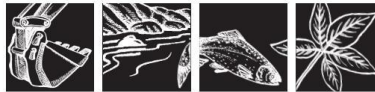


Buck Gulch Trail Pedestrian Bridges Hydrologic and Hydraulic Analysis Report

Prepared for:
Marin County Open Space District

Site Location:
611 Fairway Lane
Novato, CA
94949

Prepared by:
Karen Jamgochian, P.E.
Prunuske Chatham, Inc. (PCI Ecological)
103 Morris Street, Ste A-5
Sebastopol, CA 95472



PCI ECOLOGICAL
ESTABLISHED 1985

March 2025

Introduction

The feasibility of siting two bridges across Arroyo San Jose Creek along the Buck Gulch Falls Trail was investigated. This memo provides the results of the hydrologic and hydraulic evaluation of two bridge locations: Bridge 1 at the bottom of the trail near the existing wet crossing and Bridge 2 at a location approximately 2,000 feet upstream of Bridge 1. The following document details the hydrology and hydraulics used to determine the minimum soffit elevations for the potential bridges. The Marin County municipal code requires two feet of clearance between the bridge soffit and the 100-year storm elevation.

Hydrology

Two methods were completed to determine the peak flow of the 100-yr return interval storm: the Marin County Rational Method and the USGS Streamstats.

Marin County Rational Method

Initially, peak flow hydrology was determined using the Rational Method as defined in the County of Marin Department of Public Works Hydrology Manual Simplified Instructions (County of Marin Department of Public Works Hydrology Manual Simplified Instructions, 2000). The Rational Method uses the equation:

$$Q = CIA \quad \text{where:} \quad \begin{array}{l} Q = \text{Peak Flow Rate (cubic feet/second)} \\ C = \text{Runoff Coefficient (unitless)} \\ I = \text{Rainfall Intensity (inches/hour)} \\ A = \text{Drainage Area (acres)} \end{array}$$

Area, A

Watershed areas for the bridges were calculated by delineating the watersheds using LiDAR data and aerial imagery.

Runoff Coefficient, C

The runoff coefficient is a function of several factors including vegetation type, land use, and slope. The watershed is primarily undeveloped oak woodland. A runoff coefficient of 0.70 was used based on the recommendation of the Marin County Rational Method manual.

Rainfall Intensity, I

Rainfall intensity values vary based on the time delay for rainfall to reach a point of interest (time of concentration). This was calculated by locating the project site on Map I from the Marin County Rational Method manual and finding i_{60} . From there, Map V was used to find the Intensity Duration Zone. Buck Gulch Falls trail is in Intensity Duration Zone B1. Then, Chart K was used to determine Design Rainfall Intensities to be plugged into $Q=CIA$.

Time of Concentration, T_c

Time of concentration was found using the following equation from the Marin County Manual:

$$T_c = \frac{1.8(1.1-C)(L)^{0.5}}{[S(100)]^{0.333}} + 5 \text{ min} \quad \text{where:} \quad \begin{array}{l} T_c = \text{Time of concentration (minutes)} \\ C = \text{Runoff Coefficient (unitless)} \\ S = \text{Average ground slope (ft/ft)} \\ L = \text{Distance from distal point to point of measurement} \\ 5 \text{ min} = \text{time after rainfall starts until runoff begins} \end{array}$$

The average ground slope and distance from distal point to point of measurement were determined using GIS. All values are shown in Table 1, below.

Because the rational method is designed for smaller watersheds, it produced very conservative results (Table 1). Generally, the upper end of the watershed area limit is 160 to 200 acres. Both bridge locations have watershed areas larger than 200 acres, potentially overestimating the peak flows.

Table 1. Marin County rational method inputs and the peak flow results for the 100-yr storm for Bridges 1 and 2.

Parameter	Bridge 1	Bridge 2
T _c (min)	23.57	19.60
C (unitless)	0.70	0.70
S (ft/ft)	0.34	0.42
L (ft)	7020	4944
I (in/hr)	2.2	2.5
A (acres)	567	205
Q (ft ³ /s)	873	359

USGS Streamstats

Based on professional judgment and past experience in similar local streams that the results from the Rational Method were too high for this stream, PCI conducted a second hydrologic method using USGS Streamstats to obtain more appropriate and site-specific peak flow values. Streamstats is a USGS web application that provides basin characteristics and statistics including peak flow estimates using regional regression equations for six regions in California (USGS, 2018). The equations relate flood magnitudes of selected frequency to basin characteristics such as drainage area, precipitation, and altitude. They were developed for streams that have natural flow, or flow not substantially affected by storage (USGS, 2018).

Figure 1 and Figure 2 show the watershed areas for each bridge as delineated in USGS Streamstats.

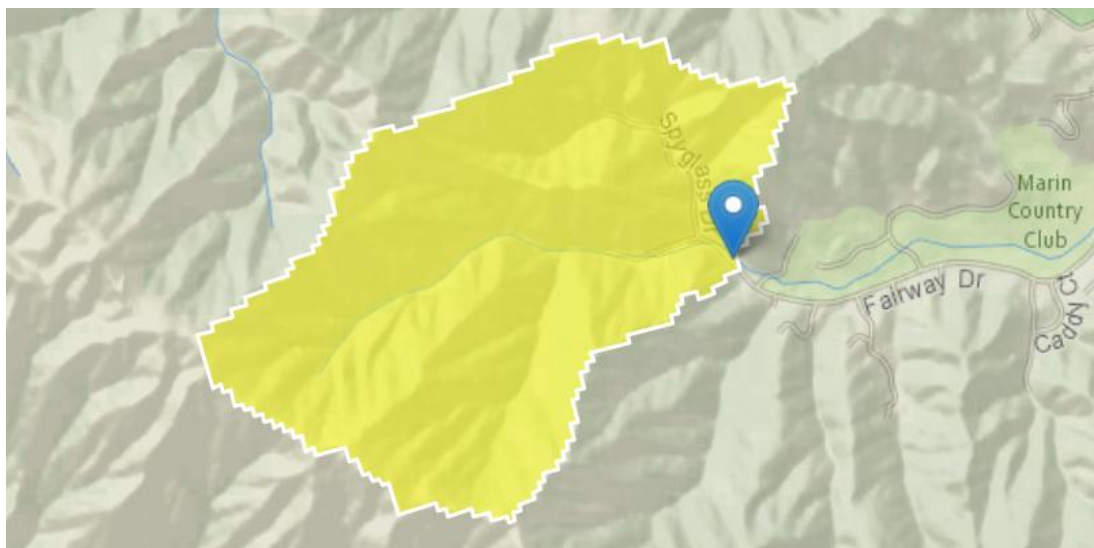


Figure 1. Bridge 1 watershed area delineated in Streamstats.



Figure 2. Bridge 2 watershed area delineated in Streamstats.

Table 2 shows the peak flows for the bridges from Streamstats, which are more in line with similar local stream hydrology. These values were used in the hydraulics analysis below.

Table 2. Streamstats peak flow hydrology for the 100-yr storm for Bridges 1 and 2.

Streamstats Hydrology (Q100)	
Location	Flow (ft ³ /s)
Bridge 1	365
Bridge 2	146

Hydraulics

Hydraulic Toolbox Channel Analysis

Open channel hydraulics were assessed using Hydraulic Toolbox, a single section hydraulic analyzer (FHWA, 2014). The model utilizes Manning's equation with a user input channel cross-section, roughness, slope, and flow rate to determine normal depth. The Marin County municipal code requires two feet of clearance between the elevations of the bridge soffit and the peak flow of the 100-yr storm. Both bridges have been set at elevations to achieve this requirement.

Normal depth at the 100-yr storm elevation through the Bridge 1 cross-section was calculated using hydrology from USGS Streamstats (Figure 3). Minor grading would be required to make the existing trail conform to the minimum required soffit level for a potential bridge and its abutments at this location.

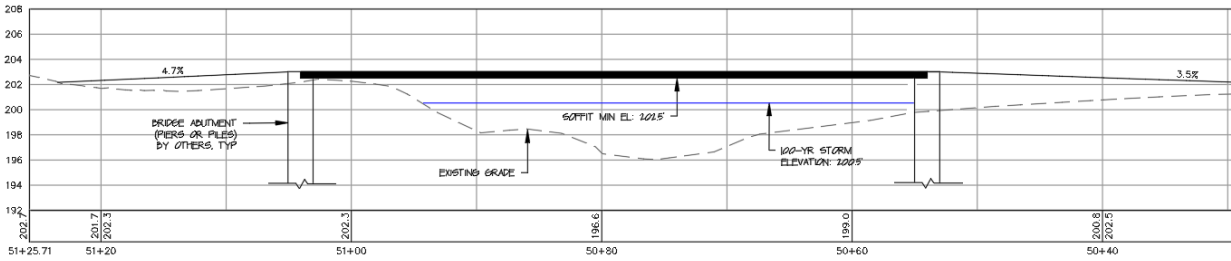


Figure 3. Water surface elevation at 100-yr storm and required Bridge 1 elevation.

Normal depth at the 100-yr storm elevation through the Bridge 2 cross-section was also calculated using hydrology from USGS Streamstats (Figure 4). A bridge at the Bridge 2 location would need to be higher than the required minimum soffit elevation in order to better connect with potential trail access improvements, allowing more freeboard than what is required.

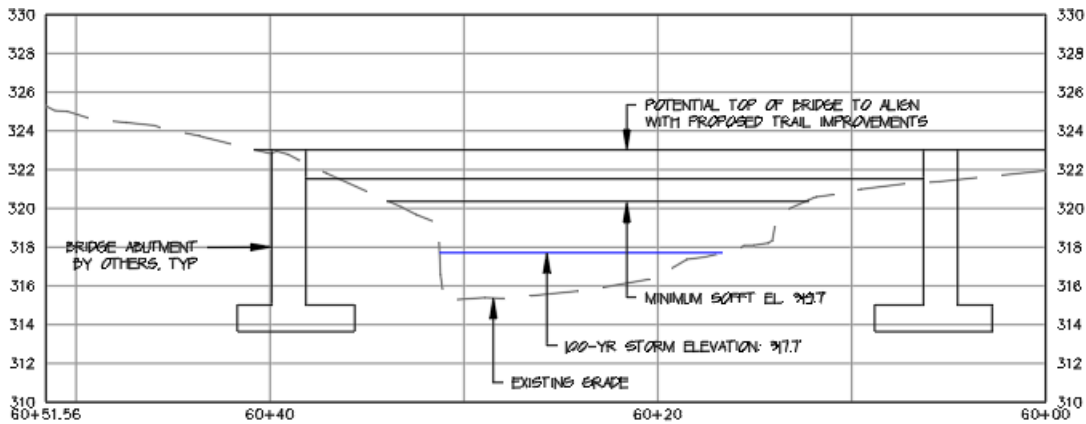
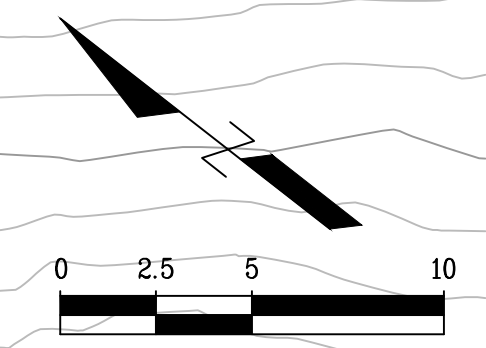
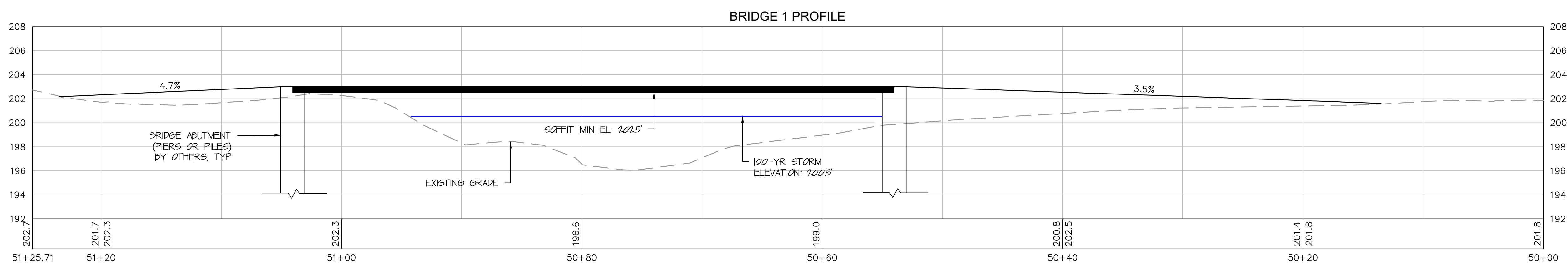



Figure 4. Water surface elevation at 100-yr storm and required soffit of potential Bridge 2 elevation.

References

- County of Marin Department of Public Works Hydrology Manual Simplified Instructions. (2000).
- FHWA. (2014, August). Hydraulic Toolbox and Desktop Reference Guide Ver 4.2. Federal Highway Administration. Retrieved from www.fhwa.dot.gov
- USGS. (2018, October 1). USGS StreamStats. Retrieved from USGS.gov: <https://streamstats.usgs.gov/ss/>

Acad File Name: G:\CAD\2020\WarmCoOpenSpaceDistrict\BuckGulch\02_MCOSSD\BUCKGULCH\Drawings\PP2.dwg
 Plot Date: 3/11/2025 11:16 AM Layout: BRIDGE 1 PLAN AND PROFILE





PCI ECOLOGICAL
 103 MORRIS STREET, SUITE A-5
 SEBASTOPOLE, CA 95472
 (707) 824-4600

PREPARED FOR:
MARIN COUNTY OPEN SPACE DISTRICT
 3501 CIVIC CENTER DRIVE, SUITE 260
 SAN RAFAEL, CA 94903

DATE: 3/11/2025
 SCALE: 1" = 5'
 MAPPING BY: EC
 DESIGNED BY: KJ
 DRAFTED BY: KJ, EC
 CHECKED BY: KJ

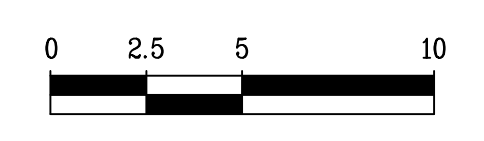
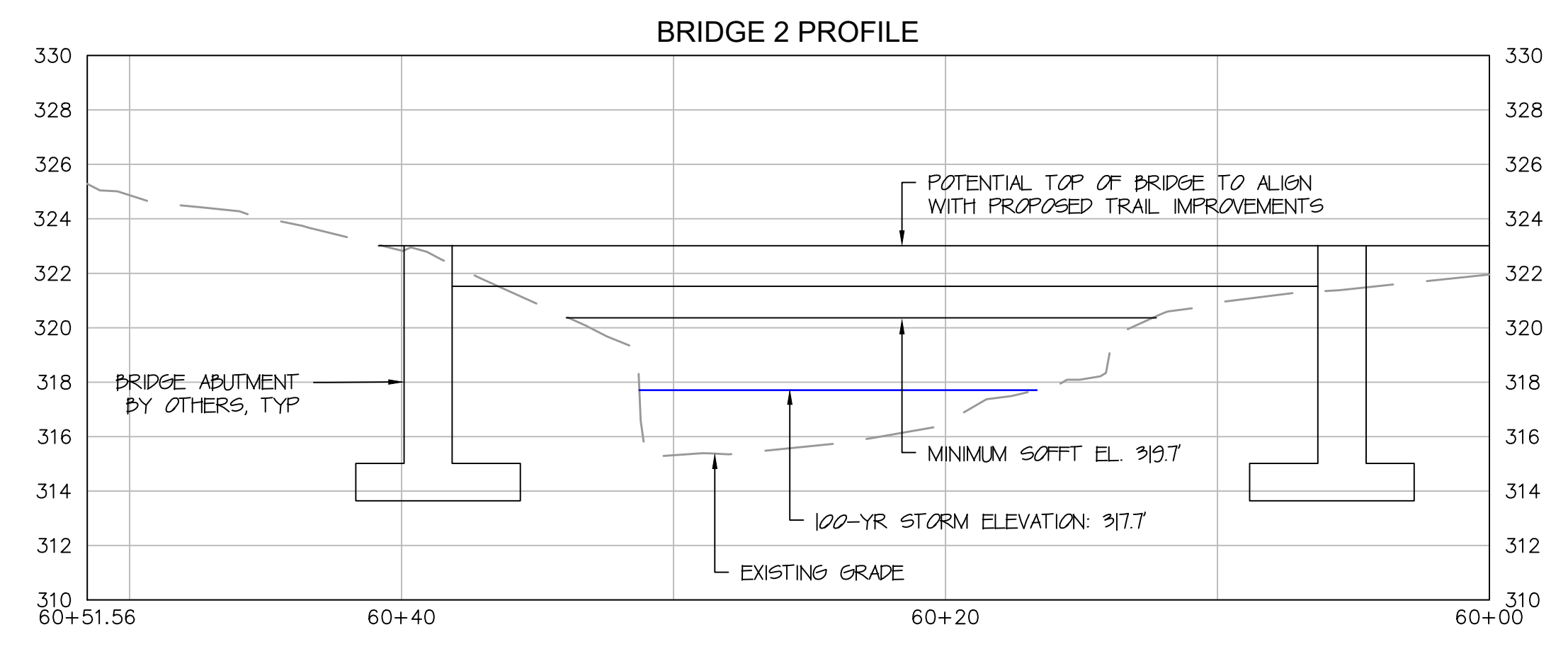
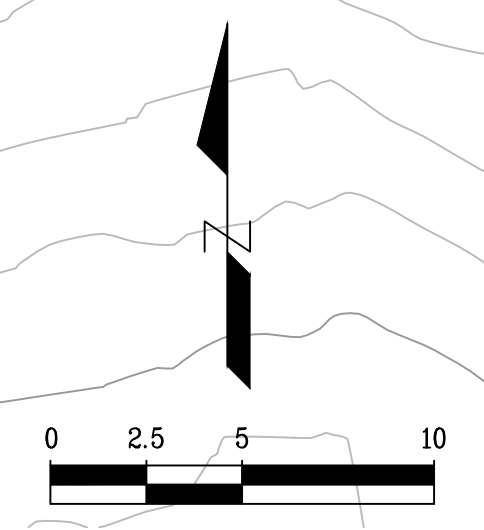
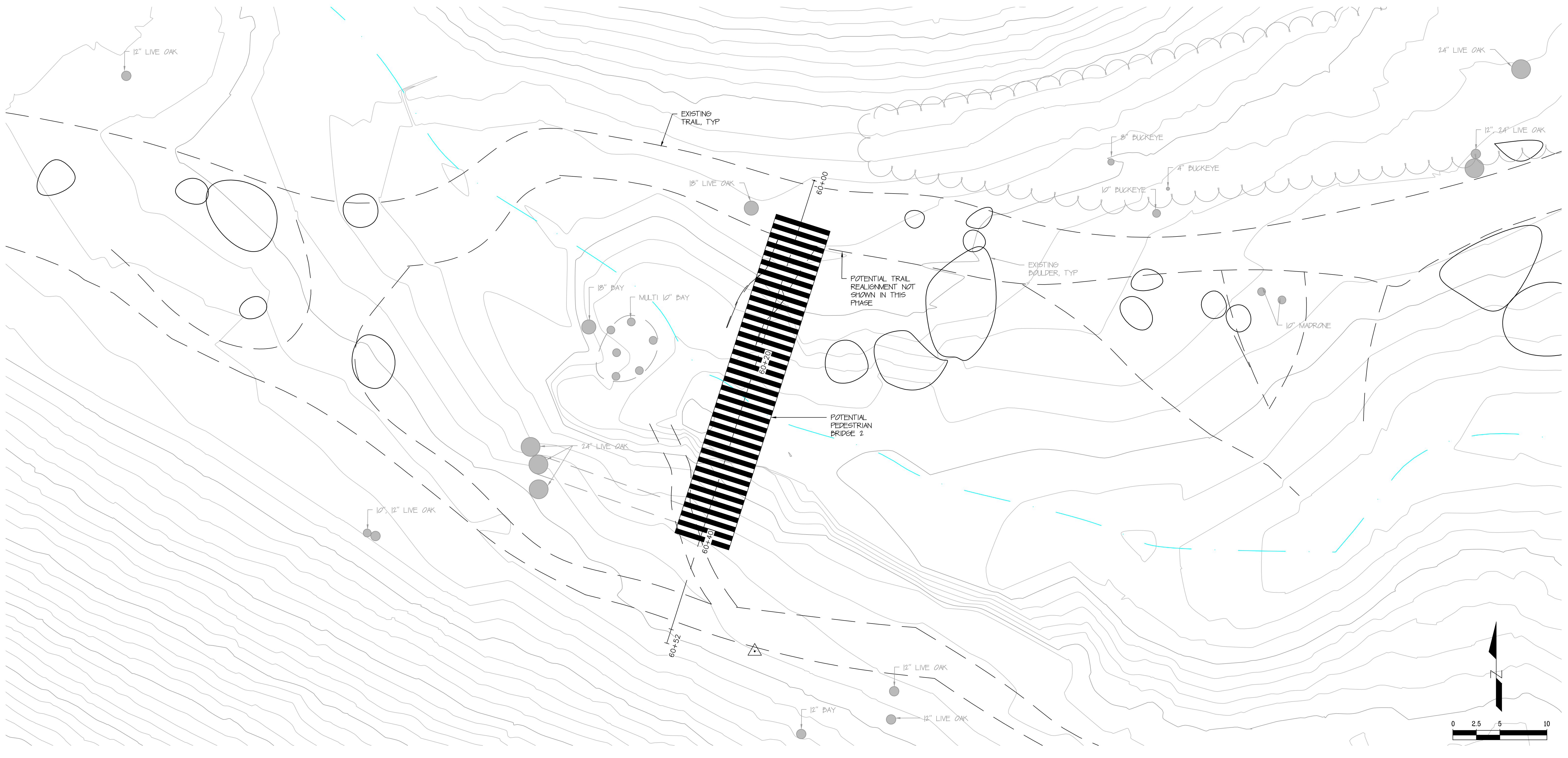
REVISIONS

NO.	DATE	DESCRIPTION
1	3/11/2025	ISSUED FOR PERMIT

BUCK GULCH FALLS TRAIL
BRIDGE PLACEMENT
BRIDGE 1 PLAN AND PROFILE

SHEET
1
 OF 2

VERIFY SCALES
 ONE INCH



VERIFY SCALES
 ONE INCH

Acad File Name: G:\CAD\2020\MarinCoOpenSpaceDistrict\BuckGulch\02_MCOOpenSpaceDistrict\02_MCOOpenSpaceDistrict\Drawings\Profile.dwg
 Plot Date: 3/11/2025 11:22 AM Layout: BRIDGE 2 PLAN AND PROFILE