Appendix F. Structure Preliminary Geotechnical Report

Last Chance Grade Permanent Restoration Project

Structure Preliminary Geotechnical Report
Alternative F Tunnel and Approach Structures

Submittal SUB-052c

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PM 12.7/16.5

Caltrans

LAST CHANCE GRADE

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Acronyms and Abbreviations

APEFZ	Alquist-Priolo Earthquake Fault Zone
APS	Advance Planning Study
ARS	Acceleration Response Spectrum
ASTM	American Society for Testing and Materials
ATV	acoustic televiewer
BGS	below the ground surface
Caltrans	California Department of Transportation
CU	consolidated undrained
CGS	California Geological Survey
CIDH	cast-in-drilled-hole
CIP	cast-in-place
CSZ	Cascadia Subduction Zone
CTM	California Test Methods
EDAS	Engineered Deformation Absorption System
EF	Earthflow Complex
H:V	horizontal to vertical
k_h	horizontal seismic coefficient
LCG	Last Chance Grade
M	Mean Earthquake Moment Magnitude
MTD	Caltrans Memo to Designers
NLCG	North Last Chance Grade Complex
OMC	operations maintenance center
PGA	peak ground acceleration
PGR	Preliminary Geotechnical Report
PM	post mile
ppm	parts per million
Project	Last Chance Grade Permanent Restoration Project
RW	retaining wall
SDC 2.0	Seismic Design Criteria Version 2.0
SEM	Sequential Excavation Method

SFRDHA	Surface Fault Rupture Displacement Hazard Analysis
SI	slope inclinometer
SPGR	Structure Preliminary Geotechnical Report
SPT	standard penetration test
TBM	tunnel boring machine
UC	unconsolidated undrained
UCERF3	Uniform California Earthquake Rupture Forecast, Version 3
U.S. 101	U.S. Highway 101
USGS	United States Geological Survey
UU	unconsolidated undrained
V_{s30}	shear wave velocity for the upper 100 feet
VWP	vibrating wire piezometer
WC	Wilson Creek Complex

1 INTRODUCTION

This Structure Preliminary Geotechnical Report (SPGR) has been prepared to support the Advance Planning Study (APS) for the tunnel and approach structures of the proposed Alternative F design option for the Last Chance Grade Permanent Restoration Project (Project). The alignments and features considered in this report are current as of October 26, 2023 (Caltrans, 2023a), the geologic and geotechnical data gathered by and on behalf of the California Department of Transportation (Caltrans) through May 31, 2021, as presented in the Preliminary Geotechnical Data Report (Final) dated July 2022 (Caltrans, 2022), and the preliminary geotechnical analyses and recommendations presented in the Preliminary Geotechnical Report (Final) (PGR) dated December 2023 (Caltrans, 2023b).

2 PROJECT DESCRIPTION

Caltrans is studying alternative alignments and design options for the Project on U.S. Highway 101 (U.S. 101). The location of the Project is shown on Plate 1a. These studies are in response to the section of U.S. 101 between post mile (PM) 12.7 and PM 16.5, extending from Wilson Creek to approximately 10 miles south of Crescent City in Del Norte County (known as "Last Chance Grade" [LCG]) that has been progressively sliding towards the Pacific Ocean since the roadway was first constructed. Due to continual road deformation resulting from slope movement, ongoing construction and maintenance activities are necessary to keep U.S. 101 open to the traveling public. The Project is considering Alternatives X and F to provide a more reliable connection, reduce maintenance costs, and protect the economy, natural resources, and cultural landscapes.

Alternative F would involve constructing an approximately 6,000-foot-long (1.1-mile) tunnel east of the existing highway to avoid the most intense areas of known landslides and geologic instability.

This alternative would be located between about PM 13.5 and PM 15.7. Main components of this alternative include the construction of tunnel portals and approaches, the tunnel, a bridge, and an operations maintenance center (OMC). The proposed bridge and the OMC are addressed in separate SPGRs (SPGR-b and SPGR-d).

Alternative F plan view and details are presented on the attached Plates 1b through 1j.

2.1 South Portal and Approach with EDAS

From the south, Alternative F would diverge from the existing highway near the end of the existing truck climbing lane (PM 14.2), traveling approximately 800 feet through a retained excavation and then a 500-foot-long cut-and-cover South Portal structure starting at PM 14.74. The portal structure would open into a two-lane, single-bore tunnel which would be approximately 200 feet below the ground surface (BGS) for most of its length. The tunnel would exit the hillside at the North Portal, near PM 15.6, and the alignment would continue through a retained excavation to the 122-foot-long Wilson Creek Tributary Bridge, a two-lane highway bridge. The alignment would rejoin existing U.S. 101 at PM 15.7.

Near where Alternative F diverges from existing U.S. 101, a concrete retaining wall on spread footings (RW 1) would be constructed on the downhill side (west) of the new road segment. This wall would be up to 20 feet high.

The approach to the South Portal would require a cut-and-cover excavation into the hillside. Retaining walls would be up to 75 feet high, with an average height of 30 feet (RW 2R/2L). The South Portal approach structure would use large diameter secant piles and engineered deformation absorption columns. This Engineered Deformation Absorption System (EDAS) is intended to absorb earthflow movement by using columns engineered to compress over time. As the earthflow continues to move downhill toward the Pacific Ocean, the portal would remain intact.

Once constructed, an intermediate-level slab and a concrete roof structure would be installed over the highway for a length of approximately 600 feet. Soil would be placed on roof and graded to match the surrounding topography. The area would then be revegetated.

2.2 Tunnel

The tunnel would be configured for two-way traffic and would be approximately 6,000 feet long. It would be sized to provide truck-height clearance (16 feet, 6 inches) for two 12-foot-wide travel lanes and two 10-foot-wide shoulders. There would be two emergency corridors on either side, and the roofs of these corridors would be bike lanes. The tunnel's interior spring line width would be 66.25 feet, and the floor to ceiling height would be 35 feet.

The tunnel would be constructed by the Sequential Excavation Method (SEM), in which the tunnel cross section is subdivided into smaller headings which are excavated and supported sequentially. The initial lining for the SEM tunnel would consist of flashcrete, rock bolts, lattice girders, and shotcrete. The flashcrete is intended to provide temporary cohesion for the exposed tunnel walls as the area is mucked and rock bolts are installed. The initial lining support would be in service for approximately one year.

The final lining would consist of cast-in-place (CIP) reinforced concrete. The tunnel lining design would incorporate a full-round permanent waterproof membrane to prevent groundwater inflow.

The tunnel would have an invert drain to collect any water that might be generated by vehicles or leakage. The tunnel profile would slope downward toward the south, and tunnel drainage would be directed to a holding facility near the South Portal for disposal.

The tunnel would include various safety features, including ventilation, lighting, longitudinal pressurized chambers for emergency egress, emergency communications systems, equipment chambers, and a fire suppression system.

2.3 North Tunnel and Bridge Approach

The tunnel would exit the hillside north of the existing slide. The North Portal headwall and immediate rock slopes would be supported by permanent rock bolts and CIP facias, while the portal approach would be supported by retaining walls (RW 3R/3L) which are anticipated to be cast-in-drilled-hole (CIDH) piles and lagging with permanent ground anchors. These retaining walls would be up to 30 feet high and would be at the south end of the Wilson Creek Tributary Bridge connecting the portal headwall to U.S. 101.

The Wilson Creek Tributary Bridge at the north portal location would be a single-span, pre-cast, concrete girder bridge approximately 122 feet long and 48 feet wide, with a single 12-foot-wide lane in each direction and 10-foot-wide shoulders. A new culvert would be installed under the northern tunnel approach between the bridge and the northern portal. The culvert would be 24 inches in diameter or larger, and approximately 200 feet long.

3 GEOTECHNICAL INVESTIGATION

To date, three phases of geotechnical investigations have been performed for the project, which were identified as Phase 1, Phase 2A, and Phase 2B. Phase 1 geotechnical explorations were completed for previously considered alternatives but not in the vicinity of the Alternative F tunnel alignment. Some Phase 2A and 2B explorations were performed in the vicinity of the Alternative F alignment.

The Phase 2A geotechnical investigation program was completed between August 19, 2019 and February 13, 2020. Field investigation work performed included the drilling and sampling of one vertical boring (RC-19-001) about 110 feet southwest of the South Portal approach and one vertical boring (RC-19-003) about 40 feet west of the North Portal headwall. Slope inclinometers (SIs) were installed in both borings to measure slope movement displacements. The boring and instrumentation records are included in Appendix A of the Preliminary Geotechnical Data Report (Final) (Caltrans, 2022).

The Phase 2B geotechnical investigation program included field reconnaissance mapping by geologists from Caltrans, Kleinfelder, and SHN Consulting Engineers and Geologists on May 4 through 6, 2020 and field exploration work September 22 through January 14, 2021. Details of the Phase 2B program, including laboratory testing results, are provided in the Preliminary Geotechnical Data Report (Final) (Caltrans, 2022). Field investigation work, field testing, and instrumentation and monitoring performed within approximately 150 feet west of the North Portal and approximately 350 feet northwest of the South Portal included the following:

- Drilling and sampling of one boring (RC-20-006) about 215 feet west of the South Portal approach and two borings (RC-20-013 and RC-20-017) about 130 feet west of the North Portal approach for subsurface characterization and to collect data for evaluation of geologic hazards.
- Downhole geophysical surveys to further characterize subsurface conditions and geologic structure including acoustic televiewer (ATV) logging in one borehole (RC-20-017).
- Packer permeability testing in one borehole (RC-20-017) to estimate hydraulic conductivity in low-permeability formations.
- Surface-based geophysical surveys performed to aid in the lateral correlation of geotechnical borings, to image subsurface structures (e.g., landslides), to obtain information on rippability for earthwork grading, and to provide data to aid the evaluation of engineering characteristics of rock and soil. Seismic refraction line

SL-11 was performed about 150 feet west of the South Portal approach and SL-16 was performed along the North Portal approach.

- Collection of instrumentation readings from SIs in three boreholes (RC-20-006, RC-20-013, and RC-20-017) to measure slope movement displacements, through November 28, 2022.
- Data collection from vibrating wire piezometers (VWPs) attached to each SI casing to measure water pressure at the depth of installation within the rock mass, through June 21, 2023.
- Time domain reflectometry cables were attached to each SI casing to measure displacement depths through deformation. However, no data were available from Caltrans as of May 31, 2021.

All borings were advanced and logged in conformance with Caltrans (2010a) Soil and Rock Logging, Classification, and Presentation Manual. All laboratory tests were performed in general accordance with California Test Methods (CTM) or American Society for Testing and Materials (ASTM) standard. Field and laboratory testing intervals are shown on the borehole records.

4 GEOTECHNICAL CONDITIONS

4.1 Geology

The LCG project is located within the Coast Ranges geomorphic province of California, near the Klamath Mountains, which lie approximately 10 miles to the east. The site is located approximately 90 miles north of the Mendocino Triple Junction, which is the crustal intersection of the Pacific, North American, and Gorda/Juan de Fuca tectonic plates. North of the triple junction, the Gorda/Juan de Fuca plate is being subducted eastward beneath the North America plate along the Cascadia Subduction Zone (CSZ), which extends approximately 800 miles from northern California to Vancouver Island, British Columbia. As is true for other coastal regions of northern California, Oregon, and Washington, the project site overlies the interface associated with the subducting crustal plate. This subduction interface is a low angle, east-dipping “megathrust” fault capable of generating great earthquakes of high magnitude (>M8.5).

The Coast Ranges in the LCG project area are underlain by regionally extensive Mesozoic- and Cenozoic-age rocks of the Franciscan Complex, an assemblage of mostly marine sedimentary materials accreted to the continental margin. The LCG site is within the Eastern belt of the Franciscan Complex (Delattre and Rosinski, 2012; Aalto, 1989), which is the oldest, least sheared, and most highly metamorphosed of the three belts (McLaughlin et al., 2000).

The Franciscan Complex at the LCG project site consists of two primary units: argillite-matrix Melange and a variety of Broken Formation units that originated as turbidite deposits of interbedded sandstone and shale. The Melange is interpreted as a large submarine landslide deposit that is in depositional contact with the underlying Broken Formation turbidite sequence (Aalto, 1989). Subsequent extensive accretion-related deformation has resulted in pervasive shearing and complex structural relationships within the two primary bedrock types.

The primary geologic hazards for the Alternative F tunnel and approach structures are landslides and seismicity. Seismic ground motions (as described below) may be significant and large enough to activate many of the nested landslides as well as create large displacement movement (measured in feet) along the basal slide planes.

The South Portal approach would be constructed within the active Earthflow Complex (EF) just south of its interface with the Wilson Creek landslide complex (WC). The nature of this interface is not fully understood and could affect the stability of the approach structure if its condition and orientation are unfavorable. The North Portal approach would be constructed just east of the main head scarp of the North Last Chance Grade landslide complex. The North Portal area includes colluvium and dormant debris landslide deposits underlain by Broken Formation.

The ongoing landslide movement could be exacerbated by earthquakes. The project site is located along the Cascadia Subduction Zone and overlies the interface associated with the subducting crustal plate. This subduction interface is a low angle, east-dipping “megathrust” fault capable of generating great earthquakes of high magnitude (>M8.5).

The overall stability of the Alternative F tunnel would not be affected by the global stability of the LCG landslide complexes if the tunnel is sufficiently deep. If the crown of the tunnel can be maintained at least 20 to 40 feet below the basal failure zone, effects of landsliding on the tunnel should be minimal. The tunnel would be subjected to both ground and groundwater pressures and could be subjected to intense seismic ground shaking (M8.57 to M8.67) during its service life.

4.2 Surface Conditions

The Alternative F tunnel would be located at depth below the northwest-southeast trending ridge that forms the dominant topographic feature of the LCG project area.

The proposed South Portal approach is on the northeast side of U.S. 101 within the limits of the active earthflow landslide. The surface topography in this area is characterized by gently rolling, irregular slopes. In general, the surface topography in this area slopes downward towards the southwest at approximately a 4H:1V average slope. The ground elevation near the South Portal approach area is approximately 580 to 700 feet.

The proposed North Portal approach is located on the southeast side of U.S. 101, where the highway turns and continues to the northeast. The North Portal approach is just east of the main head scarp of the North Last Chance Grade landslide complex (NLCG). The portal would daylight in an area Franciscan Complex Broken Formation with overlying colluvium and nearby mapped dormant debris slides. The portal headwall would be on a north-facing slope near the top of a ravine that extends northeastward toward Wilson Creek. The north-facing slope is approximately 1½H:1V to 2H:1V. The ground elevation in the North Portal approach area is approximately 740 to 910 feet.

4.3 Subsurface Conditions

The Alternative F tunnel and approach structures would be constructed through earthflow deposits and the Melange and Broken Formation of the Franciscan Complex.

The Alternative F alignment is underlain by surficial colluvium and earthflow landslide deposits from its south terminus at Station 34+36 through the cut section of the South Portal approach. The cut-and-cover section of the South Portal approach would be excavated through earthflow and Melange, encountering the inferred basal failure surface of the earthflow at approximately Station 56+00. The inferred depth to the basal failure surface is approximately 75 feet below the ground surface at the north end of the South Portal cut-and-cover approach structure, based on inclinometer data from the nearby Boring RC-20-006 and as presented in the Preliminary Geotechnical Data Report (Final) (Caltrans, 2022) and as shown in Plate 1g. Full-face SEM excavation in Franciscan Complex Melange bedrock would begin at Station 58+00.

The earthflow landslide deposits consist of a mixture of fine-grained soils, deeply weathered rock, and scattered sandstone clasts which have been transported as a sliding mass with many internal slip surfaces. Below the earthflow landslide deposits, the Melange consists of dark gray, pervasively sheared, soil-like argillite with scattered blocks of intact rock. Its Terzaghi tunnel ground classification would range from completely crushed to very blocky and seamy.

The proposed SEM tunnel would continue northward below the basal failure surface, with full-face excavation in the Melange of the Franciscan Complex for approximately the first 920 feet. The steeply dipping contact between the Melange and the Broken Formation is expected to be encountered at about Station 67+20.

The remaining length of SEM tunnel north of the contact would be excavated entirely through the Broken Formation. This material consists of blocks of gray, hard, massive to very thickly bedded sandstone with interbedded argillite separated by weak, sheared zones. Its Terzaghi tunnel ground classification would range from very blocky and seamy to moderately blocky and seamy.

The vertical distance of the inferred basal failure surface above the tunnel crown is estimated to range from about 25 feet at the south end of SEM construction to about 250 feet where the failure surface daylights near Station 68+50 (Plate 1g).

The North Portal would be located on a north-facing slope on the east side of the ridge, outside of the NLCG landslide complex. The North Portal approach structure would be constructed primarily though colluvium and underlying Franciscan Complex Broken Formation and would transition to the proposed Wilson Creek Tributary Bridge at Station 119+25, where it would span a colluvial drainage underlain by Broken Formation bedrock.

Preliminary tunnel ground classifications are provided in the PGR (Caltrans, 2023b).

5 GROUNDWATER

The area-wide hydrogeology is dominated by groundwater flow along fractures within the Melange and Broken Formation and the overlying landslide deposits. The permeability of intact rock within these formations is very low, and most groundwater occurs and is transmitted within fractures of unknown interconnection. Where water-laden fractures intersect the bluff face, groundwater discharges as a spring or seep. Groundwater is also likely entering the ocean below the shoreline.

Groundwater flow along fractures in the project area can be interrupted and redirected, perched, or locally mounded behind subsurface barriers to flow such as clay-filled landslide-failure zones.

Based on results of packer tests, hydraulic conductivity in the Broken Formation at NLCG is estimated to be 4.07×10^{-7} to 1.88×10^{-6} feet/second at depths of 170 to 180 feet and 206 to 216 feet, respectively (RC-20-017), and hydraulic conductivity in the Broken Formation at WC is estimated to be 4.19×10^{-7} to 6.22×10^{-8} feet/second at depths of 170 to 180 feet and 206 to 216 feet, respectively (RC-20-014) (Caltrans, 2023b). Hydraulic conductivity may be locally higher or lower than indicated by packer test results, and fractured intervals are likely to have the highest conductivity.

No borings have been drilled to date on the Alternative F alignment away from the portal approaches, and no VWPs have been installed to monitor alignment-specific groundwater conditions. Eight VWPs were selected as representative of groundwater conditions for Alternative F, based on their proximity to the alignment (projected perpendicularly), transducer(s) near the proposed tunnel alignment elevation, and projected geologic and hydrogeologic conditions. The table below summarizes the groundwater data obtained from these VWPs. The data spans a timeframe between September 2019 and June 2023.

Table 5-1. Groundwater Data from VWPs

Boring ID	Total Bore Depth (feet)	Surveyed Ground Surface Elevation (feet)	Approximate Projected Alternative F Location	VWP Depth (feet)	VWP Elevation (feet)	Apparent Groundwater Depth Minimum (feet)	Apparent Groundwater Elevation Maximum (feet)	Date Measured
P-19-007	305.0	585.5	South Portal Area	295	290.5	218.5	367.0	12/20/2019 through 6/21/2023
				195.0	390.5	147.8	437.7	
				95.0	490.5	82.6	502.9	
RC-20-006	251.3	619.3	South Portal Area	199.5	419.8	73.5	545.8	1/23/2021 through 6/3/2021
				129.0	490.3	65.3	554.0	
				60.0	559.3	58.2	561.1	
RC-20-005	250.0	859.1	SEM Tunnel	250.0	609.1	216.6	642.5	1/23/2021 through 6/3/2021
				232.0	627.1	205.6	653.5	
				155.0	704.1	142.9	716.2	
RC-20-014	300.0	805.1	SEM Tunnel	290.0	515.1	167.0	638.1	1/23/2021 through 6/3/2021
				225.0	580.1	167.0	638.1	
				166.0	639.1	147.8	657.3	
RC-20-015	301.0	883.4	SEM Tunnel	290.0	593.4	241.0	642.4	1/22/2021 through 6/3/2021
				255.0	628.4	149.4	734.0	
				159.0	724.4	146.7	736.7	
RC-20-017	300.0	829.4	North Portal Area	282.0	547.4	225.9	603.5	12/18/2020 through 6/21/2023
				253.0	576.4	221.8	607.6	
				217.0	612.4	207.5	621.9	
				182.0	647.4	177.8	651.6	
				150.0	679.4	137.9	691.5	
RC-19-003	100.0	840.5	North Portal Area	90.0	750.5	11.6	828.9	9/23/2019 through 4/19/2021
RC-20-013	134.7	830.5	North Portal Area	133	697.5	82.5	748.0	12/18/2020 through 2/15/2022

6 AS-BUILT DATA

Existing underground structures in the vicinity of Alternative F consist of current roadway stability structures (retaining walls) along U.S. 101. No live or abandoned underground utilities are believed to be present. SI casing and VWPs are located within and adjacent to the current roadway section near where Alternative F joins U.S. 101.

Plans and/or details for Caltrans repair structures along the existing highway alignment dated between 2015 and 2021 were provided by Caltrans but are not in the vicinity of the proposed Alternative F alignment. As-built plans for the repair structures completed in 2023 along the existing highway at PM 15.48 are available from Caltrans.

7 CORROSION EVALUATION

Four soil/rock samples and one groundwater sample were collected at various locations of the Project and were tested for corrosion as shown in the following table.

Table 7-1. Preliminary Corrosion Test Results

Boring ID	Sample Depth (feet)	Sample Description	Minimum Resistivity (ohm-cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)	Corrosive
RC-20-014	71.2 to 71.5	Sandstone with iron oxide Broken Formation	1,050	7.55	35.5	57.8	No
RC-20-019	251.6 to 251.9	Argillite interbed in sandstone of Broken Formation	5,360	6.32	5.1	1.7	No
RC-21-001	30.0 to 31.5	Argillite/Earthflow	2,170	7.59	2.5	79.1	No
RC-20-015	128.8 to 129.0	Argillite below Earthflow	2,200	7.56	2.6	126.8	No
P-20-012	-	Groundwater	-	7.58	25	110	No

According to the Caltrans Corrosion Guidelines (Caltrans, 2021a), soils are considered corrosive if the pH is 5.5 or less, or chloride content is 500 parts per million (ppm) or greater, or sulfate content is 1,500 ppm or greater. Also, as stated in the Caltrans Corrosion Guidelines, a minimum resistivity value for soil and/or water less than or equal to 1,500 ohm-cm indicates the presence of high quantities of soluble salts and a higher propensity for corrosion.

Based on the corrosion test results and Caltrans criteria, the soil samples tested were not found to be corrosive to bare metals and concrete. The corrosion potential is based on limited data and may not represent the conditions along all of Alternative F. It should be noted that the project site is not within 1,000 feet of the ocean; therefore, according to Caltrans Corrosion Guidelines (2021a), the site is not in a marine atmosphere zone.

Section 90-1.02H Concrete in Corrosive Environments of the Caltrans Standard Specifications provides specification language for corrosion resistant concrete mix designs that address corrosive conditions.

8 SEISMIC INFORMATION

8.1 Ground Motion Hazard

The project alignment is susceptible to strong earthquake-induced ground motions during the design life of the proposed structures. Following the procedures described in Caltrans Seismic Design Criteria Version 2.0 (SDC 2.0) (2019a) and October 2019 Interim Revisions to SDC 2.0 (2019b), the preliminary Acceleration Response Spectrum (ARS) curves for a 975-year Return Period was determined using the Caltrans ARS Online V3.0.2 (2021b) and utilizing the small-strain shear wave velocity for the upper 100 feet (V_{S30}) for the project site. The preliminary values of V_{S30} for the project site were estimated from the soil data of existing borings RC-19-001, RC-19-003, RC-20-006, RC-20-013, and RC-20-017, and the standard penetration test (SPT) correlations provided in the Methodology for Developing Design Response Spectrum for Use in Seismic Design Recommendations (Caltrans, 2012). The 2021 correlations described by Attachment 2 in Caltrans Geotechnical Manual – Design Acceleration Response Spectrum module (Caltrans, 2021c) were not adopted, because it was determined that they are not representative of the site conditions. In order to determine whether 2021 correlations are suitable for the site, the estimated shear wave velocity from these correlations were compared with available seismic refraction survey results near the same locations, as shown in the PGR (Caltrans, 2023b). The 2021 correlations tend to yield a lower V_{S30} value than direct shear wave velocity measurements from seismic refraction lines, while the 2012 correlations provide reasonably close results. Therefore, the 2012 correlations have been adopted for this site.

Preliminary site seismic parameters are listed in the following table.

Table 8-1. Preliminary Site Seismic Parameters

Structure/Location	**RW 1**	**Tunnel/ South Portal-RW 2R/2L**	**Tunnel/Middle**	**Tunnel/ North Portal-RW 3R/3L**
Station Range[(1)]	"F" 45+00 to "F" 49+00	"F" 52+00.00 to "F" 58+00	"F" 85+00	"F" 116+72.69 to "F" 120+00
Reference Boring(s)[(2)]	RC-19-001 RC-20-006		-	RC-19-003 RC-20-013 RC-20-017
Site Geospatial Coordinates (latitude, longitude)[(3)]	41.6247°, -124.1115°	41.6262°, -124.1109°	41.6344°, -124.1105°	41.6425°, -124.1146°
V_{S30} (m/s)	280	280	1,149[(4)]	340

Notes:
(1) Based on the current Geometric Approval Drawings dated October 26, 2023.
(2) Based on Preliminary Geotechnical Data Report (Final) (Caltrans, 2022).
(3) Estimated per Google Maps and the current Geometric Approval drawings.
(4) Estimated from the nearby P- and S-wave suspension logging data.

Based on the Caltrans ARS Online V3.0.2 (2021b), the preliminary values of Peak Ground Acceleration (PGA), the deaggregated mean earthquake moment magnitude (M) for PGA, and the mean site-to-source distance (R) for 1.0 second period spectral acceleration for various locations of the project site are summarized in the table below. The Ground Motion Data Sheets, presenting the preliminary ARS data, plots, and other relevant information are included in Appendix A. The soils for various locations of the proposed structures are identified as "Class S1", per Section 6.1 and 6.2.3 of the Caltrans SDC 2.0 (2019a).

Table 8-2. Preliminary Ground Motion Parameters

Structure/Location	RW 1	Tunnel/ South Portal-RW 2R/2L	Tunnel/Middle	Tunnel/ North Portal-RW 3R/3L
PGA (g)	0.88	0.87	0.65	0.85
Mean Earthquake Moment Magnitude	8.65	8.65	8.58	8.67
Mean Site to Fault Source Distance for S_a at 1 second (km)	20.0	20.0	20.3	20.1
Site Class(1)	S1	S1	S1	S1
Horizontal Seismic Coefficient, k_h(2)	0.29	0.29	N/A	0.28

Notes:
(1) Per Section 6.1 and 6.2.3 of the Caltrans SDC 2.0 (2019a).
(2) k_h = one-third of PGA.

According to the Caltrans Geotechnical Manual – Landslides module (Caltrans, 2020a) and Caltrans Geotechnical Manual – Embankments module (Caltrans, 2014), a horizontal seismic coefficient (k_h) for seismic slope stability analysis may be equal to one-third of the PGA at the site. Therefore, the preliminary k_h values for various locations are also tabulated in the table above to estimate the seismic lateral earth pressure for RW 1, RW 2R/2L, and RW 3R/3L and to perform the seismic slope stability analysis for portal area slopes.

8.2 Other Seismic Hazards

The proposed project site is not located within 1,000 feet of any active faults as delineated by the Alquist-Priolo Earthquake Fault Zone (APEFZ) (CGS, 2007) or Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) model (USGS, 2013). Therefore, per Caltrans MTD 20-10 (2013) and Caltrans Geotechnical Manual – Fault Rupture module (2017), the subject site is not considered susceptible to surface fault rupture hazards, and no Surface Fault Rupture Displacement Hazard Analysis (SFRDHA) is needed.

Preliminary liquefaction potential analysis for the RW 1, South Portal, and North Portal sites was performed, using the procedures outlined by Youd et al. (2001), and the blow counts and measured groundwater depths of existing Borings RC-19-001, RC-19-003, RC-20-006, RC-20-013, and RC-20-017, extracted from the Summary of Phase 1 Geotechnical Investigation (Caltrans, 2018) and Preliminary Geotechnical Data Report (Final) (Caltrans, 2022). Due to the presence of deep groundwater and fine-grained or dense materials below groundwater table, no liquefiable layers are identified. Therefore, the project site is not susceptible to liquefaction or related seismic hazards, including seismic total or differential ground settlement, seismic downdrag and lateral spreading. However, according to the empirical method proposed by Tokimatsu and Seed (1987), dry sand settlement of about 2 to 11 inches may result from the top 5 to 20 feet of subsurface materials during a design seismic event near the locations of Borings RC-20-006, and RC-20-017.

The preliminary PGA values at the South Portal and North Portal sites are 0.88g and 0.85g, respectively. Based on the current geometric drawings, the maximum heights of the retaining wall for RW 2R/2L and RW 3R/3L are 75 and 40 feet, respectively. The seismic slope stability analysis should be performed at these locations during the design process.

According to Caltrans MTD 20-13 (2010b), the tsunami hazard is significantly reduced at locations beyond one-half mile of the coast or at elevations greater than 40 feet above mean sea level. The RW 1, South Portal, and North Portal sites are located about 0.21, 0.22 and 0.27 miles from the nearest coastline, respectively, per Google Earth. However, the RW 1, South Portal, and North Portal sites are situated at elevations above +525, +540, and +840 feet, respectively (much higher than +40 feet). Therefore, the risk for tsunami-related damage does not exist, per Caltrans MTD 20-13.

9 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

Alternative F would require a large-diameter SEM tunnel approximately 6,000 feet long. The materials to be mined would range from rock which is decomposed and intensely fractured to rock which is only slightly weathered and slightly fractured. This variety in geotechnical properties presents a challenge with respect to tunnel construction. Multiple soil and rock types may be encountered within a single excavation face. A flexible construction methodology should be developed to accommodate ground conditions which are highly variable over short lateral and vertical distances.

The SEM excavations would be supported with an initial layer of flashcrete and rock bolts, followed by membrane waterproofing and a final cast-in-place concrete lining. The number of SEM excavation headings, the length of each heading, the rock bolt spacing, and the shotcrete lining thickness should be determined based on the ground support classes anticipated to be encountered. The support classes should be confirmed during construction for each excavation sequence, based on observed ground conditions and performance of previous segments.

Additional analyses are recommended, along with additional field and laboratory testing, to better define geotechnical properties and interfaces of site materials in order to develop appropriate SEM sequencing. The southernmost 920 feet of the tunnel would traverse Franciscan Complex Melange consisting of a mix of moderately weathered to decomposed sandstone blocks in a matrix of sheared argillite. The Melange is weak and is likely to have a relatively short stand-up time. If indicated by site-specific conditions, pre-excavation support should be installed for SEM construction in the Melange to limit raveling at the tunnel crown.

The soil-like nature of the Melange and the fractured nature of the Broken Formation are compatible with excavation using road headers. Drill and blasting may be more productive in areas where the Broken Formation is more intact but would be at depth and not within old-growth redwood habitat.

The final lining should be designed to accommodate the strains associated with the design seismic event. Preliminary seismic analyses indicate that the proposed 24-inch-thick lining could effectively tolerate the strains associated with deformation resulting from extreme ground shaking. These analyses should be confirmed when additional geotechnical data are available. The non-circular shape of the cavern will require more detailed analyses than a circular tunnel and may require special detailing to accommodate the anticipated racking.

The tunnel grade would increase to the north, and as a result any water entering the tunnel would flow by gravity out the South Portal. The tunnel final lining design should be detailed to be watertight and so that the long-term influence of the tunnel on the local groundwater will be negligible. Groundwater data obtained to date do not indicate high water pressure conditions along the alignment. Groundwater conditions will require further study in the next phase of subsurface investigation.

The South Portal approach cut-and-cover structure would be a major structure and would serve not only to retain the excavation at the South Portal but also to resist ongoing active earthflow movement. The design concept uses large diameter secant piles (Plate 1c) and engineered deformation absorption columns to absorb the earthflow ground movements. The secant piles should be socketed into the Melange well below the basal failure surface/zone of the EF. The EDAS should extend through the zone of earthflow movement, and the strength of the system should be engineered to slightly exceed the existing earth pressures in the earthflow. The EDAS elements would be precast and lowered as units into holes excavated with secant pile drilling equipment.

The areal extent of the EDAS should be established such that it can absorb the downslope movements of the earthflow. These movements include the currently observed downslope creep and the lateral spreading anticipated to occur as a result of the design seismic event. Lateral support of the approach structure walls should be provided by interior slabs within the approach structure. Finite element modeling should be performed to refine the design of the EDAS. In addition, the magnitude and direction of earthflow movements should be better defined by displacement monitoring to support more detailed analysis of loads on the South Portal headwall and refinement of the design of the South Portal approach EDAS.

Further study is required to establish the handling and placement requirements for the EDAS column sections. The collapsible columns would be prefabricated, transported to the site and the inserted in pre-drilled holes. The treatment depth would be to the top of the earthflow failure surface or approximately 75 feet. The columns would be pe-fabricated in shorter sections, say 25 feet, and their strengths “tuned” to the corresponding earth pressure. Due to the nature of collapsible concrete, the prefabricated columns will have to be cast in a horizonal orientation to prevent collapse of the foam concrete under its own weight. The column segments would then be lowered into a pre-drilled hole with any annular space grouted to ensure contact with the surrounding soils. Selection of equipment for installation will depend upon the final pile length, soil and rock strata, and optimal diameter. These will be assessed in the next stage of the design.

The North Portal approach would be situated on a slope with colluvium underlain by the Broken Formation. The areas above the portal will have to be evaluated for slope stability after additional borings have been completed. The extent of this stabilization work is unknown at this time but would likely involve scaling to remove loose rock, bolting of larger rock masses and the installation of a headwall to catch any rock or loose debris.

Although not specifically identified in the current design, ground improvement such as grouting or other ground treatment could be required if rock conditions encountered during tunneling or portal construction are poorer than expected.

The Alternative F tunnel alignment would be predominantly located in undeveloped land, and underground utilities or other underground right-of-way impediments are not a consideration.

There are constraints with respect to work areas for Alternative F. Construction staging areas suitable for material and muck are limited, and thus the tunneling contractor would have to secure more remote laydown areas both north and south of the project site The South Portal area would experience significant construction-related traffic. A plan for maintenance of traffic should be developed to ensure a safe condition for both the public and construction vehicles. Erosion control measures may also be required at proposed excavation locations at the North and South Portals.

10 ADDITIONAL FIELD WORK AND LABORATORY TESTING

Additional field work and laboratory testing are required to complete the geotechnical investigation for Alternative F.

10.1 Field Work

Detailed geologic mapping, including discontinuity line mapping of accessible, exposed rock surfaces, is recommended for the proposed North and South Portal areas to better characterize rock mass structures, contacts, and landslide complexes.

Additional explorations would be required to characterize ground conditions to a level of detail necessary for design and construction of the Alternative F tunnel and approach structures.

Exploratory borings are recommended at the locations listed below. However, access to drilling sites along the tunnel alignment are expected to be limited due to environmental constraints. Accordingly, other exploration methods may be necessary to characterize the subsurface conditions.

- Borings along the inferred interface of the WC and the EF, including at least one inclined boring to penetrate the contact(s).
- Borings north of the proposed South Portal headwall to better define the limits of the Melange along the tunnel alignment. Borings should extend 60 to 90 feet below the proposed invert level.
- Borings in the South Portal area along the secant pile wall locations for the cut-and-cover section and the EDAS, spaced approximately 100 feet apart and

extending at least to depths in accordance with the Caltrans Geotechnical Manual – Geotechnical Investigations module (Caltrans, 2020b).

- Borings in the North Portal area to better define the limits of the NLCG landslide deposits and the basal failure surface.
- One or more borings at the proposed North Portal headwall, extending at least 60 feet below the proposed invert level at the portal.
- Borings along the length of the proposed SEM tunnel, spaced about 500 feet apart. The borings should be staggered on either side of each tunnel alignment. Borings should extend 60 to 90 feet below the proposed invert level and sufficiently deep to confirm the depth of the basal failure surface. A boring is recommended at each proposed equipment chamber location. Vertical borings could be supplemented with horizontal or inclined borings.
- Supplemental explorations as required to define the location of faults or the basal failure surface if there are gaps or ambiguities in their definition from the borings planned for the proposed structures. The location of the supplemental explorations, if required, would be determined after other borings have been completed.

For each exploration, soil and rock samples should be collected by methods that optimize sample recovery. Logging of boreholes and collection, handling, labeling, and storage of samples should be done following Caltrans standards.

Boreholes drilled for the Alternative F tunnel and North and South Portal approach structures should include the following in-situ testing and data collection:

- Packer permeability testing in rock
- Borehole ATV
- P- and S-wave suspension (PS) logging
- Pressuremeter testing
- If possible, constant head or falling tests in overburden at the approach structures

The following types of instrumentation are anticipated to be required in the newly completed boreholes:

- Standpipe piezometers, observation wells and/or multiple-depth VWPs
- SIs

Monitoring of new and existing instrumentation, including weather stations, should continue at least through completion of the final design phase.

All boring locations and top elevations should be surveyed within a month after completion to allow accurate input of geotechnical data with respect to location and elevation of proposed underground structures.

10.2 Laboratory Testing

Laboratory testing on soil and rock samples would be required to complete characterization of ground conditions for design and construction of the proposed Alternative F tunnel and approach structures. Actual tests will depend on the type and quantity of recovered samples.

Laboratory tests on rock are anticipated to include:

- Unit weight, porosity, and specific gravity
- Unconfined compressive strength tests, with and without static elastic moduli
- Triaxial compressive strength
- Splitting tensile strength
- Direct shear strength
- Point load index strength, axial and diametral
- Pulse velocity and dynamic elastic constants
- Schmidt hammer rebound hardness
- Thin section petrographic analysis
- CERCHAR abrasiveness index
- Slake durability
- Punch penetration index
- Tunnel boring machine (TBM) drillability indices

Laboratory tests on soil are anticipated to include:

- Moisture content
- Natural density and specific gravity
- Atterberg limits
- Grain size distribution analyses
- Corrosivity tests
- Direct shear tests
- Triaxial shear tests, including consolidated undrained (CU) and unconsolidated undrained (UU) tests
- Consolidation tests
- Swell tests

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PLATES

PLOTTED: 15 Nov 2023, 9:24pm, DFahmey

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STATE OF CALIFORNIA

DEPARTMENT OF TRANSPORTATION

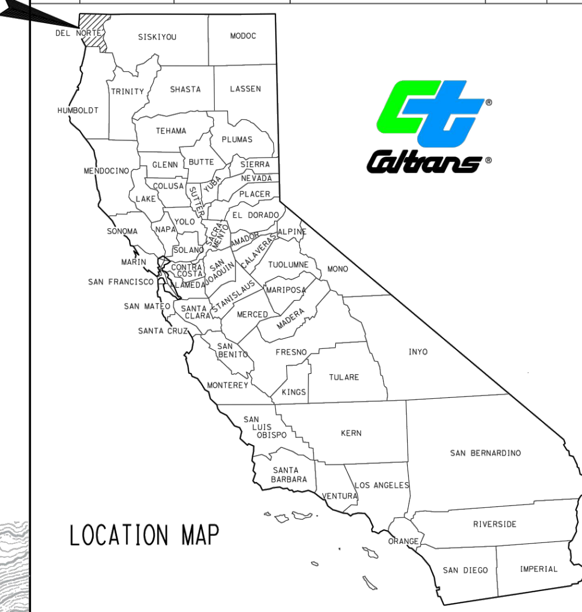
PROJECT PLANS FOR CONSTRUCTION ON

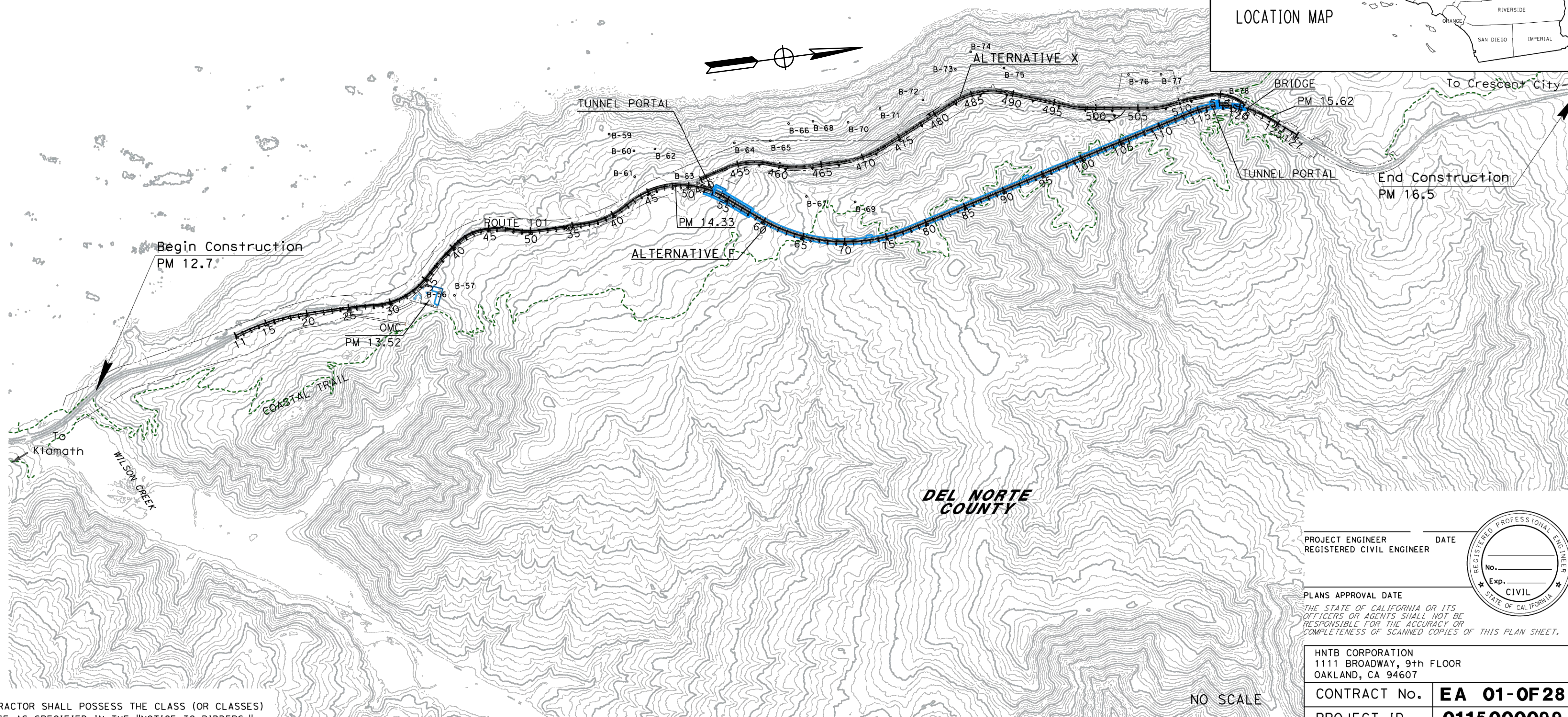
STATE HIGHWAY

IN DEL NORTE COUNTY
NEAR CRESCENT CITY
FROM WILSON CREEK BRIDGE TO
DAMNATION CREEK TRAILHEAD

TO BE SUPPLEMENTED BY STANDARD PLANS DATED 2018

GEOMETRIC APPROVAL DRAWINGS





APPROVED AS TO IMPACT ON STATE FACILITIES AND CONFORMANCE WITH APPLICABLE STATE STANDARDS AND PRACTICES AND THAT TECHNICAL OVERSIGHT WAS PERFORMED.

DATE SIGNED | LICENSE Exp DATE | REGISTRATION No. | CALTRANS DESIGN OVERSIGHT APPROVAL | CONSULTANT DESIGN MANAGER

THE CONTRACTOR SHALL POSSESS THE CLASS (OR CLASSES) OF LICENSE AS SPECIFIED IN THE "NOTICE TO BIDDERS."

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PROJECT ID	0115000099

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LAST CHANCE GRADE PERMANENT RESTORATION PROJECT STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL NOVEMBER 2023	**GEOMETRIC APPROVAL DRAWINGS** Cover Sheet	PLATE **1a**

CAD FILE: C:\Users\DFahmey\Downloads\202080000\ LAYOUT: 1a

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NOTES:

1. SEE LAYOUT SHEET FOR WALL LIMITS.
2. BROADBAND CONDUIT WILL BE ADDED TO EACH ROADWAY SECTION.

STRUCTURAL SECTIONS

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0.45' HMA (TYPE A)
0.75' Cl 2 AB

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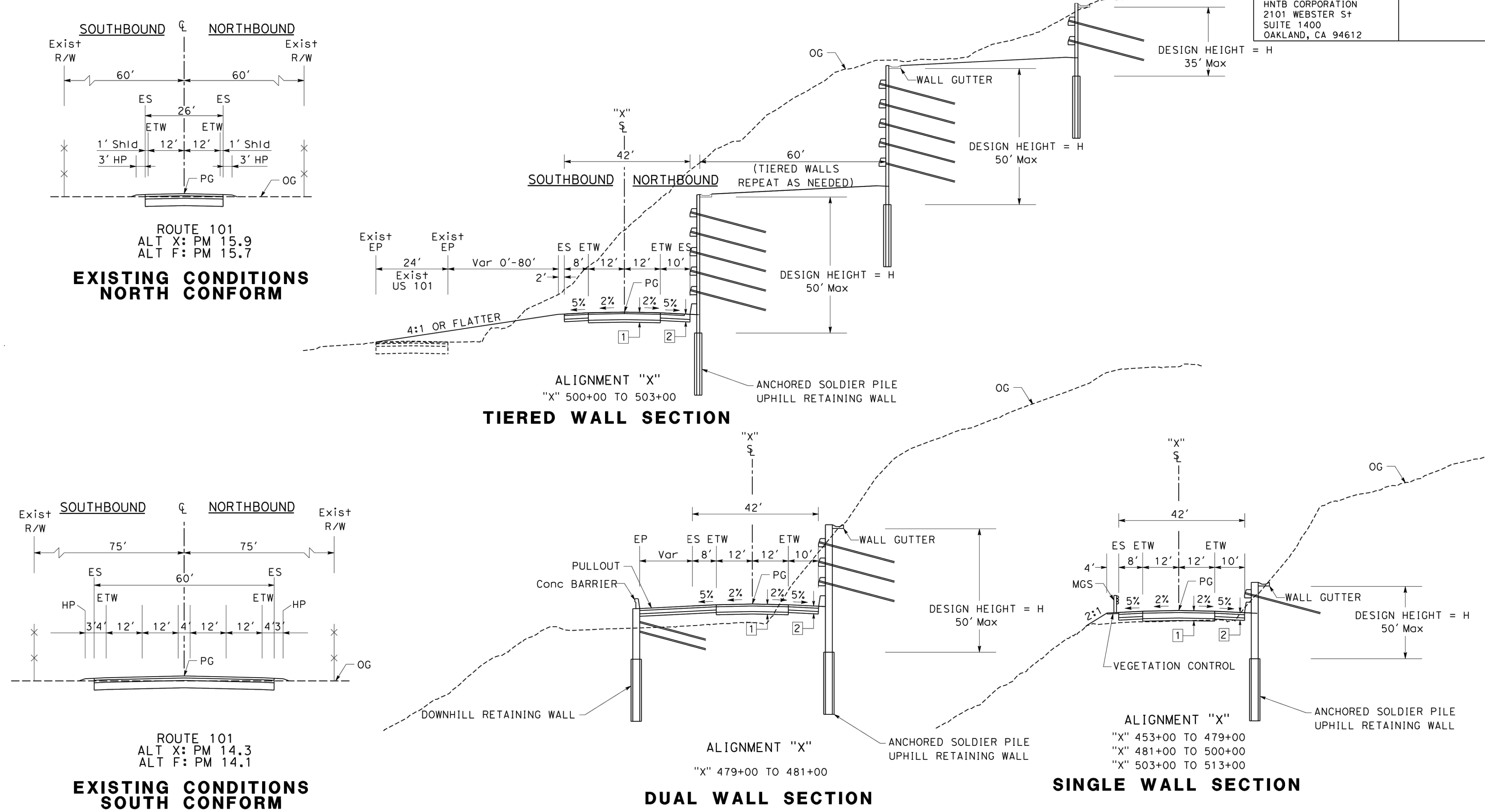

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LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet X-1

PLATE **1b**

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
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PLANS APPROVAL DATE

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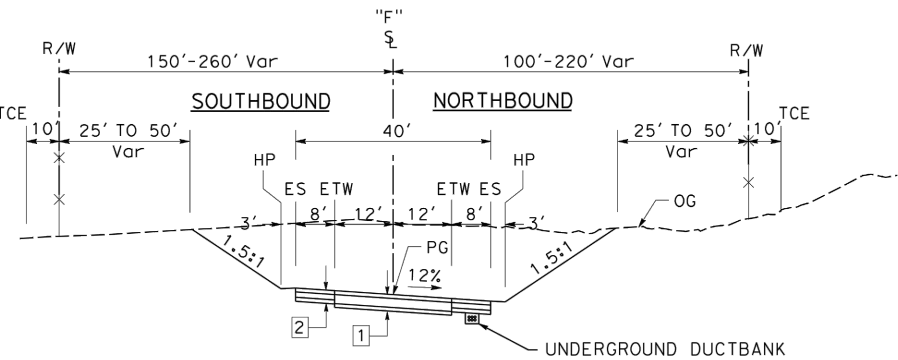

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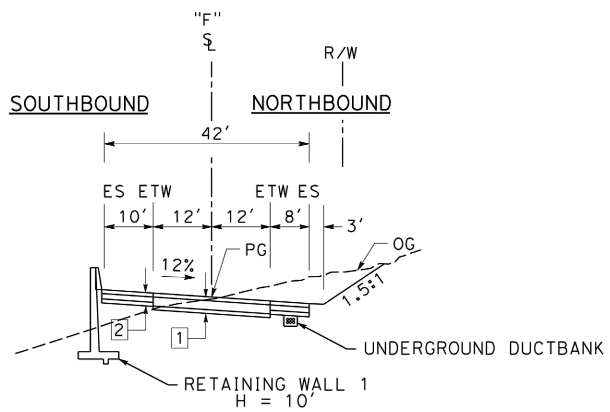

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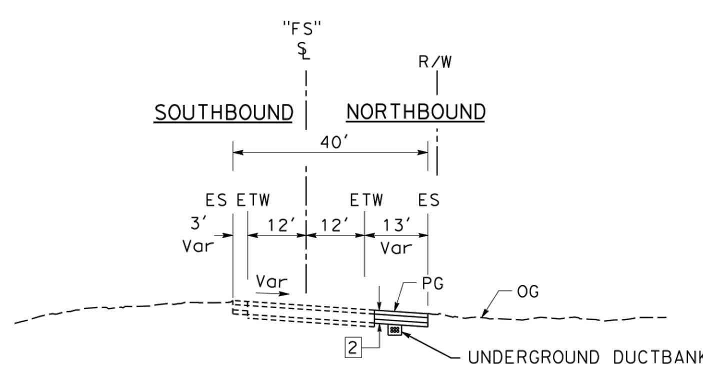

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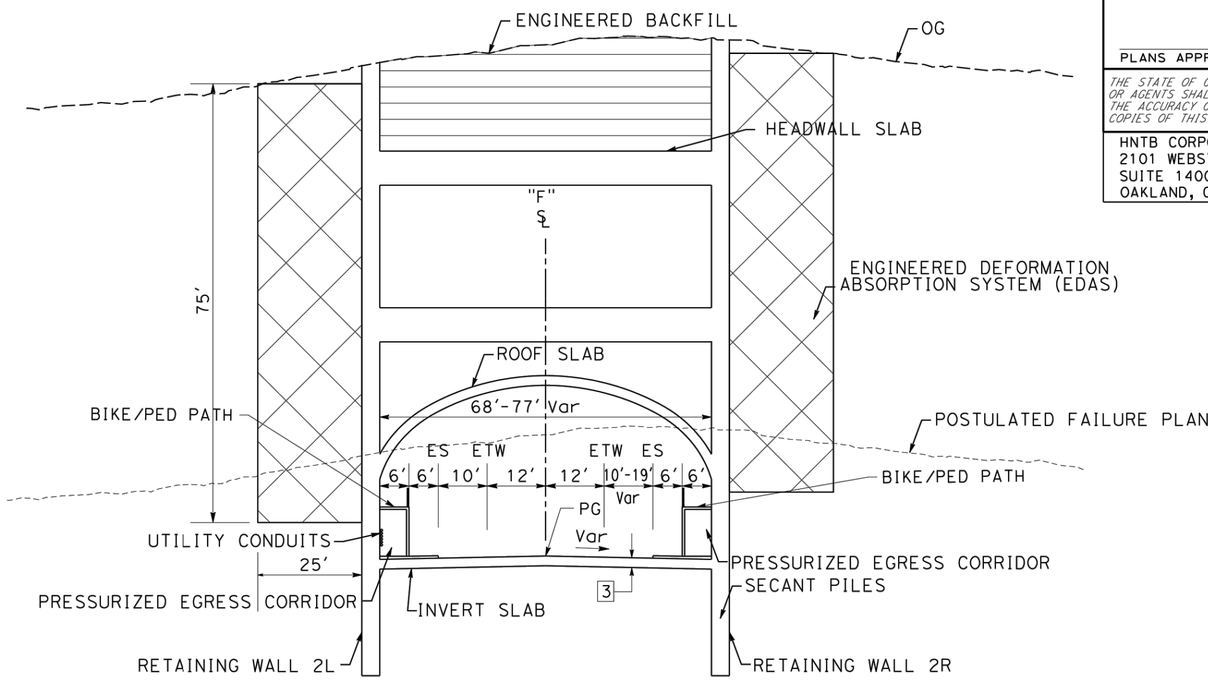

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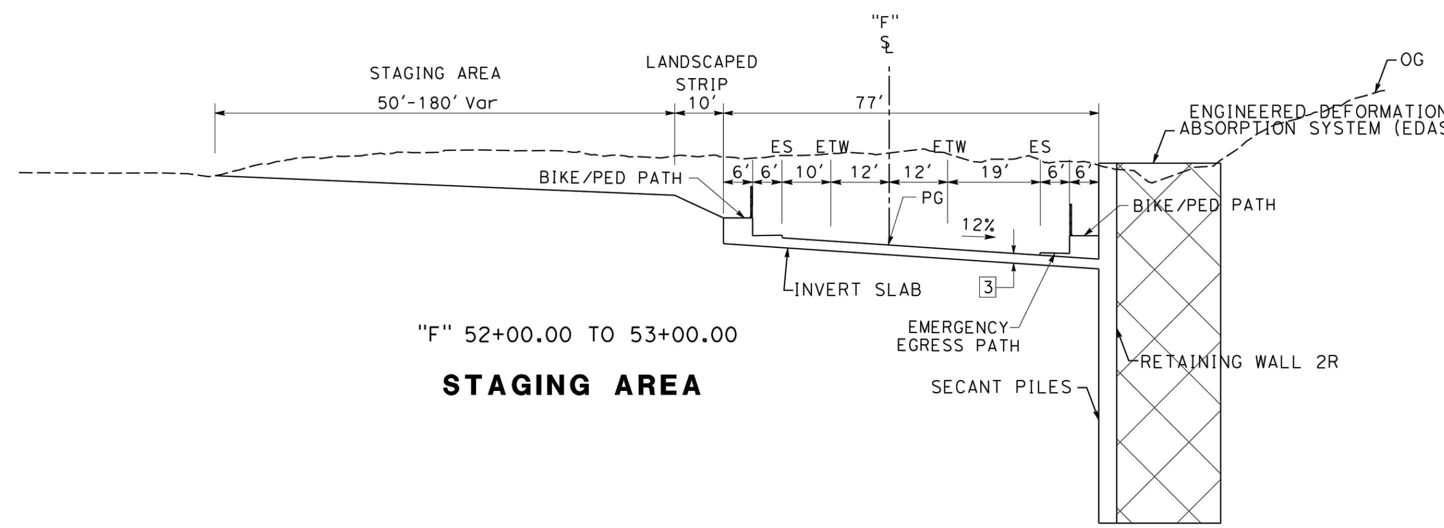

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GEOMETRIC APPROVAL DRAWINGS
Sheet X-2

NOTES:

1. BROADBAND CONDUIT WILL BE ADDED TO EACH ROADWAY SECTION.
2. INITIAL SEQUENTIAL EXCAVATION LINING (BOLTS AND SHOTCRETE) NOT SHOWN.

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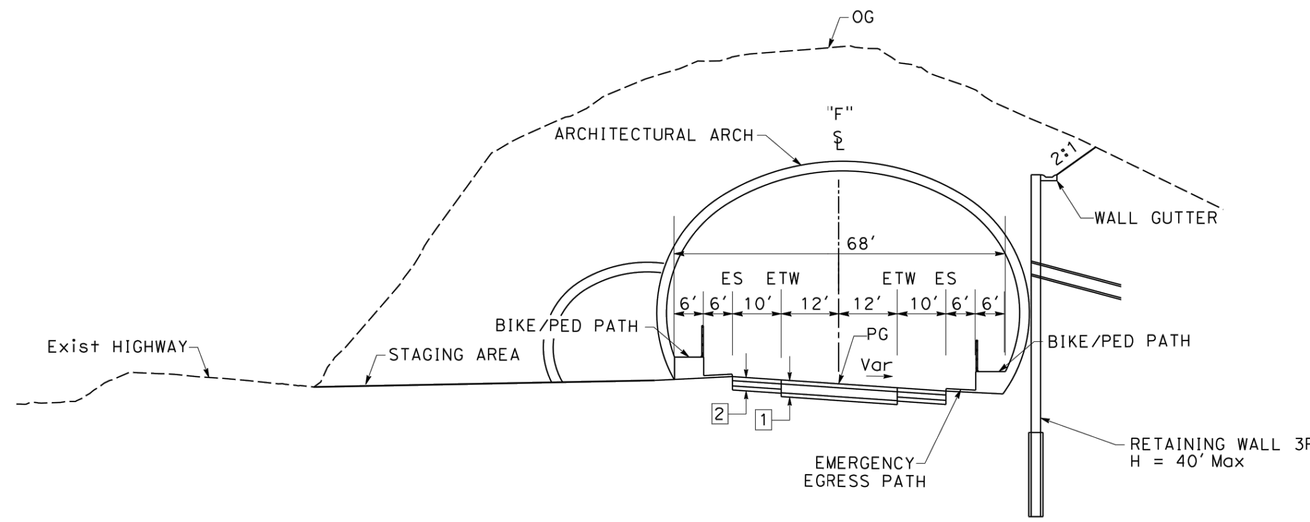

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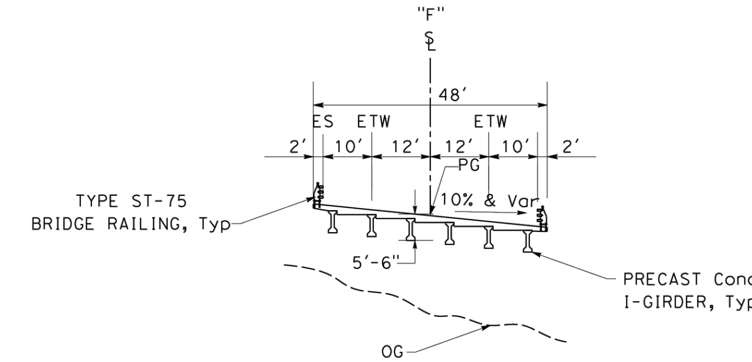

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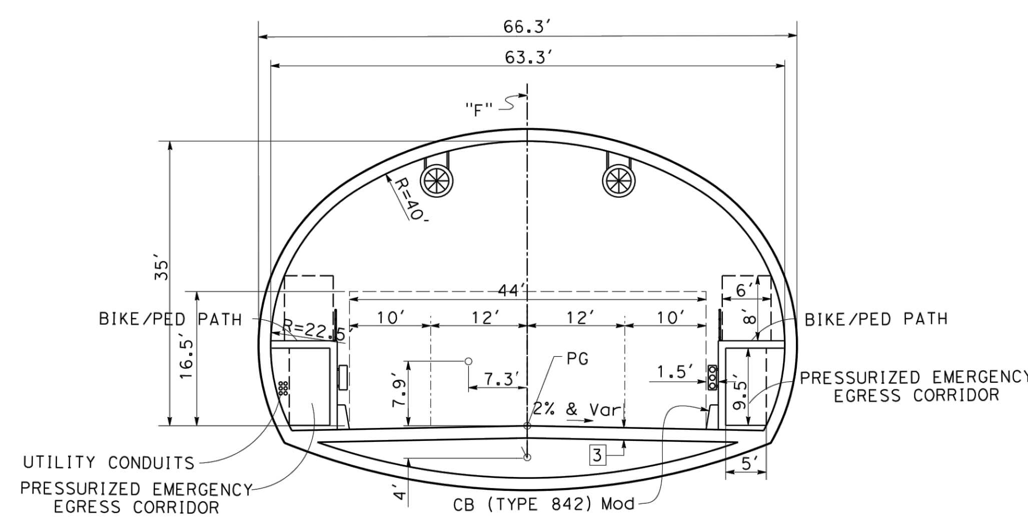

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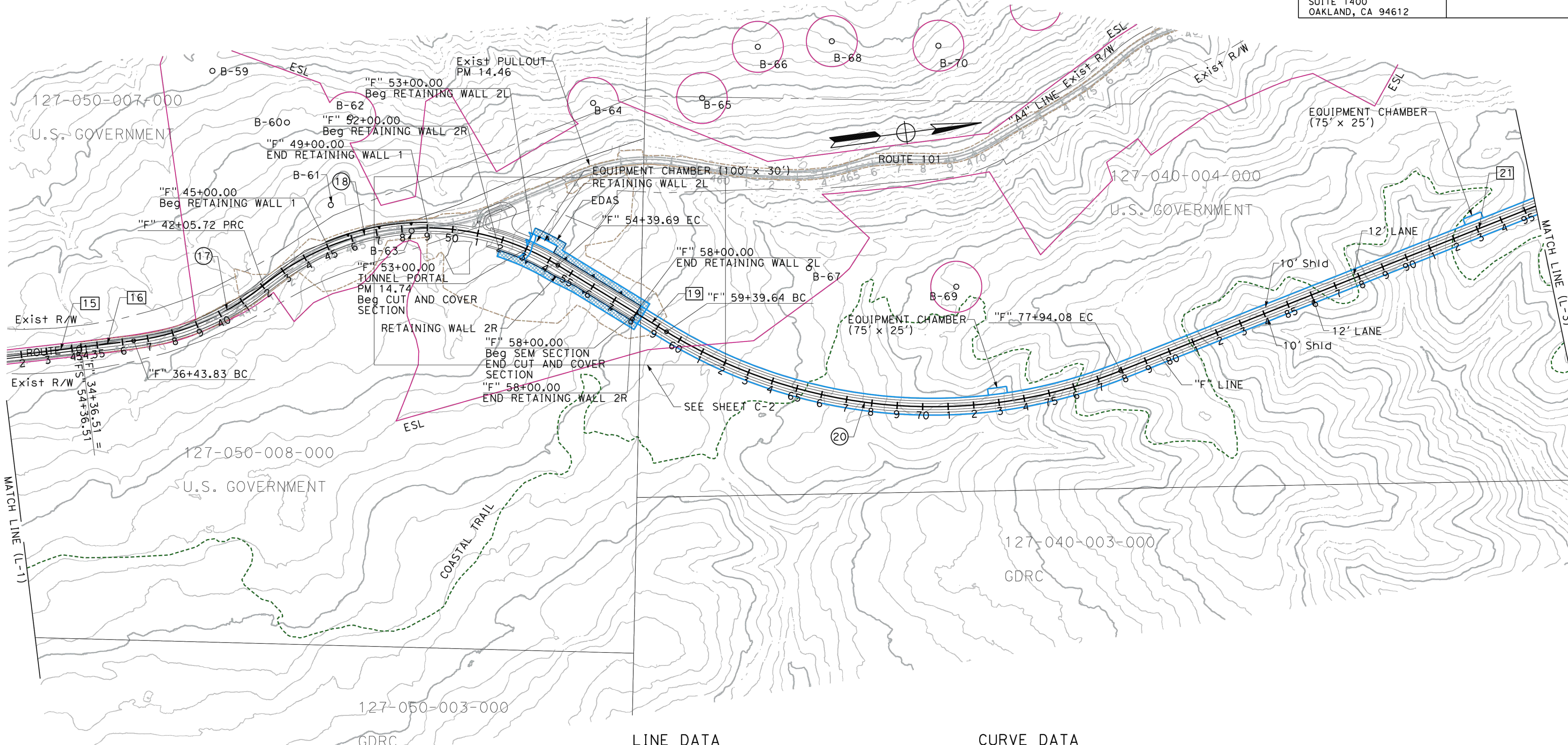
LEGEND:

- CUT/FILL LINE
- COASTAL TRAIL
- ENVIRONMENTAL STUDY LIMITS (ESL)
- Exist R/W
- STRUCTURE
- RETAINING WALL
- DRAINAGE STRUCTURE
- B-XX o BORING LOCATION



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15	337.63'	N 07°01'59" W
16	544.95'	N 07°01'59" W
19	499.95'	N 31°28'30" E
21	3636.31'	N 21°39'03" W

CURVE DATA

No.	R	Δ	T	L
17	1000.00'	32°11'37"	288.57'	561.88'
18	1000.00'	70°42'06"	709.37'	1233.98'
20	2000.00'	53°07'32"	999.90'	1854.44'

LAYOUT

ALTERNATIVE F

SCALE: 1" = 200'

L-2

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

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BORDER LAST REVISED 7/2/2010

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UNIT 0000

PROJECT NUMBER & PHASE 00000000001

PLOTTED: 15 Nov 2023, 9:26pm, DFahmey

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REFERENCE:
"STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION, PROJECT PLANS FOR CONSTRUCTION ON STATE HIGHWAY IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD, GEOMETRIC APPROVAL DRAWINGS," CONTRACT NO. EA 01-0F280, PROJECT ID 0115000099, DATED 10/26/2023.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet L-2

PLATE
1e

LEGEND:

- CUT/FILL LINE
- COASTAL TRAIL
- ENVIRONMENTAL STUDY LIMITS (ESL)
- Exist R/W
- STRUCTURE
- RETAINING WALL
- DRAINAGE STRUCTURE
- B-XX o BORING LOCATION

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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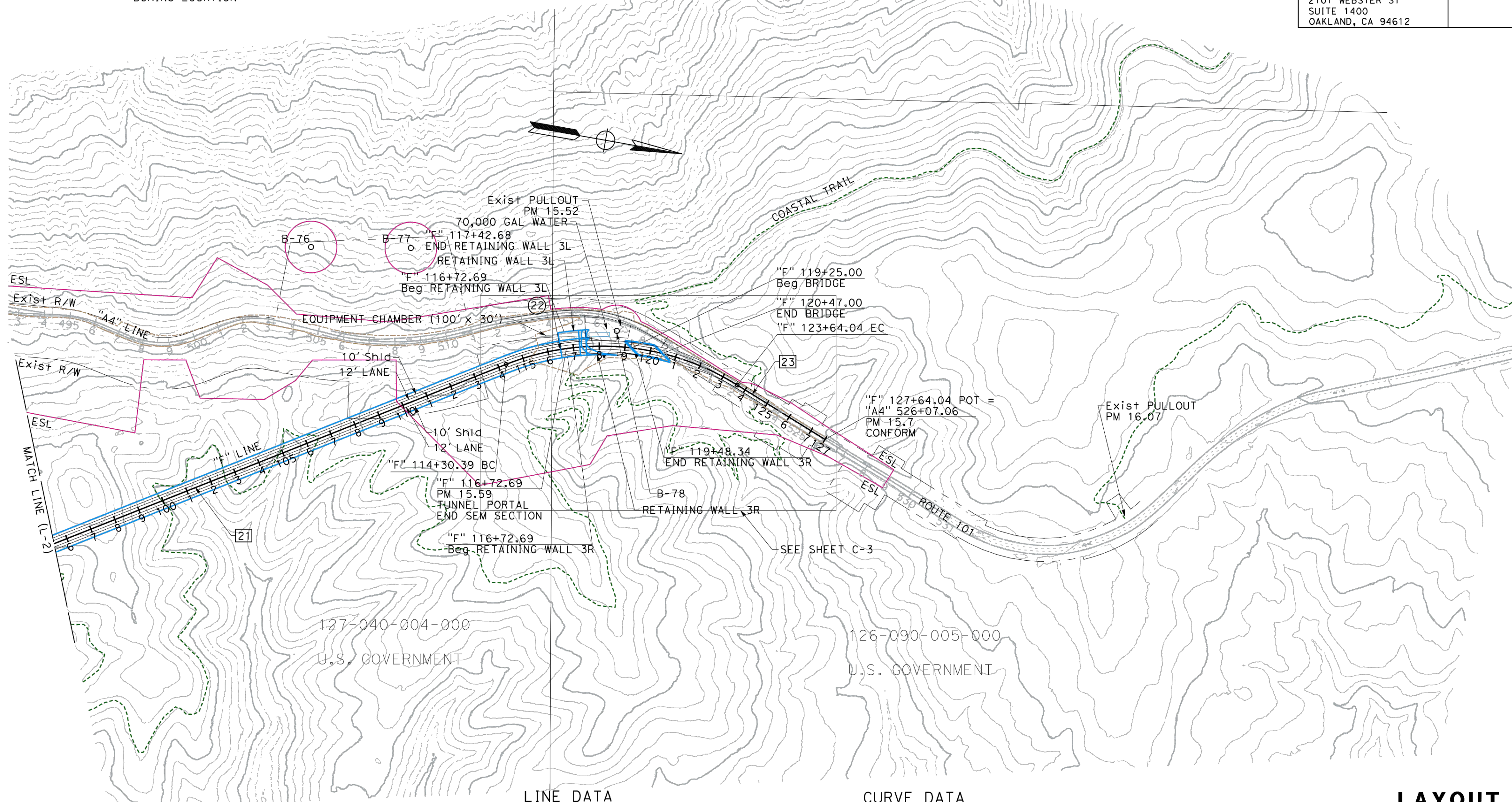

LINE DATA

No.	LENGTH	DIRECTION
21	3636.31'	N 21°39'03" W
23	400.00'	N 31°50'37" E

CURVE DATA

No.	R	Δ	T	L
22	1000.00'	53°29'40"	503.98'	933.65'

LAYOUT

ALTERNATIVE F

SCALE: 1" = 200'

L-3

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

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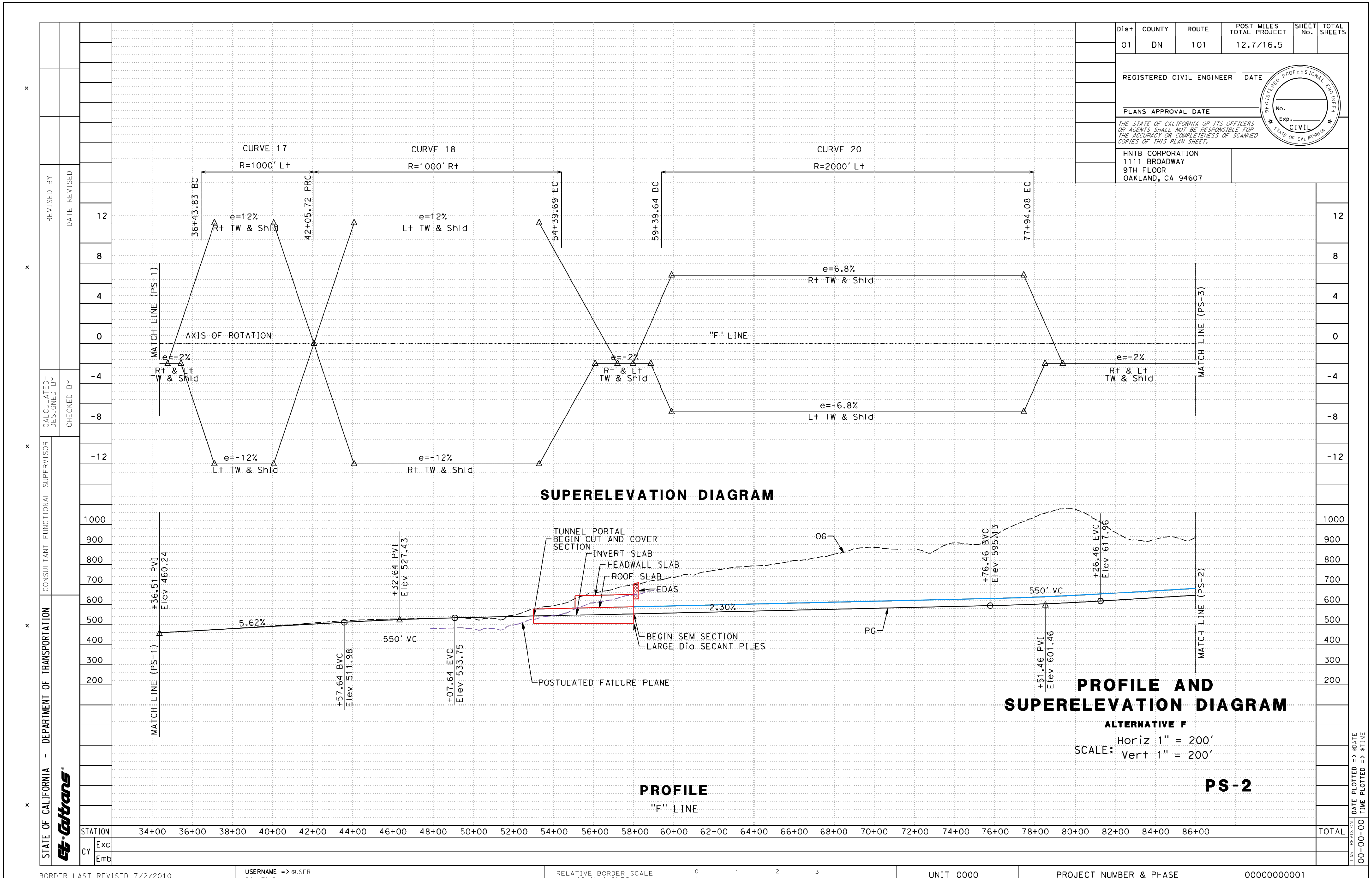
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet L-3

PLATE **1f**

PLOTTED: 15 Nov 2023, 9:27pm, DFahmey



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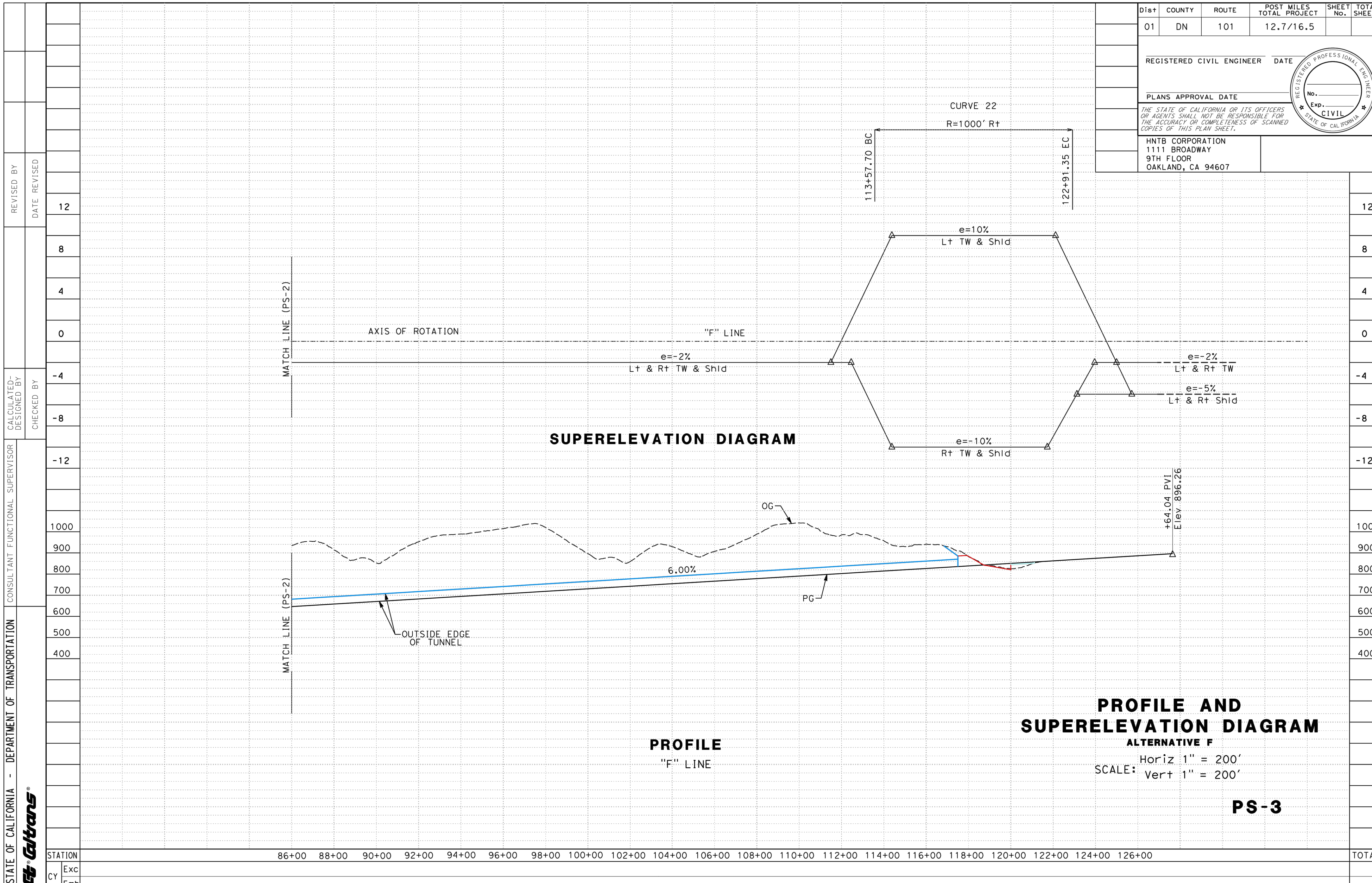
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL NOVEMBER 2023	**GEOMETRIC APPROVAL DRAWINGS** **Sheet PS-2**	PLATE **1g**



Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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PROFILE AND SUPERELEVATION DIAGRAM

ALTERNATIVE F

SCALE: Horiz 1" = 200'
Vert 1" = 200'

PS-3

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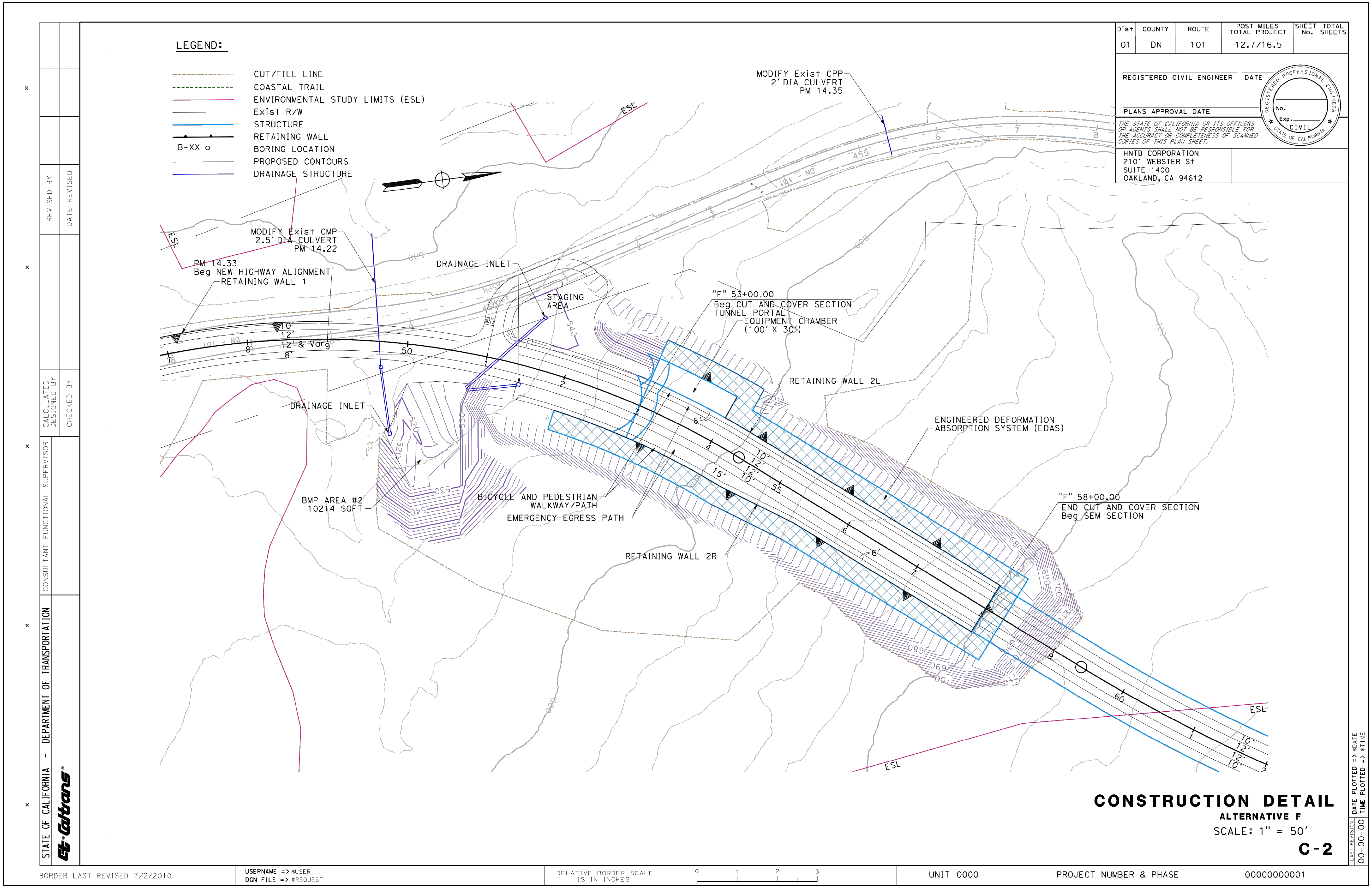
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet PS-3

PLATE **1h**

PLOTTED: 15 Nov 2023, 9:28pm, DFahmey
CAD FILE: C:\Users\DFahmey\Downloads\20208000\ LAYOUT: 1h



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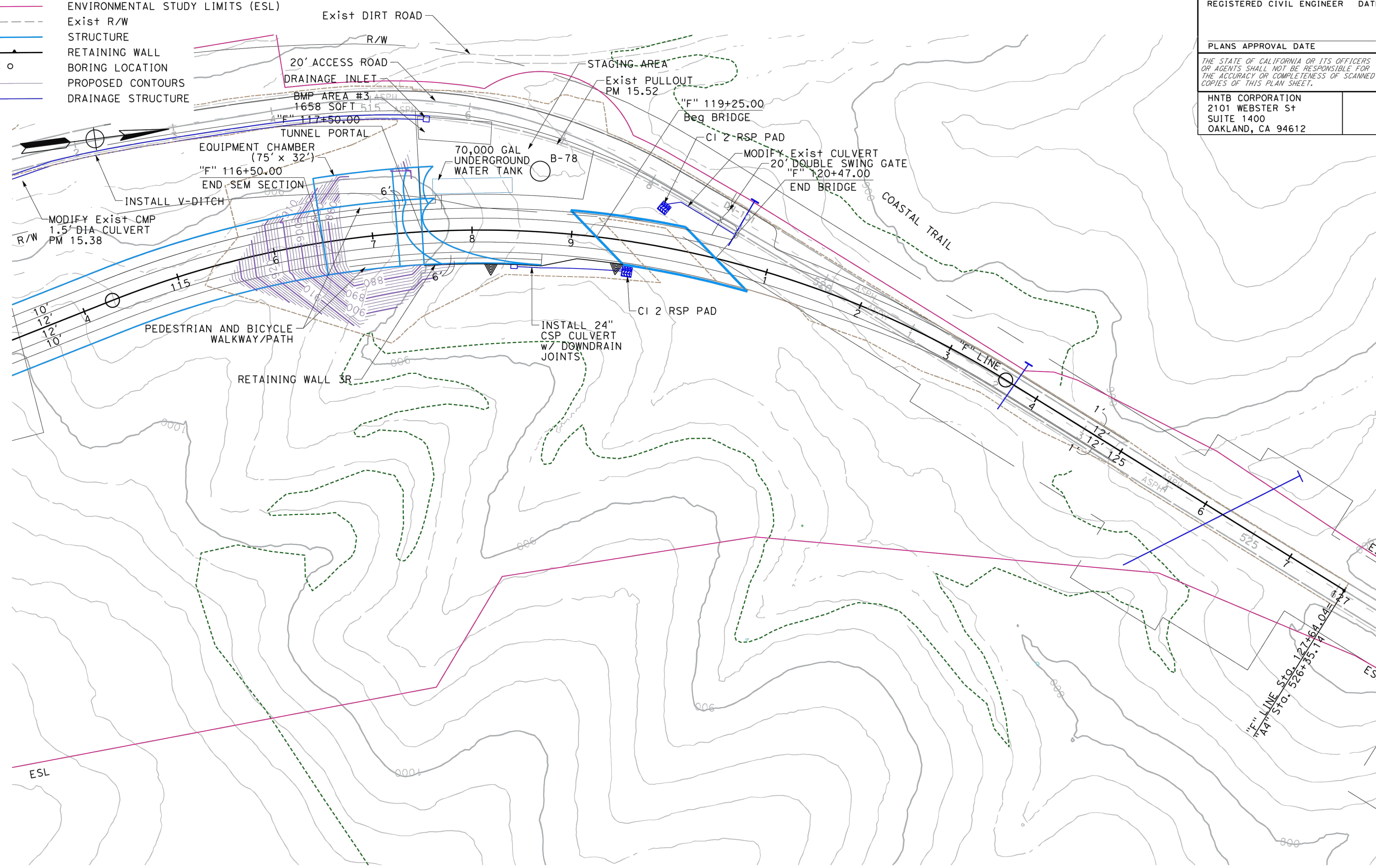
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet C-2

PLATE
1i

LEGEND:

- CUT/FILL LINE
- COASTAL TRAIL
- ENVIRONMENTAL STUDY LIMITS (ESL)
- Exist R/W
- STRUCTURE
- RETAINING WALL
- B-XX o BORING LOCATION
- PROPOSED CONTOURS
- DRAINAGE STRUCTURE



Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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CONSTRUCTION DETAIL

ALTERNATIVE F

SCALE: 1" = 50'

C-3

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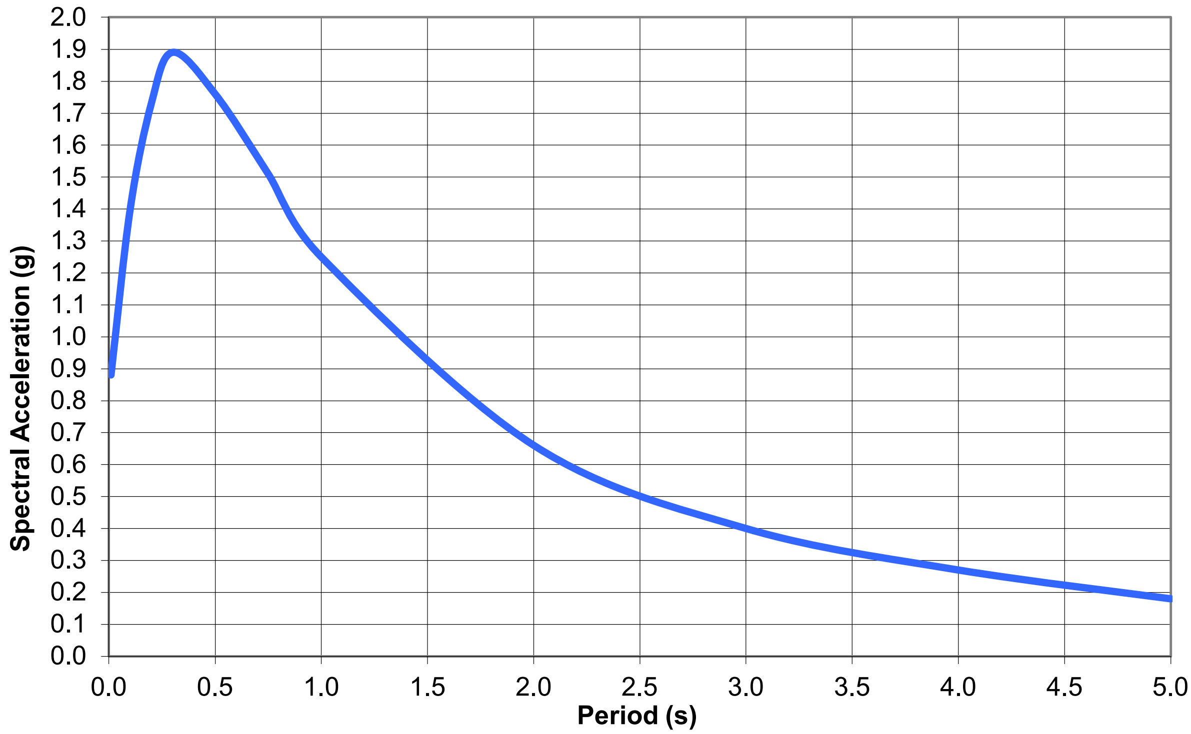
LAST CHANCE GRADE PERMANENT RESTORATION PROJECT STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL NOVEMBER 2023	GEOMETRIC APPROVAL DRAWINGS Sheet C-3	PLATE 1j

APPENDICES

APPENDIX A Preliminary Design Acceleration Response Spectra



Preliminary ARS Curve (5% Damping)

Caltrans ARS (V3.0.2) (Vs30 = 280m/s = 919ft/s)

Return Period = 975 Years

Latitude: 41.6247 Longitude:-124.1115

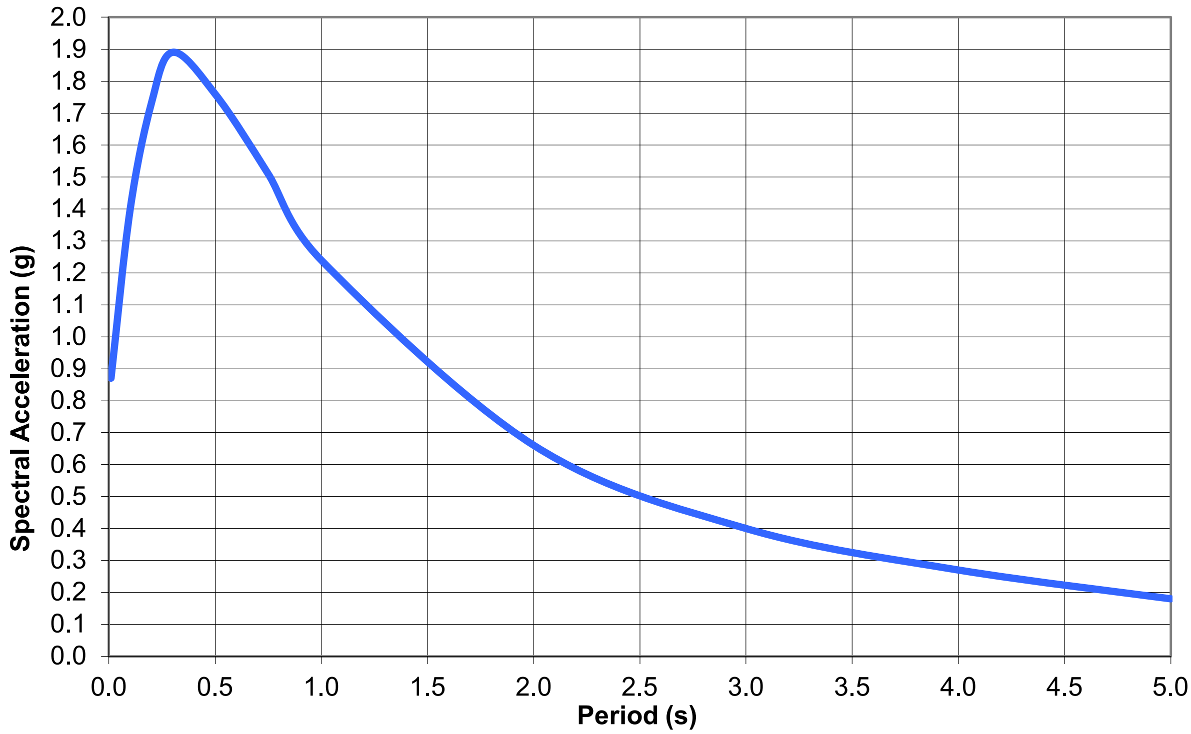
Peak Ground Acceleration (PGA) = 0.880g

Mean earthquake moment magnitude (M) for PGA = 8.65

Mean Site-to-Source Distance (R) for S1 = 20.0km = 12.4ml

Spectral Coordinates:

Period (sec)	Acc. (g)
0.01	0.880
0.10	1.400
0.20	1.730
0.30	1.890
0.50	1.760
0.75	1.510
1.00	1.250
2.00	0.660
3.00	0.400
4.00	0.270
5.00	0.180



Preliminary ARS Curve (5% Damping)

Caltrans ARS (V3.0.2) (Vs30 = 280m/s = 919ft/s)

Return Period = 975 Years

Latitude: 41.6262 Longitude:-124.1109

Peak Ground Acceleration (PGA) = 0.870g

Mean earthquake moment magnitude (M) for PGA = 8.65

Mean Site-to-Source Distance (R) for S1 = 20.0km = 12.4ml

Spectral Coordinates:

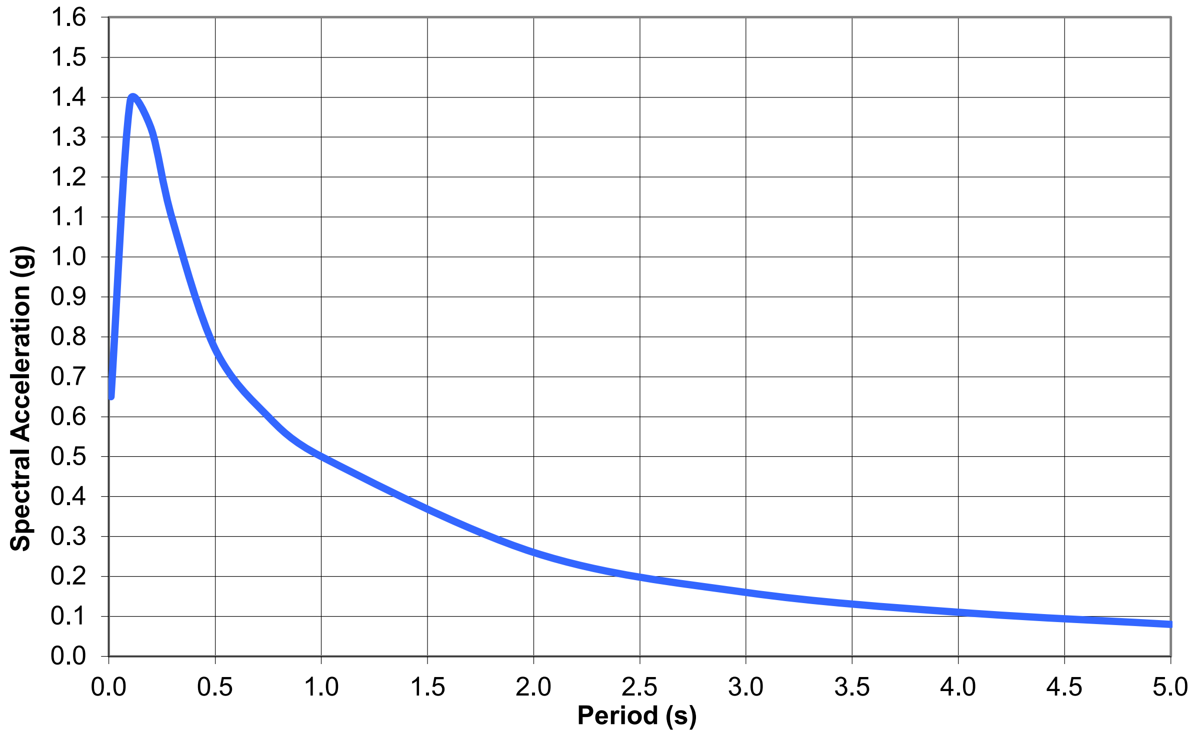
Period (sec)	**Acc.** (g)
0.01	0.870
0.10	1.400
0.20	1.730
0.30	1.890
0.50	1.760
0.75	1.510
1.00	1.240
2.00	0.660
3.00	0.400
4.00	0.270
5.00	0.180

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project Number : 20-103 Date: July, 2022

Last Chance Grade Permanent Restoration Project
Alternative F Tunnel South Portal-RW2R/2L

Preliminary ARS Curve Figure --



Preliminary ARS Curve (5% Damping)

Caltrans ARS (V3.0.2) (Vs30 = 1,149m/s = 3,770ft/s)

Return Period = 975 Years

Latitude: 41.6344 Longitude:-124.1105

Peak Ground Acceleration (PGA) = 0.650g

Mean earthquake moment magnitude (M) for PGA = 8.58

Mean Site-to-Source Distance (R) for S1 = 20.3km = 12.6ml

Spectral Coordinates:

Period (sec)	**Acc.** (g)
0.01	0.650
0.10	1.390
0.20	1.320
0.30	1.090
0.50	0.770
0.75	0.600
1.00	0.500
2.00	0.260
3.00	0.160
4.00	0.110
5.00	0.080

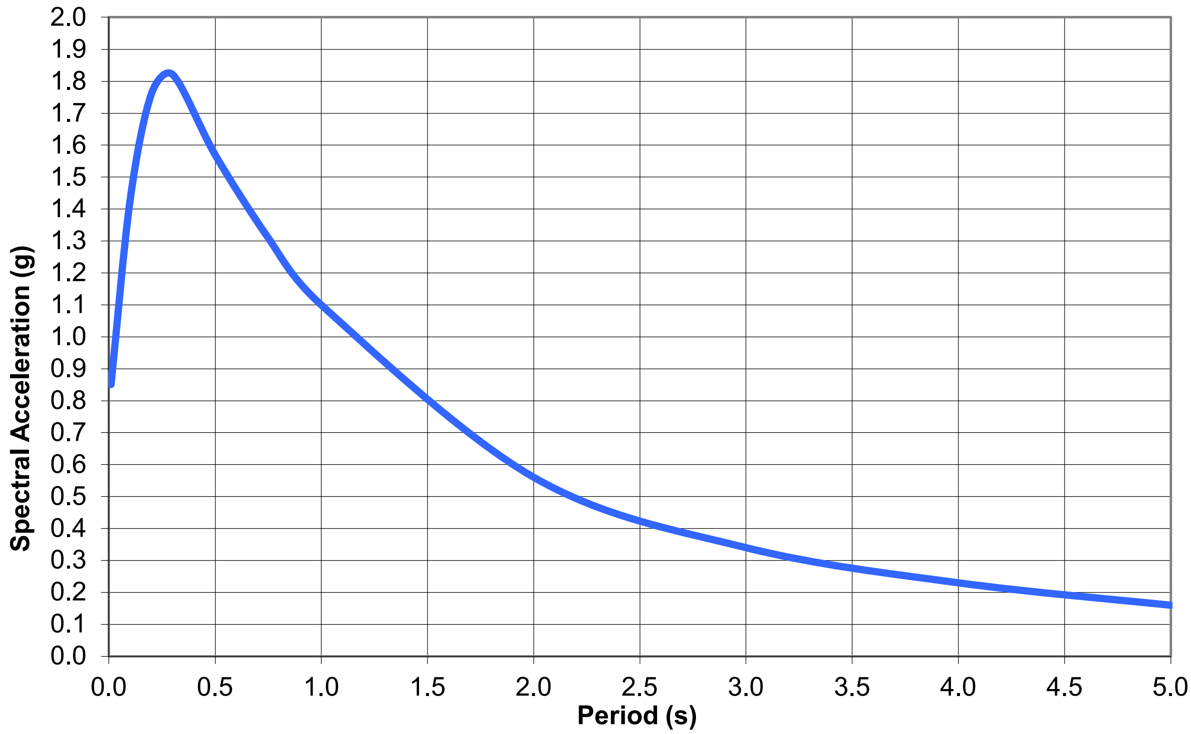
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project Number : 20-103 Date: July, 2022

Last Chance Grade Permanent Restoration Project
Alternative F Tunnel Middle Point

Preliminary ARS Curve

Figure --



Preliminary ARS Curve (5% Damping)

Caltrans ARS (V3.0.2) (Vs30 = 340m/s = 1,115ft/s)

Return Period = 975 Years

Latitude: 41.6425 Longitude:-124.1146

Peak Ground Acceleration (PGA) = 0.850g

Mean earthquake moment magnitude (M) for PGA = 8.67

Mean Site-to-Source Distance (R) for S1 = 20.1km = 12.5ml

Spectral Coordinates:

Period (sec)	**Acc.** (g)
0.01	0.850
0.10	1.430
0.20	1.760
0.30	1.820
0.50	1.570
0.75	1.310
1.00	1.100
2.00	0.560
3.00	0.340
4.00	0.230
5.00	0.160

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project Number : 20-103 | Date: July, 2022

Last Chance Grade Permanent Restoration Project
Alternative F Tunnel North Portal-RW3R/3L

Preliminary ARS Curve

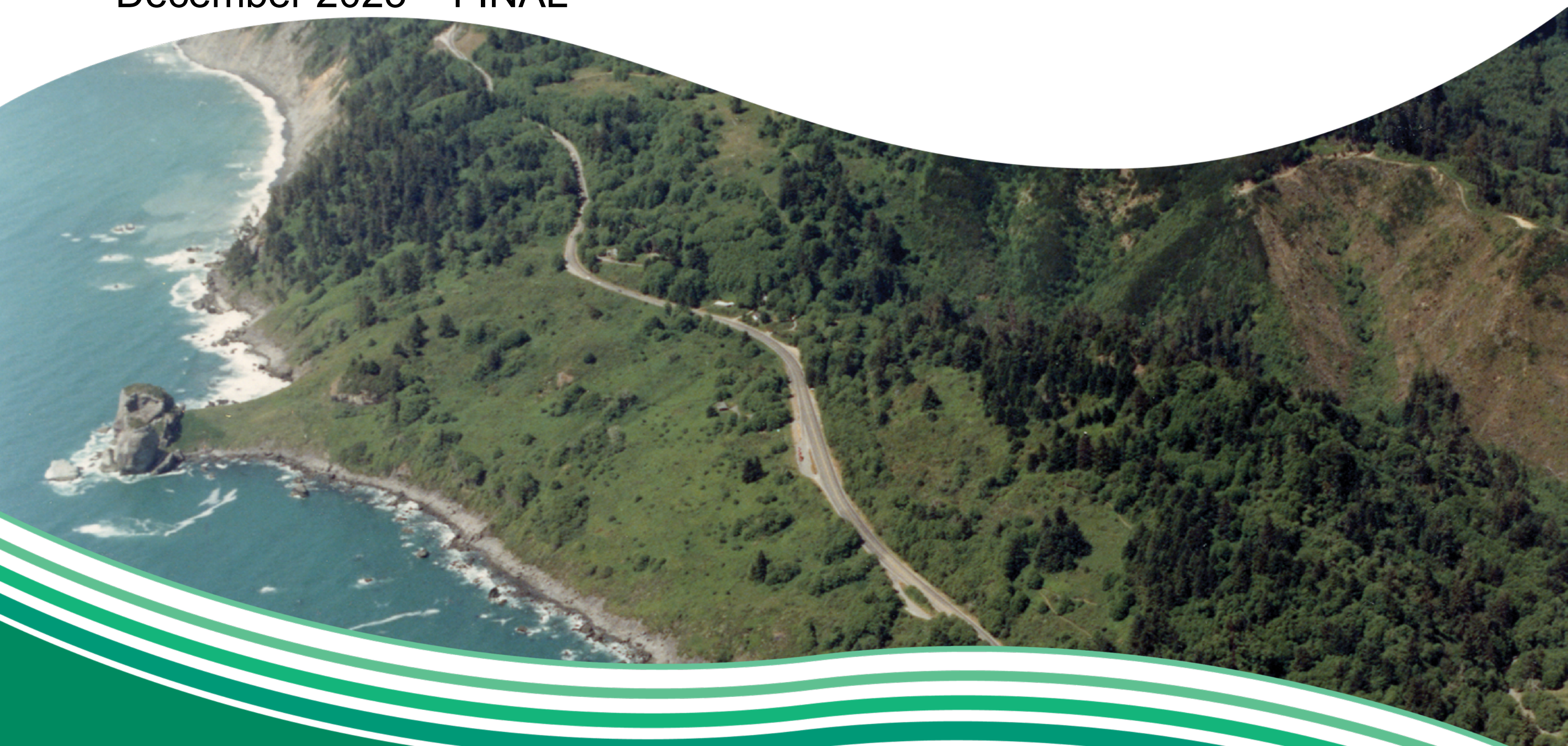
Figure --

Last Chance Grade Permanent Restoration Project

Structure Preliminary Geotechnical Report Alternative F Tunnel Operations and Maintenance Center

Submittal SUB-052d

December 2023 – FINAL



EA# 01-0F280
Project EFIS# 0115000099
Del Norte County, U.S. 101,
PM 12.7/16.5

Contents

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Acronyms and Abbreviations

APEFZ	Alquist-Priolo Earthquake Fault Zone
APS	Advance Planning Study
ARS	Acceleration Response Spectrum
ASTM	American Society for Testing and Materials
Caltrans	California Department of Transportation
CGS	California Geological Survey
CSZ	Cascadia Subduction Zone
CTM	California Test Methods
k_h	horizontal seismic coefficient
LCG	Last Chance Grade
LiDAR	light detection and ranging
M	Mean Earthquake Moment Magnitude
MSE	Mechanically Stabilized Earth
MTD	Caltrans Memo to Designers
OMC	Operations and Maintenance Center
PGA	peak ground acceleration
PGR	Preliminary Geotechnical Report
PM	post mile
ppm	parts per million
Project	Last Chance Grade Permanent Restoration Project
SDC 2.0	Seismic Design Criteria Version 2.0
SFRDHA	Surface Fault Rupture Displacement Hazard Analysis
SI	slope inclinometer
SPGR	Structure Preliminary Geotechnical Report
SPT	standard penetration test
UCERF3	Uniform California Earthquake Rupture Forecast, Version 3
U.S. 101	U.S. Highway 101
USGS	United States Geological Survey
V_{s30}	shear wave velocity for the upper 100 feet
VWP	vibrating wire piezometer

1 INTRODUCTION

This Structure Preliminary Geotechnical Report (SPGR) has been prepared to support the Advance Planning Study (APS) for the Operations and Maintenance Center (OMC) of the proposed Alternative F design option for the Last Chance Grade Permanent Restoration Project (Project). The alignments and features considered in this report are current as of October 26, 2023 (Caltrans, 2023a), the geologic and geotechnical data gathered by and on behalf of the California Department of Transportation (Caltrans) through May 31, 2021, presented in the Preliminary Geotechnical Data Report (Final) dated July 2022 (Caltrans, 2022), and the preliminary geotechnical analyses and recommendations presented in the Preliminary Geotechnical Report (Final) (PGR) dated December 2023 (Caltrans, 2023b).

2 PROJECT DESCRIPTION

Caltrans is studying alternative alignments and design options for the Project on U.S. Highway 101 (U.S. 101). The location of the project is shown on Plate 1a. These studies are in response to the section of U.S. 101 between post mile (PM) 12.7 and PM 16.5, extending from Wilson Creek to approximately 10 miles south of Crescent City in Del Norte County (known as “Last Chance Grade” [LCG]) that has been progressively sliding towards the Pacific Ocean since the roadway was first constructed. Due to continual road deformation resulting from slope movement, ongoing construction and maintenance activities are necessary to keep U.S. 101 open to the traveling public. The Project is considering Alternatives X and F to provide a more reliable connection, reduce maintenance costs, and protect the economy, natural resources, and cultural landscapes.

Alternative F would involve constructing an approximately 6,000-foot (1.1-mile) tunnel east of the existing highway to avoid the most intense areas of known landslides and geologic instability.

This alternative would be located between about PM 13.5 and PM 15.7. Main components would include a tunnel, associated north and south portals and approaches, a bridge from the north portal to connect to existing U.S. 101, and an OMC. The proposed bridge and tunnel are addressed in separate SPGRs (SPGR-b and SPGR-c).

The OMC would be located south of the tunnel at PM 13.52, and would include a building, parking spaces, and outdoor storage, as well as maintenance, operations, and emergency equipment. The building would be an approximately 12-foot-tall, 18,000-square-foot, single-story structure founded on rigid shallow foundations.

Retaining walls with perimeter chain link fencing would be located around the OMC building and yard for security purposes and to provide a grade break that allows the OMC facilities to be placed below the existing ground surface.

Construction of the OMC would involve cutting into the hillside and regrading a portion of the existing highway to create an access road to the facility. It is anticipated that porous pavement would be used to filter stormwater. The building sanitary sewer system would follow traditional plumbing methods, but it would discharge to a 3,000-gallon septic holding tank. On-site storage tanks would be provided for water, diesel, gasoline, and propane.

Alternative F OMC plan and profile views are presented on the attached Plates 1b through 1d.

3 GEOTECHNICAL INVESTIGATION

To date, three phases of geotechnical investigations have been performed for the project, which were identified as Phase 1, Phase 2A, and Phase 2B. Some Phase 1 and 2B explorations were performed in the vicinity of the Alternative F OMC. Phase 2A explorations were completed along the existing highway alignment but not in the vicinity of the OMC.

The Phase 1 geotechnical investigation program was completed between February 5, 2018 and September 27, 2018 and is summarized in the Phase 1 geotechnical investigation memorandum by Caltrans Office of Geotechnical Design (2018), which is included in Appendix A of the Preliminary Geotechnical Data Report (Final) (Caltrans, 2022). Field investigation work performed within about 150 feet of the OMC yard area included the following:

- Drilling and sampling of boring RC-18-001 for subsurface characterization and to collect data for evaluation of geologic hazards. This borehole was converted to a monitoring well, and a vibrating wire piezometer (VWP) was installed to record groundwater measurements. A slope inclinometer (SI) was installed in another borehole at the same location (RC-18-002) to measure slope movement displacements. Surface-based geophysical surveys including one seismic refraction survey (SL-1) to image subsurface structures (e.g., landslides), aid in the lateral correlation of geotechnical borings, and provide data to aid the evaluation of engineering characteristics of rock and soil.
- Collection of instrumentation readings from the SI in borehole RC-18-002, through October 13, 2020.
- Data collection from the VWP installed in borehole RC-18-001 to measure water pressure at the depth of installation within the earthflow, through January 4, 2022.

The Phase 2A geotechnical investigation program was completed between February 5, 2018 and September 27, 2018. Field investigation work performed for this program within about 800 feet south of the OMC yard area include the following:

- Drilling and sampling of one boring (RC-19-004) for subsurface characterization and to collect data for evaluation of geologic hazards.
- Collection of instrumentation readings from the SI in borehole RC-19-004, through February 6, 2020.
- Data collection from the VWP installed in borehole RC-19-004 to measure water pressure at the depth of installation within the earthflow, through February 15, 2021.

The Phase 2B geotechnical investigation program included field reconnaissance mapping by geologists from Caltrans, Kleinfelder, and SHN Consulting Engineers and Geologists on May 4 through 6, 2020 and field exploration work September 22 through January 14, 2021.

Details of the Phase 2B program, including laboratory testing results, are provided in the Preliminary Geotechnical Data Report (Final) (Caltrans, 2022). Field investigation work performed for this program within approximately 800 feet west and northwest of the OMC yard area included the following:

- Drilling and sampling of one boring (RC-21-001) approximately 800 feet northwest of the OMC yard area for subsurface characterization and to collect data for evaluation of geologic hazards.
- Surface-based geophysical surveys including a seismic refraction line (SL-42) approximately 250 feet west of the OMC yard area to image subsurface structures (e.g., landslides), aid in the lateral correlation of geotechnical borings, obtain information on rippability for earthwork grading, and provide data to aid the evaluation of engineering characteristics of rock and soil.
- Collection of instrumentation readings from the SI in RC-21-001 to measure slope movement displacements, through December 1, 2022.
- Data collection from VWPs installed in borehole RC-21-001 to measure water pressure at the depth of installation within the earthflow, through February 11, 2023.
- A time domain reflectometry cable was installed in borehole RC-21-001 to measure displacement depths through deformation; however, no data was available from Caltrans as of May 31, 2021.

Borings RC-18-001, RC-19-004, and RC-21-001 were advanced and logged in conformance with Caltrans (2010) Soil and Rock Logging, Classification, and Presentation Manual. All laboratory tests were performed in general accordance with California Test Methods (CTM) or American Society for Testing and Materials (ASTM) standard. Field and laboratory testing intervals are shown on the borehole records. Boring RC-18-002 was not sampled.

4 GEOTECHNICAL CONDITIONS

4.1 Geology

The LCG project is located within the Coast Ranges geomorphic province of California, near the Klamath Mountains, which lie approximately 10 miles to the east. The site is located approximately 90 miles north of the Mendocino Triple Junction, which is the crustal intersection of the Pacific, North American, and Gorda/Juan de Fuca tectonic plates. North of the triple junction, the Gorda/Juan de Fuca plate is being subducted eastward beneath the North America plate along the Cascadia Subduction Zone (CSZ), which extends approximately 800 miles from northern California to Vancouver Island, British Columbia. As is true for other coastal regions of northern California, Oregon, and Washington, the project site overlies the interface associated with the subducting crustal plate. This subduction interface is a low angle, east-dipping “megathrust” fault capable of generating great earthquakes of high magnitude (>M8.5).

The Coast Ranges in the LCG project area are underlain by regionally extensive Mesozoic- and Cenozoic-age rocks of the Franciscan Complex, an assemblage of mostly marine sedimentary materials accreted to the continental margin. The LCG site is within the Eastern belt of the Franciscan Complex (Delattre and Rosinski, 2012; Aalto, 1989), which is the oldest, least sheared, and most highly metamorphosed of the three belts (McLaughlin et al., 2000).

The Franciscan Complex at the LCG project site consists of two primary units: argillite-matrix Melange and a variety of Broken Formation units that originated as turbidite deposits of interbedded sandstone and shale. The Melange is interpreted as a large submarine landslide deposit that is in depositional contact with the underlying Broken Formation turbidite sequence (Aalto, 1989). Subsequent extensive accretion-related deformation has resulted in pervasive shearing and complex structural relationships within the two primary bedrock types.

The location of the proposed OMC is mapped as Landslide Deposits within the Earthflow Complex (Caltrans, 2022). The primary geologic hazards for the proposed OMC are landslides and seismicity. The landslides near the OMC are characterized as an active earthflow complex with ongoing downslope movement. Geomorphic evidence suggests the earthflows move in localized, episodic events and/or creep with movement of about 1 to 2 inches per year.

Earthquakes are another geologic hazard for the OMC. It is unclear what the magnitude of movement would be during a large regional seismic event. Seismic ground motions, as described in Section 8, may be significant and large enough to activate many of the nested landslides as well as create large displacement movement (measured in feet) along the basal failure surfaces.

4.2 Surface Conditions

The OMC would be located on the northeast side of U.S. 101, approximately 1,000 feet north of the Vista Point overlook in the area of the active earthflow landslide complex. The surface topography in this area is characterized by gently rolling, irregular slopes. In general, the surface topography at the location of the proposed OMC slopes downward towards the south to southwest. The slopes range from approximately 2.5H:1V to 6H:1V in steepness. The LiDAR survey shows several relatively flat areas in the location of former structures near U.S. 101 north of the proposed OMC (Caltrans, 2023b). The ground elevation near the OMC ranges from approximately 350 to 410 feet. Surface water drainage is anticipated to flow generally to the south to southwest.

4.3 Subsurface Conditions

At the proposed OMC, subsurface conditions include earthflow landslide deposits underlain by Franciscan Complex Melange. The landslide deposits consist of a mixture of fine-grained soils, deeply weathered rock, and scattered sandstone clasts which have been transported as a sliding mass with many internal slip surfaces. Boring records, inclinometer surveys, and cross-sectional analysis within the earthflow in the vicinity of the OMC suggest the basal failure surface/zones within borings RC-18-001/RC-18-002, RC-19-004, and RC-21-001 range from approximate depths of 49 and 118 feet. Inclinometer data collected at borehole RC-21-001 in February 2023 suggests an increased rate of movement relative to prior readings at the failure zone between approximately 90 to 96 feet. Inclinometer data from borehole RC-18-002 adjacent to the proposed OMC footprint indicates the earthflow thickness to be approximately 67 feet. The Melange below the slide debris consists of dark gray, pervasively sheared, soil-like argillite with scattered blocks of intact sandstone. Fill associated with former structures in the area may also be encountered.

It should be noted that the subsurface conditions described above are based on limited existing geotechnical data and will be verified using site-specific borings during the future design phase.

5 GROUNDWATER

The area-wide hydrogeology is dominated by groundwater flow along fractures in the bedrock, within the Melange and Broken Formations, and the overlying landslide deposits. The permeability of intact rock within these formations is very low, and most groundwater occurs and is transmitted within fractures of unknown interconnection. Where water-laden fractures intersect the bluff face, groundwater discharges as a spring or seep. Groundwater is also likely entering the ocean below the shoreline.

Groundwater flow along fractures in the project area can be interrupted and redirected, perched, or locally mounded behind subsurface barriers to flow such as clay-filled landslide-rupture zones.

VWP RC-18-001 was installed near the proposed OMC in the active earthflow. VWPs RC-19-004 and RC-21-001 were installed in the active earthflow about 800 feet south and northwest of the proposed OMC, respectively. Note that artesian conditions were encountered in VWP D-20-010, located approximately 1,200 feet northwest of the proposed OMC. The table below summarizes the groundwater data obtained from these VWPs. The data spans a timeframe between December 2018 and February 2023. No in-situ permeability testing has been performed within the earthflow in the vicinity of the proposed OMC.

Table 5-1. Groundwater Data from VWPs

Boring ID	Total Bore Depth (feet)	Surveyed Ground Surface Elevation (feet)	VWP Depth (feet)	VWP Elevation (feet)	Apparent Groundwater Depth Minimum (feet)	Apparent Groundwater Elevation Maximum (feet)	Date Measured
RC-18-001	85.3	345.1	69.8	275.3	5.5	339.6	12/4/2018 through 1/4/2022
RC-19-004	100.0	289.4	48.5	240.9	4.4	285.0	3/18/2020 through 2/15/2021
D-20-010	150.0	474.7	148.6	290.4	-8.3	447.3	12/8/2020 through 6/21/2023
			66.0	372.9	-10.1	449.0	
RC-21-001	150.0	408.4	149.0	259.4	23.7	384.7	1/16/2021 through 2/11/2023
			49.0	359.4	8.7	399.7	
			30.0	378.4	26.7	381.7	

6 AS-BUILT DATA

Existing underground structures in the vicinity of Alternative F consist of current roadway stability structures along U.S. 101. No live or abandoned underground utilities are believed to be present. SI casing and VWPs are located within and adjacent to the current roadway section near where Alternative F joins U.S. 101.

Plans and/or details for Caltrans repair structures along the existing highway alignment dated between 2015 and 2021 were provided by Caltrans but the structures are not in the vicinity of the proposed OMC. As-built plans for the repair structures completed in 2023 along the existing highway at PM 15.48 are available from Caltrans.

7 CORROSION EVALUATION

Four soil/rock samples and one groundwater sample were collected at various locations of the Project and were tested for corrosion as shown in the following table.

Table 7-1. Preliminary Corrosion Test Results

Boring ID	Sample Depth (feet)	Sample Description	Minimum Resistivity (ohm-cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)	Corrosive
RC-20-014	71.2 to 71.5	Sandstone with iron oxide Broken Formation	1,050	7.55	35.5	57.8	No
RC-20-019	251.6 to 251.9	Argillite interbed in Sandstone of Broken Formation	5,360	6.32	5.1	1.7	No
RC-21-001	30.0 to 31.5	Argillite/Earthflow	2,170	7.59	2.5	79.1	No
RC-20-015	128.8 to 129.0	Argillite below Earthflow	2,200	7.56	2.6	126.8	No
P-20-012	-	Groundwater	-	7.58	25	110	No

According to the Caltrans Corrosion Guidelines (Caltrans, 2021a), soils are considered corrosive if the pH is 5.5 or less, or chloride content is 500 parts per million (ppm) or greater, or sulfate content is 1,500 ppm or greater. Also, as stated in the Caltrans Corrosion Guidelines, a minimum resistivity value for soil and/or water less than or equal to 1,500 ohm-cm indicates the presence of high quantities of soluble salts and a higher propensity for corrosion.

Based on the corrosion test results and Caltrans criteria, the soil samples tested were not found to be corrosive to bare metals and concrete. The corrosion potential is based on limited data and may not be representative of the conditions at the OMC. It should be noted that the OMC facility is not within 1,000 feet of the ocean; therefore, according to Caltrans Corrosion Guidelines (2021a), the site is not in a marine atmosphere zone.

Section 90-1.02H Concrete in Corrosive Environments of the Caltrans Standard Specifications provides specification language for corrosion resistant concrete mix designs that address corrosive conditions.

8 SEISMIC INFORMATION

8.1 Ground Motion Hazard

The project site is susceptible to strong earthquake-induced ground motions during the design life of the proposed improvements. Since the OMC includes human occupancy structures, it should be designed in accordance with California Building Code (CBC, 2019) and the CBC seismic design criteria. In addition, the OMC is part of the Caltrans infrastructure and critical for operation of the tunnel, therefore some elements of the OMC may be designed in accordance with Caltrans seismic design criteria.

The seismic design criteria for the site in accordance with Caltrans and CBC criteria is provided in this section.

Caltrans Seismic Design Criteria

Following the procedures described in Caltrans Seismic Design Criteria Version 2.0 (SDC 2.0) (2019a) and October 2019 Interim Revisions to SDC 2.0 (2019b), the preliminary Acceleration Response Spectrum (ARS) curve for a 975-year Return Period was determined using the Caltrans ARS Online V3.0.2 (2021b) and utilizing the small-strain shear wave velocity for the upper 100 feet (V_{S30}) of the project site. The preliminary value of V_{S30} was estimated from the soil data of existing Boring RC-18-001 (approximately 150 feet north of the site), and the standard penetration test (SPT) correlations provided in the Methodology for Developing Design Response Spectrum for Use in Seismic Design Recommendations (Caltrans, 2012). The 2021 correlations described in Attachment 2 of Caltrans Geotechnical Manual – Design Acceleration Response Spectrum module (Caltrans, 2021c) were not adopted, because it was determined that they are not representative of the site conditions. In order to determine whether 2021 correlations are suitable for the site, the estimated shear wave velocity from these correlations were compared with available seismic refraction survey results near the same locations, as shown in the PGR (Caltrans, 2023b). The 2021 correlations tend to yield a lower V_{S30} value than direct shear wave velocity measurements from seismic refraction lines, while the 2012 correlations provide reasonably close results. Therefore, the 2012 correlations have been adopted for this site.

Preliminary site seismic parameters are listed in the following table.

Table 8-1. Preliminary Site Seismic Parameters

Structure	Tunnel Operations and Maintenance Center Building
Reference Boring(1)	RC-18-001
Site Geospatial Coordinates (latitude, longitude)(2)	41.616°, -124.107°
V_{S30} (m/s)	305

Notes:
(1) Based on Preliminary Geotechnical Data Report (Final) (Caltrans, 2022).
(2) Estimated from Google Maps and the current Geometric Approval Drawings.

Based on the Caltrans ARS Online V3.0.2 (2021b), the preliminary values of Peak Ground Acceleration (PGA), the deaggregated mean earthquake moment magnitude (M) for PGA, and the mean site-to-source distance (R) for 1.0 second period spectral acceleration are 0.87g, M8.64, and 20.0 km, respectively. The Ground Motion Data Sheets, presenting the preliminary ARS data, plots, and other relevant information are included in Appendix A.

According to the Caltrans Geotechnical Manual – Landslides module (Caltrans, 2020) and Caltrans Geotechnical Manual – Embankments module (Caltrans, 2014), a horizontal seismic coefficient (k_h) for seismic slope stability analysis may be equal to one-third of the PGA at the site. Therefore, a preliminary k_h value of 0.29 is recommended to estimate the seismic lateral earth pressure for the site proposed retaining walls.

California Building Code

The seismic design provisions of the California Building Code (2019) will be followed for buildings. Based on the soil data of the existing Boring RC-18-001, a site class type D was adopted to determine site coefficients.

The USGS Web Services tool (2021) and ASCE 7-16 standard were used to determine the short and long period spectral accelerations in accordance with the CBC/ASCE7-16 procedures. Preliminary ground motion parameters are shown in the following table.

Table 8-2. Preliminary Ground Motion Parameters

Site Coordinates		**Site Classification/ Risk Category**		**Site Coefficients**		**Risk–Targeted MCE_R ARS Parameters**		**Design Spectral Acceleration Parameters**	
Lat.	41.616°	Site Class	D	F_a	1.0	S_s	1.995 g	S_{MS}	1.995 g
						S_1	0.938 g	S_{M1}[1]	1.595 g
Lon.	-124.107°	Risk Category	IV	F_v	1.7[1]	T_L	16 s	S_{DS}	1.33 g
								S_{D1}[1]	1.063 g

Note:
(1) See requirements for site-specific ground motions in Section 11.4.8 of ASCE 7-16.

8.2 Other Seismic Hazards

The proposed OMC facility is not located within 1,000 feet of any active faults as delineated by the Alquist-Priolo Earthquake Fault Zone (APEFZ) (CGS, 2007) or Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) model (USGS, 2013). Therefore, per Caltrans MTD 20-10 (2013) and Caltrans Geotechnical Manual – Fault Rupture module (2017), the site is not considered susceptible to surface fault rupture hazards, and no Surface Fault Rupture Displacement Hazard Analysis (SFRDHA) is needed.

Preliminary liquefaction potential analysis was performed, using the procedures outlined by Youd et al. (2001), and the blow counts and measured groundwater depths of existing Boring RC-18-001, extracted from the Summary of Phase 1 Geotechnical Investigation (Caltrans, 2018), and Preliminary Geotechnical Data Report (Final) (Caltrans, 2022). Due to the presence of fine-grained or dense materials below groundwater table, no liquefiable layers are identified. Therefore, the project site is not susceptible to liquefaction or related seismic hazards, including seismic total or differential ground settlement, and lateral spreading. However, according to the empirical method proposed by Tokimatsu and Seed (1987), dry sand settlement of about 4 inches may result from the top 7 feet subsurface materials during a design seismic event.

The project site is located within the earthflow complex; therefore, the site has potential for earthquake-induced slope instability. The structures will be designed for ground movement in order to minimize collapse potential and improve life safety as much as possible.

According to Caltrans MTD 20-13 (2010), the tsunami hazard is significantly reduced at locations beyond one-half mile of the coast or at elevations greater than 40 feet above mean sea level. The proposed building site is located about 0.27 miles from the nearest coastline. However, because the project site is situated at elevation above +350 feet (much higher than +40 feet), the risk for tsunami-related damage does not exist, per Caltrans MTD 2013. However, potential impact of tsunami on the global stability of the site will be evaluated.

9 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

The OMC site would include a building, parking spaces, outdoor storage, and maintenance equipment. The building would be an approximately 12-foot-tall, 18,000-square-foot, single-story structure. It would contain equipment and other facilities related to tunnel maintenance, operations, and emergency response. It is anticipated the building roof would be planted (i.e., a “green” roof) to blend into the surrounding terrain.

Construction of the OMC would involve cutting into the hillside and regrading a portion of the existing highway to create an access road to the facility. It is anticipated that porous pavement would be used to filter stormwater. BMPs appropriate to site conditions and regulatory requirements will be used.

The building foundation loads are anticipated to be relatively low. Based on available information from VWPs, the preliminary assumption for the groundwater level depth is between 5 and 27 feet below the ground surface. There is no liquefaction potential, and the site is located within the earthflow complex. The proposed foundation system will be designed to maintain integrity of the supporting structure under a ground movement scenario, in order to prevent total collapse and maintain life safety.

According to the soil data from the existing Boring RC-18-001, the proposed foundations will be placed on gravelly silt, silty sand with gravel, or gravelly lean clay (colluvium).

Based on these considerations, appropriate foundation system alternatives are discussed in the following sections. It should be noted that these recommendations are based on limited soil data and may be modified and revised once additional soil data becomes available.

Due to deep-seated nature of the landslides at the site, a deep foundation system may not be the best alternative for this site. Rigid shallow foundations could provide better performance during ground movement and allow the structures to float over earthflow with less damage. The recommended foundation types for structure support are as follows:

- <u>Post-tensioned Slabs:</u> Stiff post-tensioned slabs can be used to support the proposed building structures. The slab will provide adequate stiffness to allow the supporting buildings to move as a monolithic structure with the earthflow.
- <u>Stiff Reinforced Mat Foundations:</u> A thick reinforced mat foundation or a mat foundation with rigid grade beams is another feasible foundation type for the buildings.

Per Chapter 18 - Soils and Foundations of the 2019 CBC, minimum footing embedment depth is 12 inches. A presumptive allowable vertical foundation pressure of 1.5 ksf and allowable lateral bearing pressure of 100 psf/ft can be used for preliminary design of spread footings. Allowable coefficient of friction for lateral sliding resistance is 0.25. These values can be increased by one-third when used with the alternative basic load combinations of Section 1605.3.2 of CBC 2019 that include wind or earthquake loads.

Preliminary maximum total settlement is estimated to be 2 inches, and the differential settlement can be assumed to be 50 percent of the total settlement. A modulus of subgrade reaction of 100 psi may be used for preliminary design of slabs. This value will be adjusted for the size of the loaded area.

Due to the limited soil data, presence of expansive soils beneath the footings cannot be ruled out. If further investigation indicates that expansive soils are present, the slabs will be designed for appropriate uplift pressure due to soil expansion.

Because of the expected settlement, differential settlement and horizontal movement at the subject site, flexible joints are recommended in all conduits for the OMC buildings and equipment.

Cut slopes up to 2H:1V gradient can be used for site grading. Slopes will be properly benched, and appropriate drainage and erosion control measures will be provided to prevent erosion and sloughing. The recommendations of Section 1808.7 of CBC 2019 regarding footing setback from descending slopes and clearance from ascending slopes will be followed for building structures.

Due to the existing ground slope, site grading and retaining walls will be utilized to achieve flat building pads for the structures. The proposed OMC site is almost entirely cuts into the slope on the north side of U.S. 101 highway. Retaining walls would be located around the OMC building and yard to retain the cut slopes and provide a grade break that allows the OMC facilities to be placed below the existing ground surface.

The site retaining walls are proposed to be constructed of reinforced concrete with heights up to 20 feet. Based on these assumptions, concrete cantilever walls similar to Caltrans standard walls can be used. However, it should be noted that site PGA is larger than 0.6g, and lateral earth pressures could be higher due to active earthflow at the site. Therefore, special design walls are likely to be needed for perimeter walls.

The exact dimension/configuration of the walls have not yet been developed. The OMC building construction is not intended to stabilize the deep landsliding (100+ ft deep). Wall design should be evaluated in more detail once there is more information on wall heights/configurations and better subsurface data.

Other wall types that can be considered include cantilever nongravity walls and anchored walls. Cantilever nongravity walls usually have deep embedment depths and are likely to perform poorly in an active earthflow situation. Anchored walls typically have shallower embedment depth, however, impact of active earthflow on anchor loads will be evaluated before considering these wall types. Mechanically stabilized earth (MSE) retaining walls can be considered for fill sections.

10 ADDITIONAL FIELD WORK AND LABORATORY TESTING

The proposed OMC site is approximately 350 feet long and 240 feet wide and includes about 800 feet of retaining walls. To supplement the existing subsurface data, we recommend drilling a total of eight (8) mud rotary/rock core borings. Four borings will be drilled within the footprint of the maintenance facility and office building in the north of the site, and one boring will be drilled in the area designated for the auxiliary structures in the south of the site. In addition, three borings will be drilled behind the retaining wall layout lines, on the west, north, and east of the site.

The proposed boring depth should extend at least 20 feet or three times the width of the footing (whichever greater) below the proposed shallow foundation base, with a minimum depth of 40 feet. Borings would include in-situ permeability testing and installation of instrumentation to monitor groundwater levels and landslide displacement.

Samples recovered during the field investigation will be transported to the laboratory for testing. All of the soil samples will be visually classified and moisture content/density tests will be performed. Additional samples will be selected for sieve analysis, No. 200 wash, corrosion, and direct shear and unconfined compression tests. Other laboratory tests such as Point Load Strength Index tests may be required, depending upon the nature of the soils and bedrock encountered during the investigation.

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PLATES

PLOTTED: 15 Nov 2023, 8:59pm, DFahmey

CAD FILE: C:\Users\DFahmey\Downloads\202080000\ LAYOUT: 1a

APPROVED AS TO IMPACT ON STATE FACILITIES AND CONFORMANCE WITH APPLICABLE STATE STANDARDS AND PRACTICES AND THAT TECHNICAL OVERSIGHT WAS PERFORMED.

CONSULTANT DESIGN MANAGER	CALTRANS DESIGN OVERSIGHT APPROVAL	REGISTRATION No.	LICENSE Exp DATE	DATE SIGNED

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

STATE OF CALIFORNIA

DEPARTMENT OF TRANSPORTATION

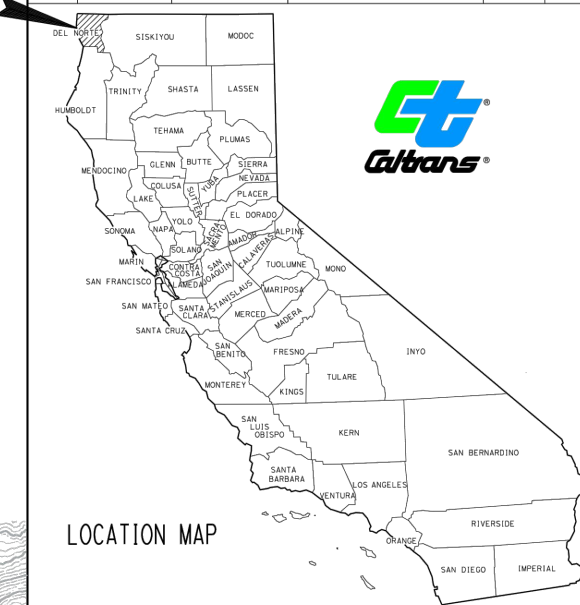
PROJECT PLANS FOR CONSTRUCTION ON

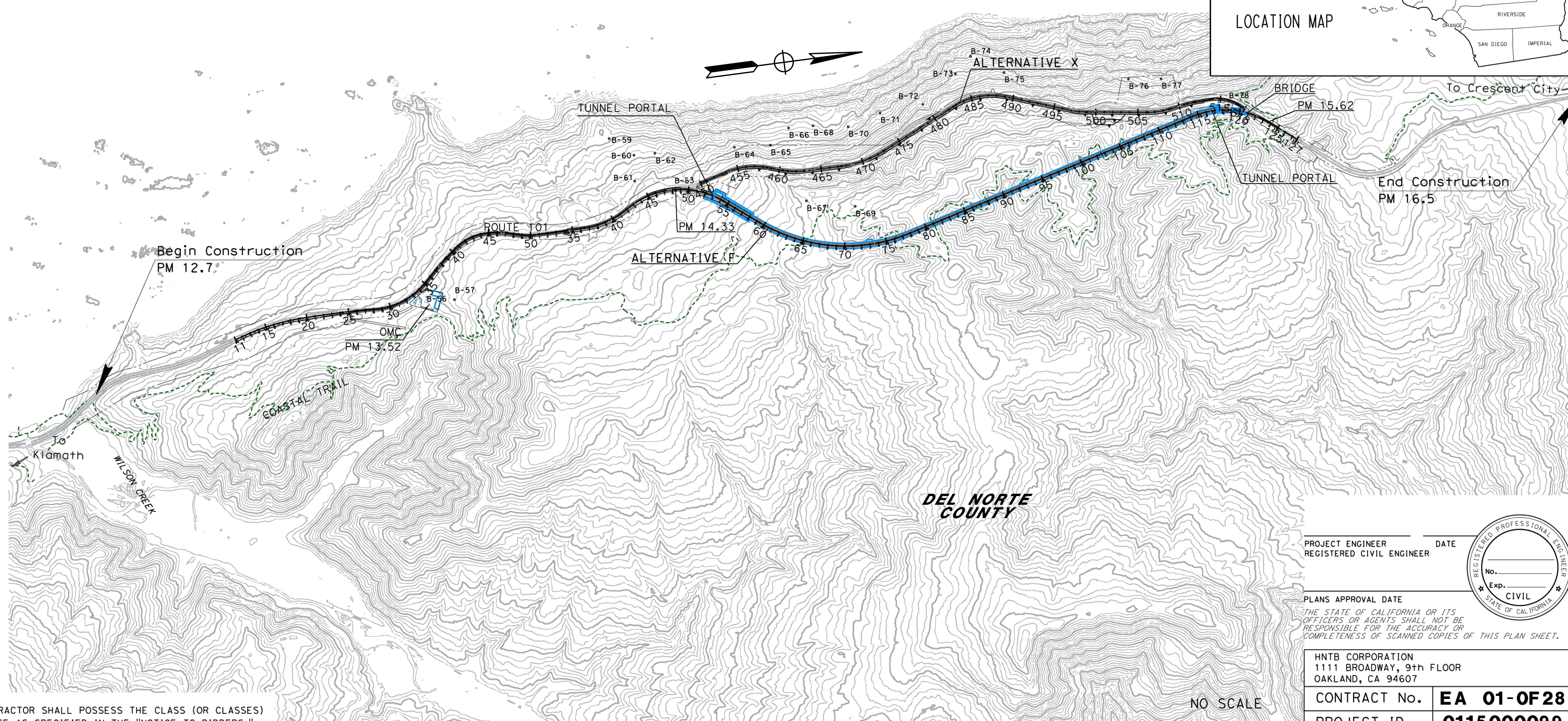
STATE HIGHWAY

IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD

TO BE SUPPLEMENTED BY STANDARD PLANS DATED 2018

GEOMETRIC APPROVAL DRAWINGS





THE CONTRACTOR SHALL POSSESS THE CLASS (OR CLASSES) OF LICENSE AS SPECIFIED IN THE "NOTICE TO BIDDERS."

PROJECT ENGINEER DATE
REGISTERED CIVIL ENGINEER

REGISTERED PROFESSIONAL ENGINEER
No.
Exp.
CIVIL
STATE OF CALIFORNIA

PLANS APPROVAL DATE

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HNTB CORPORATION
1111 BROADWAY, 9th FLOOR
OAKLAND, CA 94607

CONTRACT No.	EA 01-0F280
PROJECT ID	0115000099

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"STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION, PROJECT PLANS FOR CONSTRUCTION ON STATE HIGHWAY IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD, GEOMETRIC APPROVAL DRAWINGS," CONTRACT NO. EA 01-0F280, PROJECT ID 0115000099, DATED 10/26/2023.

LEGEND:

- CUT/FILL LINE
- COASTAL TRAIL
- ENVIRONMENTAL STUDY LIMITS (ESL)
- Exist R/W
- STRUCTURE
- RETAINING WALL
- DRAINAGE STRUCTURE
- B-XX o BORING LOCATION

Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

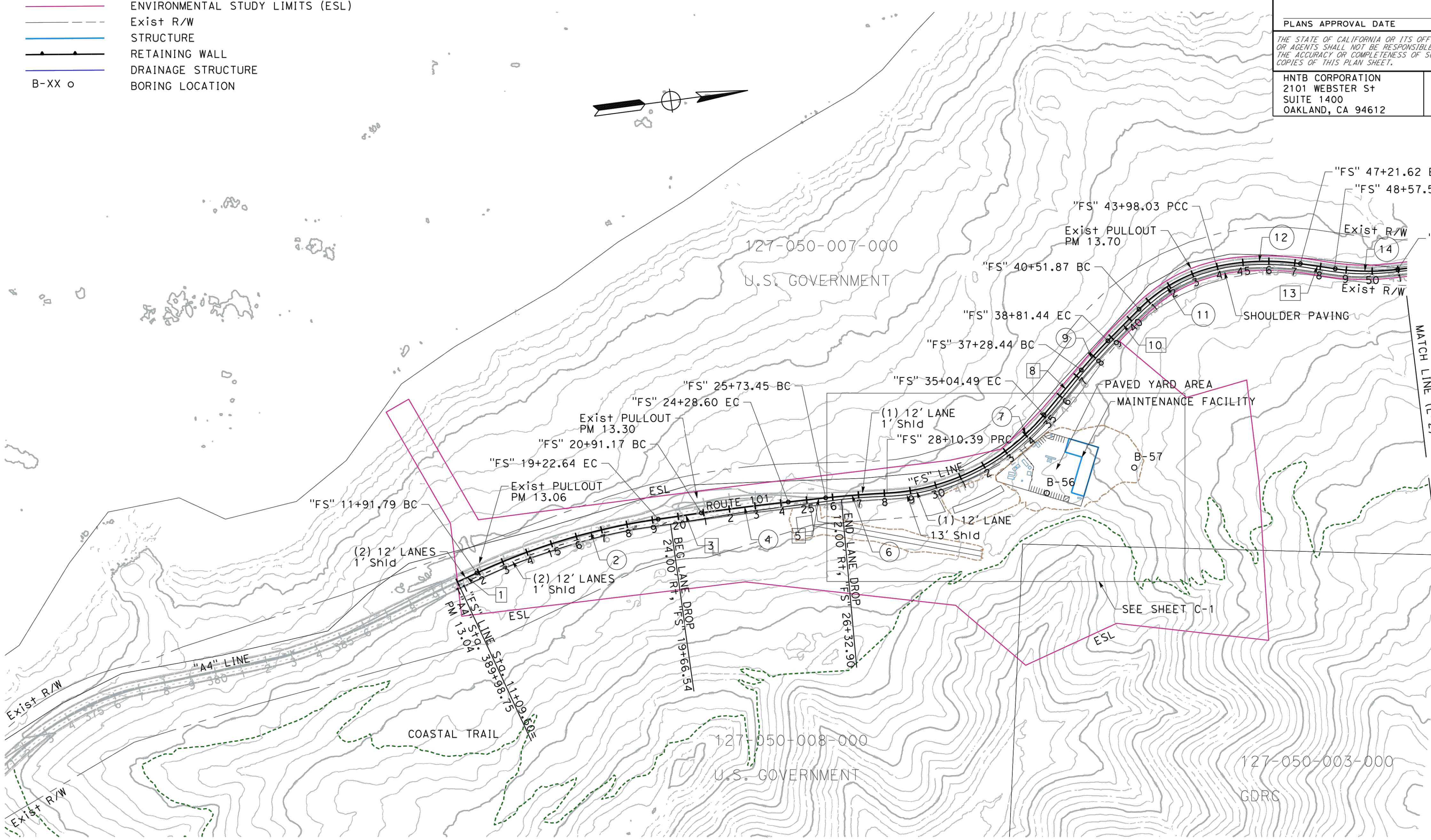
REGISTERED PROFESSIONAL ENGINEER No. Exp. CIVIL STATE OF CALIFORNIA

HNTB CORPORATION
2101 WEBSTER St
SUITE 1400
OAKLAND, CA 94612

REVISED BY | DATE REVISED | CALCULATED-DESIGNED BY | CHECKED BY | CONSULTANT FUNCTIONAL SUPERVISOR

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans



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7	840.00	47°20'38"	368.24	694.10
9	1800.00	4°51'22"	76.33	152.56
11	600.00	33°03'22"	178.05	346.16
12	900.00	20°36'02"	163.56	323.59
14	900.00	15°21'54"	121.41	241.35

LAYOUT

ALTERNATIVE F

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L-1

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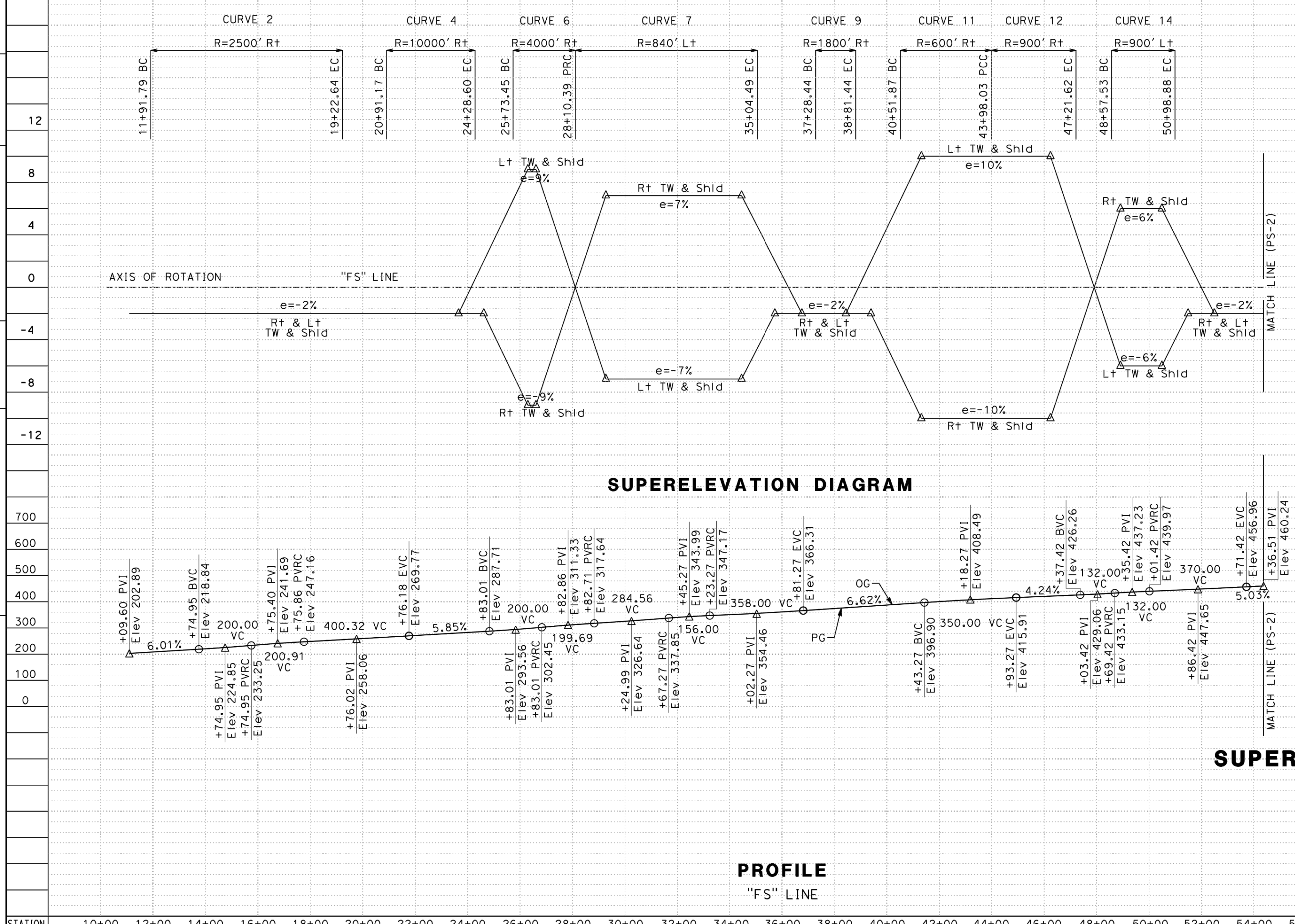
REFERENCE:
"STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION, PROJECT PLANS FOR CONSTRUCTION ON STATE HIGHWAY IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD, GEOMETRIC APPROVAL DRAWINGS," CONTRACT NO. EA 01-0F280, PROJECT ID 0115000099, DATED 10/26/2023.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet L-1

PLATE **1b**



Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER No. Exp. CIVIL STATE OF CALIFORNIA

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HNTB CORPORATION
1111 BROADWAY
9TH FLOOR
OAKLAND, CA 94607

PROFILE AND SUPERELEVATION DIAGRAM

ALTERNATIVE F

SCALE: Horiz 1" = 200'
Vert 1" = 200'

PS-1

REVISED BY | DATE REVISED | CALCULATED-DESIGNED BY | CHECKED BY | CONSULTANT FUNCTIONAL SUPERVISOR

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION Caltrans

DATE PLOTTED => $DATE
TIME PLOTTED => $TIME
LAST REVISION 00-00-00

BORDER LAST REVISED 7/2/2010 | USERNAME => $USER DGN FILE => $REQUEST | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | UNIT 0000 | PROJECT NUMBER & PHASE 00000000001

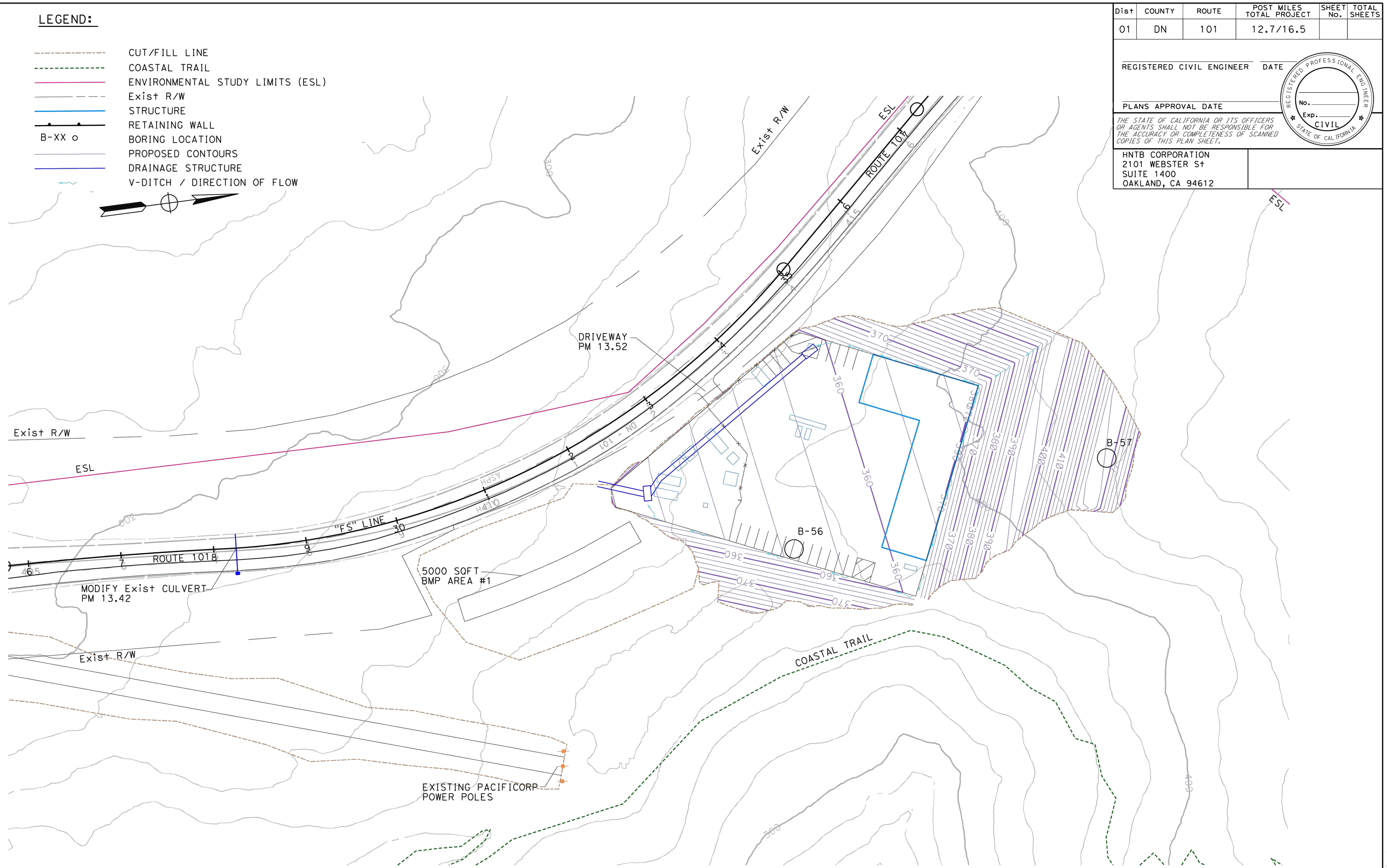
PLOTTED: 15 Nov 2023, 8:59pm, DFahmey
CAD FILE: C:\Users\DFahmey\Downloads\20208000\ LAYOUT: 1c

REFERENCE:
"STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION, PROJECT PLANS FOR CONSTRUCTION ON STATE HIGHWAY IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD, GEOMETRIC APPROVAL DRAWINGS," CONTRACT NO. EA 01-0F280, PROJECT ID 0115000099, DATED 10/26/2023.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT
STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL
NOVEMBER 2023

GEOMETRIC APPROVAL DRAWINGS
Sheet PS-1

PLATE **1c**



Dist	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
01	DN	101	12.7/16.5		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF SCANNED COPIES OF THIS PLAN SHEET.

REGISTERED PROFESSIONAL ENGINEER No. Exp. CIVIL STATE OF CALIFORNIA

HNTB CORPORATION
2101 WEBSTER St
SUITE 1400
OAKLAND, CA 94612

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

CONSULTANT FUNCTIONAL SUPERVISOR

CALCULATED-DESIGNED BY | CHECKED BY

REVISED BY | DATE REVISED

CONSTRUCTION DETAIL

ALTERNATIVE F

SCALE: 1" = 50'

C-1

LAST REVISION 00-00-00 | DATE PLOTTED => $DATE | TIME PLOTTED => $TIME

BORDER LAST REVISED 7/2/2010

USERNAME => $USER
DGN FILE => $REQUEST

RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3

UNIT 0000

PROJECT NUMBER & PHASE 00000000001

PLOTTED: 15 Nov 2023, 8:59pm, DFahmey

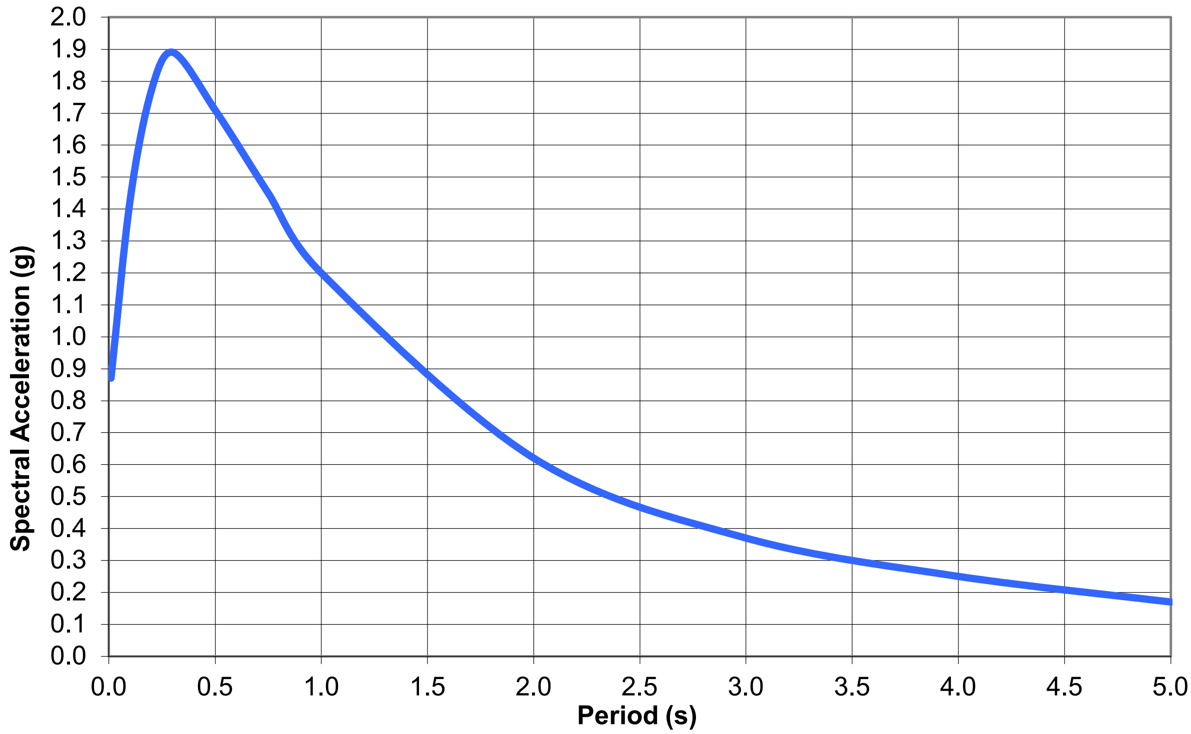
CAD FILE: C:\Users\DFahmey\Downloads\20208000\ LAYOUT: 1d

REFERENCE:
"STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION, PROJECT PLANS FOR CONSTRUCTION ON STATE HIGHWAY IN DEL NORTE COUNTY NEAR CRESCENT CITY FROM WILSON CREEK BRIDGE TO DAMNATION CREEK TRAILHEAD, GEOMETRIC APPROVAL DRAWINGS," CONTRACT NO. EA 01-0F280, PROJECT ID 0115000099, DATED 10/26/2023.

LAST CHANCE GRADE PERMANENT RESTORATION PROJECT STRUCTURE PRELIMINARY GEOTECHNICAL REPORT - FINAL NOVEMBER 2023	**GEOMETRIC APPROVAL DRAWINGS** **Sheet C-1**	PLATE **1d**

APPENDICES

APPENDIX A Preliminary Design Acceleration Response Spectra



Preliminary ARS Curve (5% Damping)

Caltrans ARS (V3.0.2) (Vs30 = 305m/s = 1,001ft/s)

Return Period = 975 Years

Latitude: 41.6160 Longitude:-124.1070

Peak Ground Acceleration (PGA) = 0.870g

Mean earthquake moment magnitude (M) for PGA = 8.64

Mean Site-to-Source Distance (R) for S1 = 20.0km = 12.4ml

Spectral Coordinates:

Period (sec)	**Acc.** (g)
0.01	0.870
0.10	1.430
0.20	1.770
0.30	1.890
0.50	1.710
0.75	1.450
1.00	1.200
2.00	0.620
3.00	0.370
4.00	0.250
5.00	0.170

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project Number : 20-103 | Date: Nov, 2023

Last Chance Grade Permanent Restoration Project
Alternative F Tunnel Operations and Maintenance Center

Preliminary ARS Curve

Figure --