Lower COM Corte Madera Creek Restoration Project

100% Design Basis Report

January 31, 2022

FRIENDS OF
CORTE MADERA CREEK
WATERSHED
PO Box 415 Larkspur CA 94977

In collaboration with

COLLEGE OF
MARIN

The 65% design plans for the Lower COM Corte Madera Creek Restoration Project were funded by the Coastal Conservancy, a California state agency, established in 1976, to protect and improve natural lands and waterways, to help people get to and enjoy the outdoors, and to sustain local economies along California's coast. It acts with others to protect and restore, and increase public access to, California's coast, ocean, coastal watersheds, and the San Francisco Bay Area. Its vision is of a beautiful, restored, and accessible coast for current and future generations of Californians. More about the Coastal Conservancy's program can be found at the Conservancy's website at scc.ca.gov.

The 100% design plans and specifications were funded by the Marin County Flood Control and Water Conservation District with support from the California Department of Water Resources.

Prepared By:

Geomorph Design Group
2100 Fourth St., No. 154
San Rafael, CA 94901

In Association With:

Stetson Engineers Inc.
2171 E. Francisco Blvd., Suite K
San Rafael, CA 94901

Miller-Pacific Engineering Group
504 Redwood Blvd, Suite 220
Novato, CA 94947

Prunuske-Chatham, Inc.
400 Morris St., Suite G
Sebastopol, CA 95472

Table of Contents

Table of Contents 1

1.0 Introduction 5

- 1.1 Project Purpose 5
- 1.2 100% Design Basis 5
- 1.3 Design Team Members, Project Stakeholders, and Abbreviations 9
- 1.4 100% Design Plan Set Contents 10
- 1.5 Lower COM Project Description – Overview 15
- 1.6 Permits and Agreements 17
  - 1.6.1 Environmental Regulatory Permits 18
  - 1.6.2 Coordination with Regulatory Agencies 19
  - 1.6.3 Right-of-Way, Easements, Agreements 21
- 1.7 Site Surveys for Design Plan Development 22
  - 1.7.1 Boundary Survey and Mapping 22
  - 1.7.2 Utility Locating and Marking 22
  - 1.7.3 Topographic Survey 22
- 1.8 Supporting Studies and Evaluations 22
  - 1.8.1 Geotechnical Investigation 22
  - 1.8.2 Hydraulic Analysis 23
  - 1.8.3 Vegetation Reconnaissance 24

2.0 Existing Utilities and Surface Features 25

- 2.1 Existing Utilities 25
- 2.2 Existing Concrete Channel 28
- 2.3 Stadium Way Pedestrian Bridge 29
- 2.5 Vest-Pocket Park and Flat Gravel-Covered Triangular Open Area 31
- 2.6 Access – West 32
- 2.7 Earthen Channel Berms 32
- 2.8 COM M&O Facility 34
- 2.9 Stormwater Drainage Facilities 34
- 2.10 Existing Rip-Rap Slope Protection 35
- 2.11 Fencing 36
- 2.12 Trees 36

3 Lower COM Project Design Features 38

4 Hydraulic and Geomorphic Design 45

- 4.1 Ross Valley and Lower COM Reach Flooding Overview 45
- 4.2 Lower COM Project Hydraulic Analysis for Design 45
- 4.3 Lower COM Project Geomorphic Analysis for Design 50
  - 4.3.1 Restored Channel Dimensions and Alignment 51
  - 4.3.2 Slope Erosion Protection Measures 52

5 Geology, Seismicity and Subsurface Conditions 58

5.1 General 58
5.2 Regional Geology 58
5.3 Seismicity 59
Regional Active Faults 59
Historic Fault Activity 59
Probability of Future Earthquakes 59
5.4 Surface Conditions 60
5.5 Field Exploration and Laboratory Testing 60
5.6 Subsurface Conditions and Groundwater 61
5.7 Previous Geotechnical Investigations 61
5.8 Geologic Hazards and Design Recommendations 62
5.9 Effect of Modifications on Concrete Channel Stability 62

6 Geotechnical Design Considerations 63
6.1 General 63
6.2 Seismic Design 63
6.3 Slope Stability Analysis 64
6.4 Creek Bank Stability and Erosion Control 65
6.5 Site Grading 65
Excavations 65
Fill Materials 66
Fill Placement and Compaction 66
Slopes 66

7 Revegetation 68
7.1 Plant Communities by Elevation Zones – Existing Conditions 68
7.2 Habitat Heterogeneity 69
7.3 Habitat Adaptation to Sea Level Rise 70
7.4 Tree Removal and Replacement 71
7.5 Creek Bank Restoration 72
7.6 Revegetation Plan 73
Plant Propagation 73
Soil Conditions and Treatments 73
Planting 74
Irrigation and Other Maintenance 75

8 Public Access Plan 76

9 Construction Implementation 77
9.1 Overview 77
9.2 Preliminary Construction Schedule 77
9.2.1 Environmental Considerations During Construction 78
9.2.2 Dewatering Plan 78
9.2.3 Mitigation Monitoring and Reporting Plan 78
9.3 Construction Sequence 79
9.4 Construction Staging and Access 81
9.5 Construction Material Requirements 81

10 Limitations 83

11 References 84

List of Tables

Table 1-1 Studies and Evaluations Completed for 100% Design 5
Table 1-2 Design Team Members and Project Stakeholders 9
Table 1-3 100% Design Plan Set Contents 10
Table 1-4 Corte Madera Creek Bed Elevation Data Sources 13
Table 1-5 Corte Madera Creek Design Tidal Water Surface Elevations 14
Table 1-6 Habitat Restoration Areas by Elevation Horizon 15
Table 1-7 Right-of-Way, Easement, or Agreement Obtained 21
Table 3-1 Key Lower COM Project Features, Elevations, and Dimensions 41
Table 4-1 Hydraulic Model Output for Bankfull Evaluated at Upstream End 48
Table 4-2 Hydraulic Model Output for Bankfull Evaluated at Downstream End 49
Table 4-3 Permissible Velocity for Selected Lining Materials 53
Table 4-4 Boulder-Anchoring Requirements for Stabilizing Large Wood 54
Table 7-1 100% Design Restoration Habitat Types 69
Table 7-2 Anticipated Sea Level Rise 70
Table 7-3 100% Design Tree Removal List 71
Table 9-1 Construction Schedule 77

List of Figures

Figure 9-1 Schematic Construction Sequence Diagram 80

List of Appendices

Appendix 1. Dewatering Plan. (Friends of Corte Madera Creek, November 27, 2020)

Appendix 2. Mitigation Monitoring and Reporting Plan (MMRP) (Friends of Corte Madera Creek, November 22, 2020)

Appendix 3. Boundary Survey Map (Oberkamper Associates, January 2020)

Appendix 4. Geotechnical Investigation Lower Corte Madera Concrete Channel (Miller-Pacific Engineering Group, December 2021)

Appendix 5. Draft Hydraulic Analysis Report for the 65% Design (Stetson Engineers, December 2020)

Appendix 6. Alternatives Analysis for Lower COM Creek Restoration Project (Geomorph Design, August 2021)

Appendix 7. Final Hydraulic Analysis Report (Stetson Engineers, February 2022)

1.0 Introduction

1.1 Project Purpose

The purpose of the Lower College of Marin (Lower COM) Corte Madera Creek Restoration Project (project) is to (1) restore as much natural functioning aquatic, tidal, transitional, and riparian upland habitat as possible within site constraints, in a manner that is adaptive to future sea level rise (SLR) and (2) accommodate floodwater delivered to the channel and convey it to the downstream end of the concrete channel where there is adequate capacity, by removing parts of the downstream end of the Army Corps of Engineers concrete flood control channel.

To restore as much habitat as possible, Lower COM project focuses on removing the downstream-most 468-foot-long section of the concrete channel, from its downstream terminus to near the domestic water and sanitary sewer utility crossings on the downstream side of the Stadium Way pedestrian bridge. The Project reach extends approximately 100 feet downstream from the channel terminus to also remove rip-rap slope protection and restore natural vegetated stream banks conforming smoothly with the earthen channel section at the downstream project limits.

1.2 100% Design Basis

This 100% Design Basis Report (DBR) documents the technical basis for the 100% Lower COM project design as shown in the 100% design plan set dated January 2022. Technical basis for the 100% design was developed from multiple studies, consultations and evaluations (Table 1-1).

Table 1-1
Studies and Evaluations Completed for 100% Design

Feature/Evaluation	Preliminary Studies/Evaluation
Utilities	T&S Locating researched and marked utilities. Geomorph Design Group (GDG) surveyed the field-marked utility locations into design plans as existing conditions. Ross Valley Sanitary District (RVSD) provided sewer utility GIS/CAD files to GDG containing sewer and other utility information in the area. Coordinate with RVSD re. adequacy of remaining hardscape area for their operations.

Right-of-Way and Easements	Oberkamper & Associates surveyed and field-marked property, right-of-way, and easement boundaries in the Project area and provided AutoCAD files to GDG. O&A also prepared Legal Descriptions and Plats for added temporary and permanent easements or agreements required for project construction.
Existing Concrete Channel	GDG researched archival concrete channel design plans and surveyed existing conditions concrete channel limits, including probing through sediment deposits to survey concrete channel floor elevations. Concrete wall and floor thickness estimated from Army Corps of Engineers design drawings and verified from concrete sample borings made by Marin County Flood Control District (District) elsewhere in the channel.
College of Marin (COM) Facilities	COM provided AutoCAD files for Maintenance & Operations (M&O) buildings, constructed in 2019 and early 2020, adjacent to the project reach. GDG surveyed existing as-built COM facilities. COM revised site plan and moved the planned “hammerhead” paved emergency vehicle turn-around farther from Corte Madera Creek to accommodate habitat restoration. COM provided comments to preliminary design re: minimum setback requirements. GDG designed modifications to the stormwater drainage facilities pre-dating and built for the M&O site development for discharging stormwater safely on the new restored creek bank slope.
Hydraulic Design	Stetson Engineers Inc. (Stetson), performed 1D/2D hydraulic model analysis of 65% and 100% design condition to determine design velocities for slope erosion protection design in the project reach and confirm by hydraulic modeling that there would be no net rise of upstream water surface elevations (i.e., the project would not create more flooding). Stetson also completed FEMA hydraulic model analysis to evaluate the Project effects on the FEMA Regulatory Floodway. Stetson’s Hydraulic Study Report is Appendix 5 to this DBR.
Geotechnical Investigation	Miller Pacific Engineering Group (MPEG) researched existing geotechnical data including data provided by COM for the M&O facility and collected new soil boring data, provided preliminary and final design recommendations, including for remediating liquefiable sands found located in the creek bank restoration area east of the concrete channel. MPEG’s Geotechnical Investigation Report is Appendix 4 to this DBR.
Structural Evaluation	MPEG advised design alternatives for partial concrete channel removal for avoiding and minimizing need for structural retrofits to stabilize remnant channel section and protect utilities.
Construction Feasibility and Logistics	GDG, Stetson, and Friends of Corte Madera Creek Watershed (Friends) convened site meeting with an experienced local general contractor to strategize minimum duration and minimum

	impact construction logistics for equipment and materials access, staging, and sequencing work, including dewatering. Youngs Construction Services (YCS) provided comments to the draft and final 100% design plans and specs re. constructability and clarity for bidding Contractors.
Construction Duration and Schedule	Contractor site meeting provided construction sequence and duration of individual construction elements, including for means and methods for minimizing duration of creek dewatering. Friends prepared preliminary construction schedule for EIR analysis, permit applications and programming.
Construction Cost Estimate	Contractor site meeting used to determine duration of work and typical unit costs. District prepared cost estimate for EIR analysis, permit applications and programming. YCS prepared a detailed independent construction cost estimate for internal Quality Control/Quality Assurance.
Sustainability	Contractor site meeting provided basis for confirming economics of materials recycling including concrete recycling and minimizing number of truck trips for materials delivery and off-haul and landfill requirements. GDG designed buried and sub-tidal rock revetments and reserve volume within boulder-anchored large wood slope protection areas to completely reuse the salvaged rip-rap on site.
Habitat Restoration	GDG configured design plan to remove as much of the concrete channel as feasible and taper-cut concrete channel walls to maximize total amount of restored natural, gradually-sloped creek bank area up to the limit of physical constraints (Stadium Way pedestrian bridge, utilities, bike routes, COM-required setbacks, District berms) with gradual slopes for natural vegetation community restoration in consultation with Prunuske-Chatham Inc. (PCI). Miller Pacific Engineering Group (MPEG) tested soil samples taken from near the design finished bank slopes to check for pollutants in the soil as may affect soil suitability for habitat restoration planting.
Adaptation to Future Sea-Level Rise (SLR)	PCI fine-tuned creek bank grading contours to restore a range of restored vegetation communities for existing and future projected sea levels and adaptability.
Stream Bank Slope Erosion Protection	GDG configured design plan to provide gradually sloped channel banks protected by biodegradable erosion control fabrics. GDG designed buried revetments to re-use rip-rap salvaged from on-site removal and minimized amount of exposed rock slope protection needed at outside bend using anchored large wood materials. Minor rock slope protection required at margins of taper-cut concrete channel walls would be vegetated to the extent practically feasible.

Public Access and Safety	Friends consulted with the COM Board of Trustees (BOT) about continued access along the right bank and with Parks about the configuration of the vest-pocket park on the left bank. The BOT requested that the existing informal, unmapped access be maintained along the right bank. Parks was in general agreement with the 65% design and developed pending park improvement plans in parallel with 100% design development. Friends coordinated with stakeholders, including Kentfield School District (KSD) and Kentfield Fire Protection District (KFD) to obtain review and approval of the Fence and Gate Plan and arranged the Technical Specifications to require Contractor to Submit a Fence & Gate Plan for final review and approval prior to construction.
Emergency Vehicle Access	Friends coordinated with COM and KFD to revise M&O facility site plan to move the planned and partially constructed hammerhead emergency vehicle turn-around farther to the west away from the project reach to accommodate habitat restoration. Friends consulted with RVSD and KFD to determine turn-around requirements at RVSD Kentfield Pump Station 15. RVSD considers the existing space in front of the pump station, as modified in the 65% design and shown in the 100% design to be adequate. KFD was provided the draft 100% designs for review prior to final plans development.
Stormwater Management	GDG configured design plan to remove the downstream portions of existing and recent as-built stormwater drainage facilities that discharge into the concrete channel so that they would discharge safely onto the rock slope protection on the restored channel bank.
Flood Management	Project by definition will not worsen flood risk because it will replace the removed portion of the concrete channel with an over-widened channel that gradually and smoothly conforms with the earthen channel-berm section downstream from the project reach. Stetson performed 1D/2D hydraulic modeling to confirm no net rise of the 100-year flood upstream and downstream from the project reach. Stetson used the FEMA hydraulic model to evaluate effects within the regulatory floodway (pending).
Environmental Permitting	To obtain feedback from environmental permitting agencies, Friends arranged for attendance at the 6/4/2020 Marin Project Coordination (MPC) meeting convened by MCSTOPPP. Friends and GDG attended a follow-up meeting with agency representatives on 6/18/2020. Consultations have been completed and/or permits have been obtained or pending from CDFW, RWQCB, Army Corps, NOAA Marine Fisheries, U.S. Fish & Wildlife Service, BCDC, California State Lands Commission.

1.3 Design Team Members, Project Stakeholders, and Abbreviations

Table 1-2
Design Team Members and Project Stakeholders

Design Team Member	Abbreviation	Role/Responsibility
Friends of Corte Madera Creek Watershed	Friends	Project Management Stakeholder Coordination
Geomorph design Group	GDG	design Team Coordination Hydraulic-Geomorphic design Slope Protection design design Plan Production
Stetson Engineers Inc.	Stetson	Hydraulic Analysis Construction Logistics Support Technical Specifications Quality Assurance/Quality Control Bid Document Production
Miller-Pacific Engineering Group	MPEG	Geotechnical Investigation Geotechnical Design Recommendations
Prunuske-Chatham, Inc.	PCI	Bank Slope Grading Design Support Habitat and Vegetation Restoration Sea-Level Rise Adaptation
Oberkamper & Associates, Inc.	O&A	Recorded Boundary Survey
T&S Locating Service	T&S	Utility Research and Field-Marking
GHD Group	GHD	Coordination with designs of upstream components of larger project
Youngs Construction Services, Inc.	YCS	Constructability Evaluation, Independent Cost Estimate, and Bid Document Review for Quality Assurance/Quality Control

Project Stakeholder	Abbreviation	Contact
Marin County Dept of Public Works	District	Joanna Dixon
College of Marin Facilities	COM	Klaus Christiansen
College of Marin Board of Trustees	BOT	David Wain Coon
Ross Valley Sewer District	RVSD	Noel Sandoval
Marin County Parks District	Parks	Tara McIntire
Marin County Stormwater Pollution Prevention Program	MCSTOPPP	Howard Bunce
Marin County Board of Supervisors	BOS	Nancy Vernon, Aide to Supervisor Rice
Kentfield Planning Advisory Board	KPAB	Anne Petersen
Kentfield School District	KSD	Raquel Rose
Kentfield Schools PTA	KSPTA	Erica Applestein
Kentfield Fire Protection District	KFD	Mark Pomi
Marin County Bicycle Coalition	MCBC	Bjorn Kriepenburg
Army Corps of Engineers	COE	Roberta Morganstern
NOAA Marine Fisheries	NMFS	Sara Azat
Regional Water Quality Control Board	RWQCB	Nicole Fairley
California Department of Fish & Wildlife	CDFW	Amanda Culpepper
SF Bay Conservation and Development Commission	BCDC	Rowan Yelton
California State Lands Commission	SLC	Dobri Tutov
Bay Delta U.S. Fish & Wildlife	USFWS	Brian Hansen

1.4 100% Design Plan Set Contents

The 100% design plan set dated contains 36 ANSI D size (22”x34”) sheets (Table 1-3).

Table 1-3
100% Design Plan Set Contents

Sheet	Title	Scale
C1	Cover Sheet	NA
C2	Air Photo Design Simulation	NA

C3	Existing Conditions Site Plan	1” = 30’
C4	30-Scale Design Plan	1” = 30’
C5	Design Longitudinal Profile	1” = 30’
C6	10-Scale Design Plan (1 of 4)	1” = 10’
C7	10-Scale Design Plan (2 of 4)	1” = 10’
C8	10-Scale Design Plan (3 of 4)	1” = 10’
C9	10-Scale Design Plan (4 of 4)	1” = 10’
C10	Typical Sections (1 of 5)	1” = 10’
C11	Typical Sections (2 of 5)	1” = 10’
C12	Typical Sections (3 of 5)	1” = 10’
C13	Typical Sections (4 of 5)	1” = 10’
C14	Typical Sections (5 of 5)	1” = 10’
C15	Stormwater Drainage Plan	1” = 30’
C16	Stormwater Outfall and Wood Connection Details	NA
C17	Boulder-Anchored Large Wood Bank Erosion Protection Plan	1” = 6’
C18	Boulder-Anchored Large Wood Bank Erosion Protection Plan	1” = 6’
C19	Construction Access, Exclusion Fencing, and Staging Plan	1” = 30’

C20	Construction Sequence Plan	1” = 30’
C21	Demolition Plan	1” = 30’
C22	Creek Dewatering Plan	1” = 30’
C23	Tree Removal Plan	1” = 30’
C24	Property, Easement, and Rights-of-Way Boundary Map	1” = 30’
C25	Erosion and Sediment Control Plan (ESCP)	1” = 30’
C26	Erosion Control Details and Notes	NA
C27	Grading Plan	1” = 30’
C28	Fence and Gate Plan	1” = 30’
C29	Fence and Gate Details	NA
C30	Slope Erosion Protection Plan	1” = 30’
C31	Slope Erosion Protection Details	NA
C32	Geotechnical Boring Map	1” = 30’
C33	Overall Construction Access Plan	1” = 60’
L1	Proposed Revegetation Plan (PCI)	1” = 30’
L2	Planting Plan Details (PCI)	NA

S1	Retaining Wall Design Plans (MPEG)	1:12

Sheet C2 shows a “before and after” digital photo simulation of existing and the 100% design made from an August 2021 bird’s eye view aerial drone photo of the project reach.

Sheet C3 (1”=30’) shows the January-February 2020 topographic survey of the existing conditions of the project reach along the concrete channel and within the broader project area, including: utility locations, boundaries of properties, easements, and rights-of-way, detailed limits of the paved multi-use path (MUP) along the left bank (Marin County Bike Route 20), tree locations, existing bank topography and rip-rap limits downstream from the channel, existing channel bed topography and bathymetric contours, existing berms, construction access, facilities and building footprints, drainage features, the gravel footpath and fence along the right bank, and utility crossings on the downstream side of Stadium Way pedestrian bridge forming the upstream limits of the project.

Sheet C4 (1”=30’) shows the proposed project conditions indicating which parts of the concrete channel walls would be removed, grading limits and new top of bank alignments, detailed restoration channel bank grading contours for distributing restoration vegetation community types, anticipated self-sustaining channel bed topography and bathymetric contours, footprints of buried rip-rap revetments, areas of slope protection, and a new top of bank retaining wall forming the limit between the restored habitat and the vest-pocket park adjacent to the MUP.

Table 1-4
Corte Madera Creek Bed Elevation Data Sources

Bed Elevation Date	Source
January 1970 (or prior)	January 1970 Army Corps of Engineers design plans
January 2018	CLE Engineering
February 2020	GDG survey February 5-6, 2020

Sheets C5 (1”=30’) shows a longitudinal profile view of the Project reach indicating which portions of the left (east) and right (west) channel walls would be removed for optimizing the habitat and transitioning from the narrow rectangular concrete channel shape to a wider restored natural channel shape. Channel bed elevation profiles are shown from three data sources (Table 1-4). All elevations given in this design report are in NAVD88 vertical datum. As well, multiple tidal water surface elevations are shown (Table 1-5):

Table 1-5
Corte Madera Creek Design Tidal Water Surface Elevations

WSE (ft NAVD88)	Source
1.7	GDG surveyed minimum water surface during February 5, 2020 low tide of minus 0.3'. Natural bed sedimentation downstream from the concrete channel prevents tides lower than 1.7' in the concrete channel.
3.5	2020 Mean Sea Level (MSL)
8.0	2020 Mean Higher High Water (MHHW)
9.5	Estimated 2050 Mean Higher High Water (MHHW)
11.0	Estimated 2100 Mean Higher High Water (MHHW)

Estimates of sea level rise in Table 1-5 are based on the San Francisco Bay Tidal Datums and Extreme Tides Study (2016), prepared by AECOM for the Federal Emergency Management Agency and the San Francisco Bay Conservation and Development Commission. The AECOM study uses National Research Council (2012) sea level rise estimates for San Francisco relative to the year 2000 (Sea-Level Rise for the Coasts of California, Oregon, and Washington, 2012). The AECOM report also provides location-specific tidal datum elevations for current conditions; for the Corte Madera Creek design, Marin Point 60 was used as the primary reference.

Sheets C6 through C9 (1"=10') show the design plan at a larger scale suitable for construction document development. These 10-scale sheets show the same information as the 30-scale sheets but at a larger scale better distinguishing adjacent and overlapping features.

Sheets C10 through C14 (1"=10') show 14 selected design cross-sections showing concrete channel wall removal, existing and proposed bed/bathymetric contours, restoration creek bank surface grading and slopes compared to the range of future sea levels, and surface and buried slope protection features. Location and estimated depth of utilities below the MUP are shown in the cross-sections.

Sheets C15 through C33 (1"=30' or varies) show individual plans for individual components and features of the project. Sheet C32 is a geotechnical boring location map showing the boundaries of the historical pre-development Corte Madera Creek channel at the site for context of boring log findings.

Sheet L1 (1”=30’) prepared by PCI, shows the revegetation zones corresponding to the tidal fluctuation-related elevation horizons and the design creek bank grading contours that were tuned to distribute the revegetation community types throughout the project area. Preliminary plant lists are provided for each of the revegetation zones: Low Marsh, High Marsh, Transition Zone, and Upland. Approximate extents, and reference vegetation type images, are provided for each zone. Sheet L2 contains planting plan details prepared by PCI.

1.5 Lower COM Project Description – Overview

The 100% design plans show that the project would restore the maximum practically feasible amount of habitat at the site by concrete channel wall removal in the project area downstream from the Stadium Way pedestrian bridge within the constraints imposed by existing utilities and facilities running under the channel and on both sides of the channel.

Table 1-6
Habitat Restoration Areas by Elevation Horizon

Habitat	Elevation (ft NAVD88)	Existing Area (sq ft)	Proposed Area (sq ft)
Open Water/ Channel	≤3.5’	23,565	30,200
Low Marsh	3.5 – 4.5’	1,744	7,000
High Marsh	4.5’ – 6.0’	2,892	8,600
Transition Zone	6.0’ – 8.0’	3,116	16,800
Uplands	≥8.0’	49,103	17,820
Total		80,420	80,420

The 100% design would remove part of the downstream 468 feet of the right (west) channel wall and part of the downstream 156 feet of the left (east) channel wall to restore gradually sloped channel banks suitable for natural revegetation and limited rock slope protection requirements. The 100% design would grade the creek bed and banks to create tidal and wetland habitats and new transitional and upland habitats and swales. Appropriate native vegetation would be established according to elevation horizons related to tidal fluctuations (Table 1-6).

The creek bank restoration contouring was designed to distribute the elevation-dependent vegetation communities and habitats throughout the project area both for existing tidal conditions and future higher sea level conditions to be adaptive to sea level rise and resilient to climate change.

Other notable project elements include:

- Hydraulic analysis to confirm project would not increase flood water surface elevations;
- Improvements to an existing MUP and vest-pocket park adjacent to the creek;
- Re-use or recycling of all materials removed for the creation of the new habitats (riprap, concrete, steel, earthen fill, vegetation, fencing, etc.).

These other elements, or actions, may likely be included as mitigation measures or special conditions:

- Configuration and phasing of construction activities (access, dewatering of the creek, concrete removal, grading, habitat restoration, etc.) to minimize duration of construction and temporary environment impacts resulting from its construction;
- Protection of the sanitary sewer and other utilities running underneath the MUP on the left (East) side of the creek;
- Maintaining adequate staging and emergency vehicle turn-around space in the vicinity of the existing sewer pump station and vest-pocket park;
- Consistency with the KFD and COM requirements for operation and maintenance of college facilities and access, including emergency access; and,
- Consistency with Marin County Parks, Safe Routes to School, and Marin County non-motorized transportation guidelines and requirements for the MUP.

The 100% design maximizes habitat restoration considering physical constraints crossing the channel and on both sides of the channel:

- Sanitary sewer siphon crossing under the concrete channel about 20 feet downstream from the Stadium Way pedestrian bridge;

- Sewer and other utilities running parallel to the left bank channel wall under the narrow asphalt-paved MUP
- Required staging, parking, and emergency equipment turn-around space adjacent to RVSD pump station;
- Required setback distance from COM M&O facilities per COM and KFD;
- Planned or potential improvements to the MUP, Vest-Pocket Park, and Stadium Way pedestrian bridge per Parks;
- Maintaining access uses similar to existing along the new top of right (west) bank per COM.

The 100% design is configured to/for:

- Minimize temporary environmental impacts of dewatering during construction;
- Make the restored habitat resilient to projected future sea level rise;
- Consistency with Marin County Parks, Safe Routes to School, and Marin County non-motorized transportation guidelines and requirements (Marin County Bike Route 20);
- Replace and convert existing and recently as-built storm drainpipes and facilities to discharge stormwater treated on M&O site onto the restored slope in area of boulder-anchored large wood for minimizing exposure of rock slope protection and storm drain outfall;
- Remove 9,200 square feet (exposed area) of existing rip-rap downstream from the concrete channel and recycle all of the salvaged material into buried revetments needed along the outside channel bend;
- Re-use or recycle all materials (rip-rap, concrete, steel, earthen fill, vegetation, fencing, etc.) removed for accommodating creek restoration; and,
- Not increasing flood water surface elevations at and near the site.

1.6 Permits and Agreements

Obtaining required regulatory permits, rights-of-way, and other authorizations and agreements for this project is the responsibility of the District. The District is the project sponsor and Lead Agency under CEQA and certified the final EIR on August 17, 2021. As such, the District is responsible for implementing the mitigation measures set forth in the final EIR and complying with regulatory permit condition. The District will construct, own, operate, and maintain the Lower COM Concrete Channel Removal Project.

1.6.1 Environmental Regulatory Permits

Implementation of the project will require regulatory approvals from:

- U.S. Army Corps of Engineers (USACE);
- San Francisco Bay Regional Water Quality Control Board (RWQCB);
- U.S. Fish and Wildlife Service (USFWS);
- California Department of Fish and Wildlife (CDFW);
- SF Bay Conservation and Development Commission (BCDC); and
- State Historic Preservation Office (SHPO).

The Dewatering Plan (Appendix 1) describes the following:

- installation of sheet pile coffer dam at downstream end of work area using a Silent Piler™
- a coffer dam composed of sandbags or similar at the Stadium Way Bridge
- dewatering with approved protection for aquatic species

The Mitigation Monitoring and Reporting Plan (Appendix 2) describes the following:

- removal by hand and salvage of tidal wetland plants in tidal areas downstream of the concrete channel that will be disturbed; this will protect salt marsh harvest mice that might be in the area
- limiting construction activities in the tidal wetlands to avoid rail breeding season
- environmental compliance monitoring by a qualified biologist approved to handle Ridgway's rails and salt marsh harvest mice when work is underway downstream of the concrete channel

All construction workers will be trained regarding sensitive resources in the area before they begin work.

The project will require a Section 408 permit, which provides approval from the USACE for modification of a previously constructed USACE project. The 408 permit is issued concurrently with the Section 404 permit and after Section 10 consultations with NOAA Fisheries (no-effect letter issued October 5, 2021) and USFWS (BO issued January 19, 2022);

Section 106 consultation with SHPO (no-effect letter issued on October 13, 2021); and Section 401 concurrence by the RWQC are issued.

The project will qualify for coverage under the USACE CWA Section 404 Nationwide Permit Program, which is a streamlined CWA Section 404 approval process. USACE will use NWP 33, restoration.

A Pre-Construction Notification (PCN) package to request coverage under the Nationwide Permit Program was prepared and submitted to the USACE. The PCN package included: the required notification form; supplemental information on the project; summary of potential impacts and impact avoidance and minimization measures; technical reports to support USACE consultation with NOAA Fisheries and USFWS; project designs; and other required information.

Project impacts within the Corte Madera Creek channel and banks will require approval from the RWQCB, which administers CWA Section 401 and the Porter-Cologne Water Quality Control Act. A project application package requesting CWA Section 401 Water Quality Certification and Waste Discharge Requirements for the proposed project was prepared and submitted to the RWQCB. The application package included: the required notification form; supplemental information on the project; summary of potential impacts and impact avoidance and minimization measures; technical reports to support USACE consultation with NOAA Fisheries and USFWS; project designs; and other required information.

Project impacts within the Corte Madera Creek channel, banks, and riparian corridor will also require approval from the CDFW, which administers California Fish and Game Code Section 1602. A project notification package for a Lake and Streambed Alteration Agreement ("LSAA") was prepared and submitted to CDFW. The submitted LSAA notification included: the required notification form; supplemental information on the project; summary of potential impacts and impact avoidance and minimization measures; technical reports to support USACE consultation with NOAA Fisheries and USFWS; project designs; and other required information. The CDFW Agreement was issued on September 27, 2021.

1.6.2 Coordination with Regulatory Agencies

MCSTOPPP schedules regular Marin Project Coordination (MCP) meetings, which provide project proponents the opportunity to meet with regulators and receive informal input in advance of submitting permit applications. The Lower COM Project was discussed at the 6/4/20, attended by representatives of the District, Marin RCD; CDFW, RWQCB, BCDC, NOAA Fisheries, USACE, GDG, and Friends. After a review of the basic project components by the GDG, the following comments were made:

- Dispose of all concrete that is removed; rock rip-rap can be buried. (Note: All of the concrete, rebar, and fencing that is removed will be recycled at the Marin Resource Recovery Center. The rock rip-rap just downstream of the concrete channel will be recycled and buried as a revetment as part of the project. There are some concrete tree planting collars within the rock rip-rap that will be recycled off-site.)
- Dewatering should be discussed in detail.
- Thoroughly address existing and future potential habitat for Ridgway's rail and salt marsh harvest mouse in permit applications.
- Review bioretention areas and swales.
- Review plant palate.
- Develop realistic monitoring success criteria for the 5-year annual monitoring plan requirement, recognizing that it may be as low as 50% total cover within the mid & high marsh habitats (i.e. it could take more than the required 5-year monitoring period to fully restore marsh vegetation).
- Permits:
    - Project will need 401, 404 (using NWP 33), and 408 permits. The 401 permit must be issued before 408 and 404 permits can be issued by the USACE. RWQCB can provide a draft version of the 401 to aid preparation of other permits.
    - The project is too long (>500 ft) to qualify for CDFW 1652 or 1653 permit, but it would qualify as an Ecological Restoration and Enhancement Project and associated application fee structure.
    - A complete list of permits (and cost) by agency should be assembled.

At the end of the 6/4/20 meeting, a follow-up meeting was requested. This was held 6/18/20 and attended by representatives of the District, Marin RCD, CDFW, RWQCB, BCDC, NOAA Fisheries, GDG, and project proponents. Key suggestions resulting from this meeting are:

- *Salix lasiolepis* (Arroyo willow) is the most salt-tolerant willow.
- Existing and future potential habitat for Ridgway's rail and salt marsh harvest mouse should be addressed in permit applications.
- The Lower COM Project can be permitted separately, but it should be included in the EIR in preparation for the Corte Madera Creek Flood Risk Management Project. Permits should be for 5 years, in case funding cannot be obtained in time for 2022 construction.

1.6.3 Right-of-Way, Easements, Agreements

Concrete removal activities will occur on property controlled by the District. Similarly, creek bank grading, revegetation, and any future enhancements of the vest-pocket park on the left bank will be on District-controlled land. However, creek bank grading, revegetation, and bio-swale/bioretention facilities on both the right (west) side of the channel will be primarily constructed on lands owned by COM. The District will need an agreement to restore the creek within COM. As well, the District will need an agreement to allow for construction access and possibly for maintenance of the restored vegetation and vegetated bio-swales and bioretention areas, and post-flood debris removal.

Table 1-7 summarizes the affected properties the types of right-of-way or easements or agreements obtained for implementing the Lower COM Project.

Table 1-7
Right-of-Way, Easement, or Agreement Obtained

Property	Lower COM Project Effect	Type of Right-of-Way/Agreement for Activity
COM	Restored Creek and Habitats	Right-of-Way, Easement or Agreement to restore creek habitats within COM.
COM	Access During Construction	Temporary Right-of-Way, Easement or Agreement for construction access to the site.
COM	Routine vegetation and stormwater drainage management	Right-of-Way, Easement, or Agreement to allow District to monitor and maintain vegetation, bio-swales/ bioretention areas, remove sediment and debris, etc.

1.7 Site Surveys for Design Plan Development

1.7.1 Boundary Survey and Mapping

Oberkamper & Associates Civil Engineers Inc. performed a boundary survey of property, right-of-way, and State Lands Commission jurisdiction in January-February 2020 (Appendix 3). The basis of survey coordinates is California Coordinate System of 1983 (CCS83), North American Datum of 1983 (NAD83) (2011) 2017.50 EPOCH. The survey basis of elevation is North America Vertical Datum of 1988 (NAVD88) via RTK connected to the CRTN.

1.7.2 Utility Locating and Marking

T&S researched and marked utilities. GDG surveyed the field-marked utility locations into design plans as existing conditions. RVSD provided sewer utility GIS/CAD files to GDG containing sewer and other utility information in the area, which GDG placed in the design plans or otherwise used to verify field-located and surveyed information.

1.7.3 Topographic Survey

In February 2020, GDG performed a topographic survey of the project area which detailed the existing concrete channel limits, marked utilities, trees, fences, and other features. GDG surveyed existing conditions concrete channel limits, including probing through sediment deposits to survey concrete channel floor elevations and verifying accuracy of 1970 Army Corps of Engineers design plans and/or as-built plans. GDG surveyed channel bed and bathymetric elevations and existing as-built facilities at the COM M&O facility.

1.8 Supporting Studies and Evaluations

1.8.1 Geotechnical Investigation

Miller-Pacific Engineering Group prepared a geotechnical investigation for the project to explore subsurface conditions and to develop geotechnical criteria for design and construction of the creek restoration project (Appendix 4):

- Review readily available geotechnical and geologic reference materials, including existing reports prepared by other consultants for previous site improvements.
- Explore subsurface conditions with four borings located within the general vicinity of the planned improvements.
- Geotechnical laboratory testing to estimate pertinent engineering properties of the soils encountered during our exploration.

- Evaluate relevant geologic hazards including seismic shaking, settlement, liquefaction, and other hazards.
- Prepare geotechnical recommendations and design criteria for related earthwork, seismic design, and other geotechnical-related items.

1.8.2 Hydraulic Analysis

Stetson Engineers performed preliminary hydraulic analyses to support the 65% and 100% design for the Lower COM Project using the HEC-RAS 1D/2D unsteady-flow hydraulic model that was initially developed jointly by Stetson Engineers and USACE in 2017 for the entire Ross Valley watershed. The model was then truncated/modified/updated by Stetson in 2018-2019 as necessary for the County's Lower Corte Madera Creek levee evaluation project. The truncated levee evaluation model for the Lower Corte Madera Creek that has a model domain below the Ross Creek confluence was used for this hydraulic analysis and further updated with the latest 2020 field survey data around the Lower COM Project area to meet the needs of this specific study.

The first part of the hydraulic analysis was for computing worst-case maximum creek flow velocities along the new restored channel banks for slope erosion protection design. The worst case was conservatively assumed as the bankfull flow at the project reach coincided with downstream mean lower low tidal condition. Refer to Appendix 5 for the 65% Hydraulic Study Report. The second part of the hydraulic analysis was for verifying that the Project will not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions, and not worsen flooding under future sea level rise conditions.

Appendix 7 contains the Hydraulic Study Report and an analysis of compliance with FEMA requirements for Regulatory floodways.

Overview of the Ross Valley Watershed-Wide HEC-RAS 1D/2D HEC-RAS Hydraulic Model

The Ross Valley watershed-wide HEC-RAS 1D/2D hydraulic model starts at the San Francisco Bay and extends about 10 miles upstream along the mainstream and tributaries of Corte Madera Creek into the upper watershed upstream of Fairfax. The model was first calibrated to the 12/15/2016 bankfull event by running and rerunning the model and adjusting the model's in-channel parameters with each iteration until the model-simulated peak water surface elevations satisfactorily matched the observed channel high water marks (HWMs). The model was then calibrated to the 12/31/2005 flood event by further adjusting the floodplain parameters until the model-simulated peak water surface elevations in the floodplain satisfactorily matched the observed floodplain HWMs. The model was finally verified to the 1/4/1982 flood event. For all the three flood events, simulation differences were well within the FEMA-required 0.5-foot range for most of the HWMs, particularly at locations where HWMs were considered most reliable. The model was peer-reviewed by USACE in 2017.

Since the time of initial development of the watershed-wide HEC-RAS 1D/2D hydraulic model in 2017, the model has been used for a number of hydraulic analyses. The hydraulic analysis that is most relevant to the Lower COM Project is the hydraulic modeling of Corte Madera Creek Option C for the Phoenix Lake Grant migration conducted by Stetson for the County in late 2017 (Stetson 2017). This hydraulic analysis included a scenario modeling of Unit 4 measures plus the Lower COM Project with preliminary conceptual designs at that time (Note: The Lower COM Project was called Phase 1 of creek restoration project at that time). This modeling analysis verified that the Lower COM Project would not worsen flooding. It would be expected that the hydraulic analysis using the truncated Lower Corte Madera Creek model would arrive at the same conclusion.

1.8.3 Vegetation Reconnaissance

PCI surveyed the existing vegetation communities along the project reach and downstream from the concrete channel to determine plant composition and elevation ranges, and to review reference/target communities in adjacent, less-disturbed reaches. Location data were captured using a GPS unit with sub-meter accuracy, and correlated with elevation data developed by others on the project team. Plant species, plant health, zonation relative to tidal elevations, and preferred slopes and exposures to flow were observed. Historic imagery was also reviewed to better understand the historic processes that shaped the current vegetation.

2.0 Existing Utilities and Surface Features

2.1 Existing Utilities

The 100% design plans show the existing survey-located above ground and below ground utilities within the project area. Please see sheets C3 and C4 for 30-scale plan views, and C6-C9 for 10-scale plan views. Please see sheets C10-C14 for 10-scale cross-section views indicating depth of utilities where applicable.

***Photo 1**. Looking upstream from the right bank access way to the Stadium Way Pedestrian Bridge, utility crossings over the channel near the bridge, and the terminus of overhead utilities routed underground at the pole in the background.*

As shown on sheet C6, water and sewer utilities cross the Corte Madera Creek concrete channel immediately downstream from the Stadium Way pedestrian bridge, then turn to continue along the left side of the concrete channel beneath the paved MUP:

- MMWD 20-inch-diameter water line (W) running over the top of channel 7 feet downstream from the pedestrian bridge; and,
- RVSD sanitary sewer (SS) main siphon running under the concrete channel floor about 18-20 feet downstream from the pedestrian bridge.

As shown in sheet C13, the 20-inch-diameter water line runs about 3 feet under the MUP about 2 feet from the channel wall. The 39-inch or 42-inch-diameter sewer pipe runs about 12 feet below the pathway about 5 feet from the channel wall.

The water and sewer utilities then turn with the MUP about 45 degrees at a point about 100 feet from the downstream end of the concrete channel wall to run southeast away from the channel (see sheet C8).

As shown in Photo 1 and on sheet C6, beginning from the east side of Stadium Way pedestrian bridge, overhead electric and telephone lines terminate at the power pole about 34 feet east from the left (east) channel wall near the east landing of Stadium Way pedestrian bridge, to go underground there and combine with the water and sewer to also run under the paved MUP closely bordering the left (east) channel wall:

- PG&E electric running about 3 feet under the MUP typically about 5 ft from the channel wall; and,
- Telephone cable running close to and parallel with the electric line.

These utilities also turn 45 degrees with the water and sewer utilities to run southeast away from the channel under or adjacent and landward from the MUP (Photo 2).

The 100% design will avoid these utilities by setting the upstream grading limits and right (west) concrete channel wall removal limits beginning 4 feet downstream from the overhead water line crossing downstream from Stadium Way pedestrian bridge (see sheet C6), and by leaving the left (east) channel wall intact in the upstream majority of the project reach. The east side grading and concrete channel wall removal limits begin 40 feet downstream from where the utilities turn 45 degrees to run east-southeast away from the channel under the MUP (see Phot 2 and sheet C8). More importantly, the east wall taper cut begins about 15 feet downstream from the existing pavement limits of the MUP to preserve an amount of the gravel-covered flat area creekward of the pathway for user safety where the MUP makes a turn.

The only overhead electric and phone lines in the project area terminate at the power pole near the east landing of Stadium Way pedestrian bridge (Photo 1, sheet C6).

Photo 2. *Looking downstream from the left bank paved multi-use pathway (MUP) where the sanitary sewer and other utilities running under the MUP turn approx. 45 degrees to the SE to depart from the edge of the channel and continue under or adjacent to the MUP. This photo also shows the flat triangular gravel-covered area with picnic tables and benches.*

Photo 3. *Looking downstream to the existing concrete channel from the Stadium Way pedestrian bridge.*

2.2 Existing Concrete Channel

The Army Corps of Engineers constructed the concrete channel in about 1970 as part of the larger Corte Madera Creek Flood Control Project. GDG's elevation and location surveys confirmed accuracy of hand-drawn January 1970 dated design plans furnished by District. Those 1970 design plans and these 100% design plans show that the survey-located concrete channel has a regular rectangular hydraulic cross-section at and near the Stadium Way pedestrian bridge, with 18-foot-high vertical concrete walls and a 33-foot-wide horizontal concrete floor (Photo 3). As shown in plan view on sheet C3 and sheet C8 and profile view on sheet C5, the concrete channel cross-section widens and deepens beginning about 300 feet downstream from the pedestrian bridge to provide a "stilling basin" that does not function because it is below the MLLW and because the channel floor is covered with 4-6 feet of sediment. Sheet C8 and sheet C5 show the location of the sediment-covered downstream limits of the concrete channel floor estimated from the 1970 design plans and confirmed by probing during field surveying. GDG confirmed the concrete channel floor elevations in the 1970 design plans by probing through accumulated sediment during the February 2020 topographic survey. Sheet C5 shows the locations of the probing concrete channel floor survey data points.

Photo 4*. Looking downstream from the concrete channel terminus to the earthen channel beyond. Sedimentation in the earthen channel prevents tides lower than 1.7 feet NAVD88 from occurring in the project reach.*

GDG did not core the concrete channel walls or floor to determine thickness. The channel wall and floor configuration shown in the design plans is from the 1970 design plans. District has performed concrete coring in other parts of the concrete channel. Those corings generally indicate other segments of the concrete channel have thicknesses matching the 1970 dated design plans for those segments.

The earthen channel portion of the Army Corps flood control channel begins immediately downstream from the concrete channel (Photo 4). The upstream end of the earthen channel is referred to as the “stilling basin” because it has a deeper dredging maintenance profile for dissipating energy where flows narrowly confined by the concrete channel suddenly widen within the earthen channel. The earthen channel has rip-rap lined banks in this expansion zone. Note that there is another separate “stilling basin” depression built into the concrete channel floor near the downstream end of the concrete channel (sheet C5), but it is filled with sediment.

2.3 Stadium Way Pedestrian Bridge

The 100% design plans show the survey-located Stadium Way pedestrian bridge (Photo 1), which has an 8-foot-wide timber deck primarily used by bicyclists and pedestrians. It was constructed around 1970 as one of the enhancements provided when the concrete channel was constructed. MUP 20 and the Stadium Way Bridge are owned by the District but managed and maintained by Parks under contract to the District. The bridge is an important feature of Marin Bicycle Route 20 and a key component of the Safe Routes to School program providing access to Kent Middle School. However, it has outlived its design life, does not meet ADA standards, and is too narrow for the heavy traffic it carries. As funding is obtained to design and construct improvements to habitat and provide increased capacity upstream of this project, the bridge will be replaced.

As shown on sheet C6, the 100% design will avoid impacting the Stadium Way pedestrian bridge by setting the upstream grading limits and right (west) concrete channel wall removal limits beginning 12 feet downstream from the bridge structure.

Padlocked emergency and maintenance vehicle access is provided from Stadium Way to the east. Keyed padlocks are for access by District, RVSD, Parks, emergency services and others.

***Photo 5**. Looking downstream to the Multi-Use Pathway (MUP) running along the top of the left (east) concrete channel wall. Note the sanitary sewer (SS) manhole and green paint marking the SS utility line running under the pathway at depth and offset from the left channel wall.*

2.4 Multi-Use Pathway (Marin Bike Route 20)

The 100% design plans show the survey-located limits of the paved multi-use pathway (MUP) (Marin Bike Route 20) (Photo 5). The MUP crosses over Stadium Way pedestrian bridge and upstream from the Stadium Way pedestrian bridge, it runs along the top of the right (west) channel wall (Photo 6). Downstream from Stadium Way pedestrian bridge, the pathway runs along the top of the left (east) channel wall for about 300 feet before it turns 45 degrees to the southeast about 110 feet from the downstream end of the concrete channel. The section of the MUP between Stadium Way and the 45-degree turn is confined between a chain-link fence on the top of the concrete channel wall and an ivy-covered fence on the other side. The paving, which starts at the edge of the concrete channel, is ~8 feet wide and the two fences are ~10.5 feet apart, relatively narrow for such a busy path with no shoulders. Near the downstream end of the project area, the MUP connects with and runs along the top of the east side earthen channel berm down to Bon Air Road.

The 100% design avoids impacting the MUP in the same way it avoids impacting Stadium Way pedestrian bridge and utilities running under and adjacent to the pathway: by setting the upstream grading limits and right (west) concrete channel wall removal limits beginning 12 feet downstream from Stadium Way pedestrian bridge, and by leaving the left (east) channel wall intact in the upstream majority of the project reach. The 100% design also provides flexibility for anticipated pathway improvements where it is bordered by the flat gravel-covered triangular open area (see Section 2.5, Photo 2).

***Photo 6**. Looking upstream to the Multi-Use Pathway (MUP) running along the top of the right (west) concrete channel wall. The MUP crosses over the channel via the Stadium Way pedestrian bridge.*

2.5 Vest-Pocket Park and Flat Gravel-Covered Triangular Open Area

The 100% design plans show a large flat, gravel-covered triangular open area creekward from where the paved MUP turns 45 degrees to run southeast away from the concrete channel (see sheet C3, Photo 2). The area borders about 190 feet of the MUP. It is used primarily by pedestrians and cyclists as an informal stopping, resting, or gathering point along the pathway. As shown on sheet C8, the area has two benches, one picnic table, and two 14-inch-diameter she-oak trees. At least one of the benches has a commemorative plaque on it honoring a resident that enjoyed sitting in this area. A central stormwater area-drain drop inlet routes stormwater to the vegetated swale draining to the southeast along the landward side of the pathway. The flat open area borders the downstream 115 feet of the left (east) channel wall. The total area is about 7,500 square feet.

The 100% design will necessarily eliminate about 4,290 square feet of the gravel-covered triangular area for restoring gradually-sloped creek banks reestablishing vegetated transitional habitats. To accomplish this restoration, the project will taper-cut and remove the downstream end of the left channel wall and restore gradually sloped channel banks smoothly transitioning with the earthen channel bank slopes at the downstream grading limits.

The design plans accommodate design in development by Marin County Parks for a vest-pocket park by preserving a stopping point or “node” along the pathway at this location delineated by the new retaining wall. According to the retaining wall design, about one-third of the existing gravel-covered area would be preserved to create two stopping/resting/gathering nodes creekward from the multi-use pathway. One of the nodes is shown near the edge of the channel downstream from the 45-degree pathway turn to maintain safety where the sight distance is limited and bicycle and walking traffic mix. The two existing trees within the area would be preserved in place. A low concrete landscape wall would create a formal edge between the gravel-covered setback and the restored habitat.

2.6 Access – West

There is an approximately 6-foot-wide plus gravel access way running along the top of the right (west) channel wall connecting from the west berm adjacent to the earthen channel downstream from the project area to the MUP at the west landing of Stadium Way pedestrian bridge (Photo 7). The project will eliminate this access way.

The 100% design provides a minimum 12-ft-wide flat unvegetated setback as an access way for potential maintenance and emergency vehicle access running between the M&O facility and the west earthen channel berm. At the request of the COM Board of Trustees, the 100% design will not change use patterns along this access way; it will provide an access way connecting the west earthen channel berm through to the MUP near Stadium Way. A new fence will be installed between the access way and the COM M&O facility.

2.7 Earthen Channel Berms

There are berms on both sides of the earthen channel downstream from the project area (see sheet C3, Photo 8). As shown on sheet C4, the 100% design will avoid impacting these berms by setting the grading limits upstream from and creekward from the berms. As shown at sheet C8, the design will provide flexibility for potential future upstream extension of the right (west) berm by providing a flat, unvegetated top of bank setback from the

Photo 7. *Looking downstream from the Stadium Way pedestrian bridge to the gravel access way running along the top of the right (west) channel wall connecting between the Multi-Use Pathway (MUP) and the west earthen channel berm.*

Photo 8. *Looking downstream to the west earthen channel berm. Construction access is through the fence gate at the right side of the photo. The 14"-dbh oak tree may need to be pruned or removed to accommodate access. Equipment and materials will be staged on the berm downstream from the access point in the background of the photo. Additional oak trees will be planted along the berm downstream from the project area to meet mitigation requirements.*

finished restored top of bank that is minimum 12-feet-wide. The setback area is suitable for emergency and maintenance vehicle access to the berm from the COM M&O facility. The setback may be converted to an upstream berm extension if needed.

2.8 COM M&O Facility

The 100% design plans show the survey-located features within the COM M&O facility constructed as of the February 2020 topographic survey, as was augmented by August 2021 drone orthophotography and limited RTK-GPS site survey. As described in the below section, the design will remove the outfalls of the pre-existing and new as-built stormwater drainage facilities near the creek in order to discharge stormwater onto the finished restored creek bank slope. As shown on sheet C8, the existing as-built bioretention area constructed by the M&O facility project will be retained and adapted by the Lower COM project.

2.9 Stormwater Drainage Facilities

The 100% design plans show survey-located pre-existing and as-built M&O developed stormwater drainage facilities within the project area. There are two existing storm drains discharging into Corte Madera Creek through the right (west) channel wall:

- 20-inch-diameter RCP outfalling about 70 feet downstream from the Stadium Way pedestrian bridge (see sheet C6). This culvert discharges from a inlet/drain northwest of the project area. The Project will not remove the channel wall where this culvert discharges and will not need to remove or decommission the outfall;

- 24-inch-diameter RCP outfalling about 250 feet downstream from the Stadium Way pedestrian bridge (see sheet C7). This culvert conveys drainage from the west of the M&O facility area and existed before the M&O facility development. The M&O facility drainage is pre-treated in bioretention areas and routed to join with the pre-existing 24” RCP so that the combined flows discharge into the concrete channel. The Project will remove the downstream segment of the 24” RCP where it is exposed for restoring gradually sloped banks for habitat restoration. The 12” RCP from the as-built bioretention area will also be exposed by the restoration grading. It will be replaced with a new 12” storm drain set at a lower elevation to minimize exposure above finished grade. Under project conditions, all stormwater flows will discharge onto the finished grade channel bed slope via the cut-end of the existing 24” RCP and the end of the new 12” storm drain directly adjacent. All flows will discharge onto rock slope protection that is part of the boulder-anchored large wood slope protection area specially configured for accepting these flows at the new outfalls. Anchored large wood above finished grade will partially shield the culvert outfalls.

There is one existing storm drain discharging into Corte Madera Creek through the left (east) channel wall:

- 10-inch-diameter CMP outfalling about 100 feet downstream from the Stadium Way pedestrian bridge (see sheet C6) discharging from an unknown drain to the east of the upstream end of the project area. The Project will not remove the channel wall where this culvert discharges and will not affect its drainage.

The 100% design project will remove a single drop-inlet area drain located within the flat gravel-covered open triangular space creekward from the multi-use pathway along the left bank. Drainage landward from the new retaining wall edge treatment bordering the vest-pocket park will be by overland flow in the landward direction from the wall and over the paved MUP to an existing drainage vegetated swale feature east of the MUP.

Other existing drainage features within the project area are the flap gates outfalling at intervals from the concrete channel walls. The flap gates were not surveyed and mapped into the design plans. Design details located in the 1970 design plans do not explain the purpose of the flap gates. Presumably they are standard details for back-draining the fill behind the concrete channel walls. The Project will remove the flap gates everywhere they occur within the wall removal sections.

2.10 Existing Rip-Rap Slope Protection

At sheet C3, the 100% design plans show areas of poorly vegetated rip-rap slope protection extending about 60 feet downstream from the existing concrete channel on both banks. These rip-rap slope protection structures were installed to provide bank erosion protection where the narrow concrete channel issues into the much wider earthen channel. The total exposed surface area is 9,200 sq ft. Some percentage of the rip-rap is covered with fine sediment and vegetation. The depth of the rip-rap is unknown, but estimated to be at least 2.5-3.0 feet.

The 100% design would remove all of the rip-rap from these areas and restore gradually sloped revegetated creek banks smoothly conforming with the earthen channel at the downstream grading limits. All of the rip-rap would be salvaged on site for re-use to construct buried and sub-tidal bench and slope revetments and boulder-anchored large wood material bank erosion protection structures along the new restored right bank outside channel bend. See Section 3 for more information.

2.11 Fencing

Galvanized chain-link fencing follows the tops of both concrete channel walls. Gates in the fencing are padlocked with keys held by District and other agencies and emergency services. The Project will necessarily remove all of the top-of channel wall fencing where the channel walls will be taper- and horizontal-cut and removed:

- Right (west) channel wall beginning 12 feet downstream from the Stadium Way pedestrian bridge; and,
- Left (east) channel wall) beginning 315 feet downstream from the pedestrian bridge.

The 100% design plans show new 42” high black vinyl chain-link fencing running down the length of the taper-cut channel walls to elevation 6.5 feet NAVD88. On the left bank, the 42” chain-link fencing extends 20 feet upstream along the existing channel wall top from the taper-cut wall to replace that portion of the existing galvanized chain-link fence that is adjacent to and a component of the vest-pocket park.

The project will remove existing black vinyl chain-link fence separating the existing gravel access way from the M&O facility. It will be replaced with similar black chain-link fence along the new access way landward from the new top of bank to maintain separation of pedestrian access and the M&O facility. Cedar split-rail and redwood wood-and-wire fences will be used to discourage pedestrians from entering the restored habitat area on the right bank.

The Contractor will be required to submit a Fence and Gate Plan for review and approval by the Owner and stakeholders prior to finalizing and implementing fence and gate installation.

2.12 Trees

The project would remove up to a total of 39 trees (36 non-natives and 3 oaks). For a description of all existing site vegetation from an ecological perspective, see Section 7.1.

The 100% design plans show survey-located trees throughout the project area. The plans indicate trees to be removed with an “X” on sheets C6-C9 (1”=10’) and are summarized in Table 7.4. The plans contain a 1”=30’ scale Tree Removal Plan showing all trees to be removed. Sheets C6-C9 show that there are very few trees on the east side of the concrete channel:

- Two 14-inch-diameter she-oak trees rooted within the flat, gravel-covered open area about 5-7 feet creekward of the MUP (sheet C8). According to the plan for vest-pocket park creekward of the multi-use pathway, the project will preserve these trees in place;

- 12-inch-diameter eucalyptus tree cluster within the left (east) bank existing rip-rap slope protection area that the project will remove; and

- A single 28-inch-diameter eucalyptus tree rooted on the left bank of the earthen channel about 6 feet downstream from the existing rip-rap slope protection area. The project will not necessarily remove this tree because it is immediately downstream from the project grading limits.

Trees on the right (west) side of the concrete channel are limited to:

- An approximately 225-foot-long discontinuous hedgerow of primarily non-native trees dominated by *Acacia sp.* on the creekward and landward sides of the black chain-link security fence separating the M&O facility from the gravel access way along the top of the west side of the concrete channel (sheets C7-C8). There is at least one oak within the downstream end of the band of trees—a 16-inch-diameter oak. The project will necessarily remove all of these trees to grade down to meet the design grades for restoring gradually sloped vegetated creek banks.

- Miscellaneous trees rooted between the earthen channel berm and the COM baseball field fence in the downstream end of the project area, including one 6-inch-diameter buckeye cluster, an 8-inch-diameter oak tree, and a 12-inch-diameter oak tree. These trees will not be removed. The upland habitat restoration in this area will be configured to retain and improve health of these trees.

- There are two other oak trees that will need to be removed by the project. A 6-inch-diameter oak tree that is rooted in the rip-rap area downstream from the concrete channel outlet and a 14-inch-diameter oak tree that is located on the gravel covered area landward from the west earthen channel berm where the construction access occurs (Photo 8). The 14-inch-diameter oak may be able to be preserved if the contractor finds the access sufficient without removing it.

3 Lower COM Project Design Features

Concrete and Earthen Fill Removal

The primary project features are removal and off-haul/recycling of parts of the left and right (east and west) concrete channel walls and removal of earthen fill behind the walls to restore gradually sloped creek banks suitable for revegetation for habitat restoration. The rough-graded banks will subsequently be detail-graded and reinforced with slope erosion protection where needed to restore gradually-sloped creek banks smoothly conforming to the taper-cut concrete channel walls and the earthen channel section at the downstream limits.

Geotechnical boring data collected by MPEG for the project indicate that the earth materials to be removed by surface grading will likely include primarily 5-7 feet of sandy granular fill overlying clayey native alluvium.

The upper fill materials are primarily sand and gravel materials:

- Clayey SAND with Gravel (SC) (MPEG B-1 & B-3)
- SAND with Gravel (SP) (MPEG B-2)
- SAND with Gravel/GRAVEL with Sand (SP/GP) (MPEG B-4)

The underlying native alluvial materials are sandy on the east side of the channel – SAND with Gravel (SP) (MPEG B-1) – and primarily medium stiff, medium plasticity silty clays on the west side of the channel:

- Silty CLAY (CL/ML) (MPEG B-2)
- Silty CLAY (CL/ML) (MPEG B-2)
- Silty CLAY (ML/CL) (MPEG B-4)

Groundwater was observed at 13 feet below the ground surface east of the channel and 10-12 feet below ground on the west side of the channel. The 65% design plan shows excavation down to elevation (-) 6.6 feet NAVD88 – about 17 feet below the ground surface along the west bank where the right (west) concrete channel wall will be horizontal cut to elevation (-) 4.0 feet and the rip-rap bench will be set to (-) 4.0 feet top elevation.

Liquifiable Soil Remediation

Borings indicate loose sands will be encountered by grading to restore the left bank in the area of the new retaining wall. Miller-Pacific recommends over-excavation and compaction of these soils and other remediation work as needed to achieve suitable relative compaction. The new retaining wall is designed for stability considering (1) presence of these soils in the vicinity and (2) for its intended purpose.

Rock Rip-Rap Removal and On-Site Re-Use

Another key project feature is removal and on-site salvage re-use of existing rock rip-rap slope protection on both banks of the earthen channel immediately downstream from the concrete channel terminus. The rip-rap will be re-used to construct a buried, sub-tidal rock rip-rap bench and slope revetments serving as a "fail-safe" bank erosion protection structure along the entire length of the restored channel's new right (west) bank outside channel bend. The buried bench and sub-tidal slope would never be visible. The top elevation of the rip-rap slope is elevation 0.0 feet. The lowest tide elevation that occurs in the project reach is 1.7 feet, controlled by the sediment deposit in the earthen channel downstream from the concrete channel.

Channel Restoration Contoured Fill

Clean fine-grained native fill will be placed and contoured to establish restored left (east) bank slope and "inside bend" channel bedform topography consistent with anticipated natural self-sustaining restored channel dimensions (e.g., see cross-sections at Sheet C11). Natural tidal action and winter storm flow dominated sediment transport processes will establish actual bed topography post-project. The preliminary estimated fill volume to rough grade the restored left bank toe and channel bed contours will be 2,000 CY. About 700 CY of this amount may be obtained from over-excavation of native material for placement of the rip-rap bench and slope revetment at the right (west) bank. Clean fill materials will be obtained from materials excavated from on-site, including by dredging channel bed materials from the dewatered area downstream from the concrete channel limits, if sufficient quantities of suitable materials are produced.

Creek Bank Slope Protection

The project minimizes need for exposed rock slope protection by taper-cutting the concrete channel walls to smoothly transition to natural gradually sloped channel banks. Limited areas of vegetated rock-and-fill slope protection will be installed along the taper cut wall boundaries where high velocity and turbulent eddying flows are anticipated. Boulder-anchored large wood slope protection structures will be installed along the length of the right bank within the lower portion of the unvegetated cohesive soil intertidal zone. The anchored wood will cover the rock blanket reinforcing this unvegetated elevation zone and create a rough surface for sediment deposition to cover the rock blanket and complex aquatic habitat and hiding areas for fish during higher tides and/or winter flows.

Restoration Planting

The 100% design plans show a template-palette based revegetation plan keyed to the different tidal fluctuation dependent elevation horizons and corresponding vegetation community habitat types. Trees planted in the upland habitat areas are expected to be sufficient in number to mitigate tree removal required by the project per the requirements of the resource agencies. Additional oak trees will be planted landward from the top of bank within the setback from the COM M&O building as well as along the west earthen channel berm to meet mitigation planting objectives as needed (Photo 8).

Emergency and Maintenance Vehicle Access

On the west side of the channel, COM revised the previously planned and designed "hammerhead" paved emergency vehicle turn-around for the M&O facility, moving it landward from the project area to accommodate gradually-sloped creek bank restoration. The 100% design provides a minimum 12-ft-wide flat unvegetated setback as an access way for potential maintenance and emergency vehicle access running between the M&O facility and the west earthen channel berm.

The project will construct a minimum 12-foot-wide open flat top of bank setback suitable for vehicle traffic connecting between the M&O hammerhead upstream and the District's berm at the earthen channel downstream. RVSD has indicated that the project would not impact their ability to access the pumping plant at the upstream end of the east earthen channel berm. KFD has not indicated that the project would impact emergency vehicle access along the MUP, including turn-around area in the vicinity of the RVSD pumping plant.

Access and Safety

On the west side, the 100% design also provides an access way for pedestriansrunning along the top of the right bank. A new fence will be installed between the access way and the COM M&O facility. Like the existing access way, it connects from the west earthen channel berm to the MUP (Marin County Bicycle Route 20) at the west landing of Stadium Way pedestrian bridge.

On the east side, the project will retain and not revise Bike Route 20 but will eliminate a portion of the flat gravel-covered "triangle" creekward of the pathway at the downstream end of the channel. The plans contain a preliminary, conceptual design landscape wall edge treatment at the new boundary between restored habitat and the paved multi-use pathway.

Table 3-1 summarizes the design objectives and considerations and relevant elevations, dimensions, and quantities for these features. The quantity estimates are for planning purposes only. Contractor is responsible for verifying all material quantity estimates in the plans.

Table 3-1
Key Lower COM Project Features, Elevations, and Dimensions

Lower COM Feature	Design Objectives	Elevations/Dimensions/ Quantities
Concrete Channel Wall Removal – West	• Remove right concrete channel wall to restore gradually sloped right channel bank • Avoid utility conflicts at Stadium Way pedestrian bridge • Remove and recycle removed steel-reinforced concrete • Smooth finish and chamfer finish cut channel walls	• 173-LF taper cut from Elev 11.6 to Elev (-)4.0 • 290-LF horizontal cut at Elev (-)4.0 • 5,477-sq ft concrete removal and off-haul • 125 LF (125 sq ft) finished surface treatment for portion of cut wall exposed above Elev 0.0 • +/- 60 LF new 42” black vinyl chain-link fence.
Concrete Channel Wall Removal – East	• Remove downstream end of left concrete channel wall to restore gradually sloped left channel bank • Avoid utility conflicts along majority of left bank • Remove and recycle removed steel-reinforced concrete • Smooth finish and chamfer finish cut channel walls	• 70-LF taper cut from Elev 11.5 to Elev 0.0 • 76-LF horizontal cut at Elev 0.0 • 974-sq ft concrete removal and off-haul • 140 LF (140 sq ft) finished surface treatment for portion of cut wall exposed above Elev 0.0 •
Tree Removal – West	• Remove trees within grading limits and construction access areas to accomplish restoration grading and implement project	• 38 total trees and tree-clusters • 3 native trees (16”-, 14”- and 6”-dbh oaks)
Tree Removal – East	• Remove trees within grading limits to accomplish restoration grading	• 1 total tree (12”-dbh eucalyptus cluster)
Surface Features Demolition & Removal – West	• Remove and dispose of fencing and stormwater facilities within grading limits to accomplish restoration grading • Minor pavement removal near Stadium Way	• 450 LF chain-link fencing • 470 LF chain-link fence on channel wall • +/- 50 LF of 12” RCP, and +/- 35 LF 24” RCP SD • 1 concrete box drop inlet

		• 250-sq ft AC pavement area near Stadium Way
Surface Features Demolition & Removal – East	• Remove gravel fill and stormwater facility from surface of flat area between multi-use pathway and channel	• 4,290 sq ft of gravel about 2.5-ft-deep (+/- 400 CY) • 170 LF chain-link fence on channel wall • 40 LF 14” diam HDPE SD • 1 concrete box drop inlet
West Earthen Channel Berm Access Way	• Maintain existing gated access at Tamalpais culvert • Provide through vehicle access from M&O facility to berm • Provide new rolling-gated access at M&O facility hammerhead	• 180 LF minimum 12-ft-wide (2,160 sq ft) flat unvegetated setback from top of bank for vehicle Way • New fence gate(s) on COM’s M&O facility
Access Way – West	• Pedestrian access way similar to existing connecting from west berm to MUP at west landing of Stadium Way Pedestrian bridge	• Use similar improvements as berm vehicle access Way • Extend access from hammerhead to MUP at Stadium Way Pedestrian bridge
Fencing – West	• Install along the landward edge of transition zone restoration planting area, berm access way and access way, along M&O facility in consultation with COM and per approved Contractor plan submittal	• +/- 1,000 LF black vinyl chain-link, cedar split-rail, and wood-wire fencing and multiple gates per plan and depending on final approved configuration per Contractor submittal
Fencing – East	• Per approved Contractor plan submittal	• +/- 50 LF new 42” black vinyl chain-link fence on taper cut wall and adjacent to vest-pocket park.
Rip-Rap Removal for On-Site Reuse	• Remove rip-rap from both sides of channel and stockpile or directly install for salvage reuse to constructed buried rip-rap bench and sub-tidal rip-rap slope revetment on west side of restored channel. Use remainder for boulder field rock mix within boulder-anchored large wood slope protection area.	• 4,700 sq ft rip-rap (exposed area) from east side of channel • 4,500 sq ft rip-rap (exposed area) from west side of channel • Total surface area and volume TBD during construction
Earth Cut and Disposal – West	• Remove soil to restore gradually sloped creek banks upslope both banks from concrete channel wall removals	• Estimated cut/fill/net volumes: 8,390 CY cut, 68 CY fill, 8322 CY net cut

Earth Cut and Disposal – East		• Estimated cut/fill/net grading volumes: 660 CY cut, 277 CY fill, 383 CY net cut • Does not include overexcavation required for remediating liquefiable soils.
Channel Restoration Contoured Fill	• Place clean native fill material to restore design bed elevation contours within restored channel	• Estimated cut/fill/net volumes: 14 CY cut, 2,243 CY fill, 2,229 CY net fill
Soil Import and Soil Amendment	• Depending on suitability of existing soils for stockpiling and reuse, and chemical analysis of soils exposed at restoration grades, soil may need to be imported and/or amended to achieve revegetation objectives.	• Overall cut/fill balance: 6476 CY net cut • See Section 7.
Buried/Underwater Recycled Rip-Rap Bench and Slope Revetment	• Install a buried erosion-proof revetment along the right bank (west) side restored channel outside bend to prevent both excessive outside bend bank erosion and channel bed scour being bifurcated by the right (west) concrete wall remainder.	• Approx. 300 LF rip-rap bench at Elev (-)4.0 varies up to 20-ft-wide • Approx. 335 LF rip-rap slope at 2(H):1(V) slope from Elev (-)4.0 to Elev 0.0 comprises • Total area +/- 6,907 sq ft
Boulder-Anchored Large Wood Bank Erosion Protection	• Provide naturalistic bank erosion protection with minimized exposed boulder rip-rap in portions of restored unvegetated cohesive soil slopes where higher flow velocities are anticipated	• +/- 4,162 sq ft
Vegetated Rock-and-Fill Slope Protection	• Provide vegetated surface erosion protection along the new transition boundaries between the taper-cut concrete walls and the restored vegetated banks slopes on both sides where high creek flows are expected to cause turbulence • High winter creek flow shear stresses near taper cut wall edges may limit successful vegetation cover establishment.	• Area 1 (West): Approx. 100 LF 10-ft-wide band of vegetated rock-and-fill slope protection adjoining upstream end of finished taper cut wall (930 sq ft) • Area 2 (East): 37 LF variably wide band of vegetated rock-and-fill slope protection between upstream end of finished taper cut wall and placeholder concrete wall edge treatment (+/- 250 sq ft)
Low Marsh Habitat	• Restore low marsh habitat with plantings between Elev 3.5 and Elev 4.5, if feasible. Non-native Spartina excluded.	• +/- 7,000 sq ft

High Marsh Habitat	• Restore high marsh habitat with plantings between Elev 4.5 and Elev 6.0	• +/- 8,600 sq ft
Transitional Habitat	• Restore transitional habitat with biodegradable erosion control fabric and plantings between Elev 6.0 and Elev 8.0	• +/- 16,800 sq ft
Upland Habitat	• Restore upland habitat with biodegradable erosion control and plantings above Elev 8.0	• +/-17,820 sq ft
Concrete Landscape Wall Edge Treatment – East	• Retaining wall landscape edge treatment between restored left bank habitat and remainder of flat gravel-covered area adjacent to Multi-Use Pathway (MUP) to be converted to vest-pocket park.	• 246 LF concrete landscape wall typical with TW Elev 12.5 and exposed bottom Elev 10.5 at top of restored vegetation slope
Stormwater Drainage – East	• Drain remainder gravel-covered area over MUP to existing vegetated swale on other side of MUP.	• Slope gravel-covered area away from the edge treatment TW Elev 12.0 toward MUP at Elev 11.6-11.8 at minimum 1% slope

4 Hydraulic and Geomorphic Design

4.1 Ross Valley and Lower COM Reach Flooding Overview

Ross Valley is naturally prone to flooding due to its geologic and geomorphic setting within a narrow valley with steep valley walls and shallow clay-rich soils. Rainfall can be intense, soils are shallow with limited absorption capacity, slopes are steep, stream channels are entrenched and, in many places, narrow with relatively little in-channel water storage capacity. Development in the Ross Valley has created expansive impermeable areas while encroaching onto the banks of the channel supplanting the natural flood attenuating capacity of the floodplain. Most of the creekbanks in the residential, commercial, and institutional areas are modified by bank erosion protection structures and retaining walls.

During prolonged and heavy storms the watershed can become saturated. If rainfall is sufficiently intense, heavy runoff can result in high flows exceeding the capacity of the creek in places where conveyance is constrained. *Incipient flooding* occurs when the threshold conveyance capacity of the creek is exceeded and breaching of the creek banks is initiated. At some locations, floodwaters breaking out of the creek return back to the creek a short distance downstream of the constraint. At other locations, floodwaters may escape and flow as a separate side-stream, apart from the main channel flow, for extended distances over the floodplain.

Within the lower Corte Madera Creek hydraulic model domain (below the Ross Creek confluence), the key breakout point where floodwaters escape from the channel is between Lagunitas Bridge and the Ross Gage, where the creek capacity at the threshold of incipient flooding was estimated about 3,400 cfs, with the corresponding magnitude level flood event about 5-year flood. The escaped flow would then flow through the Ross Commons area and then along Kent Ave to make a separate flow path from the main channel, and finally return back to the main channel downstream of the College of Marin area.

4.2 Lower COM Project Hydraulic Analysis for Design

Stetson Engineers prepared a draft hydraulic analysis for informing the 65% design (Appendix 5). That analysis documented that the 65% design the Lower COM Project:

- Would not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions;
- Would not worsen flooding for future sea level rise (SLR) scenarios; and,

- Would sustain normal high velocity flows making it prudent to install slope erosion protection in places at the site to avoid and minimize potential for creek bank erosion or slide failures that would prevent achieving ecological objectives or require maintenance and repairs.

The analysis was made using the Lower Corte Madera Creek HEC-RAS 1D/2D hydraulic model that was developed by Stetson in 2018-19. The Lower Corte Madera Creek model is a truncated/modified/updated version from the Ross Valley watershed-wide HEC-RAS 1D/2D hydraulic model developed jointly by Stetson and USACE in 2017.

The model was used to compute "worst-case" maximum velocities along the new restored channel banks for the slope protection design. The worst case was conservatively assumed as the bankfull flow at the project reach coincided with downstream mean lower low tidal condition.

The model was also used to verify that the Project will not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions (i.e., the second bullet above), and not worsen flooding under future sea level rise conditions (i.e., the third bullet above).

For the 65% design analysis (Appendix 5) the most likely future foreseeable projects in Ross Valley identified by the County include construction of the Sunnyside Nursery Flood Detention Storage (FDS) basin[1] and replacement of the Azalea Bridge in Fairfax, removal of Building Bridge #2 in San Anselmo, replacement of the four San Anselmo bridges (Nokomis Avenue Bridge, Madrone Avenue Bridge, Center Avenue Bridge, and Bridge Avenue Bridge), replacement of the Winship Avenue Bridge[2], and construction of the Unit 4 measures[3] in Ross. Figure 1 in Appendix 5 shows the locations of these foreseeable projects.

[1] The Sunnyside Nursery FDS basin has limited storage capacity (about 35 acre-ft at the spillway crest). Analysis found that it has little effect on peak discharges for large flood events (e.g., 50-year and 100-year flood events).

[2] Replacement of the four San Anselmo bridges and the Winship Avenue Bridge are being designed by Quincy Engineering, and replacement of the Azalea Bridge is being designed by California Infrastructure Consultancy (CIC). At the time of this report, Quincy has prepared preliminary designs for the four San Anselmo bridges and the Winship Avenue Bridge, and CIC has prepared preliminary designs for the Azalea Bridge. The Stetson team is preparing final designs for the SAFRR Project.

[3] The Unit 4 measures represent the Measures 1, 2, and 3 detailed in the Stetson's 2008 Letter Report to the U.S. Army Corps of Engineers, which include (1) Ross fish ladder removal, (2) transition at the fish ladder from the Unit 4 natural channel to the Unit 3 concrete channel, and (3) channel widening just upstream of the fish ladder.

Construction of the Sunnyside Nursery FDS basin and removal of Building Bridge #2 are also the two components of the San Anselmo Flood Risk Reduction (SAFRR) Project. The SAFRR Project EIR was certified on September 18, 2018 by the Marin County Board of Supervisors. Parts of the SAFRR Project is expected to be constructed by 2021 or in parallel with construction of the Lower COM Project.

The foreseeable projects are all located far upstream of the Lower CMC Project area. The foreseeable projects upstream of the Ross Creek confluence would have little effect on the hydrology and flooding of the Lower CMC Project area. The foreseeable project downstream of the Ross Creek confluence, i.e., construction of the Unit 4 measures (with removal of the Ross fish ladder in particular), would reduce the overland flow escaped from the channel reach between Lagunitas Bridge and the Ross Gage, and increase the channel flow downstream. For the Lower CMC Project area, the flooding effect from the construction of the Unit 4 measures would be a combined effect of the reduced overland flow and increased in-channel flow entering the site via the concrete channel. The previous hydraulic modeling for the Corte Madera Creek Option C of Phoenix Lake grant migration performed by Stetson for the County in late 2017 provided some verification that the lower COM channel widening would not worsen flooding under the future foreseeable projects condition.

Three flood events were evaluated: the 5-year event, the 25-year event, and the 100-year event. The 5-year event was selected as it is about the flood threshold for the Ross Valley watershed. The 25-year event was selected as it was used for the SAFRR Project EIR. The 100-year event was selected as it is the required flood event for evaluation of project impact on flooding.

The State of California Sea-Level Rise Guidance/2018 Update (California Natural Resources Agency 2017) provides a science-based methodology for state and local governments to analyze and assess the risks associated with sea level rise and incorporate sea level rise into their planning, permitting, and investment decisions. For the purpose of this study, the future sea level rise of 1.1 ft by 2050 under the "67% probability, high emissions" scenario (see Table 1 of the California Sea-Level Rise Guidance) was selected for the sea level rise modeling analysis.

Hydraulic Simulations to Analyze Worse-Case Scenario Maximum Velocities

Hydraulic simulations were performed to analyze worst-case maximum velocities along the new restored channel banks for slope protection design. The worst case was conservatively assumed as the bankfull flow at the project reach coincided with downstream mean lower low tidal condition.

Table 4-1
Hydraulic Model Output for Bankfull Evaluated at Upstream End of Project

Highlighted: Velocities exceeding 10 feet per second and Shear Stresses exceeding 2 lbs/sq ft

	River Station	WSE	Velocity	Shear Stress
		(ft NAVD88)	(fps)	(psf)
	32355	12.41	17.90	4.95
	32338	12.23	18.49	5.32
Upstream Limit Project Reach	32314.5	11.97	**18.22**	**5.23**
	32291	11.71	**15.27**	**4.36**
	32244	11.33	**11.01**	**2.25**
	32197	11.28	9.75	1.75
	32150	11.08	9.81	1.76
	32110	10.99	9.41	1.62
	32070	10.94	8.88	1.44
	32030	10.65	9.69	1.71
	32000	10.44	**10.25**	1.9
	31970	10.48	9.15	1.58
	31935	10.49	8.21	1.3
	31910	10.39	8.26	1.33
	31875	10.39	7.46	1.1
	31850	10.4	6.94	0.94
Downstream Limit Project Reach	31810	10.38	6.69	0.22
	31710	10.48	5.79	0.11
	31587	10.22	6.48	0.16

The model simulated results are shown in Tables 4-1 and 4-2. The results show that the "worst-case scenario" flow channel velocity within the project reach would vary from 6.7 fps – 18.2 fps if bankfull is evaluated at upstream end of the project reach (see Table 4-1), and from 6.8 fps – 21.4 fps if bankfull is evaluated at downstream end of the project reach (see Table 4-2). Velocities exceeding 10 feet per second (fps) with corresponding shear stresses exceeding 2 pounds per square foot (psf) may occur along the upstream 300 feet of the project reach.

Table 4-2

Hydraulic Model Output for Bankfull Evaluated at Downstream End of Project

Highlighted: Velocities exceeding 10 feet per second and Shear Stresses exceeding 2 lbs/sq ft

	River Station	WSE	Velocity	Shear Stress
		(ft NAVD88)	(fps)	(psf)
	32355	13.93	21.16	6.8
	32338	13.7	21.86	7.31
Upstream Limit Project Reach	32314.5	13.36	**21.42**	**7.08**
	32291	13.05	**17.32**	**5.41**
	32244	12.63	**12.34**	**2.71**
	32197	12.59	**10.78**	**2.04**
	32150	12.36	**10.92**	**2.08**
	32110	12.29	**10.41**	1.89
	32070	12.26	9.79	1.67
	32030	11.93	**10.76**	**2.01**
	32000	11.7	**11.38**	**2.24**
	31970	11.81	9.84	1.73
	31935	11.91	8.61	1.34
	31910	11.84	8.55	1.33
	31875	11.94	7.50	1.04
	31850	11.97	7.01	0.9
Downstream Limit Project Reach	31810	11.95	6.82	0.25
	31710	12.04	6.10	0.12
	31587	11.76	6.77	0.18

Hydraulic simulations were performed to analyze the effect of the project on WSEs/flooding under existing tide and future SLR conditions. Per FEMA guidelines, the downstream boundary condition of the model was set to the mean higher high water (MHHW) of the tide at the Corte Madera Creek estuary. Based on NOAA data, the current MHHW at the estuary is 5.9 ft NAVD88. According to the State of California Sea-Level Rise Guidance/2018 Update (California Natural Resources Agency 2017), future sea level by 2050 will rise by 1.1 ft under the “67% probability, high emissions” scenario. The two MHHW tide levels (5.9 ft and 7.0 ft NAVD88) were used for the evaluation of the project effect on WSEs/flooding under existing tide and future SLR conditions.

Please see Appendix 7 for more complete information re. final design hydraulic analysis completed for the Lower COM project including evaluation of effects on the FEMA Floodway and corresponding recommendations for floodplain management.

4.3 Lower COM Project Geomorphic Analysis for Design

The Lower COM Corte Madera Creek Restoration Project is designed to maximize the amount of restored vegetated marsh, transitional, and upland habitats – habitats that occur above Mean Sea Level (3.5 feet NAVD88) at the site by:

- Removing as much of the left (east) and right (west) concrete channel walls as possible without conflicting with existing utilities crossing the creek adjacent to Stadium Way bridge and running under the multi-use pathway (MUP) on the east side of the channel.

- Laying back the creek banks landward from the removed channel wall segments at gradual bank slopes stabilized with naturally restored vegetation that will create new top of bank limits as far from the creek as possible without conflicting with access requirements and COM's M&O facility operations on the west side, the MUP on the east side, and the earthen channel berms on both sides.

The vegetated habitats being maximized occur above MSL (3.5 feet), but some amount of the restored project area will be occupied by the restored creek channel – occupied by unvegetated intertidal mudflat and "open water" habitats occurring below MSL.

The 3.5-foot elevation contour on the 100% design plans show the preliminary design limits for the intertidal and open water habitats. The design intends to provide a suitable amount of area between the 3.5-foot design elevation contour lines on both sides of the channel to allow for natural geomorphic processes post-project, including channel bed erosion, tidal sediment flux, and sedimentation and scour of fine sediment on constructed channel bed and banks.

The 3.5-foot contour lines are configured in plan view to fit with anticipated future natural channel dynamics. This way the amount of future bank erosion might be minimized and the actual limits between unvegetated intertidal mudflat and low marsh habitat occurring at the site will be similar to the constructed channel. However, the project is also designed to allow for natural geomorphic processes to shape the channel and habitat limits. Unvegetated cohesive soil banks in the intertidal zone may appear eroded or in "poor condition" when the tide is low, even though they are perfectly natural. Along the right bank of the channel, a large percentage of the sub-vegetated horizon will be reinforced with subtidal rip-rap revetments and boulder-anchored large wood slope protection up to mean sea level.

4.3.1 Restored Channel Dimensions and Alignment

In this section, “channel” refers the portion of the site area between the 3.5-foot design elevation contours on both sides of the channel—the part of the site that will be “open water” twice a day when the tide produces a MSL water surface.

Under existing conditions, the channel is uniformly 33 feet wide between vertical concrete walls. The width gradually increases to 39 feet in the “stilling basin” area near the downstream end of the channel, before it gradually reduces back to 33 feet at the concrete channel outlet (see sheet C4).

The concrete bottom elevation also reduces about 1.8 feet within the 130-LF stilling basin area. The Army Corps of Engineers apparently designed the stilling basin for pooling and slowing low stream flows before they passed from the concrete channel to the earthen channel downstream. Because the concrete channel bottom is covered by about 4 vertical feet of sediment, the stilling basin does not affect flow hydraulics and sediment transport.

Sheet C3 shows February 2020 surveyed bathymetric elevation contours indicating the narrow bedform deposit along the left (east) channel wall where the concrete channel begins turning more sharply from right to left about 90 feet downstream from Stadium Way pedestrian bridge. The bedform is in an incipient “inside bend” bar deposit beginning where the channel begins turning at STA 322+50 and ending about 150 feet downstream near STA 321+00 where the “outside bend” scour pool along the right channel wall reaches its deepest point and the pool bottom elevation is less than (-) 5 feet. It appears that this inside bend bar/outside bend scour pool formation is sustained both by winter creek flows and daily tidal action. The bed material in the bar formation contains gravelly sand at depth that is deposited by high creek flows. The gravelly sand is covered by organic-rich fine-grained “mud” that is deposited by winter low flows and year-round daily tidal action. The top of bar elevation is just above (-) 1-foot. It is always invisible from outside of the channel because the minimum tidal elevation in the concrete channel is 1.7 feet, covering the bar by at least 2.5 feet of sediment-laden tidal flow. The narrow bar is 150-feet long.

Historical air photos of Corte Madera Creek prior to the concrete channel construction and any sort of channel confinement show exposed inside bend bars at and downstream from the project area that are uniformly about 250-feet-long.

The 100% design 3.5-foot elevation contour forming the left-side limits of the restored channel area would begin at the existing left (east) channel wall near STA 321+40 and depart from the wall to be as much as about 20 horizontal feet from the wall near STA 320+30. When the water surface elevation is at MSL, the length of the resulting exposed inside bend bar deposit would be about 250-feet-long.

The 100% design 3.5-foot elevation contour forming the right-side limits of the restored channel area would depart from the existing taper cut right (west) channel wall about 100 feet downstream from Stadium Way pedestrian bridge. At that location that width of the restored channel area matches existing – 33-feet-wide. The right-side design 3.5-foot elevation contour gradually departs from where the right channel wall is removed to increase the width of the restored channel area – measured between 3.5-foot contours on both sides – to about 57 feet. This design width is maximum feasible for meeting habitat restoration objectives considering the combination of left-side and right-side constraints near STA 320+00. As shown on sheet C4, the narrowest width between left-side and right-side constraints occurs near STA 320+00:

- Left bank channel wall primarily intact for meeting design objectives to avoid utility conflicts and maintain safe and equivalent use of the multi-use pathway.
- Maintaining and adapting the existing as-built detention basin at COM's M&O facility construction site and providing a minimum 12-foot-wide setback flat access way between finished top of bank and the detention basin. The access is for connecting potential maintenance and vehicle access between the M&O facility and the western earthen channel berm and allowing for potential future extension of the berm.

The 57-foot design restored area channel width near STA 320+00 begins increasing near the downstream end of the concrete channel for conforming with the existing contours on both sides of the earthen channel at the downstream grading limits.

4.3.2 Slope Erosion Protection Measures

Table 4-1 shows the model-calculated channel-averaged velocities and corresponding shear stresses for "worst-case scenario" hydraulic conditions when the concrete channel is flowing completely full to the top of the channel wall and downstream tides are relatively low. A maximum 18-foot per second (fps) velocity flow would enter the project reach from the upstream concrete channel. The project conditions velocity decreases from about 18 fps to about 11 fps along the taper cut channel wall to where the taper cut right bank wall top is at elevation 3.5 feet. Similar velocity flows with turbulent eddies producing higher velocity transient currents are anticipated in this expansion zone affecting the restored creek bank surface immediately landward from the taper cut wall. The project will install vegetated rock-and-fill slope protection everywhere landward of the exposed part of the taper cut right channel wall to resist surface erosion.

According to the hydraulic model analysis, the maximum channel velocity varies between 9.75 and 10.25 fps along the length of the restored right (west) edge of the channel area downstream from the taper-cut wall border. The local maximum channel velocity (10.25 fps) and shear stress (1.9 fps) would occur near STA 320+00.

Consistent with the natural creek restoration objectives of the project, the 100% design plans provide 3H:1V sloped unvegetated cohesive soil slopes in the horizon between the 0.0-foot and 3.5-foot elevation contours along the length of the right-side channel limits downstream from the taper-cut channel wall slope-protected boundary.

Fischenich (2001) published a compilation of study results indicating probable maximum velocity and shear stress limits for different native creek bank materials and erosion protection linings (Table 4-3).

Table 4-3
Permissible Velocity for Selected Lining Materials

Treatment	Permissible shear stress (psf)	Permissible velocity (fps)
Long native grasses	< 1.7	< 6
Brush mattress (willow)	< 4	< 8
Vegetated soil lift	< 6	< 9.5
Planted rock	> 6	> 9.5
12-in rock	< 4	< 12
Stiff clay	< 0.26	< 4.5
Coconut fiber with net	< 2.25	< 4
12-in rip-rap	< 5.1	< 13
18-in rip-rap	< 7.6	< 16
24-in rip-rap	< 10.1	< 18

Source: (Fischenich 2001)

Shear stresses exceeding 2 fps and approaching the 2.25-ft limit for biodegradable erosion control fabric occur throughout the upstream 300 ft of the project reach. Vegetation is not expected to occur below the 5-ft elevation contour, and it would be inappropriate to use biodegradable erosion control fabric to resist bank erosion below this elevation, without the support of establishing vegetation. Therefore, to balance among objectives of avoiding and minimizing bank erosion and providing suitable habitat and minimizing visible built infrastructure (including rock rip-rap), boulder-anchored large wood slope protection was installed along the entire right bank (outside bend) of the creek below the 3.5-ft horizon (mean sea level). Anchoring large wood to the rock blanket would both minimize the visibility of the rip-rap and encourage sedimentation to cover the rock rip-rap.

Table 4-4
Boulder-Anchoring Requirements for Stabilizing Large Wood

LARGE WOOD #	LW TYPE	LENGTH (FT)	DIAM (FT)	# ANCHOR BLDRS/ CONNECTIONS	TOTAL ANCHOR BLDR WEIGHT (TONS)	FS v. Sliding	FS v. Buoyancy
1	Log	24	2.0	2	4	1.6	2.0
2	Log	24	2.0	2	4	1.9	2.0
3	Log	18	1.5	2	4	2.9	3.7
4	Log	12	1.5	2	4	2.6	4.7
5	Log	12	1.5	2	4	2.5	4.7
6	Log-Rw	18	1.5	2	4	1.4	2.9
7	Log	36	2.5	4	8	1.7	1.7
8	Log	24	2.0	2	4	2.2	2.0
9	Log	12	1.5	2	4	4.7	4.7
10	Log	36	2.5	4	8	2.0	1.7
11	Log	24	2.0	2	4	1.9	2.0
12	Log	36	2.5	4	8	3.1	1.7
13	Log	36	2.5	4	8	2.0	1.7
14	Log	24	2.5	3	6	2.3	1.9
15	Log-Rw	8	2.0	3	6	1.2	4.2
16	Log	24	1.5	2	4	1.5	3.0
17	Log-Rw	6	2.5	2	4	2.0	3.0
18	Log-Rw	12	2.0	2	4	1.8	2.7
19	Log	12	2.5	2	4	1.3	2.4
20	Log	24	2.0	3	6	1.4	2.7
21	Log	12	1.5	2	4	2.5	4.7
22	Log	24	2.0	3	6	1.4	2.7
23	Log-Rw	12	2.5	2	4	1.5	2.0
24	Log	18	1.5	2	4	2.9	3.7
25	Log	36	2.5	4	8	1.4	1.7
26	Log	36	2.5	4	8	1.3	1.7
27	Log	18	2.0	2	4	2.3	2.5
28	Log	24	2.0	2	4	1.4	2.0
29	Log-Rw	12	1.5	3	6	1.3	4.5

30	Log-Rw	18	2.0	2	4	1.5	2.1
31	Log	36	2.5	4	8	1.7	1.7
32	Log	36	2.5	4	8	2.0	1.7
33	Log	24	2.0	2	4	2.2	2.0
34	Log	36	2.5	4	8	2.0	1.7
35	Log	24	2.0	2	4	2.2	2.0
36	Log	18	1.5	2	4	4.0	3.7
37	Log	24	2.0	2	4	1.4	2.0
38	Log-Rw	4	2.5	1	2	2.0	2.2
39	Log	12	1.5	2	4	2.6	4.7
40	Log-Rw	12	2.0	2	4	1.5	2.7
41	Log	36	2.5	4	8	2.0	1.7
42	Log	12	1.5	2	4	5.8	4.7
43	Log	18	2.0	2	4	3.0	2.5
44	Log	36	2.5	4	8	2.0	1.7
45	Log	12	1.5	2	4	4.3	4.7
46	Log	24	2.0	2	4	1.9	2.0
47	Log	36	2.5	4	8	2.4	1.7
48	Log	18	1.5	2	4	2.9	3.7
49	Log	12	1.5	2	4	3.3	4.7
50	Log	24	2.0	3	6	1.4	2.7
51	Log	18	1.5	2	4	1.8	3.7
TOTAL				131	262		

Boulder-Anchored Large Wood Slope Protection

The 100% design plans show that the right bank slope in the 0.0-3.5-ft horizon will be constructed from boulder-anchored large wood covered rock blanket to protect the slope from high velocity flows. The rock blanket forming finished grade would be comprised of imported 2-ton boulders required for anchoring the large wood material and filled in with “Boulder Field Rock Mix” sized to match the existing salvaged rip-rap rock slope protection (RSP to be removed from the downstream end the concrete channel). This existing RSP is dominated by 24” to 30” diameter materials and appears by visual inspection to resemble Caltrans Class VII or VIII RSP.

As shown in sheet C15 and sheet C16, both storm drain outfalls will discharge onto the Boulder Field Rock Mix bounded by 2-ton anchor and field boulders and anchored large wood pieces, and the finished grade of the boulder field rock mix and arrangement of large wood may be detailed at the outfall to enhance energy dissipation.

Live willow cuttings are not expected to survive if planted in the 0.0-3.5-ft horizon because of salinity in tidal inundation zone. However, live willow cuttings may be successful within vegetated rock-and-fill slope protection at higher elevations. Agency personnel suggested experimenting with arroyo willow (*Salix lasiolepis*) in the restoration planting because it is more tolerant of salinity than other willow species.

The Boulder-Anchored Large Wood Slope Protection areas are not vegetated because they occupy an elevation horizon in the intertidal zone. The roughness provided by the anchored large wood pieces is anticipated to cause sedimentation and sedimentation cover on the wood and underlying Boulder Field Rock Mix is considered a design objective for minimizing the exposure of rock materials at low tide levels.

Buried Rip-Rap Bench & Sub-Tidal Rip-Rap Slope

Below the 0.0-foot elevation, “buried rip-rap bench” and “sub-tidal rip-rap slope” revetments will be installed reusing the majority of the existing RSP salvaged from the downstream end of the concrete channel. This existing RSP is dominated by 24” to 30” diameter materials and appears by visual inspection to resemble Caltrans Class VII or VIII RSP. The remainder of the salvaged RSP will be used for boulder field rock mix filling out the limits of the Boulder-Anchored Large Wood Slope Protection area.

Vegetated Rock-and-Fill Slope Protection

Rock slope protection will be needed bordering each of the taper cut channel walls where high velocity and turbulent shearing flows are anticipated. For vegetating the rock slope protection as far as practically feasible, a vegetated rock-and-fill slope protection treatment will be used. Finished grades in areas immediately landward of both the right and left taper-cut channel wall boundaries will be constructed with large rock pieces forming a stable framework and plantable soil materials forming the matrix fill materials. Large rock pieces will form the framework of the rock-and-fill framework-matrix composition immediately landward from the taper cut walls where the turbulent eddy flow velocities will be greatest. 1-ton varying to ¼-ton rock farther from the wall boundary will be required for framework pieces. The 100% design plans show a 10-foot-wide vegetated rock-and-fill slope protection along the right (west) taper-cut wall boundary (sheet C7) and a triangular +/- 250-SF area of similar slope protection up to about 20-feet-wide at the upstream end of the left (east) taper-cut wall boundary (sheet C8). Potential high creek flow shear stresses along the landward edges of these taper-cut wall may limit successful vegetation establishment on these slope rock-and-fill protection areas. The rock-and-fill slope protection will not be feasible to install where the left bank rock-and-fill slope protection width diminishes to less than 3 feet – i.e., the width between the existing (taper-cut) channel wall and the new top of bank retaining wall is less than 3 feet. In this area, a grouted cobble slope protection similar to a standard Caltrans Rock Blanket will be installed.

Vegetated Double-Layer Erosion Control Fabric

All other finished grading areas on the restored banks upslope from the 3.5-ft and 5-ft elevation contour will be covered with a double-layer of 100% biodegradable erosion control fabric. See Sheet C29 Slope Erosion Protection Plan in the 100% design plans. The bottom layer will be an erosion control blanket (North American Green C125BN, or approved equivalent), and the top layer will be a heavy-duty 700-gram erosion control mat (Nedia Koirmat 700, or approved equivalent). According to manufacturer specifications, these biodegradable erosion control fabrics can resist surface flow velocities up to 10.0 fps and shear stresses up to 2.35 psf.

Per the planting and grading specifications, the native subgrade soils will be tested and evaluated for suitability as planting medium, and amended prior to placement of erosion control fabric as needed per review and approval of the Construction Manager and project Landscape Architect, such as by raking in a 2” lift of compost.

Biodegradable erosion control fabric is expected to last about 2-3 years after which the slope protection will be provided by established vegetation.

Stability of fastened biodegradable erosion control fabric requires adequate depth keys along the perimeter of the fabric-covered areas as well as adequate overlap and spacing of pins and stakes. Fabric key details are shown in Sheet C30 of the 100% design plans.

Biodegradable erosion protection fabric is not specified to cover final graded slopes below elevation 5.0 ft (NAVD88) where self-sustaining vegetation is not anticipated to establish (i.e., intertidal mud flat habitat). Unvegetated areas are natural in intertidal estuarine environments.

5 Geology, Seismicity and Subsurface Conditions

5.1 General

The Lower COM Creek Restoration project includes removing the portions of the concrete flood control channel downstream from the Stadium Way bridge, to restore sloped creek bank surfaces supporting intertidal mudflat, low and high marsh tidal wetland, transitional, and upland riparian woodland habitat areas and vegetation communities. This will include removal of the downstream 468 lineal feet to the west bank wall and 156 lineal feet of the east bank wall to restore creek banks to maximize potential habitat restoration. MPEG has performed geotechnical exploration work to advance the project design. Please see Appendix 4.

5.2 Regional Geology

The project site lies within the Coast Ranges geomorphic province of California. Regional topography within the Coast Ranges province is characterized by northwest-southeast trending mountain ridges and intervening valleys that parallel the major geologic structures, including the San Andreas Fault System. The province is also generally characterized by abundant landsliding and erosion, owing in part to its typically high levels of precipitation and seismic activity.

The oldest rocks in the region are the sedimentary, igneous, and metamorphic rocks of the Jurassic-Cretaceous age (190- to 65-million years old) Franciscan Complex. Within Marin County, a variety of sedimentary and volcanic rocks of Tertiary (1.8- to 65-million years old) and Quaternary (less than 1.8-million years old) age locally overlie the basement rocks of the Franciscan Complex. Tectonic deformation and erosion during late Tertiary and Quaternary time (the last several million years) formed the prominent coastal ridges and intervening valleys typical of the Coast Ranges province. The youngest geologic units in the region are Quaternary-age (last 1.8 million years) sedimentary deposits, including alluvial deposits which partially fill most of the valleys and colluvial deposits which typically blanket the lower portions of surrounding slopes.

The project site is located on Corte Madera Creek and west of San Pablo Bay. Regional geologic mapping (California Division of Mines and Geology, 1976) indicates the majority of the site is underlain by Bay Mud. Mapping indicates that the commercial and residential developments to the east and west are underlain by artificial fill over Bay Mud. However, the northern end of the site is located close to the hillside and is near a mapped boundary between Bay Mud and sandstone and shale bedrock of Cretaceous age. A Regional Geologic Map and descriptions of mapped geologic units are shown in Appendix 4 (Figure 3).

5.3 Seismicity

The project site is located within the seismically active San Francisco Bay Area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the build-up and sudden release of strain along a “fault” or zone of weakness in the earth's crust. Stored energy may be released as soon as it is generated, or it may be accumulated and stored for long periods of time. Individual releases may be so small that they are detected only by sensitive instruments, or they may be violent enough to cause destruction over vast areas.

Faults are seldom single cracks in the earth's crust but are typically composed of localized shear zones which link together to form larger fault zones. Within the Bay Area, faults are concentrated along the San Andreas Fault zone. The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination, and is radiated outward in the form of energy waves. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy becomes a long, high-amplitude motion when moving through soft ground materials, such as Bay Mud.

Regional Active Faults

An “active” fault is one that shows displacement within the last 11,000 years (i.e., Holocene) and has a reported average slip rate greater than 0.1 mm per year. The California Division of Mines and Geology has mapped various active and inactive faults in the region. These faults are shown in relation to the project site on the attached Active Fault Map, Appendix 4 (Figure 4). The nearest known active faults are the San Andreas, San Gregorio, and Hayward Faults which are located roughly 12.2 kilometers (7.6 miles) west, 13.1 kilometers (8.2 miles) west, and 16.3 kilometers (10.1 miles) east of the site, respectively.

Historic Fault Activity

Numerous earthquakes have occurred in the region within historic times. Earthquakes (magnitude 2.0 and greater) that have occurred in the San Francisco Bay Area since 1985 have been plotted on a map shown in Appendix 4 (Figure 5).

Probability of Future Earthquakes

The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the “Working Group on California Earthquake Probabilities” (USGS 2003, 2008; Field et al 2015) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3. In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

Conclusions from the most recent UCERF3 and USGS indicate the highest probability of an earthquake with a magnitude greater than 6.7 originating on any of the active faults in the San Francisco Bay region by 2043 is assigned to the Hayward/Rodgers Creek Fault system. The Hayward Fault is located approximately 16.3 kilometers (10.1 miles) east of the site and is assigned a probability of 33 percent. The San Andreas Fault, located approximately 12.2 kilometers (7.6 miles) west of the site, is assigned a 22 percent probability of an earthquake with a magnitude greater than 6.7 by 2043. Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

5.4 Surface Conditions

The site is bordered to the east by a residential development, to the west by College of Marin, to the north by Corte Madera Creek and Stadium Way, and to the south by the wider portion of Corte Madera Creek. The site is relatively flat with surface elevations ranging from about 2 to 5 feet (NAVD 88).

The existing concrete channel in the project area is approximately 400-feet-long with a crest width ranging from about 25 to 30 feet. The channel bottom and side walls are reinforced concrete. The slopes above the concrete channel are relatively flat on both sides of the channel. The slopes are vegetated with grasses, other shrubbery, and trees and biking trails.

5.5 Field Exploration and Laboratory Testing

We explored subsurface conditions near the channel on April 10, 2020 with four borings and additional borings in Fall 2021 near the vest-pocket park at the approximate locations shown in Appendix 4 (Figure 2) and Sheet C31 of the Drawings. The borings were excavated using track-mounted drilling equipment to approximate depths ranging from 26.0 to 29.5 feet below the ground surface. The borings were logged by our Field Engineer and samples were obtained for classification and laboratory testing. We prepared boring logs based on soil descriptions in the field, as well as visual examination and testing of the soil samples in our laboratory. The boring logs are presented in Appendix 4 (Appendix A).

Geotechnical laboratory testing of soil samples from the exploratory borings included determination of moisture content, dry density, unconfined compressive strength, sieve analyses, the amount of material passing a No. 200 sieve, and Atterberg Limits. The results of our laboratory tests are presented on the boring logs with the exception of the sieve analyses and Atterberg Limits which are presented on Appendix 4 (Figures A-11 through A-12). Our laboratory testing program is discussed in greater detail in Appendix 4 (Appendix A).

5.6 Subsurface Conditions and Groundwater

Field exploration by MPEG and the previous investigations by other consultants indicated that subsurface conditions are consistent with the geologic mapping and consist of artificial fill over Bay Mud with fill thickness at the boring locations ranging from about 7 to 12 feet.

The fill encountered in the borings is heterogeneous and contains variable amounts of clay, silt, sand, and gravel. While not directly observed, the fill may also contain cobbles, boulders, wood, organic material, and other debris which could not be retrieved within the samples or detected by the relatively small diameter borings. The Bay Mud generally consists of very soft to soft, compressible silty clay of high plasticity, while the deeper alluvial soils consist of a mixture medium dense to dense sand and gravel and stiff to very stiff silt and clay. The sandstone and siltstone bedrock encountered in the previous explorations is generally described as soft and severely weathered.

Groundwater was encountered during our recent field exploration in borings at about 10- to 13-feet below ground surface. Review of existing geotechnical data further indicates that groundwater was observed at approximate elevations between 5 and 17 feet below the ground surface in the previous borings. Because the borings were not left open for an extended period of time, a stabilized depth to groundwater may not have been observed. Groundwater elevations fluctuate seasonally and with changes in tidal elevations and higher groundwater levels may be present during periods of intense rainfall and/or high tide.

5.7 Previous Geotechnical Investigations

Several subsurface explorations have been conducted by other Consultants as part of the original site development and subsequent improvements. MPEG reviewed the following reports:

- A3GEO, Geotechnical Investigation Report, College of Marin Maintenance and Operations Complex, Marin County, California, dated July 21, 2017.
- Brown & Caldwell, Geotechnical Engineering Investigation Report, Kentfield Force Main Replacement Project, Marin County, California, dated February 2010.

- Harding Miller Lawson & Associates, *Soil Engineering Services, College of Marin Athletic Field, Kentfield, California,* dated March 15, 1968.

The approximate locations of the borings and CPTs from these previous investigations are shown on the Site Plan, Appendix 4 (Figure 2). The boring logs and laboratory testing from previous investigations are included under Appendix 4 (Appendix B).

5.8 Geologic Hazards and Design Recommendations

Please see Appendix 4 for a complete summary of geologic hazards present at the Project site and recommendations for hazard mitigation and project design.

As described in Section 4.3 (Appendix 4) a primary mitigation required for the Lower COM Project will be reducing risk of liquefaction presented by existing loose sands present in the soils near the grading envelope. The primary area where potentially liquefiable soils were observed is at Boring 1 in the southeastern portion of the project area. Liquefaction-induced ground settlement can damage planned improvements. Mitigation measures may include removal of potential liquefiable sands and replacement with compacted fill materials. Ground improvement (such as grouting), or inclusion of retaining structures with deeper foundations could also be utilized to mitigate liquefaction settlement. See Section 4.8 (Appendix 4) for mitigation measures related to instability and lateral deformations.

5.9 Effect of Modifications on Concrete Channel Stability

The concrete channel is rectangular with vertical concrete walls and full channel-spanning horizontal concrete floor. Complete removal of the concrete channel bottom would reduce scour protection within the channel. Based on MPEG's conversations with the design team, the planned design creek bed elevation is well above the top of the existing concrete channel floor. Therefore, MPEG recommends leaving the concrete channel floor in place and saw-cutting the concrete channel walls below the planned new creek bank grades. Leaving the bottom of the channel in place should significantly reduce project costs and will increase the stability of the channel while still allowing the natural slopes to be restored in the upper portions of the channel. More detail of the merits of this design choice can be found in the Alternatives Analysis prepared by Geomorph Design, dated August 2021 (Appendix 6).

6 Geotechnical Design Considerations

6.1 General

MPEG judges that the proposed project is feasible from a geotechnical standpoint. Primary geotechnical considerations include checking to ensure that planned excavation inclinations result in adequate factors of safety restoring the creek banks and riparian zones in a manner that reduces the potential for future erosion and instability. Surface water and groundwater control will be a significant issue during construction.

Table 6-1
2019 California Building Code Seismic Design Criteria

Parameter	Design Value
Site Class	E
Site Latitude	37.9521°N
Site Longitude	-122.5459°W
Spectral Response (short), S_S	1.500 g
Spectral Response (1-sec), S_1	0.600 g
MCE_G PGA Adjusted, PGA_M	0.648

Reference: USGS US Seismic Design Maps accessed on September 22, 2020.

6.2 Seismic Design

MPEG recommend minimum mitigation of ground shaking include seismic design per the 2019 California Building Code/ASCE 7-16. The magnitude and character of these ground motions will depend on the particular earthquake and the site response characteristics. Based on the interpreted subsurface conditions and close proximity to the San Andreas, San Gregorio, and Hayward Faults, MPEG recommend the CBC coefficients and site values shown in Table 6-1 above for use to calculate the design base shear of the new construction.

Based on the subsurface conditions, the project site is classified as a “Site Class E”. Additionally, because the S_1 value is greater than 0.20 g a site-specific ground motion analysis should be performed per the procedures outlined in ASCE 7-16. However, per ASCE 7-16 Section 11.4.8, a site-specific analysis is not required for structures located on sites classified as “Site Class E” if the Short Period Site Coefficient, F_a, is taken as equal to that of “Site Class C.” This exception applies to structures with fundamental periods within the "short-period" range. MPEG should be contacted to perform a site-specific ground motion analysis if it is determined "long-period" accelerations are needed.

6.3 Slope Stability Analysis

MPEG performed slope stability analyses in order to evaluate the impact of the proposed grading and improvements. Using the computer program Slide, Version 6.008 (Rocscience, 2011), MPEG modeled planned conditions on cross sections at Station 319+17 and 321+50. MPEG obtained engineering properties from laboratory data performed on samples collected during our exploration and reference data. The analyses were performed for both static and pseudo-static (seismic) conditions. MPEG also analyzed the potential slope displacement based on the procedures outlined by Makdisi, Bray & Travasarou (2007). For pseudo-static conditions, analyses were performed using the deterministic peak ground acceleration of about 0.32g and the CBC PGAm of 0.65g.

Under static conditions, the factor of safety for Station 319+17 against failure towards Corte Madera Creek is 11.9 as shown in Appendix 4 (Figure 10). MPEG also ran analyses assuming the alluvial sand layer liquefies during strong ground shaking. During the strong seismic shaking, the factor of safety is below 1.0, as shown in Appendix 4 (Figure 11), and therefore some seismic induced displacement is expected to occur. Once ground shaking stops, the factor of safety is above 1.0 using a residual strength for the liquefied sand. This indicates that lateral spreading towards Corte Madera Creek after an earthquake is expected to stop once ground shaking ceases. The calculated seismic induced displacement ranges from 21 to 65 inches. When the liquefiable sands are removed and replaced with compacted fill, the factor of safety under pseudo-static conditions is 1.3 as shown in Appendix 4 (Figure 12).

MPEG also performed stability analyses for Station 321+50 where no liquefiable sand layers were encountered during our exploration. Under static conditions, the factor of safety for Station 321+50 is 13.5 as shown on Appendix 4 (Figure 13). As shown on Appendix 4 (Figure 14), the factor of safety for Station 321+50 under the pseudo-static conditions is 3.03. Therefore, no seismic displacement is anticipated in that area.

The extents of the liquefiable sand layer in the southeast portion of the project area are unknown. This area should be explored further if the extent needs to be determined. Mitigation options for this lower portion of the channel include removal and replacement of the liquefiable soils with compacted fill, ground improvement to treat the soils in place, or constructing a retaining structure to protect from seismic instability towards Corte Madera Creek.

6.4 Creek Bank Stability and Erosion Control

After the top portion of the concrete channel is removed, the creek banks should be graded at inclinations no steeper than 3:1. Special provisions should be considered to reduce the potential for erosion, including measures to revegetate the creek and slow water velocity. Armoring the channel banks with log structures or other "bio-engineering" systems should be considered. As with any active waterway, erosion can occur due to high creek flows, so monitoring of the channel and repairs to damage should be performed as part of "routine" maintenance.

6.5 Site Grading

Relatively significant site grading will be required for construction of the project and will consist primarily of excavation to remove the top portion of the existing concrete channel and construct the embankments. Removal of the concrete channel will require removal and demolition of the existing concrete sidewalls and rebuilding the slopes to allow for more natural creekbanks. Earthwork for the concrete channel removal project and related improvements should be performed in accordance with the following recommendations:

Excavations

Excavations are expected to encounter fill consisting of loose to medium dense sand and gravel and medium stiff to stiff clay over soft Bay Mud. Based on our subsurface exploration and review of site history, the fill is expected to be heterogeneous and may include cobbles, boulders, wood, organic material, and other debris which could not be retrieved within the samples or detected by the relatively small diameter borings.

In unsupported excavations, the sandy and gravelly fill soils will be susceptible to flowing below groundwater and running to fast raveling above groundwater. The clayey fill soils will exhibit firm behavior while the Bay Mud will be susceptible to squeezing. In accordance with OSHA soil type designations, the fill and Bay Mud are considered "Type C" soils whereas the sandstone and shale bedrock are considered "Type A." While trenching not anticipated as part of this project, support for excavations should be installed as necessary prior to or during excavation to ensure the safety of workers and to reduce the potential for unforeseen earth failure and damage to surrounding areas.

Based on our subsurface exploration, MPEG judges the majority of site excavation can be performed with typical equipment, such as medium-size excavators. If shale and sandstone bedrock is encountered, these materials often contain inclusions and zones of harder, more resistant rock which may require specialized techniques or equipment to excavate (e.g. jackhammers or hydraulic breakers). Therefore, MPEG recommends inclusion of a line item and clear definition for “hard rock excavation” in the project bid documents. If hard rock is encountered during construction which prohibits excavation to the required depths, MPEG should be consulted to observe conditions and revise our recommendations and/or design criteria as appropriate

Fill Materials

Unless otherwise recommended by the pipe manufacturer, pipe bedding and embedment materials should consist of well-graded sand with 90 to 100 percent of particles passing the No. 4 sieve, and no more than 5 percent finer than the No. 200 sieve. Provide the minimum bedding thickness beneath the pipe in accordance with the manufacturer’s recommendations (typically 3 to 6 inches).

Fill materials used for structural backfill should consist of non-expansive materials that are free of organic matter, have a Liquid Limit of less than 40 (ASTM D 4318), a Plasticity Index of less than 20 (ASTM D 4318), and have a minimum R-value of 20 (California Test 301). The fill material should contain no more than 50 percent of particles passing a No. 200 sieve and should have a maximum particle size of 4 inches. Some of the onsite fill soils may be suitable for re-use as trench backfill. The Bay Mud is not suitable for use as fill and should be removed from the site.

Fill Placement and Compaction

Fill materials should be moisture conditioned to near the optimum moisture content prior to compaction. Properly moisture conditioned fill materials should subsequently be placed in loose, horizontal lifts of 8 inches-thick or less and uniformly compacted to at least 90 percent relative compaction. In pavement areas, the upper 12 inches of backfill should be compacted to at least 95 percent relative compaction. The maximum dry density and optimum moisture content of fill materials should be determined in accordance with ASTM D1557.

Slopes

Cut slopes into the native soils should be no steeper than 3:1. If possible, flatter slopes should be utilized to improve stability. Compacted fill slopes should be no steeper than 2:1. Rip-rap slopes could be designed at 1.5:1 or flatter inclinations. Fill slopes should be “keyed” several feet into native soil at the toe of the slope.

Temporary (steeper) cut slopes may be required during construction after the top of the concrete channel is removed until embankments are constructed. For planning purposes, these cut slopes in alluvial soils may be designed for an OSHA Type “C” soil profile. Geologic inspection during excavation will be required to verify that the above recommendations are appropriate for the conditions encountered. Even flatter temporary slopes may be needed during the winter and early spring months since high groundwater and loose sandy soils are anticipated.

7 Revegetation

Goals of the revegetation component of the project are to facilitate the development of native-dominated vegetation that:

- integrates ecologically and visually with adjacent natural vegetation;
- is diverse in structure and composition, supporting a variety of native wildlife and protecting channel banks;
- is self-sustaining after an initial establishment period, resistant to invasion by non-native species, and robust to rising sea levels and climate change; and
- provides opportunities for human visitors to study, enjoy and observe natural marsh and riparian woodland habitat.

7.1 Plant Communities by Elevation Zones – Existing Conditions

Along the concrete-lined channel, no marsh vegetation exists and only narrow bands of upland ornamental species and scattered native trees are present along the top of bank. Downstream of the concrete-lined channel, marsh vegetation begins along the channel edge, in bands corresponding to elevation and inundation patterns. The marsh vegetation zones present are similar in composition to those found along other tidal marsh/channel settings in the region. In general, at this site, lower zones occupy narrower elevation bands and narrower widths, and the upper zones are more extensive. The marsh habitats primarily support native species. Vegetation within each zone intermingles to some extent with adjacent zones.

- Low Marsh occurs just above MSL (3.5’-4.5’) and is dominated by California cordgrass, the most inundation-tolerant of local tidal marsh species. This occurs only in limited patches along the channel margins where protected from high velocity flows and where slope is gentle. Elsewhere, this elevation zone is currently unvegetated.

- High Marsh occurs at approximately 4.5’-6’ and is dominated by emergent and low-growing herbaceous species (e.g., seacoast bulrush, pickleweed, and jaumea). This vegetation is also best-developed on flats or gentle slopes, but the bulrush grows along (and stabilizes) relatively steep banks as well.

- Transition Zone vegetation occurs at approximately 6’-8’ in elevation and is the most diverse of the marsh vegetation types present, at the ecotone between salt marsh and upland. Dominants are low-growing salt-tolerant perennial herbs including alkali heath, gumplant, and saltgrass.

- Upland vegetation through the project site mostly consists of ornamental plantings, non-native grasses, and scattered native tree and shrub plantings. A number of coast live oaks are present; many of these appear stressed, potentially by soil or salinity conditions. Robust stands of coyote brush are present along the eastern downstream end of the project.

Nearby reference areas were also reviewed. An oak woodland/wet meadow restoration area is present just east of the coyote brush stand mentioned above, within an old bend of the historic channel. Coast live oak, Oregon ash, elderberry, coyote brush, toyon, and creeping wildrye are all thriving there. Just downstream of the project, relatively extensive marsh habitat is present at Creekside Park, and to a more limited extent along the relict mouth of Tamalpais Creek (entering Corte Madera Creek from the south). These two marsh areas were reviewed to help build the restoration planting palette, and may be able to serve as sources for some propagule collection.

7.2 Habitat Heterogeneity

The revegetation design intends to facilitate the full spectrum of native habitat that the area can support, low marsh through upland woodland. Open water, and some areas of unvegetated mudflat, also provide important habitat components. Variations in slope are included to add to habitat diversity, with some flats and some steeper sections to support small-scale variation in plant and wildlife usage. Some sinuosity of the contours—to the extent feasible given site constraints—is also included, to provide diverse edge microhabitats and varied exposure to flows. Table 7.1 below provides the approximate design elevations and areas for each habitat type.

Table 7-1
100% Design Restoration Habitat Types

Habitat	Elev. (ft) NAVD88	Existing Area (sq ft)	Existing Species	Proposed Area (sq ft)	Proposed Species
Open Water/ Channel	≤3.5’	23,565		30,200	None
Low Marsh	3.5 – 4.5’	1,744	*Spartina foliosa*	7,000	*Spartina foliosa*

High Marsh	4.5' – 6.0'	2,892	*Salicornia pacifica, Bulboschoenus maritimus, Jaumea carnosa*	8,600	*Salicornia pacifica, Bulboschoenus maritimus, Jaumea carnosa*
Transition Zone	6.0' – 8.0'	3,116	*Frankenia salina*, *Grindelia stricta*, *Limonium californicum*, *Distichlis spicata*	16,800	*Frankenia salina*, *Grindelia stricta*, *Limonium californicum*, *Distichlis spicata*
Uplands	≥8.0'	49,103	*Acacia spp.*, *Eucalyptus spp.*, Palms, Privet, and 3 *Quercus agrifolia*	17,820	*Acer negundo, Aesculus californius, Quercus agrifolia, Quercus lobata, Artemisia californica, Frangula californica, Baccharis pilularis, Symphocarpos mollis, Mimulus aurantiacus, Heteromeles arbutifolia, Elymus glaucus, Bromis carinatus, Amsinckia menziesii, Lupinus nanus, Achillea millefolium*

Table 7-2
Anticipated Sea Level Rise

Water Surface Elevation (ft NAVD88)	Source
1.7	GDG surveyed minimum water surface during February 5, 2020 low tide of minus 0.3'. Natural bed sedimentation downstream from the concrete channel prevents tides lower than 1.7' in the concrete channel.
3.5	2020 Mean Sea Level (MSL)
8.0	2020 Mean Higher High Water (MHHW)
9.5	Estimated 2050 Mean Higher High Water (MHHW)
11.0	Estimated 2100 Mean Higher High Water (MHHW)

7.3 Habitat Adaptation to Sea Level Rise

Based on the references used for the project, sea level rise of 1.5' and 3' are projected to occur in roughly 2050 and 2100 respectively (see table 7.2). To help ensure that the project has long-lasting benefits, the team considered these forecasts in developing the design. The goal of the revegetation is to support gradual shifting of plant communities upslope as water elevation rises. The design prioritizes gentle, gradual slopes, and includes a significant upland component that can eventually support transition zone vegetation. Sinuosity and slope variation in the design are also intended to help accommodate sea level rise; while one zone may contract in one section as waters rise, that zone will have room to expand in another section. The planting palette is selected to focus on species that readily expand by rhizomes or by self-seeding assisted by tides, when conditions are suitable, to further facilitate gradual movement.

7.4 Tree Removal and Replacement

Existing trees within the grading footprint will be removed during the initial surface features demolition and removal phase of construction. Tree plantings will be incorporated into the upland/riparian planting portions of the revegetation. Native trees will be selected and located to provide ecological benefits of riparian woodland, as well as shade and screening of views for path users and park visitors.

According to the trees located by the February 2020 survey shown in the 100% design plans, up to 39 trees and tree clusters will be removed from the west side of the channel, primarily from along the fence row between COM O&M Facility and the channel right-of-way. These 39 trees include 3 native CA riparian woodland trees – all oaks – equal to or greater than 4-inch-dbh, 2 of which are equal to or greater than 8-inch-dbh. At least one eucalyptus will be removed from the existing rip-rap slope area on the east side of the channel. The 100% design plans contain a tree removal plan (sheet C22). The plans also indicate trees to be removed with an “X” on sheets C6-C9 (1”=10’). According to the replacement ratios shown in Table 7-3, 60 trees must be planted to mitigate for removal of the 39 trees.

The 100% plans show proposed plantings and numbers, including 60 new trees and approximately 25 willows.

Table 7-3
100% Design Tree Removal List

	Species	Diameter (inches dbh)	Native/Non-Native	Location	Replacement Ratio / #
1	Eucalyptus	20	Non	M&O fence row	1
2	Acacia	6	Non	M&O fence row	1
3	Acacia	6	Non	M&O fence row	1
4	Acacia	18	Non	M&O fence row	1
5	Acacia	6	Non	M&O fence row	1
6	Acacia	12	Non	M&O fence row	1
7	Acacia	8	Non	M&O fence row	1

8	Acacia	6	Non	M&O fence row	1
9	Acacia	8	Non	M&O fence row	1
10	Acacia	8	Non	M&O fence row	1
11	Acacia	6	Non	M&O fence row	1
12	Acacia	8	Non	M&O fence row	1
13	Acacia	12	Non	M&O fence row	1
14	Acacia	12	Non	M&O fence row	1
15	Acacia	10	Non	M&O fence row	1
16	Acacia	8	Non	M&O fence row	1
17	Oak	16	Native	M&O fence row	15
18	Privet	8	Non	M&O fence row	1
19	Privet	8	Non	M&O fence row	1
20	Acacia	6	Non	M&O fence row	1
21	Acacia	8	Non	M&O fence row	1
22	Eucalyptus	8	Non	M&O fence row	1
23	Privet	8	Non	M&O fence row	1
24	Acacia	10	Non	M&O fence row	1
25	Acacia	10	Non	M&O fence row	1
26	Acacia	6	Non	M&O fence row	1
27	Acacia	8	Non	M&O fence row	1
28	Palm	?	Non	M&O fence row	1
29	Prunus	6	Non	West Gravel Path	1
30	Prunus	12	Non	West Gravel Path	1
31	Prunus	6	Non	West Rip-Rap	1
32	Oak	6	Native	West Rip-Rap	4
33	Eucalyptus	10	Non	West Berm Area	1
34	Acacia	8	Non	West Berm Area	1
35	Acacia	8	Non	West Berm Area	1
36	Palm	?	Non	West Berm Area	1
37	Palm	?	Non	West Berm Area	1
38	Oak	14	Native	Construction Access	5
39	Eucalyptus	12	Non	East Rip-Rap	1
					60

7.5 Creek Bank Restoration

Banks will be restored to a range of slopes, with most areas being relatively gentle for stability and to best support extensive marsh vegetation and migration with sea level rise. Slopes will mimic those found in less disturbed habitats downstream; some sections will be approximately 5H:1V, but extensive areas will be 10:1 or gentler.

Erosion protection measures for slopes will include installation of 100% biodegradable erosion control blankets, with more robust blankets in areas of higher flow velocity, and blankets with a more open weave in other areas and where natural reseeding of marsh species is anticipated. Plug plantings will be installed within the blanket. See Revegetation Plan section below for related discussion of soils.

In specific places, as described in Section 3.0 and Section 4.0, vegetated rock-and-fill slope protection and boulder-anchored large wood slope protection will be needed. Willows will be installed in or adjacent to rock-and-fill slope protection where hydrologic conditions allow.

7.6 Revegetation Plan

Revegetation work will begin with protecting or restoring native soils. This will include removing fill currently on top of native soil, and/or setting aside existing topsoil while grading is performed below it, and then replacing it. Following grading and restoration of topsoils, the finished surfaces will be seeded and planted with native plants. A temporary irrigation system will be installed for upland species. Maintenance and monitoring of the revegetated areas will occur for a period of 3 to 5 years to insure successful establishment of native plant communities. These revegetation actions are described in further detail below.

Plant Propagation

The revegetation effort will include a mix of seeding, container planting, salvage or transplanting of marsh species, and allowing for some natural recruitment. Pickleweed, native cordgrass, seacoast bulrush, other marsh species and creeping wild rye are likely to perform well from transplants and could be salvaged from the site or other sources along Corte Madera Creek (e.g., nearby Creekside/Hal Brown Park, and elsewhere downstream of the project site). For cordgrass, consult with the Invasive Spartina Project to ensure that only native material is used. See revegetation sheet for details.

Other plant propagules will be sourced from within Marin County, and as close to the project site as possible. Seed or propagule collection will be made at the appropriate time for each targeted species. All plant materials will be stored and grown under phytosanitary conditions and tested as remaining free from disease in the growing facility. Planting stock shall be protected from potential contamination from the point that it leaves the production or collection site until planting.

Soil Conditions and Treatments

As noted in Sections 3.9-3.11, grading is expected to expose underlying native alluvial soils (sandy on the east side of the channel and silty clay on the west side) below elevations of approximately 3’-4’. At elevations above that, clean fine-grained alluvial fill or compost soil amendment will be placed to support plant establishment. First, rip bank subsoil to 6” depth, with two diagonal passes. Add 6” to 9” topsoil, track walked in two passes to approximately 85-87% relative compaction, to achieve a topsoil layer for planting. If topsoil is not available, place 2” thick compost layer on bank, till in to a depth of 9”, and track walk in two passes, providing approximately 20% organic matter. Install 100% biodegradable C125BN erosion control blanket throughout bank and cover with 700-gram coir mat. Erosion control material will be pinned 24” on center with 18” wood wedge stakes.

Planting

Planting and seeding will commence once relocation of topsoils and any soil amendments required to correct post-grading soil conditions have been performed. The planting plan and plant species palettes are based on plant community distribution and species composition observed in and adjacent to the project site. Seed mixes in upland and bioretention areas will help provide erosion protection and contribute to establishment of native herbaceous species components of the target plant communities.

Current marsh planting numbers allow for planting in some areas and leaving openings for natural establishment in others; in the low marsh zone, plant numbers allow for planting 70% of the area; in other marsh areas, plant numbers allow for planting 50% of the area. In general, marsh plantings will be focused in the upper portions of each zone, with lower, wetter portions less densely planted. Planting numbers could be increased if more rapid establishment of plant cover is needed.

A restoration specialist will determine plant layout and supervise planting. In uplands, plants will be laid out in naturalistic clusters that provide habitat value and allow for screening or views of the marsh, as appropriate. Marsh plantings will be laid out to maximize bank protection, to best withstand flows, and to facilitate establishment of cover throughout areas that can support it. To the extent feasible, planting of upland plants will be performed during the cooler, wetter months between November 15 and January 15, preferably immediately following a rainfall of one to one and one-half inches. If seasonal rainfall is low, or does not coincide with the desired planting dates, plantings will be thoroughly watered in at planting time. Planting of marsh species will primarily occur between November 15 and April 15; March-April is preferred for best survival. However, salvaged species may be planted earlier, promptly after salvage, to limit the length of time that plants must be held and tended.

To avoid contamination of revegetation sites with exotic pathogenic *Phytophthora* species or other plant pathogens, all planting and related activities shall follow the guidance provided in the “Guidance to Minimize *Phytophthora* Contamination in Restoration Projects” (Working Group for Phytophthoras in Native Habitats, 2016), available at:

http://www.suddenoakdeath.org/wp-content/uploads/2016/04/Restoration_guidance_FINAL-111716.pdf.

For species to be restored in each zone, and extent of each zone, see Planting Plan (Sheet 29).

Irrigation and Other Maintenance

Temporary irrigation will be provided for upland plantings, for up to three years, to ensure successful plant establishment. Most marsh zones are expected to establish without irrigation. Irrigation rates will be determined based upon individual species requirements and zonation of ecotypes, and will be adjusted to provide the minimum necessary for rapid, healthy growth. See planting plan for details.

Periodic maintenance will be required during the establishment of the revegetated area. Maintenance will be performed by qualified personnel having demonstrated experience in maintenance of natural habitat areas and of native revegetation projects. At a minimum, maintenance visits will consist of a thorough walk-through of the entire site, inspection of the condition of all plantings and seeded areas, irrigation system function, weed control, and resetting or replanting, as necessary. Maintenance personnel will communicate directly with the project restoration specialist to ensure prompt response to any problems or unanticipated conditions encountered.

Any unsuccessful plantings will be replaced as needed to bring the revegetation areas of the site into compliance with the minimum success criteria established in project permits.

During ongoing site maintenance, invasive species of high concern, or any other invasive species not previously present on the site, will be promptly removed.

8 Public Access Plan

Existing public access includes a heavily used multi-use path (MUP) – Marin County Bicycle Route 20 – along the left bank of the creek. On the right bank, an informal, gravel access way exists along the District berm and top of bank adjacent to the concrete channel The MUP (Route 20) and the gravel access way are separated from the concrete channel by 6-foot chain-link fences.

Public safety and security features included in the project are designed to:

- Prevent the public from entering the construction site during construction;
- Maintain access, similar to that which exists now, on both banks of the creek downstream of Stadium Way when construction is complete;
- Enhance the experience of using the MUP, the vest-pocket park or the gravel access way by providing views of the creek and natural vegetation where the concrete channel is removed; and
- Prevent unauthorized access by persons to the M&O facilities.

The project will not change the existing use patterns of the MUP (Route 20) or the informal, gravel access way along the right bank.

COM policy prohibits public access to the M&O facility. At sheet C27 (Fence and Gate Plan) the 100% design plans show a new security fence separating the upland restored area on the right bank from the M&O facility.

The Fence and Gate Plan shows park-like fencing bordering the restored area – cedar split-rail fence, and redwood wood-and-wire fence. See Section 2 for more detail on access, fences, and gates.

9 Construction Implementation

9.1 Overview

The construction site will be accessed from College Avenue, through COM Lot 12, to the District easement that follows the alignment of the double barrel culvert containing Tamalpais and Murphy creeks (See sheet C32). This is the access currently used by the District to reach the earthen channel berm and top of concrete channel wall in the project area.

9.2 Preliminary Construction Schedule

For the purposes of environmental review, a preliminary construction schedule and construction sequencing plan was developed with consultation furnished by a local construction contractor. The actual construction schedule and sequence will vary depending on funding, contract administration, environmental permits, and stakeholder coordination, and means and methods developed by selected Contractor in coordination with the Construction Manager, District, and stakeholders. Please see the bid document package for more information.

Construction is expected to take 6 to 8 weeks during mid-August to mid-October. Construction activities will occur on weekdays between the hours of 8:00 am and 5:00 pm.

Table 9-1
Preliminary Construction Schedule

Task	Period
Preparation for construction: surveys, salvage wetland plants, clearing and grubbing	Late August
Instream construction	September—Mid-October
Install tidal wetland plants below elevation ~7 ft	Late October
Install plants in transition zone and upland areas	Mid-November—Mid January

Assumptions:

- Total construction time, excluding planting transition zone and upland planting, is expected to be 6-8 weeks.
- All heavy-equipment access will be from the right bank via the District easement and west earthen channel berm.
- Light vehicle access can be made to the left bank via the east earthen channel berm from Bon Air Road, with expressed per-use permission by RVSD and Marin County Parks.

- Heavy equipment access to the left bank will be made over the creek with a temporary clean fill bridge while the creek is dewatered.
- The start date for installation of the coffer dam will depend on the tides. Most of the work area is exposed at low tides.
- Clearing and grubbing includes salvage of riprap and high marsh vegetation around stilling basin.
- Using a large excavator for concrete removal, it will take about 6 days to remove 200-250 CY at a rate of 40 CY/day.

9.2.1 Environmental Considerations During Construction

Timing of construction will be managed and limited by potential impacts to water quality and species of concern. The construction window is limited to the dry season, typically beginning in June and concluding in October. To avoid operating heavy equipment within 1,000 feet of potential Ridgway's rails nesting habitat, in-stream work will not begin before September 1. These requirements typically do not apply to clearing and revegetation work.

Preconstruction surveys will be conducted for birds, bats, and special status species. Ridgways' rails are known to forage in the vicinity. The pickleweed in the around the stilling basin is considered potential habitat for the salt marsh harvest mouse, so the vegetation will be removed by hand before heavy equipment begins work in that area. It is unlikely that nesting birds use the trees that will be removed at the site. If pre-construction surveys confirm no nesting, tree removal will begin in mid-August.

All of the vegetation salvage and salt marsh harvest mouse exclusion fencing will be installed as part of pre-construction activities.

9.2.2 Dewatering Plan

The dewatering plan includes measures to protect aquatic species including by rescue and relocation. It is in Appendix 1.

9.2.3 Mitigation Monitoring and Reporting Plan

A Mitigation Monitoring and Reporting Plan (MMRP), which includes the measures to protect non-aquatic sensitive species, is in Appendix 2.

9.3 Construction Sequence

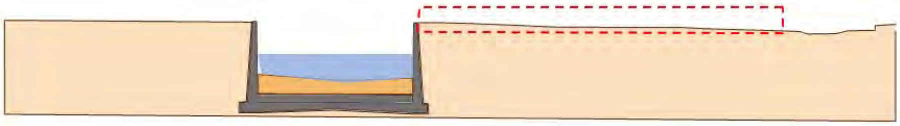
Construction should be implemented to minimize the duration of creek dewatering. It is anticipated to have a sequence similar to the following with some sequence items concurrent with others:

1. Construction access and staging area preparation. Install signage and other construction access safety measures and construction security fencing. Install erosion control, tree protection, environmental exclusion area BMPs.
2. Pre-dewatering: salvage wetland vegetation by hand in work area. Remove and stockpile for reuse portion of the rip-rap from right (west) side of channel.
3. Pre-dewatering: demolition and tree removal right side of channel.
4. Pre-dewatering: Begin excavation and selective stockpiling or off-haul of materials for rough grading on right side of channel.
5. Dewater creek and implement species rescue and relocation.
6. Taper- and horizontal-cut and off-haul to recycle right concrete channel wall.
7. Install temporary clean fill crossing from right to left side of channel.
8. Taper- and horizontal cut and off-haul to recycle left concrete channel wall.
9. Demolition, grading and liquefiable sands remediation on the left side of the channel.
10. Finish horizontal-cut left and right channel wall tops, complete rip-rap removal from right and left side of channel and reuse to install buried rip-rap bench and subtidal rip-rap slope.
11. Install boulder-anchored large wood slope erosion protection on right side of channel using stockpiled remainder salvaged rip-rap for boulder field rock mix to minimize rock import requirements.
12. Finish taper-cut right channel wall top and install live willow vegetated rock-and-fill slope protection adjacent to left bank taper-cut channel wall.
13. Install new retaining wall. Finish taper-cut left channel wall top and install live willow vegetated rock-and-fill slope protection and grouted cobble slope protection between left wall and new wall. Install cable-railing along taper-cut walls. Install vest-pocket park improvements.
14. Finish grade restored left bank slope, and install channel restoration contoured fill, and complete finished grading, soil amendment, erosion control blanket and mat installation on the left bank, removing the fill channel crossing and eliminating equipment access to the left bank in the process.
15. Install new storm drain facilities on right bank and detail finished grade of boulder rock field mix at storm drain outfalls for energy dissipation.
16. Complete finished grading, soil amendment, erosion control blanket and mat installation on the right bank.

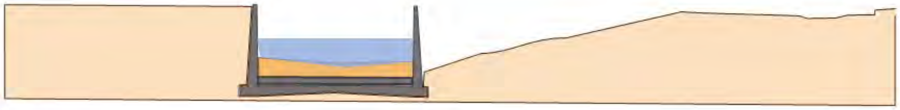
17. Rewater the reach.
18. Install fencing, gates, and other access and security improvements.
19. Install vegetation.

Figure 9.1
Construction Sequence Diagram.

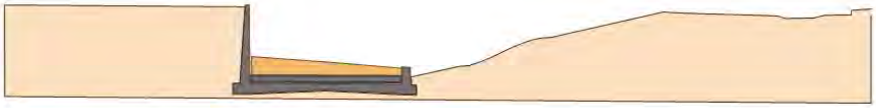
3. DEMOLITION AND TREE REMOVAL RIGHT SIDE OF CHANNEL.



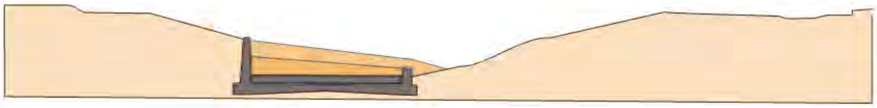
4. EXCAVATION AND SELECTIVE STOCKPILING OR OFF-HAUL OF MATERIALS FOR ROUGH GRADING ON RIGHT SIDE OF CHANNEL.



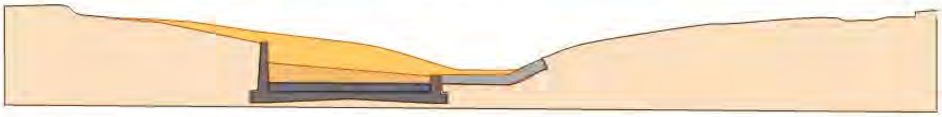
5. DEWATER CREEKAND IMPLEMENT SPECIES RESCUE AND RELOCATION.
6. TAPER- AND HORIZONTAL-CUT AND OFF-HAULT O RECYCLE RIGHT CONCRETE CHANNEL WALL.



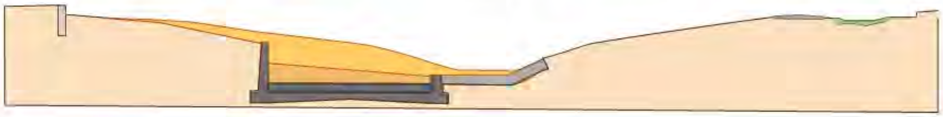
7. INSTALL TEMPORARY CLEAN FILL CROSSING FROM RIGHT TO LEFT SIDE OF CHANNEL.
8. TAPER- AND HORIZONTAL-CUT AND OFFHAUL TO RECYCLE LEFT CONCRETE CHANNEL WALL.



10. FINISH HORIZONTAL-CUT LEFT AND RIGHT CHANNEL WALL TOPS, COMPLEE RIP-RAP REMOVAL FROM RIGHT AND LEFT SIDE OF CHANNEL TO REUSE TO INSTALL BURIED RIP-RAP BENCH AND SUB-TIDAL RIP-RAP SLOPE.
13. MITIGATE LIQUEFIABLE SSANDS, FINISH GRADE RESTORED LEFT BANK SLOPE INCLUDING INSTALLING CHANNEL RETORATION CONTOURED FILL.



13. INSTALL NEW RETAINING WALL. FINISH TAPER-CUT WALL TOP AND INSTALL SLOPE PROTECTION BETWEEN LEFT BANK WAL AND NEW WALL. INSTALL CABLE-RAILINGS ALONG FINISHED TAPER CUT WALL TOPS.
14 -17. COMPLETE GRADING, CHANNEL RESTORATION CONTOURED FILL PLACEMENT, SURFACE AND DRAINAGE IMPROVEMENTS, EROSION CONTROL FABRIC INSTALLATION, AND REWATER REACH.



9.4 Construction Staging and Access

The 100% design plans show an overview of the planned construction access and staging areas at sheet C19. Main staging areas will be on-site and using the west earthen channel berm extending downstream (south) from the construction entrance near the Tamalpais—Murphy Creek culverts.

Access to the Lower COM site would occur from College Avenue through COM Parking Lot 12 and then on a paved route running immediately north from the soccer field/track facility following the existing District easement along the Tamalpais—Murphy Creek Culverts (sheet C32). The access enters near the southwest corner of the project area via an existing 20-foot-wide gate on relatively flat grade onto and over the west earthen channel levee. From past experience reported by an experienced construction contractor, it appears that the paved surfaces provide sufficient capacity to support legal AASHTO truck loads.

9.5 Construction Material Requirements

If there is a need to import topsoil or soil amendments, they will come from approved sources. Although there is some information from geotechnical borings (see boring map at sheet C31 and Geotechnical Investigation in Appendix 4) indicating that natural alluvial soils will be exposed in situ at the design bank restoration grades, the need for import materials and potential sources is not fully understood. It will be further evaluated as the Project design progresses into construction and according to the selected Contractor's means and methods, approved submittals, and review and approval by the Construction Manager and other Owner representatives. Factors will include proximity to the Lower COM site, material suitability, and production capacity.

The 100% design plans show 9,200 square feet of exposed rip-rap rock slope protection to be removed and reused as salvage on site. The actual surface area, including areas covered by sediment and vegetation, and depth of the RSP for removal and salvage is unknown. Therefore, the extent to which the remainder of the salvaged RSP after construction of the buried rip-rap bench and sub-tidal rip-rap slope, which can be used to fill out the Boulder-Anchored Large Wood Slope Protection areas of Boulder Field Rock Mix is not known.

Rock must be imported for the 2-ton anchor boulders and field boulders for Anchored Large Wood Slope Protection and the 1-ton and ¼-ton boulders for the Vegetated Rock-and-Fill Slope Protection areas, as well as river-run cobble, Class 2 Perm, 6" minus and 3" minus rock materials shown in the Drawings.

Large wood materials imported.

Contractor shall submit a Rock and Wood Handling plan and materials samples for review and approval by Construction Manager.

10 Limitations

This design basis report was prepared by Geomorph Design Group in conjunction with MPEG, Stetson, and PCI for the exclusive use of Friends of Corte Madera Creek Watershed, Coastal Conservancy, and the Marin County Flood Control and Water Conservation District for the planned Lower COM Corte Madera Creek Restoration Project. This report was prepared as documentation support for the 100% design of the project, environmental permit review, stakeholder outreach, and planning-level cost estimation. Please see Appendix 4 for expressed limitations of the Geotechnical Investigation performed for advising development of this 100% design.

11 References

A3GEO, Geotechnical Investigation Report, College of Marin Maintenance and Operations Complex, Marin County, California, dated July 21, 2017.

AECOM. 2016. San Francisco Bay Tidal Datums and Extreme Tides Study. Final Report. Prepared for/funded by Federal Emergency Management Agency and the San Francisco Bay Conservation and Development Commission. February 2016.

American Society of Civil Engineers (ASCE) (2016), “Minimum Design Loads for Buildings and Other Structures” (2016 ASCE-7), Structural Engineering Institute of the American Society of Civil Engineers.

American Concrete Institute, “318-14: Building Code Requirements for Structural Concrete and Commentary”.

American Society for Testing and Materials, (2019) “2019 Annual Book of ASTM Standards, Section 4, Construction, Volume 4.08, Soil and Rock; Dimension Stone; Geosynthetics,” ASTM, Philadelphia.

Brown & Caldwell, Geotechnical Engineering Investigation Report, Kentfield Force Main Replacement Project, Marin County, California, dated February 2010.

California Building Code, 2019 Edition, California Building Standards Commission/International Conference of Building Officials, Whittier, California.

California Department of Transportation (Caltrans) (2018), 2018 Standard Specifications.

California Department of Transportation (Caltrans) (2018), Highway Design Manual.

California Department of Transportation (Caltrans) Division of Engineering Services, Materials Engineering and Testing Services, Corrosion and Structural Concrete, Field Investigation Branch, “Corrosion Guidelines, Version 2.0”, November 2012.

California Division of Mines and Geology, “Geology of the Eastern Part of the San Rafael Area, Marin County, California." California Department of Mines and Geology, (Scale 1:12,000)”, 1976.

California Natural Resources Agency. 2017. State of California Sea Level Rise Guidance: 2018 Update (November 2017)

Fischenich, Craig. (2001). Stability Thresholds for Stream Restoration Materials. 11.

"GeoStudio 2019." GEOSLOPE, www.geoslope.com/products/geostudio.

"Guidance to Minimize *Phytophthora* Contamination in Restoration Projects" (Working Group for Phytophthoras in Native Habitats, 2016), available at: http://www.suddenoakdeath.org/wp-content/uploads/2016/04/Restoration_guidance_FINAL-111716.pdf.

Harding Miller Lawson & Associates, *Soil Engineering Services, College of Marin Athletic Field, Kentfield, California,* dated March 15, 1968.

Idriss, I.M. & Boulanger, R.W. "Soil Liquefaction during Earthquakes", Earthquake Engineering Research Institute Monograph 12, 2008.

Idriss, I.M. & Boulanger, R.W. "SPT-Based Liquefaction Triggering Procedures" Department of Civil and Environmental Engineering, College of Engineering, University of California at Davis, UCD/GCM-10/02, December 2010.

NRC (National Research Council). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Prepared by the Committee on Sea Level Rise in California, Oregon, and Washington and the National Research Council Board on Earth Sciences and Resources and Ocean Studies Board Division on Earth and Life Studies.

Occupational Safety and Health Administration (OSHA)(2005), Title 29 Code of Federal Regulations, Part 1926 (www.OSHA.gov).

Smith et al., 1976, Geology of the Upper Ross Valley and the Western Part of the San Rafael Area, Marin County, California: California Geological Survey OFR 76-2.

Stetson, 2017a. Documentation of Ross Valley HEC-RAS v5.0 1D/2D Unsteady-State Hydraulic Model. August 7, 2017.

List of Appendices

Appendix 1. Dewatering Plan. (Friends of Corte Madera Creek, November 27, 2020)

Appendix 2. Mitigation Monitoring and Reporting Plan (MMRP) (Friends of Corte Madera Creek, November 22, 2020)

Appendix 3. Boundary Survey Map (Oberkamper Associates, January 2020)

Appendix 4. Geotechnical Investigation Lower Corte Madera Concrete Channel (Miller-Pacific Engineering Group, December 2021)

Appendix 5. Draft Hydraulic Analysis Report for the 65% Design (Stetson Engineers, December 2020)

Appendix 6. Alternatives Analysis for Lower COM Creek Restoration Project (Geomorph Design, August 2021)

Appendix 7. Final Hydraulic Analysis Report (Stetson Engineers, February 2022)

Lower COM Corte Madera Creek Restoration Project Dewatering Plan

November 27, 2020

The purpose of the Lower College of Marin (Lower COM) Corte Madera Creek Restoration Project (project) is to (1) restore as much natural functioning aquatic, tidal, transitional, and riparian upland habitat as possible within site constraints, in a manner that is adaptive to future sea level rise (SLR) and (2) accommodate floodwater delivered to the channel and convey it downstream of the concrete channel where there is adequate capacity.

Purpose of this Plan

To ensure potential impacts to aquatic species are avoided or minimized, they will be protected in accordance with this Dewatering Plan. Project activities will require 650 feet of the creek to be dewatered and aquatic species relocated out of the in-stream work area. A qualified biologist, as described in the paragraph *Qualified Biologist*, will implement the plan. This project will operate under U.S. Army Corps of Engineers (USACE) Clean Water Act §404 compliance, USACE Section §408 compliance for modification of an existing USACE structure, §1602 Streambed Alteration Agreement from the California Department of Fish and Wildlife (CDFW), and §401 Certification from the San Francisco Bay Regional Water Quality Control Board (RWQCB). The USACE will consult with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) as part of the permit process.

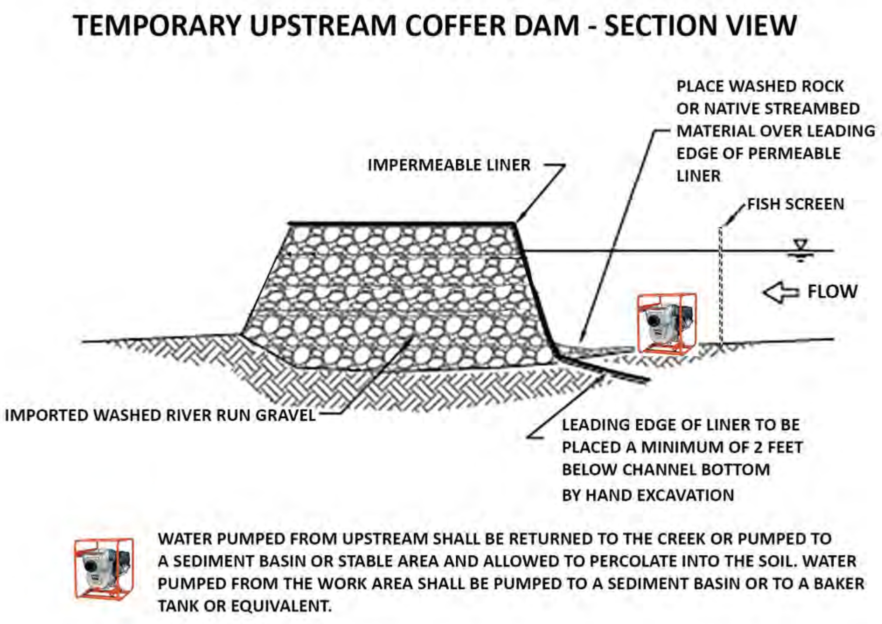
Stages of Construction

To avoid the discharge of sediment-laden water into Corte Madera Creek during construction, the work will take place during summer/fall low flow conditions. Construction is planned for the following stages:

1. Remove most of the soil behind the concrete wall on the right side of the creek (use temporary supports for the wall as necessary)
2. Install fish screens and remove fish from the project area (see below for a description of fish protection measures)
3. When fish removal is near completion, install coffer dams upstream and downstream of the work area
4. Dewater work area and complete fish removal
5. Remove a portion of the right wall to allow construction of a temporary dirt ramp across the creek to provide access for earthmoving equipment to the left bank
6. Remove the downstream section of the left wall and regrade the left bank, hauling material across the dewatered creek; no work will take place in the creek channel other than that necessary to reach the left bank
7. Remove dirt ramp and the remainder of the right wall; regrade the right bank
8. Remove the coffer dams
9. Install plants in fall and winter following construction

Upstream Coffer Dam: Large sandbags (aka super sacks: https://megasack.com/ or similar), filled with off-site gravel and/or sand will be used to construct a coffer dam in the concrete channel upstream of Stadium Way, near the upstream end of the project site (Figure 1). The upstream end of the upstream coffer dam will be reinforced with thick plastic sheeting to act as an additional barrier for water and fish traveling downstream. Water from upstream will be pumped around the work area and back into the creek or onto a stable area and allowed to infiltrate or pumped to the creek below the work area.

Figure 1: Sample coffer dam design


TEMPORARY UPSTREAM COFFER DAM - SECTION VIEW

WATER PUMPED FROM UPSTREAM SHALL BE RETURNED TO THE CREEK OR PUMPED TO A SEDIMENT BASIN OR STABLE AREA AND ALLOWED TO PERCOLATE INTO THE SOIL. WATER PUMPED FROM THE WORK AREA SHALL BE PUMPED TO A SEDIMENT BASIN OR TO A BAKER TANK OR EQUIVALENT.

Downstream Coffer Dam: Tides ranging over several feet reach into the work area from downstream and sandbags are not appropriate. Sheet piles will be installed with a silent, reaction-based hydraulic pile machine (aka Giken Silent Piler https://www.giken.com/en/products/silent_piler/ or similar) across the outer edges of the downstream work areas that will need to be dewatered, leaving an opening in the center that can be closed with a bladder or more sheet piles when it becomes necessary to dewater the work area by preventing tidal flow from entering it.

In addition to the stream flow diversion around the in-stream project area, a small dewatering basin within the work area will be dug. A sump pump of adequate capacity will be placed at the bottom of the basin to remove subsurface creek flow and keep the work area dry. The pump will be screened in accordance with *Juvenile Fish Screen Criteria for Pump Intakes* developed by (NMFS 1997) and will consist of 3/32-inch screen mesh. The water removed from the basin will be sent to a stilling basin, tank, or other approved device for final clarification prior to being returned to the creek. All silt, sand, and fines removed in the clarification process will be used in the restoration.

A NMFS-authorized biologist will be on site to oversee installation and decommissioning of the water diversion structures and to conduct aquatic species rescue in the in-stream project reach (see *Qualified Biologist* paragraph below). Coffer dams and temporary water diversions will meet all permit requirements. The stream will be returned to its natural flow and bed condition upon project completion.

Throughout project construction, a qualified biologist will make frequent visits to the project area to ensure that no aquatic animals or Ridgway's rails are being impacted by construction activities. The biologist will also monitor to ensure water quality standards are being met and sediment is not entering the watercourse.

Protection of Aquatic Species

To avoid impacts to aquatic species (i.e., steelhead trout, other resident fish), surveys and relocation activities by a qualified biologist will be conducted to avoid disturbance to these species prior to commencing project construction. If found, all species will be relocated as described in *Procedures for Removing Fish and Other Aquatic Species* below. The in-stream project area will also be swept by the qualified biologist periodically during construction to ensure no animals have moved into the area. In addition, proper erosion control and other water quality Best Management Practices (BMPs) will be implemented to avoid sedimentation and disturbance into the creek.

Immediately prior to beginning construction work, a qualified biologist will determine if any fish are present in the project vicinity. An assessment of the site will be fashioned after protocols described in the *California Salmonid Stream Habitat Restoration Manual* (CDFW 2009). The survey will be done at a low tide when the water is very shallow in the project area.

If prior to construction no fish are detected, no additional fish protection measures will be implemented. A qualified biologist will also survey the site periodically during the construction process to ensure fish have not moved into the project area. If fish are observed after construction commences, work will be stopped and appropriate actions taken to safely remove them.

Fish Capture and Relocation: If in-channel work requires dewatering, including for sediment-removal maintenance activities, fish shall be captured and relocated upstream of the project areas to avoid injury and mortality and minimize disturbance. The District shall implement the measures below or whatever more stringent species-preservation and avoidance measures are imposed by resource agencies, including NMFS and CDFW, with jurisdiction over aquatic special-status species.

1. The name(s) and credentials of qualified biologist(s) to act as construction monitors shall be submitted to CDFW and NMFS for approval at least 15 days before construction work begins.
2. Prior to and during the initiation of construction activities, a qualified fisheries biologist (i.e., approved by CDFW and/or NMFS) shall be present during installation and removal of creek-diversion structures.
3. For sites that require flow diversion and exclusion, the work area shall be blocked by placing fine-meshed nets or screens above and below the work area to prevent salmonids from re-entering the work area. To minimize the potential for re-entry, mesh diameter shall not exceed 1/8 inch. The bottom edge of the net or screen shall be secured to the channel bed to prevent fish from passing under the screen. Exclusion screening shall be placed in low-velocity areas to minimize fish impingement against the mesh. Screens shall be checked periodically and cleaned of debris to permit free flow of water.

4. Before removal and relocation on individual fish begins, a qualified fisheries biologist shall identify the most appropriate release location(s). In general, release locations should have water temperatures similar to (<3.6 degrees Fahrenheit difference) the capture location and offer ample habitat (e.g., depth, velocity, cover, connectivity) for released fish and should be selected to minimize the likelihood of reentering the work area or becoming impinged on exclusion nets or screens.
5. The means of capture shall depend on the nature of the work site and shall be selected by a qualified fisheries biologist as authorized by CDFW and NMFS. Complex stream habitat may require the use of electrofishing equipment, whereas in outlet pools, fish and other aquatic species may be captured by pumping down the pool and then seining or dip netting. Electrofishing, if necessary, shall be conducted only by properly trained personnel holding current permits from CDFW and NMFS and following NMFS electrofishing guidelines (NMFS 2000).
6. Initial fish relocation efforts shall be performed several days prior to the scheduled start of construction and continue through cofferdam installation and work-area dewatering activities.
7. Flow diversions and species relocation shall be performed during morning periods. The fisheries biologist shall survey the exclusion screening throughout the diversion effort to verify that no special-status fish, amphibians, or aquatic invertebrates are present. Afternoon pumping activities shall be limited, and pumping shall be suspended when water temperatures exceed 18 degrees Celsius. Water temperatures shall be measured periodically, and flow diversion and species relocation shall be suspended if temperatures exceed the 18-degree limit under NMFS guidelines. Handling of fish shall be minimized. When handling is necessary, personnel shall wet hands or nets before touching them.
8. Prior to translocation, fish that are collected during surveys shall be temporarily held in cool, aerated, shaded water using a five-gallon container with a lid. Overcrowding in containers shall be avoided; at least two containers shall be used, and no more than 25 fish shall be kept in each bucket. Aeration shall be provided with a battery-powered external bubbler. Fish shall be protected from jostling and noise and shall not be removed from the container until the time of release. A thermometer shall be placed in each holding container, and partial water changes shall be conducted as necessary to maintain a stable water temperature. Special-status fish shall not be held more than 30 minutes. No electrofishing should occur when water temperatures are above 18°C or are expected to rise above this temperature prior to concluding the electrofishing survey. In addition, studies by NMFS scientists indicate that no electrofishing should occur in California coastal basins when conductivity is above 350 µS/cm.
9. If fish are abundant, capture shall cease periodically to allow release and minimize the time fish spend in holding containers.
10. Fish shall not be anesthetized or measured. However, they shall be visually identified to species level, and year classes shall be estimated and recorded.
11. Reports on fish-relocation activities shall be submitted to CDFW and NMFS in within two weeks following completion of in-channel operations.

Qualified Biologist

For the purposes of the Marin County – Lower COM Corte Madera Creek Restoration Project:

- A person holding a valid collector's permit for all salmonid species subject to take from NMFS and CDFW; or
- A person with a bachelors or higher degree in fisheries biology, wildlife biology, marine biology, aquatic biology, hydrology, wetland ecology or equivalent other course of study; and 5 or more years of professional experience in fisheries research, management, and/or habitat restoration; and direct participation in 5 or more fish capture and transport events. The name(s) and credentials of qualified biologist(s) to act as construction monitors shall be submitted to CDFW and NMFS for approval at least 15 days before construction work begins.

References Cited

CDFW 2009

California Department of Fish and Wildlife. 2009. *California Salmonid Stream Habitat Restoration Manual*.

NMFS 1997

National Marine Fisheries Service. 1997. *Fish Screening Criteria for Anadromous Salmonids*.

NMFS 2000

National Marine Fisheries Service. 2000. *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.*

Lower COM Corte Madera Creek Restoration Project Mitigation Monitoring and Reporting Plan

November 22, 2020

This Mitigation Monitoring and Reporting Plan (MMRP) references the following reports:

- Final Construction Report, which will document construction, environmental compliance monitoring, and worker training conducted during construction. It will be submitted within three months of the completion of creek restoration.
- Final Restoration Report, which will document site restoration, planting, and worker training done in Year 0. It will be submitted within two months of the completion of planting.
- Implementation and Effectiveness Report, which will include the as-built drawings for the project and the results of water surface elevation measurements.
- Vegetation Monitoring Reports, which will document surveys conducted annually for five years beginning October 31 in Year 1 (the first the year following completion of construction).

The reports will be submitted to the US Army Corps of Engineers, US Fish and Wildlife Service, California Department of Fish and Wildlife, San Francisco Bay Regional Water Quality Control Board, the S.F. Bay Conservation and Development Commission, Marin County, and College of Marin.

Ultimately, responsibility for implementing the measures in this plan rests with the Marin County Flood Control and Water Conservation District (District). The measures identify specific positions responsible for monitoring and reporting, including the Construction Manager and Qualified Biological Monitors.

The following table lists mitigation measures that deal with erosion, air quality, biological resources, water quality, and cultural resources. Other mitigation measures are included in the MMRP prepared for the EIR prepared for the entire Phase 1 project, of which this is one component.

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
GEOLOGY, GEOPHYSICS, AND SOIL				
GEO-1	An erosion and sedimentation control plan shall be prepared: • The plan shall include the use of silt fences, bale dikes, and other erosion control measures during construction and shall identify the locations of vehicle access routes, equipment staging areas, and stockpile area(s). • Silt fencing shall be installed prior to construction at the outer edge of the tidal marsh habitat prior to construction to limit disturbance to this habitat. The fencing shall be maintained in good working order during the entire construction period. Erosion prevention measures will be installed on all disturbed areas. • The plan shall provide for the appropriate preparation and planting of cut-and-fill slopes as shown in the design plans to control erosion after site preparation. • Erosion control measures and construction Best Management Practices (BMPs) designed to minimize any impacts to vegetation and creek water quality shall be implemented throughout all phases of the project. • If required to maintain a work area free of excess water, other than described in the approved Dewatering Plan for the creek itself, a sump will be installed inside the additional area to be dewatered and the muddy water treated to reduce turbidity before the water is released to an upland area.	Construction Manager	Before and during construction	Construction Manager will ensure preparation of sedimentation control plan and verify compliance. Bid documents will describe requirements. Final Construction Report will document compliance.
GEO-2	A seventy-two-hour weather forecast from the National Weather Service shall be consulted prior to startup of any phase of the project and no phase of the project may be started if that phase cannot be completed prior to the onset of a storm event.	Construction Manager	During construction	Compliance documented in Final Construction Report
GEO-3	The disturbance or removal of sediment or vegetation shall not exceed the minimum necessary to complete the project. All exposed/disturbed upland areas on the project site shall be planted in accordance with the design plans.	Construction Manager	During construction	Compliance documented in Final Construction Report

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
WATER				
HYD-1	• Vehicle staging, cleaning, maintenance, refueling, and fuel storage will be located 150 feet or more from any water body or wetland. If an action cannot meet this 150-foot requirement, additional BMPs may be required and will be described for each action. • A hazardous spill plan will be developed prior to construction beginning. The plan will describe what actions will be taken in the event of a spill. The plan will also incorporate preventive measures to be implemented, such as the placement of refueling facilities, storage, and handling of hazardous materials, etc. • Equipment will be refueled only in the staging area. Fuel absorbent mats will be used when refueling equipment. • No equipment will enter open water or a flowing channel except for the materials and equipment (i.e. Silent Piler™ or similar) necessary to install the downstream coffer dam. • Machinery and implements used during the project will be in good repair, free of excessive leaks and steam cleaned off-site prior to entering the work area. Fluid leaks will either be repaired or contained within a suitable waste collection device (e.g., drip pads, drip pans). When changing hydraulic lines, care will be taken to keep hydraulic fluid from entering a water body or soils. • There will be no debris introduction into the channels, wetlands, or environmentally sensitive areas from project work. The project site will be maintained trash-free and food refuse will be contained in secure bins and removed daily. • A supply of emergency spill materials will be on hand at the project site. • Vehicles traveling on access ways and in the project area will travel at speeds no greater than 10 mph to minimize noise and dust. • All equipment operators shall be educated in the avoidance of working in areas with invasive non-native plants to prevent the spread of weeds.	Construction Manager	Before and during construction	Construction Manager will ensure preparation of hazardous spill plan and verify compliance. Bid documents will describe requirements. Final Construction Report will document compliance.

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
AIR QUALITY				
AQ-1	The project will implement mitigation measures for dust control required by the Marin County Department of Public Works. These measures include routinely watering graded surfaces as needed to prevent dust blowing, covering and/or watering trucks carrying soil, and frequently cleaning soil carried by construction vehicle tires from the site onto roads.	Construction Manager	During construction	Compliance documented in Final Construction Report
BIOLOGICAL RESOURCES				
BIO-1	No work on the project requiring heavy equipment will occur during the rail breeding season (February 1—August 31).	Construction Manager	During construction and planting	Compliance documented in Final Construction Report
BIO-2	Any work in vegetated portions of the marsh will follow the US Fish and Wildlife Service's protocols described in Walking in the Marsh.	Qualified Biological Monitor	During construction and planting	Compliance documented in Final Construction Report
BIO-3	To avoid the loss of individual Ridgway's rails, when so directed by the Biological Monitor, activities immediately adjacent to the marsh edge will not occur when the marsh plain is inundated, because protective cover for rails is limited and activities could prevent them from reaching available cover. This is typically within two hours before or after extreme high tides (6.0 feet National Geodetic Vertical Datum [NGVD]) or above, as measured at the nearest tidal station at Corte Madera Creek).	Construction Manager; Qualified Biological Monitor	During construction and planting	Compliance documented in Final Construction Report
BIO-4.	Injured Ridgway's rails shall be cared for by a licensed veterinarian or other qualified person, such as the Qualified Biological Monitor. Dead individuals shall be preserved according to standard museum techniques and held in a secure location. USFWS and CDFG shall be notified within one working day of the discovery of the death or injury of a listed species.	Qualified Biological Monitor	During construction and planting	Compliance documented in Final Construction Report
BIO-5	Prior to initiation of project work in potential salt marsh harvest mouse habitat, areas and pathways to be affected will be flagged by construction personnel and verified by a Qualified Biological Monitor (including work areas, staging areas, and access roads/paths to these work and staging areas). The flagged areas(s) will include a two-foot perimeter buffer.	Construction Manager; Qualified Biological Monitor	Before construction	Compliance documented in Final Construction Report.

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
BIO-6	All wetland vegetation and other vegetation within 50 feet of wetland vegetation requiring removal will be removed under the supervision of the USFWS and CDFW-approved Qualified Biological Monitor. Wetland vegetation will be salvaged and maintained on-site and will be replanted upon completion of construction activities. Vegetation removal shall start at the edge farthest from the salt marsh or the poorest habitat and work its way towards the salt marsh or the better salt marsh habitat. If a mouse of any species is observed within the areas being removed of vegetation, work shall be halted and the USFWS and CDFW shall be notified.	Qualified Biological Monitor	Before construction	Compliance documented in Final Construction Report.
BIO-7	To prevent salt marsh harvest mice from moving through the project site during construction, temporary exclusion fencing will be placed around defined work area(s) identified by the Qualified Biological Monitor prior to the start of construction activities. The fencing will be installed immediately after vegetation removal, with the two-foot buffer (cleared of vegetation) remaining between fencing and existing vegetation. The fence will consist of silt fencing (or similar material) and will be buried to a minimum depth of two inches so that mice cannot crawl under the fence. Fence height will be at least one foot higher than the highest adjacent vegetation, with a minimum height of two feet. All supports for the exclusion fencing will be placed on the inside of the work area. The fencing will be immediately removed upon project completion.	Construction Manager; Qualified Biological Monitor	Before construction	Compliance documented in Final Construction Report.
BIO-8	Prior to the start of daily construction activities, the Qualified Biological Monitor will inspect the exclusion fencing to ensure that it is functional (e.g., has no rips or tears, and remains buried in the ground). The fenced area(s) will also be inspected to ensure that no mice are trapped there. Any mice suspected to be salt marsh harvest mice that are found along and outside the fence will be closely monitored until they move away from the construction area.	Qualified Biological Monitor	During construction	Compliance documented in Final Construction Report.
BIO-9	To prevent potential entrapment of salt marsh harvest mice in work equipment, pipes or similar objects located in salt marsh harvest mouse habitat will be capped prior to the end of the workday and then inspected by the biological monitor prior to commencement of work activities the following day.	Qualified Biological Monitor	During construction	Compliance documented in Final Construction Report.

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/Reporting Method
BIO-10	Work in or immediately adjacent to vegetated marsh areas, as identified by the Qualified Biological Monitor, will be scheduled to avoid extreme high tides because protective cover for mice is limited at this time. Specifically, no work will occur two hours before or after extreme high tides as directed by the Qualified Biological Monitor for 6.0 feet National Geodetic Vertical Datum (NGVD) or above, as measured at the Golden Gate Bridge, or adjusted to the timing of local extreme high tide events in which the marsh plain is flooded.	Construction Manager; Qualified Biological Monitor	During construction	Compliance documented in Final Construction Report.
BIO-11	Injured salt marsh harvest mice shall be cared for by a licensed veterinarian or other qualified person, such as the Qualified Biological Monitor. Dead individuals shall be preserved according to standard museum techniques and held in a secure location. USFWS and CDFG shall be notified within one working day of the discovery of the death or injury of a listed species.	Qualified Biological Monitor	During construction	Compliance documented in Final Construction Report
BIO-12	No work on the project involving heavy equipment will occur during the breeding bird season (February 1 – August 31).	Qualified Biological Monitor	During construction and planting	Compliance documented in Final Construction and Planting Reports
BIO-13	Prior to the start of in-channel work, or the introduction of machinery into the aquatic portion of the Project Area, a Qualified Biological Monitor will inspect the area to determine if the New Zealand mud snail is present. If the highly invasive snail is found, or similar small snail species are found, specimens will be sent to experts to confirm the identity of the species. Appropriate equipment decontamination and material isolation procedures will be implemented to prevent the spread of the species outside the project area.	Qualified Biological Monitor	During construction and planting	Compliance documented in Final Construction Report
BIO-14	Work in the channel below the level of top-of-bank will be restricted to June 1 through October 31 to correspond with the appropriate work windows for listed fish species.	Construction Manager	During construction	Compliance documented in Final Construction Report

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/Reporting Method
BIO-15	Work will be conducted in isolation from flowing or tidal water except for installation of the cofferdams. Prior to the start of in-stream activities, the work area will be isolated from the main channel by cofferdams (sheet piles pushed into place, not driven), and flowing water will be diverted around the isolated area. Sandbags will be used on the upstream side of the work area.	Construction Manager	Before and during construction	Compliance documented in Final Construction Report
BIO-16	Cofferdam installation will begin during a low tide when the channel has only a minimal amount of water.	Construction Manager	Before construction	Compliance documented in Final Construction Report
BIO-17	A fisheries Qualified Biological Monitor will be onsite during cofferdam installation to ensure no listed fish are trapped in the tidal slough. If a listed fish species is observed within the tidal slough during this inspection, cofferdam installation will cease forl one full tidal cycle to allow the fish to leave on its own accord.	Qualified Biological Monitor	During coffer dam installation	Compliance documented in Final Construction Report
BIO-18	The appropriate USACE, CDFW, BCDC, and RWQCB permits will be obtained to construct the project. Additional avoidance and minimization measures recommended in these permits will be followed to reduce the potential to effect downstream fish habitat.	Marin County	Before construction	Compliance documented in Final Construction Report
BIO-19	All project personnel will receive environmental training from a Qualified Biological Monitor (approved by the USFWS and CDFW) prior to the initiation of any on-site construction work. The training will cover: 1) the natural history, identification and distribution of the salt marsh harvest mouse and California Ridgway's rail; 2) the legal protections of these species and the ramifications for take; 3) circumstances under which these species may be encountered in the course of project work; and 4) avoidance and conservation measures to ensure that no take of these species occurs. The training will also include information on other sensitive wildlife and natural communities that workers might encounter.	Qualified Biological Monitor	Before and during construction as workers are added.	Compliance documented in Final Construction Report.

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/Reporting Method
Bio-20	Prior to construction, the District shall have a qualified botanist conduct botanical surveys according to CDFW protocols (i.e., Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities [CDFW, 2018 or more current]). Surveys shall coincide with the phenological stage during which the potential special-status plant species are identifiable in the field. If no special-status plants or sensitive natural communities are observed during appropriately timed surveys by a qualified botanist, it is assumed the construction activity will have no impact on special-status plants or sensitive natural communities and no further action is required. Immediately preceding construction, the District shall flag or otherwise mark (e.g., stake, fence) areas with special-status plants or sensitive natural communities within the project area for avoidance, including a 10-foot radius buffer. The District also shall identify locations for equipment and personnel-access and materials staging that will minimize disturbance in riparian habitat and coastal brackish marsh. When heavy equipment is required, unintentional soil compaction shall be minimized by using equipment with a greater reach or using low-pressure equipment. If needed, a biological monitor shall be present during construction in areas within a 10-foot buffer of special-status plants to ensure impacts are avoided. If avoidance of any special-status plant is not possible, prior to construction the District shall coordinate with CDFW and/or USFWS to establish procedures for compensatory mitigation.	Qualified Biological Monitor	Before construction	Compliance documented in Final Construction Report

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
CULTURAL RESOURCES				
CR-1	In the event that soils containing shellfish remains are encountered, work should be halted within 50 feet of the discovery until a qualified archaeologist has been retained to inspect the discovery. • If it is determined that additional project related earthmoving will affect a prehistoric archaeological deposit, the project archaeologist shall submit a plan for its evaluation through limited hand excavation to the Marin County Planning Department for approval. • If evaluative testing demonstrates that the area contains a resource eligible for placement on the California Register of Historic Resources (CRHR), a plan for mitigation of impacts to the resource shall be submitted to the planning department for approval before work is allowed to recommence inside the zone described as archaeologically sensitive. • Archaeological mitigation can include additional hand excavation to record and/or retrieve significant archaeological data combined with archaeological monitoring of all subsequent earthmoving inside the archaeological zone to ensure that significant archaeological materials and/or data are recorded or retrieved for analysis. Monitoring also serves to identify and limit damage to human burials and associated grave goods. • In the event of discovery, the Community Development Agency, Planning Division staff shall verify that an archaeological report has been submitted and all construction work has been stopped. In the event that the report indicates that any human remains, artifacts, or other indicators of prehistoric or historic use of the parcel are encountered during site preparation or construction activities on any part of the project site, the Community Development Agency, Planning Division staff shall verify that a registered archaeologist has been retained to assess the site and had submitted a written evaluation to the Agency Director advancing appropriate conditions to protect the site and the resources discovered before work commences on the site.	Community Development Agency, Planning Division	During construction	Archeological Report and Mitigation Plan prepared by registered archaeologist

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
CR-2	Pursuant to Section 7050.5 of the Health and Safety Code, and Section 5097.94 of the Public Resources Code of the State of California in the event of the discovery of human remains during construction, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent remains. The Marin County Coroner shall be notified and shall make a determination as to whether the remains are Native American. If the Coroner determines that the remains are not subject to his/her authority, the Native American Heritage Commission shall be notified to identify descendants of the deceased Native American. If no satisfactory agreement can be reached as to the disposition of the remains pursuant to this State law, then the landowner shall re-inter the human remains and items associated with Native American burials on the property in a location not subject to further subsurface disturbance. If human remains are encountered, County staff shall verify that the County Coroner has been contacted and that all future work is carried out in accordance with Mitigation Measure CR-1.	District	During construction	Archeological Report and Mitigation Plan prepared by registered archaeologist
IMPLEMENTATION MONITORING				
IM-1	As-built drawings will be prepared.	Engineers	After construction	Drawings included in Implementation and Effectiveness Report
IM-2	Planting will be documented.	Qualified Biological Monitor; District	After planting is done	Final Planting Report will document soil replacement and planting done in Year 0.
EFFECTIVENESS MONITORING				
EM-1	Transducers will be installed pre-construction at the upstream end of the project area. Water surface elevation (WSE) will be recorded for at least two years post-construction to document WSE to evaluate the effect of the project on WSE.	District	Before and after construction	Culvert Implementation and Effectiveness Report

MM No.	Mitigation Measure	Monitoring Responsibility	Timing	Monitoring/ Reporting Method
VEGETATION MONITORING				
VM-1	Vegetation in the project areas will be monitored for five years, beginning in the first September after planting. To implement vegetation monitoring, the County will: 1. Evaluate the progress of the restoration compared to similar habitats along the creek. See Table MMRP-1 for specific vegetation criteria. 2. Select representative photo points to show the project area. 3. Conduct surveys to document the percentage of the site revegetated; plant survival, approximate percentage representation of different plant species including undesirable exotic plant species, and a qualitative assessment of plant growth rates, including adjacent transitional and upland habitats. 4. Within the project-affected areas if undesirable exotic plant species coverage is 5 percent or more of their expected zone of growth during the five-year monitoring period, the County shall take corrective action as specified by the agencies issuing approvals. Undesirable exotic species include any upland species and any tidal species listed in the California Invasive Plant Council (Cal-IPC) plant inventory.	District	Annually in September in Years 1 - 5	Annual Vegetation Monitoring Report submitted by October 31
GEOMORPHOLOGY MONITORING				
GM-1	Elevations in the restored areas would be monitored for five years, beginning in the first September after project completion. To implement this monitoring, the County will install erosion pins to document sedimentation and erosion. In channels, two would be placed horizontally on the vertical edges of the channel in the salvage area to document channel widening. Several pins will be placed in restoration areas.	District	Annually in winter in Years 1 - 5	Annual Vegetation Monitoring Report submitted by December 31

Table MMRP-1: Performance Criteria for Tidal Wetland Vegetation

Year	Average Total Plant Cover Compared to Adjacent Reference Site	Average Absolute Cover of Native Species Compared to Adjacent Reference Site	Absolute Cover Undesirable Exotic Species
One	≥10%	≥5%	≤5%
Two	≥20%	≥15%	≤5%
Three	≥35%	≥30%	≤5%
Four	≥55%	≥50%	≤5%
Five	≥80%	≥75%	≤5%

Table MMRP-2: Performance Criteria for Transition Zone and Upland Vegetation

	Average Total Plant Cover Compared to Adjacent Reference Site	Average Absolute Cover of Native Species Compared to Adjacent Reference Site	Absolute Cover Undesirable Exotic Species
One	≥10%	≥5%	≤5%
Two	≥20%	≥10%	≤5%
Three	≥30%	≥25%	≤5%
Four	≥45%	≥40%	≤5%
Five	≥50%	≥45%	≤5%

DATE OF FIELD SURVEY:

JANUARY 17, 2020

LEGEND:

◉	CENTERLINE MONUMENT FOUND PER BOOK 10 OF SURVEYS AT PAGE 13
A.P.N.	ASSESSOR PARCEL NUMBER
— — —	CORTE MADERA CREEK RIGHT OF WAY
— - —	PROPERTY LINE
— - —	CENTER LINE
- - - - - -	TIE LINE
———	EDGE OF WATER PER COUNTY AERIAL
(T)	TOTAL DISTANCE
⊕	CONTROL POINT

CP #	NORTHING	EASTING	ELEVATION	DESCRIPTION
300	2175823.9170'	5971792.0780'	11.47'	60D NAIL SET
302	2175428.0180'	5971818.4350'	11.46'	60D NAIL SET
303	2175688.4180'	5971759.2140'	11.50'	60D NAIL SET
304	2175685.5970'	5971814.8910'	11.66'	60D NAIL SET
305	2175480.2240'	5971909.7920'	11.56'	60D NAIL SET

SURVEYOR'S STATEMENT:

THIS MAP WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND IS BASED UPON A FIELD SURVEY.

DRAFT

SHANE W. RAUCH DATE
PROFESSIONAL LAND SURVEYOR #9471

SURVEYOR'S NOTES:

1. THE CORTE MADERA CREEK RIGHT OF WAY HAS BEEN ESTABLISHED USING FOUND MONUMENTS PER BOOK 10 OF SURVEYS AT PAGE 13.
2. THE COLLEGE OF MARIN BOUNDARY, SHOWN ON THE SOUTHERLY AND NORTHERLY PORTIONS OF THE MAP, WERE ESTABLISHED PER BOOK 8 OF SURVEYS AT PAGE 44.

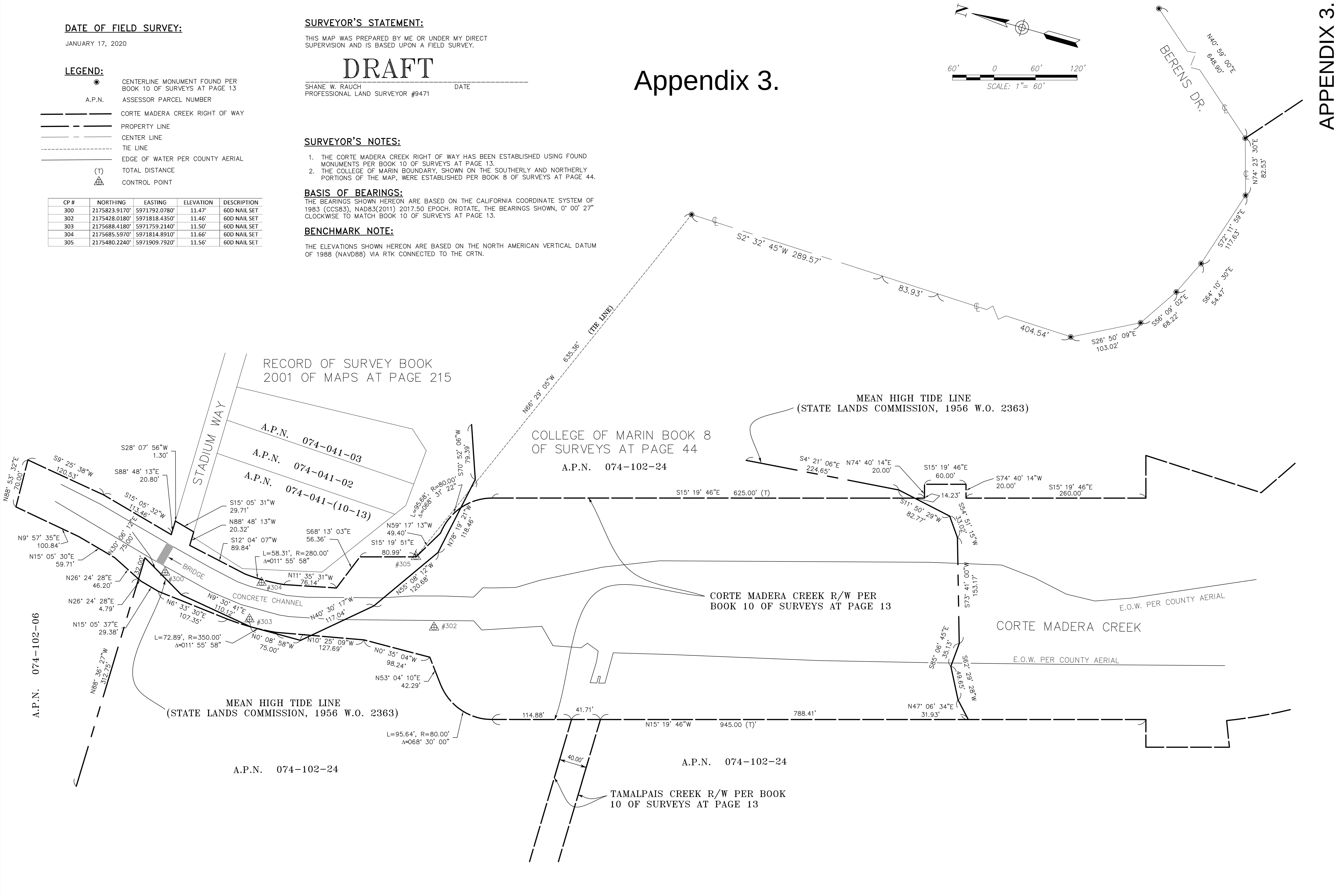
BASIS OF BEARINGS:

THE BEARINGS SHOWN HEREON ARE BASED ON THE CALIFORNIA COORDINATE SYSTEM OF 1983 (CCS83), NAD83(2011) 2017.50 EPOCH. ROTATE, THE BEARINGS SHOWN, 0° 00' 27" CLOCKWISE TO MATCH BOOK 10 OF SURVEYS AT PAGE 13.

BENCHMARK NOTE:

THE ELEVATIONS SHOWN HEREON ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) VIA RTK CONNECTED TO THE CRTN.

Appendix 3.



APPENDIX 3.

OBERKAMPER & ASSOCIATES
CIVIL ENGINEERS INC.
7200 REDWOOD BLVD SUITE 308 NOVATO, CA 94945
PHONE: (415) 897-2800
WWW.OBERKAMPER.COM

CORTE MADREA CREEK CONCRETE CHANNEL
PROJECT ADDRESS (A.P.N. 074-102-24)
CITY OF CORTE MADERA MARIN COUNTY CALIFORNIA

Scale: 1"=60'
Drawn by: OA
Field Crew: SWR / JLS
Checked by: SWR
Date: 1/29/2020

SHEET 1 OF 1

19-181

1
2
3
4
5

MPEG
MILLER PACIFIC
ENGINEERING GROUP

GEOTECHNICAL INVESTIGATION
LOWER CORTE MADERA CREEK CHANNEL
CONCRETE REMOVAL
CORTE MADERA, CALIFORNIA

December 28, 2021

Job No. 2966.001

Prepared For:
Friends of Corte Madera Creek Watershed
Attn: Sandra Guldman
P.O. Box 415
Larkspur, California 94965

CERTIFICATION

This document is an instrument of service, prepared by or under the direction of the undersigned professionals, in accordance with the current ordinary standard of care. The service specifically excludes the investigation of polychlorinated byphenols, radon, asbestos or any other hazardous materials. The document is for the sole use of the client and consultants on this project. No other use is authorized. If the project changes, or more than two years have passed since issuance of this report, the findings and recommendations must be updated.

MILLER PACIFIC ENGINEERING GROUP
(a California corporation)

REVIEWED BY:

SCOTT A. STEPHENS
GE 2398
EXP. 06/30/23

Monica Thornton
Project Engineer

Scott Stephens
Geotechnical Engineer No. 2398
(Expires 6/30/23)

Mailing Address:
P.O. Box 2802
Novato, California 94948-2802

Phone Number: (415) 382-3444
Fax Number: (415) 382-3450

Physical Address:
504 Redwood Blvd., Suite 220
Novato, California 94947

GEOTECHNICAL INVESTIGATION
LOWER CORTE MADERA CREEK CHANNEL
CONCRETE REMOVAL
CORTE MADERA, CALIFORNIA

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 PROJECT DESCRIPTION 1
3.0 SITE CONDITIONS 2
- 3.1 Regional Geology 2
- 3.2 Seismicity 2
  - 3.2.1 Regional Active Faults 3
  - 3.2.2 Historic Fault Activity 3
  - 3.2.3 Probability of Future Earthquakes 3
- 3.3 Surface Conditions 3
- 3.4 Field Exploration and Laboratory Testing 4
- 3.5 Subsurface Conditions and Groundwater 4
- 3.6 Previous Geotechnical Investigations 4

4.0 GEOLOGIC HAZARDS 5
- 4.1 Fault Surface Rupture 5
- 4.2 Seismic Shaking 5
- 4.3 Liquefaction and Related Effects 7
  - 4.3.1 Liquefaction Evaluation 7
  - 4.3.2 Post Liquefaction Settlement 8
- 4.4 Seismic Densification 9
- 4.5 Expansive Soil 9
- 4.6 Settlement 9
- 4.7 Erosion 10
- 4.8 Slope Instability/Landsliding 10
- 4.9 Flooding 11
- 4.10 Tsunami/Seiche 11
- 4.11 Corrosive Soils 12
- 4.12 Hazardous Materials 12

5.0 CONCLUSIONS AND RECOMMENDATIONS 12
- 5.1 Seismic Design 12
- 5.2 Slope Stability Analysis 13
- 5.3 Concrete Channel Removal 13
- 5.4 Creek Bank Stability and Erosion Control 14
- 5.5 Site Grading 14
  - 5.5.1 Excavations 14
  - 5.5.2 Fill Materials 14
  - 5.5.3 Fill Placement and Compaction 15
  - 5.5.4 Slopes 15
- 5.6 Wintertime Construction 15

6.0 SUPPLEMENTAL GEOTECHNICAL SERVICES 16
7.0 LIMITATIONS 16
8.0 LIST OF REFERENCES 17

FIGURE 1: SITE LOCATION MAP
FIGURE 2: SITE PLAN
FIGURE 3: REGIONAL GEOLOGIC MAP
FIGURE 4: ACTIVE FAULT MAP
FIGURE 5: HISTORIC EARTHQUAKE MAP
FIGURE 6: LIQUEFACTION SUSCEPTIBILITY MAP
FIGURE 7: LIQUEFACTION ANALYSIS PLOT
FIGURE 8: FEMA FLOOD MAP
FIGURE 9: TSUNAMI INUNDATION MAP

TABLE 1: ESTIMATED PEAK GROUND ACCELERATIONS FOR PRINCIPAL ACTIVE FAULTS
TABLE 2: PROBABILISTIC PEAK GROUND ACCELERATIONS FOR ACTIVE FAULTS
TABLE 3: 2019 CALIFORNIA BUILDING CODE SEISMIC DESIGN CRITERIA

APPENDIX A: SUBSURFACE EXPLORATION AND LABORATORY TESTING
APPENDIX B: PREVIOUS SUBSURFACE EXPLORATION
APPENDIX C: ENVIRONMENTAL TESTING RESULTS
APPENDIX D: STABILITY ANALYSES

GEOTECHNICAL INVESTIGATION
LOWER CORTE MADERA CREEK CHANNEL
CONCRETE REMOVAL
CORTE MADERA, CALIFORNIA

1.0 INTRODUCTION

This report presents the results of our Geotechnical Investigation for the Lower Corte Madera Creek Channel concrete removal project in Corte Madera, California. The project site is located east of College of Marin, south of Stadium Avenue, and west of a residential development as shown on the Site Location Map, Figure 1.

Our work was performed in accordance with our Agreement for Professional Services dated December 20, 2019. The purpose of our Geotechnical Investigation was to explore subsurface conditions and to develop geotechnical criteria for design and construction of the concrete channel removal project. The scope of our services includes:

- Review of readily available geotechnical and geologic reference materials, including existing reports prepared by other consultants for previous site improvements.
- Exploration of subsurface conditions with four borings located within the general vicinity of the planned improvements.
- Geotechnical laboratory testing to estimate pertinent engineering properties of the soils encountered during our exploration.
- Evaluation of relevant geologic hazards including seismic shaking, settlement, liquefaction, and other hazards.
- Preparing geotechnical recommendations and design criteria for related earthwork, seismic design, and other geotechnical-related items.
- Preparation of this report which summarizes our subsurface exploration and laboratory testing program, evaluation of relevant geologic hazards, and geotechnical recommendations and design criteria.

This report completes our Phase 1 services for the project. Subsequent phases of work may include geotechnical plan review and observation and testing of geotechnical-related work items during construction.

2.0 PROJECT DESCRIPTION

Based on our discussions with the project team, we understand the project includes removing the portions of the concrete flood control channel in Corte Madera Creek, (downstream from the Stadium Way footbridge) to restore the sloped creek bank surfaces supporting intertidal mudflat, low and high marsh tidal wetland, transitional, and upland riparian woodland habitat areas and vegetation communities. This will include removal of the downstream 467 lineal feet to the west bank wall and 156 lineal feet of the east bank wall to restore creek banks to maximize potential habitat restoration. A Site Plan showing existing conditions is presented on Figure 2.

3.0 SITE CONDITIONS

3.1 Regional Geology

The project site lies within the Coast Ranges geomorphic province of California. Regional topography within the Coast Ranges province is characterized by northwest-southeast trending mountain ridges and intervening valleys that parallel the major geologic structures, including the San Andreas Fault System. The province is also generally characterized by abundant landsliding and erosion, owing in part to its typically high levels of precipitation and seismic activity.

The oldest rocks in the region are the sedimentary, igneous, and metamorphic rocks of the Jurassic-Cretaceous age (190- to 65-million years old) Franciscan Complex. Within Marin County, a variety of sedimentary and volcanic rocks of Tertiary (1.8- to 65-million years old) and Quaternary (less than 1.8-million years old) age locally overlie the basement rocks of the Franciscan Complex. Tectonic deformation and erosion during late Tertiary and Quaternary time (the last several million years) formed the prominent coastal ridges and intervening valleys typical of the Coast Ranges province. The youngest geologic units in the region are Quaternary-age (last 1.8 million years) sedimentary deposits, including alluvial deposits which partially fill most of the valleys and colluvial deposits which typically blanket the lower portions of surrounding slopes.

The project site is located on Corte Madera Creek and west of San Pablo Bay. Regional geologic mapping (California Division of Mines and Geology, 1976) indicates the majority of the site is underlain by Bay Mud. Mapping indicates that the commercial and residential developments to the east and west are underlain by artificial fill over Bay Mud. However, the northern end of the site is located close to the hillside and is near a mapped boundary between Bay Mud and sandstone and shale bedrock of Cretaceous age. A Regional Geologic Map and descriptions of the mapped geologic units are shown on Figure 3.

3.2 Seismicity

The project site is located within the seismically active San Francisco Bay Area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the build-up and sudden release of strain along a “fault” or zone of weakness in the earth's crust. Stored energy may be released as soon as it is generated, or it may be accumulated and stored for long periods of time. Individual releases may be so small that they are detected only by sensitive instruments, or they may be violent enough to cause destruction over vast areas.

Faults are seldom single cracks in the earth's crust but are typically composed of localized shear zones which link together to form larger fault zones. Within the Bay Area, faults are concentrated along the San Andreas Fault zone. The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination, and is radiated outward in the form of energy waves. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy becomes a long, high-amplitude motion when moving through soft ground materials, such as Bay Mud.

3.2.1 Regional Active Faults

An "active" fault is one that shows displacement within the last 11,000 years (i.e., Holocene) and has a reported average slip rate greater than 0.1 mm per year. The California Division of Mines and Geology has mapped various active and inactive faults in the region. These faults are shown in relation to the project site on the attached Active Fault Map, Figure 4. The nearest known active faults are the San Andreas, San Gregorio, and Hayward Faults which are located roughly 12.2 kilometers (7.6 miles) west, 13.1 kilometers (8.2 miles) west, and 16.3 kilometers (10.1 miles) east of the site, respectively.

3.2.2 Historic Fault Activity

Numerous earthquakes have occurred in the region within historic times. Earthquakes (magnitude 2.0 and greater) that have occurred in the San Francisco Bay Area since 1985 have been plotted on a map shown on Figure 5.

3.2.3 Probability of Future Earthquakes

The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the "Working Group on California Earthquake Probabilities" (USGS 2003, 2008; Field et al 2015) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3. In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

Conclusions from the most recent UCERF3 and USGS indicate the highest probability of an earthquake with a magnitude greater than 6.7 originating on any of the active faults in the San Francisco Bay region by 2043 is assigned to the Hayward/Rodgers Creek Fault system. The Hayward Fault is located approximately 16.3 kilometers (10.1 miles) east of the site and is assigned a probability of 33 percent. The San Andreas Fault, located approximately 12.2 kilometers (7.6 miles) west of the site, is assigned a 22 percent probability of an earthquake with a magnitude greater than 6.7 by 2043. Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

3.3 Surface Conditions

The site is bordered to the east by a residential development, to the west by College of Marin, to the north by Corte Madera Creek and Stadium Way, and to the south by the wider portion of Corte Madera Creek. The site is relatively flat with surface elevations ranging from about 2 to 5 feet (NAVD 88).

The existing concrete channel in the project area is approximately 400-feet-long with a crest width ranging from about 25 to 30 feet. The channel bottom and side walls are reinforced concrete. The slopes above the concrete channel are relatively flat on both sides of the channel. The slopes are vegetated with grasses, other shrubbery, and trees and biking trails.

3.4 Field Exploration and Laboratory Testing

We explored subsurface conditions near the channel on April 10, 2020 and November 22, 2021 with six borings at the approximate locations shown on Figure 2. The borings were excavated using track-mounted drilling equipment to approximate depths ranging from 21.5 to 29.5 feet below the ground surface. The borings were logged by our Field Engineer and samples were obtained for classification and laboratory testing. We prepared boring logs based on soil descriptions in the field, as well as visual examination and testing of the soil samples in our laboratory. The boring logs are presented in Appendix A.

Geotechnical laboratory testing of soil samples from the exploratory borings included determination of moisture content, dry density, unconfined compressive strength, sieve analyses, the amount of material passing a No. 200 sieve, and Atterberg Limits. The results of our laboratory tests are presented on the boring logs with the exception of the sieve analyses and Atterberg Limits which are presented on Figures A-11 through A-12. Our laboratory testing program is discussed in greater detail in Appendix A.

3.5 Subsurface Conditions and Groundwater

Based on our field exploration and the previous investigations by other consultants, subsurface conditions are consistent with the geologic mapping and consist of artificial fill over Bay Mud and alluvial soils with fill thickness at the boring locations ranging from about 7 to 12 feet.

The fill encountered in the borings is heterogeneous and contains variable amounts of clay, silt, sand, and gravel. While not directly observed, the fill may also contain cobbles, boulders, wood, organic material, and other debris which could not be retrieved within the samples or detected by the relatively small diameter borings. The Bay Mud generally consists of very soft to soft, compressible silty clay of high plasticity, while the deeper alluvial soils consist of a mixture loose to dense sand and gravel and stiff to very stiff silt and clay. The sandstone and siltstone bedrock encountered in the previous explorations is generally described as soft and severely weathered.

Groundwater was encountered during our recent field exploration in borings at about 10- to 13-feet below ground surface. Review of existing geotechnical data further indicates that groundwater was observed at approximate elevations between 5 and 17 feet below the ground surface in the previous borings. Because the borings were not left open for an extended period of time, a stabilized depth to groundwater may not have been observed. Groundwater elevations fluctuate seasonally and with changes in tidal elevations and higher groundwater levels may be present during periods of intense rainfall and/or high tide.

3.6 Previous Geotechnical Investigations

Several subsurface explorations have been conducted by other Consultants as part of the original site development and subsequent improvements. Prior to completing our subsurface exploration, we reviewed the following reports:

- A3GEO, Geotechnical Investigation Report, College of Marin Maintenance and Operations Complex, Marin County, California, dated July 21, 2017.
- Brown & Caldwell, Geotechnical Engineering Investigation Report, Kentfield Force Main Replacement Project, Marin County, California, dated February 2010.
- Harding Miller Lawson & Associates, *Soil Engineering Services, College of Marin Athletic Field, Kentfield, California,* dated March 15, 1968.

The approximate locations of the borings and CPTs from these previous investigations are shown on the Site Plan, Figure 2. The boring logs and laboratory testing from previous investigations are included under Appendix B.

4.0 GEOLOGIC HAZARDS

This section summarizes our review of commonly considered geologic hazards and discusses their potential impacts on the planned improvements. The primary geologic hazards which could affect the proposed development include strong seismic ground shaking, potential liquefaction of the fill soils, settlement due to consolidation of the soft Bay Mud, and high groundwater conditions. Other geologic hazards are judged less than significant with regard to the proposed project. Each significant geologic hazard considered is discussed in further detail in the following paragraphs.

4.1 Fault Surface Rupture

Under the Alquist-Priolo Earthquake Fault Zoning Act, the California Division of Mines and Geology (now known as the California Geological Survey) produced 1:24,000 scale maps showing known active and potentially active faults and defining zones within which special fault studies are required. Based on currently available published geologic information, the site is not located within an Alquist-Priolo Special Studies Zone. We therefore judge the potential for fault surface rupture in the project area to be low.

Evaluation:	*Less than significant.*
Recommendation:	*No mitigation measures are required.*

4.2 Seismic Shaking

The site will likely experience seismic ground shaking similar to other areas in the seismically active Bay Area. The intensity of ground shaking will depend on the characteristics of the causative fault, distance from the fault, the earthquake magnitude and duration, and site-specific geologic conditions. Estimates of peak ground accelerations are based on either deterministic or probabilistic methods.

Deterministic methods use empirical attenuation relations that provide approximate estimates of median peak ground accelerations. A summary of the active faults that could most significantly affect the planning area, their maximum credible magnitude, closest distance to the center of the planning area, probable peak ground accelerations, and 84th percentile peak ground accelerations are summarized in Table 1. The calculated accelerations should only be considered as reasonable estimates. Many factors (e.g., soil conditions, orientation to the fault, etc.) can influence the actual ground surface accelerations.

Table 1 – Estimated Peak Ground Accelerations for Principal Active Faults

Fault	Moment Magnitude for Characteristic Earthquake	Closest Estimated Distance (km)	Median Peak Ground Acceleration (g)^{2,3}	84% Peak Ground Acceleration (g)^{2,3}
San Andreas	8.0	12.2	0.32	0.51
San Gregorio	7.4	13.1	0.29	0.45
Hayward	7.3	16.3	0.25	0.40
Rodgers Creek	7.3	25.5	0.19	0.32
Contra Costa	6.5	34.6	0.11	0.19

1.) Values determined using Google Earth KML Files showing Quaternary Faults & Folds in the US obtained from USGS website September 22, 2020.
2.) Values determined using Vs^{30} = 180 m/s for Site Class "E" ("Soft Soil" Conditions) in accordance with the 2019 CBC and 2016 ASCE-7. See additional discussion regarding Site Class determination and preliminary recommended seismic design criteria in Section 5.1.
3.) Values determined using Pacific Earthquake Engineering Research Center (PEER) NGS-West2 Excel Spreadsheet, http://peer.berkeley.edu/ngawest2/databases/

Probabilistic Seismic Hazard Analysis analyzes all possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults.

We calculated the peak ground acceleration for two separate probabilistic conditions; the 2 percent chance of exceedance in 50 years (2,475-year statistical return period) and the 10 percent chance of exceedance in 50 years (475-year statistical return period). The peak ground acceleration values were calculated utilizing the USGS Unified Hazard Tool (USGS, 2020). The results of the probabilistic analyses are presented below in Table 2.

Table 2 – Probabilistic Peak Ground Accelerations for Active Faults

Probability of Exceedance	Statistical Return Period	Magnitude	Peak Ground Acceleration (g)
2% in 50 years	2,475 years	7.4	0.71
10% in 50 years	475 years	7.3	0.45

Reference: USGS Unified Hazard Tool accessed on September 22, 2020. Site Class E= 180 (ft/sec)

Ground shaking can result in structural failure and collapse of structures or cause non-structural building elements (such as light fixtures, shelves, cornices, etc.) to fall, presenting a hazard to building occupants and contents. Compliance with provisions of the most recent version of the California Building Code (2019 CBC) should result in structures that do not collapse in an earthquake. Damage may still occur, and hazards associated with falling objects or non-structural building elements will remain.

The potential for strong seismic shaking at the project site is high. Due to their proximity and historic rates of activity, the San Andreas and San Gregorio Faults present the highest potential for severe ground shaking. The significant adverse impact associated with strong seismic shaking is potential damage to the creekbank and related improvements.

Evaluation:	*Less than significant with mitigation.*
Recommendation:	*Minimum mitigation includes design of new structures in accordance with the provisions of the 2019 California Building Code or subsequent codes in effect when final design occurs.*

4.3 Liquefaction and Related Effects

Liquefaction refers to the sudden, temporary loss of soil strength during strong ground shaking. The strength loss occurs as a result of the build-up of excess pore water pressures and subsequent reduction of effective stress. While liquefaction most commonly occurs in saturated, loose, granular deposits, recent studies indicate that it can also occur in materials with relatively high fines content provided the fines exhibit lower plasticity. The effects of liquefaction can vary from cyclic softening resulting in limited strain potential to flow failure which cause large settlements and lateral ground movements. Lateral spreading refers to a specific type of liquefaction-induced ground failure characterized primarily by horizontal displacement of surficial soil layers as a consequence of liquefaction of a subsurface granular layer (Youd, 1995). Lateral spreads generally move down gentle slopes or slip toward a free face such as an incised river channel.

As shown on Figure 6, regional liquefaction hazard maps indicate the site is mapped within a zone of very high susceptibility to liquefaction (ABAG Hazard Map, 2020). The results of our subsurface exploration indicate the site is underlain by fill over clayey alluvium which includes localized, loose to medium dense sand deposits encountered from about 5 to 15 feet below ground surface in Boring 1 may be susceptible to loss of soil strength during a seismic event. The sandy soils in our other borings are relatively dense and/or include relatively high percentage of fine-grained soils of moderate plasticity which generally suggests a low risk of susceptibility to liquefaction. The extent and location of sand deposits is expected to be variable and would correlate with former historic creek locations.

4.3.1 Liquefaction Evaluation

To evaluate soil liquefaction, the seismic energy from an earthquake is compared with the ability of the soil to resist pore pressure generation, known as the Cyclic Resistance Ratio (CRR). The earthquake energy is termed the cyclic stress ratio (CSR) and is a function of the maximum considered earthquake peak ground acceleration (PGA) and depth. Soil resistance to liquefaction is based on its relative density, and the amount and plasticity of the fines (silts and clays). The relative density of cohesionless soil is correlated with the Standard Penetration Test (SPT) blow count data measured in the field and corrected for hammer efficiency, overburden, and percent fines to determine the $(N_1)_{60,CS}$ value. Cone Penetration Test data, corrected for overburden, can also be utilized to determine the relative density of a soils and subsequently its resistance to liquefaction.

We analyzed the potential for liquefaction utilizing the data from our borings by the procedures outlined by Idriss and Boulanger (2008 & 2010), considering a magnitude 8.0 earthquake producing a PGA of 0.65-g, which corresponds to the PGA_m value as defined in ASCE 7-16 Section 11.8.3. The results of our liquefaction analyses, including post-liquefaction settlement predictions, are presented on Figure 7. The results indicate localized soil layers at Boring 1 may liquefy under a strong seismic event. Based on the exploration to date, the liquefiable soils were encountered on the east side of the channel in the vicinity of Boring 1 within the upper 15 feet.

4.3.2 Post Liquefaction Settlement

We predicted the amount of post liquefaction settlement utilizing the procedures outlined by Idriss and Boulanger (2008 & 2010), which indicate post liquefaction settlement can occur in soils that exhibit a factor of safety against liquefaction of 2.0 or less. Based on our analyses, we predict up to 5-inches of settlement may occur during the design seismic event.

Additionally, we utilized the procedures outlined by Ozocak and Sert (2010) to calculate the Liquefaction Potential Index (LPI), which is a gauge to determine if liquefiable layers will impact the ground surface. LPI is a function of the thickness, depth, and factor of safety against liquefaction in the individual layers within a soil column. The resulting LPI value corresponds to a relative potential for surface deformation impacting the ground surface. Typically, an LPI value of zero indicates the liquefiable layer will not impact the ground surface; while a value less than 5 has a low probability, value between 5 and 15 have a moderate probability and an LPI value greater than 15 have a high probability of surface impact. The results of our liquefaction analyses for Boring 1, located near the southeast end of the project area, indicate LPI values up to 22. These results suggest a high probability of liquefaction effects at the ground surface near that location.

Based on our calculations, as described above, it is our opinion that liquefaction presents a moderate risk of damage.

Evaluation: *Less than significant with mitigation.*

Mitigation: *The primary area where potentially liquefiable soils were observed is at Boring 1 in the southeastern portion of the project area. Liquefaction-induced ground settlement can damage planned improvements. Mitigation measures may include removal of potential liquefiable sands and replacement with compacted fill materials. Ground improvement (such as grouting), or inclusion of retaining structures with deeper foundations could also be utilized to mitigate liquefaction settlement. In addition to vertical settlements, instability and lateral displacements can occur in areas underlain by liquefiable soils during a strong seismic event. Mitigation measures related to instability and lateral deformations are discussed in Section 4.8.*

4.4 Seismic Densification

Seismic ground shaking can induce settlement of unsaturated, loose, granular soils. Settlement occurs as the loose soil particles rearrange into a denser configuration when subjected to seismic ground shaking. Varying degrees of settlement can occur throughout a deposit, resulting in differential settlement of structures founded on such deposits. Based on our subsurface exploration data, subsurface soils above groundwater level are generally classified as loose to medium dense sands and silts in the fill material. Therefore, the risk of seismic densification is moderate.

Evaluation:	*Less than significant.*
Recommendation:	*Measures may include compaction of the upper portion loose sandy soil as part of the site grading. Considering not structural improvements are planned the risk of a couple inches of seismic induced settlement in the upper portion of the planned creek banks may be acceptable.*

4.5 Expansive Soil

Expansive soils will shrink and swell with fluctuations in moisture content and are capable of exerting significant expansion pressures on building foundations, interior floor slabs and exterior flatwork. Distress from expansive soil movement can include cracking of brittle wall coverings (stucco, plaster, drywall, etc.), racked door and/or window frames, uneven floors, and cracked slabs. Flatwork, pavements, and concrete slabs-on-grade are particularly vulnerable to distress due to their low bearing pressures.

The near-surface soils in the borings are generally characterized as medium dense clayey sands suggesting low expansion potential. Therefore, the risk of expansive soil affecting the proposed improvements is considered low.

Evaluation:	*Less than significant.*
Recommendation:	*No mitigation measures are required.*

4.6 Settlement

Soft to medium stiff clays underlie a majority of the project site and significant settlement can occur if new loads are applied. The rate and magnitude of potential settlements are dependent on the new loads that are applied, the thickness of compressible material, and the inherent compressibility properties of the soft clays. For deep clay deposits, consolidation settlement would be expected to take many decades to complete.

Differential settlements are also possible due to variations in the thickness of compressible clay, variations in new long-term loads (fill thickness) and variations in historic use of the land, i.e., old channels or low points through the site that may have required thicker fills. Considering the planned project involves mostly excavation, and no new significant fills or structural loads are planned, the risk of induced total and differential settlements at the site is low.

Evaluation:	*Less than significant.*
Recommendation:	*Provided no significant new loads are applied to the underlying clays, no mitigation measures are required.*

4.7 Erosion

Sandy soils on most slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated surface water flow. The potential for erosion is increased when established vegetation is disturbed or removed during normal construction activity.

The existing concrete channel is vertical. Most of the creekbank slopes above the channel are vegetated with thick groundcover including ivy, grasses, and other vegetation. Anecdotal evidence suggests no significant active erosion is occurring at the site over the previous few decades but changes in the channel geometry, a fallen tree, especially large flood flows or other conditions can induce new erosion which can then be aggravated by a loss of vegetation cover. Removing the sides of the concrete channel to restore the natural creekbank will expose soils that are susceptible to erosion. Therefore, the risk of erosion affecting the proposed improvements is considered high.

Evaluation:	*Less than significant with mitigation.*
Recommendation:	*Minimum erosion control measures for the project area should include revegetating disturbed ground surfaces and monitoring the area for future erosion. Channel restoration should be carefully designed to reduce channel velocities and eroded areas should be repaired or protected as soon as possible so larger "failures" do not occur. Erosion control measures during and after construction, at a minimum, should conform to the most recent version of the Erosion and Sediment Control Field Manual (California Regional Water Quality Control Board, 2002).*

4.8 Slope Instability/Landsliding

Weak soils and bedrock on moderate to steep slopes can move downslope due to gravity. Slope instability is often initiated or accelerated by soil saturation, groundwater pressure or seismic shaking. Slope movement can vary from slow, shallow soil creep to large, sudden debris flows. Landslides can cause significant damage to structures and improvements. The topography behind the concrete channel is currently relatively flat and the planned grading after wall removal will be sloped at a maximum inclination of 3:1 (horizontal:vertical) with most areas sloped at flatter inclinations.

As discussed further in Section 5.2, our analyses indicate the proposed improvements have adequate factors of safety against instability under static conditions. However, under seismic conditions, the southeastern portion of the project area has a factor of safety against slope instability below 1.0. This is primarily due to the low strength properties associated with the potentially liquefiable sands encountered in Boring 1. Therefore, we evaluated potential seismically induced deformations in accordance with procedures outlined by Bray and Travasarou (Bray & Travasarou, 2007). Based on our calculations, seismic induced deformations of about one to six inches could occur on the east bank near Station 319+17. These estimates are based upon a median displacement of three inches plus or minus one standard deviation. The risk of damage to the planned flood protection improvements is moderate during a seismic event and low during static conditions.

Evaluation:	*Potentially Significant.*
Recommendation:	*If the estimated displacements are not acceptable, mitigation measures could include removing the liquefiable soils and replacing with import fill, ground improvement measures such as grouting to improve the liquefiable soils or installing retaining structures. More detailed discussion of options is presented in Section 5.2.*

4.9 Flooding

As shown on Figure 8, the project site is located within a FEMA 100-year flood zone (ABAG Hazard Map, 2020). Corte Madera Creek is susceptible to flooding during a high rainfall event. Therefore, the risk of damage due to large-scale flooding is moderate to high.

Evaluation:	*Unavoidable significant hazard.*
Recommendation:	*Flooding in the project area is an existing hazard that would need to be address by modification and improvements within the entire watershed area. The planned project will locally improve drainage conditions and would be a small first step in reducing the overall flood hazard. The amount of improvement would need to be determined by others.*

4.10 Tsunami/Seiche

Seiche and tsunamis are short duration, earthquake-generated water waves in large, enclosed bodies of water and the open ocean, respectively. The extent and severity of a seiche would be dependent upon ground motions and fault offset from nearby active faults. As shown on Figure 9, the project site is mapped within a tsunami inundation zone (ABAG Hazard Map, 2020). Therefore, the risk of damage due to seiche/tsunami is moderate.

According to data from the National Oceanic and Atmospheric Administration (NOAA), approximately 77 credible seiches or tsunamis have been recorded or observed within the San Francisco Bay area since 1700. Damage at San Rafael resulted from the 1960 Chile earthquake (Magnitude 9.5) and the 1964 Alaska earthquake (Magnitude 9.2). The 1964 tsunami was the most damaging historic event, with a maximum wave height of 1.22-meters recorded at San Rafael (NOAA 2013b).

There have been eight credible local seiche events observed in San Francisco Bay between 1854 and 1906, six of which are attributed to earthquake activity and two to landslides. The Mare Island earthquake caused the largest seiche with 0.6-meter amplitude waves near Benicia and is attributed to slip on the Rodgers Creek fault. No confirmed seiche has been recorded in San Francisco Bay since 1906. In light of the recorded history of seiche in San Francisco Bay, we judge that the risk of seiche or tsunami in excess of a couple feet is low. Additionally, since the site is in a creek upstream of the bay and open ocean, high velocity tsunami waves are unlikely. A short-term elevated water level would be expected with tsunami or seiche event.

Evaluation:	*Less than significant.*
Recommendation:	*Considering the site will experience seasonal variation in water level and water velocity much higher than seiche or tsunami waves, no mitigation measures are anticipated. If a tsunami or seiche were to occur, creek banks should be inspected, and any damage repaired.*

4.11 Corrosive Soils

Corrosive soil can damage buried metallic structures, cause concrete spalling, and deteriorate rebar reinforcement. The downstream portions of the project site may be subject to tidal waters with high soluble salts that results in soils with high chloride concentrations and low electrical resistivity, each of which are indicators of susceptibility to corrosion. We therefore judge there is a moderate risk of damage to new buried structures improvements and corrosion should be considered during design of the site improvements.

Evaluation:	*Less than significant.*
Recommendation:	*No mitigation measures are required unless buried concrete and steel structures are planned.*

4.12 Hazardous Materials

Environmental testing was performed on a composite sample created from discreet samples from the borings. Composite samples were created from soils in Borings 1, 2, 3, and 4. Samples were collected by drive sampler to acquire undisturbed soil in 2"x6" pre-cleaned and decontaminated brass liners. We transported soil samples along with a chain of custody form to Alpha Analytical Laboratories, Inc. in Petaluma, CA. Samples were tested for heavy metals (CAM 17 metals), TPH (gas, diesel and motor oil), semi-volatile organic compounds and polychlorinated biphenyls (PCBs). Hazardous materials were not detected or were within standard background levels for Marin County. The results of the analytical tests are presented in Appendix C.

Evaluation:	*Less than significant.*
Recommendation:	*No mitigation measures are required.*

5.0 CONCLUSIONS AND RECOMMENDATIONS

We judge that the proposed project is feasible from a geotechnical standpoint. Primary geotechnical considerations include checking to ensure that planned excavation inclinations result in adequate factors of safety restoring the creek banks and riparian zones in a manner that reduces the potential for future erosion and instability. Surface water and groundwater control will be a significant issue during construction.

5.1 Seismic Design

We recommend minimum mitigation of ground shaking to include seismic design per the 2019 California Building Code/ASCE 7-16. The magnitude and character of these ground motions will depend on the particular earthquake and the site response characteristics. Based on the interpreted subsurface conditions and close proximity to the San Andreas, San Gregorio, and Hayward Faults, we recommend the CBC coefficients and site values shown in Table 3 below be used to calculate the design base shear of the new construction.

Based on the subsurface conditions, the project site is classified as a "Site Class E". Additionally, because the S_1 value is greater than 0.20g a site-specific ground motion analysis should be performed per the procedures outlined in ASCE 7-16. However, per ASCE 7-16 Section 11.4.8, a site-specific analysis is not required for structures located on sites classified as "Site Class E" if the Short Period Site Coefficient, F_a, is taken as equal to that of "Site Class C". This exception applies to structures with fundamental periods within the "short-period" range. We should be contacted to perform a site-specific ground motion analysis if it is determined "long-period" accelerations are needed.

Table 3 – 2019 California Building Code Seismic Design Criteria

Parameter	Design Value
Site Class	E
Site Latitude	37.9521°N
Site Longitude	-122.5459°W
Spectral Response (short), S_S	1.500 g
Spectral Response (1-sec), S_1	0.600 g
MCE_G PGA Adjusted, PGA_M	0.648

Reference: USGS US Seismic Design Maps accessed on September 22, 2020.

5.2 Slope Stability Analysis

We performed slope stability analyses in order to evaluate the impact of the proposed grading and improvements. Using the computer program Slide 2 (Rocscience, 2021), we modeled planned conditions on cross sections at Stations 319+17 and 321+50. We estimated engineering properties from laboratory data performed on samples collected during our exploration and reference data. The analyses were performed for both static and pseudo-static (seismic) conditions. For seismic conditions, we evaluated potential displacements using a peak ground acceleration of 0.32 g which was calculated using deterministic methods for a magnitude 8.0 earthquake occurring along the San Andreas Fault at 12.2 kilometers (7.6 miles) west of the site. Our analyses also considered a peak ground acceleration of 0.56 g which was estimated using probabilistic methods with a return period of 950 years.

The results of our stability analyses are summarized in Appendix D. A factor of safety greater than 1.5 is maintained under static conditions as well as under seismic conditions using the deterministic peak ground acceleration of 0.32 g. factor of safety decreases to less than 1.0 under seismic conditions using the 975-year return period in which the peak ground acceleration increases to 0.56 g. As previously discussed, we evaluated potential deformations that could occur under the larger earthquake using methods outlined by Bray and Travasarou. Based on our calculations, seismic induced lateral deformations of about one to six inches could occur on the east side bank near Station 319+17. These estimates are based upon a median displacement of three inches plus or minus one standard deviation.

5.3 Concrete Channel Removal

Complete removal of the channel bottom would require deep excavations, temporary shoring and would reduce scour protection within the channel. Based on our conversations with the design team, we understand the planned creek bed elevation is well above the top of the existing concrete within the channel. Therefore, we recommend leaving the concrete channel bottom in place and saw-cutting the concrete channel walls below the planned new creek bank grades. Leaving the bottom of the concrete channel in place should significantly reduce project costs and will increase the stability of the channel while still allowing the natural slopes to be restored in the upper portions of the channel.

5.4 Creek Bank Stability and Erosion Control

After the top portion of the concrete channel is removed, the creek banks should be graded at inclinations no steeper than 3:1. Special provisions should be considered to reduce the potential for erosion, including measures to revegetate the creek and slow water velocity. Armoring the channel banks with log structures or other “bio-engineering” systems should be considered. As with any active waterway, erosion can occur due to high creek flows, so monitoring of the channel and repairs to damage should be performed as part of “routine” maintenance.

5.5 Site Grading

Relatively significant site grading will be required for construction of the project and will consist primarily of excavation to remove the top portion of the existing concrete channel and construct the embankments. Removal of the concrete channel will require saw cutting and demolition of the existing concrete sidewalls and rebuilding the slopes to allow for more natural creekbanks. Earthwork for the concrete channel removal project and related improvements should be performed in accordance with the following recommendations:

5.5.1 Excavations

Excavations are expected to encounter fill consisting of loose to medium dense sand and gravel and medium stiff to stiff clay over soft Bay Mud. Based on our subsurface exploration and review of site history, the fill is expected to be heterogeneous and may include cobbles, boulders, wood, organic material, and other debris which could not be retrieved within the samples or detected by the relatively small diameter borings.

In unsupported excavations, the sandy and gravelly fill soils will be susceptible to flowing below groundwater and running to fast raveling above groundwater. The clayey fill soils will exhibit firm behavior while the Bay Mud will be susceptible to squeezing. In accordance with OSHA soil type designations, the fill and Bay Mud are considered “Type C” soils whereas the sandstone and shale bedrock are considered “Type A”. Temporary support for excavations should be installed prior to or during excavation to ensure the safety of workers and to reduce the potential for trench failure and damage to surrounding areas.

Based on our subsurface exploration, we judge the majority of site excavation can be performed with typical equipment, such as medium-size excavators. If shale and sandstone bedrock is encountered, these materials often contain inclusions and zones of harder, more resistant rock which may require specialized techniques or equipment to excavate (e.g., jackhammers or hydraulic breakers). Therefore, we recommend inclusion of a line item and clear definition for “hard rock excavation” in the project bid documents. If hard rock is encountered during construction which prohibits excavation to the required depths, we should be consulted to observe conditions and revise our recommendations and/or design criteria as appropriate.

5.5.2 Fill Materials

Unless otherwise recommended by the pipe manufacturer, pipe bedding and embedment materials should consist of well-graded sand with 90 to 100 percent of particles passing the No. 4 sieve, and no more than 5 percent finer than the No. 200 sieve. Provide the minimum bedding thickness beneath the pipe in accordance with the manufacturer’s recommendations (typically 3 to 6 inches).

Fill materials used for structural backfill should consist of non-expansive materials that are free of organic matter, have a Liquid Limit of less than 40 (ASTM D 4318), a Plasticity Index of less than 20 (ASTM D 4318), and have a minimum R-value of 20 (California Test 301). The fill material should contain no more than 50 percent of particles passing a No. 200 sieve and should have a maximum particle size of 4 inches. Some of the onsite fill soils may be suitable for re-use as trench backfill. The Bay Mud is not suitable for use as fill and should be removed from the site.

5.5.3 Fill Placement and Compaction

Fill materials should be moisture conditioned to near the optimum moisture content prior to compaction. Properly moisture conditioned fill materials should subsequently be placed in loose, horizontal lifts of 8 inches-thick or less and uniformly compacted to at least 90 percent relative compaction. In pavement areas, the upper 12 inches of backfill should be compacted to at least 95 percent relative compaction. The maximum dry density and optimum moisture content of fill materials should be determined in accordance with ASTM D1557.

5.5.4 Slopes

Cut slopes into the native soils should be no steeper than 3:1. If possible, flatter slopes should be utilized to improve stability. Compacted fill slopes should be no steeper than 2:1. Rip-rap slopes could be designed at 1.5:1 or flatter inclinations. Fill slopes should be “keyed” several feet into native soil at the toe of the slope.

Temporary (steeper) cut slopes may be required during construction after the top of the concrete channel is removed until embankments are constructed. For planning purposes, these cut slopes in alluvial soils may be designed for an OSHA Type “C” soil profile. Geologic inspection during excavation will be required to verify that the above recommendations are appropriate for the conditions encountered. Even flatter temporary slopes may be needed during the winter and early spring months since high groundwater and loose sandy soils are anticipated.

5.6 Wintertime Construction

While wintertime site work could be considered, from a geotechnical perspective, wet conditions will generally make it much more difficult to maintain a workable site, compact fill, and prevent site erosion. The seasonally high groundwater level will make it difficult to maintain stability of temporary construction slopes in saturated sands and would likely require groundwater pumping to dewater the site and allow construction to occur.

6.0 SUPPLEMENTAL GEOTECHNICAL SERVICES

We must review the plans and specifications when they are nearing completion to confirm that the intent of our recommendations has been incorporated and to provide supplemental recommendations as needed. During construction, we must inspect geotechnical items relating to earthwork. We should observe the excavations, proper moisture conditioning of soils, fill placement and compaction, and other geotechnical-related work items.

7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in Marin County at the time the report was prepared. This report has been prepared for the exclusive use of the project Owner and/or their assignees specifically for this project. No other warranty, expressed or implied, is made. Our evaluations and recommendations are based on the data obtained during our subsurface exploration program and our experience with soils in this geographic area.

8.0 LIST OF REFERENCES

A3GEO, Geotechnical Investigation Report, College of Marin Maintenance and Operations Complex, Marin County, California, dated July 21, 2017.

American Society of Civil Engineers (ASCE) (2016), “Minimum Design Loads for Buildings and Other Structures” (2016 ASCE-7), Structural Engineering Institute of the American Society of Civil Engineers.

American Concrete Institute, “318-14: Building Code Requirements for Structural Concrete and Commentary”.

American Society for Testing and Materials, (2019) “2019 Annual Book of ASTM Standards, Section 4, Construction, Volume 4.08, Soil and Rock; Dimension Stone; Geosynthetics,” ASTM, Philadelphia.

Brown & Caldwell, Geotechnical Engineering Investigation Report, Kentfield Force Main Replacement Project, Marin County, California, dated February 2010.

California Building Code, 2019 Edition, California Building Standards Commission/International Conference of Building Officials, Whittier, California.

California Department of Transportation (Caltrans) (2018), 2018 Standard Specifications.

California Department of Transportation (Caltrans) (2018), Highway Design Manual.

California Department of Transportation (Caltrans) Division of Engineering Services, Materials Engineering and Testing Services, Corrosion and Structural Concrete, Field Investigation Branch, “Corrosion Guidelines, Version 2.0”, November 2012.

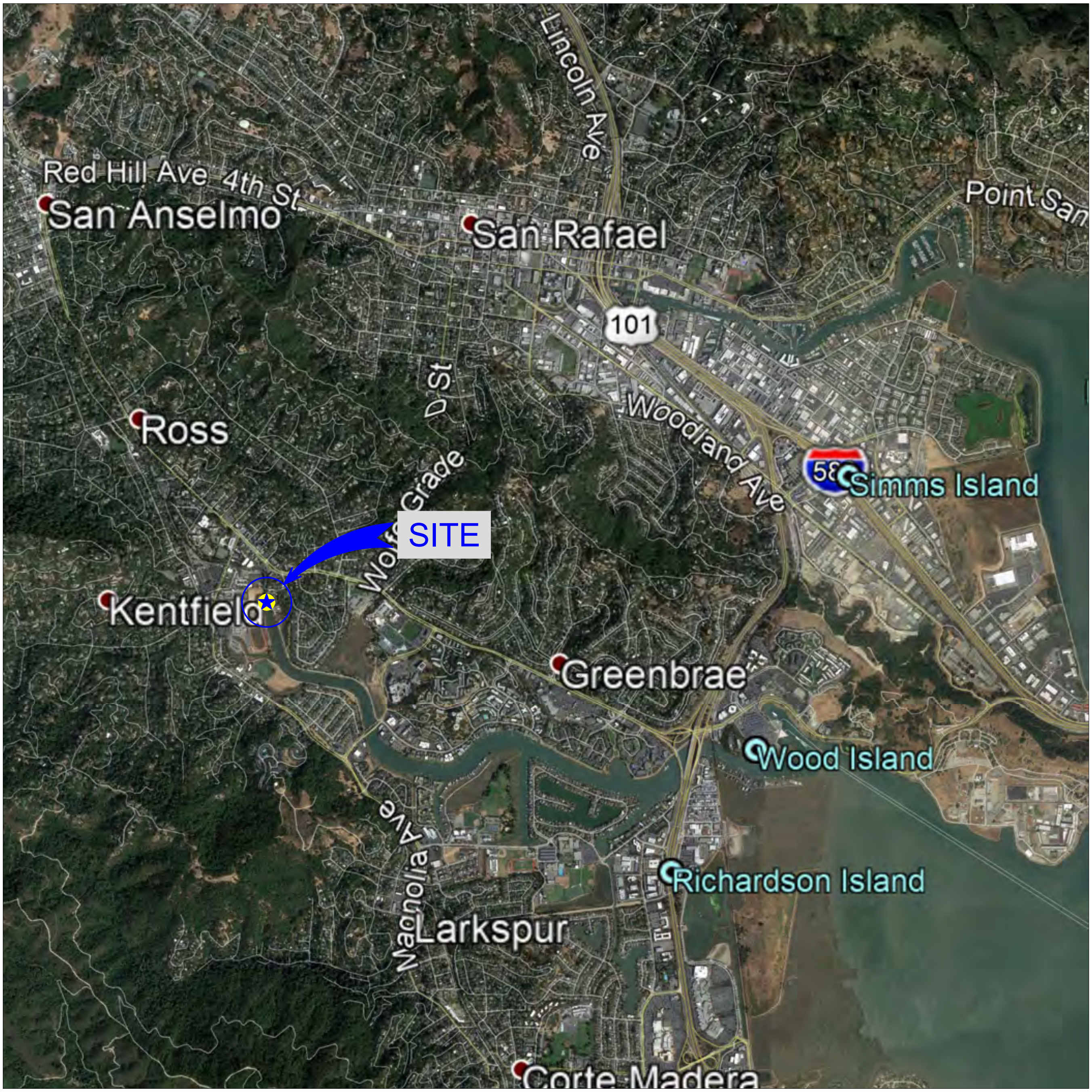
California Division of Mines and Geology, “Geology of the Eastern Part of the San Rafael Area, Marin County, California." California Department of Mines and Geology, (Scale 1:12,000)”, 1976.

Harding Miller Lawson & Associates, *Soil Engineering Services, College of Marin Athletic Field, Kentfield, California,* dated March 15, 1968.

Idriss, I.M. & Boulanger, R.W. “Soil Liquefaction during Earthquakes”, Earthquake Engineering Research Institute Monograph 12, 2008.

Idriss, I.M. & Boulanger, R.W. “SPT-Based Liquefaction Triggering Procedures” Department of Civil and Environmental Engineering, College of Engineering, University of California at Davis, UCD/GCM-10/02, December 2010.

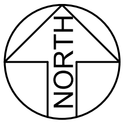
Occupational Safety and Health Administration (OSHA)(2005), Title 29 Code of Federal Regulations, Part 1926 (www.OSHA.gov).



SITE COORDINATES
LAT. 37.9521°
LON. -122.5459°

SITE LOCATION

N.T.S.



REFERENCE: Google Earth, 2020

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

SITE LOCATION MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

1
FIGURE

LEGEND

B-1	BORING LOCATION BY MPEG, 2020
CPT-1	CPT LOCATION BY A3GEO, 2017
B-1	BORING LOCATION BY A3GEO, 2017
CPT-1	CPT LOCATION BY BROWN AND CALDWELL, 2010
B-1	BORING LOCATION BY BROWN AND CALDWELL, 2010
B-1	BORING LOCATION BY UNITED STATES ARMY CORPS OF ENGINEERS, 1965
B-1	BORING LOCATION BY HARDING MILLER LAWSON, 1968

NORTH

SCALE

0 75 150 300 FEET

MPEG MILLER PACIFIC ENGINEERING GROUP

FILE: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

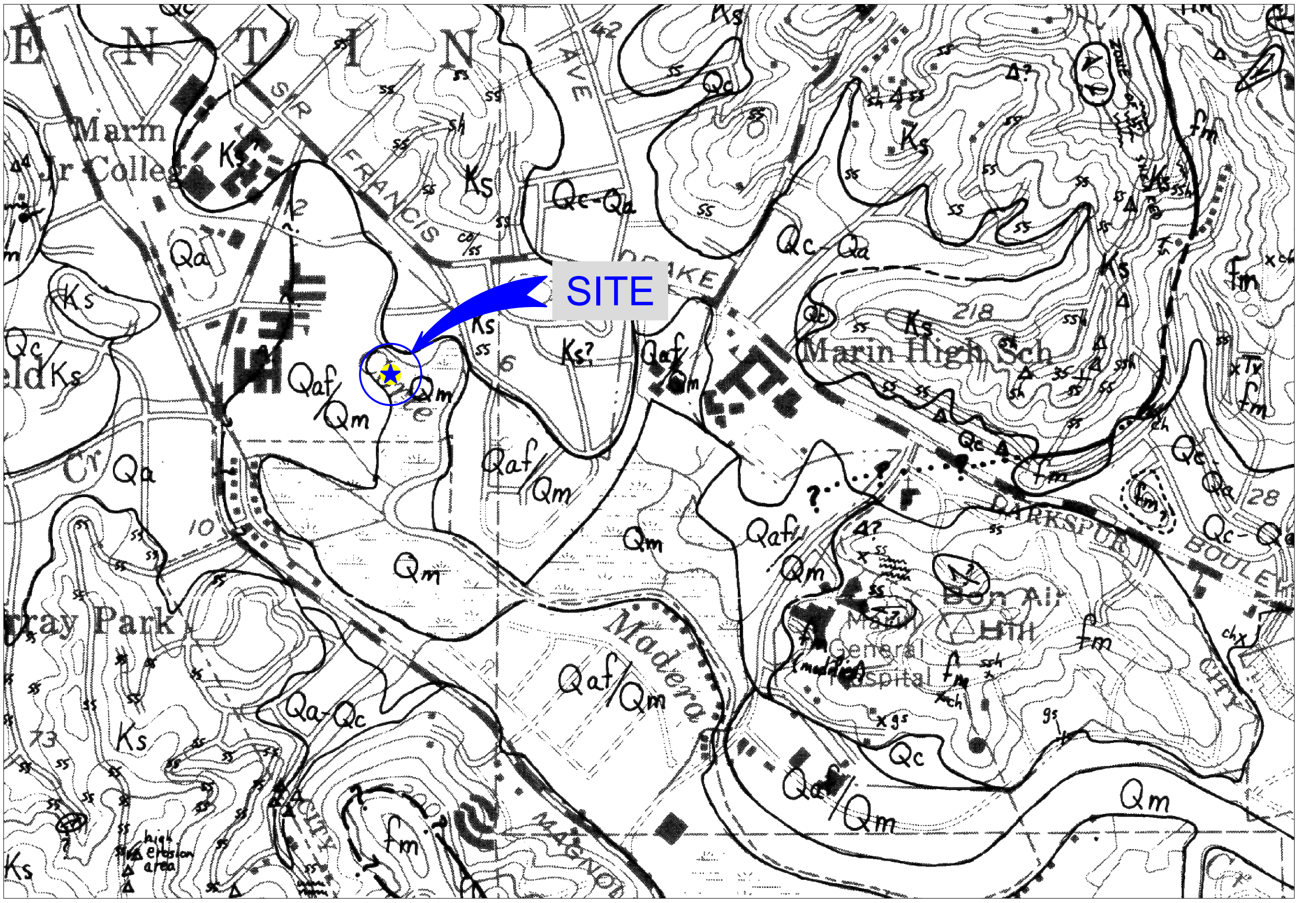
SITE PLAN

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 9/22/2020

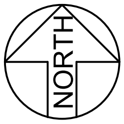
Designed ZMS
Drawn ZMS
Checked SAS

2
FIGURE



REGIONAL GEOLOGIC MAP

(NOT TO SCALE)



LEGEND

Qaf	Artificial Fill (Quaternary) Deposits of rock, soil, or bay mud placed by man upon natural surfaces, mostly for engineering purposes. Highly variable from place to place as to composition, degree of compaction, etc.
Qm	Bay Mud (Quaternary) Marshlands, former marshlands, and mudflats bordering San Francisco and San Pablo Bays. Mostly at or below sea level, these are thick deposits of unconsolidated, low-density, semi-fluid, highly compressible, highly impermeable silty clay.
Ks	Sandstone and Shale (Cretaceous)

REFERENCE: Rice, S.J., Strand, R.G., and Smith, T.C., "Geology of the Eastern Part of the San Rafael Area" *in* Geology for Planning in Central and Southeastern Marin County, California, California Department of Conservation, Division of Mines and Geology Open-File Report 76-2 S.F., Plate 1C, Map Scale 1:12,000

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

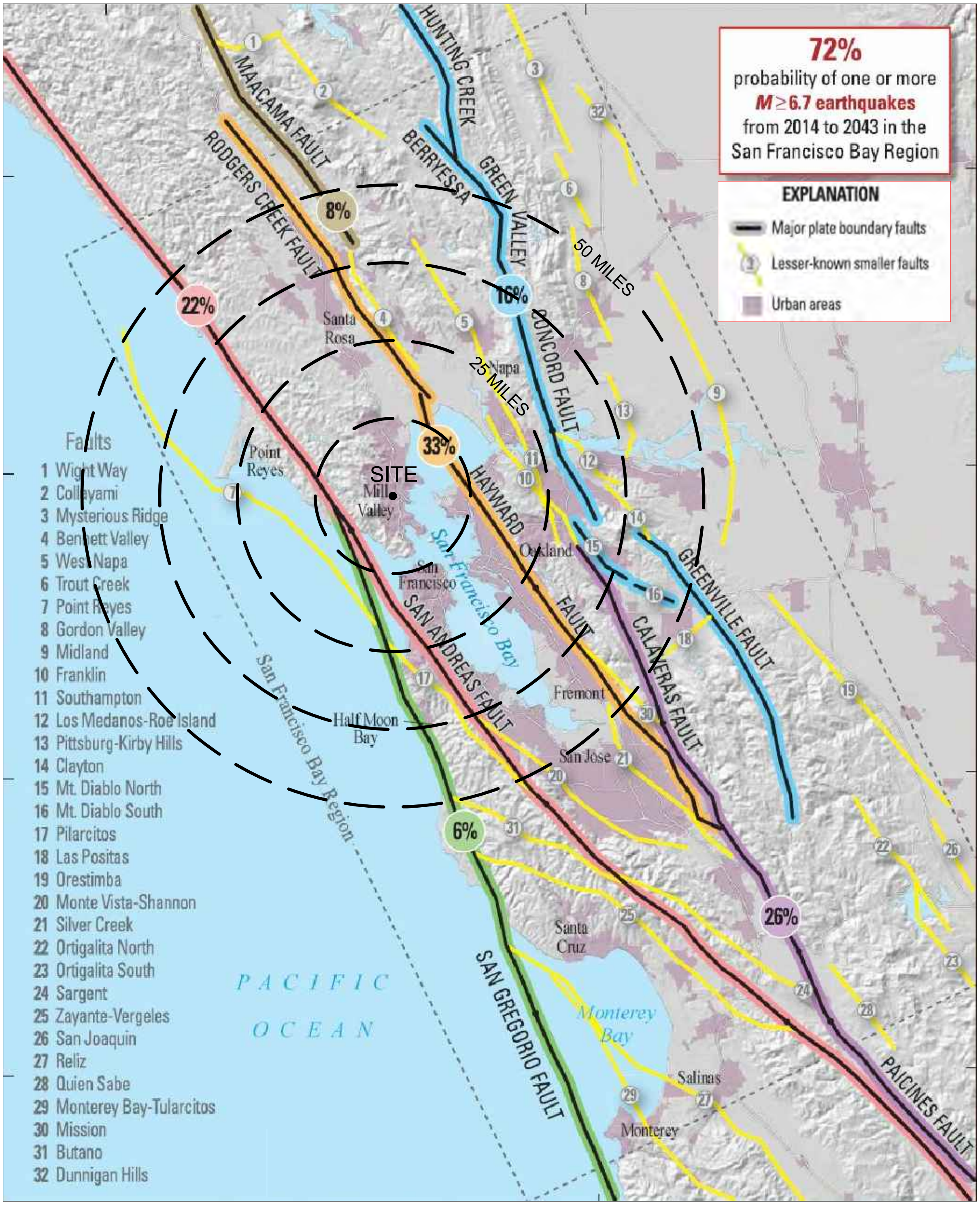
REGIONAL GEOLOGIC MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

3
FIGURE



SITE COORDINATES
LAT. 37.9521°
LON. -122.5459°

SCALE

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

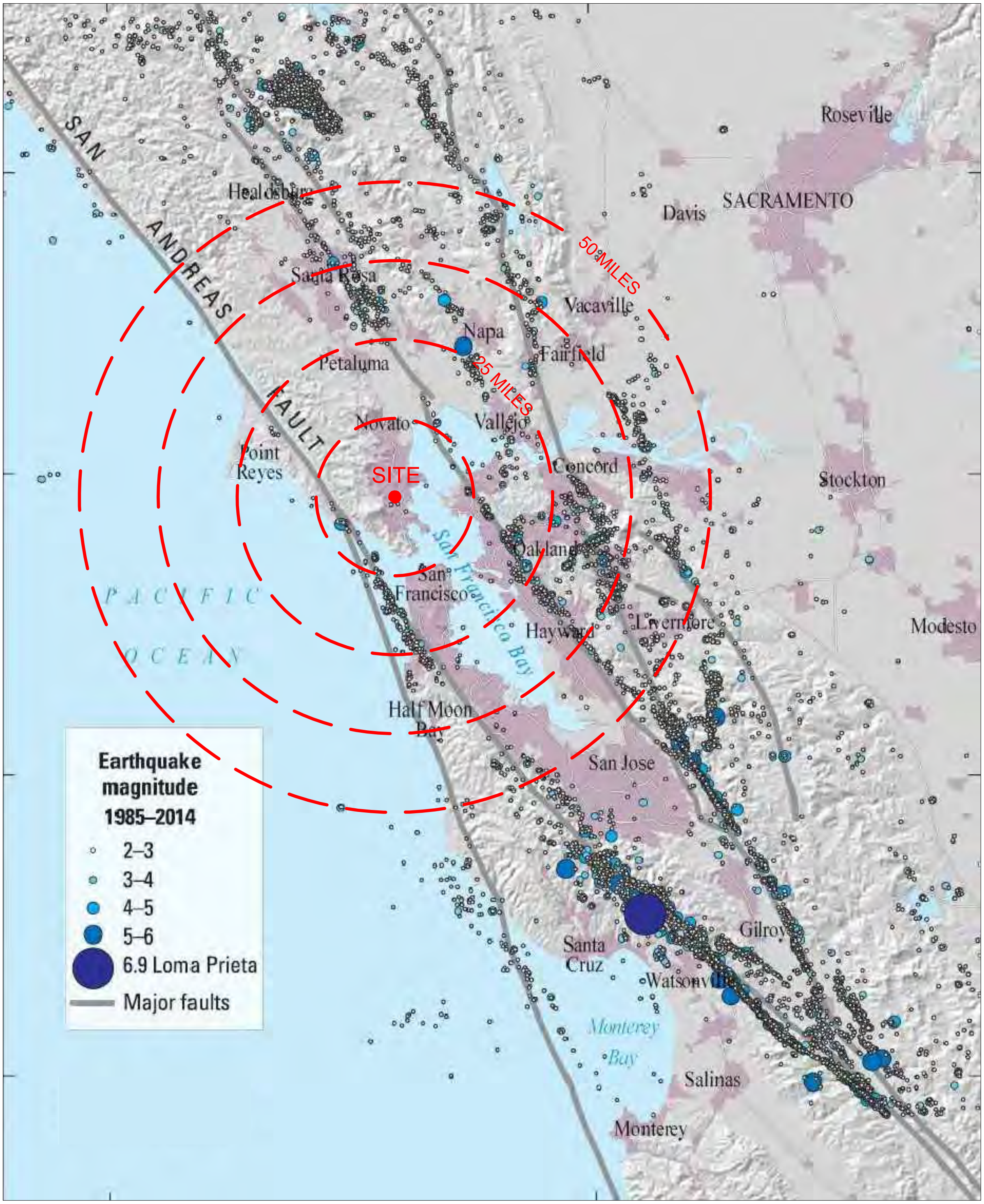
ACTIVE FAULT MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

4
FIGURE



SITE COORDINATES
LAT. 38.0000°
LON. -122.0000°

SCALE
0 12.5 25 50 MILES

NORTH

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Earthquakes Greater Than Magnitude 2.0 in the San Francisco Bay Region from 1985-2014, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

MPEG
MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

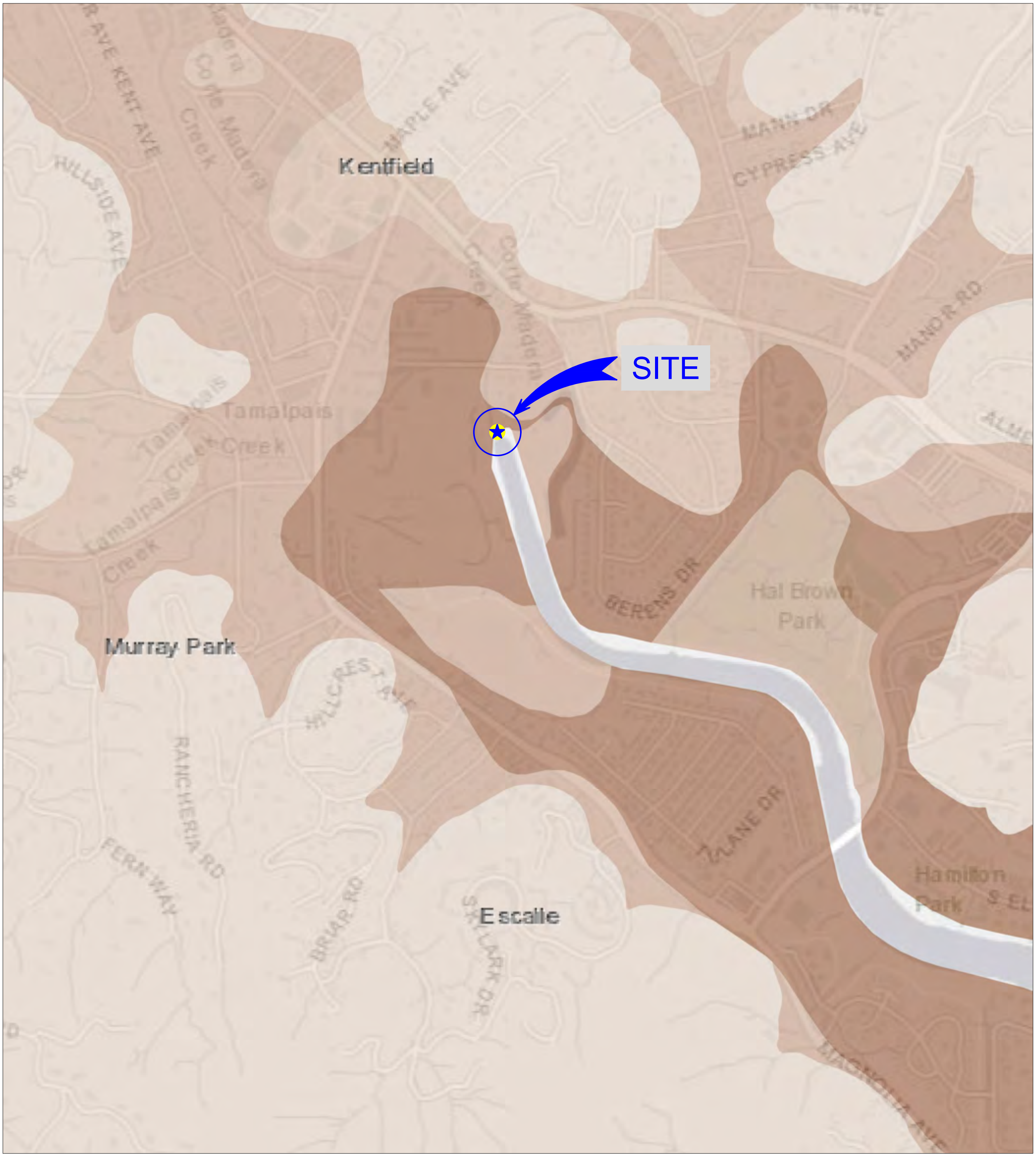
HISTORIC EARTHQUAKE MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001
Date: 9/22/2020

Drawn MMT
Checked

5
FIGURE



Susceptibility Level:

▨ Very High ▨ Moderate ▨ Very Low

▨ High ▨ Low

No Scale

NORTH

Reference: ABAG Hazard Map Viewer.

MILLER PACIFIC ENGINEERING GROUP

A CALIFORNIA CORPORATION, © 2020, ALL RIGHTS RESERVED

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

LIQUEFACTION SUSCEPTIBILITY MAP

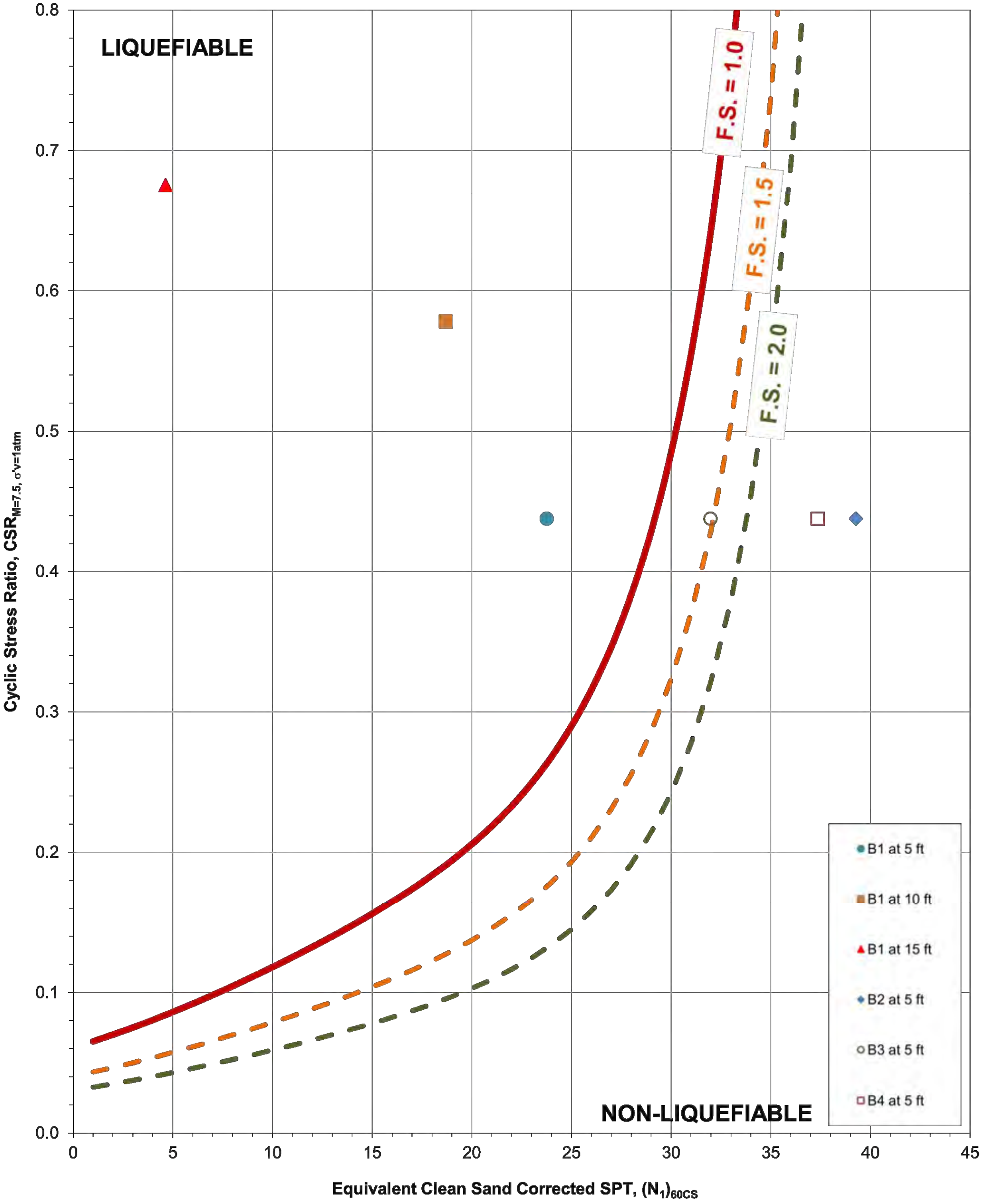
Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

6
FIGURE

Liquefaction Analysis
(Idriss, I.M.& Boulanger, R.W., 2008 & 2010)



MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

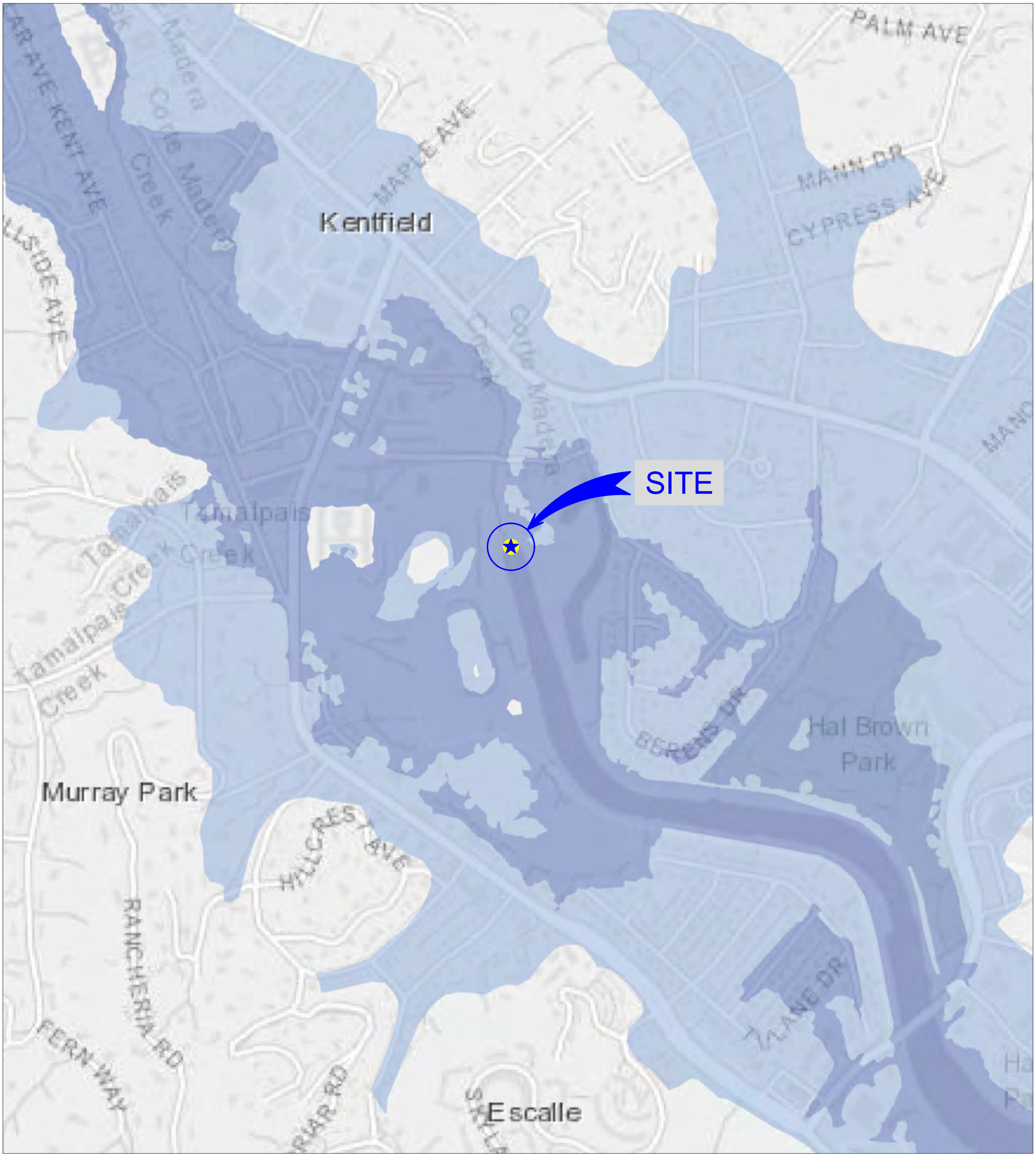
LIQUEFACTION ANALYSIS PLOT

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

7
FIGURE



FEMA Flood Hazard:

▨ 100-Year

▨ 500-Year

No Scale

NORTH

Reference: ABAG Hazard Map Viewer.

MPEG MILLER PACIFIC ENGINEERING GROUP

A CALIFORNIA CORPORATION, © 2020, ALL RIGHTS RESERVED

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

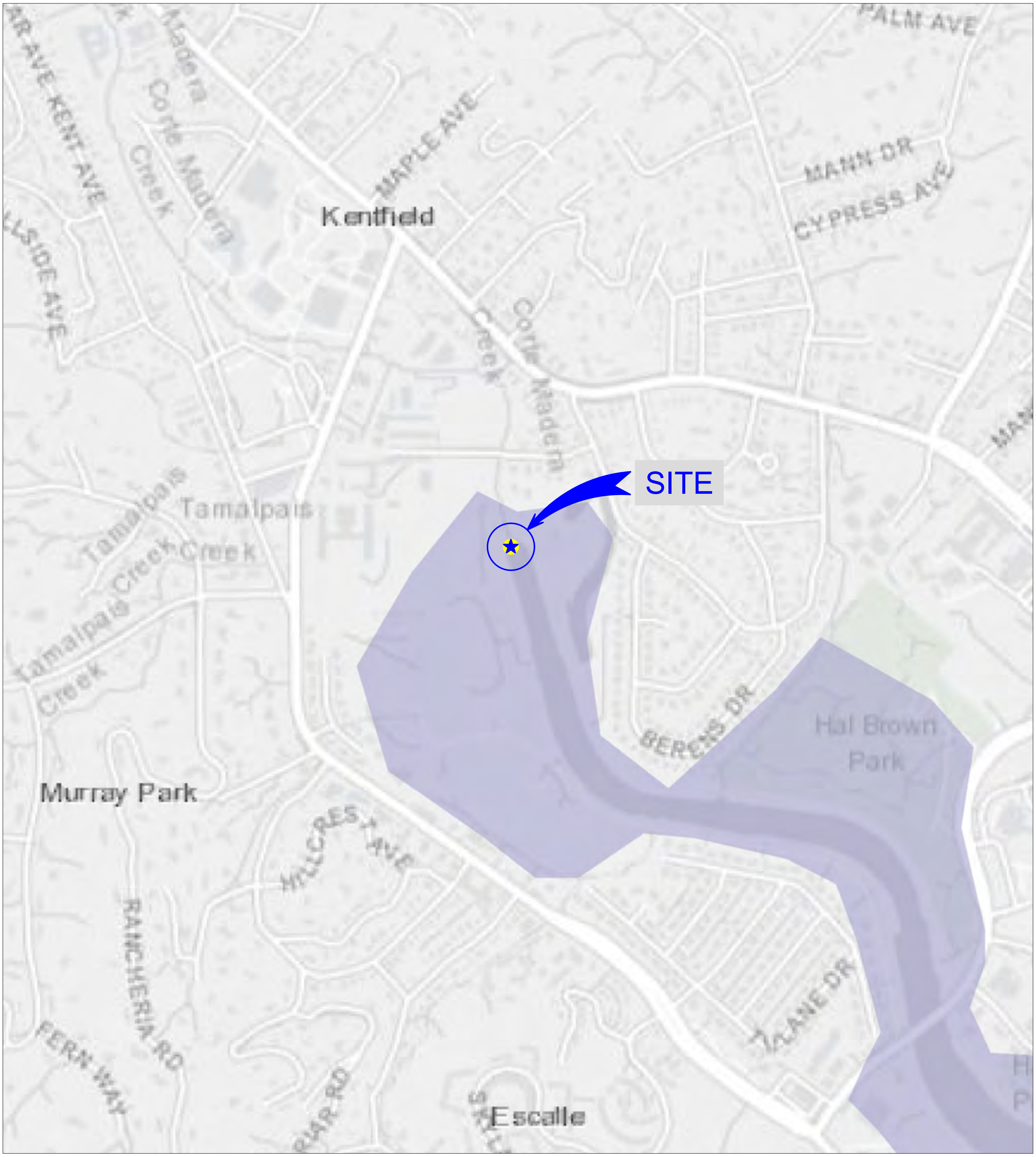
FEMA FLOOD MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

8
FIGURE



Tsunami Hazard:

▨ Evacuation Zone

No Scale

Reference: ABAG Hazard Map Viewer.

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 Figures.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

TSUNAMI INUNDATION MAP

Lower Corte Madera Creek
Concrete Channel Removal
Corta Madera, California

Project No. 2966.001 Date: 9/22/2020

Drawn MMT
Checked

9
FIGURE

APPENDIX A
SUBSURFACE EXPLORATION AND GEOTECHNICAL LABORATORY TESTING

A. SUBSURFACE EXPLORATION

We explored subsurface conditions with six exploratory borings drilled with track-mounted equipment on April 10, 2020 and November 22, 2021 at the approximate locations shown on the Site Plan, Figure 2. The exploration was conducted under the technical supervision of our Field Engineer who examined and logged the soil materials encountered and obtained samples. The subsurface conditions encountered in the test borings are summarized and presented on the Boring Logs, Figures A-2 through A-12.

“Undisturbed” samples were obtained using a 3-inch diameter, split-barrel Modified California Sampler with 2.5 by 6-inch tube liners or a Standard Penetration Test (SPT) Sampler. The samplers were driven by a 140-pound hammer at a 30-inch drop. The number of blows required to drive the samplers 18 inches was recorded and is reported on the boring logs as blows per foot for the last 12 inches of driving. The samples obtained were examined in the field, sealed to prevent moisture loss, and transported to our laboratory

B. GEOTECHNICAL LABORATORY TESTING

We conducted geotechnical laboratory tests on selected intact samples to classify soils and to estimate engineering properties. The following laboratory tests were conducted in general accordance with the ASTM standard test method cited:

- Laboratory Determination of Water (Moisture Content) of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D 2216
- Density of Soil in Place by the Drive-Cylinder Method, ASTM D 2937
- Unconfined Compressive Strength of Cohesive Soil, ASTM D 2166
- Amount of Material in Soils Finer than No. 200 (75-µm) Sieve, ASTM D1140
- Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis, ASTM D6913
- Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index, ASTM D 4318

The moisture content, dry density, amount of material passing a No. 200 sieve and unconfined compression test results are shown on the exploratory boring logs while the results of the sieve analyses and Atterberg Limits are shown on Figures A-13 through A-16. The exploratory boring logs, description of soils encountered, and the laboratory test data reflect conditions only at the location of the boring at the time they were excavated or retrieved. Conditions may differ at other locations and may change with the passage of time due to a variety of causes including natural weathering, climate, and changes in surface and subsurface drainage.

MAJOR DIVISIONS		SYMBOL	DESCRIPTION
COARSE GRAINED SOILS over 50% sand and gravel	CLEAN GRAVEL	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
	GRAVEL with fines	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	CLEAN SAND	SW	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly sands, little or no fines
	SAND with fines	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS over 50% silt and clay	SILT AND CLAY liquid limit <50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	SILT AND CLAY liquid limit >50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS		PT	Peat, muck, and other highly organic soils
ROCK			Undifferentiated as to type or composition

KEY TO BORING AND TEST PIT SYMBOLS

CLASSIFICATION TESTS

PI	PLASTICITY INDEX
LL	LIQUID LIMIT
SA	SIEVE ANALYSIS
HYD	HYDROMETER ANALYSIS
P200	PERCENT PASSING NO. 200 SIEVE
P4	PERCENT PASSING NO. 4 SIEVE

SAMPLER TYPE

■	MODIFIED CALIFORNIA	☒	HAND SAMPLER
▯	STANDARD PENETRATION TEST	☒	ROCK CORE
▨	THIN-WALLED / FIXED PISTON	X	DISTURBED OR BULK SAMPLE

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the excavation location during the time of exploration. Subsurface rock, soil or water conditions may vary in different locations within the project site and with the passage of time. Boundaries between differing soil or rock descriptions are approximate and may indicate a gradual transition.

STRENGTH TESTS

UC	LABORATORY UNCONFINED COMPRESSION
TXCU	CONSOLIDATED UNDRAINED TRIAXIAL
TXUU	UNCONSOLIDATED UNDRAINED TRIAXIAL
	UC, CU, UU = 1/2 Deviator Stress
DS (2.0)	DRAINED DIRECT SHEAR (NORMAL PRESSURE, ksf)

SAMPLER DRIVING RESISTANCE

Modified California and Standard Penetration Test samplers are driven 18 inches with a 140-pound hammer falling 30 inches per blow. Blows for the initial 6-inch drive seat the sampler. Blows for the final 12-inch drive are recorded onto the logs. Sampler refusal is defined as 50 blows during a 6-inch drive. Examples of blow records are as follows:

25	sampler driven 12 inches with 25 blows after initial 6-inch drive
85/7"	sampler driven 7 inches with 85 blows after initial 6-inch drive
50/3"	sampler driven 3 inches with 50 blows during initial 6-inch drive or beginning of final 12-inch drive

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

SOIL CLASSIFICATION CHART

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

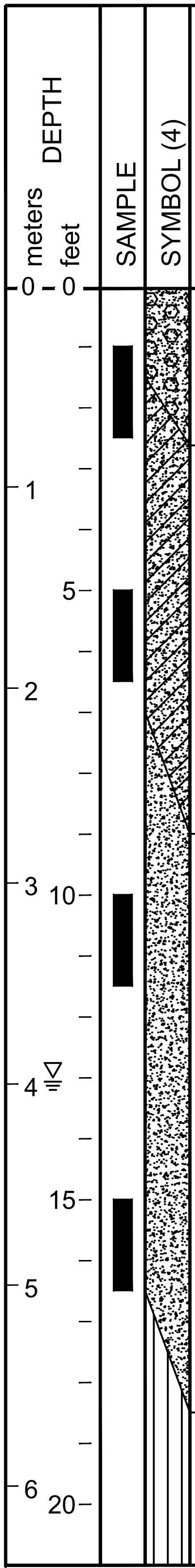
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-1
FIGURE

BORING 1

EQUIPMENT: Track-Mounted Drill Rig with
4.0-inch Solid Flight Auger
DATE: 4/10/2020
ELEVATION: 11 - feet*
*REFERENCE: Google Earth, 2020



	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
Aggregate Subbase Gray, dry to moist, gravel and sand, gravel up to 1.5-inch. [Fill]	30		10.5			
Clayey SAND with Gravel (SC) Medium-dark brown, moist, medium dense, fine grained sand, ~40-45% medium plasticity clay, gravels up to 1.5-inch. [Fill]	18	113	11.7		P200 41.5%	
SAND with Gravel (SP) Medium-dark brown, moist, medium dense, fine grained sand, ~20% gravels up to 1.5-inch, ~5% fines. [Alluvium]	20	111	18.3	UC 1150	P200 4.5%	SA
Grades to very loose.	5	110	21.4	UC 200	LL:39 PI:17	SA P200 1.9%
SILT/CLAY (ML/CL) Dark gray, moist, soft to medium stiff, low to medium plasticity silt and/or clay, minor organics. [Alluvium]						

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-2
FIGURE

BORING 1
(CONTINUED)

DEPTH meters feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
20 7 25 8			**SILT/CLAY (ML/CL)** Dark gray, moist, soft to medium stiff, low to medium plasticity silt and/or clay, minor organics. [Alluvium]						
	▨		**Clayey SILT (ML)** Dark gray, moist, stiff, low plasticity silt and/or clay, minor organics. [Alluvium]	12		31.4		LL:44 PI:8	
9 30 10 35 11 12 40			Bottom of boring at 29.5 feet. Groundwater observed at 13 feet during drilling.						

∇ Water level encountered during drilling

▼ Water level measured after drilling

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

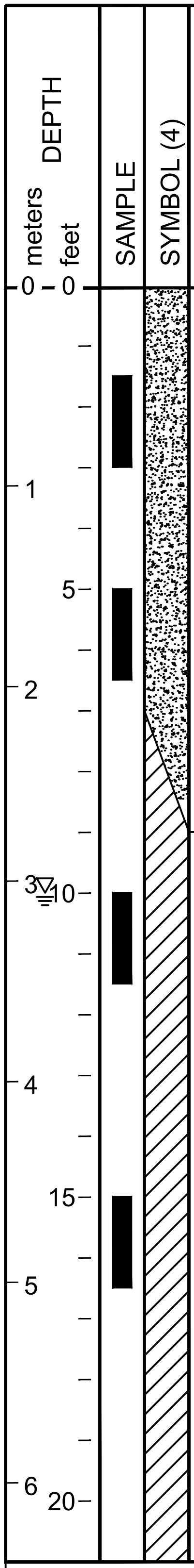
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-3
FIGURE

BORING 2

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 4/10/2020
ELEVATION: 10 - feet*
*REFERENCE: Google Earth, 2020



BORING 2	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
Sand with Gravel (SP) Dark brown, moist, ~50% fine to coarse grained sand, ~48% subangular to subrounded gravel up to 1-inch, minor fines (~2%). [Fill]						
	23	121	11.1			
	44	122	9.4	UC 2250	P200 1.5%	SA
Silty CLAY (CL/ML) Dark brown, moist, soft to medium stiff, medium to high plasticity silt, minor organics. [Alluvium]						
	9					
	11	91	30.5	UC 300		

∇ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG
MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California
Project No. 2966.001
Date: 12/21/2021

Drawn MNT
Checked

A-4
FIGURE

BORING 2
(CONTINUED)

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
7	20			Silty CLAY (CL/ML) Dark brown, moist, medium stiff, medium to high plasticity, minor organics. [Alluvium]						
	25			Sandy Silt (ML) Medium mottled gray, blue, green and brown, moist, soft, low to medium plasticity silt, ~40-45% fine grained sand. [Alluvium]	6		24.8		P200 57.8%	
8 9 10 11 12	30 35 40			Bottom of boring at 26 feet. Groundwater observed at 10 feet during drilling.						

▽ Water level encountered during drilling

▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG
MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001
Date: 12/21/2021

Drawn MNT
Checked

A-5
FIGURE

BORING 3

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 4/10/2020
ELEVATION: 10 - feet*
*REFERENCE: Google Earth, 2020

DEPTH feet	SAMPLE		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0		**Clayey SAND with Gravel (SC)** Medium brown, moist, medium dense, fine to medium grained sand, ~40-45% medium plasticity clay, gravels up to 1-inch. [Fill]						
	■		18	124	11.3	UC 2125		
5		Grades to fine to course grained sand.						
	■		28	117	12.1	UC 1940	P200 41.8%	SA
10		**Sandy CLAY with Gravel (CL)** Medium brown, moist, medium plasticity, ~40-45% fine to medium grained sand, gravels up to 1-inch. [Fill]						
	■		20	113	16.3	UC 2085	P200 53.4%	
∇								
		Silty CLAY (CL/ML) Dark brown, moist, medium stiff, medium to high plasticity clay and silt, minor organics. [Alluvium]						
15	X X X X		10		22.6			LL:37 PI:21
20								

Depth scale: meters 0, 1, 2, 3, 4, 5, 6; feet 0, 5, 10, 15, 20

∇ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG
MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California
Project No. 2966.001
Date: 12/21/2021

Drawn MNT
Checked

A-6
FIGURE

meters DEPTH feet	SAMPLE	SYMBOL (4)	BORING 3 (CONTINUED)	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
20 7 25 8		▥	Silty CLAY (CL/ML) Dark brown, moist, medium stiff, medium to high plasticity clay and silt, minor organics. [Alluvium]						
	▭	▨	CLAY (CL/CH) Dark gray-brown, saturated, stiff, medium to high plasticity clay. [Alluvium]	24		27.4			
9 30 10 35 11 12 40			Bottom of boring at 29.5 feet. Groundwater observed at 12 feet during drilling.						

▽ Water level encountered during drilling

▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

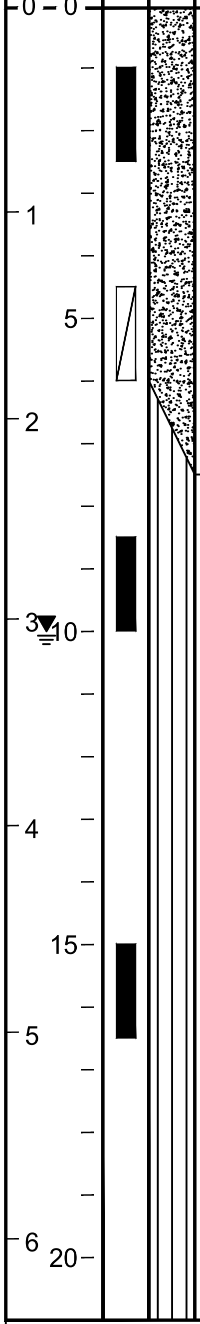
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-7
FIGURE

BORING 4

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 4/10/2020
ELEVATION: 11 - feet*
*REFERENCE: Google Earth, 2020



	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
SAND with Gravel/GRAVEL with Sand (SP/GP) Medium brown, moist, medium dense, fine to coarse grained sand, subangular to angular gravels up to 1-inch. [Fill]	26	119	31.9			
	24		13.7			
SILT/CLAY (ML/CL) Dark gray, moist, medium stiff, low to medium plasticity, minor organics. [Alluvium]	7	90	31.9	UC 605	LL:33 PI:10	
	9	76	40.9	UC 1260		

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001
Date: 12/21/2021

Drawn MNT
Checked

A-8
FIGURE

BORING 4 (CONTINUED)

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)	BORING 4 (CONTINUED)	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
	20			Silt/Clay (ML/CL) Dark gray, moist, very stiff, low to medium plasticity, minor organics.						
7										
	25									
8										
				CLAY (CL/CH) Dark gray-brown, saturated, very stiff, medium to high plasticity clay. [Alluvium]	54					
9	30			Bottom of boring at 29.5 feet. Groundwater observed at 10 feet during drilling.						
10										
	35									
11										
12	40									

∇ Water level encountered during drilling

▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001

Date: 12/21/2021

Drawn MNT

Checked

A-9

FIGURE

BORING 5

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 11/22/2020
ELEVATION: 11 - feet*
*REFERENCE: Google Earth, 2020

DEPTH meters feet	SAMPLE	SYMBOL (4)	Description	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
			Sandy CLAY with Gravel (CL) red-brown, moist, stiff to very stiff, low to medium plasticity [Fill]	41	119	11.5	2900 UC		
			Clayey SAND (SC) dark gray, moist, medium dense, fine- to medium-grained [Alluvium]	23	118	13.2	675 UC	31.0% P200	
			Sandy CLAY (CH) dark gray, moist, medium stiff, medium to high plasticity [Alluvium]	9		21.1		53.7% P200, SA	
			Clayey SAND (SC) dark gray, moist, medium stiff, medium plasticity [Alluvium]	3		25.9		44.0% P200, SA	
			CLAY with Sand (CH) dark gray, moist, soft, medium to high plasticity [Alluvium]	3		30.8		81.9% P200	

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

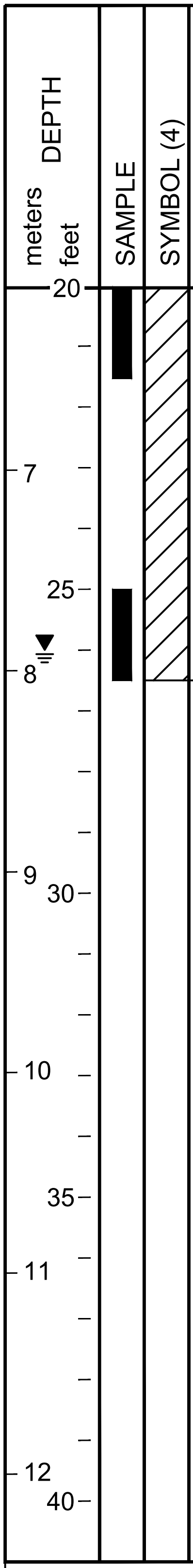
Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-10
FIGURE

BORING 5
(CONTINUED)



	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
CLAY with Sand (CH) dark gray, moist, soft, medium to high plasticity [Alluvium]	13	102	26.0			
	12	97	27.7			
Bottom of boring at 26.5 feet. Groundwater observed at 26 feet during drilling.						

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-11
FIGURE

BORING 6

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 11/22/2020
ELEVATION: 11 - feet*
*REFERENCE: Google Earth, 2020

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0	0		▨	Sandy CLAY with Gravel (CL) brown, slightly moist, hard, low to medium plasticity [Fill]						
1		■	▨		66	121	8.6			
	5		░	Clayey SAND (SC) dark gray, moist, medium dense, fine- to medium-grained [Alluvium]						
2		■	░		25	113	12.2		37.9% P200	LL 32 PL 22 PI 10
3	10	■	▨	CLAY (CH) dark gray, moist, medium stiff, high plasticity, few organics [Alluvium]	7	59	69.1	650 UC		
4			▨							
5	15	■	▨		8		25.8			
			▨	Bottom of boring at 21.5 feet. No groundwater observed during drilling.						
6	20	■	▨		11	103	25.5	550 UC		

∇ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

BORING LOG

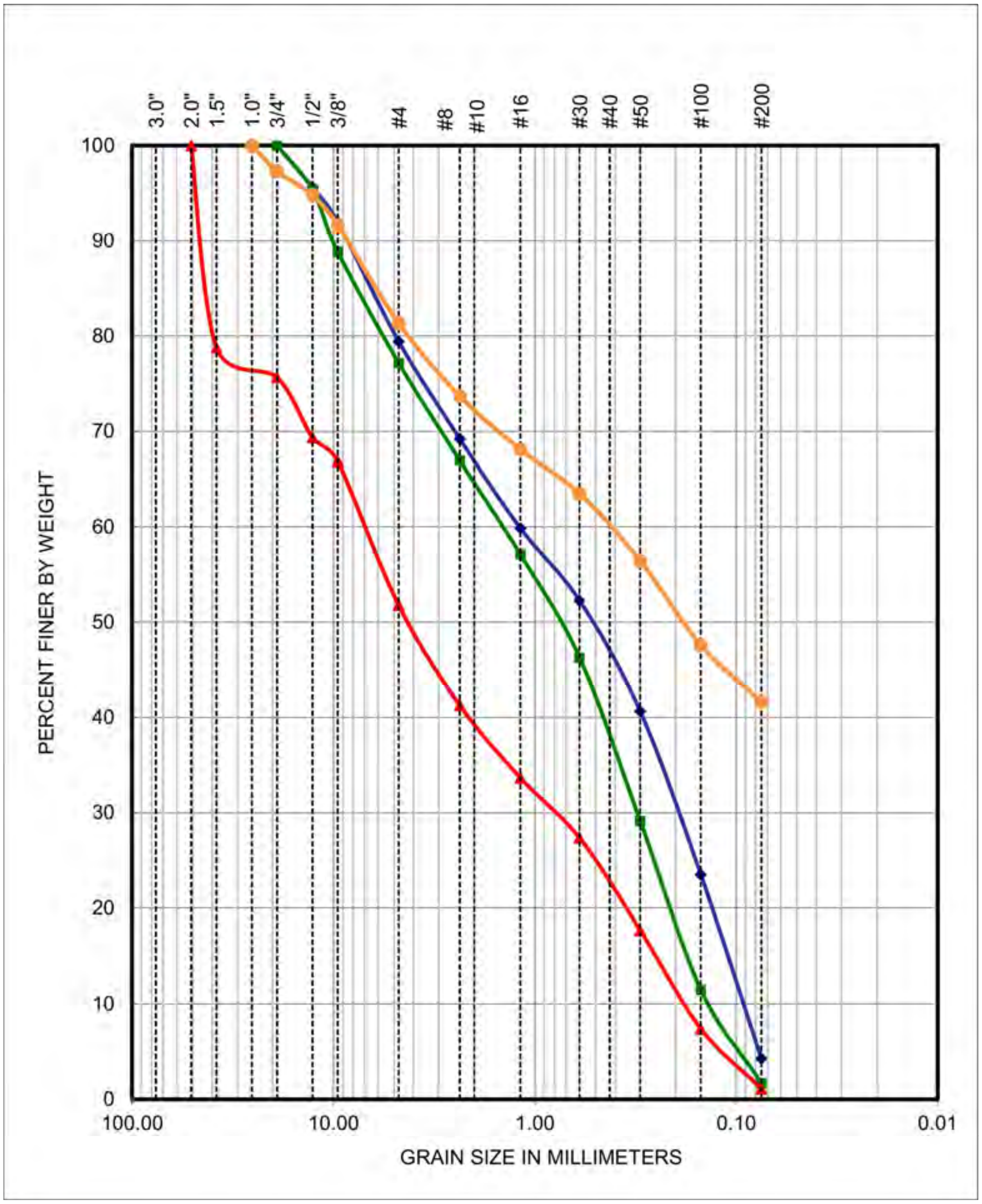
Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-12
FIGURE

MILLER PACIFIC ENGINEERING GROUP
PARTICLE SIZE ANALYSIS - ASTM D 6913 & ASTM D 1140



SYMBOL	SAMPLE SOURCE	CLASSIFICATION
◆	B1 @ 10.5'	SAND with Gravel (SP)
■	B1 @ 16.0'	SAND with Gravel (SP)
▲	B2 @ 6.0'	SAND with Gravel (SP)
●	B3 @ 6.0'	Clayey SAND with Gravel (SC)

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

SIEVE ANALYSIS RESULTS

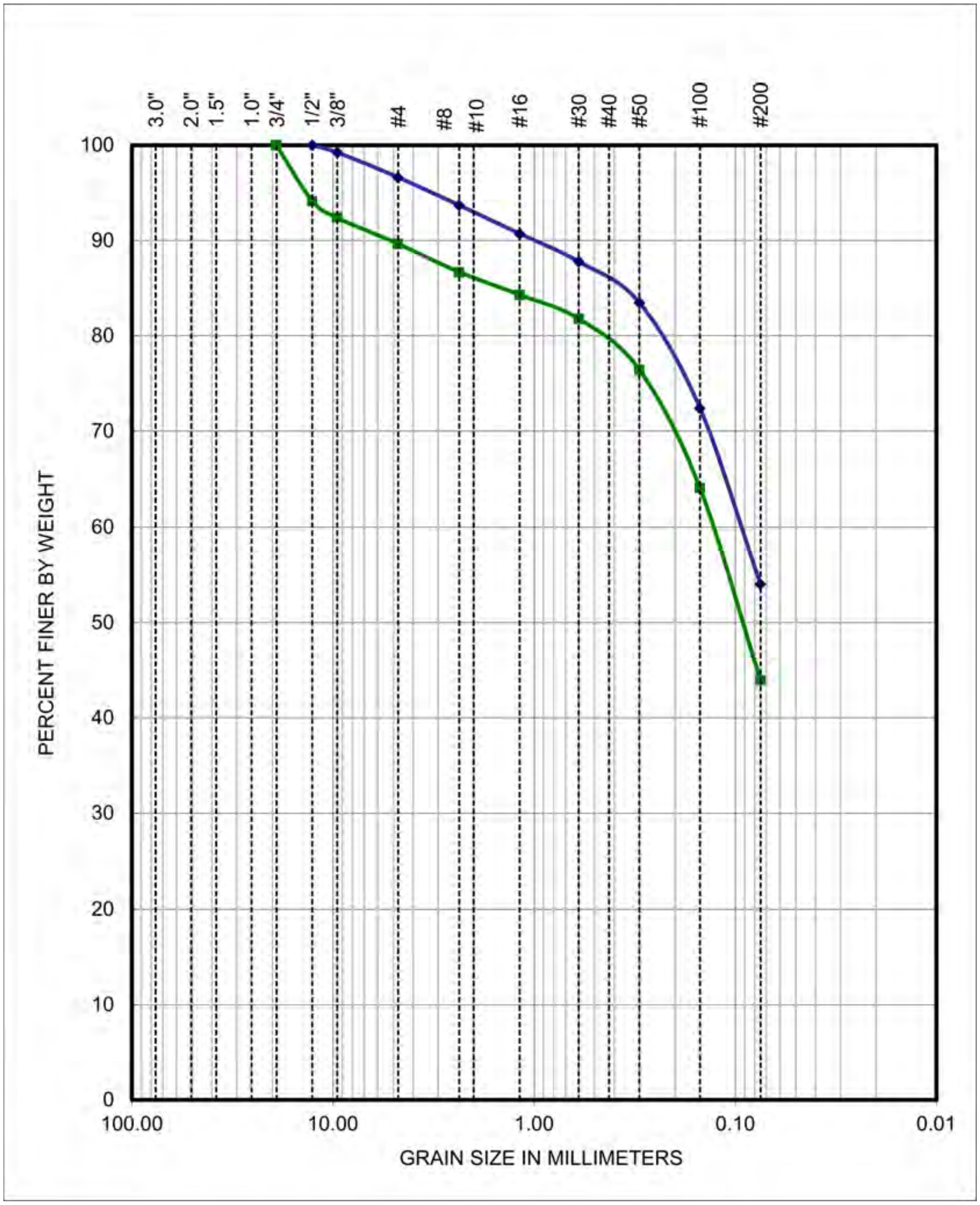
Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-13
FIGURE

MILLER PACIFIC ENGINEERING GROUP
PARTICLE SIZE ANALYSIS - ASTM D 6913 & ASTM D 1140



SYMBOL	SAMPLE SOURCE	CLASSIFICATION
◆	B5 @ 10.0'	Sandy CLAY (CL)
■	B5 @ 11.5'	Silty SAND (SM)

MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

SIEVE ANALYSIS RESULTS

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

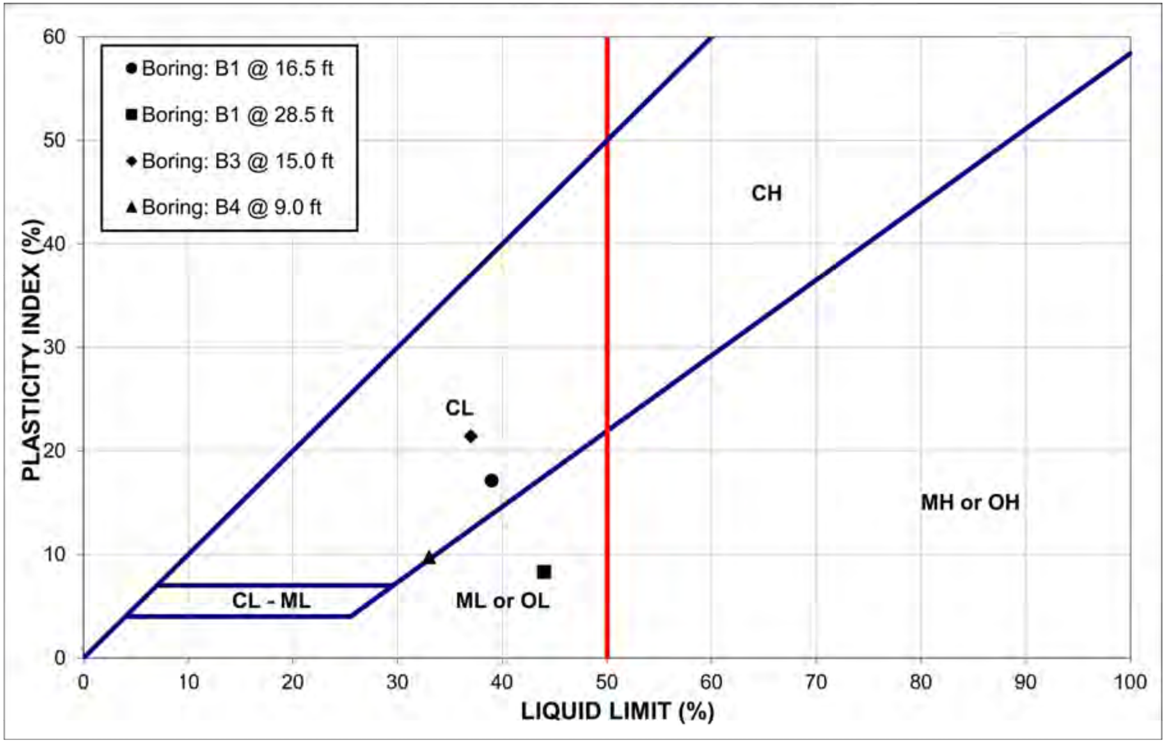
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-14
FIGURE

MILLER PACIFIC ENGINEERING GROUP

ATTERBERG LIMITS TEST (ASTM D 4318)



Sample	Classification	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Boring: B1 @ 16.5 ft	CLAY (CL) dark gray	39	22	17
Boring: B1 @ 28.5 ft	SILT (ML) dark gray	44	36	8
Boring: B3 @ 15.0 ft	CLAY with Sand and Gravel (CL) dark brown	37	16	21
Boring: B4 @ 9.0 ft	SILT/CLAY (ML/CL) gray	33	23	10

MPEG MILLER PACIFIC ENGINEERING GROUP

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

ATTERBERG LIMITS TEST RESULTS

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

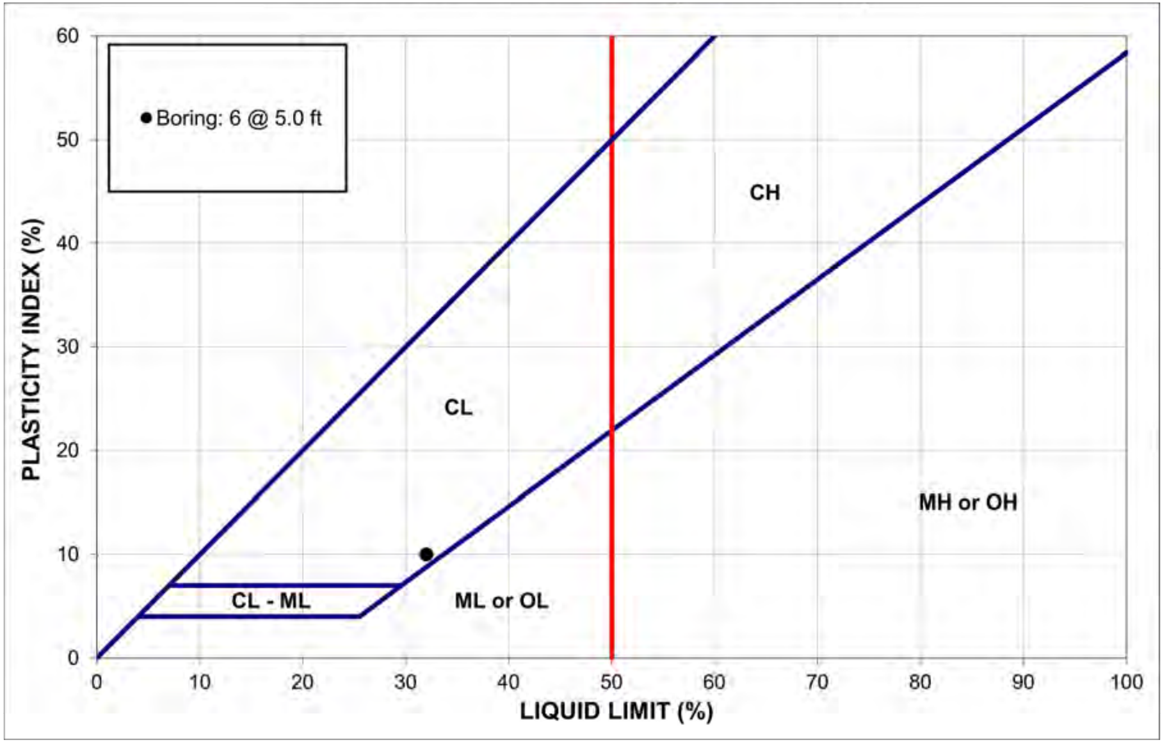
Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

A-15
FIGURE

MILLER PACIFIC ENGINEERING GROUP

ATTERBERG LIMITS TEST (ASTM D 4318)



Sample	Classification	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Boring: 6 @ 5.0 ft	Clayey SAND (SC) Dark gray	32	22	10

MILLER PACIFIC ENGINEERING GROUP

A CALIFORNIA CORPORATION, © 2020, ALL RIGHTS RESERVED

FILENAME: 2966.001 BL.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

ATTERBERG LIMITS TEST RESULTS

Lower Corte Madera Creek
Concrete Channel Removal
Corte Madera, California

Project No. 2966.001 Date: 12/21/2021

Drawn MNT
Checked

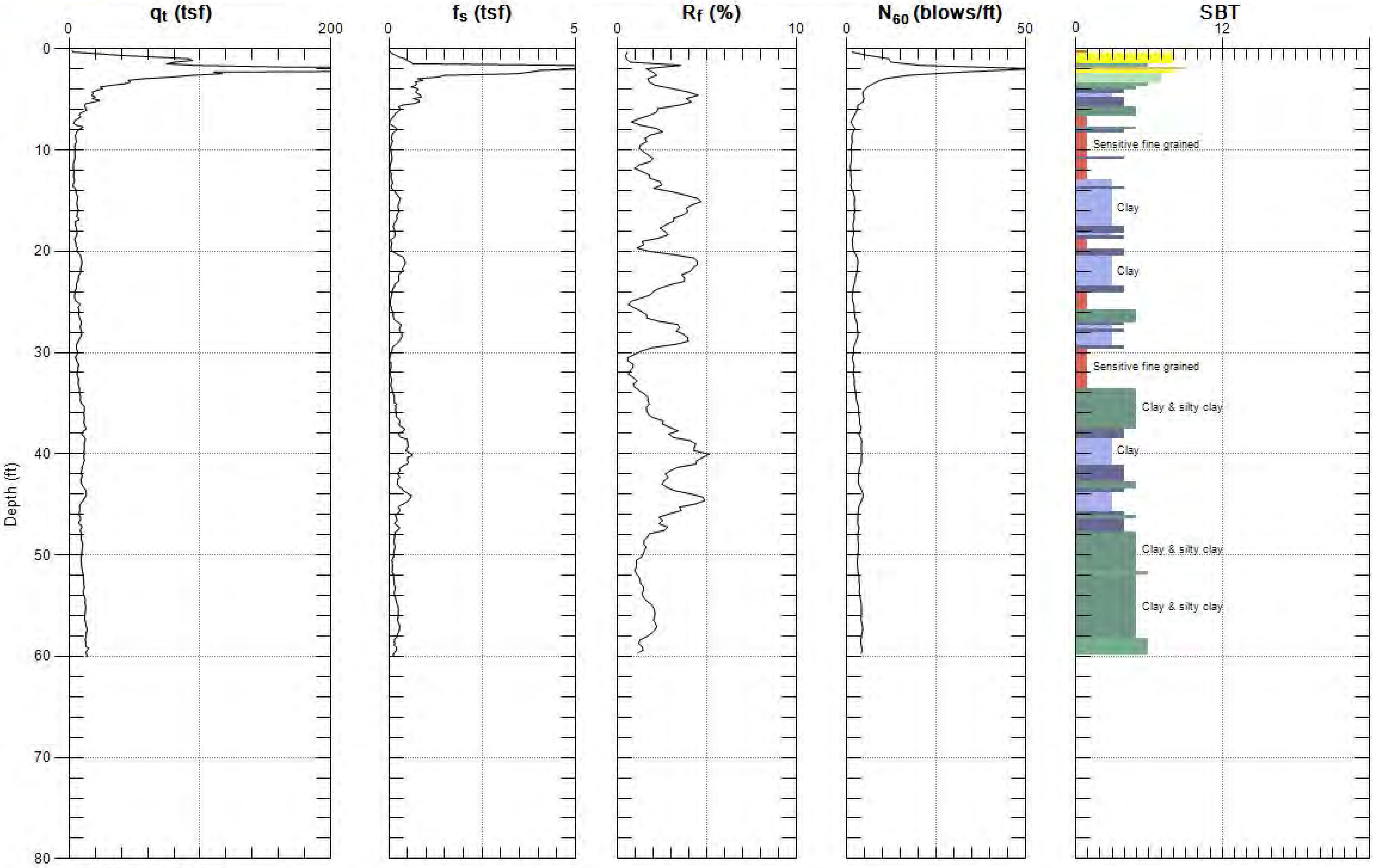
A-16
FIGURE

APPENDIX B
PREVIOUS SUBSURFACE EXPLORATION BY OTHERS

A3GEO

Site: COLLEGE OF MARIN
Sounding: CPT-1

Engineer: J.VANDENBERG
Date: 5/1/17 10:01



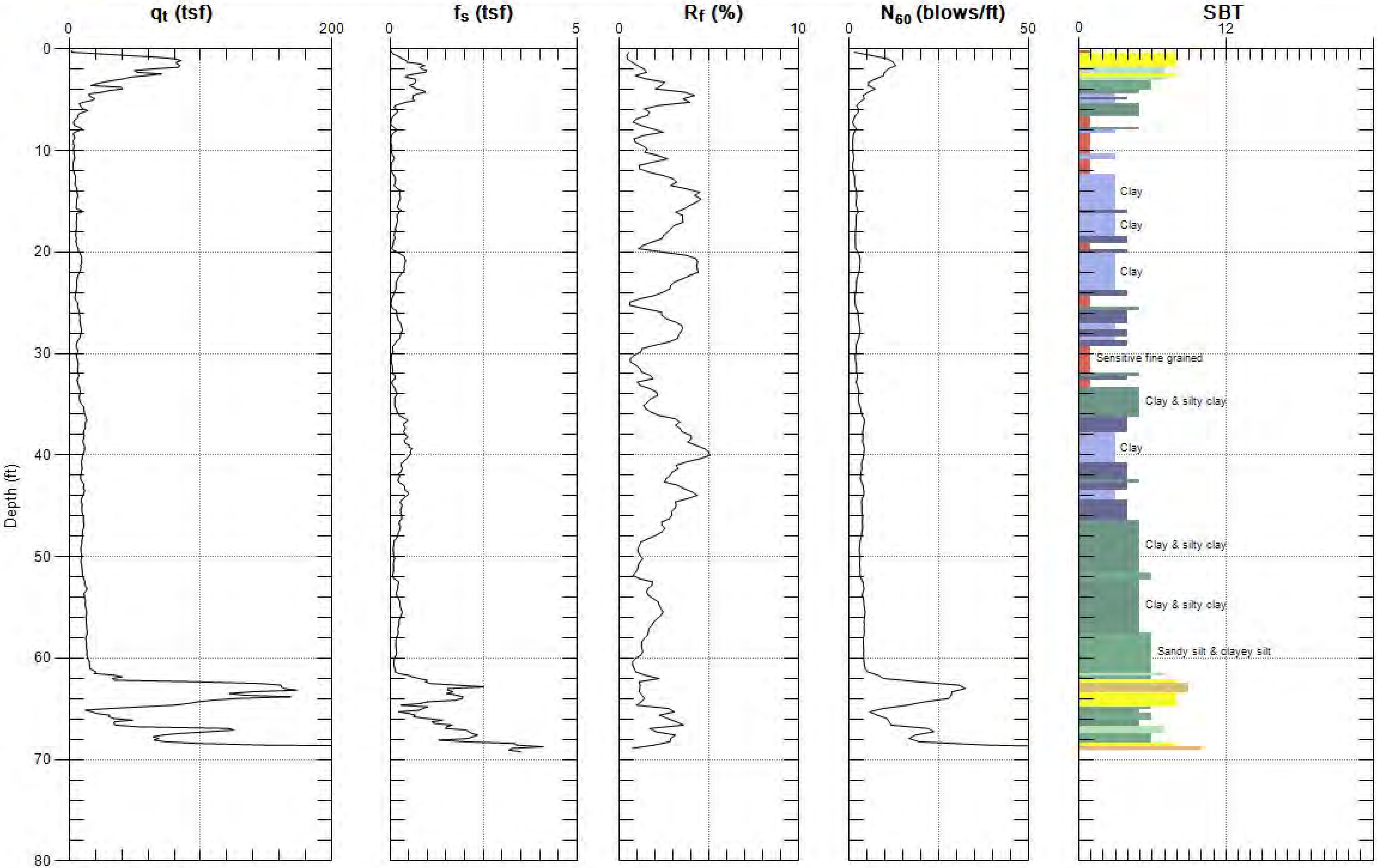
Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **A3GEO**

Site: COLLEGE OF MARIN
Sounding: CPT-1R

Engineer: J.VANDENBERG
Date: 5/1/17 01:41



Max. Depth: 69.226 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

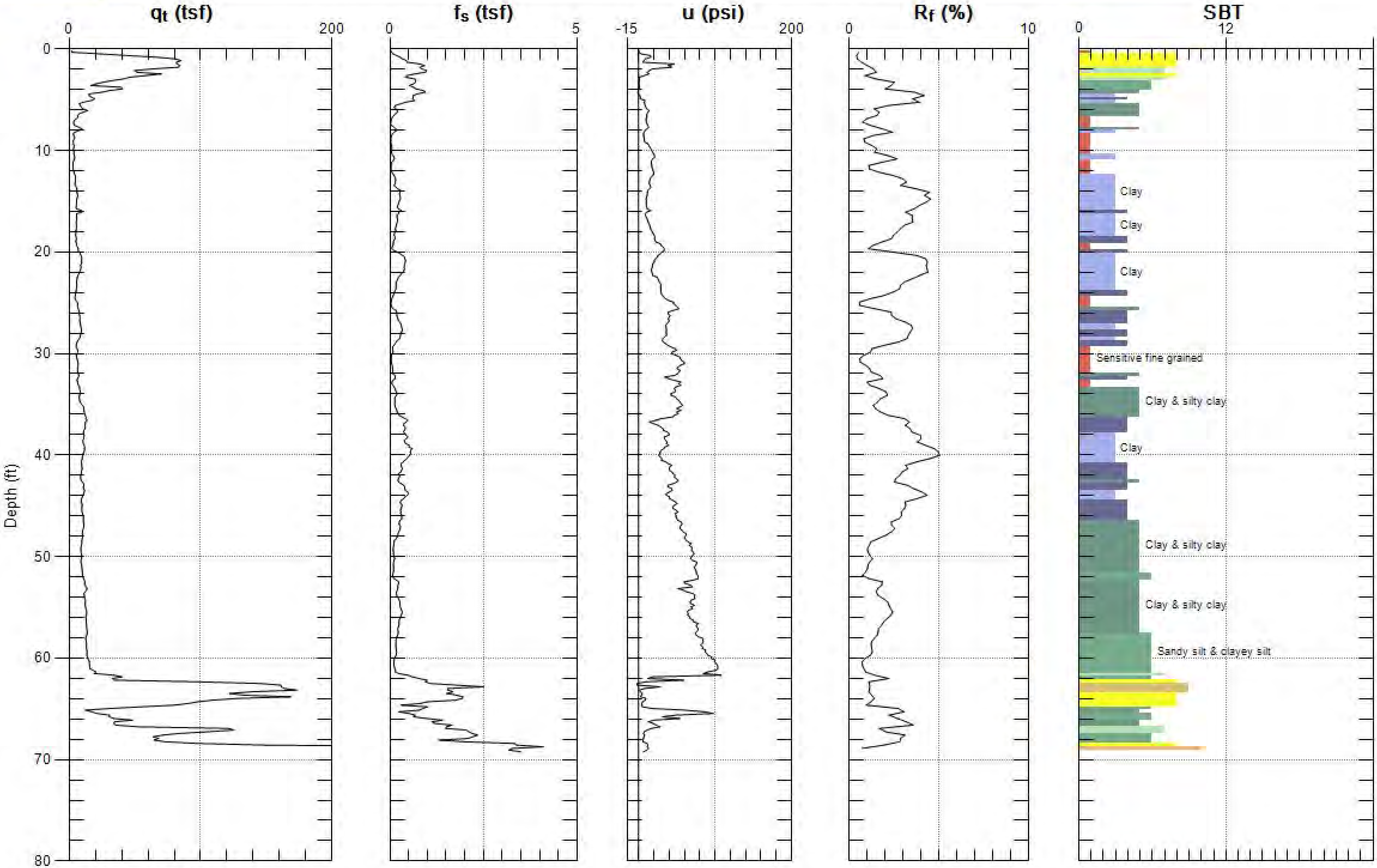
A3GEO

Site: COLLEGE OF MARIN

Sounding: CPT-1R

Engineer: J.VANDENBERG

Date: 5/1/17 01:41



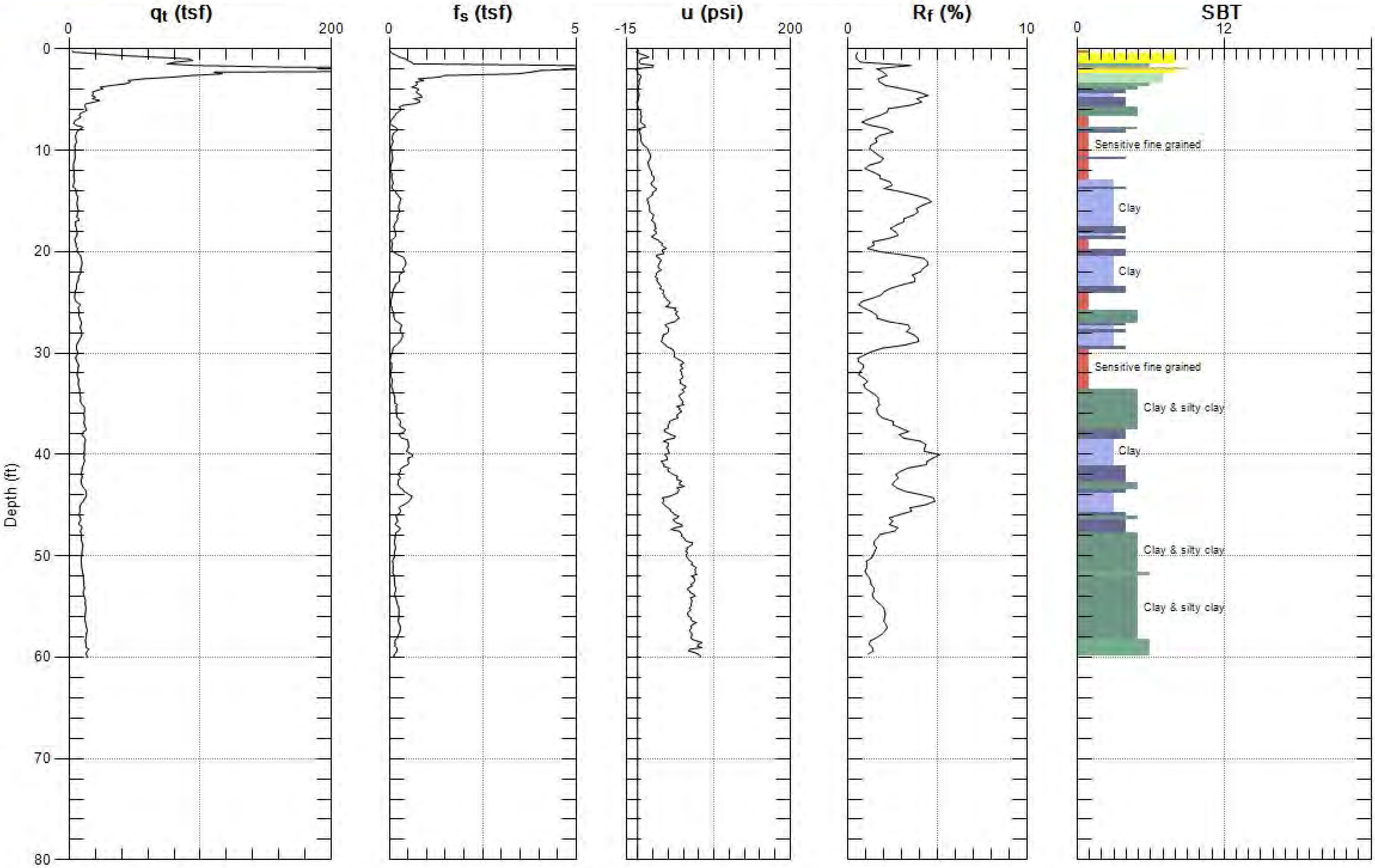
Max. Depth: 69.226 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **A3GEO**

Site: COLLEGE OF MARIN
Sounding: CPT-1

Engineer: J.VANDENBERG
Date: 5/1/17 10:01



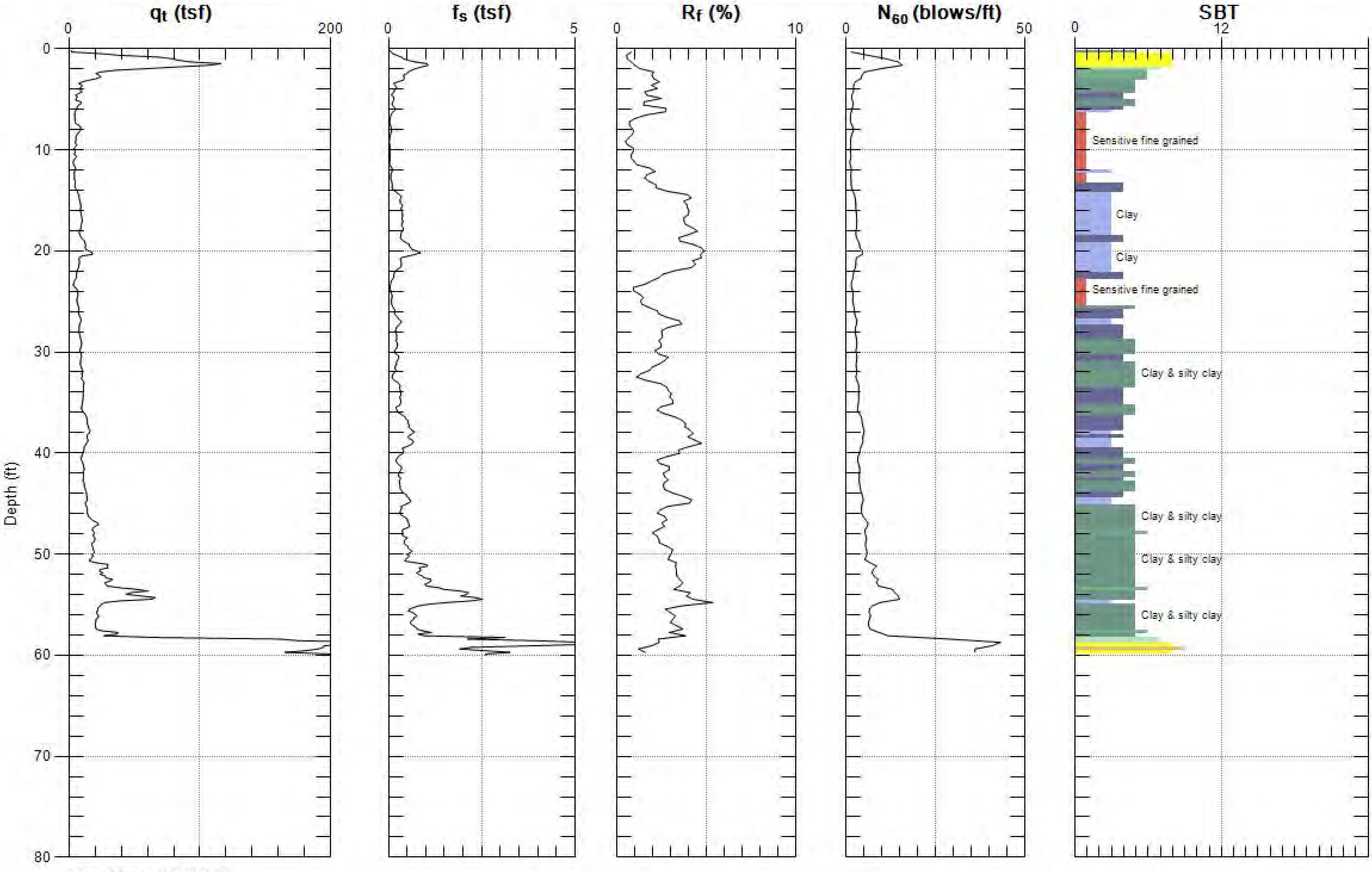
Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **A3GEO**

Site: COLLEGE OF MARIN **Engineer: J.VANDENBERG**

Sounding: CPT-2 **Date: 5/1/17 08:17**



Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

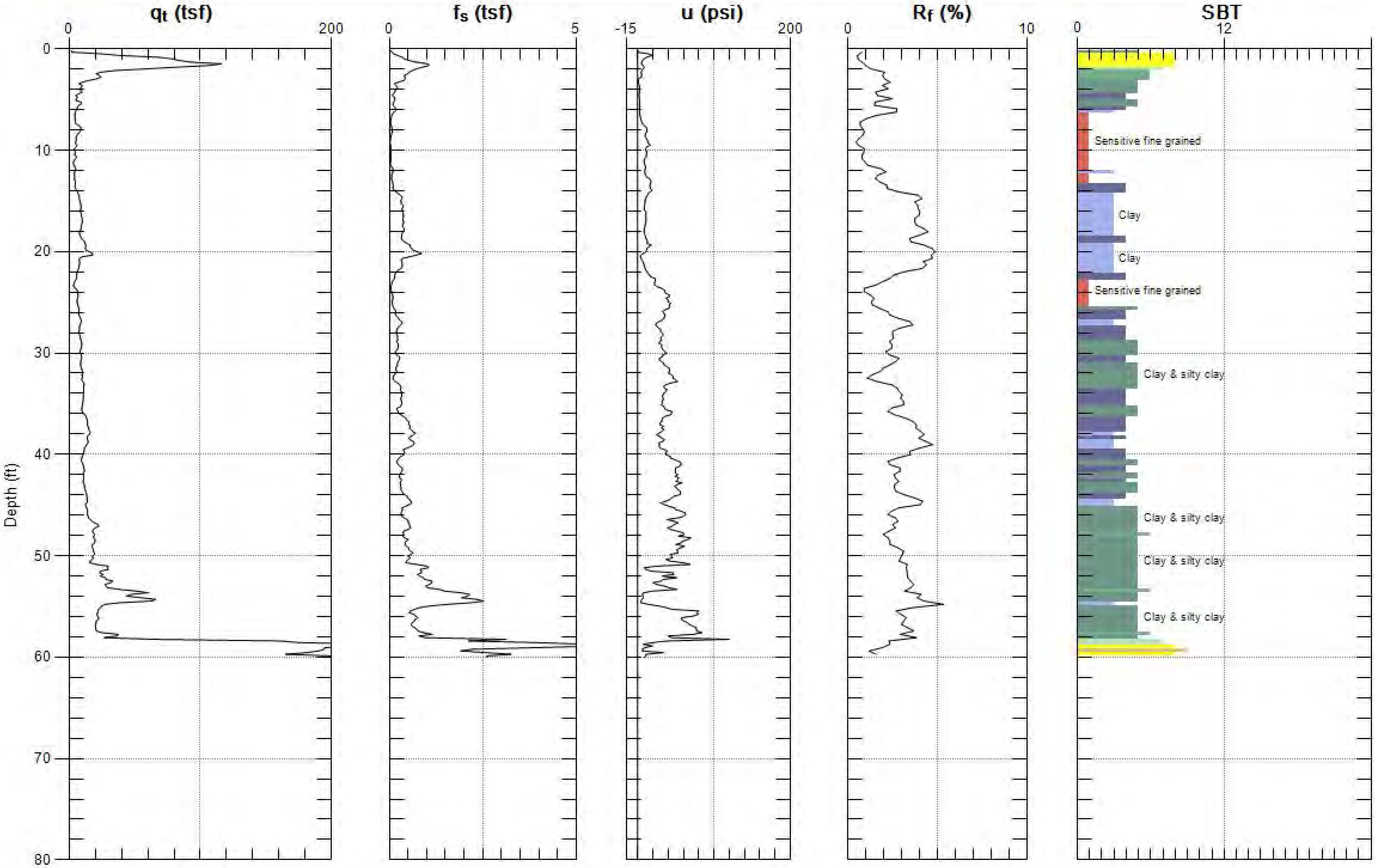
A3GEO

Site: COLLEGE OF MARIN

Sounding: CPT-2

Engineer: J.VANDENBERG

Date: 5/1/17 08:17



Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG

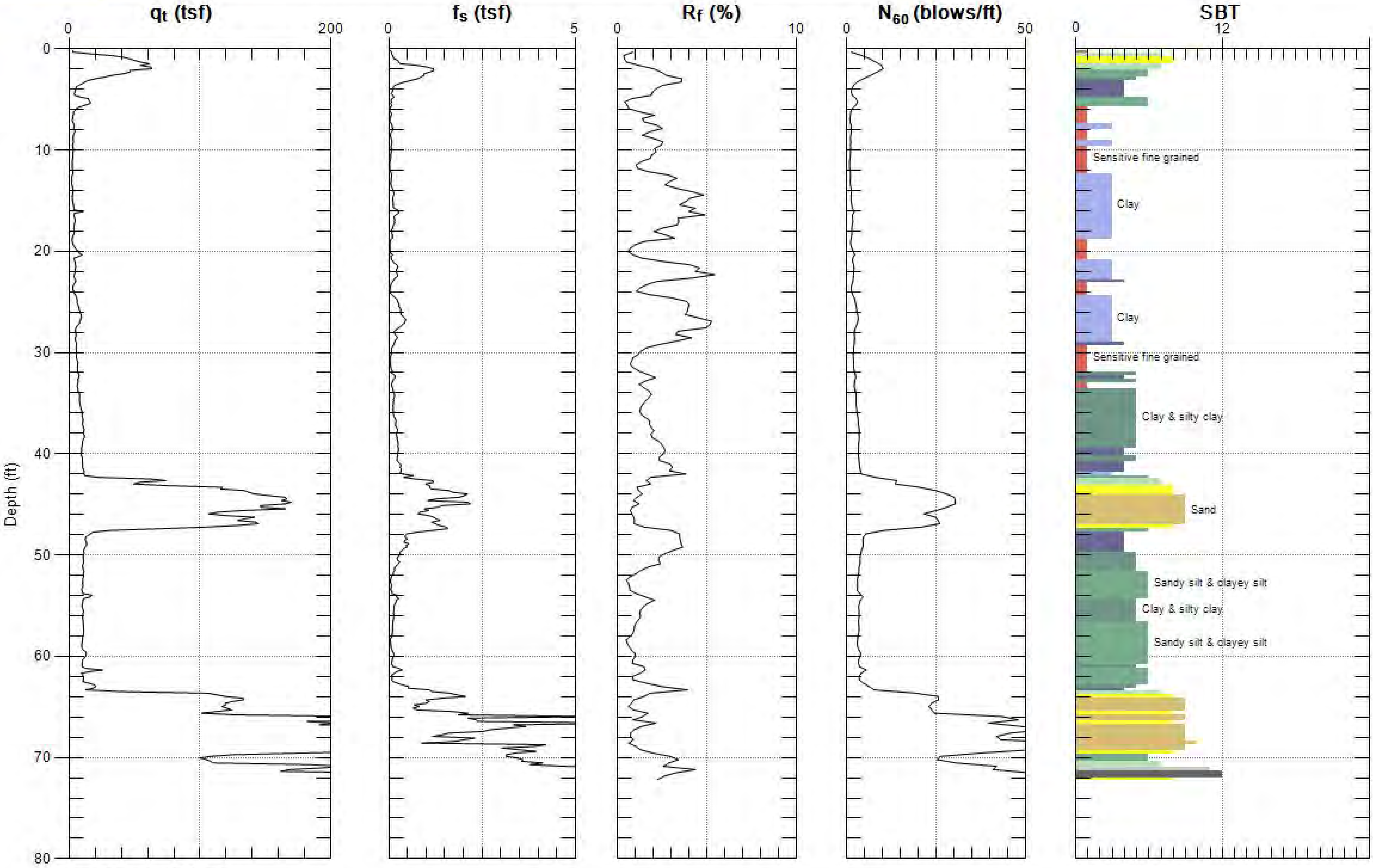
A3GEO

Site: COLLEGE OF MARIN

Sounding: CPT-3

Engineer: J.VANDENBERG

Date: 5/1/17 12:12



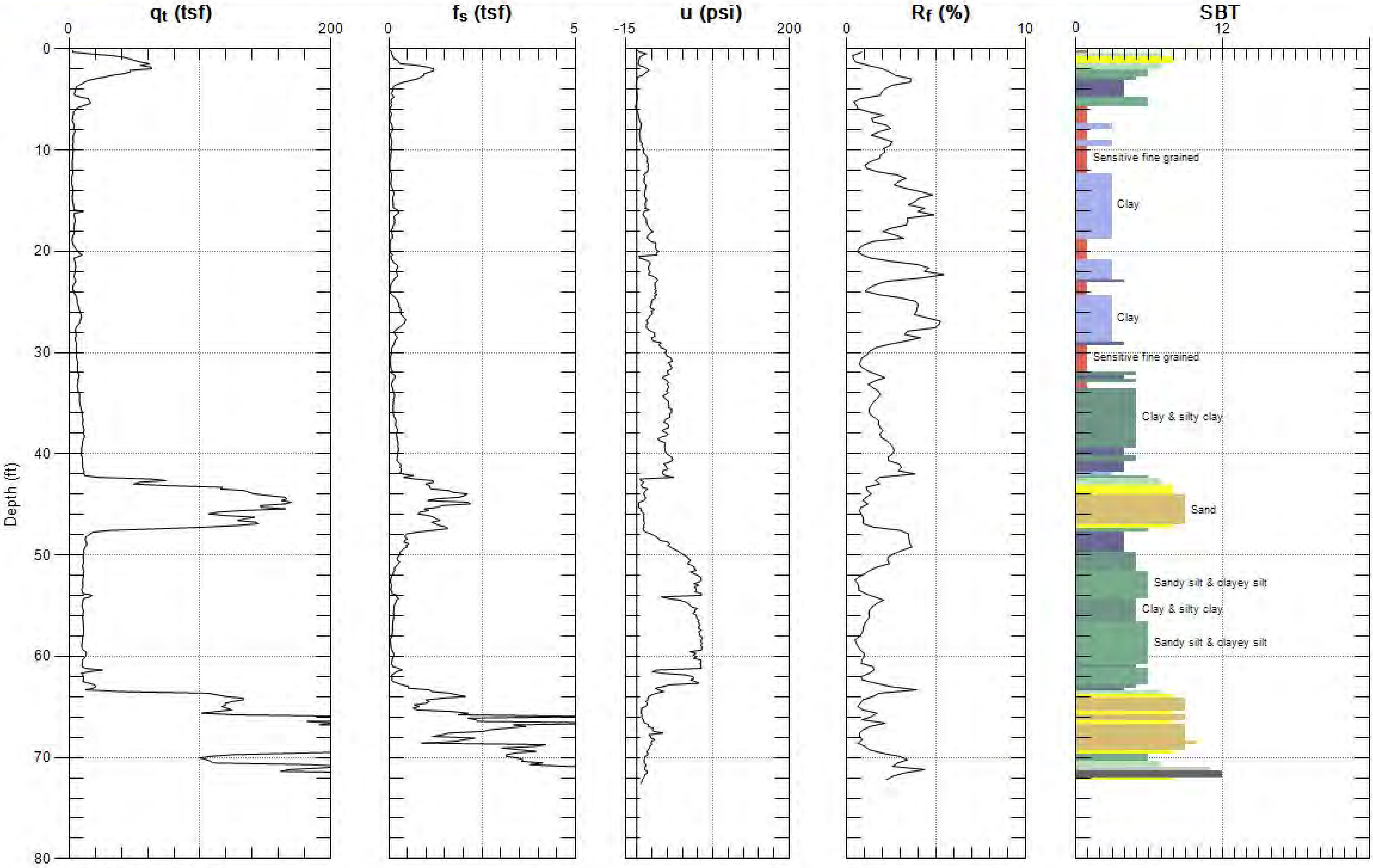
Max. Depth: 72.507 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **A3GEO**

Site: COLLEGE OF MARIN
Sounding: CPT-3

Engineer: J.VANDENBERG
Date: 5/1/17 12:12



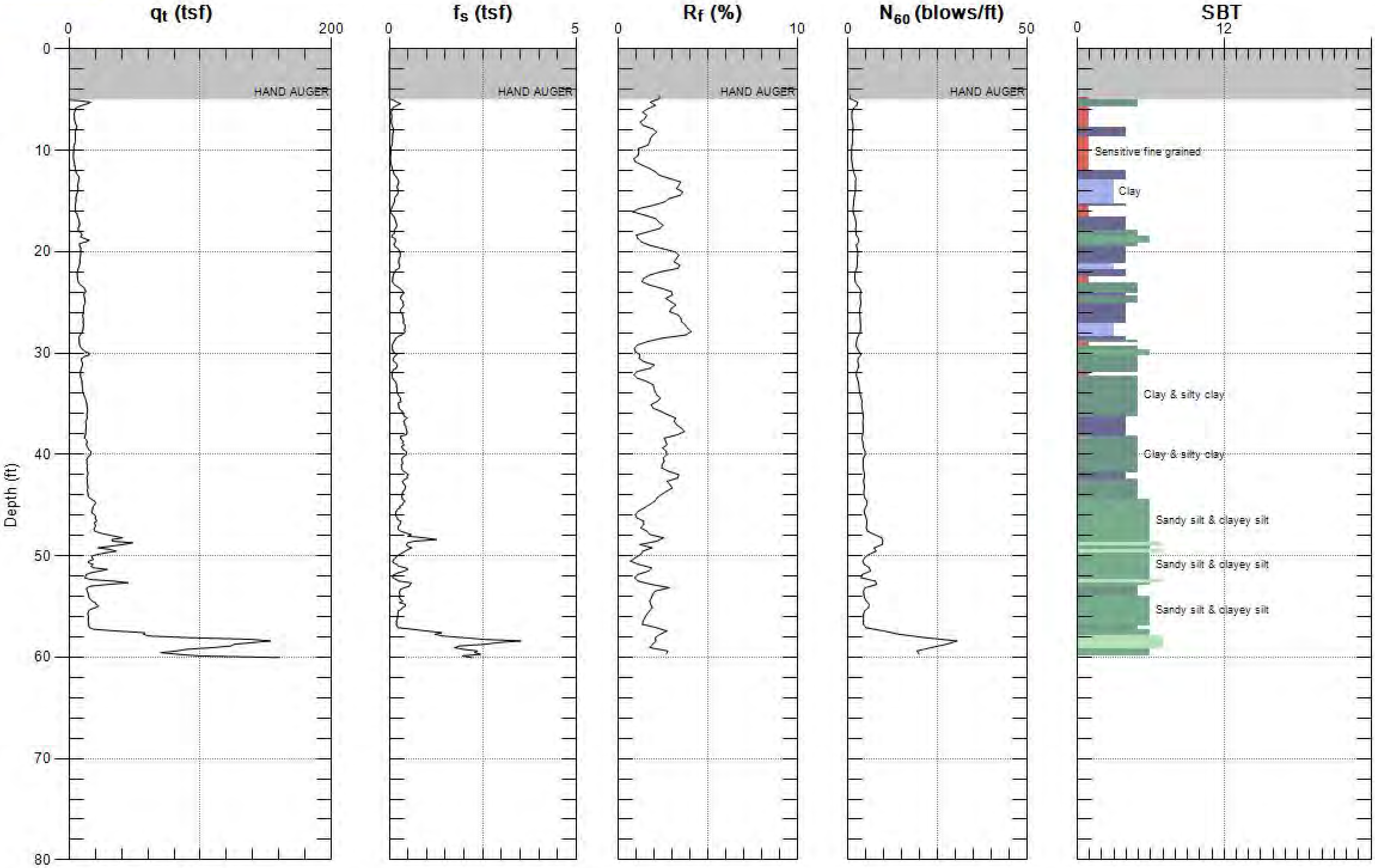
Max. Depth: 72.507 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **A3GEO**

Site: COLLEGE OF MARIN
Sounding: CPT-4

Engineer: J.VANDENBERG
Date: 5/1/17 06:48



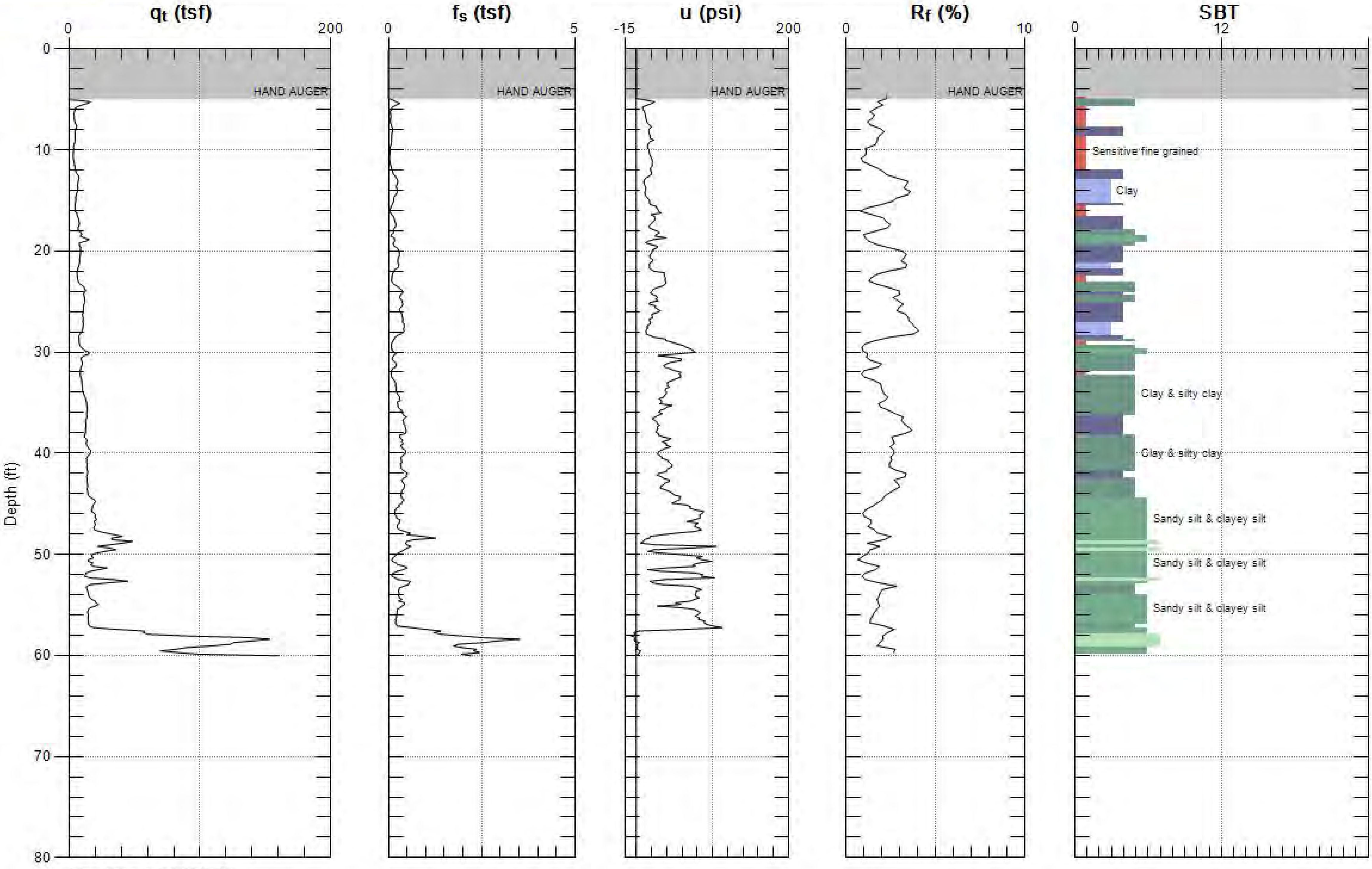
Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

A3GEO

Site: COLLEGE OF MARIN
Sounding: CPT-4

Engineer: J.VANDENBERG
Date: 5/1/17 06:48



Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

UNIFIED SOIL CLASSIFICATION CHART

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS: more than 50% retained on No. 200 sieve	COARSE GRAINED SOILS: 50% or more of coarse fraction on No. 4 sieve	CLEAN GRAVELS	GW	Well graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH SAND	GM	Silty gravels and gravel-sand-silt mixtures
			GC	Clayey gravels and gravel-sand-clay mixtures
	SANDS: more than 50% passing on No. 4 sieve	CLEAN SANDS	SW	Well graded sands and gravelly sand, little or no fines
			SP	Poorly graded sands and gravelly sand, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS: 50% or more passing No. 200 sieve	SILTS AND CLAY: Liquid Limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAY: Liquid Limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic clays
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS			PT	Peat, muck, and other highly organic soils

BOUNDARY CLASSIFICATION AND GRAIN SIZES

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

U.S. Standard No. 200	No. 40	No. 10	No. 4	3/4"	3"	12"
Sieve Sizes 0.075 mm	0.425 mm	2 mm	3/16"			

SYMBOLS

⧗ Modified California (MC) Sampler (3" O.D.)	▯ ROCK CORE (RC)	✋ Disturbed Sample
⧗ Standard Penetration Test: SPT (2" O.D.)	■ Shelby Tube, pushed or used Ostenberg Sampler	Water Levels ▽ At time of drilling ▼ At end of drilling ⧗ After drilling

ABBREVIATIONS

Item	Meaning
LL	Liquid Limit (%) (ASTM D 4318)
PI	Plasticity Index (%) (ASTM D 4318)
-200	Passing No. 200 (%) (ASTM D 1140)
TXCU	Laboratory consolidated undrained triaxial test of undrained shear strength (psf) (ASTM D 4767)
TXUU	Laboratory unconsolidated, undrained triaxial test of undrained shear strength (psf) (ASTM D 2850)
psf/tsf	pounds per square foot / tons per square foot
psi	pounds per square inch
OD	Outside Diameter
ID	Inside Diameter

NOTES

1. Stratification lines represent the approximate boundaries between material types and the transitions may be gradual.
2. Modified California (MC) blow counts were adjusted by multiplying field blow counts by a factor of 0.63.
3. Recorded blow counts have not been adjusted for hammer energy.

A3GEO

KEY TO EXPLORATORY BORING LOGS

A3GEO, Inc.
1331 7th Street; Unit E
Berkeley, CA 94710
Telephone: 510-705-1664

BORING NUMBER B-1

CLIENT College of Marin

PROJECT NAME Kentfield M&O Building

PROJECT NUMBER 1106-8A

PROJECT LOCATION Kentfield, CA

DATE STARTED 5/1/17 **COMPLETED** 5/1/17

GROUND ELEVATION 8 ft **HOLE SIZE** 6"

DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.

GROUND WATER LEVELS:

DRILLING METHOD Hollow Stem Auger

▽ **AT TIME OF DRILLING** 6.50 ft / Elev 1.50 ft

LOGGED BY JV **CHECKED BY** DKM

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0	▩	POORLY-GRADED SAND (SP) - brown, loose, fine to medium grained, trace subrounded gravel, moist [FILL]	GB						
5			MC	4	0.75	95	28		
	▥	▽ SILT (ML) - brown, medium stiff, with silt, no sand or gravel, thin rootlets, moist							
	▰	Fat Clay (CH) - dark gray, soft, some fine sand, with silt, wet							
10			MC	4	0				
	▨	Sandy Lean Clay (CL) - gray, fine sand, medium stiff, wet							
15			ST			98	27		Consolidation Test TXUU: c = 652psf PI = 13 LL=33
20		- grayish brown, medium stiff to stiff, moderate plasticity	MC	8	1.0				
25			ST		0.75	99	26		Consolidation Test TXUU: c = 1,370psf PI = 22 LL=46
30		- increase plasticity, decrease sand	MC	8	0.75				
		- silty sand lens							
35									

(Continued Next Page)

BORING NUMBER B-1

CLIENT College of Marin
PROJECT NAME Kentfield M&O Building
PROJECT NUMBER 1106-8A
PROJECT LOCATION Kentfield, CA
DATE STARTED 5/1/17 **COMPLETED** 5/1/17
GROUND ELEVATION 8 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
∇ **AT TIME OF DRILLING** 6.50 ft / Elev 1.50 ft
LOGGED BY JV **CHECKED BY** DKM
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
35	▨	Sandy Lean Clay (CL) - grayish brown, fine sand, medium stiff to stiff, wet							
40	▨								
45	▨	- decrease plasticity, increase sand, with silt - increase stiffness - fine to medium grained sandy clay at bottom of sample	ST		>4.5				

Bottom of borehole at 47.5 feet.
1. Stratification lines represent the approximate boundaries between material types. Transistions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Groundwater measured at 6.5' at time of drilling.
4. Hole was backfilled immediately after drilling.

A3GEO, Inc.
1331 7th Street; Unit E
Berkeley, CA 94710
Telephone: 510-705-1664

BORING NUMBER B-2

PAGE 1 OF 2

CLIENT	College of Marin	**PROJECT NAME**	Kentfield M&O Building
PROJECT NUMBER	1106-8A	**PROJECT LOCATION**	Kentfield, CA
DATE STARTED	5/1/17 **COMPLETED** 5/1/17	**GROUND ELEVATION**	8 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR	Gregg Drilling and Testing, Inc.	**GROUND WATER LEVELS:**	
DRILLING METHOD	Hollow Stem Auger	**AT TIME OF DRILLING**	---
LOGGED BY	JV **CHECKED BY** DKM	▼ **AT END OF DRILLING**	6.00 ft / Elev 2.00 ft
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
0	▨	CLAYEY SAND (SC) - brown/gray, loose, with gravel, moist [FILL]	GB						
	▨	SANDY LEAN CLAY (CL) - gray, medium stiff, fine grained sand, with silt, moist to wet							
5		▼							
10									
15									
20									
25									
30									
35									

(Continued Next Page)

A3GEO, Inc.
1331 7th Street; Unit E
Berkeley, CA 94710
Telephone: 510-705-1664

BORING NUMBER B-2

CLIENT College of Marin
PROJECT NAME Kentfield M&O Building
PROJECT NUMBER 1106-8A
PROJECT LOCATION Kentfield, CA
DATE STARTED 5/1/17 **COMPLETED** 5/1/17
GROUND ELEVATION 8 ft **HOLE SIZE** 6"
DRILLING CONTRACTOR Gregg Drilling and Testing, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY JV **CHECKED BY** DKM
▼ **AT END OF DRILLING** 6.00 ft / Elev 2.00 ft
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	ADJUSTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	% RECOVERED	OTHER LAB TESTS / NOTES
35	▨	SANDY LEAN CLAY (CL) - gray, medium stiff, fine grained sand, with silt, moist to wet*(continued)* - medium stiff to stiff - increase sand, decrease plasticity, wet	ST		0.75 1.5				1,000 psi down pressure
40									
45									
50									
55									
60		POORLY-GRADED SAND (SP) - gray, medium dense, medium to coarse grained, trace silt, wet	MC	18	1.0				
	▨	SANDY LEAN CLAY (CL) - brownish gray, stiff, very fine grained sand, with silt, moderate plasticity, wet							

Bottom of borehole at 61.5 feet.
1. Stratification lines represent the approximate boundaries between material types. Transitions may be gradual.
2. Blow counts shown here for MC samples have been adjusted to SPT values by multiplying field blow counts by a factor of 0.63.
3. Groundwater measured at 6' after drilling.
4. Hole was backfilled immediately after drilling.

GEOTECH BH COLUMN TERM NOTE LEFT ALIGNED - A3GEO DATA TEMPLATE.GDT - 6/2/17 19:12 - A:\A3GEO PROJECTS\1106 - COM\1106-8A KENTFIELD M&O BUILDING\BORELOGS\1106-8A-BORELOGS.GPJ

LOG OF BORING B-1 ①

LOCATION: See Figure I-1
④ BORING SURFACE ELEVATION: 10'
EXISTING FORCEMAIN INVERT ELEVATION: 6'

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ③	DESCRIPTION ②	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
	1				**SILTY LEAN CLAY WITH SAND (CL/ML) TO SILTY SAND (SM) - FILL** - yellowish brown - few to little clay - nonplastic - moist ⑤										
5						10									
	2		4		**FAT CLAY (CH) and ORGANIC CLAY (OH) - YOUNG BAY MUD** - very dark gray - some silt, few to little sand - trace to few peat - high plasticity - very soft to soft - moist to wet	71	58						1.03		
10	3		3												
	4		2					55	26		11	89 **FINES** 49% Silt 40% Clay			
15	5		pushed												
						30	94								
	6		8	▼	**LEAN CLAY (CL) and ORGANIC CLAY (OL/OH) - BAY MUD** - dark greenish gray with dark gray brown mottling - some silt, few sand - trace peat - medium to high plasticity - medium stiff - wet	32	91							300	15°
	7		10								7	93 **FINES** 46% Silt 47% Clay			
20	8		6					40	17						
	9		9		**FAT CLAY (CH) - BAY MUD** - dark greenish gray with variegated olive brown - few silt, trace sand - high plasticity - soft to medium stiff - wet	31	101						1.22		
25	10		10												
	11		4												

CONSOLIDATION TEST
SAMPLE 5 (15-1/2 ft)
$C_C = 0.26$
$e_O = 0.835$
Preconsolidation Pressure = 2.7 ksf

CONTINUED ON FIGURE B-1 (2 OF 2) AT 27 FEET

NOTES
① Drilled 9/23/08 using a Mobile B24 drill rig, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text in Section I and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level measured in boring at depth of 17 feet after drilling. Static groundwater depth is unknown.
④ Approximated from existing forcemain plans (Nute, 1972) and September 2008 Mark Thomas & Company survey.
⑤ Projected existing 36" forcemain pipeline.

DCM | GEOENGINEERS

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, CA
LOG OF BORING B-1

FIGURE
B-1
(1 of 2)

FILE NO. 18174-001-00
JANUARY 2010

LOG OF BORING B-1 CONT'D①

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER	DESCRIPTION	% MOISTURE %	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE			UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR	
										Gravel (> #4 sieve) %	Sand (#4 to #200 sieve) %	Fines (< #200 sieve) %		Cohesion p.s.f.	Internal Friction Angle
	11		4		**CONTINUED FROM FIGURE B-1 (1 OF 2) AT 27 FEET**										
					FAT CLAY (CH) - BAY MUD - dark greenish gray with variegated olive brown - few silt, trace sand - high plasticity - soft to medium stiff - wet										
30															
	12		7			25									
35					**FAT CLAY (CH) - BAY MUD** - dark greenish gray - few silt, trace sand - high plasticity - stiff - wet										
	13		12			25									
40					**BOTTOM OF BORING AT 40 FEET**										
45															
50															

NOTES

① see notes on Figure B-1 (1 of 2).

DCM | GeoEngineers

FILE NO. 18174-001-00

JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

LOG OF BORING B-1 CONT'D

FIGURE
B-1
(2 of 2)

LOG OF BORING B-2 ①

LOCATION: See Figure I-1

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ③	DESCRIPTION ②	MOISTURE	DRY DENSITY lbs./ft.^{3}	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (>#4 sieve) %	Sand (#4 to #200 sieve) %	Fines (<#200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	Internal Friction Angle
					McALLISTER AVENUE: 6" ASPHALTIC CONCRETE										
					SILTY SAND (SM) to SILTY LEAN CLAY WITH SAND (CL/ML) - brownish yellow - few to little clay, trace gravel - completely-weathered bedrock - nonplastic - moist to dry										
5	1	☒				15									
					SILTY SANDSTONE to SANDY SILTSTONE - greenish gray and yellowish brown - few to little clay-sized particles - very soft to soft rock hardness - very severe to severe weathering										
	2	☒													
10	3	◣	50/5"			13	118						3.97		
	4	◣	50/5"												
				▼											
15															
	5	◣	73			10				7 ④	52	41			
20				▽											
					CLAYEY SILTSTONE - blue gray - medium to moderately hard rock hardness - slight to moderate weathering										
	6	◣	50/4"												
25	7	◣	50/0"												
					BOTTOM OF BORING AT 25 FEET **(DRILLING REFUSAL IN BEDROCK)**										

FINES
28% Silt
13% Clay

DRILL RATE

DEPTH INTERVAL (ft)	**AVERAGE DRILL RATE**
12 - 17	4 minutes/foot
18 - 23	6 minutes/foot
24 - 25	8 minutes/foot
25	2 minutes, no advance

NOTES
① Drilled 9/26/08 using a Mobile B24 drill rig, 5" diameter solid stem augers, rock bit, and a 30" drop by 140 lb. cathead sampling hamme
② See report text in Section I and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level measured in boring at depth of 13 feet after drilling. Static equilibrium groundwater depth is unknown.
④ Cemented gravel-size bedrock particles that did not disaggregate during grain size analysis.

DCM | GEOENGINEERS

FILE NO. 18174-001-00
JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California
LOG OF BORING B-2

FIGURE
B-2

LOG OF BORING B-3 ①

LOCATION: See Figure I-1

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ③	DESCRIPTION ②	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	Sand (#4 to #200 sieve) %	Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	Internal Friction Angle
					McALLISTER AVENUE: 6" ASPHALTIC CONCRETE OVER 8" AGGREGATE BASE (SILTY GRAVEL - GM)										
	1	☒			**LEAN TO FAT CLAY (CL/CH)** - very dark gray - few silt, trace sand - high plasticity - moist to wet	26									
5	2	■	18	▼	**LEAN CLAY WITH SAND (CL) grading below to CLAYEY SAND (SC)** - brownish yellow with greenish gray halos around rootlet pores - little to some silt - medium plasticity - stiff clay, loose to medium dense sand - wet to moist	25	98						3.48		
10	3	■	69		**SILTY SANDSTONE and SANDY SILTSTONE** - layered yellowish brown and light gray - few chert concretions - medium to moderately hard rock hardness, except for hard to very hard chert concretions - severe to moderate weathering	14	122						4.76		
	4	■	83/11"												
	5	◣	50/3"												
15				▽											
	6	◣	50/1"												
20															
	7	◣	50/2"												
					BOTTOM OF BORING AT 23 FEET **(DRILLING REFUSAL IN BEDROCK)**										
25															

DRILL RATE

DEPTH INTERVAL (ft)	AVERAGE DRILL RATE
13 - 18	7 minutes/foot
18 - 23	12 minutes/foot

NOTES

① Drilled 9/26/08 using a Mobile B24 drill rig, 5" diameter solid stem augers, rock bit, and a 30" drop by 140 lb. cathead sampling hamme

② See report text in Section I and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.

③ Free groundwater level measured in boring at depth of 6 feet after drilling. Static equilibrium groundwater depth is unknown.

DCM | GeoEngineers

FILE NO. 18174-001-00

JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California
LOG OF BORING B-3

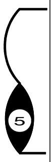
FIGURE
B-3

LOG OF BORING B-4 ①

LOCATION: See Plate I-1

④ BORING SURFACE ELEVATION: 8'
EXISTING FORCEMAIN INVERT ELEVATION: 2 to 6'

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ③	DESCRIPTION ②	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					SANDY LEAN CLAY (CL) TO CLAYEY SAND WITH GRAVEL (SC) - FILL - olive brown - medium plasticity fines - wet										
	1	☒								18	45	37			
5				▼											
	2	☒						40	18						
	3		pushed		**ORGANIC CLAY (OH) and FAT CLAY (CH) - YOUNG BAY MUD**	57	68						0.82		
10	4	■	2		- dark greenish gray - few silt, trace sand - trace to few peat, and sulfur odor - high plasticity			127	79						
	5		pushed			95	48							270	12°
	6	◣	1		- very soft - wet										
15															
					SILTY SAND (SM) from 18½' to 19½'										
	7	◣	1		- nonplastic - very loose - wet					20	70	10			
20					**BOTTOM OF BORING AT 20 FEET**										
25															



CONSOLIDATION TEST
SAMPLE 5 (13 ft)
$C_C = 0.92$
$e_O = 2.71$
Preconsolidation Pressure = 0.84 ksf

NOTES
① Drilled 9/23/08 using a Mobile B24 drill rig, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text in Section I and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ Free groundwater level measured in boring at depth of 5 feet after drilling. Static groundwater depth is unknown.
④ Approximated from existing forcemain plans (Nute, 1972) and September 2008 Mark Thomas & Company survey.
⑤ Projected existing 36" forcemain pipeline where invert elevation = El. 2'.

DCM | GeoEngineers

FILE NO. 18174-001-00 | JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California
LOG OF BORING B-4

FIGURE
B-4

LOG OF BORING B-5 ①

LOCATION: See Plate I-1
④ BORING SURFACE ELEVATION: 53'
PROJECTED STATION: 81+00
NEW FORCEMAIN INVERT ELEVATION: 42'

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER ③	DESCRIPTION ②	MOISTURE	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE			UNCONFINED COMPRESSIVE STRENGTH k.s.f.	DIRECT SHEAR	
										Gravel (>#4 sieve) %	Sand (#4 to #200 sieve) %	Fines (<#200 sieve) %		Cohesion p.s.f.	Internal Friction Angle
					UPPER VIA CASITAS AT S. ELISEO DR.: **6" ASPHALTIC CONCRETE**										
	1	☒			**SILTY SAND (SM)** - blue gray - completely-weathered sandstone - nonplastic	7									
5	2	◤	50/1"		**SILTY SANDSTONE** - blue gray and olive - moderately hard rock - moderately weathered - dry										
					BOTTOM OF BORING AT 5½ FEET **(DRILLING REFUSAL IN BEDROCK)** ⑤										
10															
15															
20															
25															

DRILL RATE

DEPTH INTERVAL (ft)	AVERAGE DRILL RATE
0 - 5	4 minutes/foot
5 - 5½	10 minutes total

NOTES

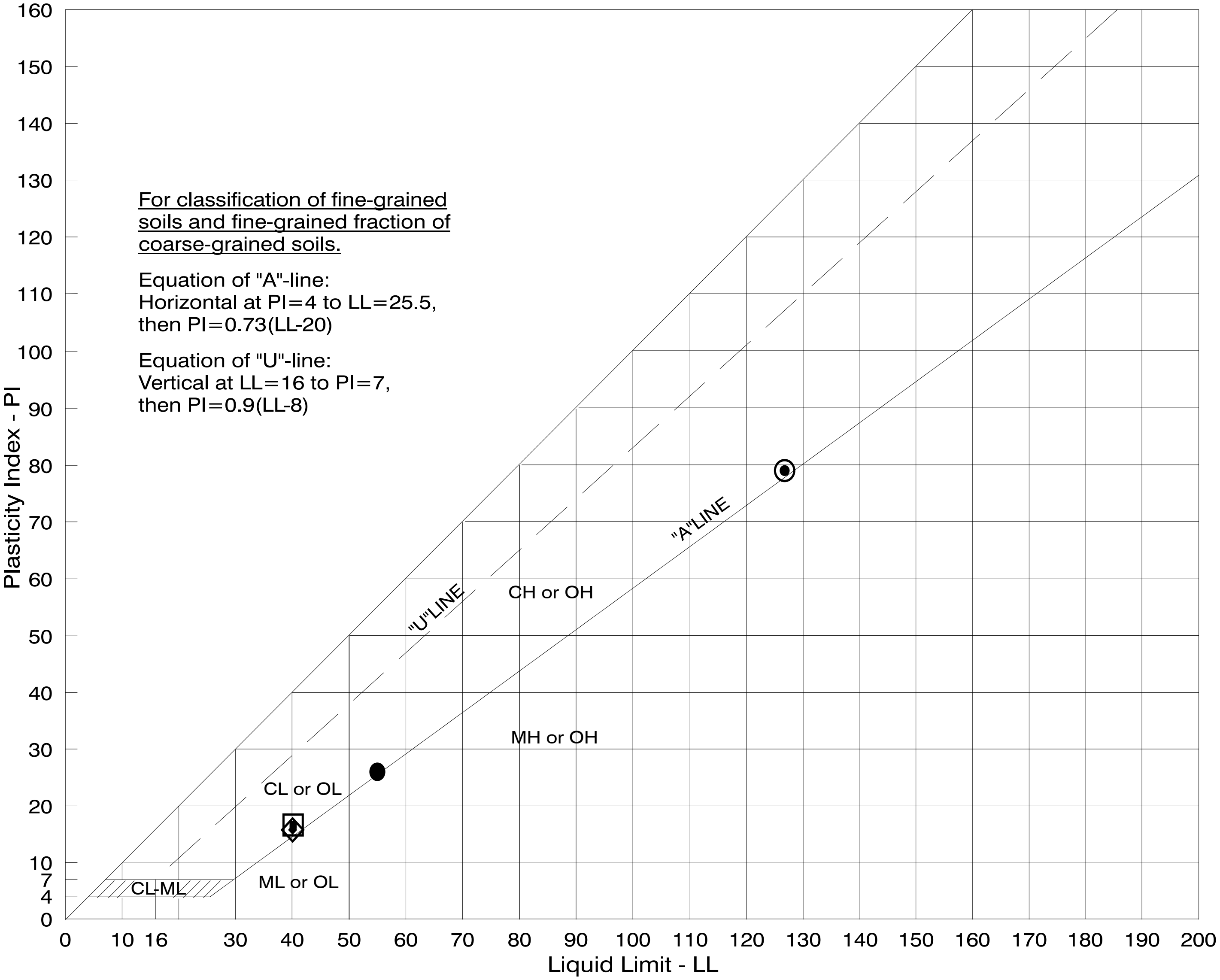
① Drilled 9/23/08 using a Mobile B24 drill rig, 5" diameter solid stem augers, and a 30" drop by 140 lb. cathead sampling hammer.
② See report text in Section I and figures in Appendices A and C for definitions, lab test results, and additional soil descriptions.
③ No free groundwater level encountered during drilling. Static equilibrium groundwater depth is unknown.
④ Rounded from in-progress plans (Brown and Caldwell, 2009).
⑤ Projected new 42" forcemain pipeline.

DCM | GEOENGINEERS

FILE NO. 18174-001-00 | JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California
LOG OF BORING B-5

FIGURE
B-5



For classification of fine-grained soils and fine-grained fraction of coarse-grained soils.

Equation of "A"-line:
Horizontal at PI=4 to LL=25.5,
then PI=0.73(LL-20)

Equation of "U"-line:
Vertical at LL=16 to PI=7,
then PI=0.9(LL-8)

TEST SYMBOL	BORING SAMPLE NO.	DEPTH (ft)	LIQUID LIMIT - LL	PLASTICITY INDEX - PI	RATIO①	GROUP ② SYMBOL
●	B-1-4	11-13	55	26	0.8	CH
◈	B-1-8	19½-21½	40	17	0.88	CL
⊡	B-4-2	5-6	40	18	not run	CL
⊙	B-4-4	9-10½	127	79	0.35	OH

① If ratio of Liquid Limit (oven dried) to Liquid Limit (not dried) is less than 0.75, specimen classifies as organic
② Classification of fines < 0.425mm

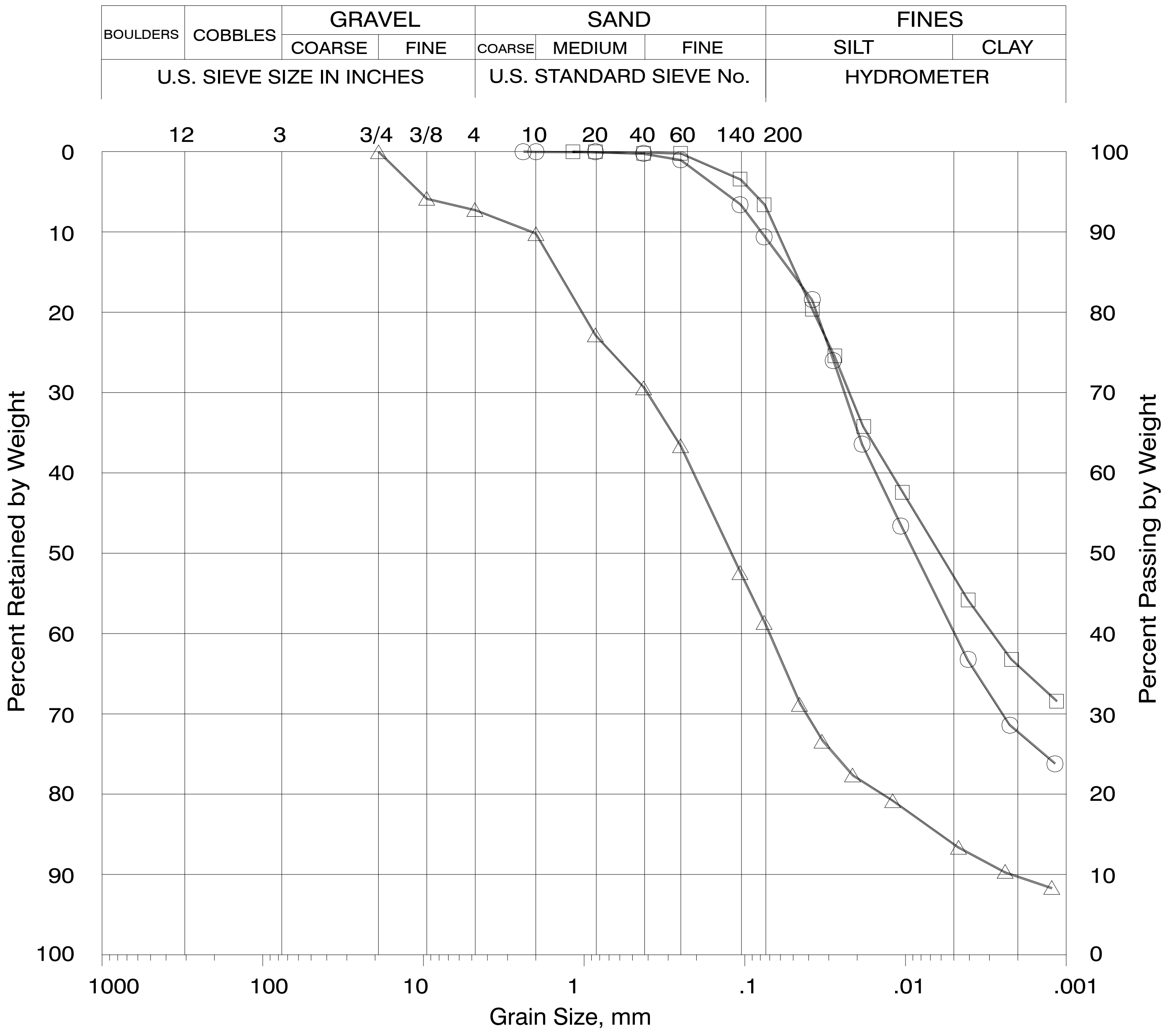
DCM | GeoEngineers

FILE NO. 18174-001-00 JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

PLASTICITY INDEX

FIGURE
C-1



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (feet)
○	B-1-4	11-13
□	B-1-7	18-19½
△	B-2-5	17-18½

NOTE: The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Figure A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

DCM | GEOENGINEERS

FILE NO. 18174-001-00 | JANUARY 2010

BROWN & CALDWELL

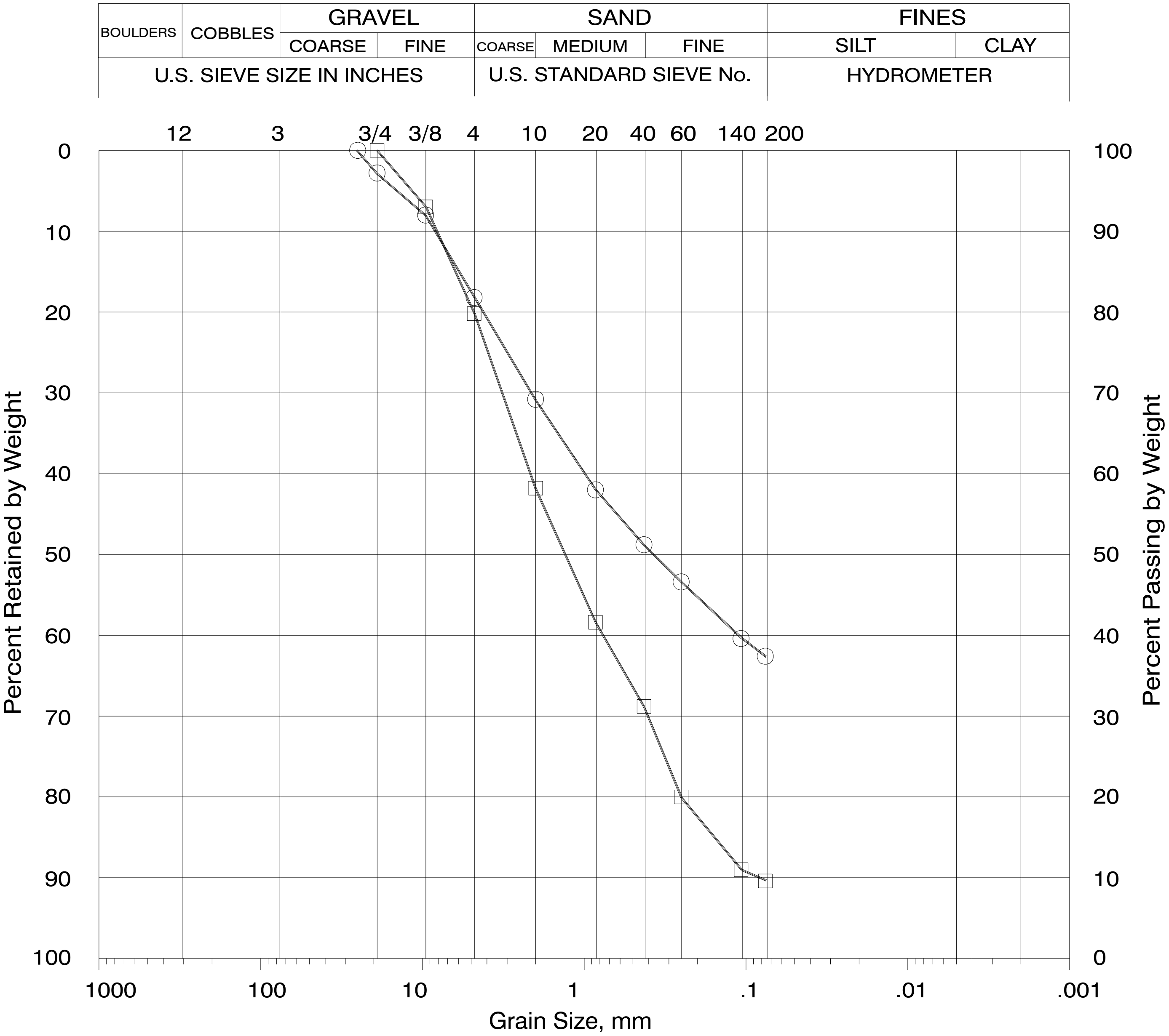
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

GRAIN SIZE ANALYSIS

FIGURE

C-2

(1 of 2)



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (feet)
○	B-4-1	2-3
□	B-4-7	18½-19½

NOTE: The largest particle (grain) size that could have been sampled from our borings by our sample barrels is a function of the inside diameter of the sample barrels used (see Figure A-1). Therefore, there may be larger particles (e.g., coarse gravel, cobbles or boulders) in the soils sampled than reflected on the boring logs and grain size distribution curves provided in this report.

DCM | GeoEngineers

BROWN & CALDWELL

Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

GRAIN SIZE ANALYSIS

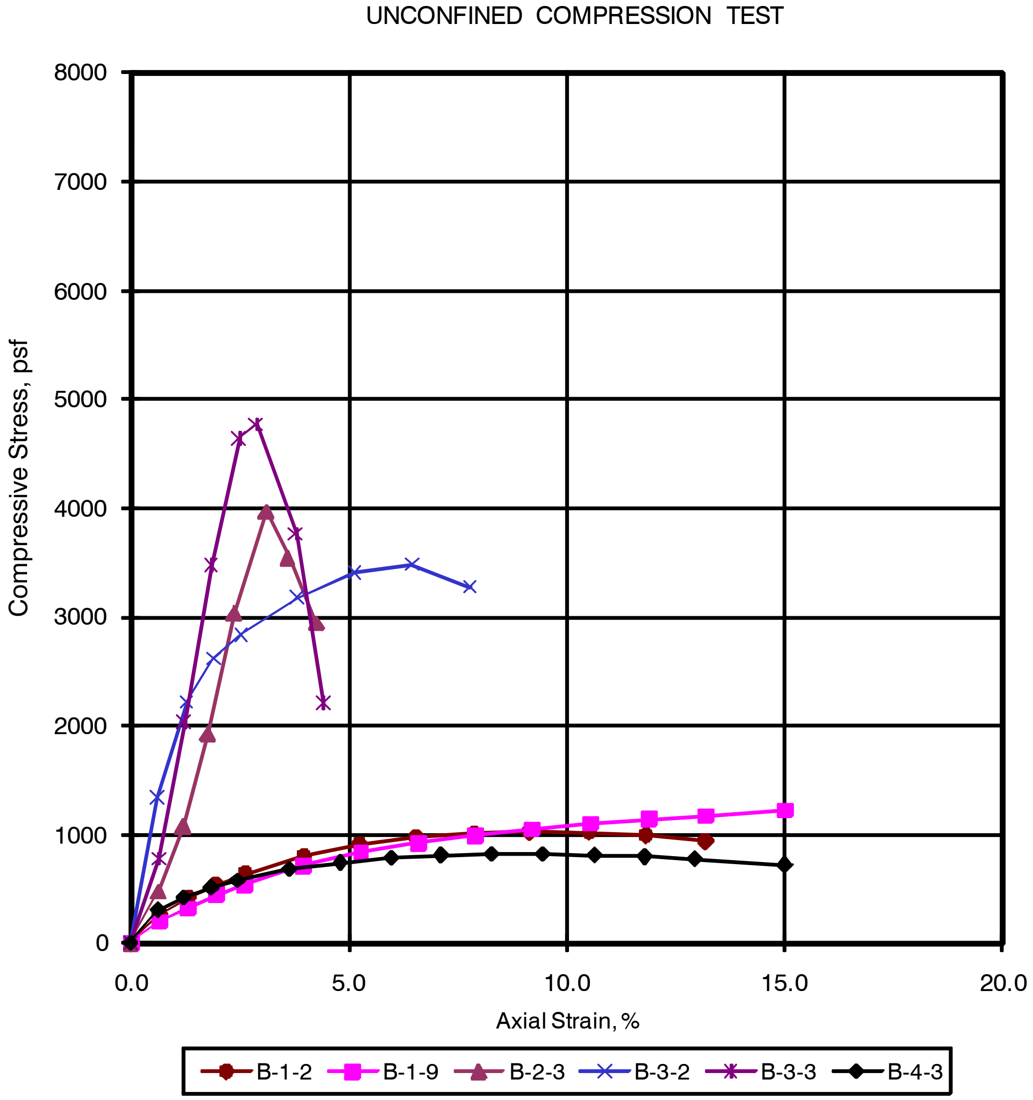
FIGURE

C-2

(2 of 2)

FILE NO. 18174-001-00

JANUARY 2010



BORING SAMPLE NO.	B-1-2	B-1-9	B-2-3	B-3-2	B-3-3	B-4-3
MAXIMUM UNCONFINED STRESS, psf	1026	1222	3965	3479	4762	824
% STRAIN @ PEAK STRESS	9.2	15.0	3.1	6.5	2.9	8.3
DEPTH, ft.	9-9½	24-24½	11-11½	6-6½	11-11½	8-8½
WATER CONTENT, %	71	31	13	25	14	57
DRY DENSITY, pcf	58	101	118	98	122	68
SATURATION, %	100	100	83	93	96	100

Maximum Unconfined Stress cut-off = 15% strain
Average Strain Rate = 0.07 in/min.

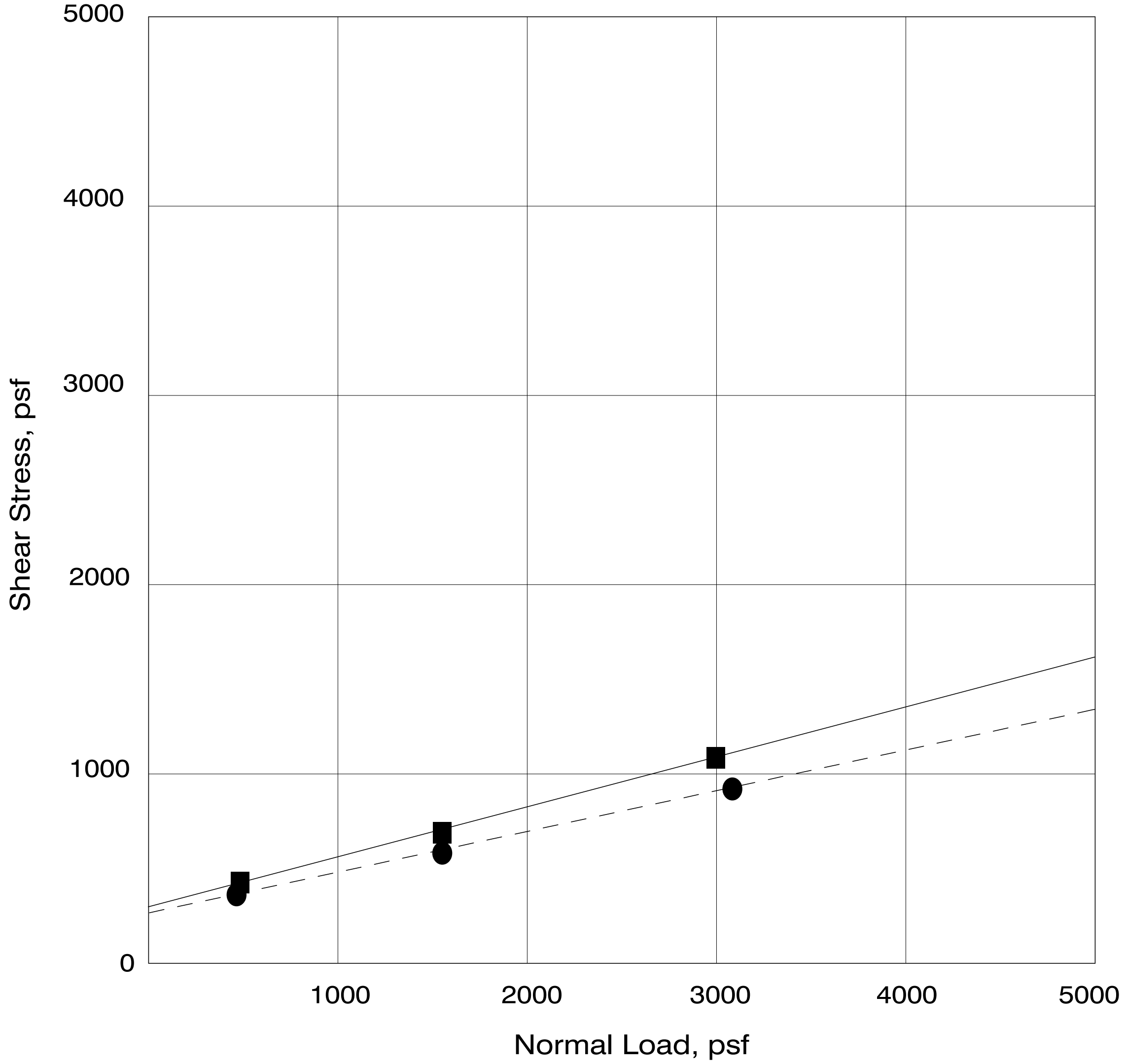
DCM | GEOENGINEERS

FILE NO. 18174-001-00 JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

UNCONFINED COMPRESSION

FIGURE
C-3



TEST SYMBOL	GRAPH LINE	BORING SAMPLE NO.	DEPTH (ft)	COHESION (p.s.f.)	INTERNAL FRICTION ANGLE (degrees)	AVE. DRY DENSITY (pcf)/ MOISTURE CONTENT (%)	
						BEFORE TEST	AFTER TEST
■	———	B-1-6	17½-18	300	15	91/32	93/30
●	– – – -	B-4-5	12½-13	270	12	48/95	52/82

DCM | GEOENGINEERS

FILE NO. 18174-001-00

JANUARY 2010

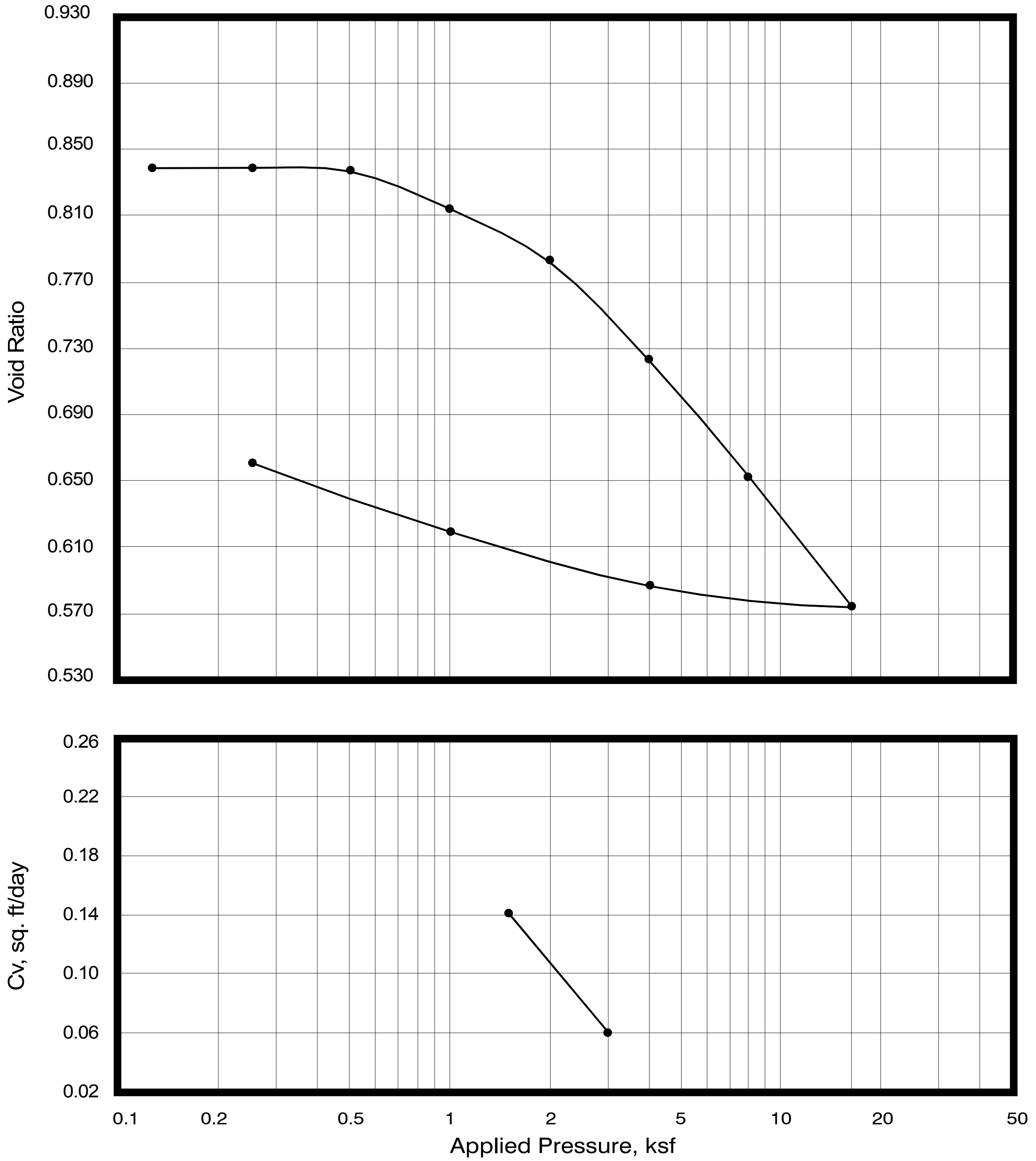
BROWN & CALDWELL

Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

DIRECT SHEAR

FIGURE

C-4



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (ft)	BEFORE TEST CONDITIONS			PRE-CONSOLIDATION PRESSURE (ksf)	C_r	C_c	e_o
			SATURATION (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)				
●	B-1-5	15½	96	30	94	2.70	0.05	0.26	0.835

DCM | GeoEngineers

FILE NO. 18174-001-00

JANUARY 2010

BROWN & CALDWELL

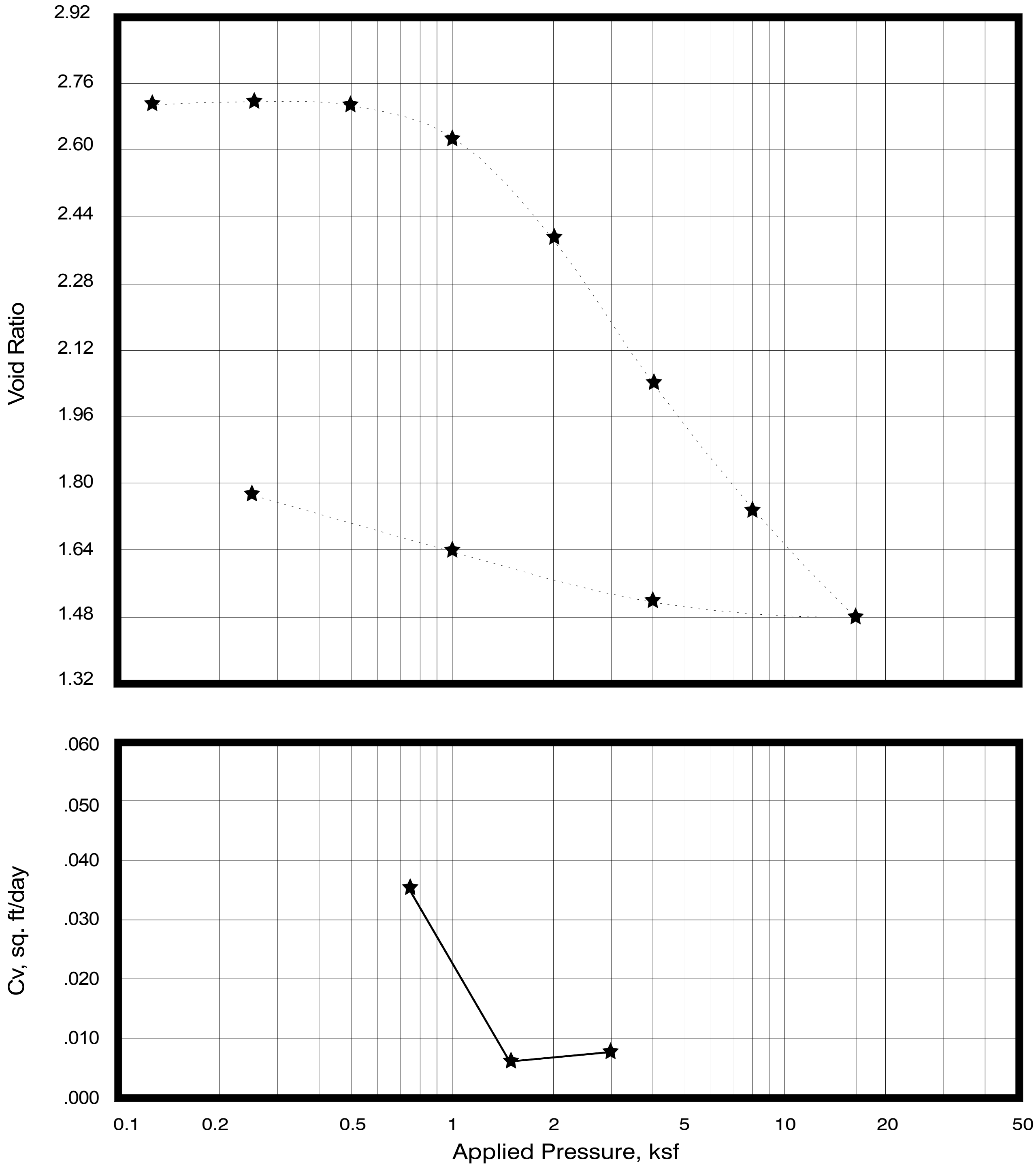
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

CONSOLIDATION

FIGURE

C-5

(1 of 2)



TEST SYMBOL	BORING SAMPLE NO.	DEPTH (ft)	BEFORE TEST CONDITIONS			PRE-CONSOLIDATION PRESSURE (ksf)	C_r	C_c	e_o
			SATURATION (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)				
★	B-4-5	13	93	94	47	0.84	0.16	0.92	2.710

DCM | GeoEngineers

FILE NO. 18174-001-00

JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

CONSOLIDATION

FIGURE

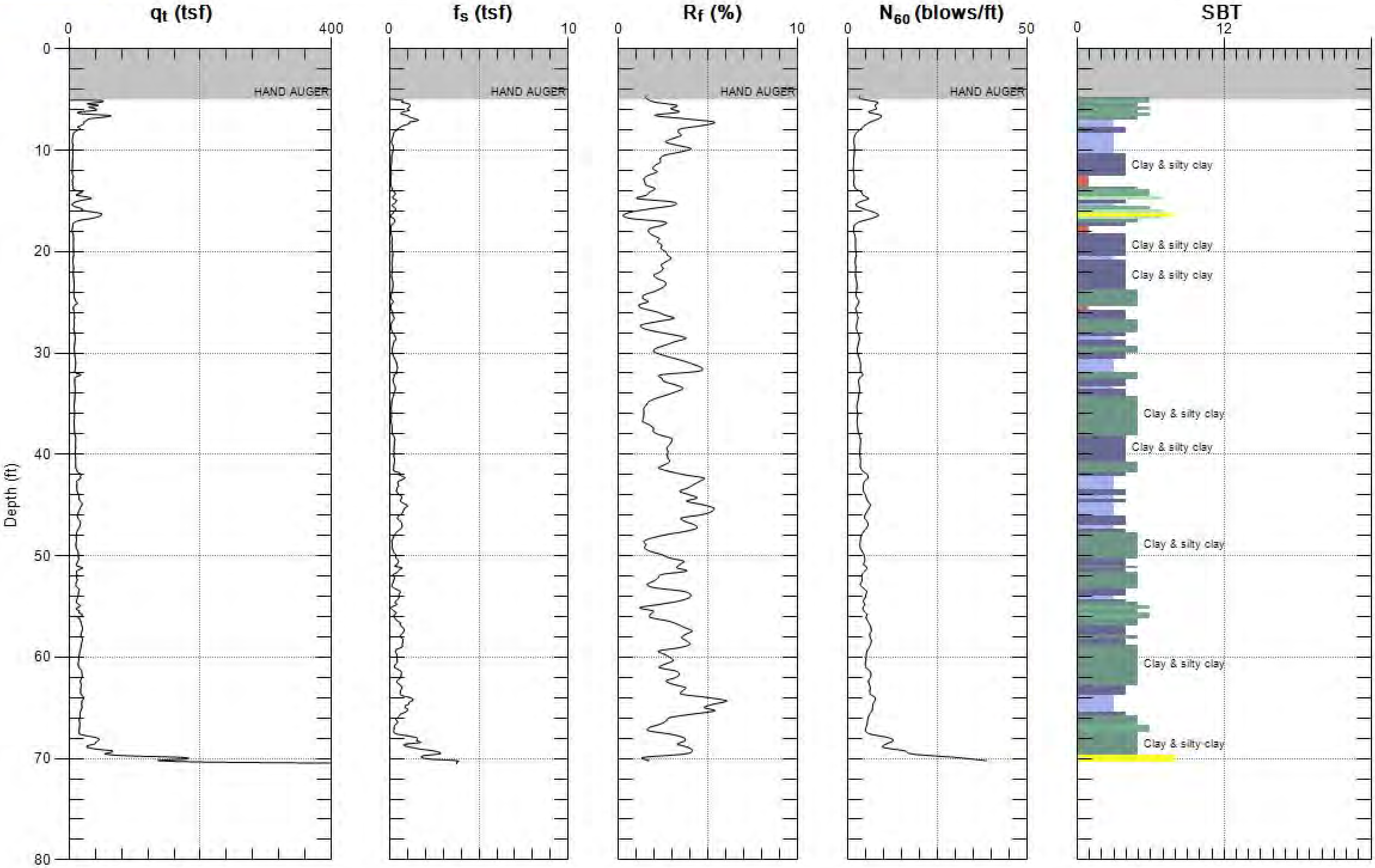
C-5

(2 of 2)

DCM/GEOENGINEERS

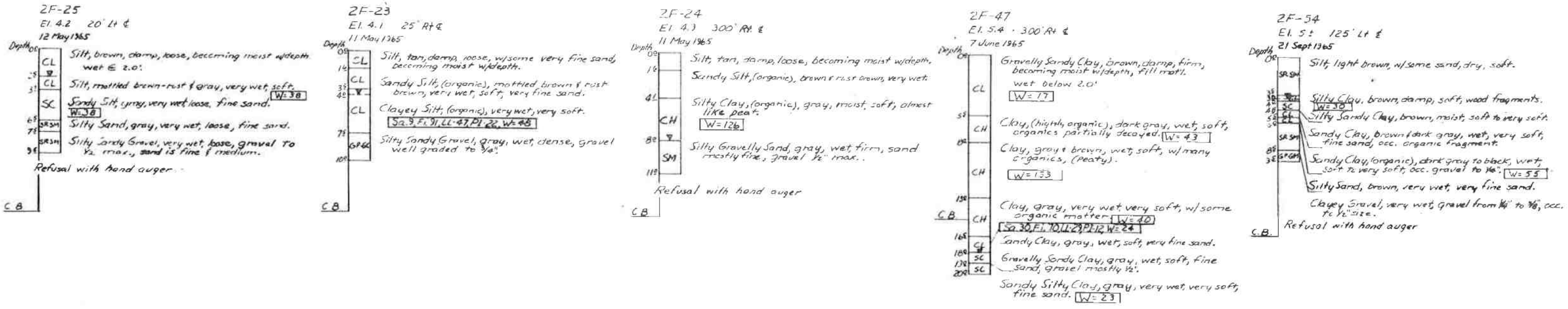
Site: KENTFIELD FORCE
Sounding: CPT-02

Engineer: D.NEILSON
Date: 2009-12-01 11:02



Max. Depth: 70.538 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



LEGEND:

Gr 10 = 10 percent gravel
Sa 20 = 20 percent sand
Fi 70 = 70 percent fines
LL 25 = Liquid Limit 25 percent
PI 5 = Plasticity Index = 5
G : Specific gravity
O = Organic Content = 7 percent
W : Moisture content
▼ : Free water level at completion of hole
▭ : Laboratory test results
C B : Channel Bottom (Proposed)
2F : Auger boring
7F Undisturbed Sample boring
|P| Undisturbed push tube sample

Reference: United States Army Corps of Engineers (USACE), 1967, Design Memorandum No. 2 Corte Madera Creek Flood Control Project, Marin County, California Local Protection Works Bon Air Road to Sir Francis Drake Boulevard; dated: November, 1967, U.S. Army Engineer District, San Francisco, California.

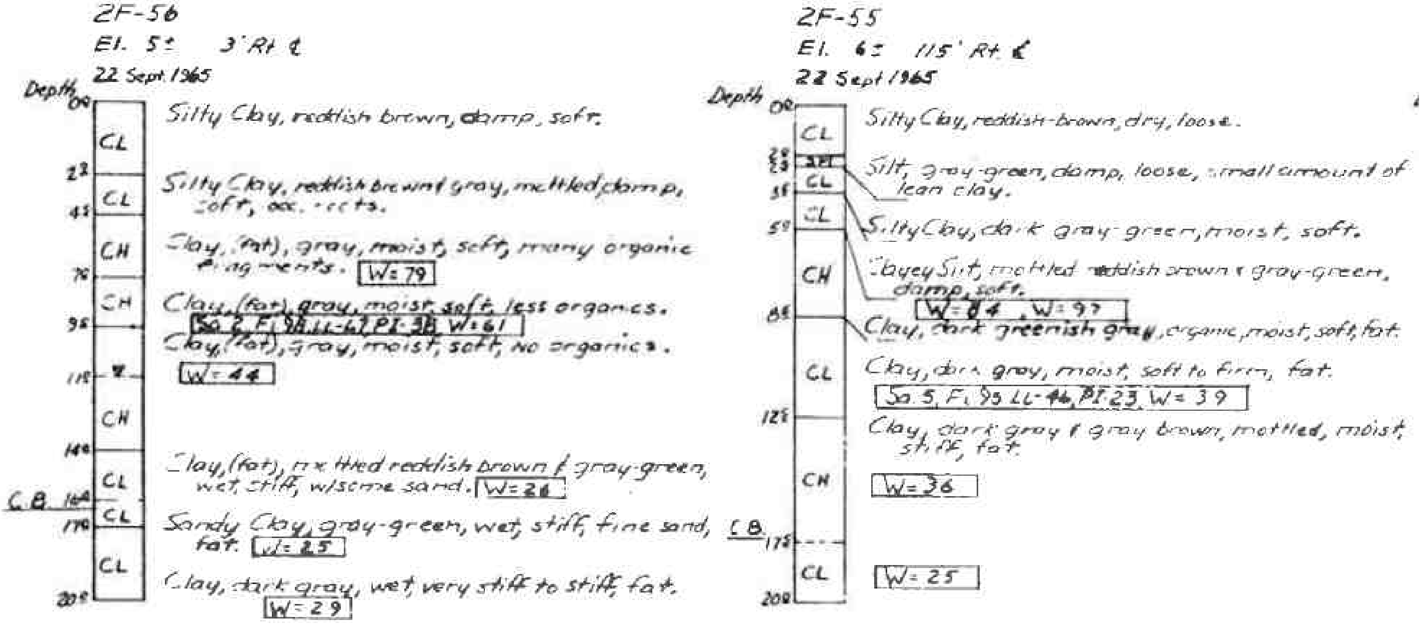
DCM | GEOENGINEERS

FILE NO. 18174-001-00 | JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

LOG OF REFERENCE
BORINGS 2F-25 TO 2F-54

FIGURE
F-5



LEGEND:

Gr 10 = 10 percent gravel
Sa 20 = 20 percent sand
Fi 70 = 70 percent fines
LL 25 = Liquid Limit 25 percent
PI 5 = Plasticity Index = 5
G = Specific gravity
O = Organic Content = 7 percent
W = Moisture content
▼ = Free water level at completion of hole
☐ = Laboratory test results
C B = Channel Bottom (Proposed)
2F = Auger boring
7F Undisturbed sample boring
▯ Undisturbed push tube sample

Reference:

United States Army Corps of Engineers (USACE), 1967, Design Memorandum No. 2 Corte Madera Creek Flood Control Project, Marin County, California Local Protection Works Bon Air Road to Sir Francis Drake Boulevard; dated: November, 1967, U.S. Army Engineer District, San Francisco, California.

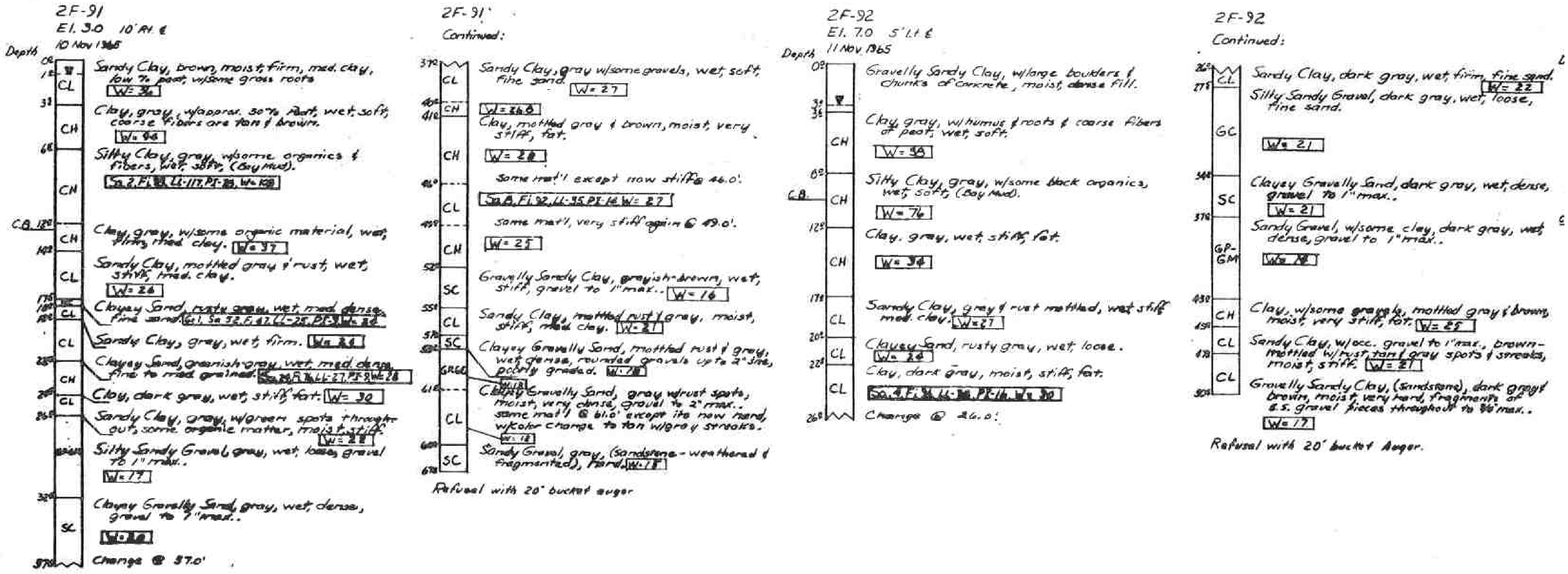
DCM | GeoEngineers

FILE NO. 18174-001-00
JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

LOG OF REFERENCE BORINGS 2F-55 & 2F-56

FIGURE
F-6



2F-91
El. 3.0 10' Rt. ℄
10 Nov 1965

Sandy Clay, brown, moist, firm, med. clay, low % peat, w/some grass roots [W= 36]

Clay, gray, w/approx. 30% Peat, wet, soft, coarse fibers are tan & brown. [W= 96]

Silty Clay, gray, w/some organics & fibers, wet, soft, (Bay Mud). [Sa 2, Fi 98, LL-117, PI-85, W= 108]

Clay, gray, w/some organic material, wet, firm, med. clay. [W= 37]

Sandy Clay, mottled gray & rust, wet, stiff, med. clay. [W= 26]

Clayey Sand, rusty gray, wet, med. dense, fine sand. [Gr 1, Sa 52, Fi 47, LL-25, PI-5, W= 26]

Sandy Clay, gray, wet, firm. [W= 24]

Clayey Sand, greenish-gray, wet, med. dense, fine to med. grained. [Sa 26, Fi 74, LL-27, PI-9, W= 28]

Clay, dark gray, wet, stiff, fat. [W= 30]

Sandy Clay, gray, w/green spots throughout, some organic matter, moist, stiff. [W= 28]

Silty Sandy Gravel, gray, wet, loose, gravel to 1" max.. [W= 17]

Clayey Gravelly Sand, gray, wet, dense, gravel to 1" max.. [W= 18]

Change @ 37.0'

2F-91
Continued:

Sandy Clay, gray w/some gravels, wet, soft, fine sand. [W= 27]

[W= 268]
Clay, mottled gray & brown, moist, very stiff, fat.
[W= 28]

Same mat'l except now stiff @ 46.0'.
[Sa 8, Fi 92, LL-35, PI-14, W= 27]

Same mat'l, very stiff again @ 49.0'.
[W= 25]

Gravelly Sandy Clay, grayish-brown, wet, stiff, gravel to 1" max.. [W= 16]

Sandy Clay, mottled rust & gray, moist, stiff, med. clay. [W= 21]

Clayey Gravelly Sand, mottled rust & gray, wet, dense, rounded gravels up to 2" size, poorly graded. [W= 18]

[W= 18]
Clayey Gravelly Sand, gray w/rust spots, moist, very dense, gravel to 2" max.. Same mat'l @ 61.0' except its now hard, w/color change to tan w/gray streaks. [W= 18]

Sandy Gravel, gray, (Sandstone - weathered & fragmented), hard. [W= 18]

Refusal with 20" bucket auger

2F-92
El. 7.0 5' Lt ℄
11 Nov 1965

Gravelly Sandy Clay, w/large boulders & chunks of concrete, moist, dense fill.

Clay, gray, w/humus & roots & coarse fibers of peat, wet, soft. [W= 58]

Silty Clay, gray, w/some black organics, wet, soft, (Bay Mud). [W= 76]

Clay, gray, wet, stiff, fat. [W= 34]

Sandy Clay, grey & rust mottled, wet, stiff, med. clay. [W= 27]

Clayey Sand, rusty gray, wet, loose. [W= 24]

Clay, dark gray, moist, stiff, fat. [Sa 4, Fi 96, LL-58, PI-16, W= 30]

Change @ 26.0'

2F-92
Continued:

Sandy Clay, dark gray, wet, firm, fine sand. [W= 22]

Silty Sandy Gravel, dark gray, wet, loose, fine sand. [W= 21]

Clayey Gravelly Sand, dark gray, wet, dense, gravel to 1" max.. [W= 21]

Sandy Gravel, w/some clay, dark gray, wet, dense, gravel to 1" max.. [W= 18]

Clay, w/some gravels, mottled gray & brown, moist, very stiff, fat. [W= 25]

Sandy Clay, w/occ. gravel to 1" max., brown-mottled w/rust, tan & gray spots & streaks, moist, stiff. [W= 21]

Gravelly Sandy Clay, (Sandstone), dark gray & brown, moist, very hard, fragments of S.S. gravel pieces throughout to ¾" max.. [W= 17]

Refusal with 20' bucket Auger.

LEGEND:

Gr 10 = 10 percent gravel
Sa 20 = 20 percent sand
Fi 70 = 70 percent fines
LL 25 = Liquid Limit 25 percent
PI 5 = Plasticity Index = 5
G : Specific gravity
O : Organic Content : 7 percent
W : Moisture content
▼ : Free water level at completion of hole
▭ : Laboratory test results
C B : Channel Bottom (Proposed)
2F : Auger boring
7F Undisturbed sample boring
Undisturbed push tube sample

Reference: United States Army Corps of Engineers (USACE), 1967, Design Memorandum No. 2 Corte Madera Creek Flood Control Project, Marin County, California Local Protection Works Bon Air Road to Sir Francis Drake Boulevard; dated: November, 1967, U.S. Army Engineer District, San Francisco, California.

DCM | GEOENGINEERS

FILE NO. 18174-001-00 JANUARY 2010

BROWN & CALDWELL
Sanitary District No. 1 of Marin County
Kentfield Forcemain Replacement Project
Marin County, California

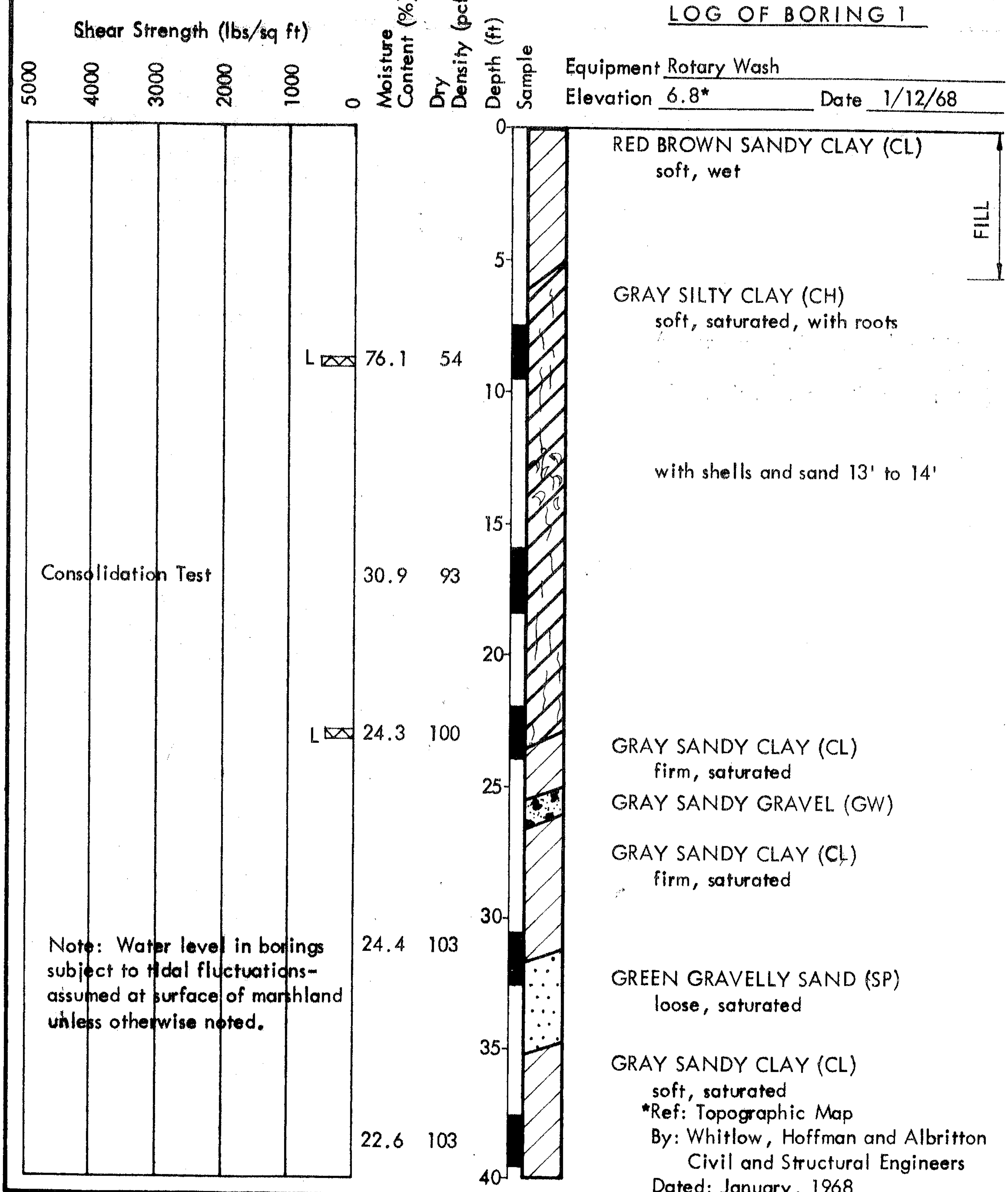
LOG OF REFERENCE
BORINGS 2F-91 & 2F-92

FIGURE
F-7

LOG OF BORING 1

Equipment Rotary Wash

Elevation 6.8* Date 1/12/68



Moisture Content (%)	Dry Density (pcf)
76.1	54
30.9	93
24.3	100
24.4	103
22.6	103

Consolidation Test

RED BROWN SANDY CLAY (CL)
soft, wet

GRAY SILTY CLAY (CH)
soft, saturated, with roots

with shells and sand 13' to 14'

GRAY SANDY CLAY (CL)
firm, saturated

GRAY SANDY GRAVEL (GW)

GRAY SANDY CLAY (CL)
firm, saturated

GREEN GRAVELLY SAND (SP)
loose, saturated

GRAY SANDY CLAY (CL)
soft, saturated

Note: Water level in borings subject to tidal fluctuations-assumed at surface of marshland unless otherwise noted.

*Ref: Topographic Map
By: Whitlow, Hoffman and Albritton
Civil and Structural Engineers
Dated: January, 1968

HARDING MILLER LAWSON & ASSOCIATES
soil mechanics engineers

Job No: 273.19 Appr: /rr Date: 2/6/68

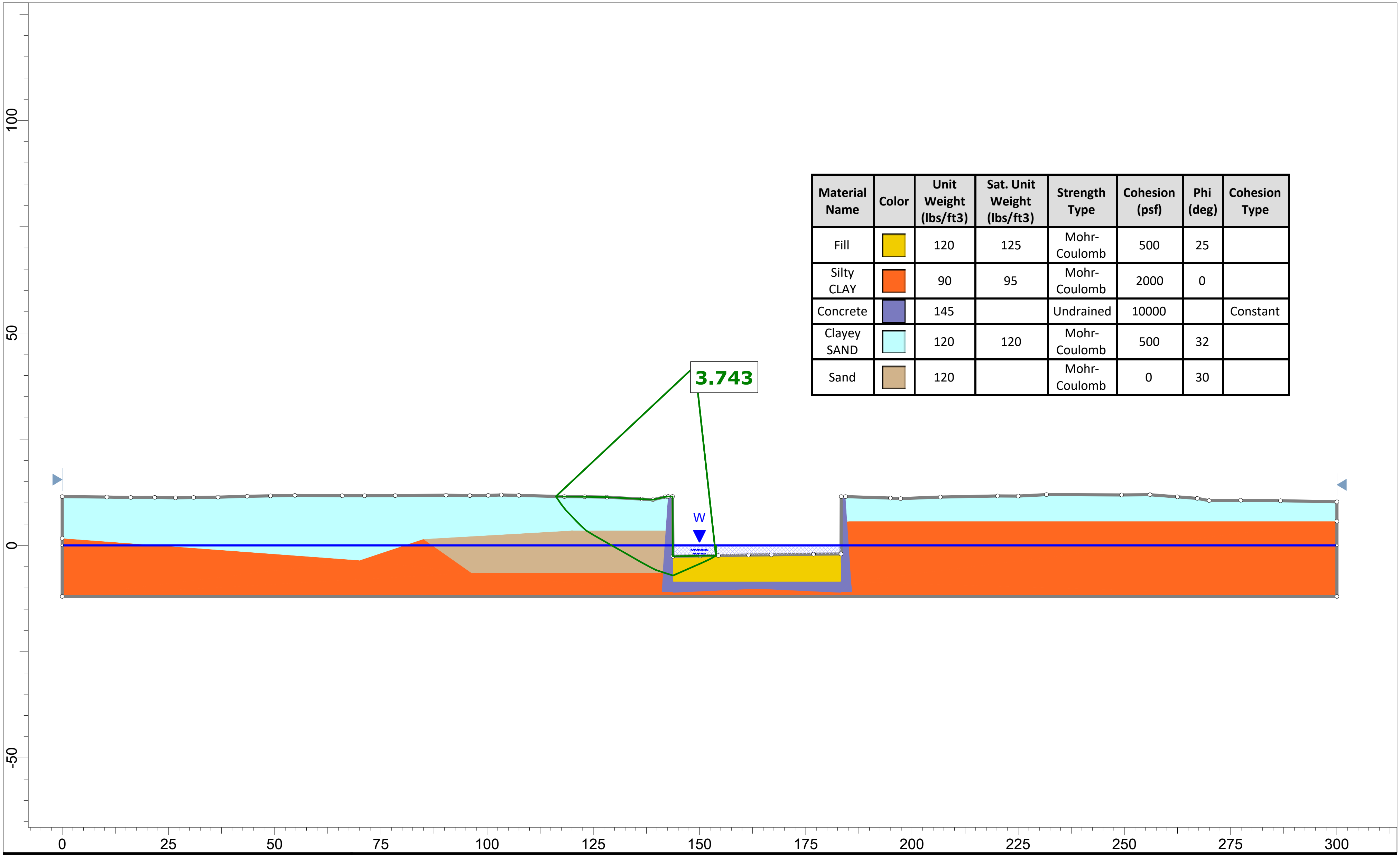
LOG OF BORING 1
College of Marin
Kentfield, California

PLATE
3

MPEG MILLER PACIFIC ENGINEERING GROUP

APPENDIX D

STABILITY ANALYSES



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project Lower Corte Madera Creek Channel

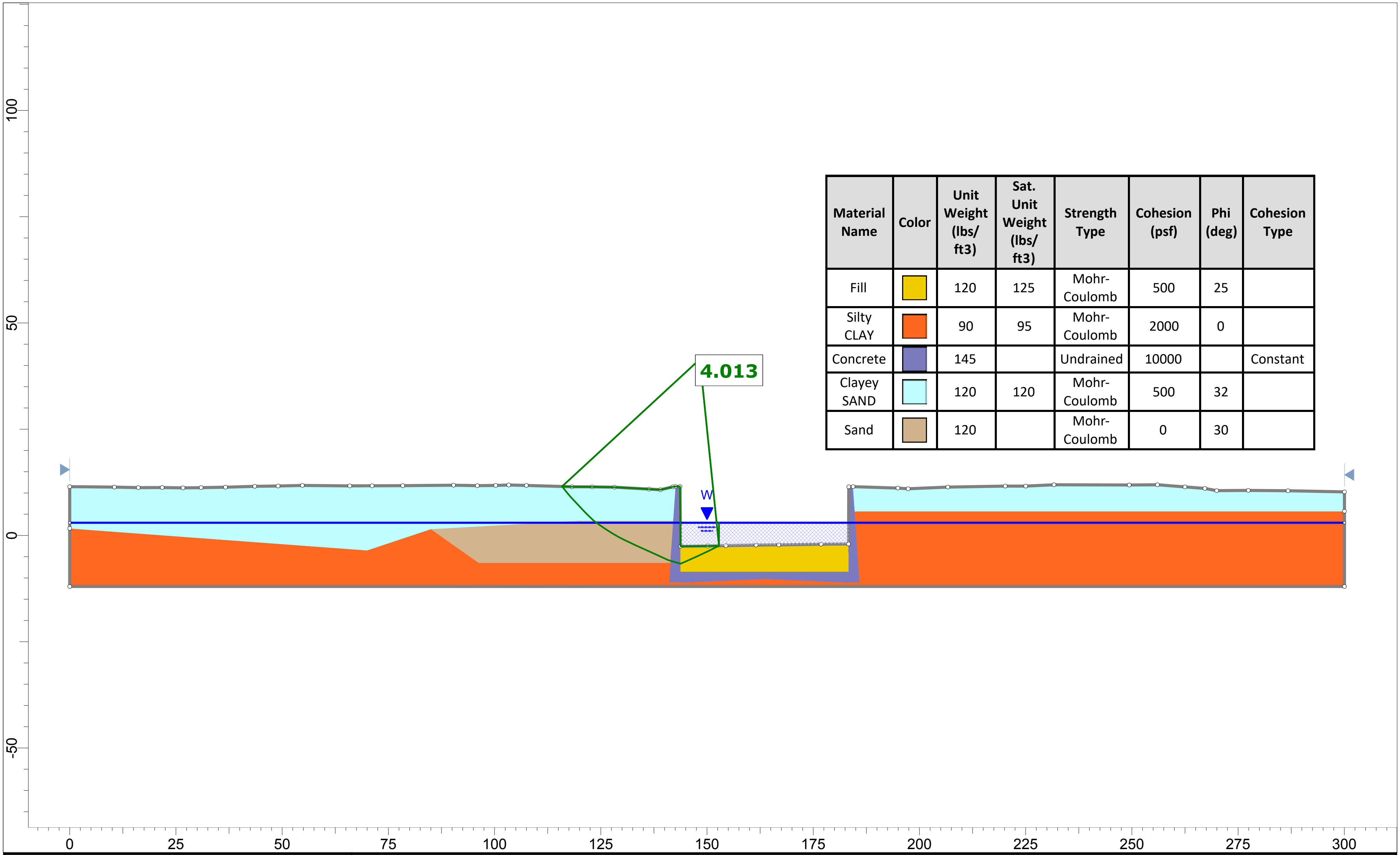
Analysis Description STA 319+17, Existing Conditions, Static, GW at 0 ft

Drawn By RCA

Company Miller Pacific Engineering Group

Date 12/29/2021

File Name 2966.001 319+17, Existing Conditions, Static, GW at 0 ft.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project
Lower Corte Madera Creek Channel

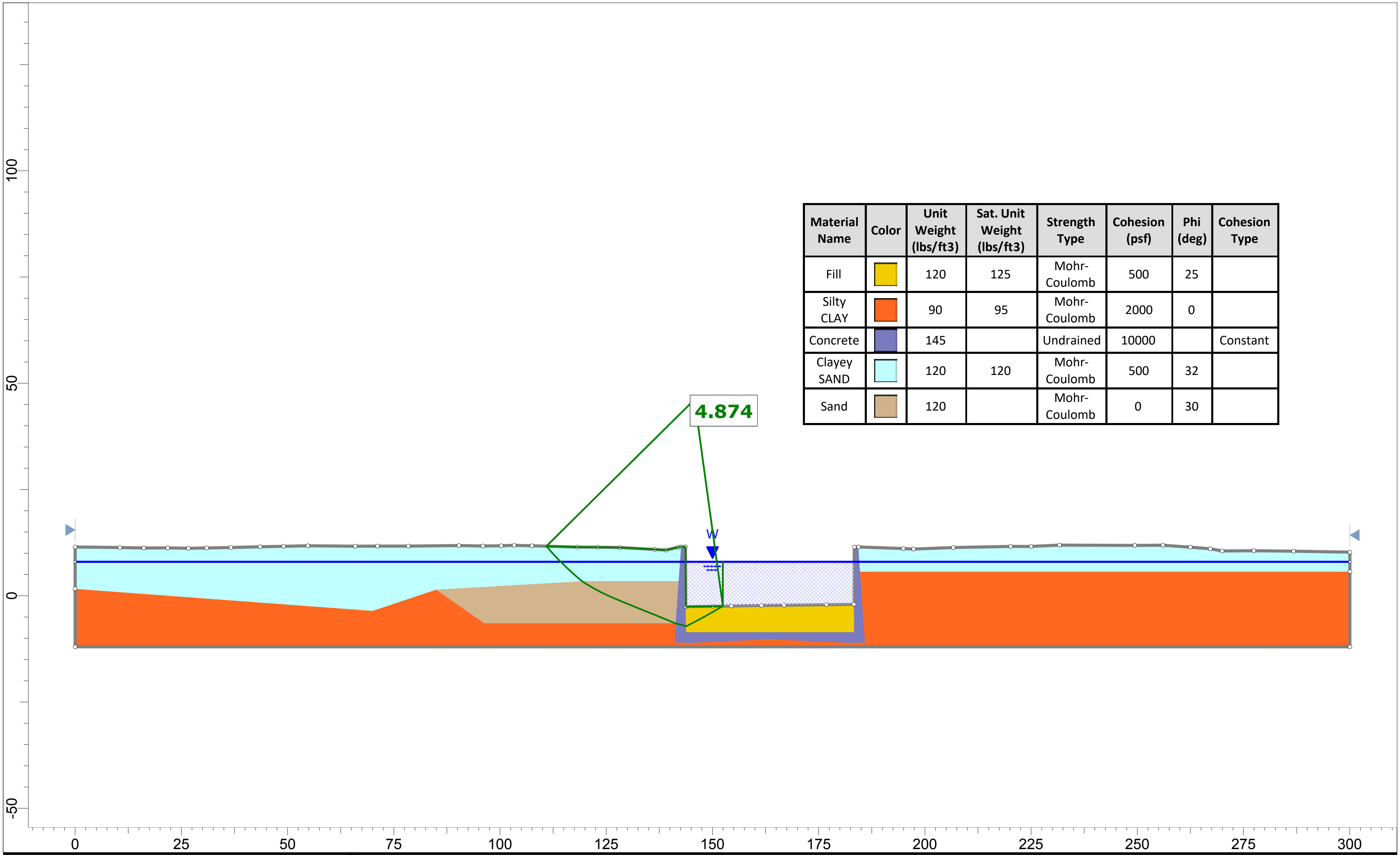
Analysis Description
STA 319+17, Existing Conditions, Static, GW at 3 ft

Drawn By
RCA

Company
Miller Pacific Engineering Group

Date
12/29/2021

File Name
2966.001 319+17, Existing Conditions, Static, GW at 3 ft.slim



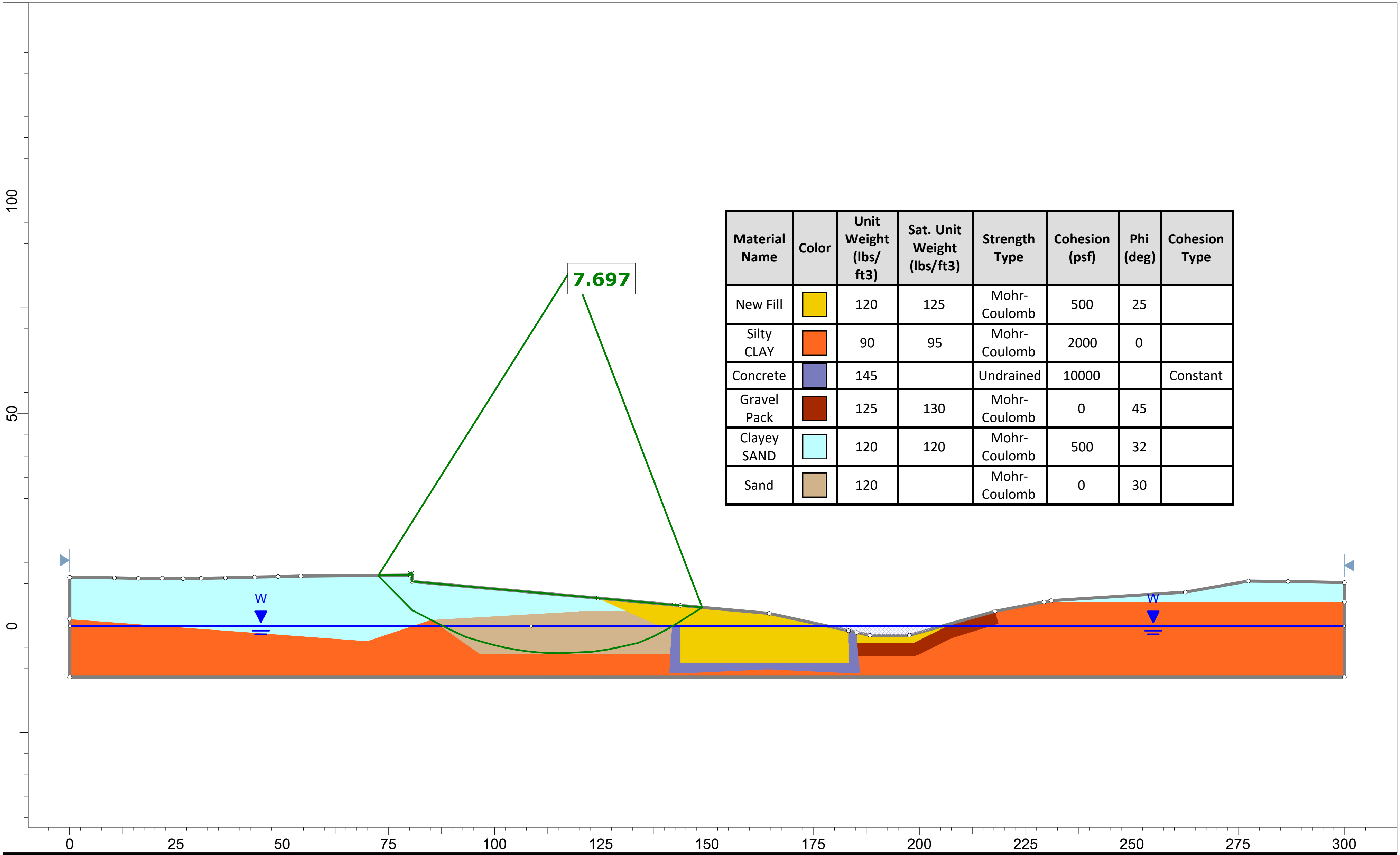
Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project	Lower Corte Madera Creek Channel
Analysis Description	STA 319+17, Existing Conditions, Static, GW at 8 ft

Drawn By	RCA	*Company*	Miller Pacific Engineering Group
Date	12/29/2021	*File Name*	2966.001 319+17, Existing Conditions, Static, GW at 8 ft.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
New Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Gravel Pack	🟫	125	130	Mohr-Coulomb	0	45	
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project Lower Corte Madera Creek Channel

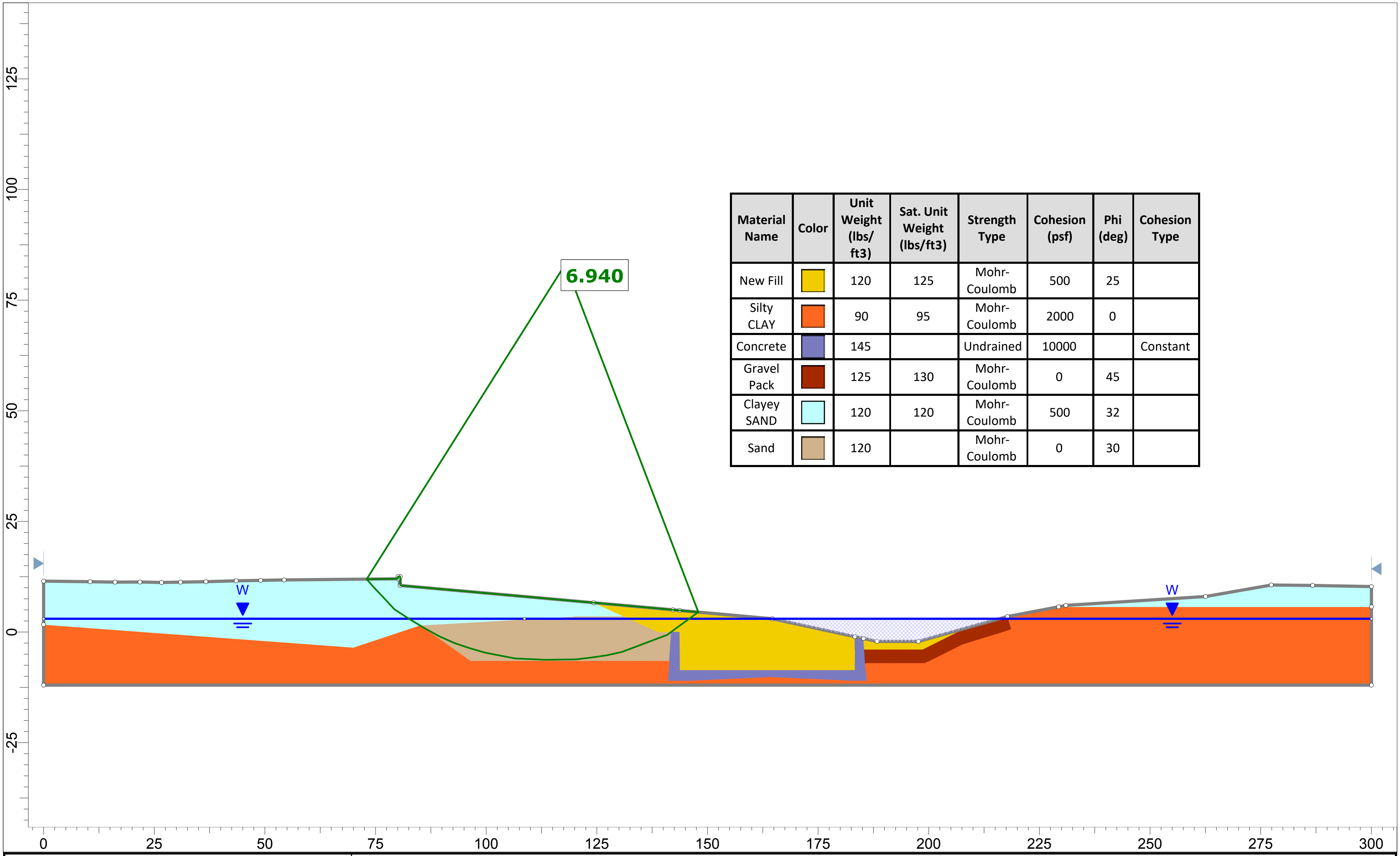
Analysis Description STA 319+17, Proposed Conditions, Static, GW at 0 ft

Drawn By RCA

Company Miller Pacific Engineering Group

Date 12/29/2021

File Name 2966.001 319+17, Proposed Conditions, Static, GW at 0 ft.slim

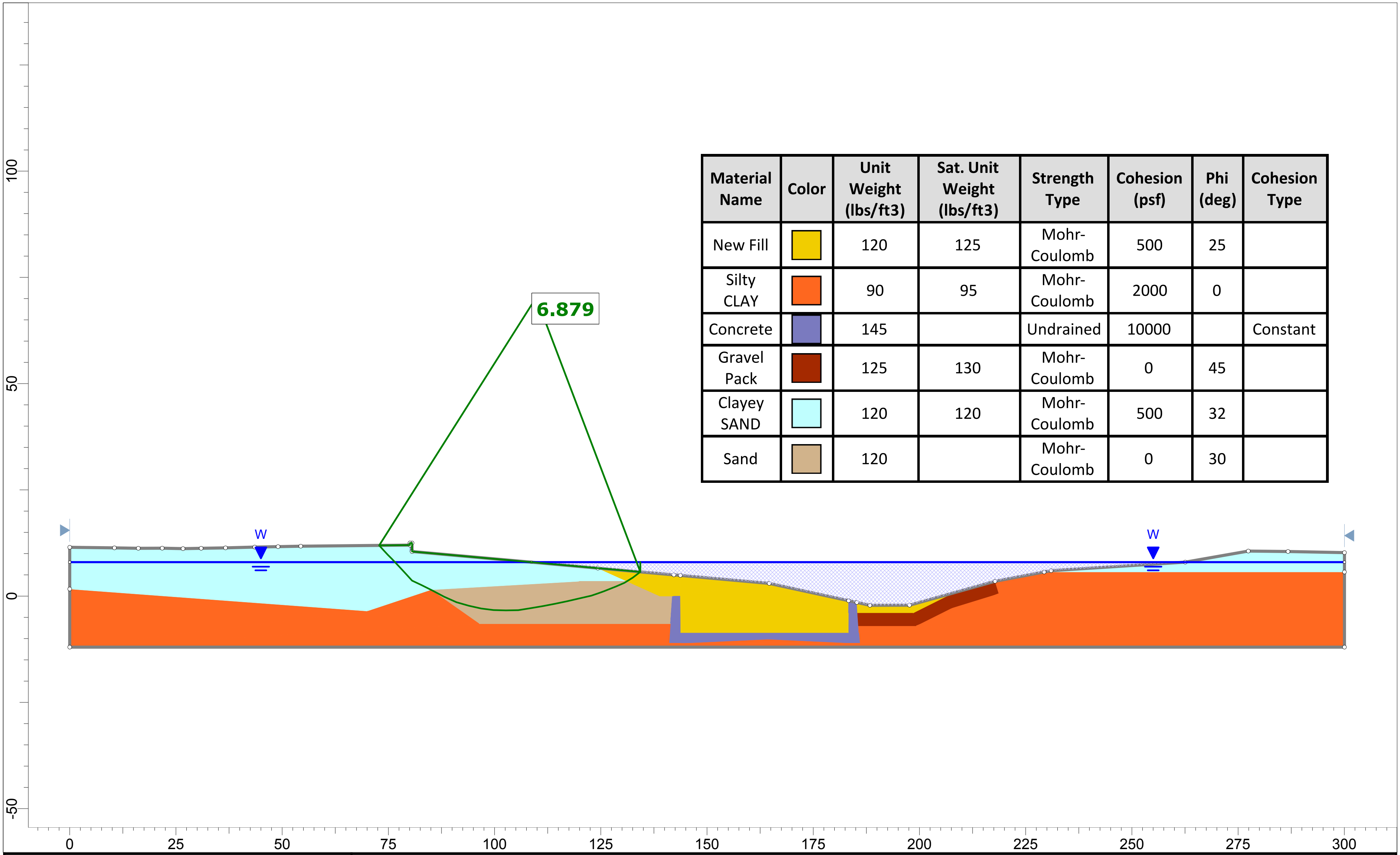


Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
New Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45	
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

Project Lower Corte Madera Creek Channel	
Analysis Description STA 319+17, Proposed Conditions, Static, GW at 3 ft	
Drawn By RCA	*Company* Miller Pacific Engineering Group
Date 12/29/2021	*File Name* 2966.001 319+17, Proposed Conditions, Static, GW at 3 ft.slim

SLIDEINTERPRET 9.019

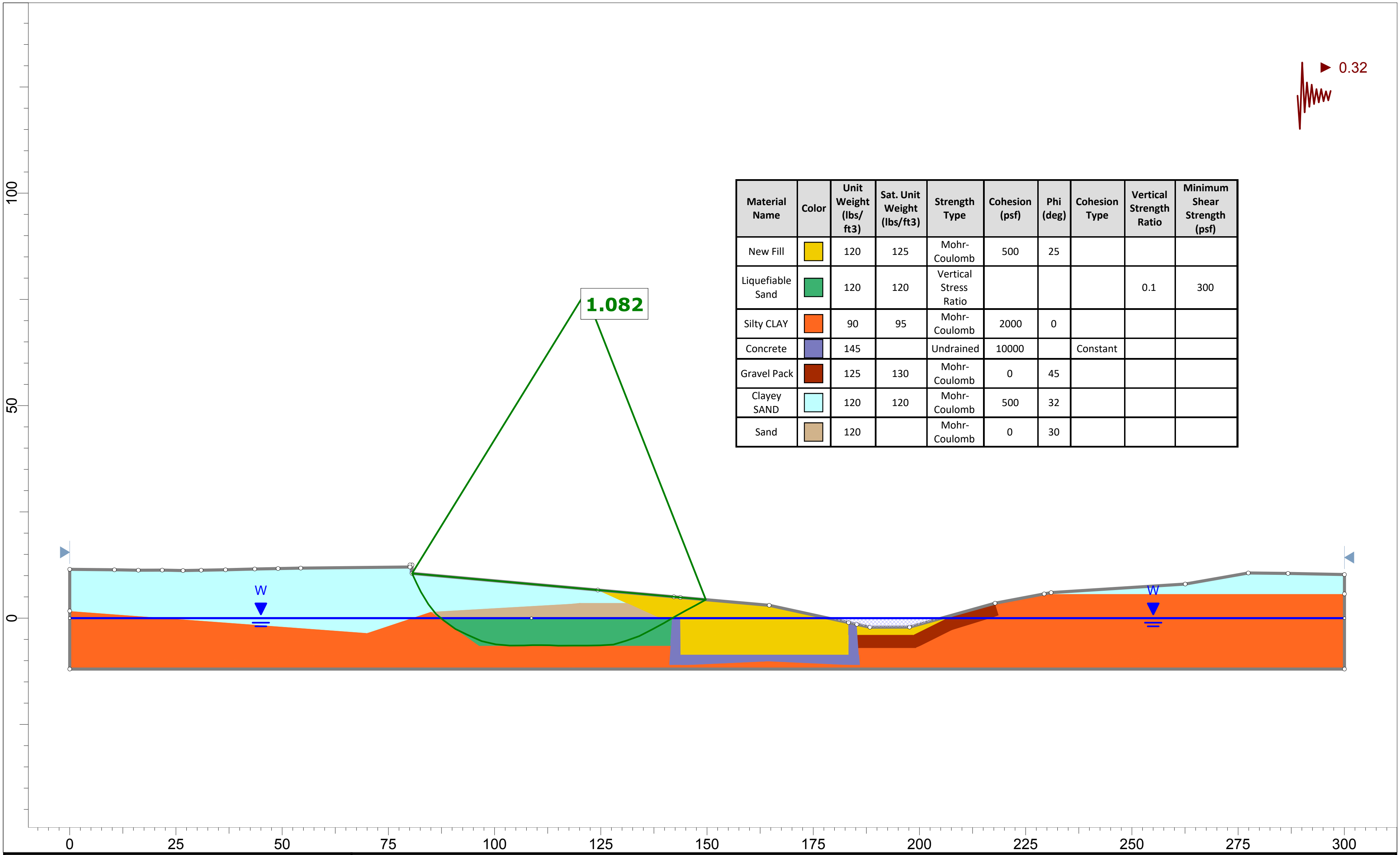


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
New Fill	🟨	120	125	Mohr-Coulomb	500	25	
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0	
Concrete	🟪	145		Undrained	10000		Constant
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45	
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32	
Sand	🟫	120		Mohr-Coulomb	0	30	

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project	Lower Corte Madera Creek Channel
Analysis Description	STA 319+17, Proposed Conditions, Static, GW at 8 ft
Drawn By	RCA
Company	Miller Pacific Engineering Group
Date	12/29/2021
File Name	2966.001 319+17, Proposed Conditions, Static, GW at 8 ft.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			
Sand	🟫	120		Mohr-Coulomb	0	30			

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project Lower Corte Madera Creek Channel

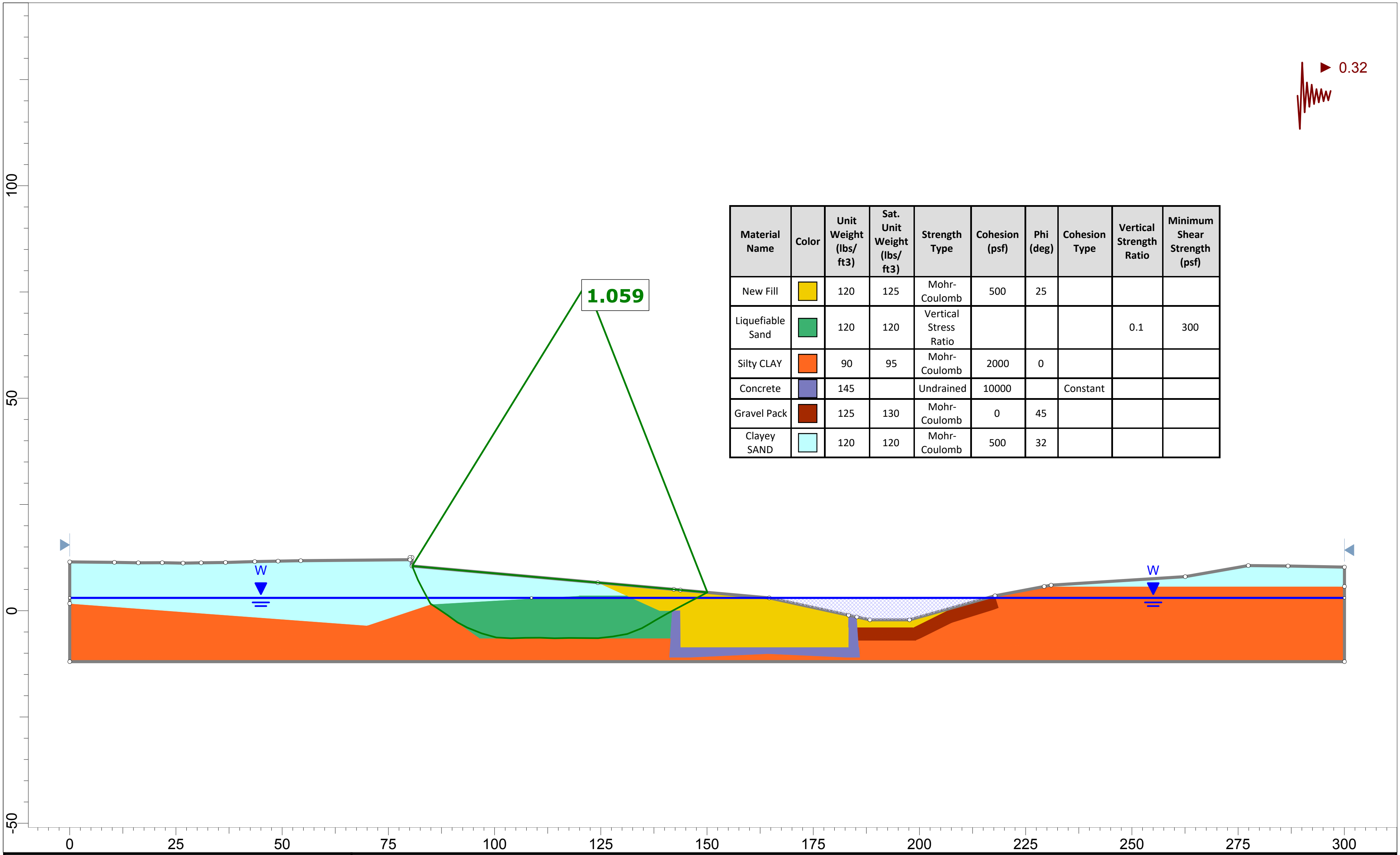
Analysis Description STA 319+17, Proposed Conditions, MCE - Deterministic, GW at 0 ft

Drawn By RCA

Company Miller Pacific Engineering Group

Date 12/29/2021

File Name 2966.001 319+17, Proposed Conditions, MCE - Deterministic, GW at 0 ft.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟫	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			

MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project
Lower Corte Madera Creek Channel

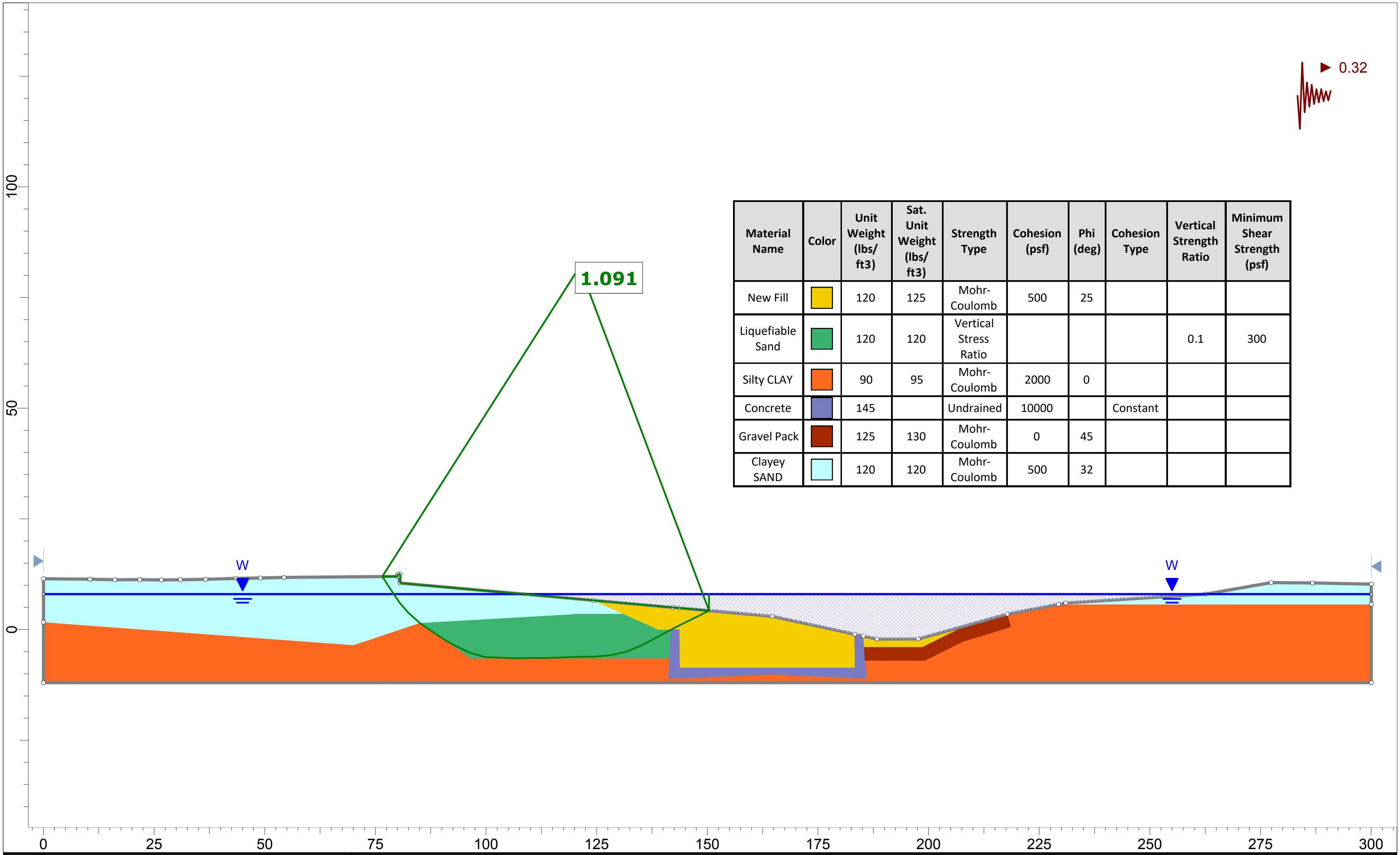
Analysis Description
STA 319+17, Proposed Conditions, MCE - Deterministic, GW at 3 ft

Drawn By
RCA

Company
Miller Pacific Engineering Group

Date
12/29/2021

File Name
2966.001 319+17, Proposed Conditions, MCE - Deterministic, GW at 3 ft.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟫	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project
Lower Corte Madera Creek Channel

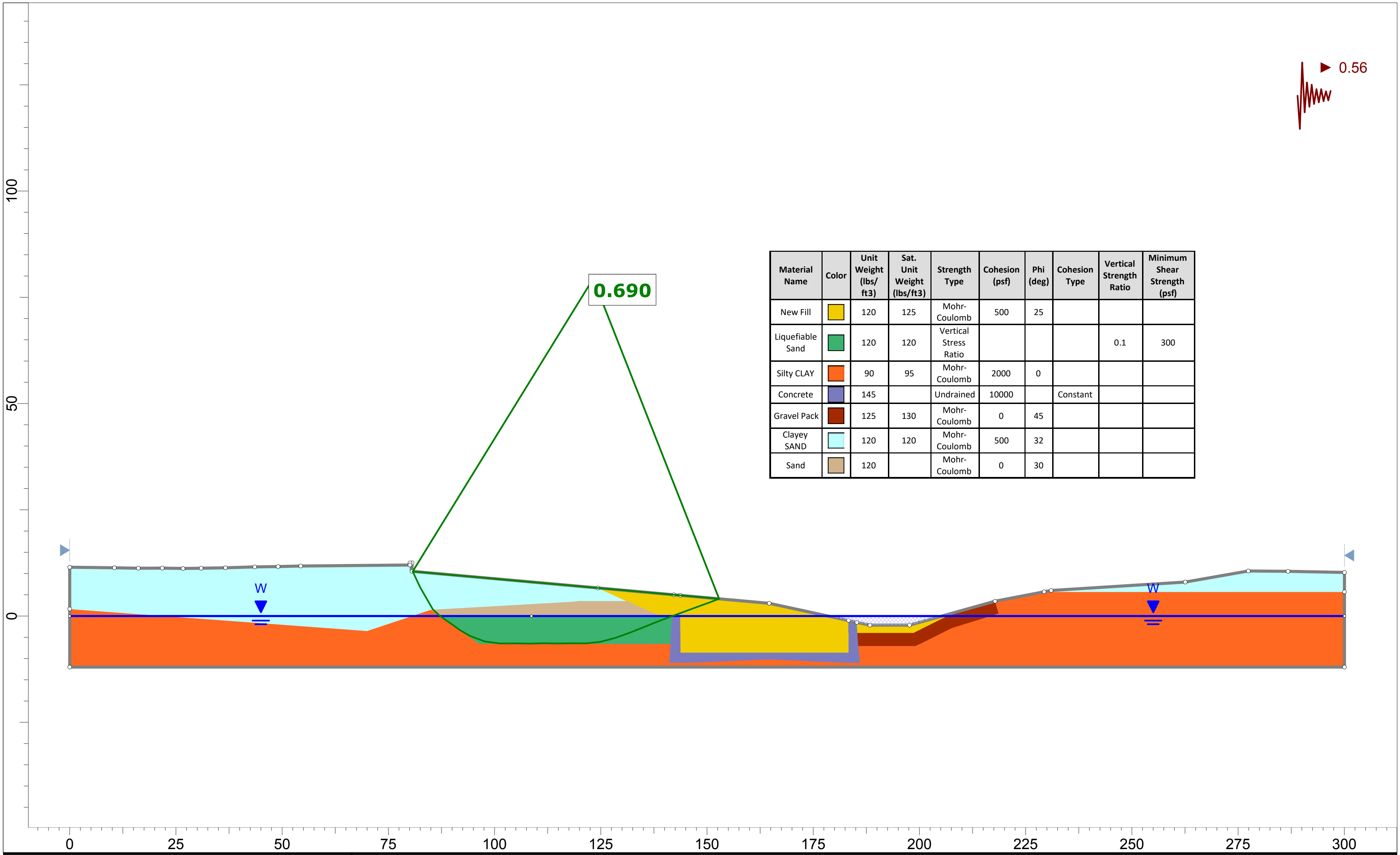
Analysis Description
STA 319+17, Proposed Conditions, MCE - Deterministic, GW at 8 ft

Drawn By
RCA

Company
Miller Pacific Engineering Group

Date
12/29/2021

File Name
2966.001 319+17, Proposed Conditions, MCE - Deterministic, GW at 8 ft slim

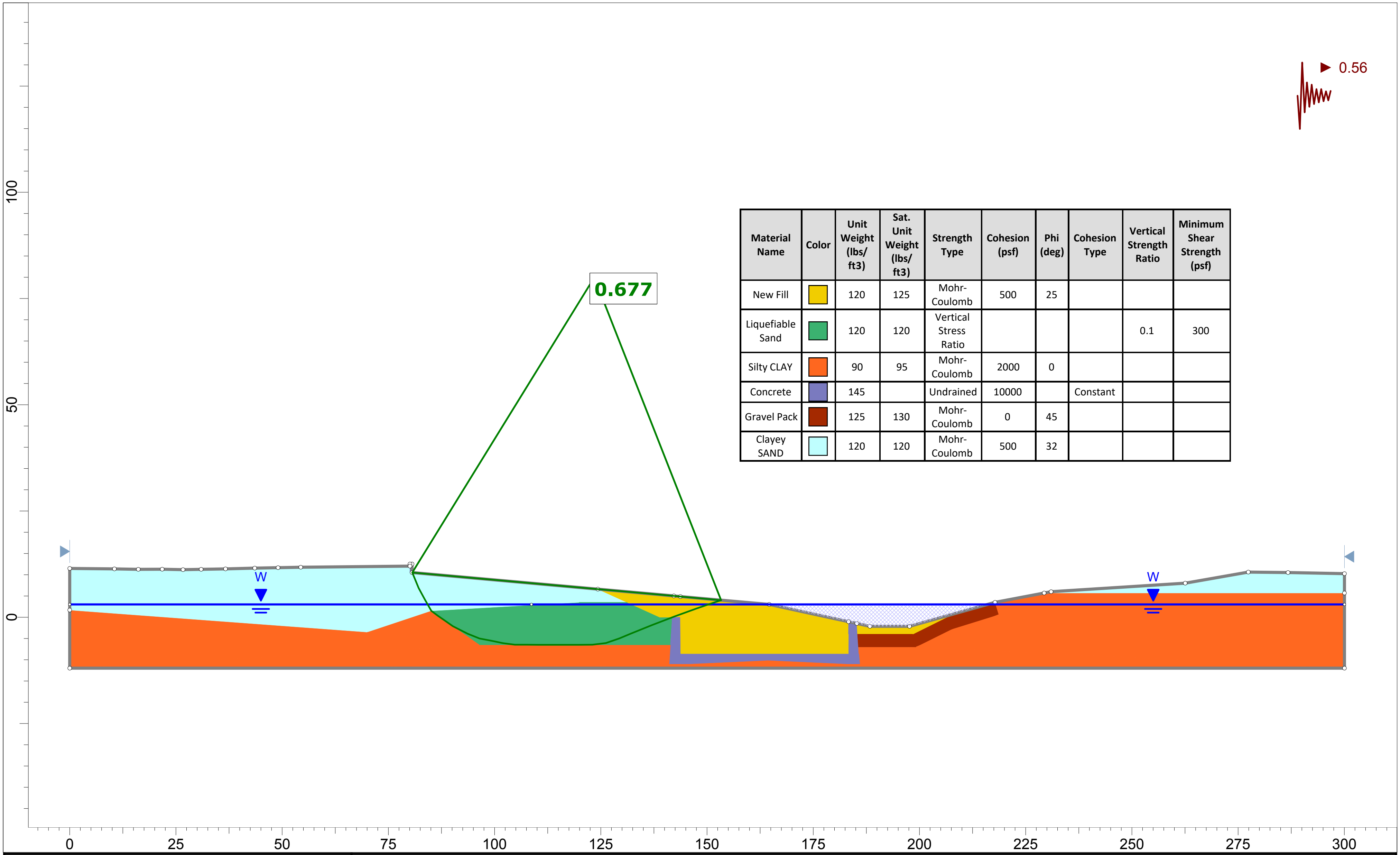


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			
Sand	🟫	120		Mohr-Coulomb	0	30			

MPEG MILLER PACIFIC ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project	Lower Corte Madera Creek Channel
Analysis Description	STA 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 0 ft
Drawn By	RCA
Company	Miller Pacific Engineering Group
Date	12/29/2021
File Name	2966.001 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 0 ft slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			

MPEG
MILLER PACIFIC
ENGINEERING GROUP
SLIDEINTERPRET 9.019

Project
Lower Corte Madera Creek Channel

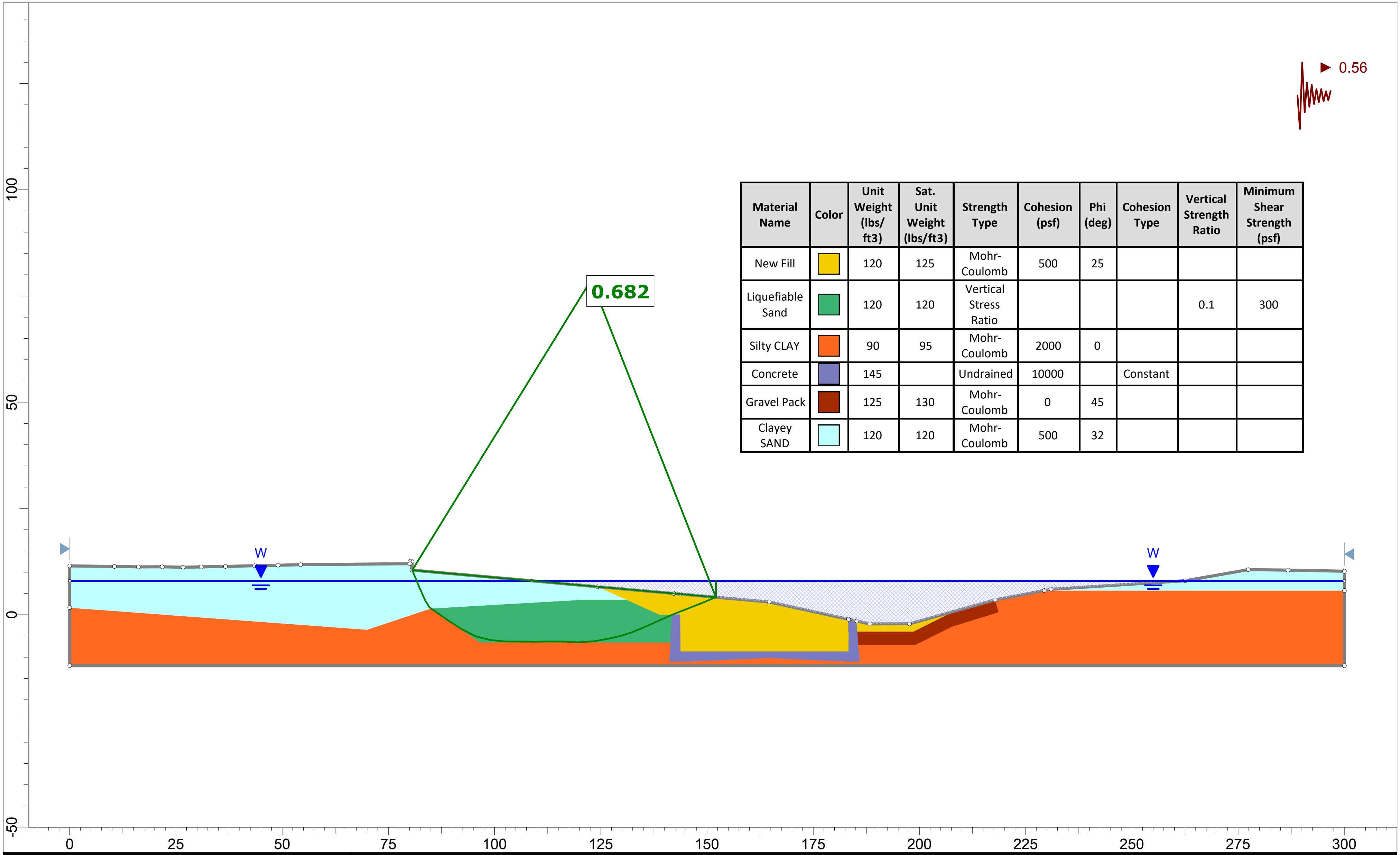
Analysis Description
STA 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 3 ft

Drawn By
RCA

Company
Miller Pacific Engineering Group

Date
12/29/2021

File Name
2966.001 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 3 ft slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (psf)
New Fill	🟨	120	125	Mohr-Coulomb	500	25			
Liquefiable Sand	🟩	120	120	Vertical Stress Ratio				0.1	300
Silty CLAY	🟧	90	95	Mohr-Coulomb	2000	0			
Concrete	🟪	145		Undrained	10000		Constant		
Gravel Pack	🟥	125	130	Mohr-Coulomb	0	45			
Clayey SAND	🟦	120	120	Mohr-Coulomb	500	32			

MPEG
MILLER PACIFIC
ENGINEERING GROUP

SLIDEINTERPRET 9.019

Project
Lower Corte Madera Creek Channel

Analysis Description
STA 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 8 ft

Drawn By
RCA

Company
Miller Pacific Engineering Group

Date
12/29/2021

File Name
2966.001 319+17, Proposed Conditions, MDE - 950 Return Period, GW at 8 ft.slim

Lower COM Concrete Channel Removal Project
DRAFT Hydraulic Analysis Report for the 65% Design

December 2020

Prepared for:
Friends of Corte Madera Creek
Larkspur, CA

Prepared by:
Stetson Engineers Inc
San Rafael, CA

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 PROJECT PURPOSE 1

1.2 HYDRAULIC ANALYSIS PURPOSE 1

1.3 ROSS VALLEY AND LOWER CORTE MADERA CREEK (CMC) FLOODING OVERVIEW 4

2.0 OVERVIEW OF THE HEC-RAS MODDEL USED FOR THE HYDRAULIC ANALYSIS 5

2.1 OVERVIEW OF THE ROSS VALLEY WATERSHED-WIDE HEC-RAS 1D/2D HYDRAULIC MODEL 5

2.2 OVERVIEW OF THE TRUNCATED LOWER CMC HEC-RAS 1D/2D HYDRAULIC MODEL 6

3.0 HYDRAULIC ANALYSIS AND RESULTS 12

4.0 REFERENCES 24

1.0 INTRODUCTION

1.1 PROJECT PURPOSE

The Lower College of Marin (Lower COM) Concrete Channel Removal Project (project) is to remove parts of the downstream end of the Army Corps of Engineers concrete flood control channel to restore as much natural functioning aquatic, tidal, transitional, and riparian upland habitat as possible within site constraints, in a manner that is adaptive to future sea level rise (SLR).

The Lower COM project focuses on removing the downstream-most 468-foot-long section of the concrete channel, from its downstream terminus to near the domestic water and sanitary sewer utility crossings on the downstream side of the Stadium Way footbridge. The Project reach extends approximately 100 feet downstream from the concrete channel terminus to also remove rip-rap slope protection and restore natural vegetated stream banks conforming smoothly with the earthen channel section at the downstream project limits.

The project design consists of three (3) stages: 30% design, 65% design, and 100% design.

1.2 HYDRAULIC ANALYSIS PURPOSE

The design of the project requires the detailed hydraulic analysis to demonstrate that the project will meet the following standards:

- Lower COM Project sustains normal high velocity flows without significant creek bank erosion or slide failures that would prevent achieving ecological objectives or require maintenance and repairs for avoiding impacts to COM or Park facilities or utilities.
- Lower COM Project does not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions;
- Lower COM Project does not worsen flooding for future sea level rise (SLR) scenarios.

The purpose of this report is to document the detailed hydraulic analysis and to provide the hydraulic design basis for the project. The foreseeable projects and the projected future sea level rise considered in this hydraulic analysis are described below.

Foreseeable Projects

The most likely future foreseeable projects in Ross Valley identified by the County include construction of the Sunnyside Nursery Flood Detention Storage (FDS) basin[1] and replacement of

---

[1] The Sunnyside Nursery FDS basin has limited storage capacity (about 35 acre-ft at the spillway crest). Analysis found that it has little effect on peak discharges for large flood events (e.g., 50-year and 100-year flood events).

the Azalea Bridge in Fairfax, removal of Building Bridge #2 in San Anselmo, replacement of the four San Anselmo bridges (Nokomis Avenue Bridge, Madrone Avenue Bridge, Center Avenue Bridge, and Bridge Avenue Bridge), replacement of the Winship Avenue Bridge[2], and construction of the Unit 4 measures[3] in Ross. Figure 1 shows the locations of these foreseeable projects. Construction of the Sunnyside Nursery FDS basin and removal of Building Bridge #2 are also the two components of the San Anselmo Flood Risk Reduction (SAFRR) Project. The SAFRR Project EIR was certified on September 18, 2018 by the Marin County Board of Supervisors. The SAFRR Project is expected to be constructed by 2021.

As shown in Figure 1, the foreseeable projects are all located far upstream of the Lower COM Project area. The foreseeable projects upstream of the Ross Creek confluence would have little effect on the hydrology and flooding of the Lower COM Project area. The foreseeable project downstream of the Ross Creek confluence, i.e., construction of the Unit 4 measures (with removal of the Ross fish ladder in particular), would reduce the overland flow escaped from the channel reach between Lagunitas Bridge and the Ross Gage, and increase the channel flood flow downstream. For the Lower COM Project area, the flooding effect from the construction of the Unit 4 measures would be a combined effect of the reduced overland flow and increased channel flow. The previous hydraulic modeling for the Corte Madera Creek Option C of Phoenix Lake grant migration performed by Stetson for the County in late 2017 provided some verification that the lower COM channel widening would not worsen flooding under the future foreseeable projects condition[4]. For this reason, the foreseeable projects condition was not explicitly simulated in this 65% design stage.

Sea Level Rise

The State of California Sea-Level Rise Guidance/2018 Update (California Natural Resources Agency, 2017) provides a science-based methodology for state and local governments to analyze and assess the risks associated with sea level rise and incorporate sea level rise into their planning, permitting, and investment decisions. For the purpose of this study, the future sea level rise of 1.1 ft by 2050 under the “67% probability, high emissions” scenario (see Table 1 of the California Sea-Level Rise Guidance) was selected for the sea level rise modeling analysis.

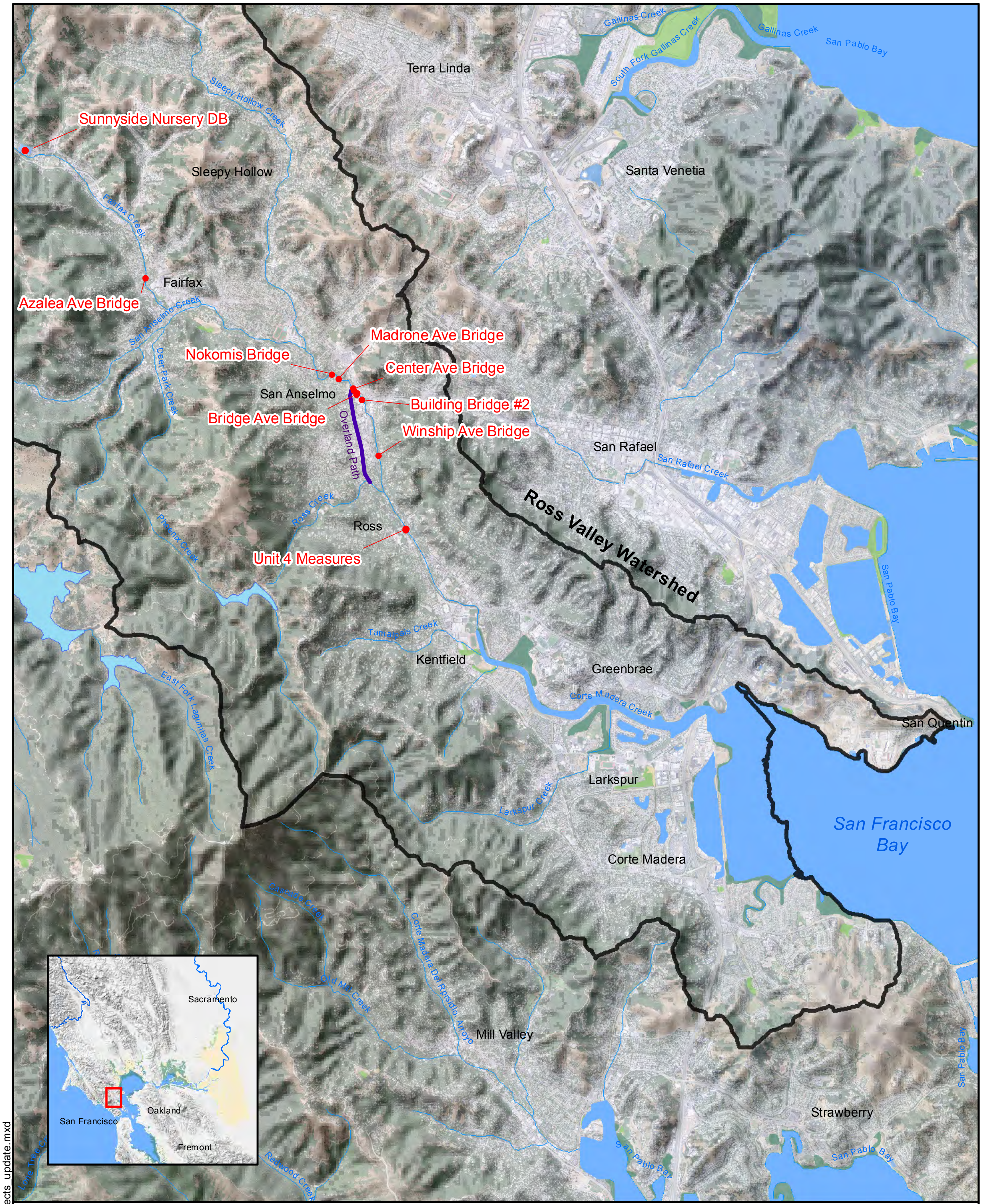
---

[2] Replacement of the four San Anselmo bridges and the Winship Avenue Bridge are being designed by Quincy Engineering, and replacement of the Azalea Bridge is being designed by California Infrastructure Consultancy (CIC). At the time of this report, Quincy has prepared preliminary designs for the four San Anselmo bridges and the Winship Avenue Bridge, and CIC has prepared preliminary designs for the Azalea Bridge. The Stetson team is preparing final designs for the SAFRR Project.

[3] The Unit 4 measures represent the Measures 1, 2, and 3 detailed in the Stetson’s 2008 Letter Report to the U.S. Army Corps of Engineers, which include (1) Ross fish ladder removal, (2) transition at the fish ladder from the Unit 4 natural channel to the Unit 3 concrete channel, and (3) channel widening just upstream of the fish ladder.

[4] The hydraulic analysis for the Corte Madera Creek Option C of Phoenix Lake grant migration included a scenario modeling of the Unit 4 measures plus the Lower COM Project with preliminary conceptual designs at that time. Note that the Lower COM Project was called Phase 1 of creek restoration project at that time.

FIGURE 1



LOCATION OF MOST LIKELY FUTURE-FORESEEABLE PROJECTS

STETSON
ENGINEERS INC.

N

0 0.5 1
Miles

J:\jn2551\ForeseeableProjects_update.mxd

1.3 ROSS VALLEY AND LOWER CORTE MADERA CREEK FLOODING OVERVIEW

Ross Valley is naturally prone to flooding by its location, geologic and geomorphic setting: Rainfall can be intense, soils are shallow with limited absorption capacity, slopes are steep, stream channels are entrenched and, in many places, narrow with relatively little in-channel storage capacity. Residential, commercial, and institutional development in the Ross Valley has created expansive impermeable areas while encroaching onto the banks of the channel supplanting the natural flood attenuating capacity of the floodplain. The effects of creekside structures have been superimposed on this naturally flood-prone system.

During prolonged and heavy storms the watershed can become saturated. If rainfall is sufficiently intense, heavy runoff can result in high flows exceeding the capacity of the creek in places where conveyance is constrained. *Incipient flooding* occurs when the threshold conveyance capacity of the creek is exceeded and breaching of the creek banks is initiated. At some locations, floodwaters breaking out of the creek return back to the creek a short distance downstream of the constraint. At other locations, floodwaters may escape and flow as a separate side-stream, apart from the main channel flow, for extended distances over the floodplain.

Within the lower Corte Madera Creek model domain (below the Ross Creek confluence), the key breakout point where floodwaters escape from the channel is between Lagunitas Bridge and the Ross Gage, where the creek capacity at the threshold of incipient flooding was estimated about 3,400 cfs, with the corresponding magnitude level flood event about 5-year flood. The escaped flow would then flow through the Ross Commons area and then along Kent Ave to make a separate flow path from the main channel, and finally return back to the main channel downstream of the College of Marin area. Under the foreseeable project condition, as mentioned earlier, construction of the Unit 4 measures (with removal of the Ross fish ladder in particular), would reduce the overland flood flow escaped from the channel reach between Lagunitas Bridge and the Ross Gage, and increase the channel flood flow downstream.

2.0 OVERVIEW OF THE HEC-RAS MODDEL USED FOR THE HYDRAULIC ANALYSIS

The hydraulic analysis to support the 65% design for the Lower COM Project was performed using the HEC-RAS 1D/2D unsteady-flow hydraulic model that was initially developed jointly by Stetson Engineers and USACE in 2017 for the entire Ross Valley watershed (Stetson, 2017a), and then truncated/modified/updated by Stetson in 2018-19 as necessary for the County's Lower Corte Madera Creek levee evaluation project (Stetson, 2019). The truncated levee evaluation model for the Lower Corte Madera Creek that has a model domain below the Ross Creek confluence was used for this hydraulic analysis and further updated with the latest 2020 field survey data around the Lower COM Project area to meet the needs of this specific study.

The following provides an overview of the Ross Valley watershed-wide HEC-RAS 1D/2D hydraulic model and the truncated Lower Corte Madera Creek model construction.

2.1 OVERVIEW OF THE ROSS VALLEY WATERSHED-WIDE HEC-RAS 1D/2D HYDRAULIC MODEL

The Ross Valley watershed-wide HEC-RAS 1D/2D hydraulic model starts at the San Francisco Bay and extends about 10 miles upstream along the mainstream and tributaries of Corte Madera Creek into the upper watershed upstream of Fairfax. The model was first calibrated to the 12/15/2016 bankfull event by running and rerunning the model and adjusting the model's in-channel parameters with each iteration until the model-simulated peak water surface elevations satisfactorily matched the observed channel high water marks (HWMs). The model was then calibrated to the 12/31/2005 flood event by further adjusting the floodplain parameters until the model-simulated peak water surface elevations in the floodplain satisfactorily matched the observed floodplain HWMs. The model was finally verified to the 1/4/1982 flood event. For all the three flood events, simulation differences were well within the FEMA-required 0.5-foot range for most of the HWMs, particularly at locations where HWMs were considered most reliable. The model was peer-reviewed by USACE in 2017.

Since the time of initial development of the watershed-wide HEC-RAS 1D/2D hydraulic model in 2017, the model has been used for a number of hydraulic analyses. The hydraulic analysis that is most relevant to the Lower COM Project is the hydraulic modeling of Corte Madera Creek Option C for the Phoenix Lake Grant migration conducted by Stetson for the County in late 2017 (Stetson, 2017b). This hydraulic analysis included a scenario modeling of the Unit 4 measures plus the Lower COM Project with preliminary conceptual designs at that time (Note: The Lower COM Project was called Phase 1 of creek restoration project at that time). This modeling analysis verified that the Lower COM Project would not worsen flooding. It would be expected that the hydraulic analysis using the truncated Lower Corte Madera Creek model would arrive at the same conclusion. For this reason, the foreseeable projects condition was not explicitly simulated in this 65% design stage.

2.2 OVERVIEW OF THE TRUNCATED LOWER CMC HEC-RAS 1D/2D HYDRAULIC MODEL

In the Ross Valley watershed model that was developed jointly by Stetson and USACE[5] in 2017, the Corte Madera Creek earthen channel and its floodplain, as configured by USACE, was represented entirely (both channel and floodplain combined) as a 2D Flow Area with a computational mesh cell size of 20 ft by 20 ft. During the 2018-19 hydraulic analysis for the Lower Corte Madera Levee Evaluation Project, after consultation with County staff, it was decided to convert the model to a combined 1D/2D model (1D channel and 2D floodplain). Meanwhile, as the focus of the study area moved from the upper watershed to the lower watershed, the upper watershed portion of the model was truncated at the Ross Creek confluence to reduce the model simulation time (Stetson, 2019).

The truncated model was then updated from the 2004 bathymetric survey to the 2018 bathymetric survey of the earthen channel, and the earthen channel portion was calibrated/verified to the observed water level hydrographs at the Bon Air Bridge for the following three bankfull events:

- 12/15/2016 event (model calibration event; peak flow at the Ross Gage: 3,400 cfs)
- 1/10/2017 event (model verification event; peak flow at the Ross Gage: 3,700 cfs)
- 2/7/2017 event (model verification event; peak flow at the Ross Gage: 3,700 cfs

Following is an overview of the Lower Corte Madera Creek model construction.

1D/2D Modeled Areas Configuration

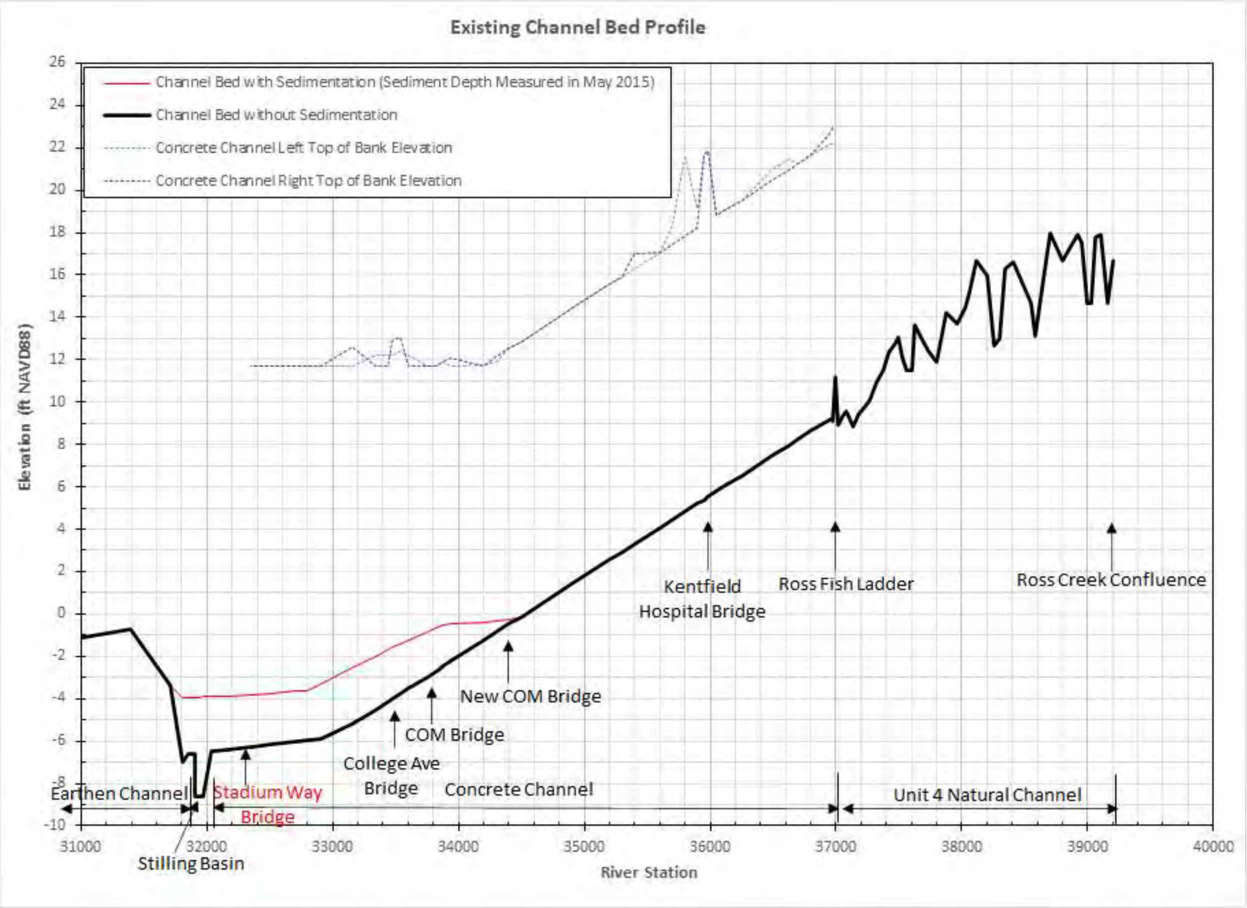
In general, the 2D Flow Areas cover most of the floodplain and the 1D Flow Areas cover the channel of the entire lower Corte Madera Creek. The lateral extents of the 2D Flow Areas encompass the approximate 500-year flood inundation area as indicated in the Federal Emergency Management Agency's (FEMA's) 2014 Flood Insurance Rate Maps (FIRMs), Stetson Engineer's MIKE FLOOD floodplain maps contained in the 2011 Ross Valley Capital Improvement Plan (CIP) study, and as inferred by the locations of the High Water Marks (HWMs) for the 1982 and 2005 floods. Non-flood-prone areas adjacent to the channel and some areas of the floodplain where minor or localized flooding occurs, but where the detail provided by 2D simulation is not needed, were also identified as 1D Flow Areas in order to minimize model computational time and avoid unnecessary model development effort. To allow flow exchange between 1D channel and 2D Flow Areas, lateral links were placed along the tops of the channel banks. Figure 2 shows the 1D/2D configuration of the Lower CMC HEC-RAS model.

---

[5] USACE developed the downstream portion of the model which starts immediately downstream of the Ross Creek confluence with Corte Madera Creek and extends downstream to the bay encompassing the Corte Madera Creek Flood Control Project. Stetson developed the upstream portion of the model, which extends to the Fairfax area, and then merged the two model portions to arrive at a single comprehensive Ross Valley 1D/2D unsteady-flow hydraulic model covering the entire Corte Madera Creek mainstem and major tributaries. Stetson then calibrated/verified the merged model

1D Cross-Sections

The 1D cross-sections were derived from the existing Ross Valley HEC-RAS 1D steady-flow hydraulic model that was developed by Stetson Engineers in 2011 for the Ross Valley CIP Study. The 1D channel cross-section geometry data were collected from field surveys performed in 2004 – 2020 for natural channels and the Corps' as-built designs for the concrete channel. 1D cross-sections for the concrete channel were adjusted to reflect deposited sediment based on field surveys of sediment deposition conducted in 2015 and 2016 (see the graph below for the deposited sediment depth).



Terrain[6]

The terrain used in the hydraulic model was derived from two sources. The channel cross-section area was derived from the existing Ross Valley HEC-RAS 1D steady-flow hydraulic model and the earthen channel bathymetric survey. The overbank area terrain was derived from the 2010 LiDAR survey point data provided by Marin County. A GIS Triangulated Irregular Network

---

[6] Terrain or topographical relief refers to the vertical and horizontal dimensions of land surface and is usually expressed in terms of the elevation, slope, and orientation of terrain features. Terrain affects surface water flow and distribution.

surface was created from the two data sources, which was then converted to a Digital Elevation Model to be used by RASMapper in HEC-RAS to create a terrain surface for the hydraulic model.

2D Grid Cell Size

The primary grid cell size for the 2D Flow Areas is 20 feet by 20 feet in the lower portion of the model (downstream of the Ross Creek confluence). Additional effort was made to enhance the topography representation at key locations (e.g., top of bank areas, berms, roads) using break lines (see additional description of break lines below) and fine mesh size of 2 feet by 2 feet. The topographic resolution is sufficient to capture topography of streets and most flow barriers such as berms or other high ground features. The effects of building structures were represented in the model by using a very high Manning's n roughness[7] for grid cells where structures are located (see additional description of Manning's n below) to allow floodwater to enter buildings but at very slow speed. Fences were excluded from the model since fences are not expected to have an important effect on blocking or redirecting flows during the flood events modeled. This is because the fences are often not impermeable or are not typically designed to withstand floodwaters and, as such, can be easily pushed over during floods.

Break Lines[8]

Break lines are included in the 2D computational mesh in order to align the cell edges with high ground. Aligning the cell edges with high ground ensures that barriers to flow, such as berms or roads, are correctly represented in the computational mesh. Without break lines, flow may cross a high ground barrier prematurely.

Manning's n Roughness Values

Manning's n values are used to account for the resistance to flow exerted by the ground surface or other surface (e.g., vegetation) that the flowing water is exposed to. A greater n value indicates greater surface roughness and resistance to flow. The n values for the 1D channel were initially based on the existing Ross Valley HEC-RAS 1D steady-state hydraulic model. The n values for the 2D Flow Areas were initially based on land cover data (i.e., parcels, buildings, streets, parking lots, etc.) and the HEC-RAS version 5 User's Manual (HEC, 2016). These initial Manning's n values were then modified as needed to reflect observed hydraulic conditions during the calibration of the combined 1D/2D model.

---

[7] Another way to represent building structures in a 2D model is to set high ground surface elevations for building footprints. This representation would cause buildings to act like flow barriers — no floodwater would enter buildings. This representation was not used because it would not account for the volume of floodwater that enters buildings and would create dry areas in building footprints which is not realistic.

[8] Break lines are used to define features such as berms, roads, channel top-of-bank areas, and other high ground features. Break lines force surface triangulation along the break line preventing triangulation across the break line when developing the topographic Digital Elevation Model.

Bridges/Culverts/Building Structures and Modeling Method

The truncated model represents all structures (except the most downstream Highway 101 Bridge, which does not obstruct flows during up to the 500-year flood event due to its elevation above the channel) crossing the modeled creek channels including six bridges (i.e., Bon Air Rd Bridge, Stadium Way pedestrian bridge, College Ave Bridge, College of Marin bridge, Kentfield Hospital bridge, and Lagunitas Rd Bridge) and one fish ladder (i.e., Ross Fish Ladder). Five of the bridges are modeled using either "Energy-Based" method or "Pressure and/or Weir Flow" method[9], and one bridge (i.e., the Kentfield Hospital Bridge) was simulated as "XS with Lid" method due to model limitation. The Ross Fish Ladder was simulated as an "Inline Structure" method.

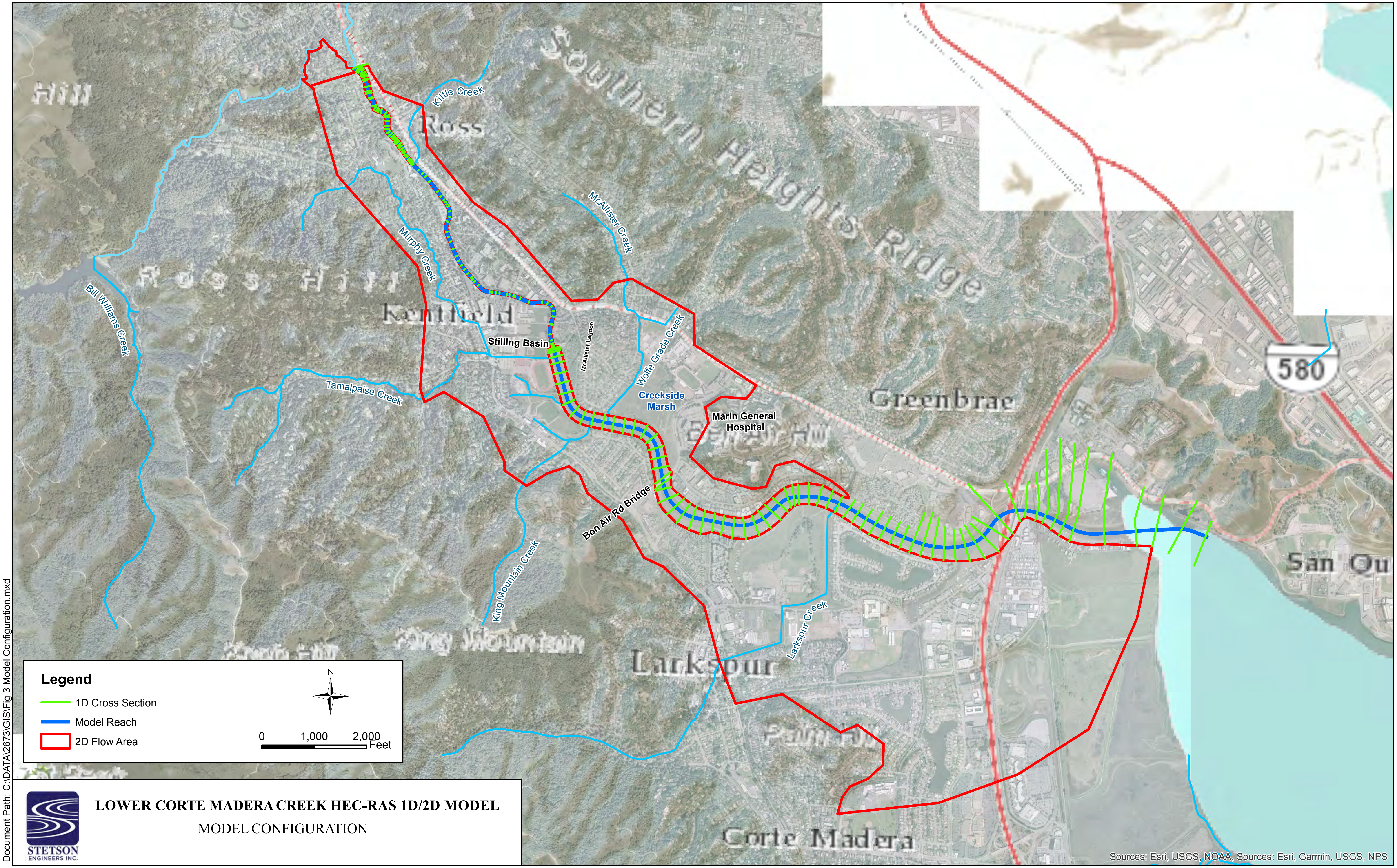
Hydraulic Model Boundary Conditions

The upstream boundaries are located immediately downstream of Ross Creek confluence with San Anselmo Creek, the upstream limit of the main channel of Corte Madera Creek. The upstream boundary conditions are the inflow hydrographs during the selected flood event. There are 8 inflow locations in the model, including point source inflows at the upper boundaries and point source lateral inflows and uniform lateral inflows along the reaches (see Figure 3 for the flow input locations). The downstream boundary was set as the observed time-varying San Francisco Bay tide for the model calibration/verification events, and constant mean higher high water (MHHW) for the design and analyses of alternatives.

---

[9] The HEC-RAS program has the ability to compute high flows (flows that come into contact with the maximum low chord of the bridge deck) by either the Energy equation or by using separate hydraulic equations for pressure and/or weir flow. The energy-based method is applied to high flows in the same manner as it is applied to low flows. Computations of the energy-based method are based on balancing the energy equation through the bridge. Energy losses are based on friction and contraction/expansion losses. The energy-based method is commonly used for the conditions when the bridge deck is a small obstruction to the flow and the bridge opening is not acting like a pressurized orifice, or the bridge is highly submerged. The pressure and/or weir flow method is commonly used for the conditions when the bridge deck is a large obstruction to the flow and a backwater is created due to the constriction of the flow, or the bridge is overtopped but is not highly submerged by the downstream tail water.

FIGURE 2



Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS

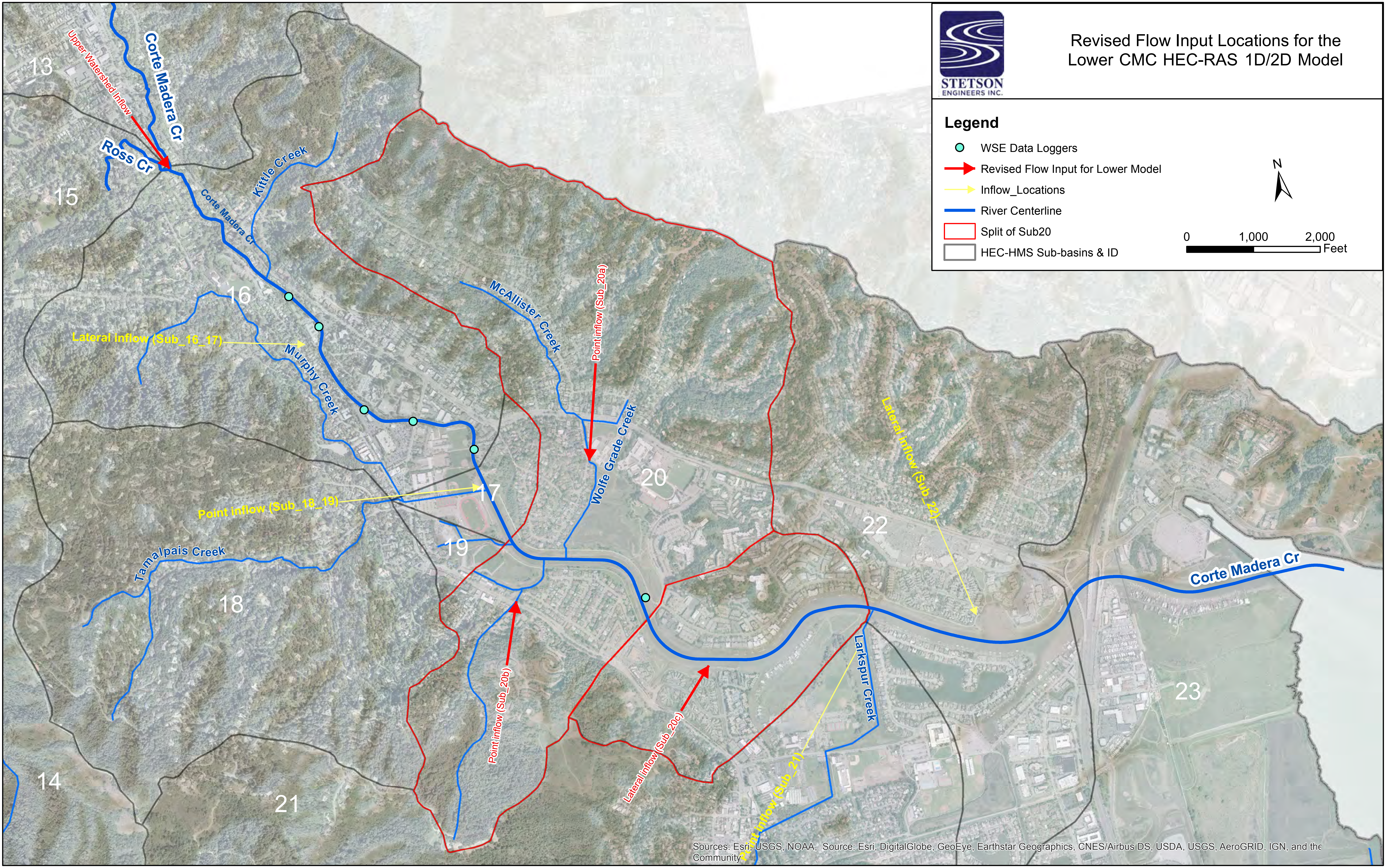
Document Path: C:\DATA\2673\GIS\Fig 3 Model Configuration.mxd

LOWER CORTE MADERA CREEK HEC-RAS 1D/2D MODEL

MODEL CONFIGURATION

STETSON
ENGINEERS INC.

FIGURE 3



Revised Flow Input Locations for the Lower CMC HEC-RAS 1D/2D Model

Legend

- ● WSE Data Loggers
- Revised Flow Input for Lower Model
- Inflow_Locations
- River Centerline
- ☐ Split of Sub20
- ☐ HEC-HMS Sub-basins & ID

Sources: Esri, USGS, NOAA, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

C:\DATA\2673\GIS\Fig 4 Revised Flow Input Locations for Levee Evaluation Model.mxd

6/27/2018

3.0 HYDRAULIC ANALYSIS AND RESULTS

As stated in Section 1.2, the hydraulic design for the Lower COM Project should document:

- Lower COM Project sustains normal high velocity flows without significant creek bank erosion or slide failures that would prevent achieving ecological objectives or require maintenance and repairs for avoiding impacts to COM or Park facilities or utilities.
- Lower COM Project does not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions;
- Lower COM Project does not worsen flooding for future sea level rise (SLR) scenarios.

The hydraulic design was supported using the Lower Corte Madera Creek HEC-RAS 1D/2D hydraulic model that was developed by Stetson in 2018-19. The Lower Corte Madera Creek model was a truncated/modified/updated version from the Ross Valley watershed-wide HEC-RAS 1D/2D hydraulic model developed jointly by Stetson and USACE in 2017.

The first part of the hydraulic analysis was for computing worst-case maximum creek flow velocities along the new restored channel banks for slope erosion protection design. The worst case was conservatively assumed as the bankfull flow at the project reach coincided with downstream mean lower low tidal condition.

The second part of the hydraulic analysis was for verifying that the Project will not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions, and not worsen flooding under future sea level rise conditions.

The preliminary hydraulic analysis completed pertinent to the 30% design for the Lower COM Project mainly involved an analysis of worst-case maximum velocities along the new restored channel banks for slope protection design (i.e., the first bullet above).

In this 65% design stage for the Lower COM Project, hydraulic analysis was performed to verify that the Project will not cause increased flood water surface elevations at or near the Lower COM site for flows up to the regulatory 100-year flood for both existing and future foreseeable conditions (i.e., the second bullet above), and not worsen flooding under future sea level rise conditions (i.e., the third bullet above).

As explained in Section 1.2, the foreseeable projects are all located far upstream of the Lower COM Project area (see Figure 1). The foreseeable projects upstream of the Ross Creek confluence would have little effect on the hydrology and flooding of the Lower COM Project area. The foreseeable project downstream of the Ross Creek confluence, i.e., construction of the Unit 4 measures (with removal of the Ross fish ladder in particular), would reduce the overland flow escaped from the channel reach between Lagunitas Bridge and the Ross Gage, and increase the channel flow downstream. For the Lower COM Project area, the flooding effect from the construction of the Unit 4 measures would be a combined effect of the reduced overland flow and increased channel flow. The previous hydraulic modeling for the Corte Madera Creek Option C of Phoenix Lake grant migration performed by Stetson for the County in late 2017 provided some verification that the lower COM channel widening would not worsen flooding under the future foreseeable projects condition[10]. For this reason, the foreseeable projects condition was not explicitly simulated in this 65% design stage.

A total of three flood events were selected for the purpose of this study; the 5-year event, the 25-year event, and the 100-year event. The 5-year event was selected as it is about the flood threshold for the Ross Valley watershed. The 25-year event was selected as it was used for the SAFRR Project EIR. The 100-year event was selected as it is the required flood event for evaluation of project impact on flooding.

Following is a summary of model data preparation, modeling results of worst-case maximum velocities, and modeling results of the project effects to the upstream water surface elevations and flooding under existing and future sea level rise conditions.

Topographic Data Preparation

The existing condition channel topo data came from two data sources. One was from the earthen channel bathymetric survey conducted by CLE in January 2018 for the Lower Corte Madera Creek levee evaluation project, which covers the channel from the estuary to the Stadium Way bridge at Kentfield. The other was from the topographic survey for this project area conducted by GDG in February 2020, which covers the channel and top of banks from Stadium Way bridge to about 200 ft downstream of the stilling basin.

The project condition channel topography was based on the 65% grading plan.

The existing condition survey data and the project condition grading plan were then merged to the watershed scale LiDAR topo (flown in year 2010) to form two seamlessly integrated terrain datasets for use by the existing condition model and the project condition model respectively.

Model Preparation

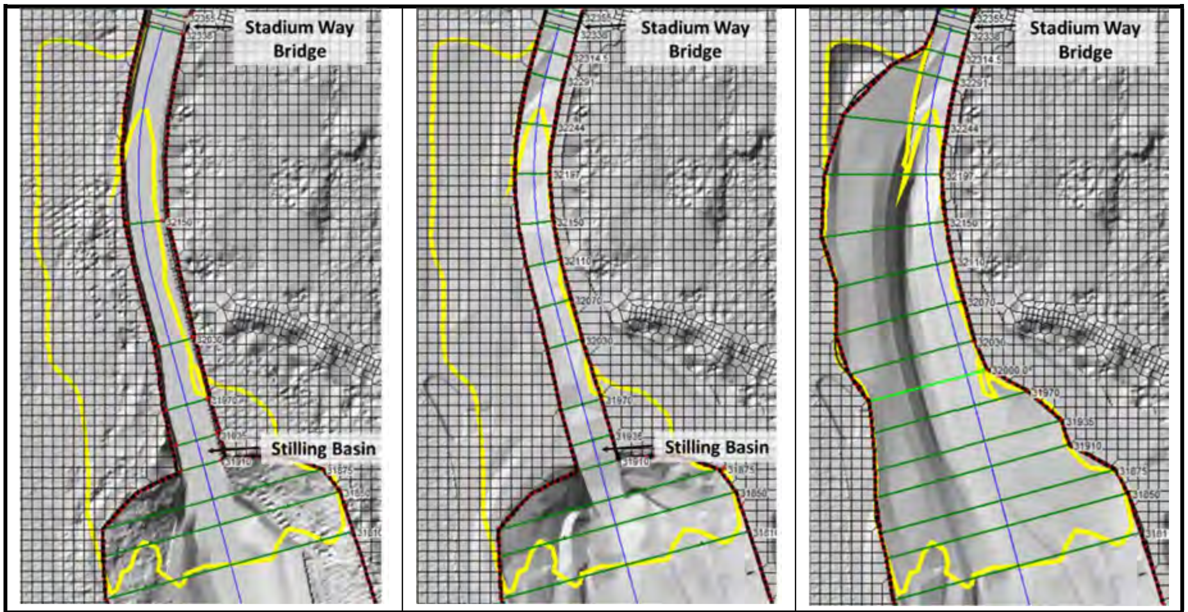
The Lower Corte Madera Creek HEC-RAS 1D/2D hydraulic model does not have enough cross-sections (XS) within the project footprint required to conduct this analysis (Figure 4 (a)). A few more model XS were added to the previous model within the project area footprint, as shown in Figure 4(b), and the XS profiles were also updated to the 2020 topographic survey data. The updated existing condition model was then used to create the project condition model by extending the XS alignment to cover the entire grading plan footprint (Figure 4 (c)).

The XS profiles of the updated existing condition model and the project condition model were then updated to the corresponding terrain datasets prepared above. The typical XS profile for the updated existing and project conditions are shown in Figure 5. The channel roughness (Manning's n) was also adjusted from 0.033 to 0.035 to reflect the anticipated increased channel

---

[10] The hydraulic analysis for the Corte Madera Creek Option C of Phoenix Lake grant migration included a scenario modeling of the Unit 4 measures plus the Lower COM Project with preliminary conceptual designs at that time. Note that the Lower COM Project was called Phase 1 of creek restoration project at that time.

roughness after converting the existing concrete channel to the natural channel. The Manning's n of 0.033 was the calibrated value for the lower concrete channel and the upper earthen channel under existing conditions.



(a) Previous existing condition model

(b) Updated existing condition model

(c) Updated project condition model

Figure 4 Model Update for the Corte Madera Creek Restoration Project
(Green lines are XS alignments; Yellow polygons are project grading plan footprint)

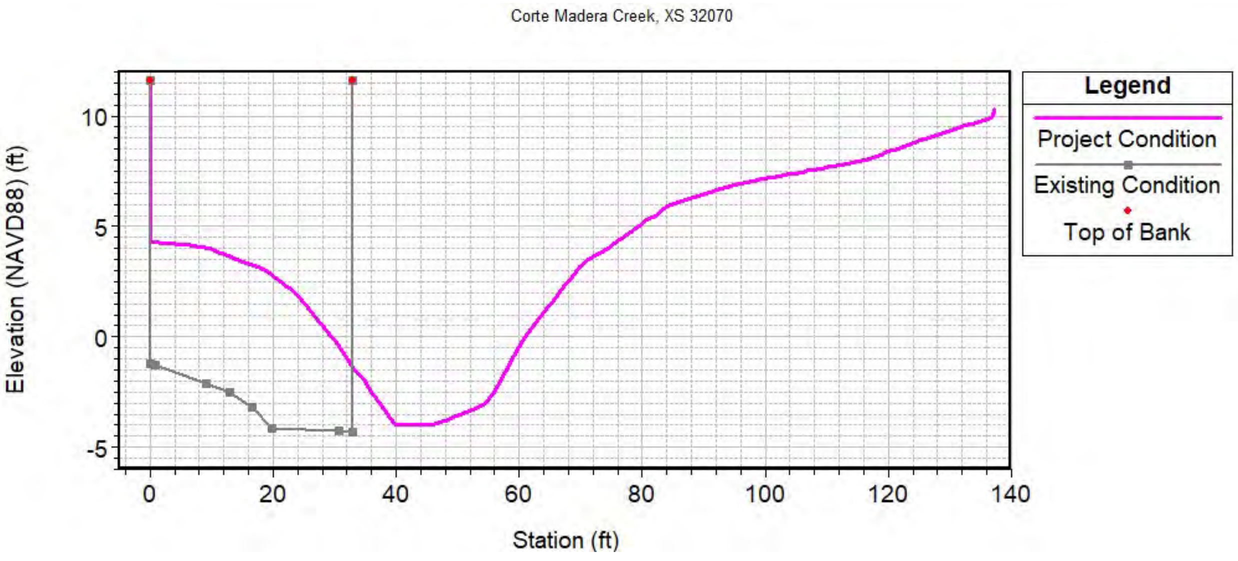


Figure 5 Typical XS Profile Comparison Between Existing and Project Condition

Hydraulic Simulations to Analyze Worse-Case Scenario Maximum Velocities

Hydraulic simulations were performed to analyze worst-case maximum velocities along the new restored channel banks for slope protection design. The worst case was conservatively assumed as the bankfull flow at the project reach coincided with downstream mean lower low tidal condition.

Based on the topo, the top of the bank elevation within the project reach is about 12 ft NAVD88. In order to achieve bankfull flow at the project site, the project condition model was further modified by adding unlimited high “glass walls” on both sides of the channel along the top of the channel banks so that all the flows would be contained in the channel. The model was run iteratively with gradual increasing of the inflows, until the WSE within the project reach rises to 12 ft NAVD88 at the upstream end and the downstream end of the project reach respectively. During the iterations, the downstream tidal boundary condition was kept at MLLW conditions (0.06 ft NAVD88) all the time so that the channel WSE profile would have a steeper hydraulic gradient and, thus, the higher velocity and shear stress for the project site. Figure 6 shows the WSE profiles for the bankfull conditions evaluated at the upstream end of the project reach and evaluated at the downstream end of the project reach.

The model simulated results are shown in Tables 1 and 2 (refer to Figure 7 for the river stations in the tables). The results show that the “worst-case scenario” flow channel velocity within the project reach would vary from 6.7 fps – 18.2 fps if bankfull is evaluated at upstream end of the project reach (see Table 1), and from 6.8 fps – 21.4 fps if bankfull is evaluated at downstream end of the project reach (see Table 2).

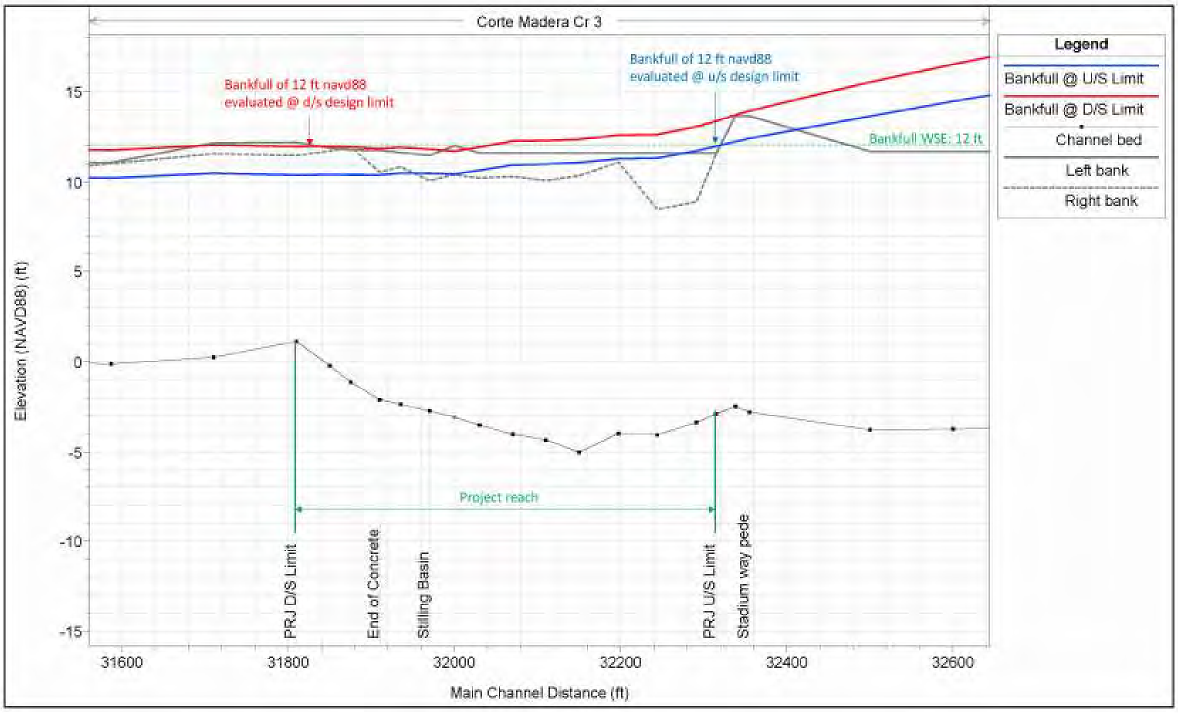


Figure 6 HEC-RAS Simulated Bankfull WSE Profiles along the Project Reach

Table 1 Model Output for Bankfull Evaluated at Upstream End of Project

	River Station	**WSE**	**Velocity**	**Shear Stress**
		(ft NAVD88)	**(fps)**	**(lb/sq ft)**
	32355	12.41	17.90	4.95
	32338	12.23	18.49	5.32
Upstream Limit Project Reach	32314.5	11.97	**18.22**	5.23
	32291	11.71	**15.27**	4.36
	32244	11.33	**11.01**	2.25
	32197	11.28	**9.75**	1.75
	32150	11.08	**9.81**	1.76
	32110	10.99	**9.41**	1.62
	32070	10.94	**8.88**	1.44
	32030	10.65	**9.69**	1.71
	32000	10.44	**10.25**	1.90
	31970	10.48	**9.15**	1.58
	31935	10.49	**8.21**	1.30
	31910	10.39	**8.26**	1.33
	31875	10.39	**7.46**	1.10
	31850	10.40	**6.94**	0.94
Downstream Limit Project Reach	31810	10.38	**6.69**	0.22
	31710	10.48	5.79	0.11
	31587	10.22	6.48	0.16

Table 2 Model Output for Bankfull Evaluated at Downstream End of Project

	River Station	WSE	Velocity	Shear Stress
		(ft NAVD88)	(fps)	(lb/sq ft)
	32355	13.93	21.16	6.80
	32338	13.70	21.86	7.31
Upstream Limit Project Reach	32314.5	13.36	**21.42**	7.08
	32291	13.05	**17.32**	5.41
	32244	12.63	**12.34**	2.71
	32197	12.59	**10.78**	2.04
	32150	12.36	**10.92**	2.08
	32110	12.29	**10.41**	1.89
	32070	12.26	**9.79**	1.67
	32030	11.93	**10.76**	2.01
	32000	11.70	**11.38**	2.24
	31970	11.81	**9.84**	1.73
	31935	11.91	**8.61**	1.34
	31910	11.84	**8.55**	1.33
	31875	11.94	**7.50**	1.04
	31850	11.97	**7.01**	0.90
Downstream Limit Project Reach	31810	**11.95**	**6.82**	0.25
	31710	12.04	6.10	0.12
	31587	11.76	6.77	0.18

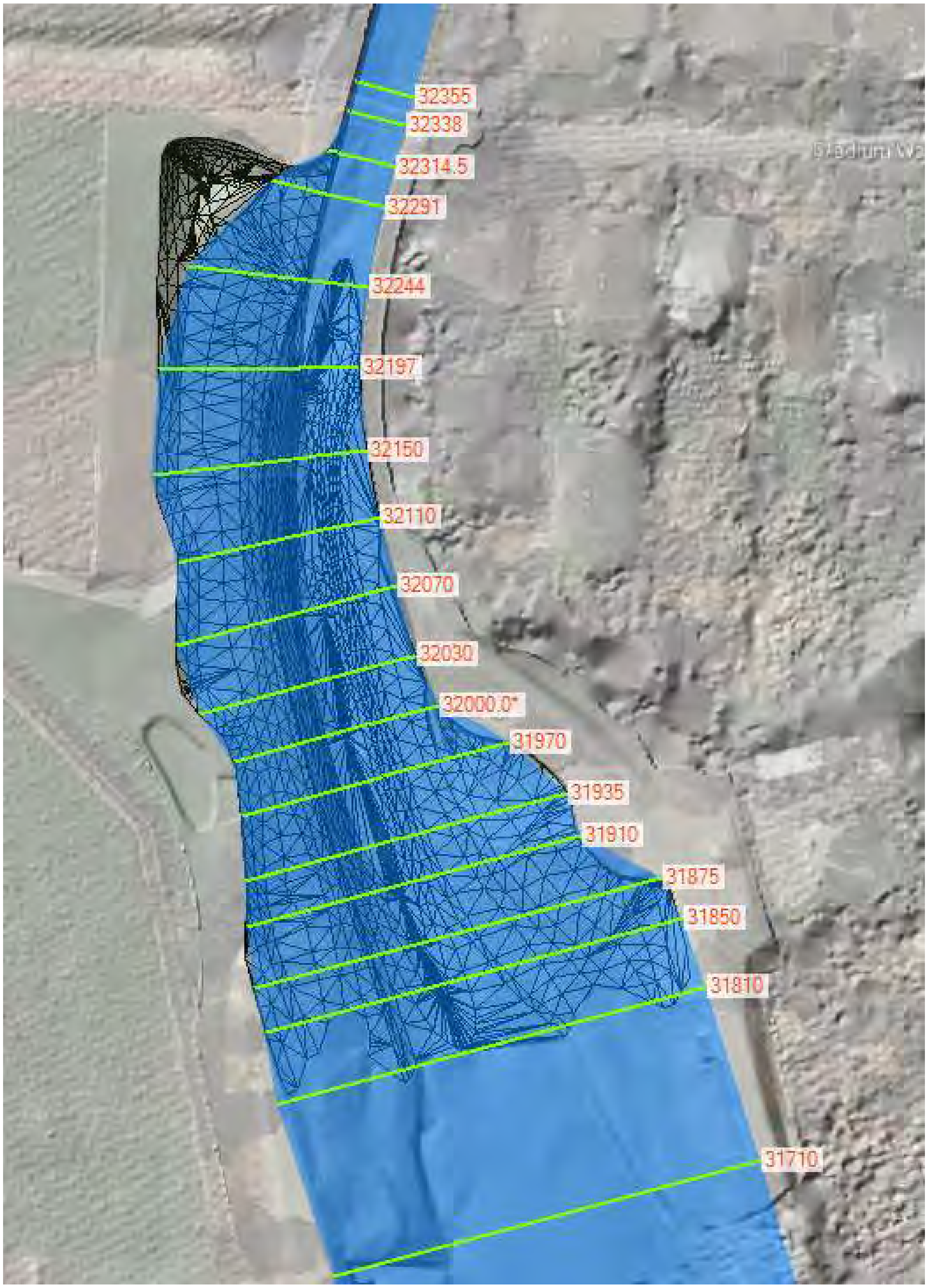


Figure 7 HEC-RAS Model XS Locations and River Stations

Hydraulic Simulations to Analyze the Project Effects on WSEs/Flooding under Existing Tide and Future Sea Level Rise Conditions

Hydraulic simulations were performed to analyze the effect of the project on WSEs/flooding under existing tide and future SLR conditions. Per FEMA guidelines, the downstream boundary condition of the model was set to the mean higher high water (MHHW) of the tide at the Corte Madera Creek estuary. Based on NOAA data, the current MHHW at the estuary is 5.9 ft NAVD88. According to the State of California Sea-Level Rise Guidance/2018 Update (California Natural Resources Agency, 2017), future sea level by 2050 will rise by 1.1 ft under the "67% probability, high emissions" scenario. The two MHHW tide levels (5.9 ft and 7.0 ft NAVD88) were used for the evaluation of the project effect on WSEs/flooding under existing tide and future SLR conditions.

Note that future foreseeable projects condition was not simulated in this 65% design stage.

Three flood events (Q5, Q25, and Q100) were simulated. Figures 8 and 9 compare the model-simulated channel WSE profiles between existing and project conditions under the existing tide condition. Figures 10 and 11 compare the model-simulated channel WSE profiles between existing and project conditions under the future SLR condition. The results show that, for all the simulated flood events, regardless of the flood magnitude or the downstream tidal boundary conditions, the project would increase the channel WSE for most of the reach within the project footprint and decrease the WSE upstream of the project footprint. The maximum increase would occur right before the downstream end of the existing concrete channel, with the increase at about 0.7 ft – 0.9 ft depending on the specific flood. The maximum decrease would occur right downstream of the Stadium Way pedestrian bridge, with the maximum decrease at about 0.4 ft – 0.7 ft depending on the specific flood. The future SLR condition would cause an overall WSE increase of about 0.3 ft - 0.5 ft, compared with the existing tidal condition for both the existing and project conditions. The relative WSE changes between flood events caused by the project under future SLR condition is similar to those under the existing tide condition, meaning that the SLR itself would not alter the project effect pattern on the channel WSE profiles.

Figure 12 shows the changes in the HEC-RAS model-simulated floodplain inundation extent and depth between the Lower COM Project and existing conditions for the 100-year flood under the existing tide condition. Figure 13 shows the changes in the HEC-RAS model-simulated floodplain inundation extent and depth between the Lower COM Project and existing conditions for the 100-year flood under the future SLR condition. The results in Figures 12 and 13 do not show any increased water surface elevations in the floodplain, indicating that the Lower COM Project would not worsen flooding under both existing tide and future SLR conditions.

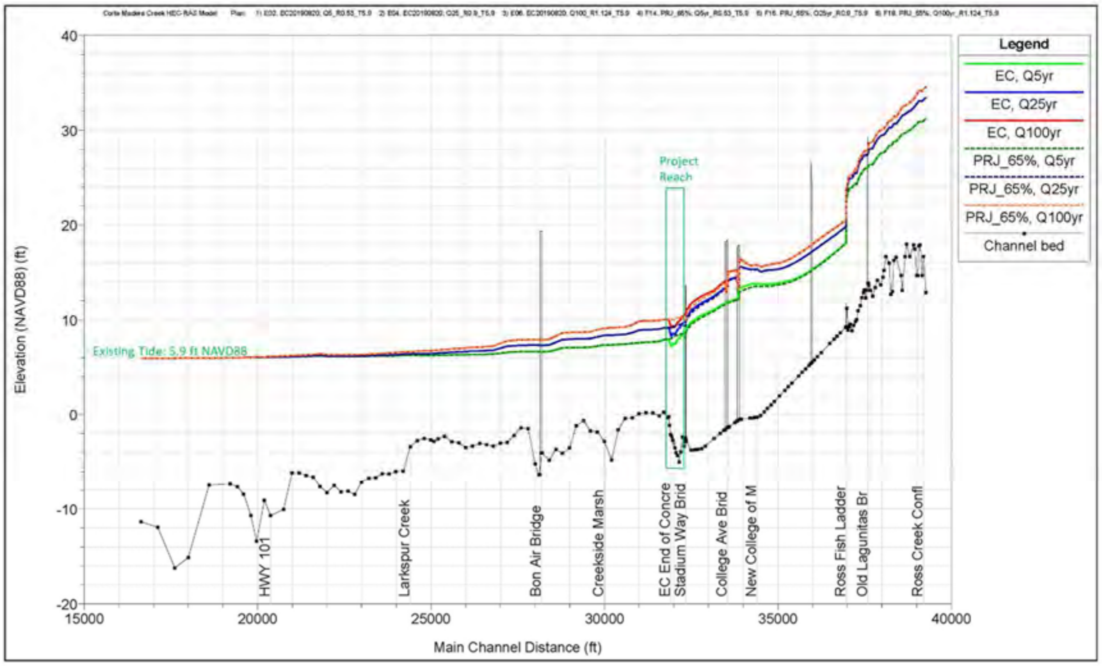


Figure 8 HEC-RAS Simulated WSE Profiles along the Entire Model Domain under Existing Tidal Condition

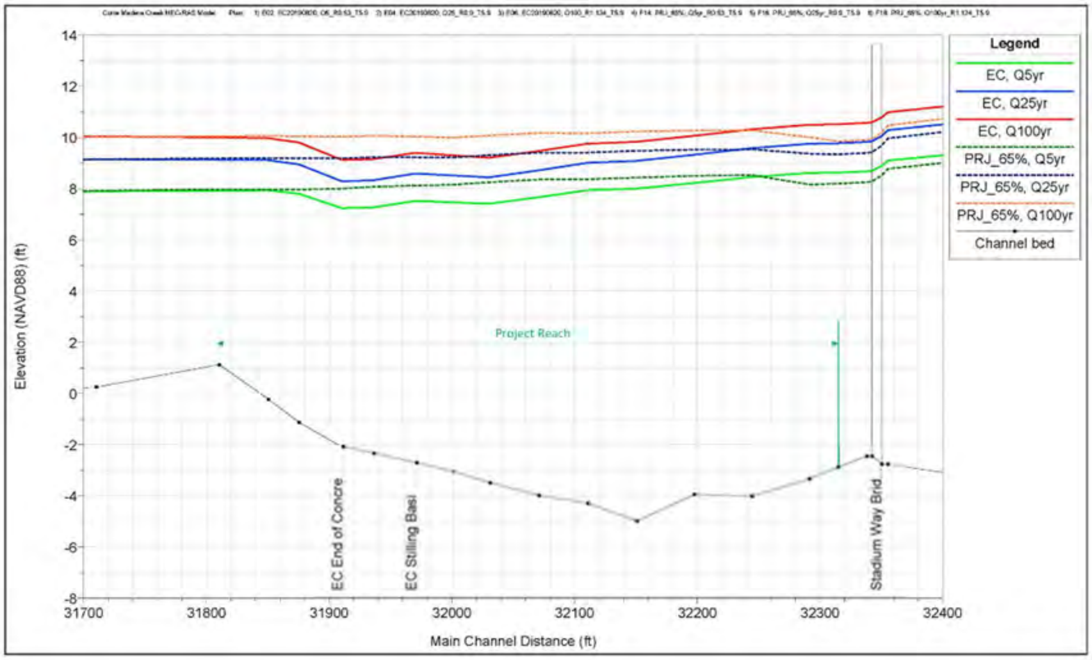


Figure 9 HEC-RAS Simulated WSE Profiles along the Project Reach under Existing Tidal Condition

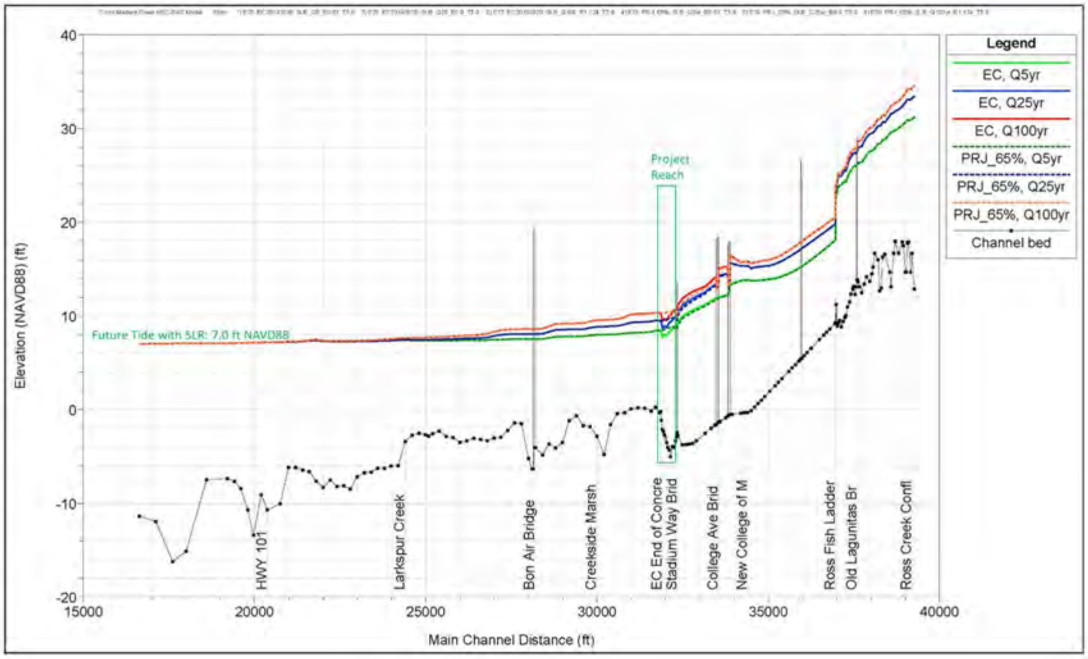


Figure 10 HEC-RAS Simulated WSE Profiles along the Entire Model Domain under Future SLR Condition

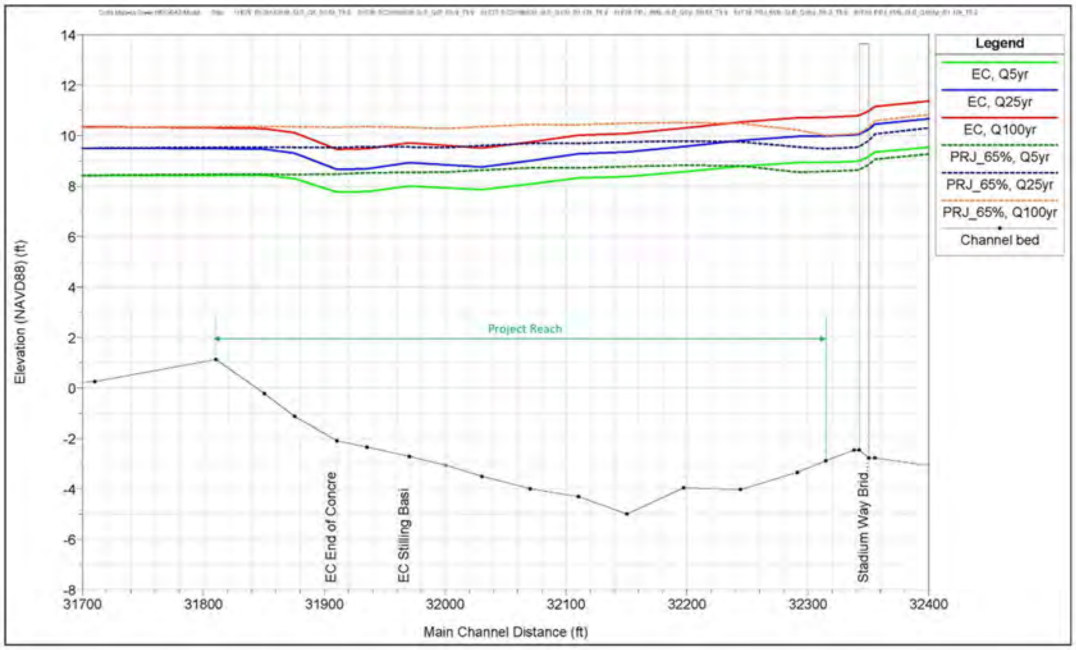
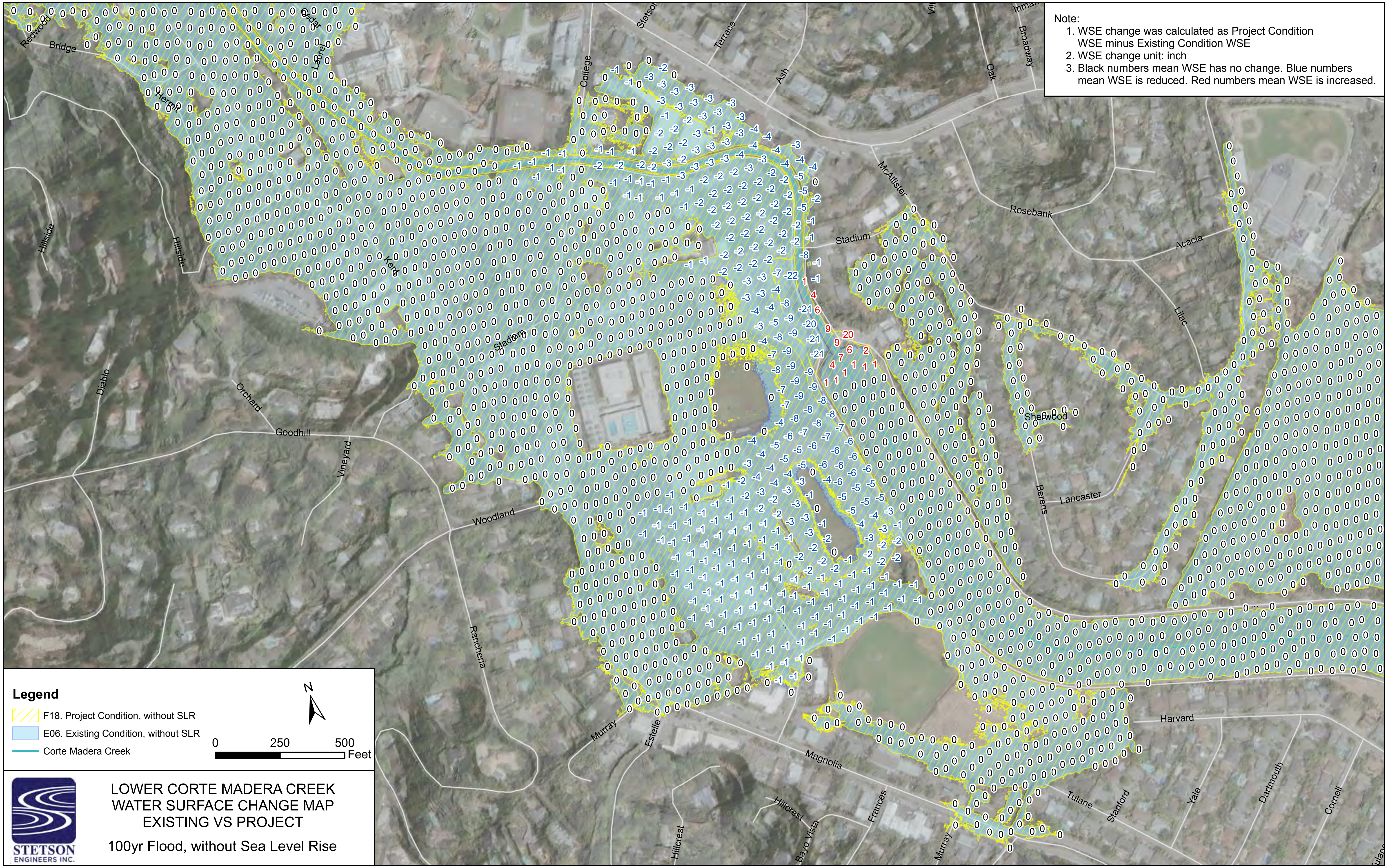


Figure 11 HEC-RAS Simulated WSE Profiles along the Project Reach under Future SLR Condition

FIGURE 12



Note:

1. WSE change was calculated as Project Condition WSE minus Existing Condition WSE
2. WSE change unit: inch
3. Black numbers mean WSE has no change. Blue numbers mean WSE is reduced. Red numbers mean WSE is increased.

Legend

▨	F18. Project Condition, without SLR
🟦	E06. Existing Condition, without SLR
—	Corte Madera Creek

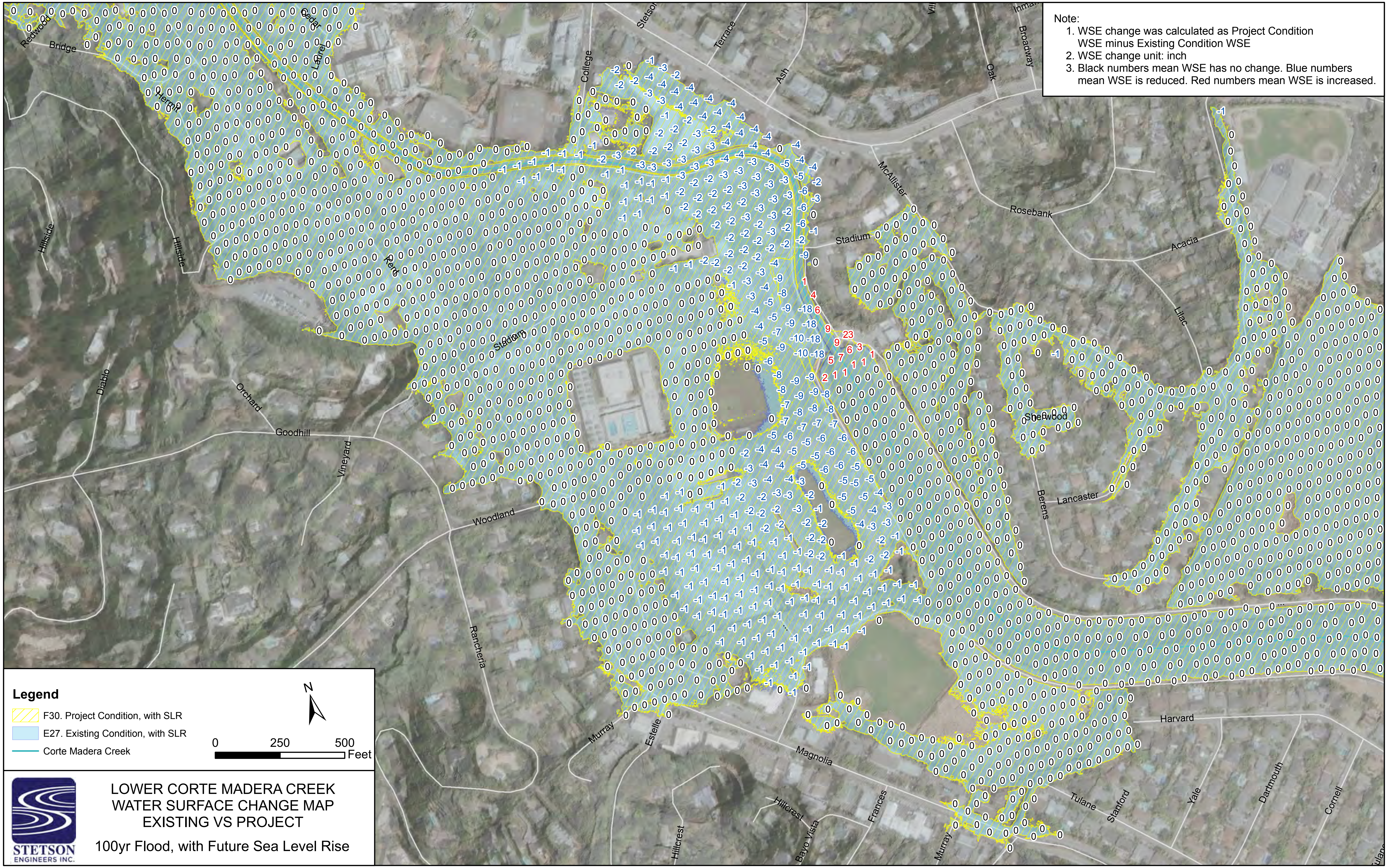
STETSON ENGINEERS INC.

LOWER CORTE MADERA CREEK
WATER SURFACE CHANGE MAP
EXISTING VS PROJECT

100yr Flood, without Sea Level Rise

C:\DATA\2747\GIS\FIG 1 Lower CMC WSE change map.mxd 11/20/2020

FIGURE 13



Note:

1. WSE change was calculated as Project Condition WSE minus Existing Condition WSE
2. WSE change unit: inch
3. Black numbers mean WSE has no change. Blue numbers mean WSE is reduced. Red numbers mean WSE is increased.

Legend

- ▨ F30. Project Condition, with SLR
- 🟦 E27. Existing Condition, with SLR
- — Corte Madera Creek

N

0 250 500 Feet

STETSON ENGINEERS INC.

LOWER CORTE MADERA CREEK
WATER SURFACE CHANGE MAP
EXISTING VS PROJECT

100yr Flood, with Future Sea Level Rise

C:\DATA\2747\GIS\FIG 2 Lower CMC WSE change map.mxd 11/20/2020

4.0 REFERENCES

California Natural Resources Agency. 2017. State of California Sea Level Rise Guidance: 2018 Update (November 2017)

Stetson, 2017a. Documentation of Ross Valley HEC-RAS v5.0 1D/2D Unsteady-State Hydraulic Model. August 7, 2017.

Stetson, 2017b. Report on Hydraulic Modeling of Corte Madera Creek Option C for the Phoenix Lake Grant. September 5, 2017.

Stetson, 2019. Existing Conditions Hydraulic Evaluation of the Corte Madera Creek Levees. October 7, 2019.

U.S. Army Corps f Engineers/Hydrologic Engineering Center, 2016. HEC-RAS User's Manual. February, 2016.

Looking upstream from near the Army Corps of Engineers Concrete Channel outlet during near minimum tidal elevation (February 2020)

Alternatives Analysis

Lower COM Corte Madera Creek Habitat Restoration Project
Kentfield, California
August 2021

geomorph
DESIGN

MATT SMELTZER
C71671
Exp. 12/31/21
CIVIL

Prepared by:
Matt Smeltzer, P.E.
Engineer/Geomorphologist
CA Civil Engineer #71671

Northern California 2100 Fourth Street, No. 154, San Rafael, CA 94901
Interior Alaska 129 Kristin Drive, Fairbanks, AK 99712
mobile/office 510-219-1064
www.geomorphdesign.com

Summary

The objective of the Lower COM Project is to restore Corte Madera Creek from near the Stadium Way bridge to the downstream end of the Army Corps of Engineers concrete flood control channel to tidal wetland, transitional, and upland habitat that is resilient to climate change within the practical limits imposed by existing underground utilities and easement boundaries, and consistent with continuing safe use of the Multi-Use Pathway and other existing land uses.

The proposed project (Alternative 1) is the only alternative that meets the project objective in a manner that minimizes temporary environmental and construction impacts to an acceptable level.

Opportunities and Constraints

Under existing conditions, Corte Madera Creek flows within an approximately rectangular concrete channel comprised of an approximately 33-foot-wide 18-inch-thick steel-reinforced flat concrete channel floor with approximately 18-foot-high vertical steel-reinforced concrete retaining walls on both sides. The channel walls are 12-inches-wide at the top increasing to 30-inches wide at the bottom. The walls and floor are structurally integral and the floor is, structurally, the foundation for the walls.

Nowhere in the project site is the concrete channel floor exposed. Sediment covers the entire concrete channel floor to a depth varying from 3 feet to 7 feet and averaging about 4 feet. The concrete channel floor elevation gradually slopes down from elevation -6.5 feet to -6.7 feet (NAVD88 datum).

The lowest tidal water level in the channel is -1.7 feet NAVD88. The water levels in the concrete channel are maintained by a gravel bar sediment deposit in the earthen channel section downstream from the concrete channel outlet.

Habitat restoration requires removing all or part of the concrete channel to allow the creek to flow over a wider area with natural material and naturally formed channel banks that are gradually sloped for supporting a range of wetland, transitional, and upland habitats.

Alternatives Analyzed

Alternative 1. Proposed Project
Alternative 2. Complete Concrete Channel Floor Removal and New Left Bank Wall Foundation.
Alternative 3. Partial Concrete Channel Floor Removal.
Alternative 4. No Project.

Table 1.
Volume Steel-Reinforced Concrete (Cubic Yards)

	Existing to Remain	Removed from Existing	New	Total Resulting
Alternative 1	1,717	406	9	1,726
Alternative 2 (Option A)	1,015	1,018	262	1,277
Alternative 2 (Option B)	917	1,206	471	1,388
Alternative 2 (Option C)	1,015	1,018	247	1,262
Alternative 2 (Option D)	1,015	1,018	207	1,222
Alternative 2 (Option E)	983	1,140	5	988
Alternative 3	1,252	817	75	1,327
Alternative 4	2,123	0	0	2,123

Limitations for Concrete Wall Removal Imposed by Existing Utilities

1. An existing 20-inch-diameter water supply pipe crosses over the concrete channel about 8-10 feet downstream from the Stadium Way bridge. To avoid impacts to the water pipe, potential channel wall removal must end not closer than 4 feet from this crossing, or about 15 feet downstream from the bridge. Wall removal must create a new sloping top of wall running downstream from the removal limit so that a gradual transition can be accomplished between the vertical concrete wall and gradually sloped natural surface banks downstream.

2. There are significant utility, right-of-way width, and land use limitations preventing removal of the left bank channel wall (the left side of the channel is defined looking downstream) or the east side of the channel. First, there is a 42-inch-diameter sanitary sewer pipe running behind and about 6-9 feet from the wall at an elevation between -1 and -4 feet NAVD88. Potential wall removal would be prevented below approximately elevation 3 feet NAVD88 (approximately Mean Sea Level). A steel-reinforced concrete encasement would be required covering over the sewer line. Second, the right-of-way extends only about 12-14 horizontal feet from the top of the left bank channel wall before it meets private property. This does not provide enough room to restore a gradually sloped vegetated creek bank. Third, the Multi-Use Pathway (MUP) runs along the top of the channel bank within the 12-14-foot-wide right-of-way. It is not feasible to maintain safe use of the MUP at a lowered elevation because it would then be subject to inundation by very high tides and during winter floods.

3. The left bank utility, right-of-way, and land use limitations end about 300 feet downstream from the bridge where the private property ends and the utilities and MUP

turn 45 degrees away from the channel. Potential left bank channel wall removal must end about 10 feet downstream from the utility and pathway turning point, and taper down gradually downstream from the removal limit.

Limitations for Concrete Floor Removal

1. An existing sanitary sewer pipe passes under the concrete channel floor about 15-20 feet downstream from the Stadium Way Pedestrian Bridge. Potential channel floor removal must remain at least 10 feet from the sanitary sewer crossing, or about 30 feet downstream from the bridge. A new steel-reinforced concrete or sheet pile "cut-off" wall would be required at the upstream limits of concrete floor removal—along and joining with the cut floor section—to cover exposed steel reinforcement on the cut section, structurally stabilize the new floor limit, and prevent potential undermining of the floor limit by scour. The cut-off wall would need to extend down to minimum 4 feet below the bottom of the cut floor section, or about elevation -12.0 ft NAVD88.

2. Downstream from the setback from sanitary sewer crossing, concrete channel floor removal is limited by structural and environmental concerns.

    A. Removing the entire channel floor is structurally infeasible because the left bank channel wall cannot be stabilized in place without constructing new structural retrofits beyond the right-of-way and within private property each of the channel. Removing the entire 33-foot-width of the channel floor would remove the foundation of the left bank channel wall. The geotechnical-structural options for stabilizing the left bank channel wall in place all require deadmen and/or tie-backs extending 20 or more feet east from the right-of-way limits. In places the necessary retrofits would extend into existing residential building footprints.

    B. Removing only the right half of the channel floor width may be structurally feasible because the remainder of the floor would act as an "L-footing" for the left bank channel wall. Potential removal of the right half of the channel floor would need to end about 180 feet downstream from the bridge where the taper-cut right bank channel wall removal ends. Similarly, the left half of the downstream end of the channel floor could also be removed ending about 395 feet downstream from the bridge. A new steel-reinforced concrete or sheet pile "cut-off" wall down to minimum elevation -12 feet would need to be constructed along and joining with the entire cut floor section to cover the steel and stabilize the floor limit. Partial concrete floor removal would have substantially more temporary environmental and construction impacts than leaving the concrete floor intact below grade:

i. The creek would need to be dewatered to a lower elevation to allow for silt and sand removal and then concrete demolition and removal.
ii. The creek would need to be dewatered to a still lower elevation to allow for forming and pouring approximately 250 lineal feet (76 CY) of cast-in-place steel-reinforced concrete cut-off walls to a depth of -12 feet.
iii. The total duration of creek dewatering would be extended 2-3 months, or more should typical 30-day concrete curing time requirements apply.

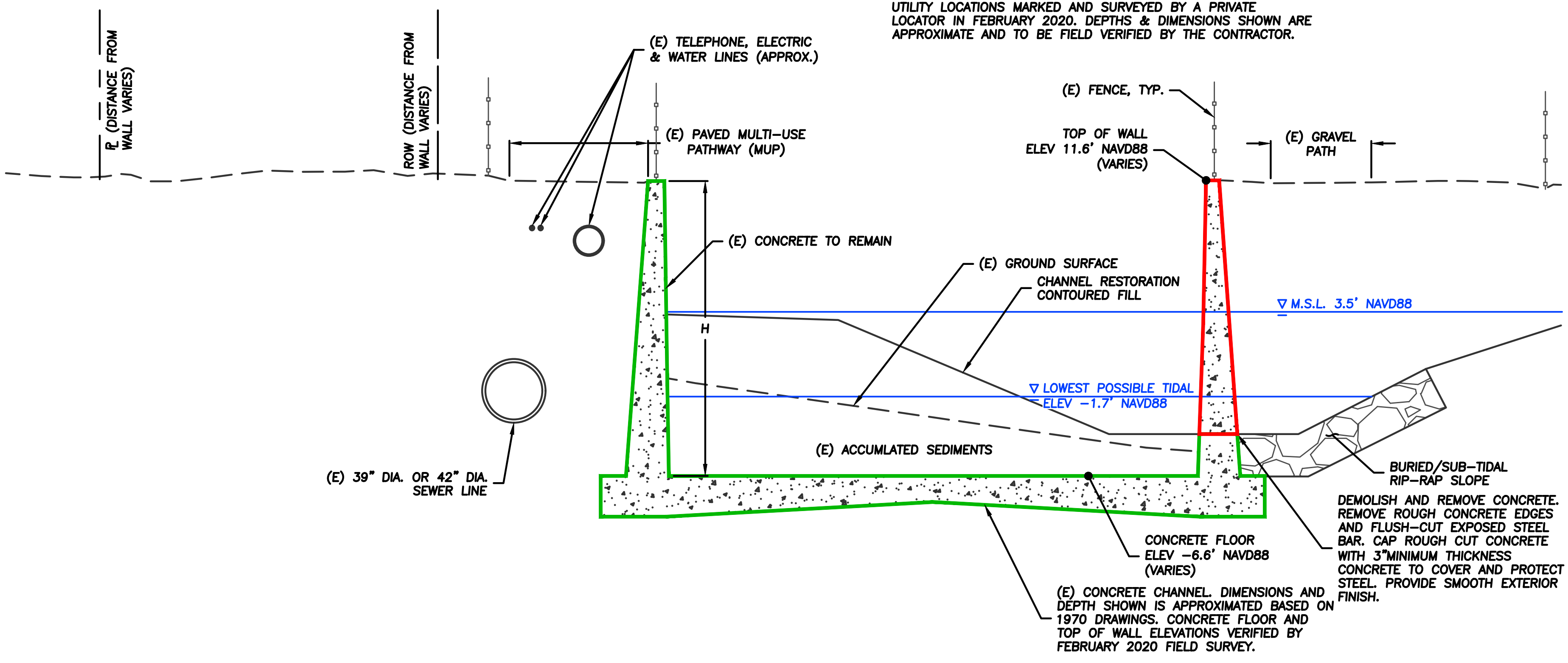
Conclusion

The proposed project (Alternative 1) is the only alternative that meets the project objective in a manner that minimizes temporary environmental and construction impacts to an acceptable level.

Appendices

Cross-Section Diagrams of Alternatives (7 p.)

NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.



DEMOLISH AND REMOVE CONCRETE. REMOVE ROUGH CONCRETE EDGES AND FLUSH–CUT EXPOSED STEEL BAR. CAP ROUGH CUT CONCRETE WITH 3"MINIMUM THICKNESS CONCRETE TO COVER AND PROTECT STEEL. PROVIDE SMOOTH EXTERIOR FINISH.

(E) CONCRETE CHANNEL. DIMENSIONS AND DEPTH SHOWN IS APPROXIMATED BASED ON 1970 DRAWINGS. CONCRETE FLOOR AND TOP OF WALL ELEVATIONS VERIFIED BY FEBRUARY 2020 FIELD SURVEY.

NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST–PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 1 – PROPOSED PROJECT
SCALE: 1" = 10'
SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 406 CY
🟩	EXISTING CONCRETE TO REMAIN: 1,717 CY
🟪	NEW CONCRETE: 9 CY

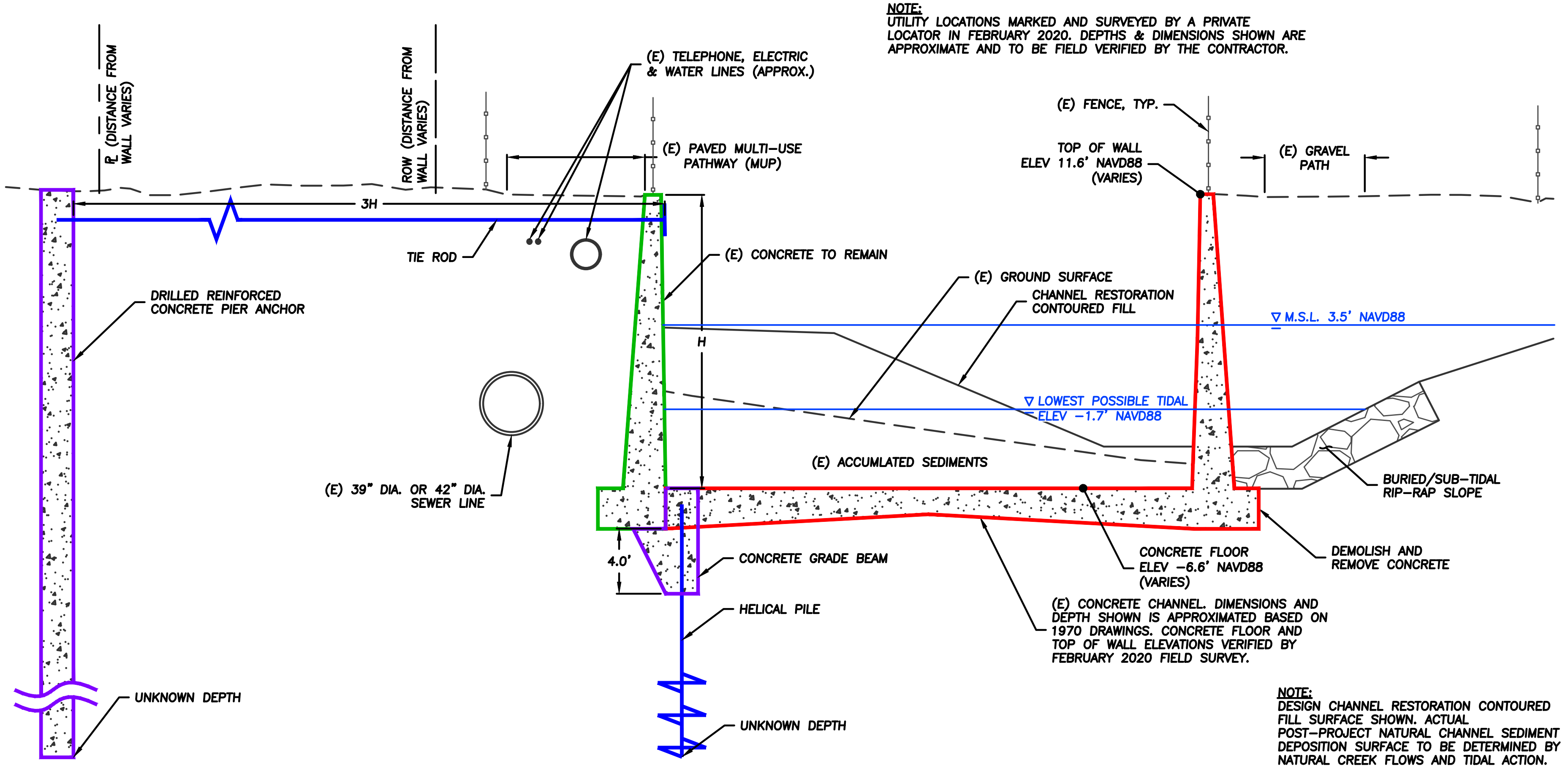
LOWER COM CORTE MADERA CREEK RESTORATION PROJECT
CORTE MADERA CREEK
ALTERNATIVE 1 - PROPOSED PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

geomorphDESIGN

Date: 6 AUG 2021
Design by: MS
Drawn by: BRS
Checked by: MS
Scale: 1" = 10'

FIG.1



NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.

NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST–PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 2 - COMPLETE FLOOR REMOVAL - FOUNDATION OPTION A

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 1,108 CY
🟩	EXISTING CONCRETE TO REMAIN: 1,015 CY
🟪	NEW CONCRETE: 262 CY

ALTERNATIVE 2A - COMPLETE FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

geomorphDESIGN

Date:
6 AUG 2021

Design by:
MS

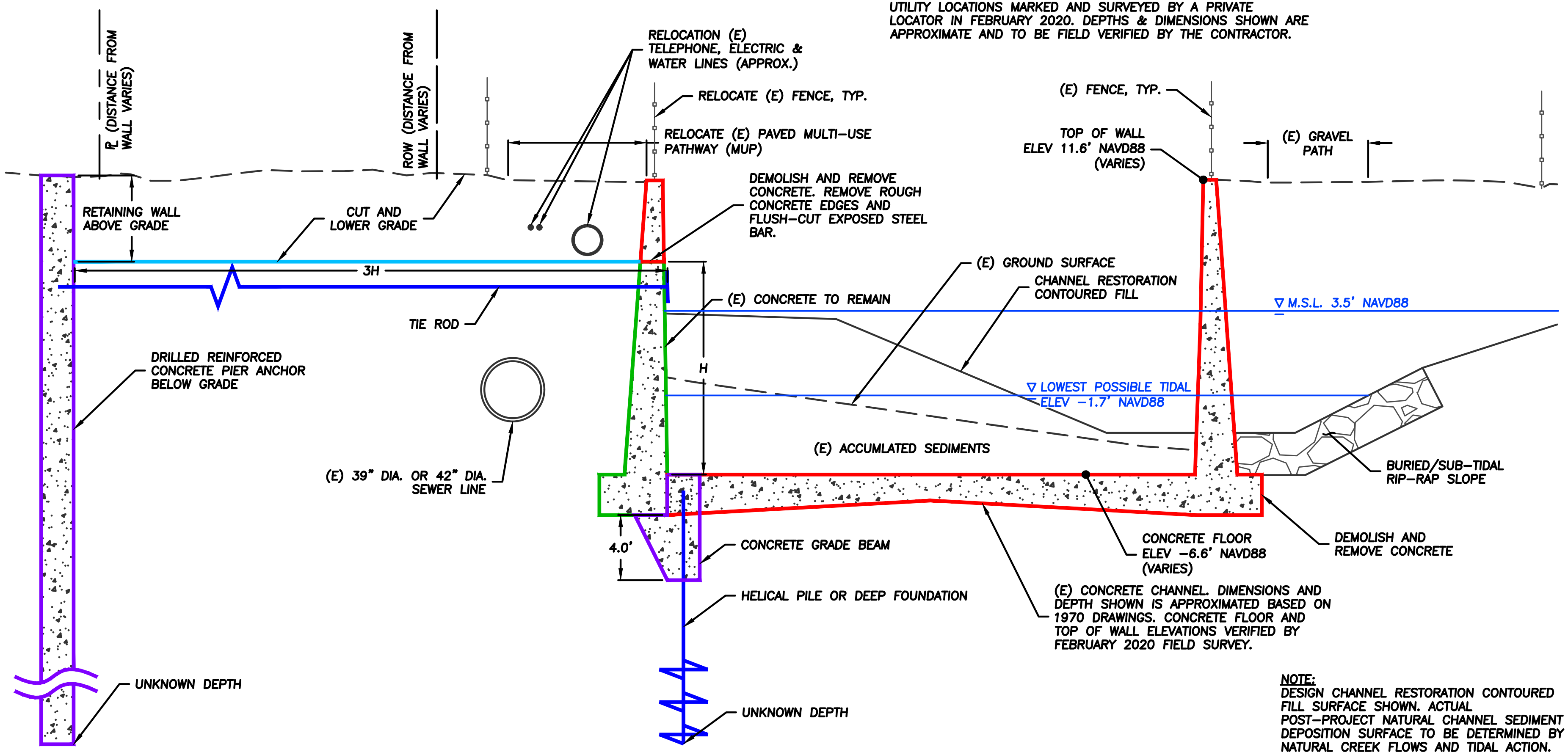
Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.2

NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.



NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST-PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 2 - COMPLETE FLOOR REMOVAL - FOUNDATION OPTION B

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 1,206 CY
🟩	EXISTING CONCRETE TO REMAIN: 917 CY
🟪	NEW CONCRETE: 471 CY

ALTERNATIVE 2B - COMPLETE FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

Date:
6 AUG 2021

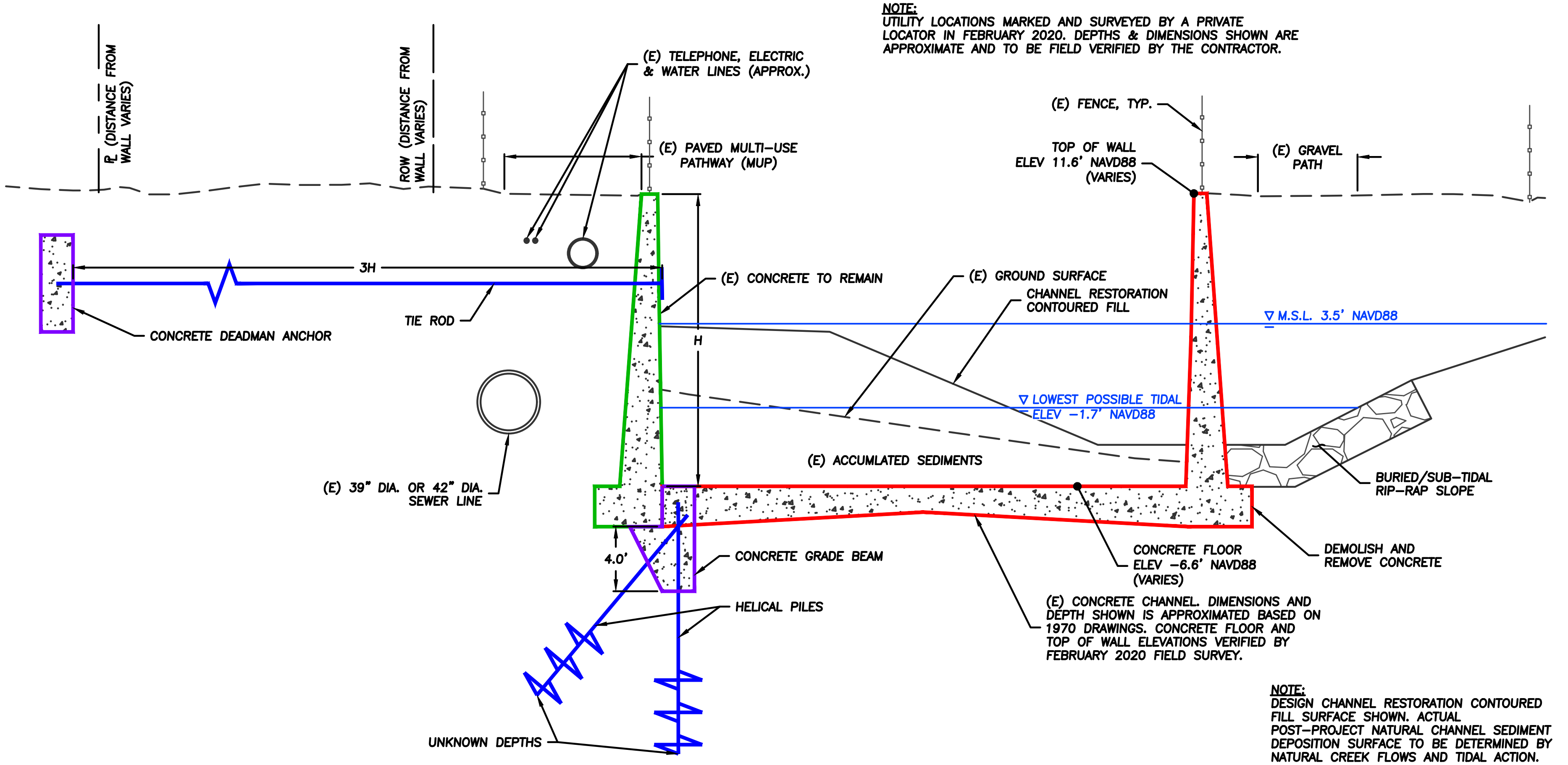
Design by:
MS

Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.3



NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.

NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST–PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 2 - COMPLETE FLOOR REMOVAL - FOUNDATION OPTION C

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 1,108 CY
🟩	EXISTING CONCRETE TO REMAIN: 1,105 CY
🟪	NEW CONCRETE: 247 CY

ALTERNATIVE 2C - COMPLETE FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

geomorphDESIGN

Date:
6 AUG 2021

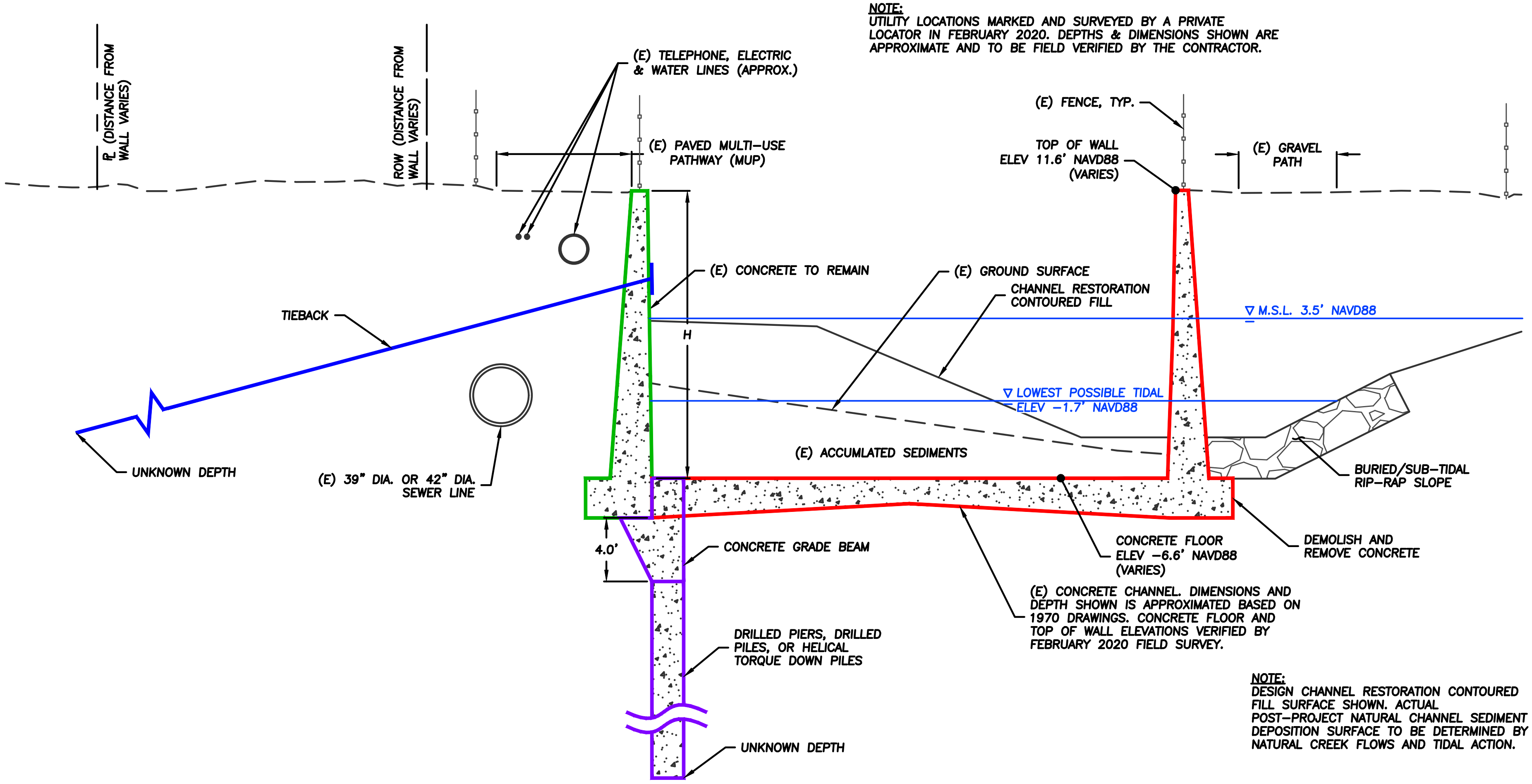
Design by:
MS

Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.4



NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.

NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST-PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 2 - COMPLETE FLOOR REMOVAL - FOUNDATION OPTION D

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 1,108 CY
🟩	EXISTING CONCRETE TO REMAIN: 1,105 CY
🟪	NEW CONCRETE: 207 CY

ALTERNATIVE 2D - COMPLETE FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

Date:
6 AUG 2021

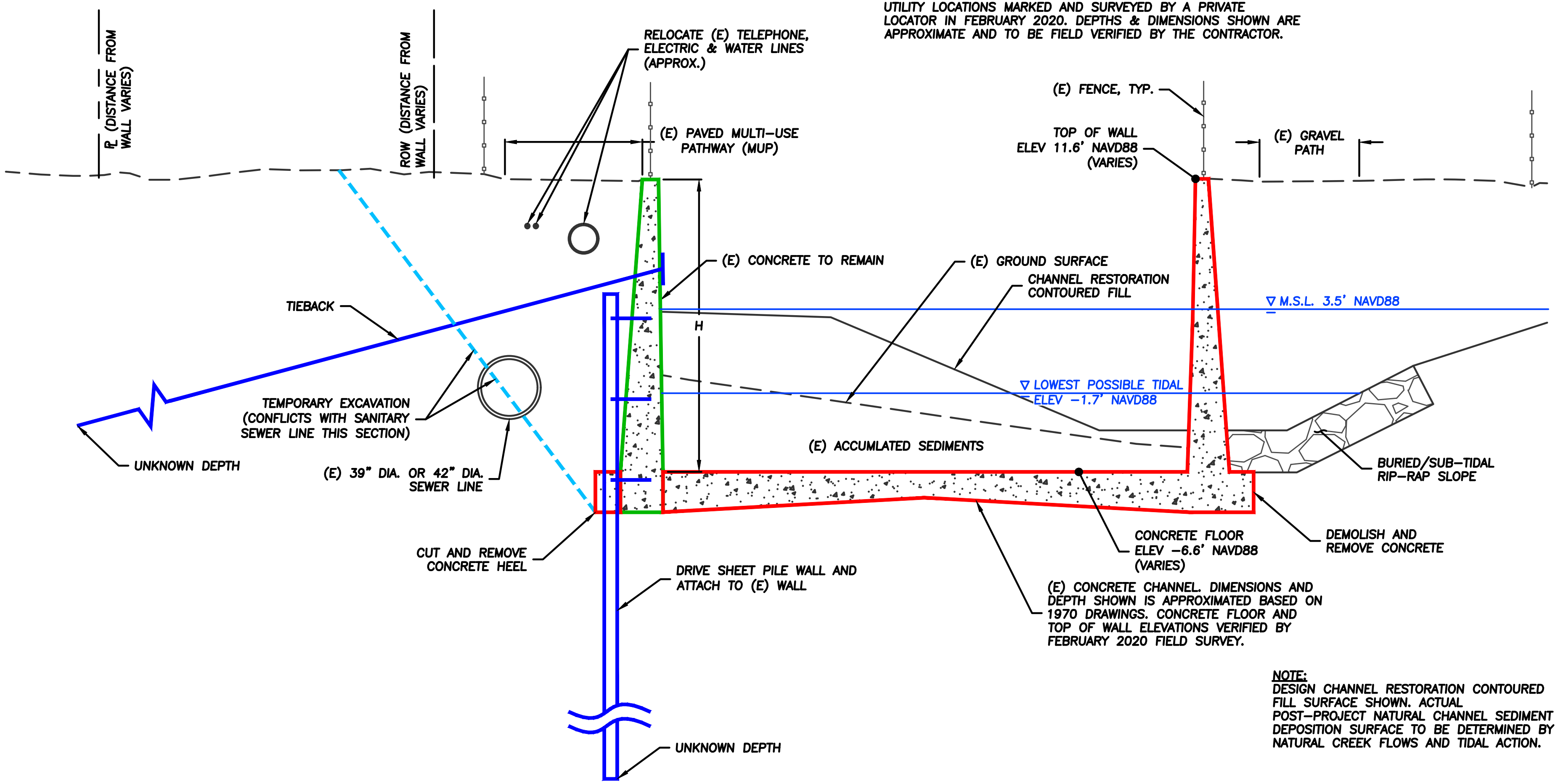
Design by:
MS

Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.5



NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.

NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST-PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 2 - COMPLETE FLOOR REMOVAL - FOUNDATION OPTION E

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 1,140 CY
🟩	EXISTING CONCRETE TO REMAIN: 983 CY
🟪	NEW CONCRETE: 5 CY

ALTERNATIVE 2E - COMPLETE FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

geomorphDESIGN

Date:
6 AUG 2021

Design by:
MS

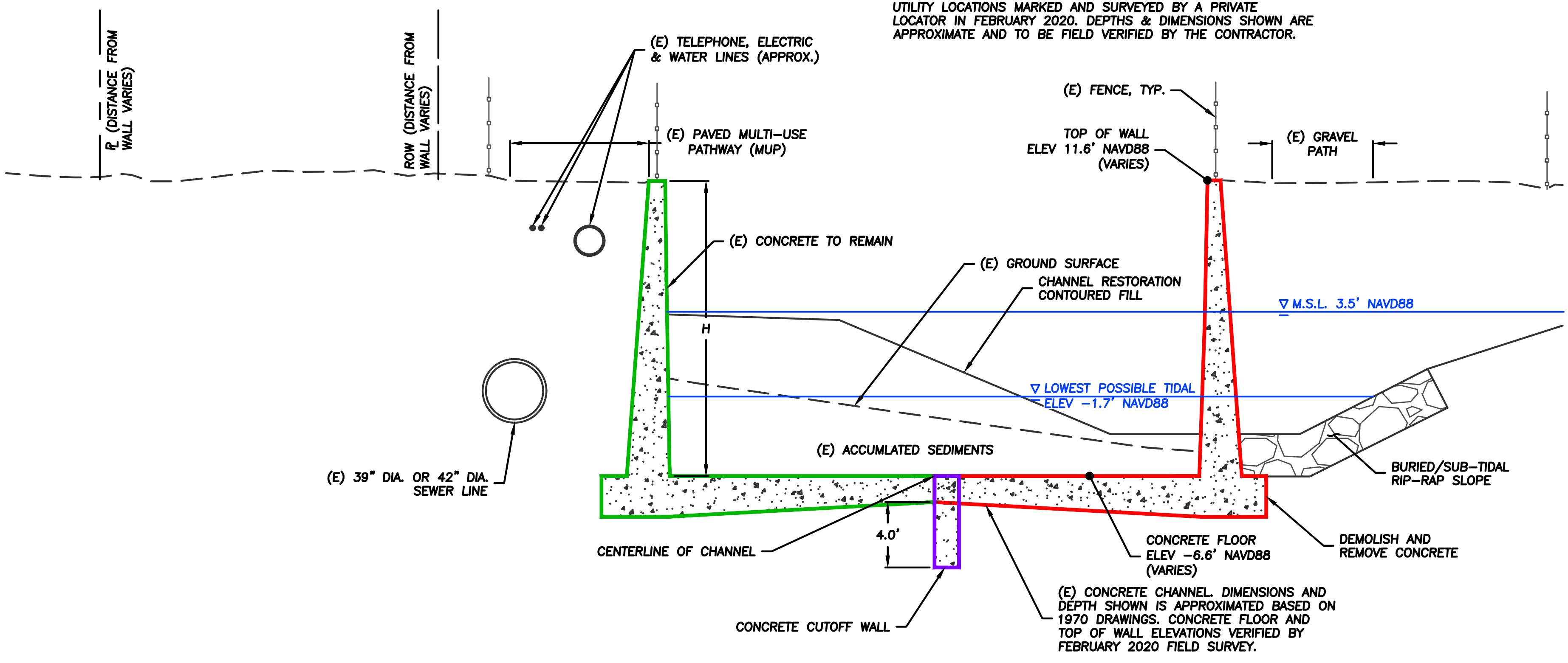
Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.6

NOTE:
UTILITY LOCATIONS MARKED AND SURVEYED BY A PRIVATE LOCATOR IN FEBRUARY 2020. DEPTHS & DIMENSIONS SHOWN ARE APPROXIMATE AND TO BE FIELD VERIFIED BY THE CONTRACTOR.



NOTE:
DESIGN CHANNEL RESTORATION CONTOURED FILL SURFACE SHOWN. ACTUAL POST-PROJECT NATURAL CHANNEL SEDIMENT DEPOSITION SURFACE TO BE DETERMINED BY NATURAL CREEK FLOWS AND TIDAL ACTION.

ALTERNATIVE 3 - PARTIAL FLOOR REMOVAL

SCALE: 1" = 10'

SECTION 321+50 FT

QUANTITIES LEGEND

🟥	EXISTING CONCRETE TO BE REMOVED: 871 CY
🟩	EXISTING CONCRETE TO REMAIN: 1,252 CY
🟪	NEW CONCRETE: 75 CY

ALTERNATIVE 3 - PARTIAL FLOOR REMOVAL

CORTE MADERA CREEK

LOWER COM CORTE MADERA CREEK RESTORATION PROJECT

Geomorph DESIGN
2100 Fourth Street, No. 154
San Rafael, CA 94901
(510) 219-1064
www.geomorphdesign.com

Date:
6 AUG 2021

Design by:
MS

Drawn by:
BRS

Checked by:
MS

Scale:
1" = 10'

FIG.7

Appendix 7. Final Hydraulic Analysis Report (Stetson Engineers, February 2022)

(Pending Completion)