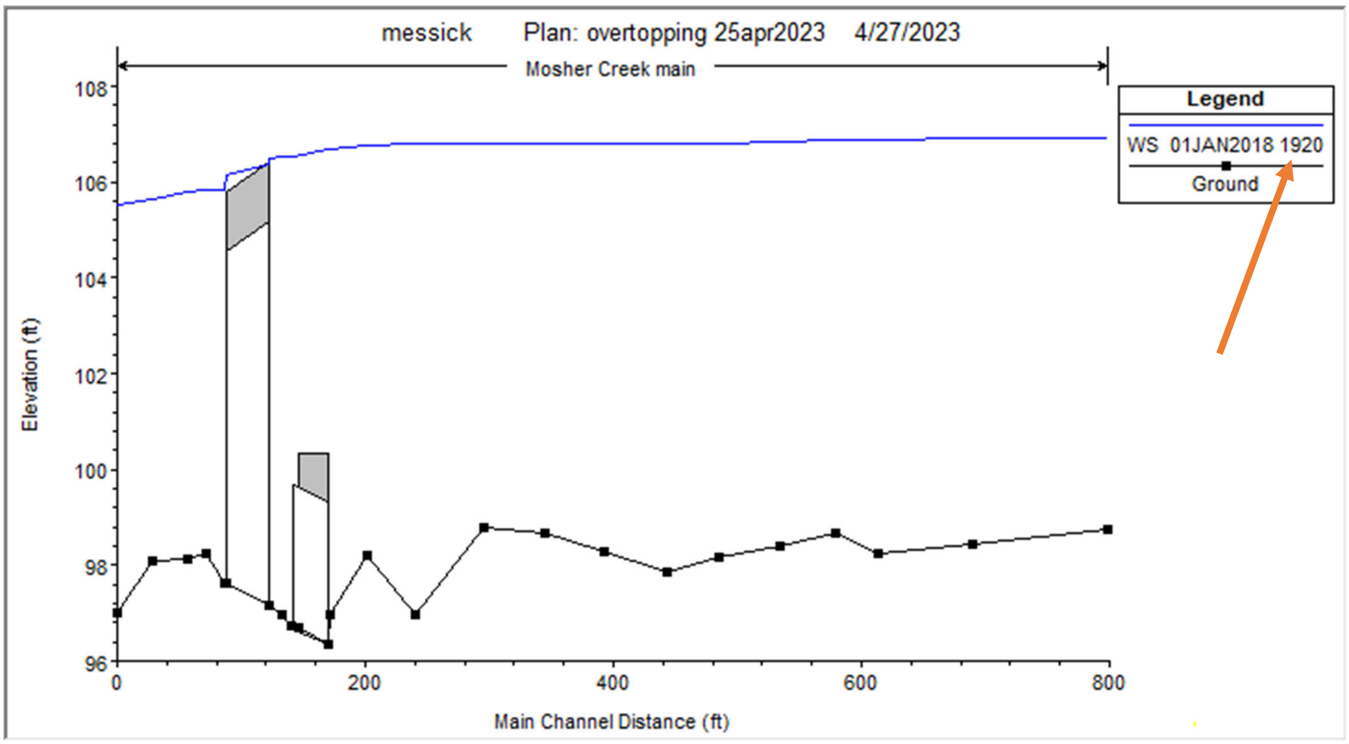
HEC-RAS River: Mosher Creek Reach: main Profile: Max WS (Continued)

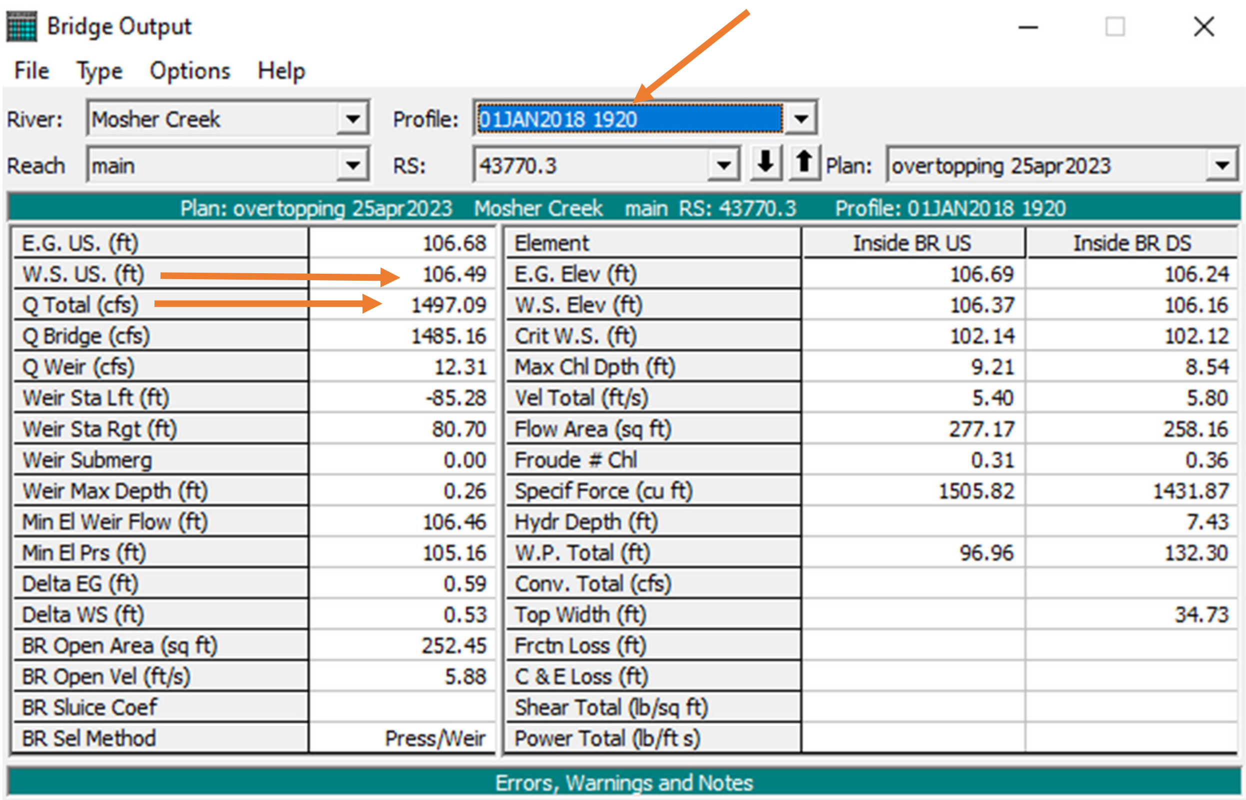
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
main	43777	Max WS	100yr exist 25apr2023	673.11	97.13	104.98	100.50	105.08	0.000539	2.57	266.52	67.92	0.18
main	43777	Max WS	100yr prop 25apr2023	675.43	97.16	104.94	100.60	105.04	0.000546	2.51	269.12	63.94	0.18
main	43770.3			Bridge									
main	43742	Max WS	100yr exist 25apr2023	673.08	97.60	104.88		104.99	0.000572	2.76	253.67	46.11	0.19
main	43742	Max WS	100yr prop 25apr2023	675.40	97.62	104.90		104.99	0.000543	2.50	269.99	65.78	0.18
main	43727	Max WS	100yr exist 25apr2023	673.10	98.24	104.92		104.98	0.000472	2.05	327.96	172.95	0.16
main	43727	Max WS	100yr prop 25apr2023	675.42	98.24	104.93		104.99	0.000356	1.96	344.16	173.65	0.14
main	43711	Max WS	100yr exist 25apr2023	673.10	98.12	104.91		104.97	0.000502	2.10	319.84	203.92	0.17
main	43711	Max WS	100yr prop 25apr2023	675.42	98.12	104.91		104.98	0.000504	2.11	320.10	204.03	0.17
main	43684	Max WS	100yr exist 25apr2023	673.10	98.09	104.86		104.96	0.000845	2.50	269.51	253.09	0.21
main	43684	Max WS	100yr prop 25apr2023	675.42	98.09	104.86		104.96	0.000849	2.51	269.76	253.20	0.21
main	43655	Max WS	100yr exist 25apr2023	673.08	97.00	104.82	100.93	104.93	0.000907	2.63	257.54	154.02	0.22
main	43655	Max WS	100yr prop 25apr2023	675.40	97.00	104.83	100.93	104.94	0.000910	2.64	257.81	154.17	0.22

APPENDIX E – OVERTOPPING AND FLOOD OF RECORD

Overtopping

Based on the proposed roadway profile, water will begin to overtop the road at an approximate elevation of 106.5. To determine the discharge that results in a WSE of 106.5 at the upstream face of the bridge, the proposed condition model was re-run using the same input flow hydrograph, but scaled 2.25 times (i.e. peak discharge is 1,700 cfs vs 100-yr discharge of 755 cfs). Results of the analysis indicate that the roadway will overtop when approximately 1,500 cfs is flowing in the creek. This occurs at simulation time 19:20 as shown in the profile and table below.




Bridge Output

File Type Options Help

River: Mosher Creek Profile: 01JAN2018 1920

Reach main RS: 43770.3 Plan: overtopping 25apr2023

Plan: overtopping 25apr2023 Mosher Creek main RS: 43770.3 Profile: 01JAN2018 1920

		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	106.68	E.G. Elev (ft)	106.69	106.24
W.S. US. (ft)	106.49	W.S. Elev (ft)	106.37	106.16
Q Total (cfs)	1497.09	Crit W.S. (ft)	102.14	102.12
Q Bridge (cfs)	1485.16	Max Chl Dpth (ft)	9.21	8.54
Q Weir (cfs)	12.31	Vel Total (ft/s)	5.40	5.80
Weir Sta Lft (ft)	-85.28	Flow Area (sq ft)	277.17	258.16
Weir Sta Rgt (ft)	80.70	Froude # Chl	0.31	0.36
Weir Submerg	0.00	Specif Force (cu ft)	1505.82	1431.87
Weir Max Depth (ft)	0.26	Hydr Depth (ft)		7.43
Min El Weir Flow (ft)	106.46	W.P. Total (ft)	96.96	132.30
Min El Prs (ft)	105.16	Conv. Total (cfs)		
Delta EG (ft)	0.59	Top Width (ft)		34.73
Delta WS (ft)	0.53	Frctn Loss (ft)		
BR Open Area (sq ft)	252.45	C & E Loss (ft)		
BR Open Vel (ft/s)	5.88	Shear Total (lb/sq ft)		
BR Sluice Coef		Power Total (lb/ft s)		
BR Sel Method	Press/Weir			

Errors, Warnings and Notes

Flood of Record

There is a stream gage on Dry Creek approximately 15.5 miles northwest of the project (USGS Gage #11329500). Flows in Dry Creek are not affected by regulation or diversion. There are 50 peak discharge records available that were recorded between 1927 and 1987. The highest peak discharge in Dry Creek was 30,300 cfs recorded February 1986. The gage data from #11329500 was analyzed using program HEC-SSP (version 2.2, Bulletin 17C). Results of the statistical analysis indicate that the February 1986 storm had a recurrence interval of approximately 90-years (1.09 percent chance of occurring in any given year). The results also indicate that the 100-year discharge in Dry Creek at the gage is approximately 35,950 cfs. Applying the same ratio of the historical recorded discharge to the 100-year (30,300/35,950) to the 100-year discharge in Mosher Creek of 755 cfs, the 90-year discharge in Mosher Creek at the project is estimated to be approximately 636 cfs. From the results of the 100-yr proposed condition analysis, the time of the simulation that corresponded with 636 cfs through the bridge was approximately 19:20. The WSE at the upstream face of the bridge at time 19:20 in the simulation is approximately 104.9.

The scour condition is Live Bed.

HEC-18 5th Edition - Scour Calculation Spreadsheet (1D)

Critical Velocity Calculation (Clear vs. Live Bed Determination)

***Critical Velocity* (V_c): The velocity above which the bed material of size D, D_{50}, etc. and smaller will be transported. Critical velocity is used as an indicator for clear-water or live-bed scour.**

→ If the mean velocity (V) of the upstream reach is equal to or less than the critical velocity (V_c) of the median diameter (D_{50}) of the bed material, then contraction and local scour will be clear-water.

→ If the mean velocity (V) of the upstream reach is greater than the critical velocity (V_c) of the median diameter (D_{50}) of the bed material, then contraction and local scour will be live-bed.

Parameter	Metric		US	
Median Diameter of Bed Material (D_{50}):	0.20	(mm)	0.2	(mm)
Average Upstream Depth (y):	1.49	(m)	4.90	(ft)
Critical Velocity Parameter (K_u):	6.19	($m^{1/2}/s$)	11.17	($ft^{1/2}/s$)
Average Upstream Velocity (V):	0.661	(m/s)	2.17	(ft/s)
Critical Velocity (V_c):	0.387	(m/s)	**1.3**	(ft/s)

$$V_c = K_u\, y^{1/6}\, D^{1/3}$$

*Note: To determine Live Bed Scour vs Clear Scour, D in the equation above is set equal to D_{50}

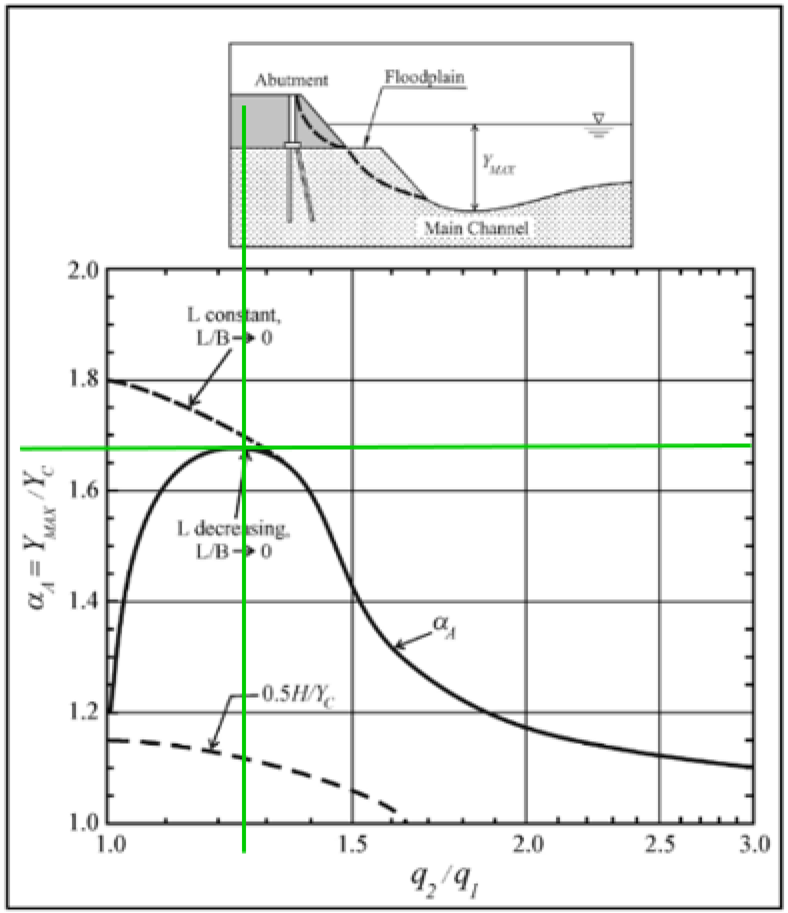
Upstream $V \le V_c$: Clear Water Contraction Scour

Upstream $V > V_c$: Live Bed Contraction Scour

Proceed to Live Bed Contraction Scour Tab

Abutment Scour Condition A

The amplification factor for abutment scour Condition A is 1.68.



2a) Scour occurring when the abutment is in or close to the main channel (Live Bed)

$$y_c = y_1 \left(\frac{q_{2c}}{q_1} \right)^{6/7}$$

$$y_{max} = \alpha_A \, y_c$$

$$y_s = y_{max} - y_0$$

Parameter	Description	Metric Units		US Units		Notes
y_1	Upstream flow depth	1.49	(m)	4.90	(ft)	*Flow area of bridge / W_2*
y_0	Flow depth prior to scour	1.76	(m)	5.77	(ft)	*Data from chosen upstream XS*
α_a	Amplification factor for live-bed conditions	1.68	-	**1.68**	-	*For spill through abutments: Use Figure 8.9* *For wingwall abutments: Use Figure 8.10*
W_1	Width of the upstream channel	16.25	(m)	53.31	(ft)	*Width of Flow upstream of the bridge section*
Q_1	Flow in the upstream channel	19.06	(m^3/s)	673.2	(ft^3/s)	*Flow upstream of the bridge section*
q_{2c}	Unit discharge in the constricted opening accounting for non-uniform flow distribution	1.46	(m^2/s)	15.74	(ft^2/s)	*Estimated as the total discharge in the bridge opening divided by the width of the bridge opening: Q_2 / W_2*
q_1	Upstream unit discharge	1.17	(m^2/s)	12.63	(ft^2/s)	*Q_1 / W_1*
q_2/q_1	Ratio of unit discharge	1.25	(m)	1.25	(ft)	*Value used in Figure 8.9 and Figure 8.10 to determine amplification factor*
y_c	Flow depth including live-bed contraction scour	1.80	(m)	5.92	(ft)	*Equation Above*
y_{max}	Max flow depth resulting from abutment scou	3.03	(m)	9.94	(ft)	*Equation Above*

Live Bed Abutment Scour Depth (y_s)	**4.2**	**(ft)**
	1.3	(m)

~DRAFT~

Abutment Scour Condition C

Scour Condition C assumes the abutment fills wash out and the abutment pile acts as a pier in the channel. Pier scour for a 2-foot pile is shown below.

RIVER FOCUS
WATER RESOURCE CONSULTANTS

HEC-18 5th Edition - Scour Calculation Spreadsheet (1D)

Pier Scour

***Pier Scour* is a function of bed material characteristics, bed configuration, flow characteristics, fluid properties, and the geometry of the pier and footing.**

1). HEC-18 5th Edition Pier Scour Equation (based on the CSU Equation)

HEC-18 Equation: $\frac{y_s}{y_1} = 2.0\, K_1\, K_2\, K_3 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43}$

In terms of y_s/a: $\frac{y_s}{a} = 2.0\, K_1\, K_2\, K_3 \left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43}$

Parameter	Description	Metric Units		US Units		Notes
y_1	Flow depth directly upstream of the pier	1.49	(m)	4.90	(ft)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
θ	Angle of attack of the flow (skew)	0	(deg)	0	(deg)	*Bridge Skew*
K_1	Correction factor for Pier nose shape	1.1	-	1.1	-	*Use Figure 7.3 and Table 7.1* ***If θ > 5 degrees, K_1 = 1.0***
K_2	Correction factor for angle of attack of flow	1.0	-	1.0		*$K_2 = [(\cos(\theta) + \sin(\theta) * L/A)^{0.65}]$ (where L/A_{max} = 12)*
K_3	Correction factor for bed condition	1.1	-	1.1	-	*Use Table 7.3*
a	Pier Width (including bottom width)	0.6	(m)	2.00	(ft)	*Bottom Pier Width; no floating debris included*
L	Length of Pier	0.0	(m)	0.0	(ft)	*See Figure 7.3 for Guidance*
V_1	Velocity of flow directly upstream of the pier	0.98	(m/s)	3.23	(ft/s)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
Fr_1	Froude Number directly upstream of the pier	0.26	-	0.26	-	*$Fr_1 = [V_1 / (gy_1)^{1/2}]$*

HEC-18 Equation Maximum Pier Scour Depth (y_s)	**3.7**	**(ft)**
	1.1	(m)

***Note for Round Nose Piers:**

Maximum Scour Depth (y_s) is typically ≤ (2.4 * a) for Fr ≤ 0.8 → 2.4 * a = 4.80

Maximum Scour Depth (y_s) is typically ≤ (3.0 * a) for Fr > 0.8 → 3.0 * a = 6.00

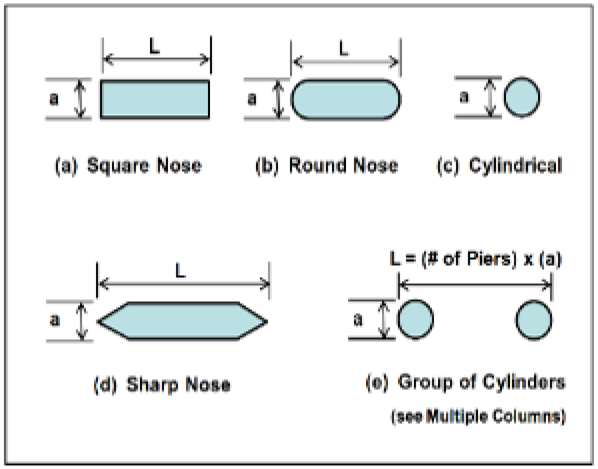


Figure 7.3. Common pier shapes.

Table 7.1. Correction Factor, K_1, for Pier Nose Shape.	
Shape of Pier Nose	K_1
(a) Square nose	1.1
(b) Round nose	1.0
(c) Circular cylinder	1.0
(d) Group of cylinders	1.0
(e) Sharp nose	0.9

Table 7.3. Increase in Equilibrium Pier Scour Depths, K_3, for Bed Condition.		
Bed Condition	Dune Height ft	K_3
Clear-Water Scour	N/A	1.1
Plane bed and Antidune flow	N/A	1.1
Small Dunes	$10 > H \geq 2$	1.1
Medium Dunes	$30 > H \geq 10$	1.2 to 1.1
Large Dunes	$H \geq 30$	1.3

APPENDIX G – ROCK RIP RAP SIZING

(to be included with final report if needed)

APPENDIX H – LOCATION HYDRAULIC STUDY FORM

LOCATION HYDRAULIC STUDY FORM

Dist. ______10____Co.__San Joaquin_____Rte. ______Messick Road__Project ID: ____Bridge # 29C0274____
Federal-Aid Project Number:___________BRLO-5929(254)_____________________

Floodplain Description:

Mosher Creek flows northwesterly through the project site through the northern part of San Joaquin County and drains an indeterminate size basin at the bridge. The area surrounding the project is rural and agricultural. The channel is approximately 52 feet wide (top of bank to top of bank) and approximately 7 feet deep (top of bank to toe of bank) through the project area. The channel bottom is sparsely vegetated, and the banks and overbank areas are more heavily vegetated. Mosher Creek through the project area is within an existing FEMA Zone AE floodplain with base flood elevations (BFE's) determined and a floodway.

1. Description of Proposal *(include any physical barriers i.e. concrete barriers, sound walls, etc. and design elements to minimize floodplain impacts)*

The County of San Joaquin proposes to demolish and replace the existing Messick Road Bridge (29C0274) that crosses Mosher Creek with a new bridge structure. The Messick Road Bridge carries one 10-foot lane of traffic in each east-west direction and has no shoulders. The existing bridge was constructed in 1931 and consists of timber decking with asphalt concrete (AC) overlay supported on concrete columns. The replacement bridge would maintain the existing lane configuration but would incorporate 3-foot shoulders within County right of way. The profile of the proposed bridge would match the existing configuration to reduce impact to the structure approach areas. The number of spans associated with the bridge would be reduced from the current three-span configuration to a single span. The proposed structure would be supported by abutments at each bank of the creek founded on Cast in Steel Shell (CISS) or Cast in Drilled Hole (CIDH) piles. Wing walls would be constructed adjacent to the abutments and rock slope protection would be placed along the exterior of each wing wall. A new metal beam guard rail is proposed at all tie-in points to the bridge barriers to meet current American Association of State Highway and Transportation Officials (AASHTO) and Caltrans standards.

The existing Messick Road Bridge is over 90 years old and does not meet current bridge design standards. Structural and functional deficiencies have been identified for the bridge, such as section loss in substructure, decay in substructure, intolerable deck geometry, and substandard bridge and approach railings. The proposed project would construct a new bridge meeting current engineering standards to enhance the safety of motorists and bicyclists in the project area.

2. ADT: Current__87___ Projected _____87 (2030)______

3. Hydraulic Data: Base Flood Q100= 755 CFS

WSE100= 104.9 ft (NAVD-88)_

The flood of record, if greater than Q100:

Q= n/a CFS WSE= n/a

Overtopping flood Q=__1,500 CFS WSE= 106.5 ft (NAVD-88)___

Are NFIP maps and studies available? NO__________YES___X_____

The project is within a FEMA designated Zone AE floodplain with BFE's determined and a floodway as shown on Figure 1.

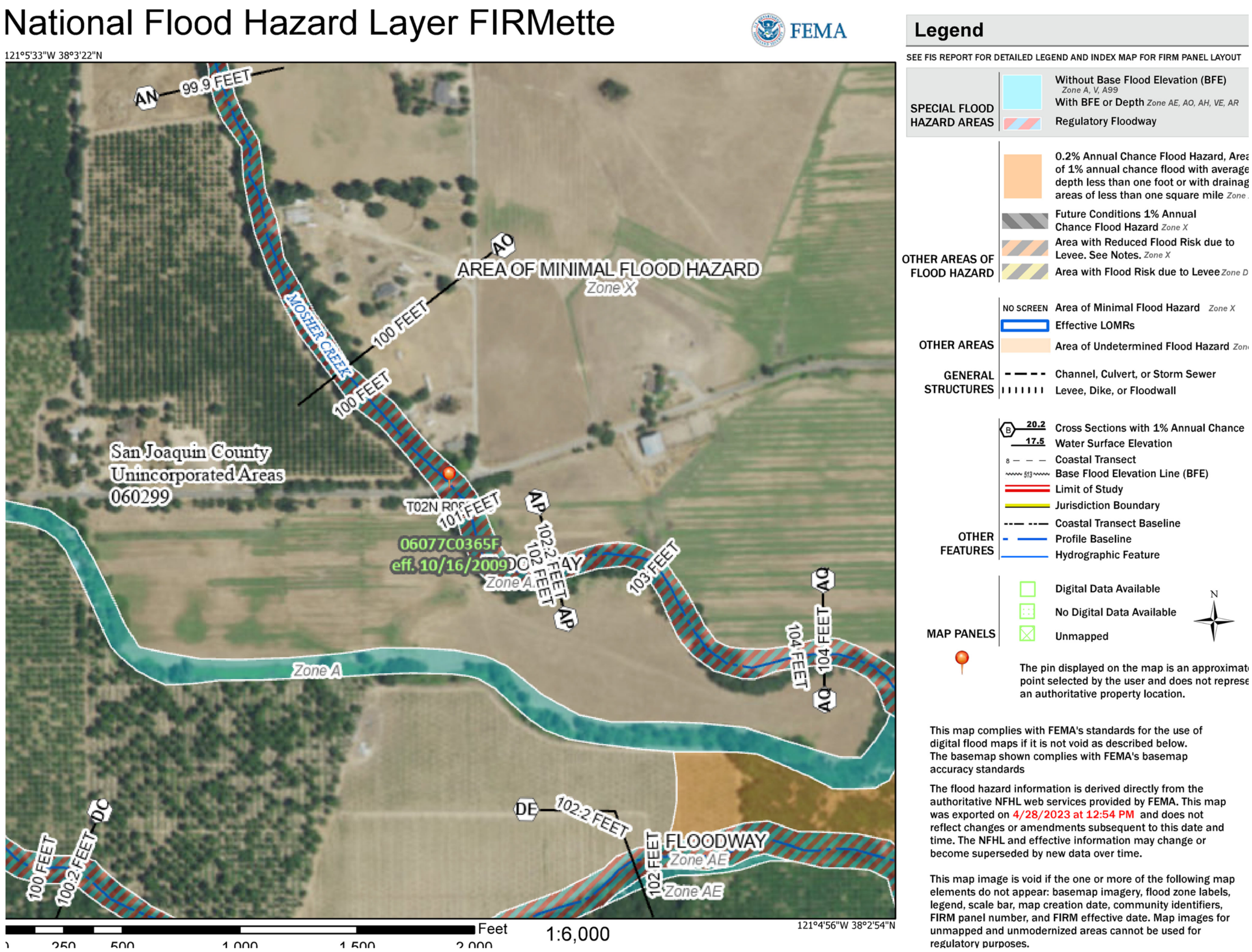


Figure 1. FEMA FIRMette of Map Number 06077C0365F effective October 16, 2009.

4. Is the highway location alternative within a regulatory floodway? NO ______ YES____X_

Messick Road crosses the floodway. The new bridge will replace the existing bridge at the same location.

5. Attach map with flood limits outlined showing all buildings or other improvements within the base floodplain.

As shown in Figure 1, the base floodplain appears to be contained by the banks of Mosher Creek. Figure 2 shows the computed 100-year inundation limits in the vicinity of the project for both the existing and proposed conditions. There is shallow flooding in the overbank areas (less than 1 foot depth) as shown by the progression of Figure 3 (depths less than 0.5 feet eliminated) and Figure 4 (depths less than 1 foot eliminated).

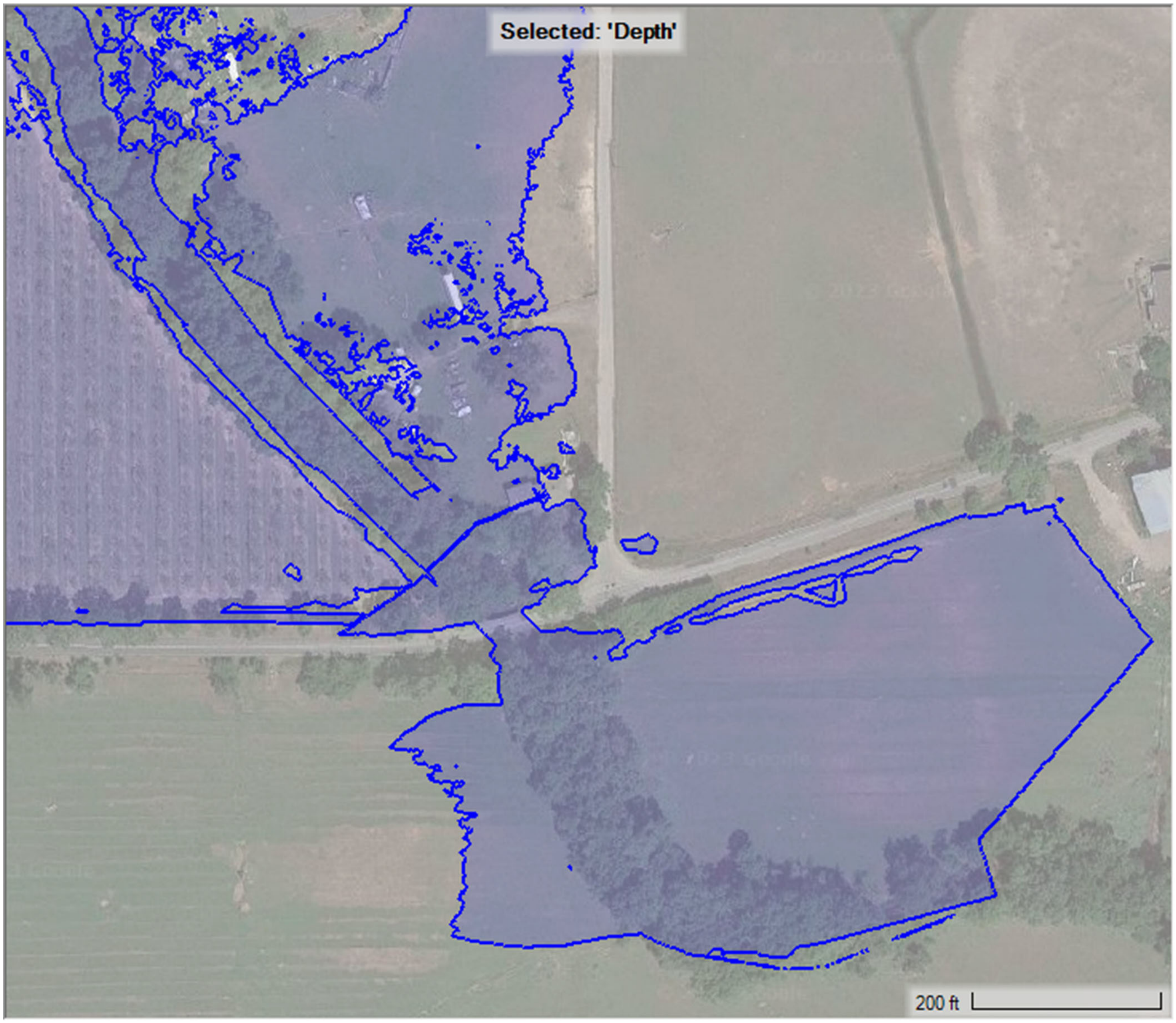


Figure 2. 100-year Inundation limits for existing and proposed conditions.

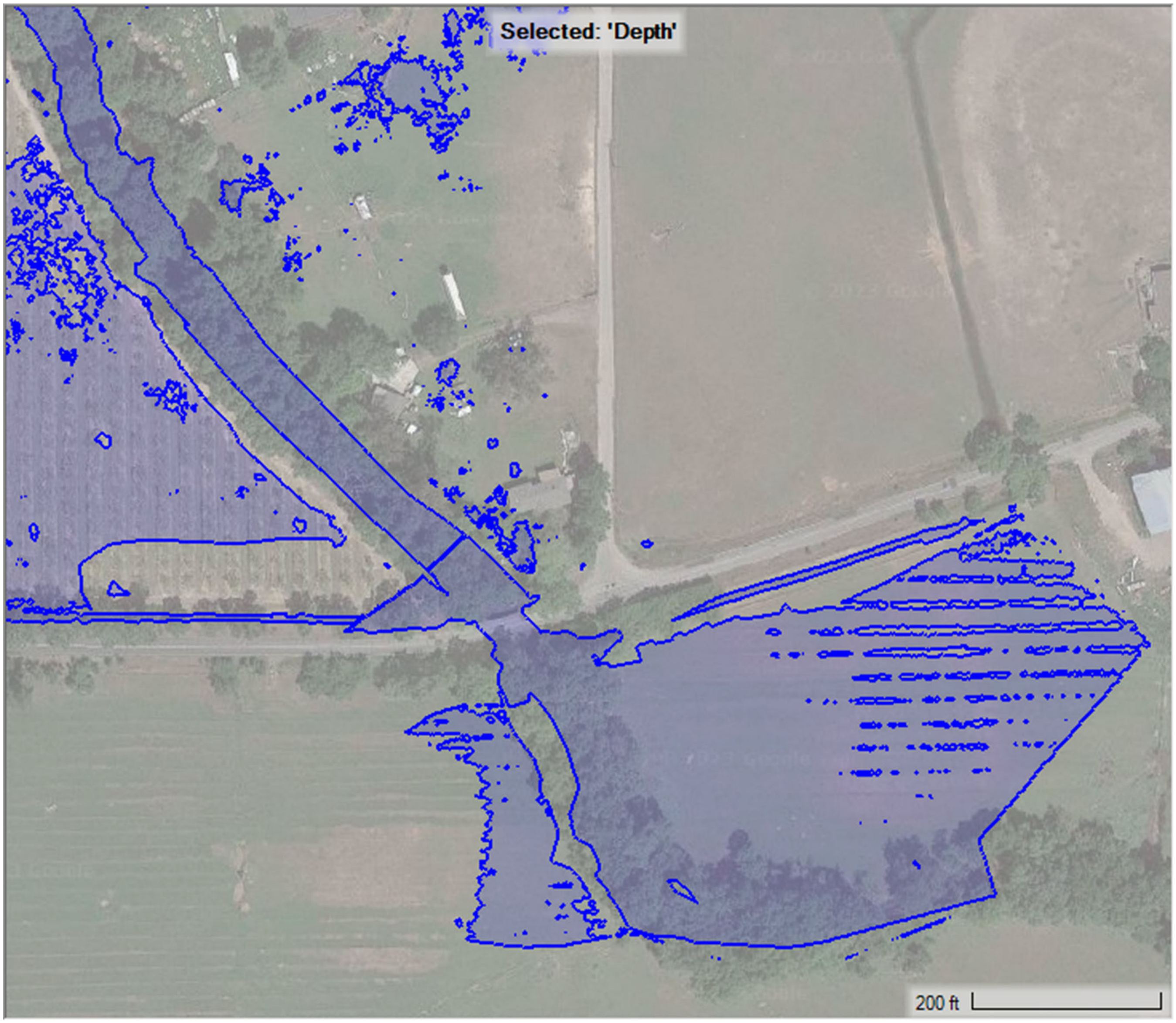


Figure 3. 100-year Inundation limits with depths less than 0.5 feet eliminated (existing and proposed conditions).

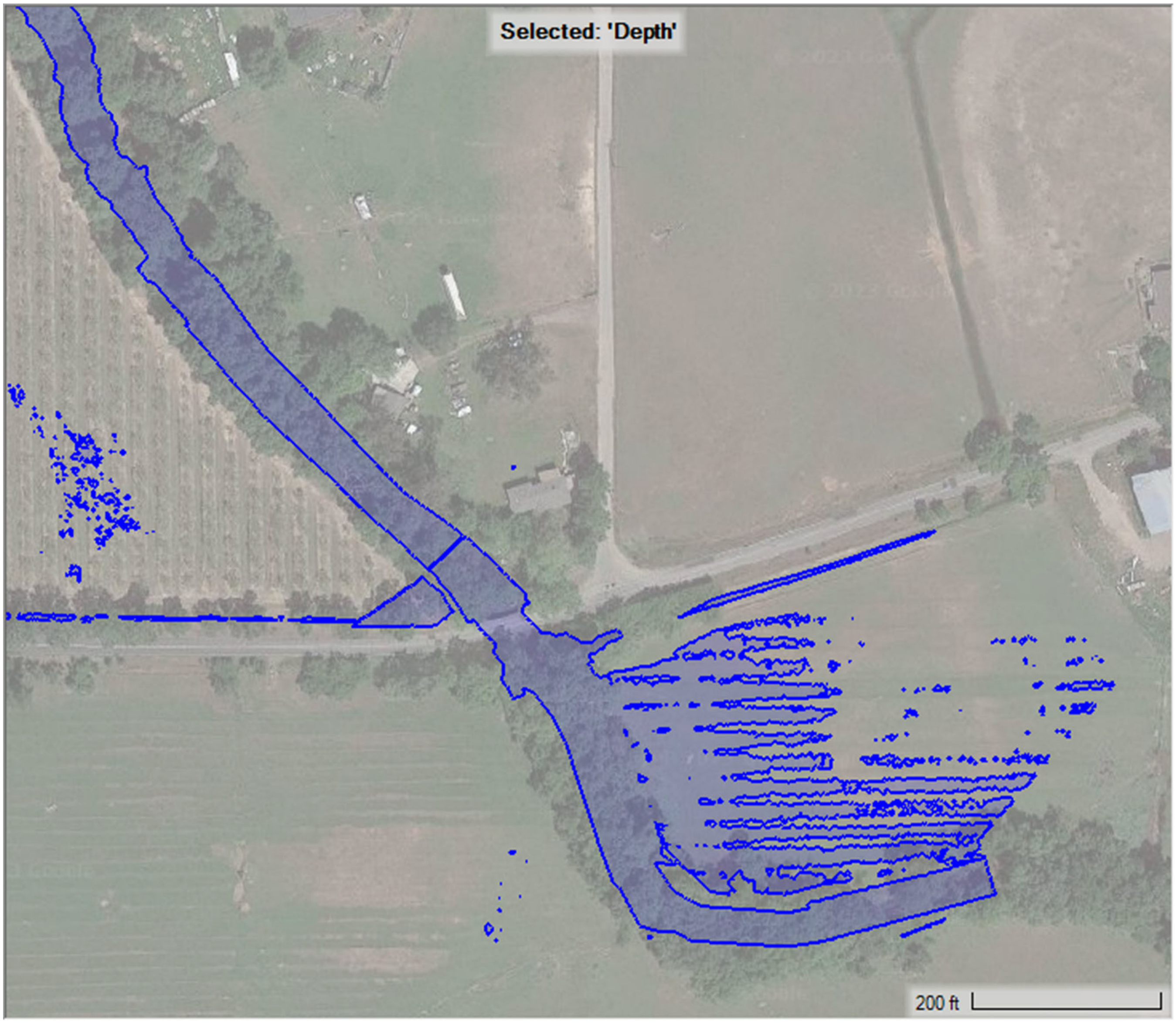


Figure 4. 100-year Inundation limits with depths less than 1 foot eliminated (existing and proposed conditions).

Figure 5 shows the algebraic difference between the 100-year proposed maximum WSE and existing maximum WSE. It is color graduated in increments of 0.01 feet. Areas in green indicate a decrease in WSE and areas in red indicate an increase in WSE under the proposed condition. As shown in Figure 5, the WSE is decreased upstream from the bridge and increased within a small area downstream. The majority of the area downstream is unchanged. As shown in Figure 6, the amount of decrease just upstream from the bridge is approximately 0.04 feet and the amount of increase just downstream is approximately 0.02 feet. The WSE profile returns to the existing condition approximately 32 feet downstream from the bridge.

Increases in WSE within a floodway are prohibited. The results presented are based on a 35% design of the roadway, bridge, and grading. During the 65% design phase, the roadway profile, bridge length, and grading will be revised to eliminate the areas of increased WSE. This can be achieved by either shortening the bridge span, changing the channel grading, or a combination of both. The road profile and bridge deck will also be raised to provide freeboard on the downstream side of the bridge. In the final design, the bridge geometrics and grading will be designed to cause no rise in WSE, and pass the 100-yr design storm without going under pressure flow.

Figure 5. Algebraic difference between 100-year proposed WSE and existing WSE (green indicates a decrease in WSE, red an increase, grey no change)

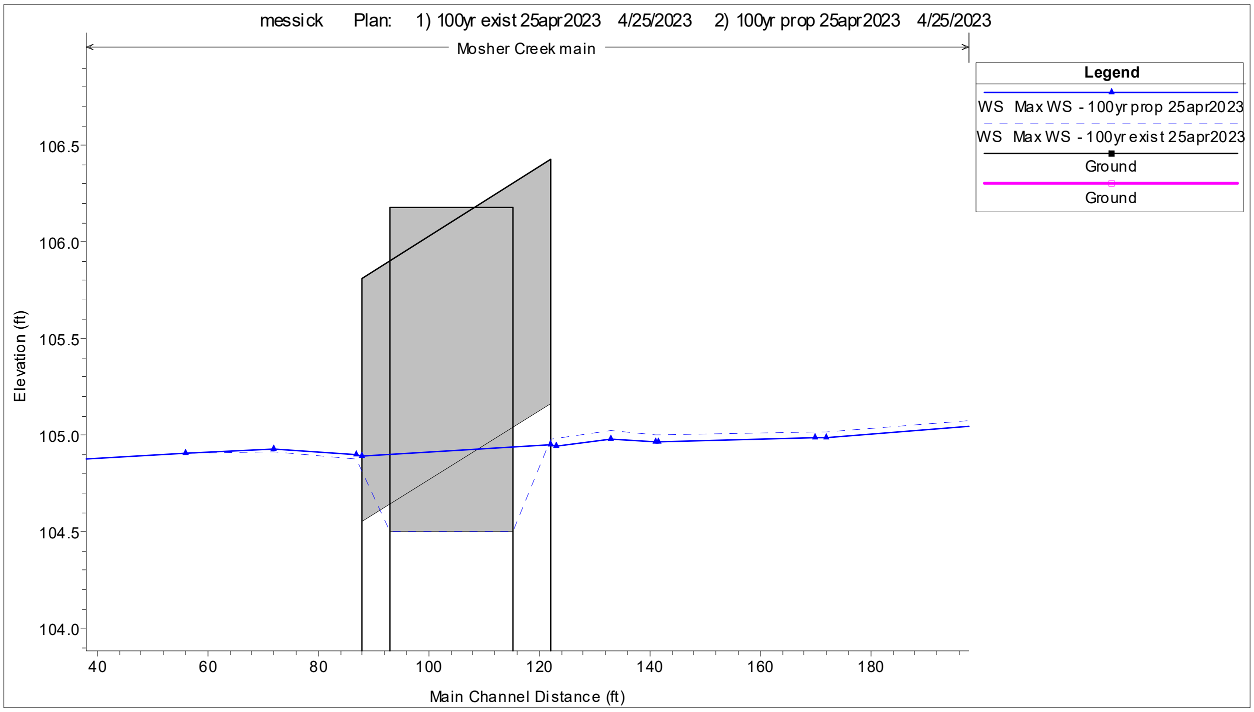


Figure 6. WSE comparison between existing (dashed) and proposed (solid) conditions for the 100-yr discharge.

Potential Q100 backwater damages:

A. Residences? NO__________YES___X_____

There is one residence just northeast of the bridge. The WSE will be unchanged at this residence and the residence will not be impacted by this project.

B. Other Bldgs? NO__________YES___X_____

There are several miscellaneous structures northeast of the bridge. The WSE will be unchanged at these structures and they will not be impacted by this project.

C. Crops? NO__________YES___X_____

There are agricultural fields adjacent to the channel in the vicinity of the project. The WSE is lowered upstream from the project and mostly unchanged downstream. A small area just downstream from the bridge will have an increase in WSE of approximately 0.02 feet. This area is not within an existing field. There will be no impact caused by the project on the existing fields.

D. Natural and beneficial Floodplain values? NO____X_____YES__________

"Natural and beneficial flood-plain values" shall include but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

The WSE is lowered upstream and mostly unchanged downstream. There will be no impact on the natural and beneficial floodplain values.

6. Type of Traffic:

A. Emergency supply or evacuation route? NO____X_____YES__________

B. Emergency vehicle access? NO__________YES___X_____

C. Practicable detour available? NO__________YES___X_____

D. School bus or mail route? NO__________YES __X_____

7. Estimated duration of traffic interruption for 100-year event hours:____0______

8. Estimated value of Q100 flood damages (if any) – moderate risk level.

A.	Roadway	\$ 0
B	Property	\$ 0
	Total	\$ 0

9. Assessment of Level of Risk

Low___X______

Moderate______

High__________

For High Risk projects, during design phase, additional Design Study Risk Analysis may be necessary to determine design alternative.

LOCATION HYDRAULIC STUDY FORM cont.

Dist.___10_______Co.__San Joaquin____Rte.___Messick Road__P.M.___
Federal-Aid Project Number: BRLO-5929(254) _____Project ID______Bridge No.__29C0274_

PREPARED BY:

Signature:
I certify that I have conducted a Location Hydraulic Study consistent with 23 CFR 650 and that the information summarized in items numbers 3, 4, 5, 7, and 9 of this form is accurate.

____ *Date* __________________
District Hydraulic Engineer *(capital and 'on' system projects)*

____ *Date* __________________
Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

Is there any longitudinal encroachment, significant encroachment, or any support of incompatible Floodplain development? NO____X_____YES_________

If yes, provide evaluation and discussion of practicability of alternatives in accordance with 23 CFR 650.113

Information developed to comply with the Federal requirement for the Location Hydraulic Study shall be retained in the project files.

I certify that item numbers 1, 2, 6 and 8 of this Location Hydraulic Study Form are accurate and will ensure that Final PS&E reflects the information and recommendations of said report:

____ *Date* __________________
District Project Engineer *(capital and 'on' system projects)*

____ *Date* __________________
Local Agency Project Engineer (*local assistance projects)*

CONCURRED BY:
I have reviewed the quality and adequacy of the floodplain submittal consistent with the attached checklist, and concur that the submittal is adequate to meet the mandates of 23 CFR 650.

____ *Date* __________________
District Project Manager *(capital and 'on' system projects)*

____ *Date* __________________
Local Agency Project Manager *(Local Assistance projects)*

____ *Date* __________________
District Local Assistance Engineer *(or District Hydraulic Branch for very complex projects or when required expertise is unavailable. Note: District Hydraulic Branch review of local assistance projects shall be based on reasonableness and concurrence with the information provided).*

I concur that the natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

____ *Date* __________________
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.

APPENDIX I – SUMMARY FLOODPLAIN ENCROACHMENT REPORT

SUMMARY FLOODPLAIN ENCROACHMENT REPORT

Dist. _____10_________Co. ___San Joaquin___ Rte.__Messick Road__ K.P. ____________
Federal-Aid Project Number: BRLO-5929(254) Project No.: _____ Bridge No. ___29C0274______

Limits:

The County of San Joaquin proposes to demolish and replace the existing Messick Road Bridge (29C0274) that crosses Mosher Creek with a new bridge structure. The Messick Road Bridge carries one 10-foot lane of traffic in each east-west direction and has no shoulders. The existing bridge was constructed in 1931 and consists of timber decking with asphalt concrete (AC) overlay supported on concrete columns. The replacement bridge would maintain the existing lane configuration but would incorporate 3-foot shoulders within County right of way. The profile of the proposed bridge would match the existing configuration to reduce impact to the structure approach areas. The number of spans associated with the bridge would be reduced from the current three-span configuration to a single span. The proposed structure would be supported by abutments at each bank of the creek founded on Cast in Steel Shell (CISS) or Cast in Drilled Hole (CIDH) piles. Wing walls would be constructed adjacent to the abutments and rock slope protection would be placed along the exterior of each wing wall. A new metal beam guard rail is proposed at all tie-in points to the bridge barriers to meet current American Association of State Highway and Transportation Officials (AASHTO) and Caltrans standards.

The existing Messick Road Bridge is over 90 years old and does not meet current bridge design standards. Structural and functional deficiencies have been identified for the bridge, such as section loss in substructure, decay in substructure, intolerable deck geometry, and substandard bridge and approach railings. The proposed project would construct a new bridge meeting current engineering standards to enhance the safety of motorists and bicyclists in the project area.

Floodplain Description:

Mosher Creek flows northwesterly through the project site through the northern part of San Joaquin County and drains an indeterminate size basin at the bridge. The area surrounding the project is rural and agricultural. The channel is approximately 52 feet wide (top of bank to top of bank) and approximately 7 feet deep (top of bank to toe of bank) through the project area. The channel bottom is sparsely vegetated, and the banks and overbank areas are more heavily vegetated. Mosher Creek through the project area is within an existing FEMA Zone AE floodplain with base flood elevations (BFE's) determined and a floodway.

	No	Yes
1. Is the proposed action a longitudinal encroachment of the base floodplain? *The proposed bridge is not a longitudinal encroachment.*	_x_	___
2. Are the risks associated with the implementation of the proposed action significant? *The level of risk to the floodplain of the project site is low because the action is to replace the existing bridge with a bridge that has equivalent hydraulic properties.*	_x_	___

3. Will the proposed action support probable incompatible floodplain development? _x_ ___
Support of incompatible floodplain development would encourage, allow, serve, or otherwise facilitate incompatible floodplain development, such as commercial development or urban growth. The project would maintain local access and would not create new access to developed land. Therefore, the proposed bridge will not support incompatible floodplain development.

4. Are there any significant impacts on natural and beneficial floodplain values? _x_ ___
The proposed construction will have only minor impact to the existing riparian habitat in the creek at the bridge site.

5. Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain. _x_ ___
Best management practices for erosion control measures should be used for proposed construction to minimize temporary impacts to the floodplain during construction.

6. Does the proposed action constitute a significant floodplain encroachment as defined in 23 CFR, Section 650.105(q). _x_ ___
The project does not have the potential to cause interruption or termination of the roadway or bridge for emergency vehicles or evacuation, does not have significant risk, and down not have significant adverse impact on natural and beneficial floodplain values. Thus, the project does not constitute a significant floodplain encroachment.

7. Are Location Hydraulic Studies that document the above answers on file? If not explain. ___ _x_

PREPARED BY:

____ *Date* __________________
District Project Engineer *(capital and 'on' system projects)*

____ *Date* __________________
Local Agency Project Engineer *(local assistance projects)*

CONCURRED BY:

____ *Date* __________________
District Project Manager *(capital and 'on' system projects)*

____ *Date* __________________
District Local Assistance Engineer *(Local Assistance projects)*

I concur that impacts to natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

____ *Date* __________________
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.