State of California – Department of Transportation
Division of Engineering Services
Office of Design and Technical Services
Structures Hydraulics and Hydrology Branch

# Structures
# Draft Final Hydraulic Report

## Albion River Bridge (Replacement)

Located on Route 1 over Albion River in the
County of Mendocino California

PROJECT:

Albion River Bridge
Exist Bridge ## 10-0136
New Bridge ## TBD
EA: 01-40110
EFIS: 01 0000-0154

LOCATION:

01-MEN-01-PM 43.74

DATE:

January 30, 2024

REGISTERED CIVIL ENGINEER (SIGNATURE):

The Professional Engineer's (P.E.) seal and signature will be included on the Final Hydraulic Report. See Note on the following page.

RONALD McGaugh, PE
Registration Number C61217

This report has been prepared under my direct supervision as the professional engineer in charge of the work, per the provisions of the Professional Engineers Act of the State of California.

Note: This is a Draft Final Hydraulic Report which has been completed based on the current design alternatives and other current information. The information reported in this study is considered valid (checked). However, any changes to the currently proposed bridge design details and/or other study assumptions may require changes to the hydraulic/scour analyses and report; therefore, the **Information provided in this report is considered "draft" and subject to revision**. The Final Hydraulic Report will include the Professional Engineer's (P.E.) seal and signature. It will be delivered when all bridge design details have been finalized for Final Structure Plans, Specifications, and Estimates (SPS&E).

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## 1.0 GENERAL:

The project proposes to replace the existing structure (Bridge No. 10-0136) with a bridge that meets modern structural and seismic safety standards. The project site is located on State Route 1. (see Figure 1). The project is near the coast approximately 15 miles south of Fort Bragg and 147 miles north of San Francisco.

### *1.1 Project History*

The existing bridge was built in 1944 and is a 34-span bridge. The superstructure is comprised of an asphalt concrete roadway surface on top of a timber deck truss, which is supported by a riveted steel deck truss. The substructure was made of timber tower bents on the combination of RC (reinforced concrete) pedestal and RC pedestal spread footings on driven timber piles. The bridge has been declared functionally obsolete with deficient railing.


Graphic 1.0.1 Site Map of Project Location

### *1.2 Current Scour Status Albion River Bridge:*

The existing bridge was evaluated by the Office of State Scour Evaluations for the Federal Highway Administration's (FHWA) National Bridge Inventory (NBI) Item 113 code. The 113 code is used to identify the current status of the bridge regarding the structure's vulnerability to scour. The evaluation on 10/17/2022, bridge 10-0136 was determined not to be scour critical, and the NBI Item 113 code was determined to be 5-"Bridge foundations determined to be stable for assessed or calculated scour conditions: scour is determined to be within the limits of footing or piles by assessment (i.e., bridge foundations are on rock formations that have been determined to resist scour within the service life of the bridge), by calculations or by installation of properly designed countermeasures."

### *1.3 Data Sources and References:*

The data and references for this hydraulic report were obtained from the following sources:

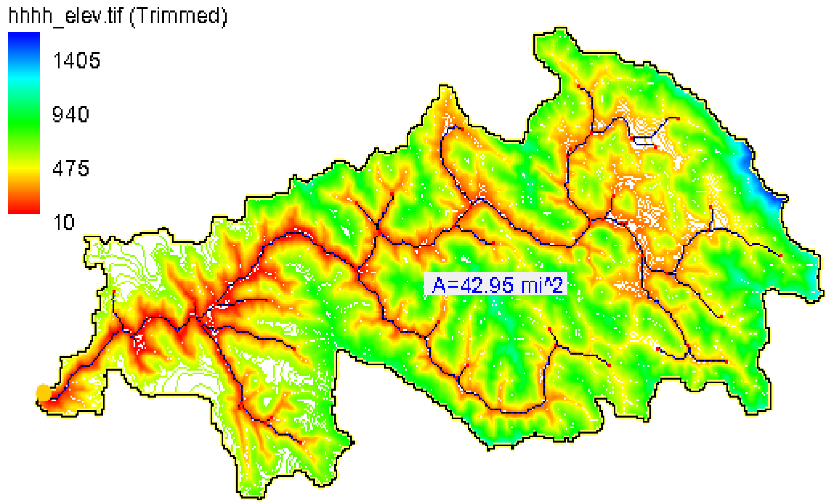
- Caltrans Bridge Maintenance Inspection Records.
- Albion River Bridge Replacement / Rehabilitation Project / Hydraulics and Sediment Analysis Report by Caltrans dated June 2020
- Structures Revised Final Hydraulic Report Albion River Bridge Replacement by Ginger Lu dated 4/14/2014.
- Topographical ground survey data provided by Preliminary Investigations/District 1 Office of Field Surveys, completed in August 2023.
- Field photo documentation from BIRIS and Structure Maintenance Investigations.
- FEMA (April 29, 2022) "Flood Insurance Study for Mendocino County, California, and Incorporated Areas, Flood Insurance Study Number 06045CV001D.
- Methods for determining magnitude and frequency of floods in California, based on data through the water year 2006: U.S. Geological Survey Scientific Investigations Report 2012-5113
- APS Plans from Bridge Design Section printed August 2021
- U.S. Department of Transportation Federal Highway Administration Hydraulic Engineering Circular No. 18 (HEC-18), Dr. L.A. Arneson Evaluating Scour at Bridges Fifth Edition and/or Streamstats Software program from USGS
- State of California Department of Transportation (Caltrans) MTD 16-1, 2017 Hydraulic Design for Structures Over Waterways
- National Cooperative Highway Research Program's *NCHRP Report 24-20 - Estimation of Scour at Bridge Abutments*.
- FEMA Guidance for Flood Risk Analysis and Mapping Coastal Wave Runup and Overtopping
- National Research Council's 2018 report titled "State of California Sea-Level Rise Guidance" and adopted by the California Coastal Commission
- WMS-Water Modeling Software (v. 11.0.05) developed by the U.S. Bureau of Reclamation / Aquaveo
- SMS-Surface Modeling Software( v.13.0.12) developed by the U.S. Bureau of Reclamation / Aquaveo
- FHWA HY8 Culvert Hydraulic Analysis Program
- Elevation data from USGS National Map, Lidar data from District 2, and Old Caltrans survey data from 2006

### *1.4 Geographical Reference – Vertical Datum:*

Unless otherwise stated, all vertical elevations in this final hydraulic report are based on the North American Vertical Datum of 1988 (NAVD88). The NAVD88 elevations referenced in this report can be converted into the National Geodetic Vertical Datum of 1929 (NVGD29) by the datum shift formula of NGVD29 = NAVD88 –2.93 feet. This datum shift was obtained from the National Geodetic Survey software, VERTCON (v. 2.0), and FEMA.

## 2.0 PROJECT WATERSHED:

Albion River drains a watershed of 42.6 square miles and is not a tributary to any other River or Creek. Albion River flows from east to west. The channel bed slope was estimated to be an average of 0.0007 ft/ft within 1000' of the project sites. Elevations in the drainage basin range from 10 feet to 1567 feet. The area covered by forest for this watershed is 68%. The percentage of lakes and ponds is 0.38%.




Graphic 2.0.1 Watershed of the bridge site

Near the bridge site, the terraces in this ecological region form an elevated coastal plain that has less relief (200–800 feet) than the adjacent Coastal Range mountains. Quaternary and Tertiary sandstones and mudstones form the terraces, and some areas are deeply dissected, forming ravines that expose Cretaceous sedimentary rocks. Soil moisture regimes are udic and some aquic, and soil temperatures are isomeric. Monthly and annual temperature variations are minimal and summer fog is common. Vegetation includes coastal grasslands and shrubs, stunted beach pine, Bishop pine, or pygmy cypress, along with areas of some grand fir and western hemlock. Terrace soils are typically unsuitable for redwoods, although they occur in ravines and on some bluffs.

### *2.1 Streambed/Basin*

The existing bridge has minimal hydraulic skew. For the channel bottom, there is no Log of Test Borings for the existing structure. A review of BIRIS does not indicate the composition of the streambed. Other research information suggests that the majority of the streambed of Albion River is composed of gravelly loam. The creek bed varies from all silt to small cobbles in the project area. The Albion River originates 15 miles east from coastal mountains and empties into the Pacific Ocean at the mouth of the river near Albion. Much of the watershed is owned by Mendocino Redwood Company and other lumber companies, and only a small percentage of parcels are owned by ranches and private residences. Logging and milling used to be the major industries in the area. Due to the dismantled railroad and the negative impacts of excessive sedimentation from logging and milling, the logging business was greatly reduced in recent years.

## 3.0 PROJECT DESIGN FLOOD DISCHARGES:

The current FEMA Flood Insurance Study for Mendocino County, (April 29, 2022) does not contain any information about the river. Graphic 8 on page 8 is the FEMA flood map of Albion River at the site. Since the river is ungaged in a rural setting without any storage basins upstream, National Streamflow Statistics Method (NSS or Regional Regression Method) is used to approximate the 50-year and 100-year flood events. The calculated discharges in cubic feet per second (cfs) are in Table 3.0.1.

The river is classified as a Regulatory Floodway. Throughout the bridge site, most of the flood area is classified as Zone A, which is the flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined in the Flood Insurance Study by detailed methods of analysis. Base Flood Elevations or depths are not shown within this zone.

Table 3.0.1: Albion River Watershed Discharge Values

| Flood Frequency | Design Flood Discharge(cfs) |
|---|---|
| $O^{200}$ | 11750 |
| $O^{100}$ | 10377 |
| $O^{50}$ | 8936 |
| $O^{10}$ | 5680 |

## 4.0 DESIGN OBJECTIVES:

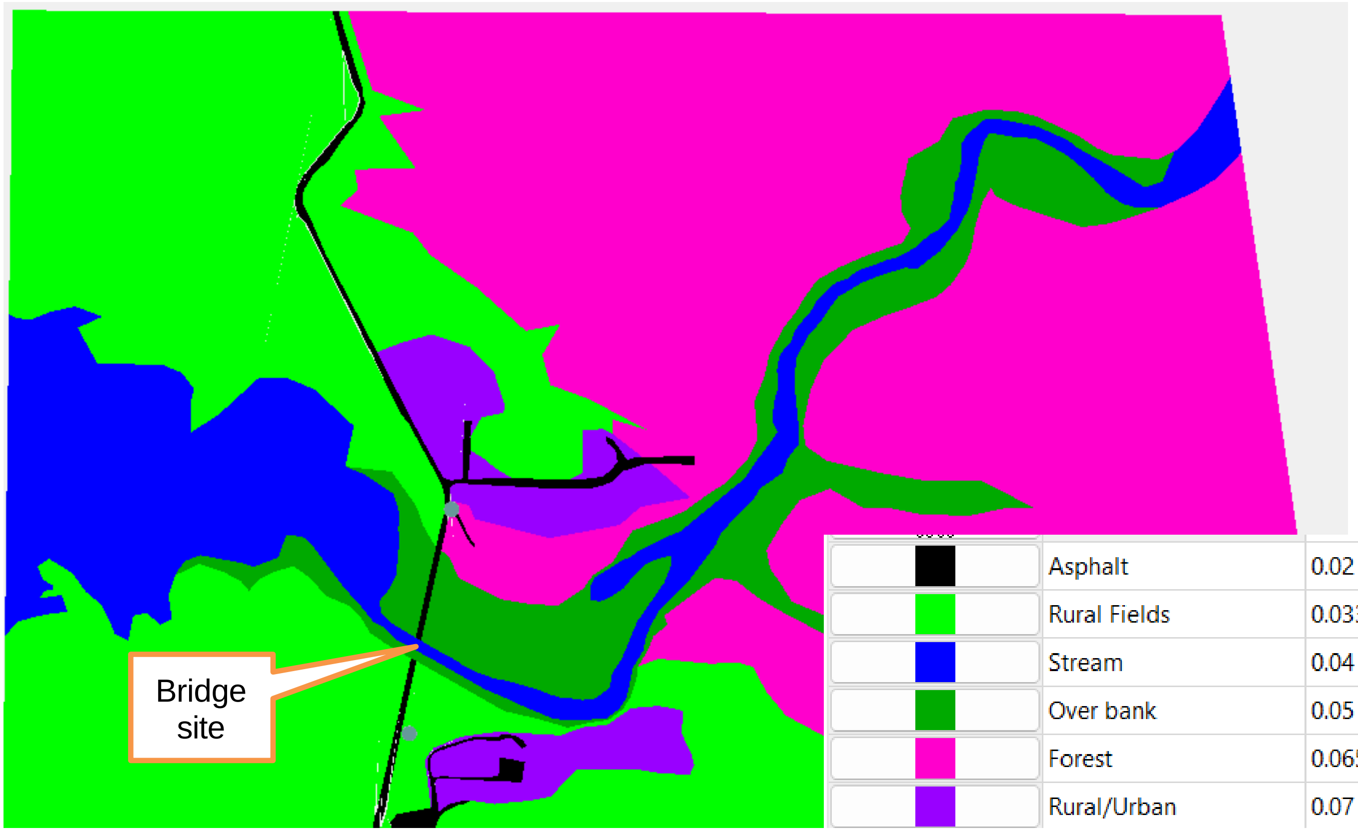
This hydraulic report investigates replacing the existing bridge with a longer wider structure capable of carrying the entire anticipated flow of the creek. It addresses the scour and hydraulic impacts of the proposed work on the Albion River Bridge and the impacts on the floodplain. There are 5 Planning Study Plans (Alternatives) to be analyzed as shown on pages 20 through 24. Proposed changes may slightly change the existing floodplain shown on the FEMA Graphic 11.0.1 on page 19. Hydraulic analyses were calculated using the (SHR-2D) hydraulic modeling software (v. 13.1.17) developed by the U.S. Bureau of Reclamation / Aquaveo.

## 5.0 SURFACE-WATER MODELING SYSTEM (SMS) SRH-2D MODELING APPROACH AND METHODOLOGY:

Information used for modeling includes topographical land surveys collected by aerial LiDAR; in-stream surveys collected by bathymetric methods by Caltrans' Structure Maintenance and Investigations' Hydraulic Inspection Branch from 2023, Microstation drawing from Preliminary Investigations, and the latest Federal Emergency Management Agency's (FEMA) Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRM). See the Sections below for additional assumptions used in hydraulic modeling.

### *5.1 Manning's Roughness Coefficients, "n":*

Manning's "n" values had slight changes within the hydraulic model study area. For hydraulic modeling purposes, the roughness coefficients were broken down into six areas as shown in the following Graphic 5.1.1. The estimated values were based on field observations, site and aerial photos, and engineering judgment. The Surface-Water Modeling System (SMS) SRH-2D Modeling program was allowed to automatically composite Manning's "n" values where appropriate.




Graphic 5.1.1 Manning's Roughness Coefficients, "n"

The estimated values were based on field observations, site and aerial photos, and engineering judgment. The Surface-Water Modeling System (SMS) SRH-2D Modeling program was allowed to automatically composite Manning's "n" values where appropriate.

### *5.2 Modeling Alignments:*

Due to each Planning Study having different offsets between the existing alignments and the Alternative alignments, the existing structure and the proposed modeled structures will not be compared against each other.

### *5.3 Tidal Considerations:*

The closest tidal benchmark for the project is located at Arena Cove, CA (Station # 9416841), which is about 28 miles south of the project site, and it was checked and accepted by the National Oceanic and Atmospheric Administration in December 2011. This information was from https://tidesandcurrents.noaa.gov. For the tidal impacts and their effect on this project please refer to Table 5.3.1.

Table 5.3.1: Tidal Effects

| Datum | Value(ft) | Description |
|---|---|---|
| HAT | 7.48 | Highest Astronomical Tide |
| MHHW | 5.73 | Mean Higher-High Water |
| MHW | 5.06 | Mean High Water |
| MTL | 3.04 | Mean Tide Level |
| MSL | 3.00 | Mean Sea Level |
| MLW | 1.01 | Mean Low Water |
| MLLW | -0.14 | Mean Lower-Low Water |
| NAVD88 | 0.00 | North American Vertical Datum of 1988 |

The Highest Astronomical Tide is an extreme event that would happen once or twice a year. For the Maximum tide observed for this station, the depth of flow through the proposed bridge for all Alternatives for the bridges would be below the soffit. For the average daily high tide, the Mean Higher High-Water flow is below the $Q_{100}$ elevations and will not add any additional conditions to alter the Q100 parameters.

### *5.4 Sea Level Rise Considerations*

Table 5.4.1 provides the Sea Level Rise projections for the Albion River Bridge replacement project. This table is from the 2018 Caltrans and Ocean Protection Council (OPC) SLR Guidance Manual. It is important to note that Table 5.4.1 is Table 7 from the Caltrans and Ocean Protection Council (OPC) SLR guidance page 17. For permit requirements, the California Coastal Commission (CCC) requires using the “Medium-High Risk Aversion” values from the table.

Table 5.4.1 (this is an image) Sea Level Rise

| | | Probabilistic Projections (in feet) (based on Kopp et al. 2014) | | | | | H++ scenario (Sweet et al. 2017) *Single scenario |
|---|---|---|---|---|---|---|---|
| | | MEDIAN | LIKELY RANGE | | 1-IN-20 CHANCE | 1-IN-200 CHANCE | |
| | | 50% probability sea-level rise meets or exceeds... | 66% probability sea-level rise is between... | | 5% probability sea-level rise meets or exceeds... | 0.5% probability sea-level rise meets or exceeds... | |
| | | | | Low Risk Aversion | | Medium - High Risk Aversion | Extreme Risk Aversion |
| High emissions | 2030 | 0.3 | 0.2 - | 0.5 | 0.5 | 0.7 | 1.0 |
| | 2040 | 0.5 | 0.3 - | 0.7 | 0.9 | 1.2 | 1.6 |
| | 2050 | 0.7 | 0.5 - | 1.0 | 1.2 | 1.8 | 2.6 |
| Low emissions | 2060 | 0.8 | 0.5 - | 1.1 | 1.4 | 2.2 | |
| High emissions | 2060 | 1.0 | 0.6 - | 1.3 | 1.7 | 2.5 | 3.7 |
| Low emissions | 2070 | 0.9 | 0.5 - | 1.3 | 1.8 | 2.9 | |
| High emissions | 2070 | 1.2 | 0.8 - | 1.7 | 2.2 | 3.3 | 5.0 |
| Low emissions | 2080 | 1.0 | 0.6 - | 1.6 | 2.1 | 3.6 | |
| High emissions | 2080 | 1.5 | 1.0 - | 2.2 | 2.8 | 4.3 | 6.4 |
| Low emissions | 2090 | 1.2 | 0.7 - | 1.8 | 2.5 | 4.5 | |
| High emissions | 2090 | 1.8 | 1.1 - | 2.6 | 3.4 | 5.4 | 8.0 |
| Low emissions | 2100 | 1.3 | 0.7 - | 2.1 | 3.0 | 5.4 | |
| High emissions | 2100 | 2.1 | 1.3 - | 3.1 | 4.1 | 6.7 | 9.9 |
| Low emissions | 2110* | 1.4 | 0.8 - | 2.2 | 3.1 | 6.0 | |
| High emissions | 2110* | 2.3 | 1.5 - | 3.2 | 4.2 | 7.0 | 11.6 |
| Low emissions | 2120 | 1.5 | 0.9 - | 2.5 | 3.6 | 7.1 | |
| High emissions | 2120 | 2.6 | 1.8 - | 3.8 | 5.0 | 8.2 | 13.9 |
| Low emissions | 2130 | 1.7 | 0.9 - | 2.8 | 4.1 | 8.1 | |
| High emissions | 2130 | 2.9 | 1.9 - | 4.3 | 5.7 | 9.7 | 16.2 |
| Low emissions | 2140 | 1.8 | 0.9 - | 3.1 | 4.6 | 9.4 | |
| High emissions | 2140 | 3.2 | 2.1 - | 4.8 | 6.5 | 11.1 | 18.7 |
| Low emissions | 2150 | 1.9 | 0.9 - | 3.4 | 5.1 | 10.7 | |
| High emissions | 2150 | 3.6 | 2.3 - | 5.4 | 7.3 | 12.6 | 21.5 |

Even higher values could occur with one or more combinations of strong storms, high tide events, wind waves, and high flow events on the rivers.

### *5.5 Tsunami Effects*

Caltrans requires that the design of all new bridges within five miles of the coast (and in bays) must include a hazard tsunami evaluation. This office (Structure Hydraulics) assists with the tsunami hazard evaluation, and Structure Design evaluates the loading and structural design using information supplied by our unit. This information includes the maximum wave height and the wave velocity. Caltrans evaluates bridges for the tsunami hazard consistent with a 5% probability of being exceeded in 50 years.

A tsunami can damage a bridge if the waves are high enough to strike the deck. However, the design tsunami at most locations along California's coast should be below the superstructure. Therefore, wherever possible, new bridges should be designed so the tsunami flows below the soffit (or bottom girder flange). According to the ASCE Tsunami Hazard Tool based on ASCE Tsunami model 7-22, the conservative estimate maximum wave height elevation is 41.0 ft NAVD88, with a wave velocity of 43.7 feet per second. These conservative values should cover all Alternatives for this report and will be revised once a preferred alternative is chosen.

### *5.6 Oceanic Waves and Total Water Levels*

Graphic 5.6.1
Wave Runup


*The storm surge stillwater elevation (SWEL) and added effects of wave setup*

The Total Water Level (TWL) is the sum of the SWEL, the wave setup, and the wave runup as shown in Graphic 5.6.1. The TWL from Table 16 in the FEMA Flood Insurance Study is shown below. Transects 49 and 50 were used for TWL calculations for this project.

Partial FEMA Table 16: Summary of Coastal Transect Mapping Considerations

| | | Starting Wave Conditions for the 1-Percent-Annual-Chance (ft NAVD88) | | Total Water Elevation | | | | |
|---|---|---|---|---|---|---|---|---|
| Flood Source | Coastal Transect | Significant Wave Height Hs (ft) | Peak Wave Period Tp (sec) | 10-Percent-Annual-Chance | 4-Percent-Annual-Chance | 2-Percent-Annual-Chance | 1-Percent-Annual-Chance | 0.2-Percent-Annual-Chance |
| Pacific Ocean | 49 | * | * | 43.3 | * | 48.0 | 49.9 | 54.0 |
| Pacific Ocean | 50 | * | * | 21.0 | * | 23.2 | 24.0 | 25.7 |

Note: Average elevations given; elevation may vary within the area of the transect cited

Zone VE (shown on Firm Maps) is subdivided into elevation zones and BFEs are provided on the FIRM. The limit of Zone VE shown on the FIRM is defined as the farthest inland extent of any of these criteria (determined for the 1% annual chance flood condition):

- The primary frontal dune zone is defined in 44 CFR Section 59.1 of the NFIP regulations. The primary frontal dune represents a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes that occur immediately landward and adjacent to the beach. The primary frontal dune zone is subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune zone occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.
- The wave runup zone occurs where the (eroded) ground profile is 3.0 feet or more below the 1-percent annual chance TWL.
- The wave overtopping splash zone is the area landward of the crest of an overtopped barrier, in cases where the potential 1-percent annual chance is TWL.
- The breaking wave height zone occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the SWEL elevation).
- The high-velocity flow zone is landward of the overtopping splash zone (or area on a sloping beach or other shore type), where the product of depth of flow multiplied by the flow velocity squared ($hv^2$) is greater than or equal to 200 $ft^3/sec^2$. This zone may only be used on the Pacific Coast.

## 6.0 HYDRAULIC MODELING RESULTS:

Analyzing the Albion River Bridge at existing conditions, all floodwaters from the design flood discharges are contained within the floodplain throughout the hydraulic study area of the project sites. The proposed structure contains all flows in the floodplain.

### *6.1 Stage, Velocity, and Freeboard at the Albion River Bridge:*

Table 6.1.1 through Table 6.1.5 summarizes the hydraulic results at the water surface elevations at the lowest chord of the proposed replacement structures. This model assumes all the flow will get to the proposed bridge with minimal changes to the existing grading of the channel and conditions noted in the Planning Study Plans. Values for the tables below are at the upstream face of the structures. Using the proposed bridge soffit elevation and the calculated water surface elevations, the available freeboard at the bridge was computed.

The Planning Study Plans for these proposed Alternatives indicate variations in the cross slope but do not indicate where these changes will occur so all calculations for the report will use 2% for all cross slopes for this evaluation. This information is important to the calculations for the freeboard. For the Final FHR, the cross slopes will be revised.

Table 6.1.1: Hydraulic Results Albion River Bridge ALT 1A Under Proposed Conditions.

| Design Flood Discharge (cfs) for Q100 | Soffit Elevation (1) (ft) | Water Surface Elevation (ft) | Maximum Channel Velocity (fps) | Available Freeboard (ft) |
|---|---|---|---|---|
| 10377 | 142.4 | 11.0 | 8.1 | 131.4 |

**Notes:**

(1) – Bridge soffit elevation was calculated near proposed Pier 2.
(2)--These calculations did not include any possible backwater effects from the Albion River

| **Tidal** | | | **Proposed Water surface elevations at lowest point on proposed bridge deck** | **Freeboard** |
|---|---|---|---|---|
| Datum | Description | Elevation (ft) | | |
| HAT | Highest Astronomical Tide | 7.48 | 11.0 | 131.4 |
| MLLW | Mean Lower-Low Water | -0.14 | 11.0 | 131.4 |

| **Sea Level Rise Projected Year** | **Medium-High Risk Aversion** | **Sea Level Rise Projection NAVD88(feet)** | **Proposed Water surface elevations NAVD88(feet)** | **Freeboard** |
|---|---|---|---|---|
| | Likely Range | 3.2+3.0=6.2 | 11.0 | 131.4 |
| 2100 | 1 in 200 Chance | 6.8+3.0=9.8 | 11.0 | 131.4 |
| | H+++ | 10.0+3.0=13.0 | 13.0 | 129.4 |
| **Tsunami Effects** Total Water Height Elevation(ft) | | 3.0 | 44.0 | 98.4 |
| **Wave Runup Elevation** 1% Annual Chance | | N/A | 49.9 | 92.5 |

Table 6.1.2: Hydraulic Results Albion River Bridge ALT 1B Under Proposed Conditions.

| Design Flood Discharge (cfs) for Q100 | Soffit Elevation (1) (ft) | Water Surface Elevation (ft) | Maximum Channel Velocity (fps) | Available Freeboard (ft) |
|---|---|---|---|---|
| 10377 | 157.3 | 11.0 | 8.1 | 146.3 |

**Notes:**

(1) – Bridge soffit elevation was calculated near proposed Pier 3
(2)--These calculations did not include any possible backwater effects from the Albion River
(3)-- Due to arch construction for this Alternative, the lowest elevation of the bottom of the slab over the flow in the stream is considered the minimum soffit bridge elevation. The proposed arch members will be exposed to stream pressure.

| **Tidal** | | | **Water surface elevations at downstream edge of the proposed arch** | **Freeboard** |
|---|---|---|---|---|
| Datum | Description | Elevation (ft) | | |
| HAT | Highest Astronomical Tide | 7.48 | 11.0 | 146.3 |
| MLLW | Mean Lower-Low Water | -0.14 | 11.0 | 146.3 |

| Sea Level Rise Projected Year | Medium-High Risk Aversion | Sea Level Rise Projection NAVD88(feet) | Proposed Water surface elevations NAVD88(feet) | Freeboard |
|---|---|---|---|---|
| | Likely Range | 3.2+3.0=6.2 | 11.0 | 146.3 |
| 2100 | 1 in 200 Chance | 6.8+3.0=9.8 | 11.0 | 146.3 |
| | H+++ | 10.0+3.0=13.0 | 13.0 | 144.3 |
| **Tsunami Effects** Total Water Height Elevation | | 3.0 | 44.0 | 113.3 |
| **Wave Runup Elevation** 1% Annual Chance | | N/A | 49.9 | 107.4 |

Table 6.1.3: Hydraulic Results Albion River Bridge ALT 2A Under Proposed Conditions.

| Design Flood Discharge (cfs) for Q100 | Soffit Elevation (1) (ft) | Water Surface Elevation (ft) | Maximum Channel Velocity (fps) | Available Freeboard (ft) |
|---|---|---|---|---|
| 10377 | 137.0 | 11.3 | 7.4 | 125.7 |

**Notes:**

(1) – Bridge soffit elevation was calculated near proposed Pier 2.
(2)--These calculations did not include any possible backwater effects from the Albion River

| **Tidal** | | | **Proposed Water surface elevations at lowest point on proposed bridge deck** | **Freeboard** |
|---|---|---|---|---|
| Datum | Description | Elevation (ft) | | |
| HAT | Highest Astronomical Tide | 7.48 | 11.3 | 125.7 |
| MLLW | Mean Lower-Low Water | -0.14 | 11.3 | 125.7 |

| **Sea Level Rise Projected Year** | **Medium-High Risk Aversion** | **Sea Level Rise Projection NAVD88(feet)** | **Proposed Water surface elevations NAVD88(feet)** | **Freeboard** |
|---|---|---|---|---|
| | Likely Range | 3.2+3.0=6.2 | 11.3 | 125.7 |
| 2100 | 1 in 200 Chance | 6.8+3.0=9.8 | 11.3 | 125.7 |
| | H+++ | 10.0+3.0=13.0 | 13.3 | 123.7 |
| **Tsunami Effects** Total Water Height Elevation | | 3.0 | 44.0 | 93.0 |
| **Wave Runup Elevation** 1% Annual Chance | | N/A | 49.9 | 87.1 |

Table 6.1.4: Hydraulic Results Albion River Bridge ALT 2B Under Proposed Conditions.

| Design Flood Discharge (cfs) for Q100 | Soffit Elevation (1) (ft) | Water Surface Elevation (ft) | Maximum Channel Velocity (fps) | Available Freeboard (ft) |
|---|---|---|---|---|
| 10377 | 158.5 | 11.2 | 7.6 | 147.3 |

**Notes:**

(1) – Bridge soffit elevation was calculated near proposed Pier 4.
(2)--.These calculations did not include any possible backwater effects from the Albion River
(3)-- Due to arch construction for this Alternative, the lowest elevation of the bottom of the slab over the flow in the stream is considered the minimum soffit bridge elevation. The proposed arch members will be exposed to stream pressure.

| **Tidal** | | | **Water surface elevations at downstream edge of the proposed Arch/Pier 4** | **Freeboard** |
|---|---|---|---|---|
| Datum | Description | Elevation (ft) | | |
| HAT | Highest Astronomical Tide | 7.48 | 11.2 | 147.3 |
| MLLW | Mean Lower-Low Water | -0.14 | 11.2 | 147.3 |

| Sea Level Rise Projected Year | Medium-High Risk Aversion | Sea Level Rise Projection NAVD88(feet) | Proposed Water surface elevations NAVD88(feet) | Freeboard |
|---|---|---|---|---|
| | Likely Range | 3.2+3.0=6.2 | 11.2 | 147.3 |
| 2100 | 1 in 200 Chance | 6.8+3.0=9.8 | 11.2 | 147.3 |
| | H+++ | 10.0+3.0=13.0 | 13.0 | 145.5 |
| **Tsunami Effects** Total Water Height Elevation | | 3.0 | 44.0 | 114.5 |
| **Wave Runup Elevation** 1% Annual Chance | | N/A | 49.9 | 108.6 |

Table 6.1.5: Hydraulic Results Albion River Bridge ALT 3A Under Proposed Conditions.

| Design Flood Discharge (cfs) for Q100 | Soffit Elevation (1) (ft) | Water Surface Elevation (ft) | Maximum Channel Velocity (fps) | Available Freeboard (ft) |
|---|---|---|---|---|
| 10377 | 149.4 | 11.1 | 7.7 | 138.3 |

**Notes:**

(1) – Bridge soffit elevation was calculated near Proposed Pier 2.
(2)--These calculations did not include any possible backwater effects from the Albion River

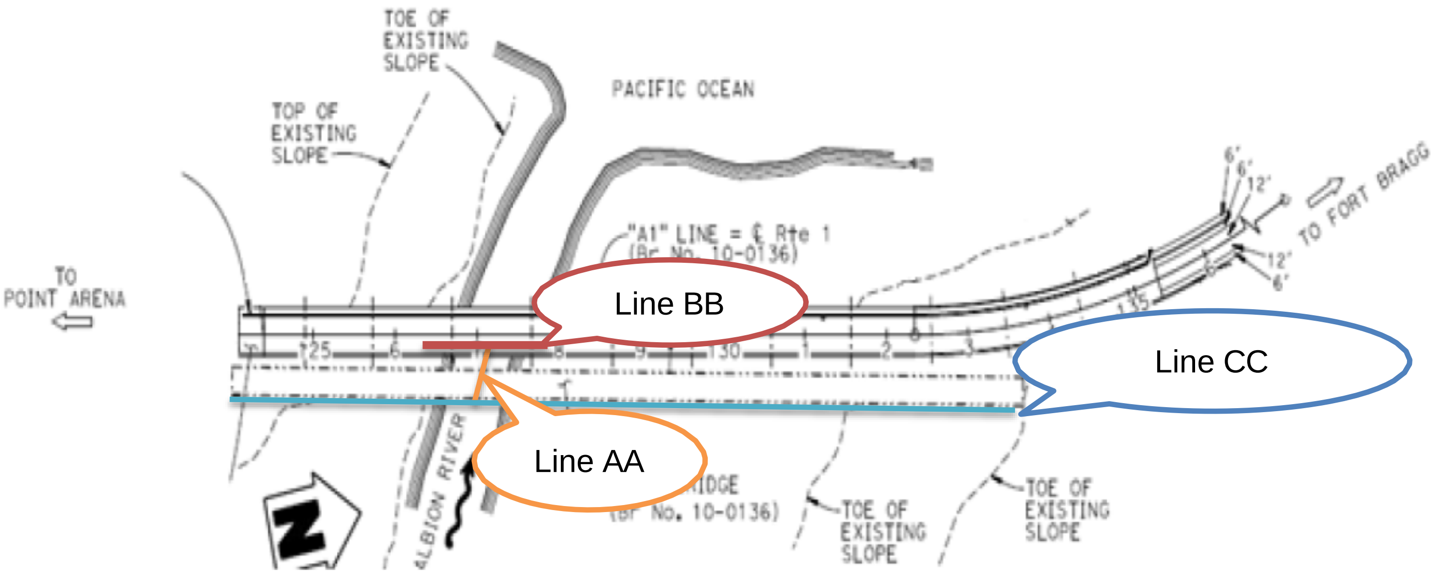
| **Tidal** | | | **Proposed Water surface elevations at lowest point on proposed bridge deck** | **Freeboard** |
|---|---|---|---|---|
| Datum | Description | Elevation (ft) | | |
| HAT | Highest Astronomical Tide | 7.48 | 11.1 | 138.3 |
| MLLW | Mean Lower-Low Water | -0.14 | 11.1 | 138.3 |

| Sea Level Rise Projected Year | Medium-High Risk Aversion | Sea Level Rise Projection NAVD88(feet) | Proposed Water surface elevations NAVD88(feet) | Freeboard |
|---|---|---|---|---|
| | Likely Range | 3.2+3.0=6.2 | 11.1 | 138.3 |
| 2100 | 1 in 200 Chance | 6.8+3.0=9.8 | 11.1 | 138.3 |
| | H+++ | 10.0+3.0=13.0 | 13.0 | 136.4 |
| **Tsunami Effects** Total Water Height Elevation | | 3.0 | 44.0 | 105.4 |
| **Wave Runup Elevation** 1% Annual Chance | | N/A | 49.9 | 99.5 |

The Caltrans Memo to Designers 16-1 states the general criteria for setting the soffit elevation are to pass the greater of (1) Design Flood (typically Q50 + 2 feet of freeboard), or (2) Base Flood ($Q_{100}$ without freeboard). The hydraulic results indicate this general freeboard criterion is met for the proposed conditions.

### *6.2 Existing and Proposed Comparison Data:*

The following diagram is a typical idealized representation of the 5 Alternatives shown for this project. The diagram includes the Proposed Alternatives and the Existing Bridge. Parameters needed for cross section comparison information and location are shown in Table 6.2A-1. For a visual representation on the Line AA location / lengths, please refer to the Plans 11.0.2 - 11.0.6 in Section 11 of this report.




Line AA is the profile line down the centerline of the channel perpendicular to the channel banks. The length of Line AA is also the distance between Line CC and Line BB
Line BB is the upstream location at the bottom of the structure deck for Alternative 1A, Alternative 1B, and Alternative 3A.
Line BB is the upstream location for the bottom of the box girder for Alternative 2A and Alternative 2B.
Line CC is the location of the upstream edge of deck of the Existing Bridge. This line is also(only for purposes of this report) used as a comparison reference line.

Table 6.2.1 Comparison Cross Section Line Locations

| Alternatives | Line CC Water surface elevation (ft) | Line BB Water surface elevation (ft) | Line AA length (ft) Proposed bridges located further upstream than the existing bridge are shown as negative(-) |
|---|---|---|---|
| Existing Bridge | 11.2 | N\A | N\A |
| Alternative 1A | 11.2± | 11.0 | 15.8± |
| Alternative 1B | 11.2± | 11.0 | 15.0± |
| Alternative 2A | 11.2± | 11.3 | -143.2± |
| Alternative 2B | 11.2± | 11.2 | -67.6± |
| Alternative 3A | 11.2± | 11.1 | 9.5± |

The upstream edge of the bridge deck is typically used to generate cross-sections and determine WSE in a flood event; however, given that the upstream edge of the bridge deck differs for each alternative, the WSE was estimated for each alternative using the upstream edge of the existing bridge as a common point of reference. Based on Table 6.2.1, since there is no change in water surface elevation at the reference line (Line CC) for all Alternatives, there is no anticipated change of the lateral extents of the floodplain for all proposed Alternatives. A more refined analysis will be prepared following selection of the preferred Alternative.

### *6.3 Waterway Impacts on the Albion River Bridge/ Floodplain*:

For the proposed conditions it is anticipated there will not be any backwater conditions that would adversely affect the channel to pass the design flood event. Reviewing the floodway boundaries from existing to proposed conditions, there will not be large apparent changes in the lateral extents of the flow boundaries from existing to proposed conditions. Therefore, through hydraulic modeling, it was determined that the proposed project would not require FEMA map revisions to the floodplain.

## 7.0 STREAMBED AND CHANNEL SLOPES:

There is no As-Built Log of Test Borings (LOTB) or geological reports available at the time of writing this report. Based on photographic observations from BIRIS and other sources the ground is assumed to be a combination of Holocene undifferentiated stream channel deposits, which consist of boulders, cobbles, gravel, sand, silt, and clay within active stream channels and floodplains with silt and sand estuarine deposits locally. The canyon walls are light-colored, well cemented to deeply weathered and sheared, clastic sedimentary rocks, including arkosic sandstone, pebble conglomerate, and shale, with lesser amounts of greenstone, chert, and limestone. For purposes of this report the streambed will be considered scourable, with the stream bed as stable and the stream banks are stable

## 8.0 DRIFT/FLOATING DEBRIS:

BIRIS did not indicate occasional large drift accumulations. In general, historical and current site-specific documents tend to indicate that floating drift/debris should not be expected to be a significant issue at this bridge during typical high flood conditions. It is noted that this river used to be used as a “logging” river. Debris during a tsunami event for this project is not a concern for the hydraulics for the replacement alternatives.

## 9.0 SCOUR AND CHANNEL DEGRADATION:

A scour analysis was calculated following the guidelines set forth by the FHWA’s Hydraulic Engineering Circular Number 18 (HEC-18) - Evaluating Scour at Bridges, 5th Edition, and the National Cooperative Highway Research Program’s NCHRP Report 24- 20 - Estimation of Scour at Bridge Abutments. HEC-18 defines total scour as a summation of three components: 1) long-term degradation of the river bed, 2) contraction scour at the bridge, and 3) local scour at the piers and abutments.

### *9.1. Long-Term Degradation Changes:*

The long-term streambed elevation changes at the existing bridge were analyzed. The projected degradation trends using historical channel cross sections collected at the upstream face of the existing bridge using a 75-year (assumed serviceable life for the proposed structure) were calculated. At the project location, there are no long-term streambed elevation changes and there is no expected degradation trend for any of the proposed Alternatives.

### *9.2 Contraction Scour:*

Contraction scour is a lowering of the streambed across the stream or waterway bed at the bridge caused when the flow area of a stream at the flood stage is reduced, either by a natural constriction of the stream channel or by a bridge structure. Contraction scour can occur through the constriction of the channel caused by the bridge in either the horizontal or vertical direction (pressure-flow contraction scour). At the project location, contraction scour will be accounted for in the NCHRP Report 24-20 -Estimation of Scour at Bridge Abutments. There is no additional contraction scour for the new proposed bridge Alternatives.

### *9.3 Local Pier and Abutment Scour:*

Local scour involves the removal of bed material around piers, abutments, and embankments. It is caused by an acceleration of flow and resulting vortices induced by obstructions to the flow. For the local scour conditions for the structure, both local pier and local abutment scour were typically analyzed. Proposed abutments are located beyond the edges of the Albion River, so no flow reaches them for scouring purposes for all Alternatives. For the following tables, only foundational elements that are intersected by the flow are shown in the tables.

Table 9.3.1: Total Scour Analysis for Proposed Alternative 1A.

| **Bridge Substructure Component 22.5-foot square column** | **Short-Term Scour Depths** | **Long-Term Scour Depths** | | **Total Scour Depths (ft)** | **Total Scour Elevation (ft)** |
|---|---|---|---|---|---|
| | **Local Scour (ft)** | **Degradation (ft)** | **Contraction Scour (ft)** | | |
| Pier 2 | 27.0 | 0 | 0 | 27.0 | -22.0 |
| Pier 3 | 12.4 | 0 | 0 | 12.4 | -2.4 |

All calculations in the table are based on a 100-year flow

Table 9.3.2: Total Scour Analysis for Proposed Alternative 1B.

| **Bridge Substructure Component 22.5-foot square column** | **Short-Term Scour Depths** | **Long-Term Scour Depths** | | **Total Scour Depths (ft)** | **Total Scour Elevation (ft)** |
|---|---|---|---|---|---|
| | **Local Scour (ft)** | **Degradation (ft)** | **Contraction Scour (ft)** | | |
| There are no piers/spandrel foundations in the flow for this Alternative | | | | | |

All calculations in the table are based on a 100-year flow

Table 9.3.3: Total Scour Analysis for Proposed Alternative 2A.

| **Bridge Substructure Component 20-foot square column** | **Short-Term Scour Depths** | **Long-Term Scour Depths** | | **Total Scour Depths (ft)** | **Total Scour Elevation (ft)** |
|---|---|---|---|---|---|
| | **Local Scour (ft)** | **Degradation (ft)** | **Contraction Scour (ft)** | | |
| Pier 2 | Ensure that pier footing elements do not come within 4 feet of the original ground | | | | |
| Pier 3 | 2.4 | 0 | 0 | 2.4 | 8.2 |

All calculations in the table are based on a 100-year flow

Table 9.3.4: Total Scour Analysis for Proposed Alternative 2B.

| **Bridge Substructure Component 22.5-foot square column** | **Short-Term Scour Depths** | **Long-Term Scour Depths** | | **Total Scour Depths (ft)** | **Total Scour Elevation (ft)** |
|---|---|---|---|---|---|
| | **Local Scour (ft)** | **Degradation (ft)** | **Contraction Scour (ft)** | | |
| Pier 4/Spandrel Foundation | 18.1 | 0 | 0 | 18.1 | -10.5 |
| Pier 9/Spandrel Foundation | Out of the flow | | | | |

All calculations in the table are based on a 100-year flow

Table 9.3.5: Total Scour Analysis for Proposed Alternative 3A.

| Bridge Substructure Component 22.5-foot square column | Short-Term Scour Depths | Long-Term Scour Depths | | Total Scour Depths (ft) | Total Scour Elevation (ft) |
|---|---|---|---|---|---|
| | Local Scour (ft) | Degradation (ft) | Contraction Scour (ft) | | |
| Pier 2 | 13.3 | 0 | 0 | 13.3 | -7.2 |
| Pier 3 | 7.9 | 0 | 0 | 7.9 | 2.4 |

All calculations in the table are based on a 100-year flow

## 10.0 CONCLUSIONS AND RECOMMENDATIONS:

- There will be ample freeboard as designed for all Alternatives for the peak of the $Q_{100}$ event.
- Minimal navigational clearance will be met on all Alternatives.
- Foundations for the existing bridge are typically cut-off 3 feet below the existing or proposed grade (whichever is lower). For any special circumstances of the foundations, needs to be noted in the plans.
- It is important to note that the north-end footing of the existing steel span support is to remain in place. This footing will not affect the new bridge alternatives.
- If there is a significant change in the Planning Study Plans as this project develops or a final Alternative has been selected, please resubmit a request for the proposed structure(s) to be reanalyzed.
- The proposed bridge replacement Alternatives were analyzed through hydraulic modeling and determined not to cause any significant hydraulic or scour-related issues.
- There are no expected hydraulic constraints.

**Albion River Bridge as Seen from the Albion River Inn (Looking South)**

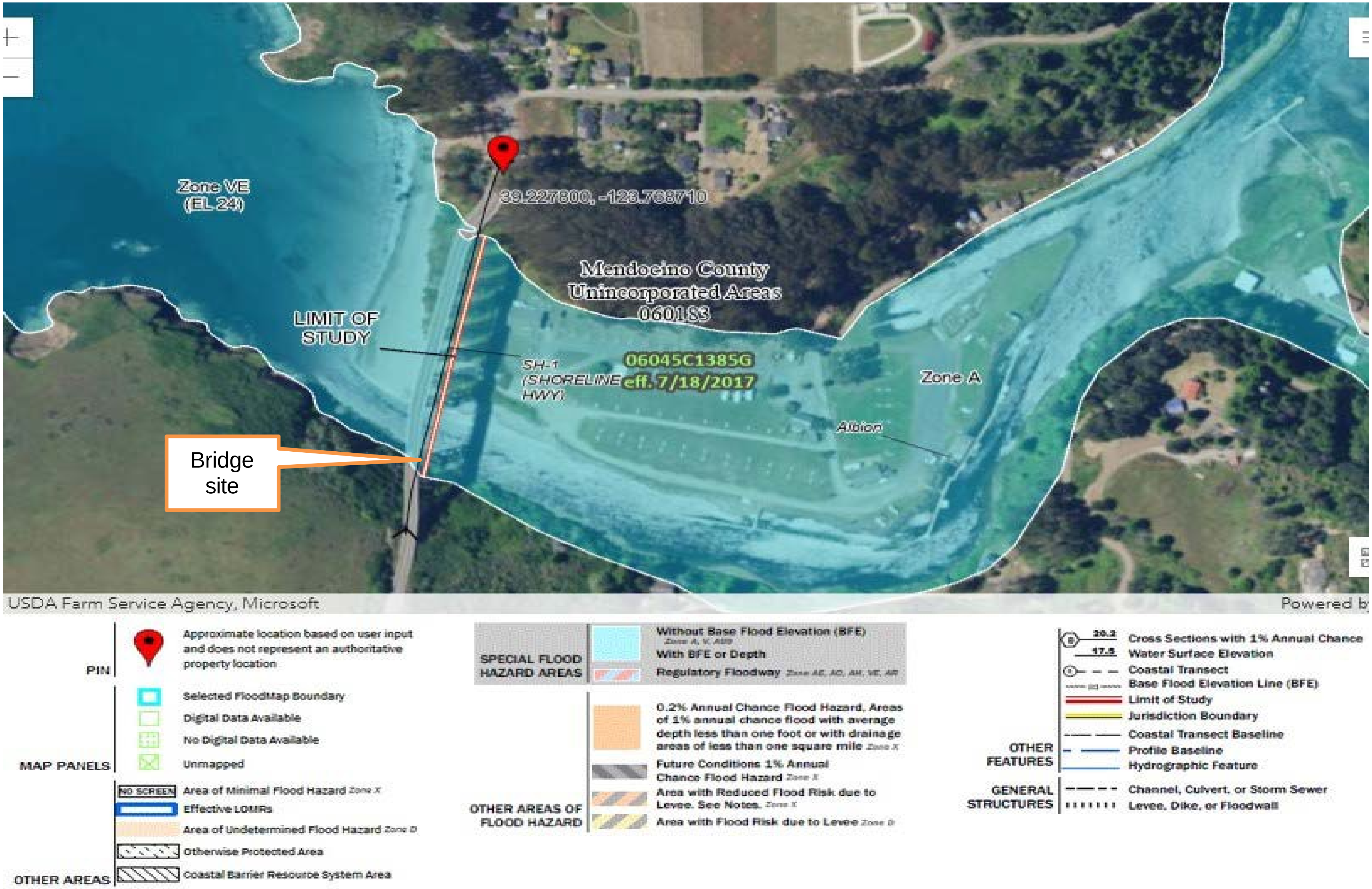
Graphic 10.0.1 Views of the existing structure

## 11.0 SUMMARY INFORMATION FOR THE BRIDGE DESIGNER:

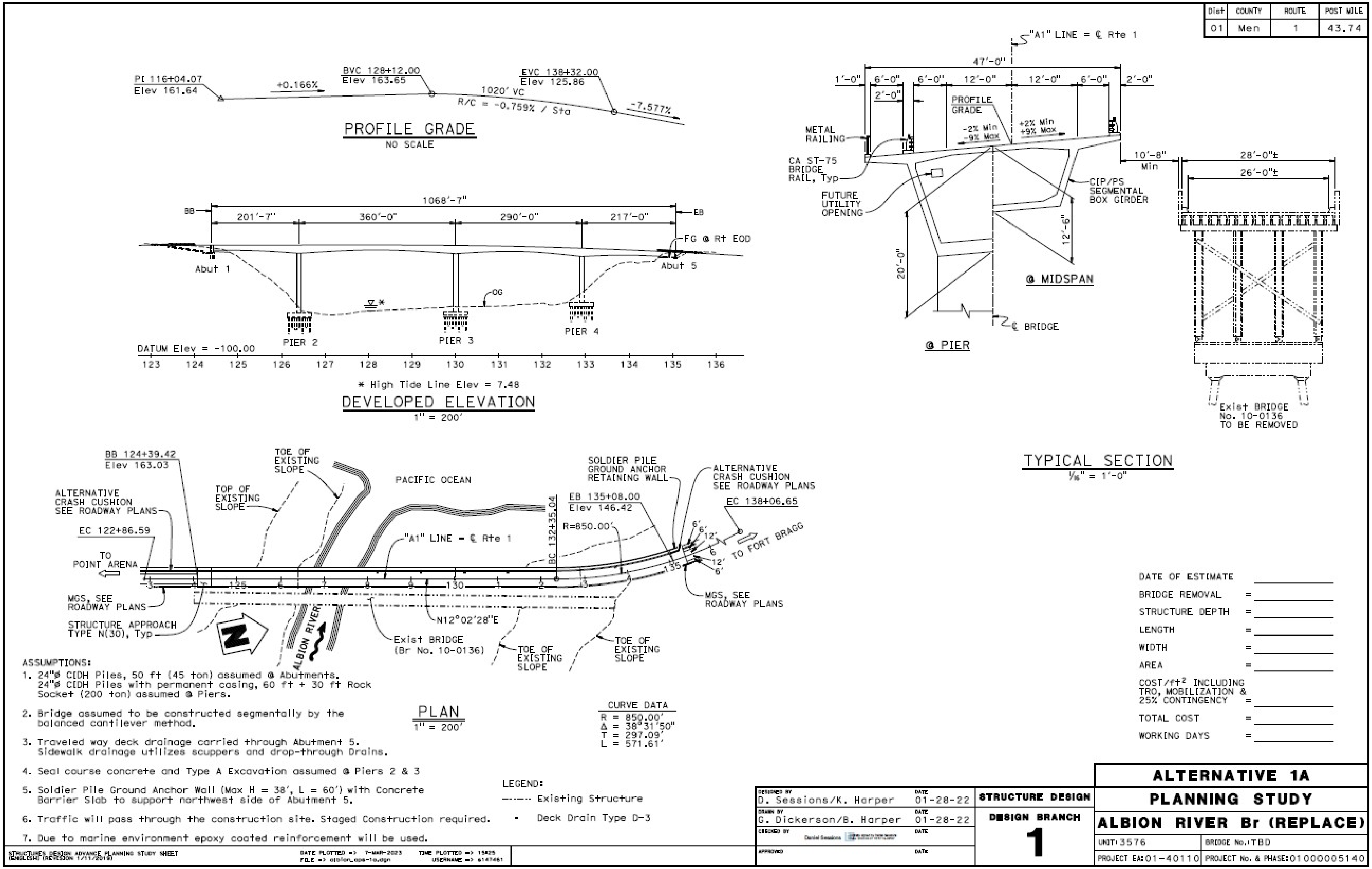
Table 11.0.1: Summary Information for the Bridge Engineer

| HYDROLOGIC SUMMARY | | | |
|---|---|---|---|
| | Design Flood | Base Flood | Scour Check Flood |
| Flood Frequency | 50-year | 100-year | 200-year |
| Discharge | 8936 cfs | 10377 cfs | 11750 cfs |
| Bridge Water Surface Elevation | 10.4± | 11.2± | TBD at final alternative Selection |
| Maximum Stream Velocity | 7.4± ft/s | 8.2± ft/s | TBD at final alternative Selection |
| 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 State and interested or affected parties should make their own investigation. | | | |

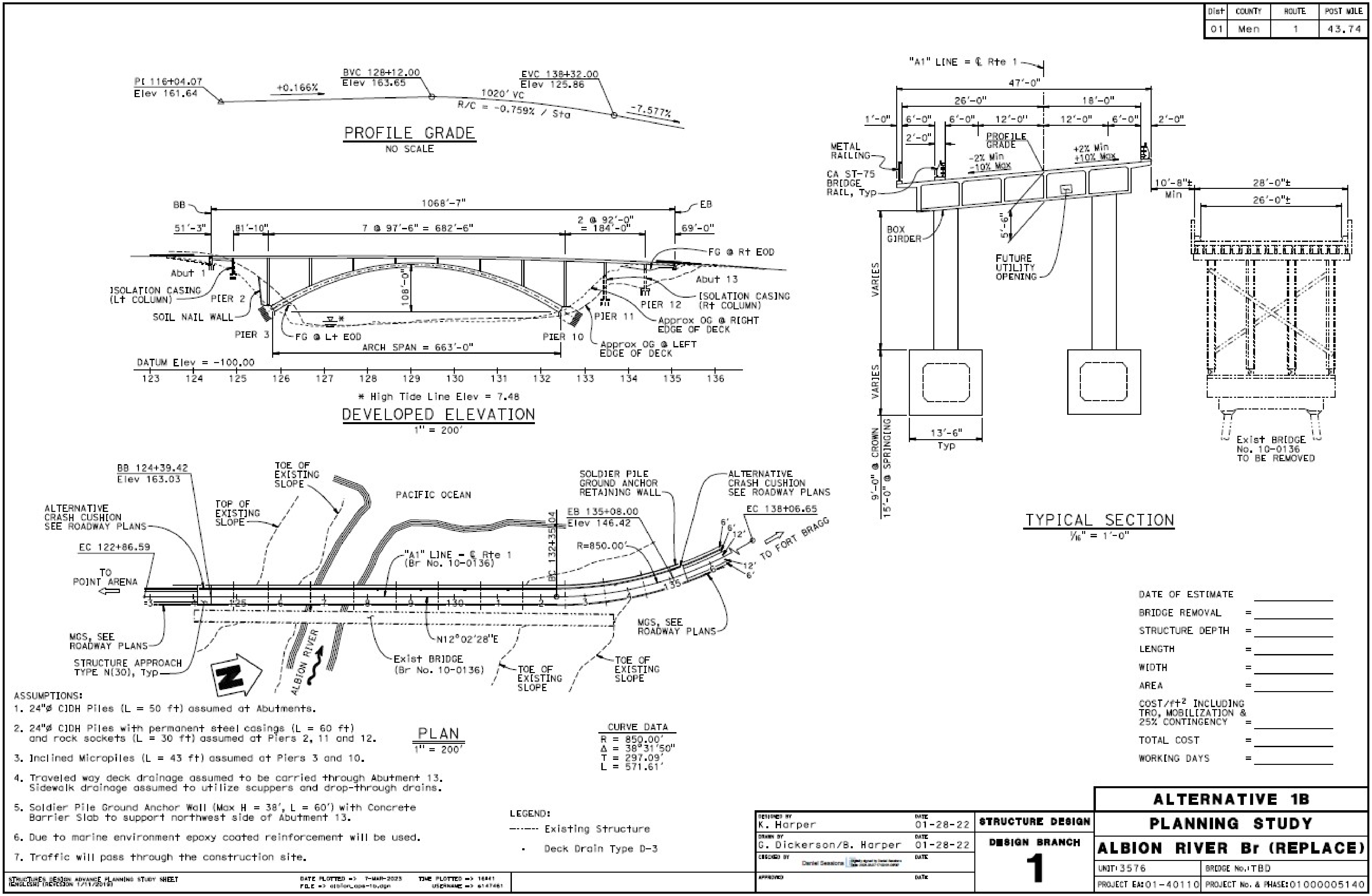
Scour Data Table to be provided for Final Hydraulic Report



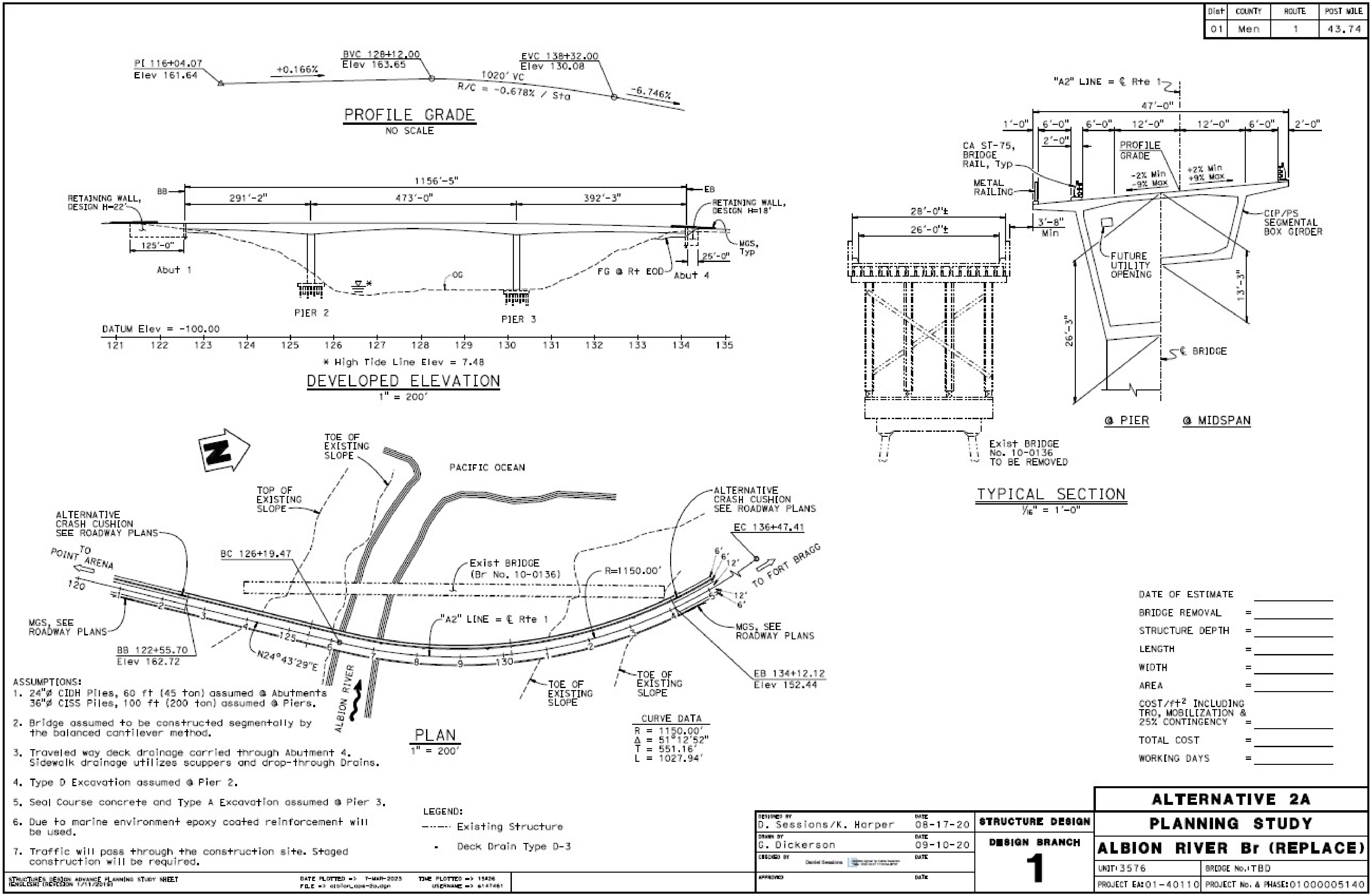

Graphic 11.0.1: FEMA Map of Project Area



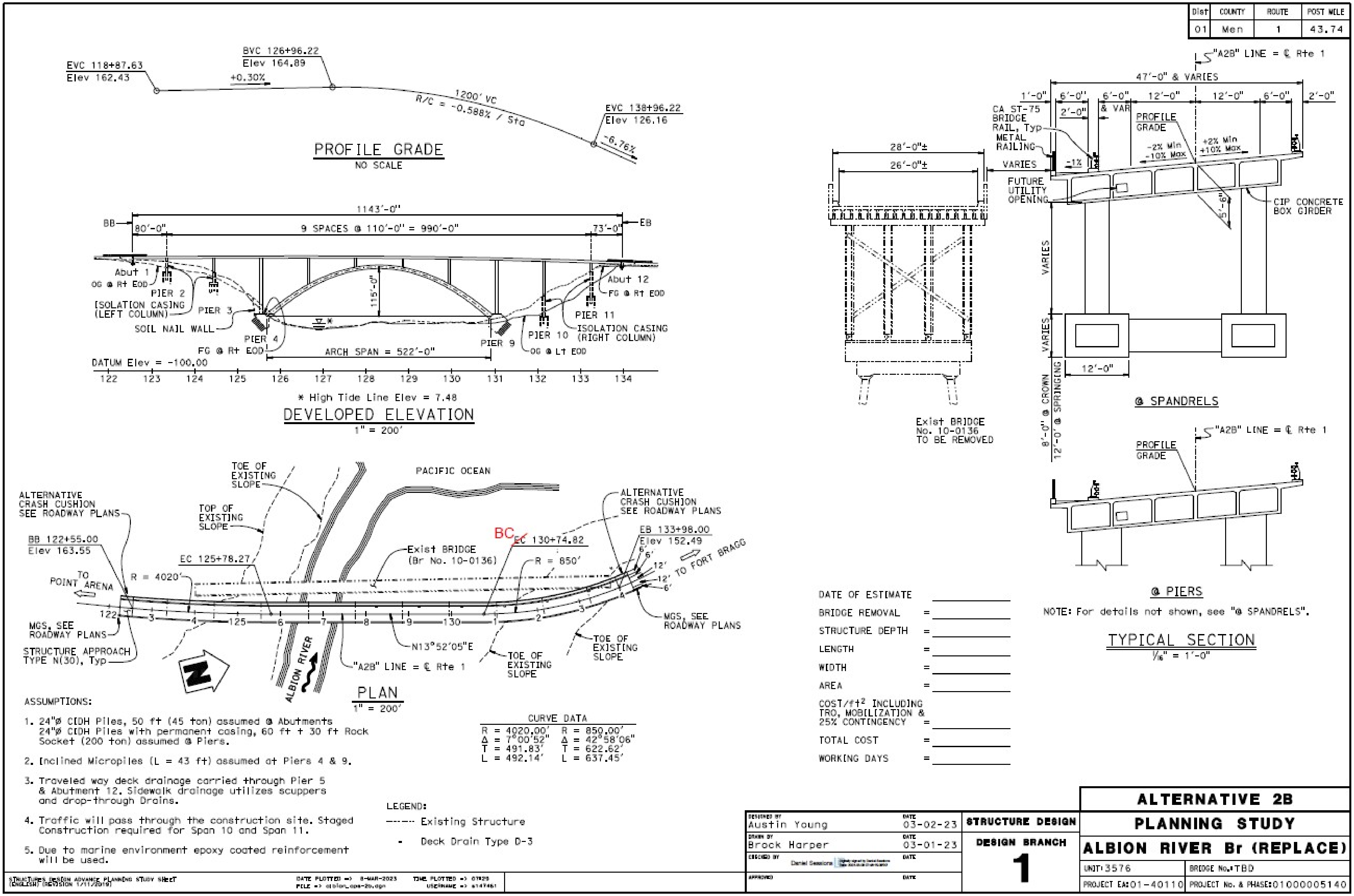

Graphic 11.0.2: Proposed Planning Study Plans 1A



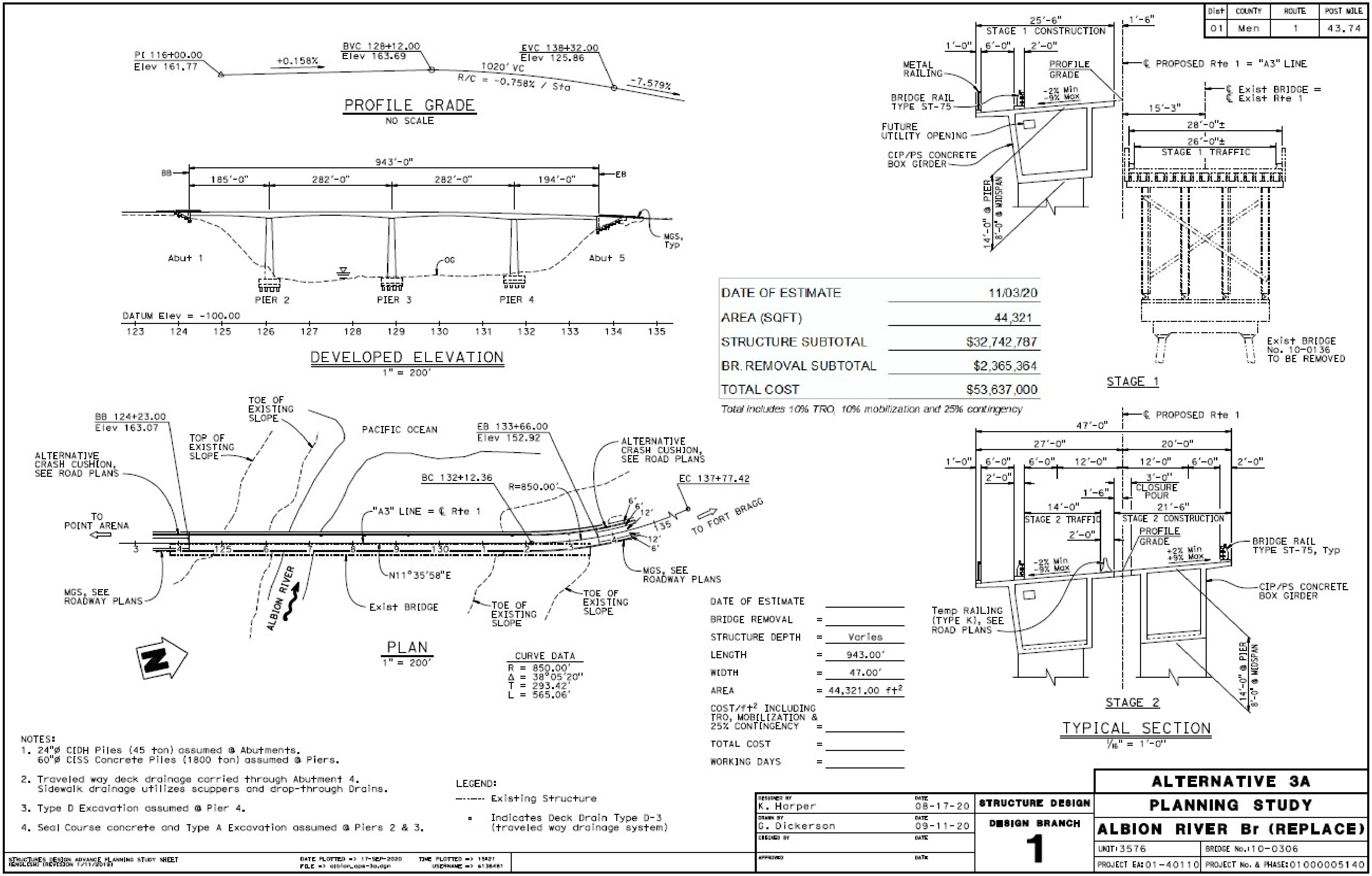

Graphic 11.0.3: Proposed Planning Study Plans 1B




Graphic 11.0.4: Proposed Planning Study Plans 2A




Graphic 11.0.5: Proposed Planning Study Plans 2B




Graphic 11.0.6: Proposed Planning Study Plans 3A