Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services
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October 24, 2017
CAInc File No. 16-337.4

Mr. Howard Dashiell, PE
Mendocino County Department of Transportation
340 Lake Mendocino Drive
Ukiah, CA 95482

Subject: **Geotechnical Memorandum**
Mountain View Road (CR 510) Failure at MP 16.62
Mendocino County, California

Dear Mr. Dashiell,

Crawford & Associates, Inc. (CAInc) prepared this Geotechnical Memorandum for the Mountain View Road Failure at Milepost (MP) 16.62 in accordance with Project Work Order No. 4 under Mendocino County Board of Supervisors (BOS) Agreement 16-099 and Mendocino County Department of Transportation (MCDOT) Agreement 16-0048, made on December 06, 2016. This memo provides repair alternatives and recommendations for permanent road repair with a soldier pile tieback wall.

Please contact us if you have questions or require additional information.

Sincerely,

Crawford & Associates, Inc.,

Ryan Houghton

Ryan Houghton, PE
Project Engineer

Reviewed By,

Rick Sowers

Rick Sowers, PE, CEG
Principal

RYAN R. HOUGHTON
C 87322

RICHARD D. SOWERS
C38788

RICHARD D. SOWERS
No. 1104

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1 INTRODUCTION

This Geotechnical Memorandum summarizes the results of our geotechnical investigation completed at the Mountain View Road (CR 510) Failure at MP 16.62. This work was completed in accordance with Work Order No. 4 agreement with Mendocino County Department of Transportation (MCDOT) and summarizes the site earth materials and their properties, evaluates alternative repair options, and provides recommendations for permanent repair with a soldier pile tieback wall.

2 GEOTECHNICAL SERVICES

To prepare this report, Crawford & Associates (CAInc):

- Discussed the project with MCDOT.
- Reviewed published topographic, geologic, and seismic mapping of the site.
- Reviewed SHN Engineers and Geologist survey data, received via electronic transfer from MCDOT on June 23, 2017.
- Performed surface geologic reconnaissance of the site and immediate vicinity.
- Drilled and sampled three roadway-level test borings on June 26-27, 2017 and August 22, 2017.
- Performed laboratory testing and geotechnical engineering analysis in support of the recommendations contained herein.

3 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The project is located on Mountain View Road (CR 510) at MP 16.62, approximately 8 miles southwest of Boonville, off of SR 128. Site latitude is approximately 38.979038° and longitude -123.474531°, per Google Earth. See Figure 1 for Vicinity Map.

3.2 SITE DESCRIPTION

Mountain View Road at this location traverses a steep (generally 1.5H:1V), southeast-facing slope, approximately 200 feet above the headwaters of Minnie Creek. The road is aligned roughly east-west at the failure site, with sharp turns (nearly 90 degree) on either side.

The road is a paved, two-lane section approximately 20 feet wide and established in a combination cut/fill section. Inboard cuts are approximately 10-15 feet high with slopes of 1:1. The fill is estimated to be approximately 6-8 feet deep along the outboard side of the road, with slopes directly below the road being approximately 1.2:1 to 1.9:1 (H:V). The approximate site elevation is 1880 feet per USGS topographic mapping; a topographic survey completed by SHN Consulting Engineers & Geologist, Inc.[1] used a vertical datum (based on NAVD88) established via GPS observations from a previous survey completed at MP 15.80. Three control points were established in the vicinity of the project, with the closest one to the site being CP#5, with an elevation of 1999.74 feet. Based on the project datum, the site elevations ranges between 2020 and 2004 feet.

The subject road failure is approximately 100 feet in length and involved a 2-3 foot "slump" of the outboard (eastbound) lane. Additionally, a portion (approximately 40-50 feet) of the inboard (westbound) lane at the east end of the failure, slumped about 1-2 feet. No definitive headscarp was

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[1] CAD drawings of Topographic Survey completed by SHN received electronically on 06/23/2017

developed due to this failure. Surface cracks were evident within the slumped road surface as well as running down slope along the eastern side of the failure. No surface cracks were evident upslope. An underground fiber optic cable, which runs down the center of the inboard lane, was not disrupted by the failure, based on conversation with the Level3 USA marker. A photo of the failure is included within the attached Figure 2.

The road gradient, based on the topography survey from SHN, ascends 7.5% to 14.3% east to west. Hillside runoff and surface runoff is collected along a small, unlined ditch that flows west to east. Areas of the ditch were almost complete filled with debris, providing very little capacity to convey storm water. There were no culverts within the site vicinity.

The County filled in a portion of the slumped area after our initial site visit to allow for safe passage of vehicles through the site. During that work, part of the cut-slope (on the east end) was carved back, exposing weathered rock. Additionally, weathered rock was evident at the west end within the existing cut-slope.

See Figure 1 for the regional topography in the vicinity of the site and Figure 2 for local site topography and location of the borings.

4 GEOLOGIC SETTING

4.1 REGIONAL GEOLOGY

The project site lies within the Coast Ranges Geomorphic Province, characterized by a series of northwest trending mountain ranges sub-parallel to the San Andreas Fault. The Coast Ranges is composed of thick Mesozoic and Cenozoic sedimentary strata. The northern Coast Ranges are dominated by the irregular, knobby, landslide-topography of the Franciscan Complex. Regional geologic mapping[2] shows the site as being underlain by Cretaceous-Tertiary age Coastal Belt Franciscan (TKf) rock, which consist of marine sandstone, shale, and conglomerate.

See Figure 3 for a Regional Geologic Map.

4.2 SITE GEOLOGY AND LANDSLIDE MAPPING

No published local geologic mapping or landslide mapping was available for this site. The inboard cut exposes fractured sandstone consistent with Franciscan formation rock. There was no observed evidence of past landslides in the site vicinity; however, the slopes below the site (extending to Minnie Creek) are irregular and subject to sliding.

4.3 FAULTS AND SEISMIC ACTIVITY

Based on California Geologic Survey (CGS) fault data[3], the nearest faults to the site are unnamed Pre-Quaternary faults (no activity in last 1.6 million years) located approximately 2.0 miles southwest of the site. The nearest active fault (defined as surface displacement within the last 11,000 years) is a part of the north coast section of the San Andreas Fault Zone, located approximately 8.7 miles southwest of the

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[2] Wagner, D.L. and Bortugno, E.J. (1982), Geologic Map of Santa Rosa Quadrangle, Regional Map Series, Map No. 2A, California Division of Mines and Geology, Scale 1:250,000

[3] California Geologic Survey, 2010 Fault Activity Map of California, GIS data

site. The site is located in an area with risks of strong seismic ground motions, having a probabilistic seismic hazard peak ground acceleration (PGA) of approximately 0.54g[4].

See Figure 4 for Fault Activity Map.

5 SUBSURFACE CONDITIONS

5.1 EXPLORATION

CAInc retained Taber Drilling to drill and sample two roadway-level test borings (B1 – B2) on either side of the failure area to a maximum depth of 40 feet below the ground surface (bgs), and minimum elevation of 1977 feet. Subsequently, Geo-Ex Subsurface Exploration was retained to drill and sample one boring (B3) through the center of the failure area to a depth of 51.5 feet bgs (elevation 1957.8 feet.) Drilling was conducted from 06/27/17 to 06/28/17 with Taber and 8/22/17 with Geo-Ex. See Figure 2 for the Exploration Location Map.

Taber used a Diedrich D-120 high-torque truck-mounted drill rig to complete the test borings using 8” hollow-stem auger and 4” solid-stem auger drilling equipment. Geo-Ex used a CME-45 track-mounted drill rig (due to access constraints) to complete the test boring within the failure area, using 4” solid-stem auger and 3.8” rotary wash drilling equipment. Auger refusal was reached in the rock unit of B1, B2, and B3 at approximate depths of 40 feet, 29 feet, and 20 feet bgs respectively. Drilling was noted as becoming “hard” (typically characterized as near maximum drill rig effort and audible drill chatter/screeching) within B1, B2, and B3 at 28 feet, 9 feet, and 18 feet bgs respectively.

Soil/weathered rock samples were recovered by means of a 2.0-inch O.D. “Standard Penetration” split-spoon sampler with 1.4-inch stainless steel liners and a 3.0-inch O.D. “Modified California” split-spoon sampler with 2.4-inch stainless steel liners. Both samplers were advanced with standard 350 ft-lbs striking force using a 140 lbs. automatic hammer and a drop height of 30 inches. An energy hammer analysis was not performed specific to this project/site for either drill rig. Based on the most recent calibration tests provided by the drillers, Taber’s drill rig has a hammer efficiency of 91% (test preformed 5/29/2017) and Geo-Ex’s drill rig has a hammer efficiency of 75% (test performed 10/16/15.) Sampler penetration resistance was recorded to provide a field measure of relative densities and can be correlated to soils strength and bearing characteristics. The field-recorded (uncorrected) blow counts are shown on the boring logs provided in Appendix A.

CAInc logged all the test borings consistent with the Unified Soil Classification System (USCS) and the Caltrans 2010 Logging Manual. Selected portions of recovered soil drive samples were retained in sealed containers for laboratory testing and reference. Groundwater observations were recorded during drilling operations when encountered and drilling method allowed. At completion, the borings were cement grout backfilled per Mendocino County Environmental Health Division requirements.

5.2 SOIL DESCRIPTION

Based on the test boring data, we divide the subsurface soils into three general material units, as described in Table 1 below. Refer to the boring logs in Appendix A for more specific soil/rock descriptions, boring details and elevations.

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[4] USGS Unified Hazard Tool (2014 data), assuming Site Class C and a return period of 975 years (5% in 50 years)

Table 1: Subsurface Soils

Unit	Location	Depth Range (bgs, ft)	Soil Description
1	B1/B2 B3	0.0 to 6.5 0.0 to 8.0	**Fill and/or Native Residual Soil** – loose to medium dense, brown clayey sand with gravel and clayey gravel with sand. Pocket Penetrometer[1] (PP) tests on samples ranges from 2.5 to +4.5 tsf, field SPT Blow Counts[2] (N) ranges from 10-25 blows per foot (bpf).
2	B1/B3	6.5-8.0 to 18.0	**"Weak" Weathered Rock** – decomposed, very soft, light brown to dark brown greywacke sandstone. PP tests on samples ranges from 3.0 to +4.5 tsf, field SPT Blow Counts (N) ranges from 5-24 blows per foot (bpf).
3	B2 B1/B3	6.5 to 29.0 18.0 to 51.5	**"Intact" Weathered Rock** – very intensely to intensely weathered, very intensely fractured greywacke sandstone. Moderately to slightly weathered rock at bottom of B1 and B2. Shale encountered at 35 feet in B3. Rock color predominately brown to gray. PP tests on samples all +4.5 tsf with SPT Blow Counts >50 bpf (typically reaching blow count refusal[2].)

Note: 1. Pocket Penetrometer (PP) is a field measure for approximating the unconfined compressive strength of soil.
2. Field SPT Blow Counts (N) is a measure of Standard Penetration Test blows per foot. Refusal defined as 50 blows in less than 6".

5.3 GROUNDWATER

Free groundwater was encountered within the test boring B1 at 32 feet bgs. Groundwater was not encountered within B2 or within the augered portion of B3 (upper 20 feet.) Water within B1 likely represents perched or isolated groundwater overlying the intact rock. No evidence of springs was observed upslope or downslope of site; there is a heavy tree and brush cover in the site vicinity, but no "marshy" vegetated areas. We noted some areas of wet ground during our initial site review on May 9, 2017, but these areas were essentially dry during our field investigations in June and August, 2017.

We interpret groundwater within the rock unit to be variable and controlled by the degree of weathering and fracturing and may locally yield water, which we expect can be controlled by pumping. Groundwater levels in general will fluctuate due to changes in precipitation, seasonal fluctuations, and other factors.

6 LABORATORY TESTING

CAInc completed the following laboratory tests on representative soil samples obtained from the test borings:

- Moisture Content/Unit Weight (ASTM D2216/2937)
- Particle Size Analysis (ASTM D422)
- Plasticity Index (ASTM D4318)
- Unconfined Compression (ASTM D2166)
- Sulfate/Chloride Content (CTM 417/422)
- pH/Minimum Resistivity (CTM 643)

Table 2 below summarizes the material properties determined from lab testing of the underlying soil/rock units.

Table 2: Material Properties

Material Unit	In-Situ Densities (Total - pcf)	Moisture Content (%)
1	104.0 – 120.0 (Avg. = 111.2)	3.8 – 9.4 (Avg. = 6.2)
2	95.7 – 133.6 (Avg. = 116.8)	5.3 – 17.3 (Avg. = 8.8)
3	98.9 – 151.2 (Avg. = 123.6)	5.5 – 10.2 (Avg. = 7.4)

Three unconfined compression test were completed on samples of weathered rock and resulted in a range of 1037 psf to 4637 psf. We consider the lower range results to be influenced by fractures within the rock samples and not necessarily representative of the actual in-situ material strength. Pocket penetrometer tests were consistently greater than 4.50 tsf on samples of weathered rock (tested within confinement of the steel sample liners.) Neglecting the lower result (sample containing significant amounts of fractured rock) results in average unconfined compression strength of 3,960 psf.

A chemical analysis was completed on one sample for corrosion potential. See Table 3 below for summary of test results.

Table 3: Soil Corrosion Test Summary

Boring-Sample No.	Depth (ft)	pH	Minimum Resistivity (ohm-cm)	Chloride Content (ppm)	Sulfate Content (ppm)
B2-1	6.0	4.77	3,220	3.5	13.3

According to Caltrans Corrosion Guidelines, a site is considered to be corrosive to foundation elements (concrete/steel) if one or more of the following conditions exist: Chloride concentration is greater than or equal to 500 ppm, sulfate concentration is greater than or equal to 2000 ppm, minimal resistivity of 1000 ohm-cm or less, or the pH is 5.5 or less. Based on the test results above and Caltrans guidelines, site soils are considered **potential corrosive** to concrete/steel foundation elements due to low pH. These tests are only an indicator of soil corrosivity and the designer should consult with a corrosion engineer if these values are considered significant.

See Appendix B for a complete summary of Laboratory Testing Results.

7 CONCLUSIONS

The road failure occurred primarily within fill material, residual soil, and/or weak rock. We conclude the primary causes of slope failure to be the inherent weakness of the fill/residual soil and the high degree of saturation from seasonal storm water infiltration during this past very wet winter. Without remedial work, expect additional slope movement during future wet seasons, with possible progression both head-ward and laterally.

In analyzing potential repair options, we considered a Tieback Soldier Pile wall; a Mechanically Stabilized Earth (MSE) wall; a Reinforced Fill Slope; and RSP Fill Slope for permanent repair. The following summarizes the key elements of each option:

1. **Soldier Pile Tieback Wall:**
    - Drill vertical soldier piles and anchor piles into the “intact” weathered rock unit.
    - Install tiebacks from soldier piles to anchor piles for control of lateral stresses.
    - Construct lagging and/or facing elements to support backfill.
    - Install sub-drainage behind the wall for control of hydrostatic forces.
    - Install trenched under-drain along inboard side of road to intercept shallow subsurface water.
    - Control surface runoff to direct water away from the slide area, such as with an AC dike.
    - Reconstruct pavement section.

2. **Mechanically Stabilized Earth (MSE) Wall:**
    - Excavate and remove disturbed slide materials within the wall area.
    - Establish base of wall into the “intact” weathered rock unit, as verified by CAInc.
    - Construct the wall and new embankment using new cut from the excavation.
    - Install sub-drainage behind the wall, with gravity relief.
    - Install trenched under-drain along inboard side of road to intercept shallow subsurface water.
    - Control surface runoff to direct water away from the slide area, such as with an AC dike.
    - Reconstruct pavement section.

3. **Reinforced Fill Slope:**
    - Excavate and remove disturbed slide materials.
    - Place compacted fill with reinforcing fabric or geo-grid at 1 foot intervals.
    - Construct exterior slope of 1.5:1.
    - Install trenched under-drain along inboard side of road to intercept shallow subsurface water.
    - Trim ground surface outside of reinforced section to drain.
    - Control surface runoff to direct water away from the slide area, such as with an AC dike.
    - Reconstruct pavement section.

4. **RSP (Rock Slope Protection) Fill Slope:**
    - Excavate a minimum 8-foot wide key at the base of the slope, with minimum 2 feet embedment into the “intact” weathered rock unit and temporary back-slope about 0.75:1.
    - Place rock slope protection (e.g. 1-ton rock) with filter fabric backing and a 1:1 finished slope.
    - Provide toe drain with gravity outlet.
    - Control surface runoff to direct water away from the slide area, such as with an AC dike.
    - Reconstruction pavement section.

We consider other options less appropriate for this site. The existing slopes are too steep for a typical 2:1 (H:V) reconstructed embankment section. Rigid wall systems, such as reinforced concrete cantilever wall, are not recommended due to height requirements and limited tolerance for movement. Significant road realignment and/or significant grade changes are not viable due to the existing curvature and high cuts already present at the site.

8 RECOMMENDATIONS

We recommend the Soldier Pile Tieback wall as the preferred repair option. This option will achieve secure support within the “intact” weathered rock unit and provide lateral resistance to active pressures. Additionally, this option will limit the environmental impact downslope of the failure. See Figure 5 for typical section of a tieback wall.

The MSE wall and RSP Fill options would be at least 15-20 feet high in order to fully engage the stable Unit 2 rock, thus require significant excavations likely extending beyond the County Right-of-Way, as well as having a greater environmental impact within the project vicinity. Construction may also require a road closure, which is not feasible since Mountain View Road is a major collector.

A Reinforced Fill Slope is potentially feasible, but would require significant excavation as well to engage "intact" rock. This option may also be vulnerable to future slides downslope translating up and impacting repair. Finally, it would impact the downslope area more than the soldier pile tieback wall option in regard to right-of-way acquisition and environment. A significant number of trees would need to be cleared to construct the slope.

The following summarizes our recommended active and passive Equivalent Fluid Pressures (EFP) for design of the soldier pile tieback wall. Include traffic loading in determination of design wall pressures.

- An active EFP of 40 pcf/ft for imported structural backfill meeting Caltrans 2015 Specifications[5]
- An active EFP of 50 pcf/ft for native backfill materials
- A passive EFP of 500 pcf/ft for the weathered rock unit

The passive resistance of the piles embedded into weathered rock can be applied to an effective pile width of 3x the pile diameter, provided that the pile spacing is greater than the effective pile width.

We consider cast-in-drilled-hole (CIDH) piles with a minimum diameter of 24 inches appropriate for this project. For design, consider the piles essentially "fixed" at 3 feet below the rock line. Provide additional lateral capacity by installing an H-pile "core", or other reinforcement, within the pile excavations. Place concrete in clean, dry excavations, as soon as possible after completion of drilling. We expect that groundwater seepage into the pile excavations can be controllable by pumping, if necessary, for dry-season construction (e.g., late summer to early fall).

Retain the backfill between the soldier piles with wood lagging and/or concrete facing placed between the H-pile flanges. Provide wall drainage by means of either (1) a permeable material section (e.g., Class-2 Permeable Material per Caltrans Section 68), wrapped in filter fabric, (2) permeable backfill (e.g., clean drain rock) with filter fabric backing, or (3) prefabricated drainage panel attached behind the wall. Provide a perforated gravity drainpipe located behind the bottom of the wall.

We recommend the soldier piles achieve a minimum 20 feet of embedment below the pile fixity point and into the "intact" weathered rock unit. The wall length should extend a minimum of 10 feet beyond the extents of the slide limits. For a wall positioned as shown in Figures 2 and 5, the estimated rock surface near the center of the slide is elevation 1991 feet (per project datum), corresponding to a minimum pile tip elevation of 1968 feet (approximate pile length of 44 feet based on road section shown in attached Figure 5.) Minimum pile tip elevation assumes 3 feet from estimated rock line to pile fixity point and 20 feet of rock embedment. The "intact" rock unit is estimated to be 2003 feet at the western end of the failure and 1999 feet at the eastern end, corresponding to tip elevations of 1980 feet and 1976 feet, respectively. The pile tip elevations can vary linearly at intermediary locations along the wall line (i.e., from elev. 1980 feet at the west end to elev. 1968 feet at the center, then from elev. 1968 feet to elev. 1976 feet at the east end).

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[5] Material assumed to be fully drained with unit weight of 120 pcf and friction angle of 34 deg. per Caltrans

Resist lateral wall forces with horizontal tieback rods connected to CIDH anchor piles drilled along the inboard side of the road. Embed the anchor piles a minimum of 15 feet below the pile fixity point into the "intact" weathered rock unit. The estimated rock surface below the inboard lane of the road at the center of the slide is elevation 1998.5 feet, corresponding to a minimum pile tip elevation of 1980.5 feet. The minimum pile tip elevations at the west and east ends of the failure are estimated as 1992.5 and 1982.5 respectively. The pile tip elevations can vary linearly at intermediary locations along the wall line.

Variations in the rock surface may be nonlinear and change abruptly; therefore, the final tip elevations should be made on the basis of specific field review by a CAInc representative.

We recommend construction of a trenched under-drain (e.g., per Caltrans "Standard Plans") along the inner road area to intercept shallow seepage. Construct the under-drain to minimum depth 5 feet below road grade and backfill with permeable material enclosed in filter fabric. Place low permeability soil (compacted structure backfill or cohesive native soil) within the uppermost 6 inches to prevent surface water from entering the under-drain. See Figure 5 for typical section of tieback wall.

9 RISK MANAGEMENT

Our experience and that of our profession clearly indicates that the risks of costly design, construction, and maintenance problems can be significantly lowered by retaining the geotechnical engineer of record to provide additional services during design and construction.

For this project, CAInc should be retained to:

- Review and provide comments on the civil plans, grading/foundation plans, and specifications prior to construction.
- Monitor construction to check and document our report assumptions. At a minimum, CAInc should monitor initial pile excavations and sub-drainage requirements.
- Update this report if design changes occur, two years or more lapses between this report and construction, and/or site conditions have changed.

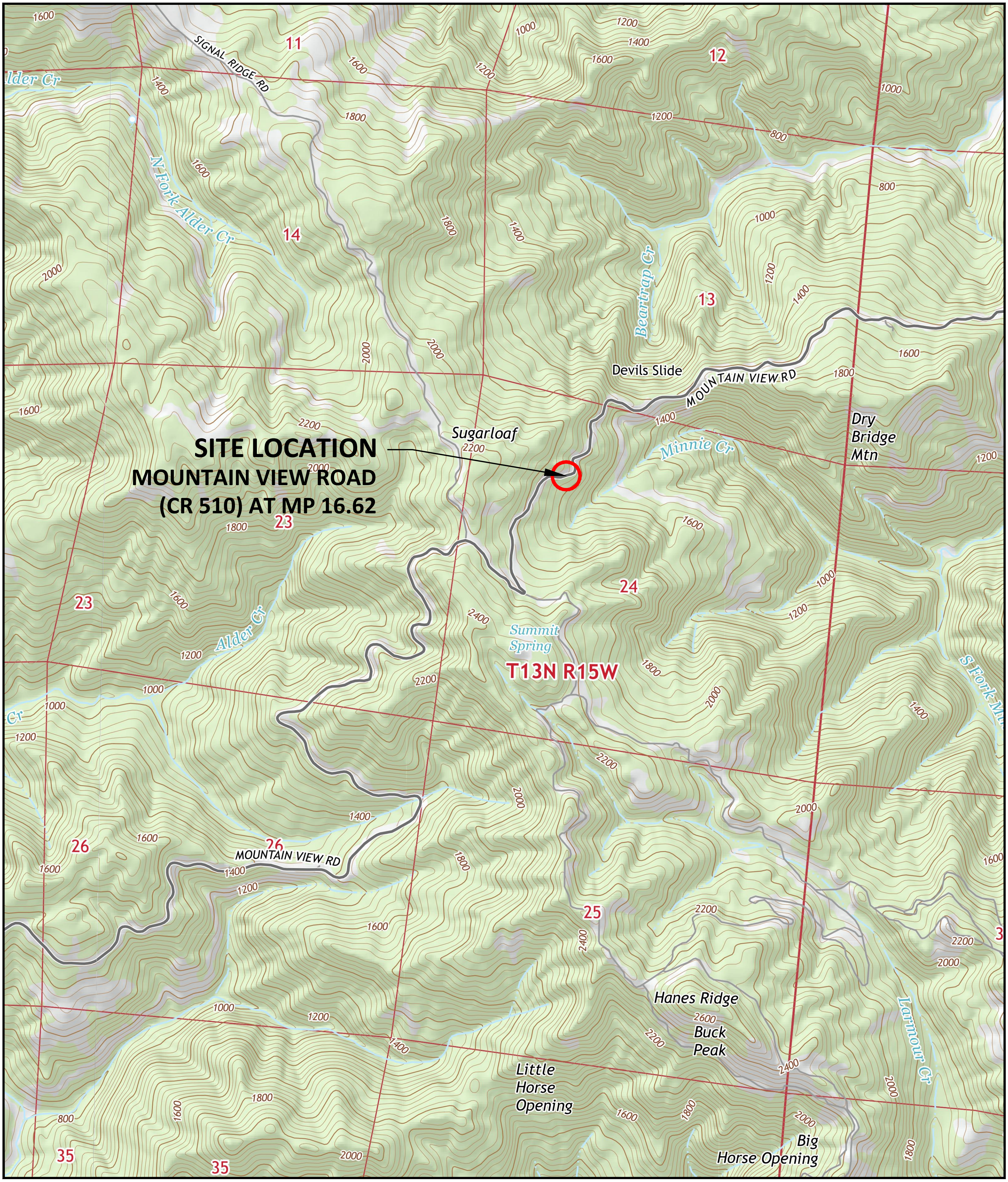
10 LIMITATIONS

CAInc performed these services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. This report is based on the current site and project conditions and should be used only for the evaluation and design of repair alternative for the Mountain View Road slope failure at MP 16.62.

It is assumed the soil/rock and groundwater conditions interpreted/encountered in the borings provided in Appendix A are representative of the subsurface conditions at the site. Actual conditions between explorations could be different. The interface shown between soil/rock materials on the boring logs is approximate. The transition between materials may be abrupt or gradual. Recommendations are based on the final logs, which represent our interpretation of the field logs and general knowledge of the site and geological conditions.

Modern design and construction is complex and it is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

FIGURES



NORTH

Map Sources:

1. USGS 7.5' Topographic Maps 2015, Zeni Ridge, Mendocino County, California, Scale 1:24000

2. USGS 7.5' Topographic Maps 2015, Eureka Hill, Mendocino County, California, Scale 1:24000

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GEOTECHNICAL INVESTIGATION
MOUNTAIN VIEW ROAD (CR 510)
FAILURE AT MP 16.62

MENDOCINO COUNTY, CA

Figure 1
Vicinity Map

Proj. No: 16-337.4
Scale: 1"= 2,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16–337.X Mendocino 2016 Quadrennial Support Project\16–337.4 Mountain View Road (CR 510) at MP 16.62\CAD\16–337.4–Mountain View Road at MP 16.62.dwg Plot Date: May 25, 2017 at 3:56pm

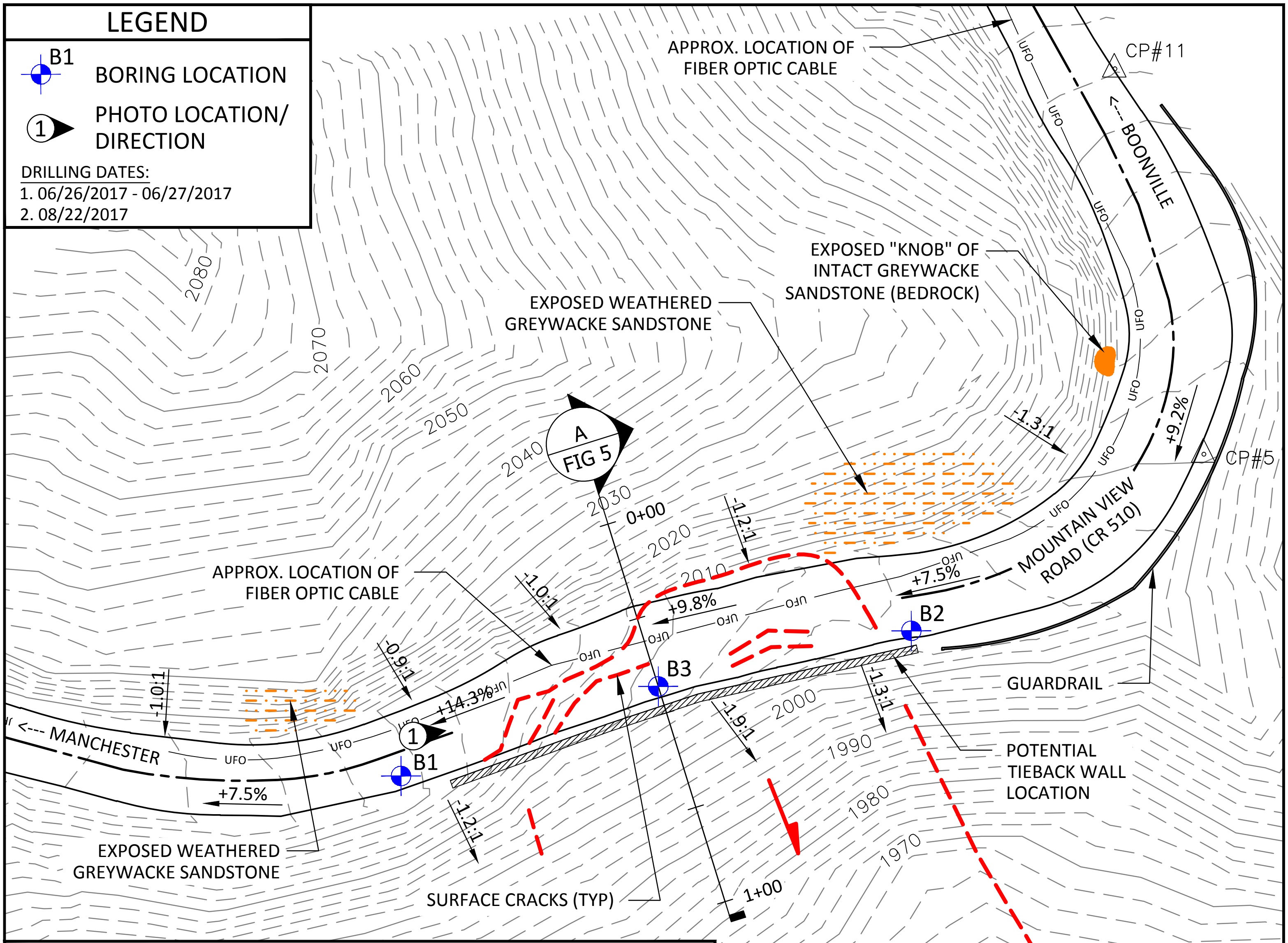

Photo 1 - Road Failure, Looking East

NORTH

Map Source:
Topographic Base Map provided by MCDOT via electronic transfer on 06/23/17. Survey was performed by SHN Engineers and Geologist, Inc.

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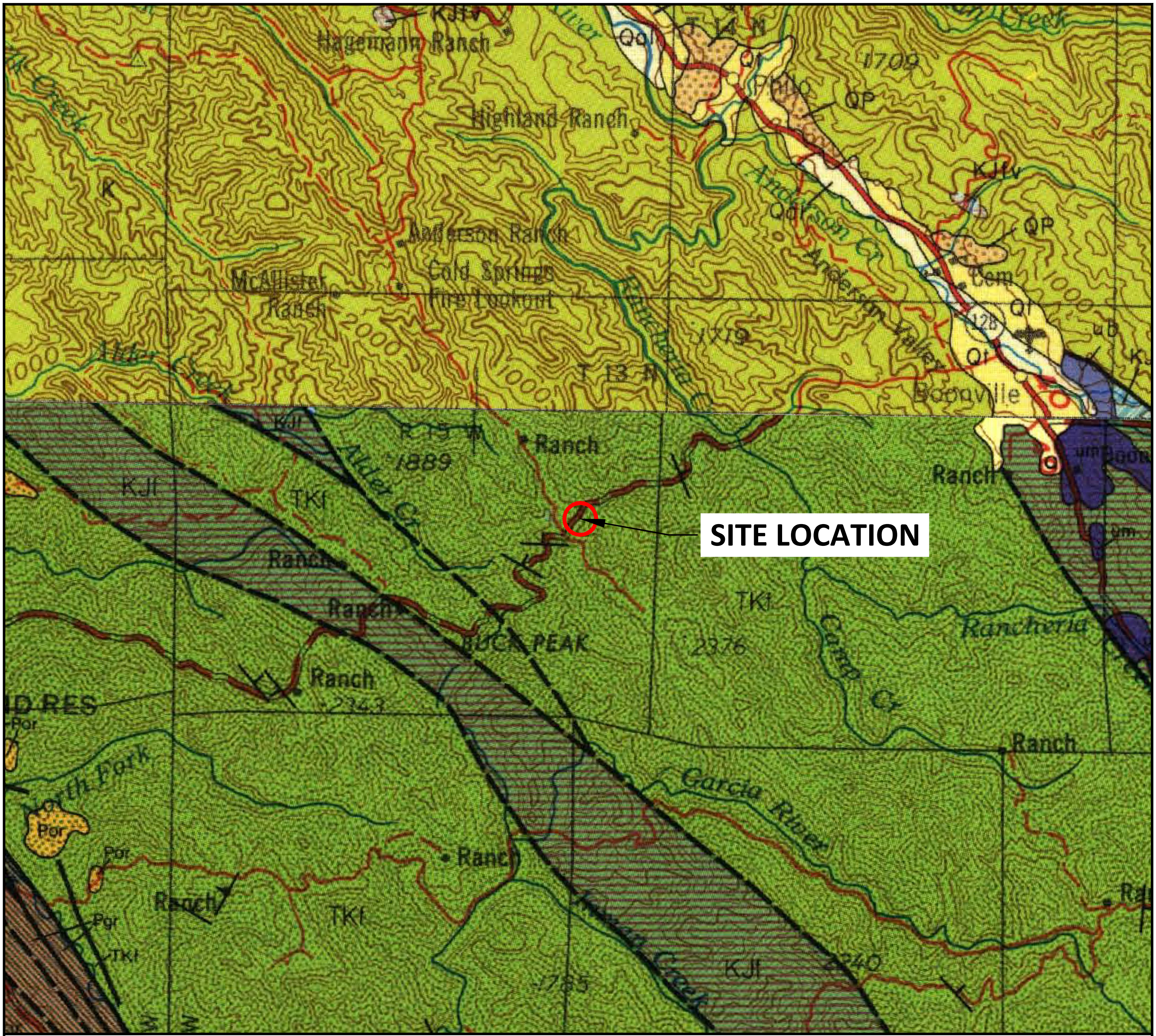
GEOTECHNICAL INVESTIGATION
MOUNTAIN VIEW ROAD (CR 510)
FAILURE AT MP 16.62

MENDOCINO COUNTY, CA

Figure 2
Exploration Location Map

Proj. No:	16-337.4
Scale:	1" = 40'
Date:	05/26/2017

Path: \\psf\Home\Box\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.4 Mountain View Road (CR 510) at MP 16.62\CAD\16-337.4-Mountain View Road at MP 16.62.dwg Plot Date: Oct 20, 2017 at 5:14pm



LEGEND

Geologic Formations

Ukiah Sheet:

K	**Undivided Marine Sedimentary Rocks (Cretaceous)** - *sandstone, shale, and conglomerate*

Santa Rosa Sheet:

TKl	**Coastal Belt Franciscan (Cretaceous-Tertiary)** - *marine sandstone, shale, and conglomerate*
KJf	**Franciscan Complex (Jurassic-Cretaceous)** - *sandstone, shale, conglomerate, chert, greenstone, metagraywacke; horizontal pattern denotes melange terran*

CONTACT
(Dashed where approximately located, gradational or inferred)

FAULT
(Dashed where approximately located)

NORTH

Map Sources:
1. Wagner, D.L. and Bortugno, E.J., 1982, Geologic Map of the Santa Rosa Quadrangle, Regional Map Series, Map No. 2A, California Division of Mines and Geology, Scale 1:250,000
2. Jennings, C.W. and Strand, R.G., 1960, Geologic Map of California, Ukiah Sheet, California Division of Mines and Geology, Scale 1:250,000

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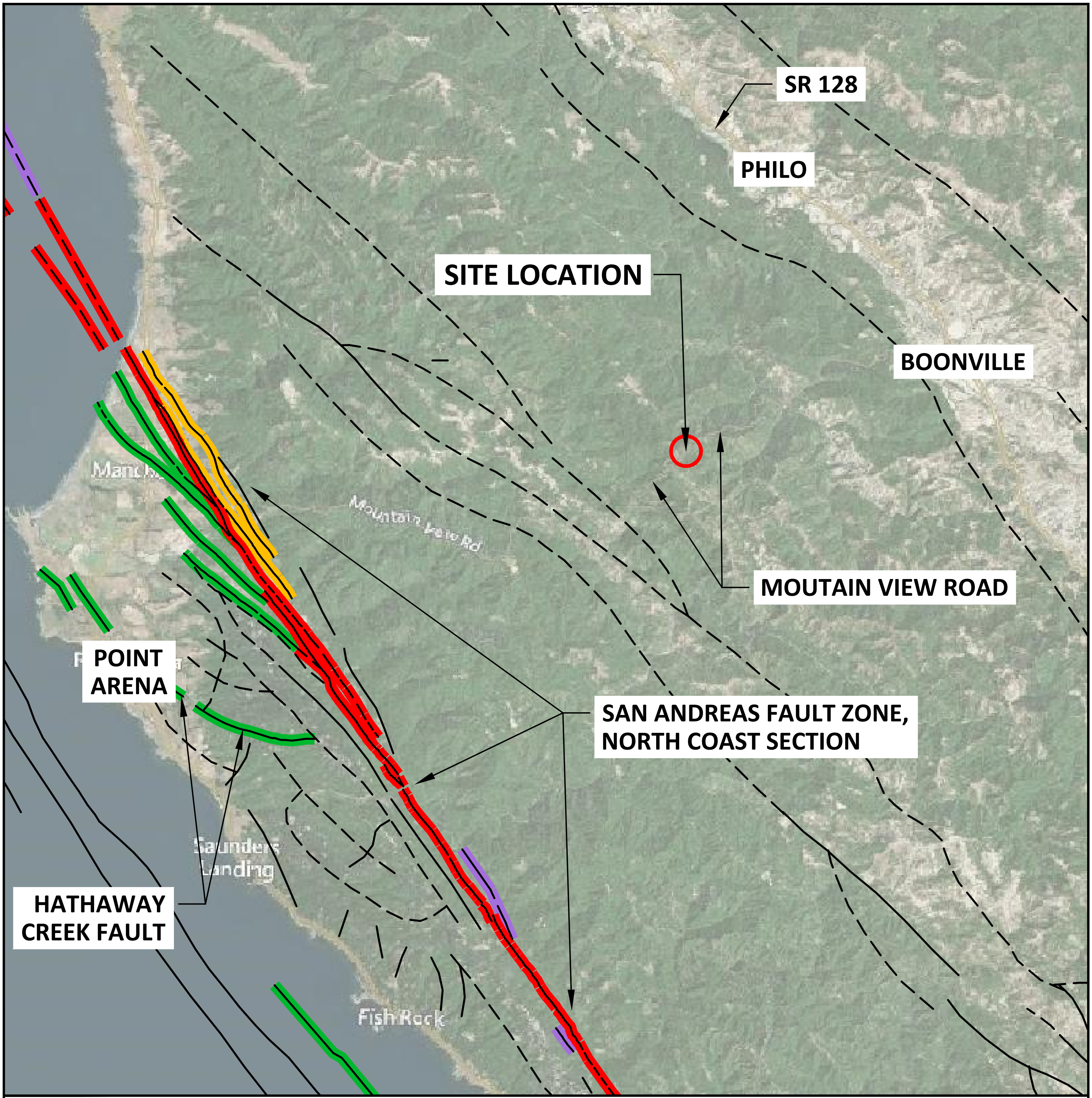
GEOTECHNICAL INVESTIGATION
MOUNTAIN VIEW ROAD (CR 510)
FAILURE AT MP 16.62

MENDOCINO COUNTY, CA

Figure 3
Regional Geologic Map

Proj. No: 16-337.4
Scale: 1" = 10,000'
Date: 05/26/2017

Path: \\psf\Home\Box Sync\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.4 Mountain View Road (CR 510) at MP 16.62\CAD\16-337.4-Mountain View Road at MP 16.62.dwg Plot Date: May 25, 2017 at 6:04pm



LEGEND

CGS Faults (Last Activity Age)

- 🟥 <200 years (Historic)
- 🟧 <11,700 years (Holocene)
- 🟩 <700,000 years (Late Quaternary)

CGS Faults (Last Activity Age)

- 🟪 <1.6 million years (Quaternary)
- ——— >1.6 million years (Pre-Quaternary)

Fault Location

- ——— Certain
- — — — Approx. or Inferred
- - - - - - Concealed

NORTH

Map Sources:

1. Base map via AutoCAD Civil 3D geolocation tool

2. Fault data via CGS Fault Activity Map of California 2010 GIS data

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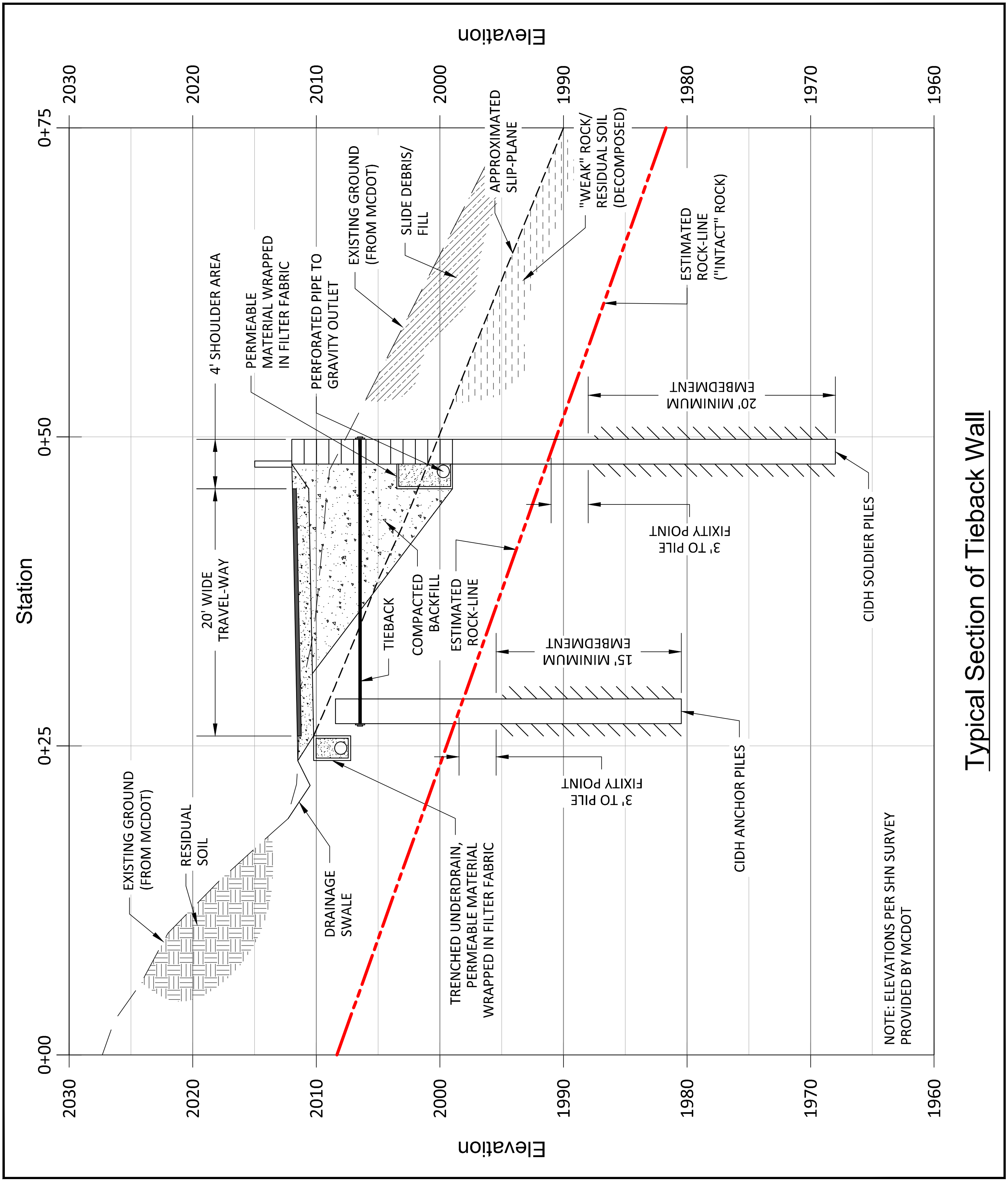
GEOTECHNICAL INVESTIGATION
MOUNTAIN VIEW ROAD (CR 510)
FAILURE AT MP 16.62

MENDOCINO COUNTY, CA

Figure 4
Fault Activity Map

Proj. No: 16-337.4
Scale: 1" = 15,000'
Date: 05/26/2017



Typical Section of Tieback Wall

NORTH

Data Source:
Topographic Base Map provided by MCDOT via electronic transfer on 06/23/17. Survey was performed by SHN Engineers and Geologist, Inc.

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GEOTECHNICAL INVESTIGATION
MOUNTAIN VIEW ROAD (CR 510)
FAILURE AT MP 16.62

MENDOCINO COUNTY, CA

Figure 5
Typical Section of Tieback Wall

Proj. No: 16-337.4
Scale: 1" = 10'
Date: 05/26/2017

Path: \\psf\Home\Box\Projects\16-337.X Mendocino 2016 Quadrennial Support Project\16-337.4 Mountain View Road (CR 510) at MP 16.62\CAD\16-337.4-Mountain View Road at MP 16.62.dwg Plot Date: Oct 20, 2017 at 5:17pm

APPENDIX A

BORING LOG LEGEND
BORING LOGS

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names	Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435)
CL	Collapse Potential (ASTM D 4546)
CP	Compaction Curve (CTM 216)
CR	Corrosion, Sulfates, Chlorides (CTM 643, CTM 417, CTM 422)
CU	Consolidated Undrained Triaxial (ASTM D 4767)
DR	Drained Residual Shear Strength (ASTM D 6467)
DS	Direct Shear (ASTM D 3080)
EI	Expansion Index (ASTM D 4829)
M	Moisture Content (ASTM D 2216)
OC	Organic Content (ASTM D 2974)
P	Permeability (CTM 220)
PA	Particle Size Analysis (ASTM D 422)
PI	Liquid Limit, Plastic Limit, Plasticity Index (AASHTO T 89, AASHTO T 90)
PL	Point Load Index (ASTM D 5731)
PM	Pressure Meter
R	R-Value (CTM 301)
SE	Sand Equivalent (CTM 217)
SG	Specific Gravity (AASHTO T 100)
SW	Swell Potential (ASTM D 4546)
UC	Unconfined Compression - Soil (ASTM D 2166) Unconfined Compression - Rock (ASTM D 7012-C)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850)
UW	Unit Weight (ASTM D 7263)

SAMPLER GRAPHIC SYMBOLS

- ☒ Standard Penetration Test (SPT)
- ⧗ Standard California Sampler (ID 2.5 in.)
- ⧗ Modified California Sampler (ID 2.0 in.)
- ▯ Shelby Tube
- ▯ Piston Sampler
- ▯ NX Rock Core
- ▯ HQ Rock Core
- ▩ Bulk Sample
- ◩ Other (see remarks)

DRILLING METHOD SYMBOLS

- ▯ Auger Drilling
- ▯ Rotary Drilling
- ☒ Dynamic Cone or Hand Driven
- ☒ Diamond Core

WATER LEVEL SYMBOLS

- ▽ First Water Level Reading (during drilling)
- ▼ Static Water Level Reading (short-term)
- ▼ Static Water Level Reading (long-term)

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010) with Errata Sheet (2015).

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Boring Record Legend

Soil Legend

Sheet 1 of 2

CONSISTENCY OF COHESIVE SOILS

Descriptor	Unconfined Compressive Strength (tsf)	Pocket Penetrometer (tsf)	Torvane (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 - 0.50	0.25 - 0.50	0.12 - 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 - 1.0	0.50 - 1.0	0.25 - 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1.0 - 2.0	1.0 - 2.0	0.50 - 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2.0 - 4.0	2.0 - 4.0	1.0 - 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

APPARENT DENSITY OF COHESIONLESS SOILS

Descriptor	SPT N_{60} (blows / 12 inches)
Very Loose	0 - 5
Loose	5 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

MOISTURE

Descriptor	Criteria
Dry	No discernable moisture
Moist	Moisture present, but no free water
Wet	Visible free water

PERCENT OR PROPORTION OF SOILS

Descriptor	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

SOIL PARTICLE SIZE

Descriptor		Size
Boulder		> 12 inches
Cobble		3 to 12 inches
Gravel	Coarse	3/4 inch to 3 inches
	Fine	No. 4 Sieve to 3/4 inch
Sand	Coarse	No. 10 Sieve to No. 4 Sieve
	Medium	No. 40 Sieve to No. 10 Sieve
	Fine	No. 200 Sieve to No. 40 Sieve
Silt and Clay		Passing No. 200 Sieve

PLASTICITY OF FINE-GRAINED SOILS

Descriptor	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll, and not much time is required to reach the plastic limit; it cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

CEMENTATION

Descriptor	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

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Boring Record Legend

Soil Legend

Sheet 2 of 2

ROCK GRAPHIC SYMBOLS

⊠	IGNEOUS ROCK
▤	SEDIMENTARY ROCK
▨	METAMORPHIC ROCK

BEDDING SPACING

Descriptor	Thickness or Spacing
Massive	> 10 ft
Very thickly bedded	3 ft - 10 ft
Thickly bedded	1 ft - 3 ft
Moderately bedded	4 in - 1 ft
Thinly bedded	1 in - 4 in
Very thinly bedded	1/4 in - 1 in
Laminated	< 1/4 in

WEATHERING DESCRIPTORS FOR INTACT ROCK

	Diagnostic Features					
	Chemical Weathering-Discoloration-Oxidation		Mechanical Weathering and Grain Boundary Conditions	Texture and Solutioning		
Descriptor	Body of Rock	Fracture Surfaces		Texture	Solutioning	General Characteristics
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No solutioning	Hammer rings when crystalline rocks are struck.
Slightly Weathered	Discoloration or oxidation is limited to surface of, or short distance from, fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted	Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe-Mg minerals are "rusty"; feldspar crystals are "cloudy"	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation (refer to grain boundary conditions)	All fracture surfaces are discolored or oxidized; surfaces are friable	Partial separation, rock is friable; in semi-arid conditions, granitics are disaggregated	Altered by chemical disintegration such as via hydration or argillation	Leaching of soluble minerals may be complete	Dull sound when struck with hammer; usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures or veinlets. Rock is significantly weakened.
Decomposed	Discolored of oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil; partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as "stringers" or "dikes".

Note: Combination descriptors (such as "slightly weathered to fresh") are used where equal distribution of both weathering characteristics is present over significant intervals or where characteristics present are "in between" the diagnostic feature. However, combination descriptors should not be used where significant identifiable zones can be delineated. Only two adjacent descriptors shall be combined. "Very intensely weathered" is the combination descriptor for "decomposed to intensely weathered".

PERCENT CORE RECOVERY (REC)

$$\frac{\Sigma \text{ Length of the recovered core pieces (in.)}}{\text{Total length of core run (in.)}} \times 100$$

ROCK QUALITY DESIGNATION (RQD)

$$\frac{\Sigma \text{ Length of intact core pieces > 4 in.}}{\text{Total length of core run (in.)}} \times 100$$

Note: RQD* indicates soundness criteria not met

REFERENCE: Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010).

ROCK HARDNESS

Descriptor	Criteria
Extremely Hard	Specimen cannot be scratched with pocket knife or sharp pick; can only be chipped with repeated heavy hammer blows
Very hard	Specimen cannot be scratched with pocket knife or sharp pick; breaks with repeated heavy hammer blows
Hard	Specimen can be scratched with pocket knife or sharp pick with heavy pressure; heavy hammer blows required to break specimen
Moderately Hard	Specimen can be scratched with pocket knife or sharp pick with light or moderate pressure; breaks with moderate hammer blows
Moderately Soft	Specimen can be grooved 1/16 in. with pocket knife or sharp pick with moderate or heavy pressure; breaks with light hammer blow or heavy hand pressure
Soft	Specimen can be grooved or gouged with pocket knife or sharp pick with light pressure, breaks with light to moderate hand pressure
Very Soft	Specimen can be readily indented, grooved, or gouged with fingernail, or carved with pocket knife; breaks with light manual pressure.

FRACTURE DENSITY

Descriptor	Criteria
Unfractured	No fractures
Very Slightly Fractured	Core lengths greater than 3 ft.
Slightly Fractured	Core lengths mostly from 1 ft. to 3 ft.
Moderately Fractured	Core lengths mostly from 4 in. to 1 ft.
Intensely Fractured	Core lengths mostly from 1 in. to 4 in.
Very Intensely Fractured	Mostly chips and fragments.

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Boring Record Legend

Rock Legend

Sheet 1 of 1

LOG OF BORING B1

PROJECT NO: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
LOCATION: Mtn. View Road, Boonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RRH
DEPTH OF BORING: 40.04 (ft)

BEGIN DATE: 6/27/17
COMPLETION DATE: 6/27/17
SURFACE ELEVATION: 2020.73 (ft)*
SURFACE CONDITION: Asphalt
WATER DEPTH: 32 (ft)
READING TAKEN: 6/27/17
HAMMER EFFICIENCY: 91 (%)

DRILLING CONTRACTOR: Taber Drilling
DRILLING METHOD: Solid-Stem Auger
DRILL RIG: Diedrich D-120 (Truck)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 4"
BACKFILL METHOD: Type II-V Portland Cement Grout

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
							■	ASPHALT.										
							▨	CLAYEY SAND with GRAVEL (SC); loose to medium dense; brown; dry to moist; coarse to fine GRAVEL; coarse to fine SAND; low to medium plasticity fines [FILL].										
	1																	
2019	2																	
	3																	
2017	4																	
	5	⧗	1	3 5 5	10	2.5 +4.5	▨	About 34% GRAVEL; about 43% SAND; about 23% fines.	50									
2015	6										18	28	5.3	104.1	23			
							☰	SEDIMENTARY ROCK (GREYWACKE SANDSTONE), light brown, very intensely weathered, very soft, very intensely fractured, dry to moist [FRANCISCAN FORMATION].										
	7																	
2013	8																	
	9																	
2011	10	☒	2	2 2 3	5	4.0 +4.5		Decomposed.	50									
	11																	
2009	12																	
	13																	
2007	14																	
	15	☒	3	1 5 7	12	3.0 +4.5			67									
2005	16												5.3 5.3	90.9 104.8				Unconfined Comp. Test UC = 3,283 psf
	17																	
2003	18						☰	SEDIMENTARY ROCK (GREYWACKE SANDSTONE), brown, intensely weathered, soft, very intensely fractured, moist, mottled [FRANCISCAN FORMATION].										Increased drilling effort at 18'
	19																	
2001	20	☒	4	6 21 15	36	+4.5 +4.5			83									
	21												6.2	101.7				
1999	22																	
	23																	

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PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B1
ENTRY BY: RRH
CHECKED BY: RDS

		FIELD									LABORATORY							
ELEVATION (ft)	**DEPTH (ft)**	**SAMPLE**	**SAMPLE NO**	**BLOWS PER 6 IN.**	**BLOWS PER FOOT**	**POCKET PEN. (TSF)**	**GRAPHIC LOG**	**DESCRIPTION**	**RECOVERY(%)**	**RQD (%)**	**PLASTIC LIMIT**	**LIQUID LIMIT**	**MOISTURE (%)**	**D. DENSITY (PCF)**	**% PASSING 200 SIEVE**	**DRILL METHOD**	**CASING DEPTH**	**REMARKS**
								SEDIMENTARY ROCK (Greywacke Sandstone) *(continued)*.										
	25		5	25 50/3"	50/3	+4.5		Very intensely weathered, shale in tip.	89				8.2	116.5				
1995	26																	
	27																	
1993	28																	Hard drilling at 28'
	29																	
1991	30		6	50/6"	REF	+4.5			100				5.5	112.8				
	31																	Very hard drilling, audible drill "screech and chatter" at 31'
1989	32 ▼																	
	33																	
1987	34																	
	35																	Extremely hard drilling, pronounced "screech and chatter" at 34.5'
1985	36																	
	37																	
1983	38																	
	39																	
1981	40		7	50/.5"	REF			Gray, moderately to slightly weathered, moist to wet. Bottom of borehole at 40.0 ft bgs	100									Essential auger refusal
	41							Backfilled with cement grout, no field inspection required per MCDEH Inspector Will Nalty										
1979	42							*Elevation Reference: CP#5, Elev. 1999.74 per SHN survey										
	43																	
1977	44																	
	45																	
1975	46																	
	47																	
1973	48																	
	49																	
1971	50																	
	51																	
1969	52																	
	53																	

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PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B1
ENTRY BY: RRH
CHECKED BY: RDS SHEET 2 of 2

LOG OF BORING B2

PROJECT NO: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
LOCATION: Mtn. View Road, Boonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: RRH
DEPTH OF BORING: 29.04 (ft)

BEGIN DATE: 6/26/17
COMPLETION DATE: 6/26/17
SURFACE ELEVATION: 2005.64 (ft)*
SURFACE CONDITION: Asphalt
WATER DEPTH: Not Encountered (ft)
READING TAKEN: 6/26/17
HAMMER EFFICIENCY: 91 (%)

DRILLING CONTRACTOR: Taber Drilling
DRILLING METHOD: Hollow-Stem Auger
DRILL RIG: Diedrich D-120 (Truck)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 8"
BACKFILL METHOD: Type II-V Portland Cement Grout

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								ASPHALT. CLAYEY SAND with GRAVEL (SC); medium dense; brown; dry to moist; fine GRAVEL; coarse to fine SAND; low to medium plasticity fines [FILL].										
	1																	
2004	2																	
	3																	
2002	4																	
	5		1	10 12 13	25	+4.5 +4.5		About 27% GRAVEL; about 41% SAND; about 32% fines.	67				9.4	109.7	32			Chemical Analysis pH = 4.77 Min Resist. = 3220 ohm-cm Chloride = 3.5 ppm Sulfate-S = 13.3 ppm
2000	6							SEDIMENTARY ROCK (GREYWACKE SANDSTONE), brown, very intensely weathered, very soft, very intensely fractured [FRANCISCAN FORMATION].										
	7																	
1998	8																	
	9																	Hard drilling, scattered drill "screech and chatter" at 9'
1996	10		2	30 25 24	49	+4.5 +4.5		Moist, with scattered moderately to intensely weathered rock fragments (coarse sand to fine gravel in size).	61									
	11																	
1994	12																	
	13																	
1992	14																	
	15		3	40 50/5"	50/5	+4.5			73				7.5	105.3				
1990	16																	
	17																	
1988	18																	
	19																	
1986	20		4	50/6"	REF				50				6.2	93.1				
	21																	
1984	22																	
	23																	Extremely hard drilling, pronounced "screech and chatter" at 23'

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PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B2
ENTRY BY: RRH
CHECKED BY: RDS

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Greywacke Sandstone) *(continued)*.										
	25		5	50/.5"	REF			Gray, moderately to slightly weathered.	100									
1980	26																	
	27																	
1978	28																	
	29		6	50/.5"	REF			Bottom of borehole at 29.0 ft bgs	0									Essential auger refusal
1976	30							Backfilled with cement grout, field inspected by MCDEH Inspector Will Nalty										
	31							*Elevation Reference: CP#5, Elev. 1999.74 per SHN survey										
1974	32																	
	33																	
1972	34																	
	35																	
1970	36																	
	37																	
1968	38																	
	39																	
1966	40																	
	41																	
1964	42																	
	43																	
1962	44																	
	45																	
1960	46																	
	47																	
1958	48																	
	49																	
1956	50																	
	51																	
1954	52																	
	53																	

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PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B2
ENTRY BY: RRH
CHECKED BY: RDS SHEET 2 of 2

LOG OF BORING B3

PROJECT NO: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
LOCATION: Mtn. View Road, Boonville
CITY/COUNTY: Mendocino
CLIENT: MCDOT
LOGGED BY: JJW
DEPTH OF BORING: 51.5 (ft)

BEGIN DATE: 8/22/17
COMPLETION DATE: 8/22/17
SURFACE ELEVATION: 2009.37 (ft)*
SURFACE CONDITION: Asphalt
WATER DEPTH: Not Encountered (ft)
READING TAKEN: 8/22/17
HAMMER EFFICIENCY: 75 (%)

DRILLING CONTRACTOR: Geo-Ex Subsurface Exploration
DRILLING METHOD: Solid-Stem Auger, Rotary Wash
DRILL RIG: CME 45 (Track)
HAMMER TYPE: Automatic, 140 lbs, 30" drop
SAMPLER TYPE & SIZE: SPT (ID 1.4") and CAL (ID 2.4")
BOREHOLE DIAMETER: 4"
BACKFILL METHOD: Type I/II Portland Cement Crout

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								ASPHALT.										
	1							CLAYEY GRAVEL with SAND (GC); brown; dry; coarse to fine GRAVEL; coarse to fine SAND; low to medium plasticity fines [FILL].										
2007	2																	
	3																	
2005	4																	
	5		1	5 6 8	14	+4.5		Hard; about 62% GRAVEL; about 25% SAND; about 13% fines.	56				3.8	100.2	13			
2003	6																	
	7																	
2001	8							SEDIMENTARY ROCK (GREYWACKE SANDSTONE), dark brown to brown, decomposed, very soft, very intensely fractured, moist to wet, mottled [FRANCISCAN FORMATION].										
	9																	
1999	10		2	9 6 6	12	+4.5 3.0			67				17.3	108.6				
	11																	
1997	12																	
	13																	
1995	14																	
	15		3	6 12 12	24	+4.5			67				7.4	124.4				Unconfined Comp. Test UC = 4,637 psf
1993	16																	
	17																	
1991	18							SEDIMENTARY ROCK (GREYWACKE SANDSTONE), dark brown to brown, very intensely weathered, intensely fractured, moist [FRANCISCAN FORMATION].										hard drilling, screeching noises
	19																	
1989	20		4	50/5"	REF	+4.5		Intensely weathered.	100									
	21																	
1987	22																	
	23																	
1985	24																	
	25		5	50/5"	REF	+4.5			100									

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Geotechnical Engineering, Design and Construction Services

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1100 Corporate Way, Suite 230
Sacramento, CA 95831
(916) 455-4225

PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B3
ENTRY BY: RRH
CHECKED BY: RDS SHEET 1 of 2

FIELD											LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
								SEDIMENTARY ROCK (Greywacke Sandstone) *(continued)*.										
	27																	
1981	28																	
	29																	
1979	30																	
	31																	
1977	32																	
	33																	
1975	34																	
	35		6	30 40 50	90	+4.5		With gray shale.	67				7.9	140.1				Unconfined Comp. Test UC = 1,037 psf
1973	36																	
	37																	
1971	38																	
	39																	
1969	40		7	23 50/3"	50/3	4.5			67									
	41																	
1967	42																	
	43																	
1965	44																	
	45																	
1963	46																	
	47																	
1961	48																	
	49																	
1959	50		8	44 35 50	85	+4.5 +4.5		Varying degree of weathering (decomposed to intensely weathered).	61				10.2	135.3				
	51																	
1957	52							Bottom of borehole at 51.5 ft bgs										
	53							Backfilled with cement grout, field inspected by MCDEH Inspector Gary Leonard										
1955	54							*Elevation Reference: CP#5, Elev. 1999.74 per SHN survey										
	55																	
1953	56																	
	57																	

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PROJECT NUMBER: 16-337.4
PROJECT: Mtn. View Road Failure MP 16.62
BORING: B3
ENTRY BY: RRH
CHECKED BY: RDS SHEET 2 of 2

APPENDIX B

LABORATORY AND FIELD TEST RESULTS SUMMARY

Job: **Mountain View Road (CR 510) Slide at MP 16.62**
Job No: **16-337.4**
Date: **10/16/17**

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Taber Since 1954
Sacramento | Modesto | Pleasanton | Rocklin | Ukiah

Laboratory/Field Test Summary

						Moisture/Density			Classification							Strength		Chemical Analysis			
									Atterberg Limits												
	Boring I.D.	Sample I.D.	Sample Depth (ft)	USCS Class.	Blow Counts N_{60} (bpf)	Dry Density (pcf)	Moist. Content (%)	Wet Density (pcf)	Liquid Limit	Plastic Limit	Plasticity Index	Gravel (%)	Sand (%)	Fines (%)	Organic Content (%)	Pocket Pent. (tsf)	Uncon. Comp. (psf)	pH	Min. Resist. (ohm-cm)	Chloride (ppm)	Sulfate-S (ppm)
Soldier Pile Wall	B1	1	5.0	SC	10	104.1	5.3	109.6	28	18	10	34	43	23		2.5					
	B1	2	10.0	D. Rock	8											4.0 - +4.5					
	B1	3A	15.0	D. Rock	18	90.9	5.3	95.7								3.0					
	B1	3B				104.8	5.3	110.4								+4.5	3,283				
	B1	4	20.0	D. Rock	55	101.7	6.2	108.0								+4.5					
	B1	5	25.0	D. Rock	50/3"	116.5	8.2	126.1								+4.5					
	B1	6	30.0	D. Rock	REF	112.8	5.5	119.0								+4.5					
	B1	7	40.0	D. Rock	REF																
	B2	1	5.0	SC	25	109.7	9.4	120.0				27	41	32		+4.5		4.77	3,220	3.5	13.3
	B2	2	10.0	D. Rock	74											+4.5					
	B2	3	15.0	D. Rock	50/5"	105.3	7.5	113.2								+4.5					
	B2	4	20.0	D. Rock	REF	93.1	6.2	98.9													
	B2	5	25.0	D. Rock	REF																
	B2	7	29.0	D. Rock	REF																
	B3	1	5.0	GC	11	100.2	3.8	104.0				62	25	13		+4.5					
	B3	2	10.0	D. Rock	15	108.6	17.3	127.4								3.0 - +4.5					
	B4	3	15.0	D. Rock	30	124.4	7.4	133.6								+4.5	4,637				
	B5	4	20.0	D. Rock	REF											+4.5					
	B6	5	25.0	D. Rock	REF											+4.5					
	B7	6	35.0	D. Rock	113	140.1	7.9	151.2								+4.5	1,037				
	B8	7	40.0	D. Rock	50/3"											4.5					
	B9	8	50.0	D. Rock	106	135.3	10.2	149.1								+4.5					

Note: We consider the lower range of values to reflect fractured rock within the samples and not representative of the in-situ rock strength.

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Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 7/13/17
Technician: MEA

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B1-1	B1-3	B1-4	B1-5	B1-6
USCS Symbol	ML	ML	MH	ML	GM
Depth (ft.)	6	15.5	20.5	25	30
Sample Length (in.)	5.959	3.778	5.310	5.722	6.084
Diameter (in.)	2.420	1.408	1.421	1.403	1.422
Sample Volume (ft^3)	0.01586	0.00340	0.00487	0.00512	0.00559
Total Mass Soil+Tube (g)	991.1	147.9	358.8	413.6	422.4
Mass of Tube (g)	202.6	0.0	120.0	120.9	120.4
Tare No.	P7	H2	G6	G22	H21
Tare (g)	132.4	20.6	13.4	13.6	13.3
Wet Soil + Tare (g)	609.5	63.2	82.3	63.1	83.1
Dry Soil + Tare (g)	585.4	61.1	78.3	59.3	79.4
Dry Soil (g)	453.0	40.5	64.9	45.8	66.1
Water (g)	24.1	2.2	4.0	3.7	3.7
Moisture (%)	**5.3**	**5.3**	**6.2**	**8.2**	**5.5**
Dry Density (pcf)	**104.1**	**90.9**	**101.7**	**116.5**	**112.8**

Notes:

Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 7/18/17
Technician: MEA

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B2-1	B2-3	B2-4		
USCS Symbol	GW	GM	GM		
Depth (ft.)	6	15	20		
Sample Length (in.)	4.838	5.757	3.931		
Diameter (in.)	2.421	1.401	1.408		
Sample Volume (ft^3)	0.01289	0.00514	0.00354		
Total Mass Soil+Tube (g)	911.1	385.4	279.7		
Mass of Tube (g)	209.6	121.5	120.7		
Tare No.	R11	F2	C7		
Tare (g)	126.3	13.5	13.6		
Wet Soil + Tare (g)	603.9	81.6	78.9		
Dry Soil + Tare (g)	562.8	76.8	75.1		
Dry Soil (g)	436.5	63.3	61.4		
Water (g)	41.1	4.8	3.8		
Moisture (%)	**9.4**	**7.5**	**6.2**		
Dry Density (pcf)	**109.7**	**105.3**	**93.1**		

Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 9/22/17
Technician: ETT/HFW

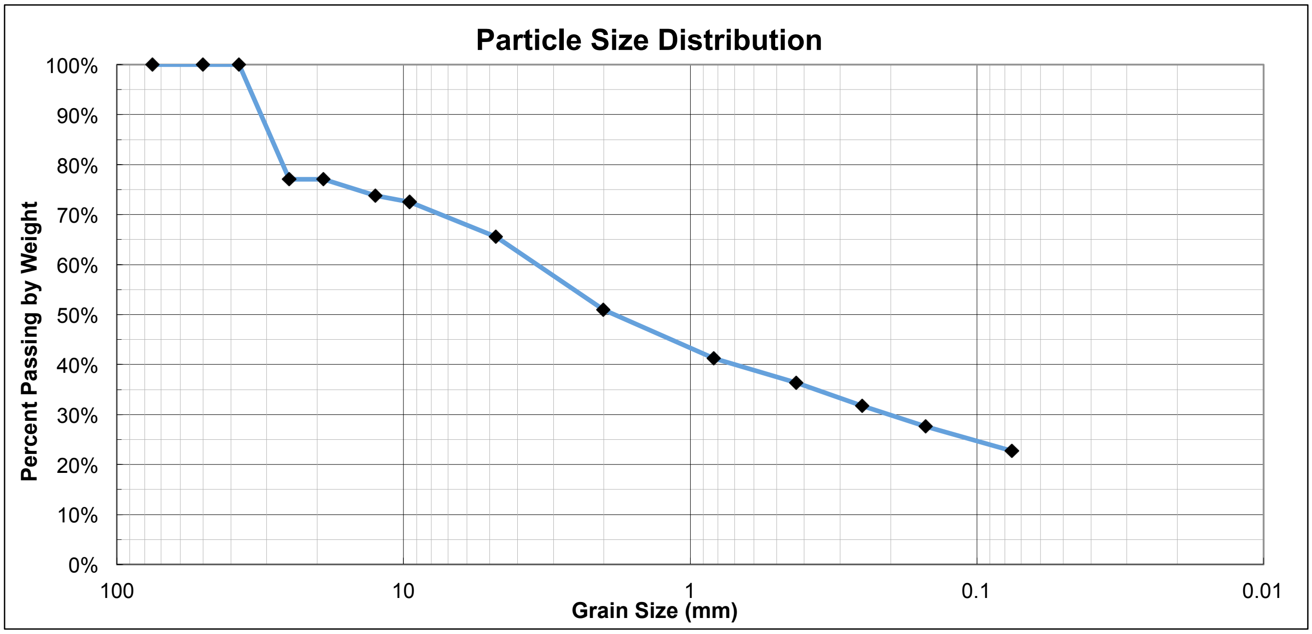
MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	B3-1	B3-2	B3-3A	B3-6A	B3-8
USCS Symbol	ML	CL	D.ROCK	D.ROCK	D.SHALE
Depth (ft.)	6.0	11.0	15.5	35.5	51.0
Sample Length (in.)	5.705	5.585	3.314	3.363	4.584
Diameter (in.)	2.389	1.418	1.386	1.406	1.412
Sample Volume (ft^3)	0.01480	0.00510	0.00289	0.00302	0.00415
Total Mass Soil+Tube (g)	949.5	413.6	175.4	207.2	403.8
Mass of Tube (g)	251.1	118.6	0.0	0.0	122.9
Tare No.	R16	B10	H1	G6	D6
Tare (g)	129.2	13.8	13.5	13.4	13.7
Wet Soil + Tare (g)	466.7	57.0	77.9	77.6	65.7
Dry Soil + Tare (g)	454.3	50.6	73.4	72.9	60.9
Dry Soil (g)	325.1	36.8	59.9	59.5	47.3
Water (g)	12.4	6.4	4.5	4.7	4.8
Moisture (%)	**3.8**	**17.3**	**7.4**	**7.9**	**10.2**
Dry Density (pcf)	**100.2**	**108.6**	**124.4**	**140.1**	**135.3**

Notes:

Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 7/13/17
Technician: CAP
Sample ID: B1-1
Depth: 6
USCS Classification: Silty Sand with Gravel

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	23	11	15	15	13	
0	**34**		**43**			**23**

		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	103.8	77%
		3/4"	19.0	103.8	77%
	Fine	**1/2"**	12.5	118.8	74%
		3/8"	9.50	124.6	72%
		#4	4.75	156.1	66%
Sand	Coarse	**#10**	2.00	222.1	51%
	Medium	**#20**	0.825	266.0	41%
		#40	0.425	288.5	36%
	Fine	**#60**	0.250	309.2	32%
		#100	0.150	328.1	28%
		#200	0.075	350.2	23%

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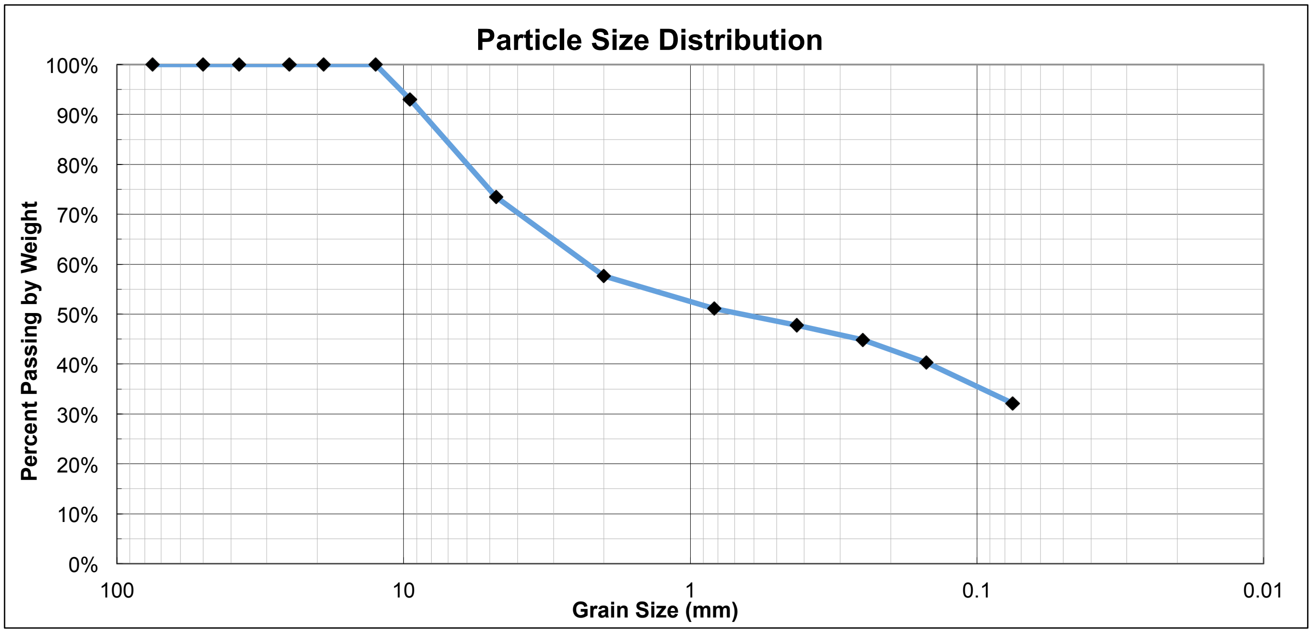
Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 7/21/17
Technician: CAP
Sample ID: B2-1
Depth: 6
USCS Classification: Silty sand with gravel

ASTM 6913 - Method A



% Cobble	**% Gravel**		**% Sand**			**% Fines**
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	27	15	10	16	
0	**27**		**41**			**32**

		Sieve #	**Opening** mm	**Cummulative Mass Retained (g)**	**% Passing** %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	30.3	93%
		#4	4.75	116.0	73%
Sand	Coarse	**#10**	2.00	184.8	58%
	Medium	**#20**	0.825	213.5	51%
		#40	0.425	227.9	48%
	Fine	**#60**	0.250	240.9	45%
		#100	0.150	260.5	40%
		#200	0.075	296.2	32%

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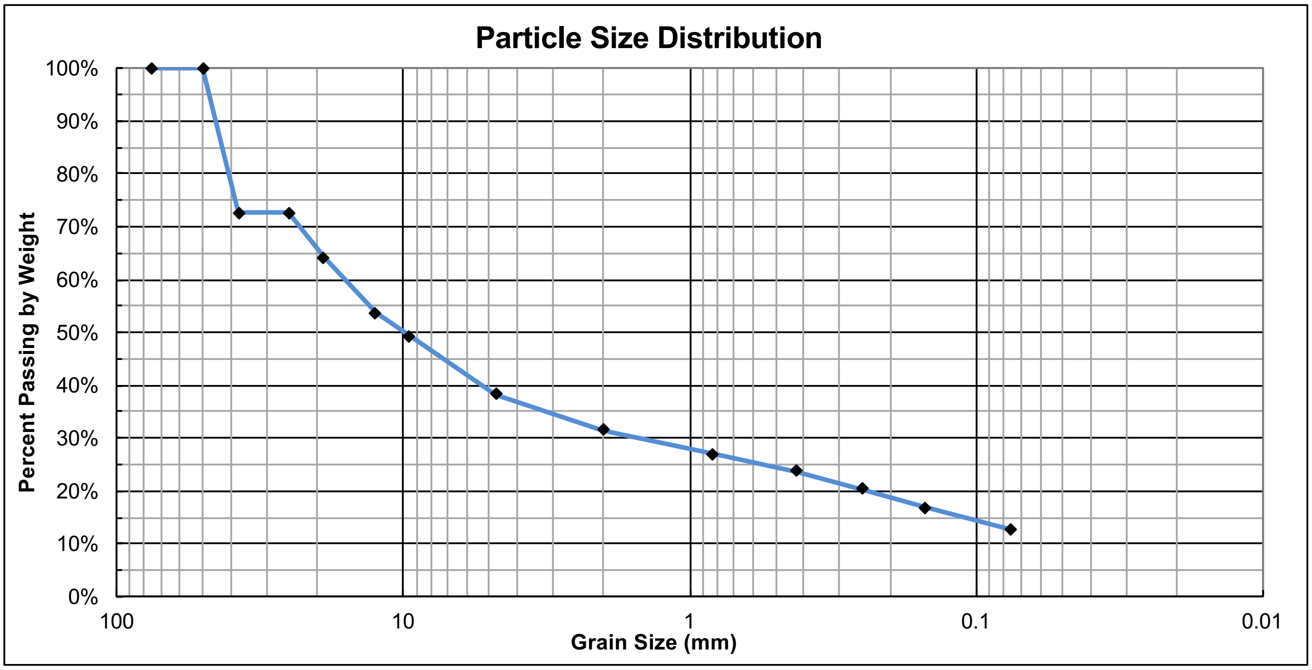
Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 9/22/17
Technician: ETT
Sample ID: B3-1
Depth (ft): 6.0
USCS Classification: Poorly Graded Gravel with Silt and Sand

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	36	26	7	7	11	
0	**62**		**25**			**13**

		Sieve #	**Opening** mm	**Cummulative** **Mass Retained (g)**	**% Passing** %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	89.2	73%
		1"	25.0	89.2	73%
		3/4"	19.0	116.3	64%
	Fine	**1/2"**	12.5	150.7	54%
		3/8"	9.50	165.0	49%
		#4	4.75	200.6	38%
Sand	Coarse	**#10**	2.00	222.9	31%
	Medium	**#20**	0.825	237.5	27%
		#40	0.425	247.9	24%
	Fine	**#60**	0.250	259.0	20%
		#100	0.150	270.3	17%
		#200	0.075	284.0	13%

Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 7/21/17
Technician: MEA
Sample ID: B1-1
Depth: 6'

Plastic Index - ASTM D4318

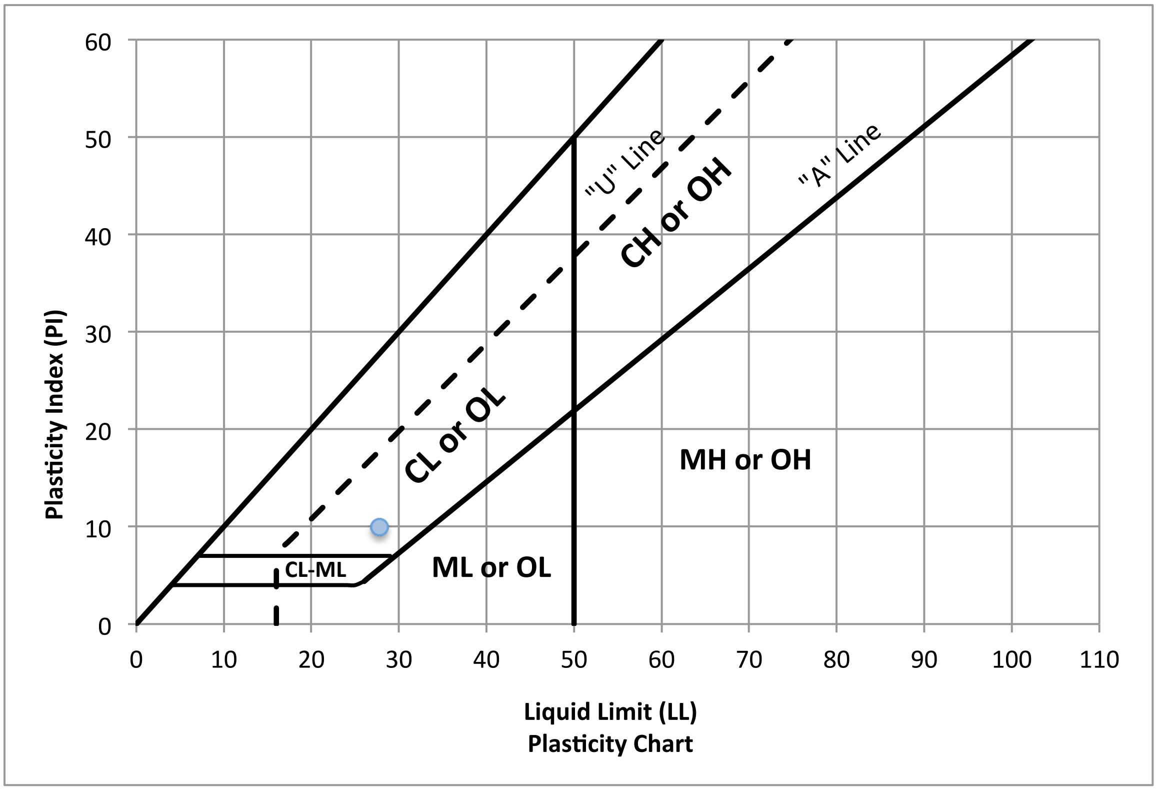
PI	10	**LL**	28	**PL**	18

Plastic Limit

	1	2	3	4
Moisture (%)	**17.4**	**17.6**	**18.5**	

Liquid Limit

	1	2	3	4
Blowcounts	33	29	29	17
Moisture (%)	**26.7**	**27.6**	**27.6**	**28.6**



Plasticity Chart

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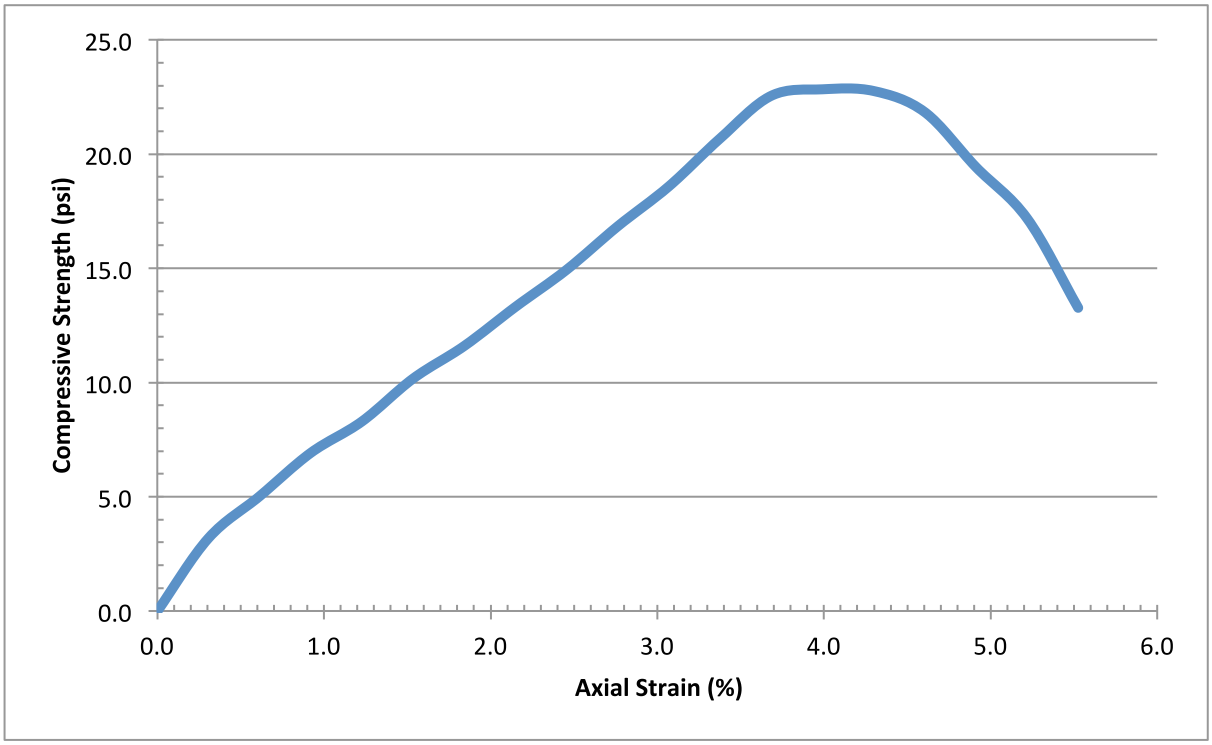
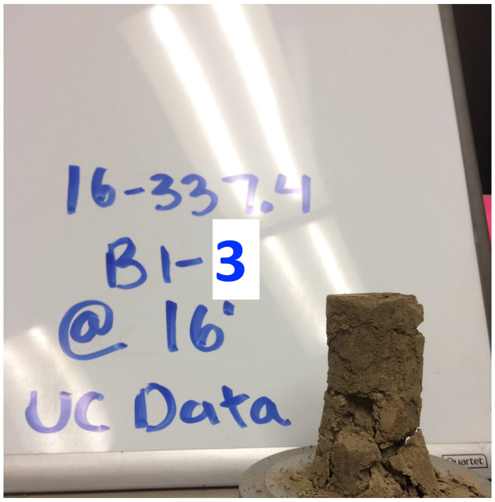
Project Name: Mountain View Rd @ 16.62
CAInc File No: 16-337.5
Date: 7/19/17
Technician: HFW
Sample ID: B1-3 Depth (ft): 16.0
USCS Classification: D.Rock

UNCONFINED COMPRESSION TEST - D2166



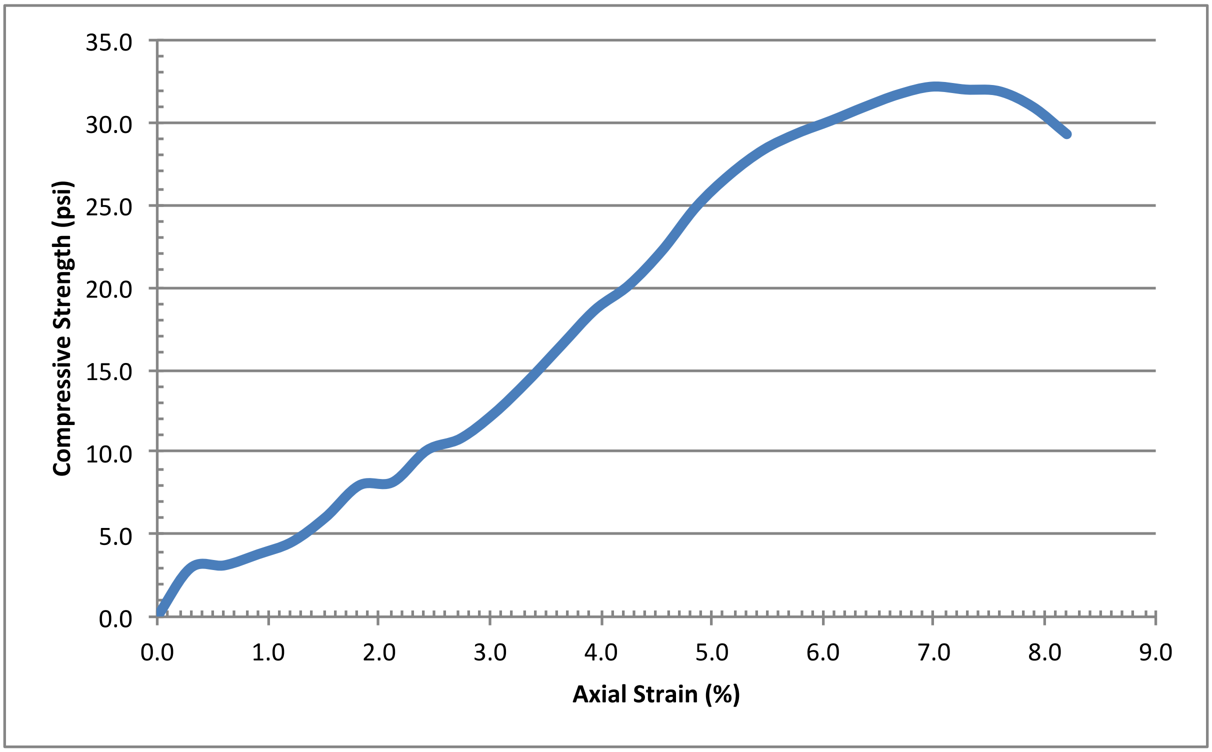
Dry Density (pcf)	**104.8**
Water Content (%)	**5.3**
Unconfined Compressive Strength (psi)	**22.8**
Unconfined Compressive Strength (psf)	**3283**
Average Height (in)	3.278
Average Diameter (in)	1.408
Rate of strain (%)	1.0
Strain at Failure (%)	4.0

Notes:



Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 9/20/17
Technician: HFW
Sample ID: B3-3 Depth (ft): 15.5
USCS Classification: D. Rock

UNCONFINED COMPRESSION TEST - D2166



Dry Density (pcf)	**124.4**
Water Content (%)	**7.4**
Unconfined Compressive Strength (psi)	**32.2**
Unconfined Compressive Strength (psf)	**4637**
Shear Strength (psf)	**2318.4**
Average Height (in)	3.314
Average Diameter (in)	1.386
Rate of strain (%)	1.0
Strain at Failure (%)	7.0

Notes:

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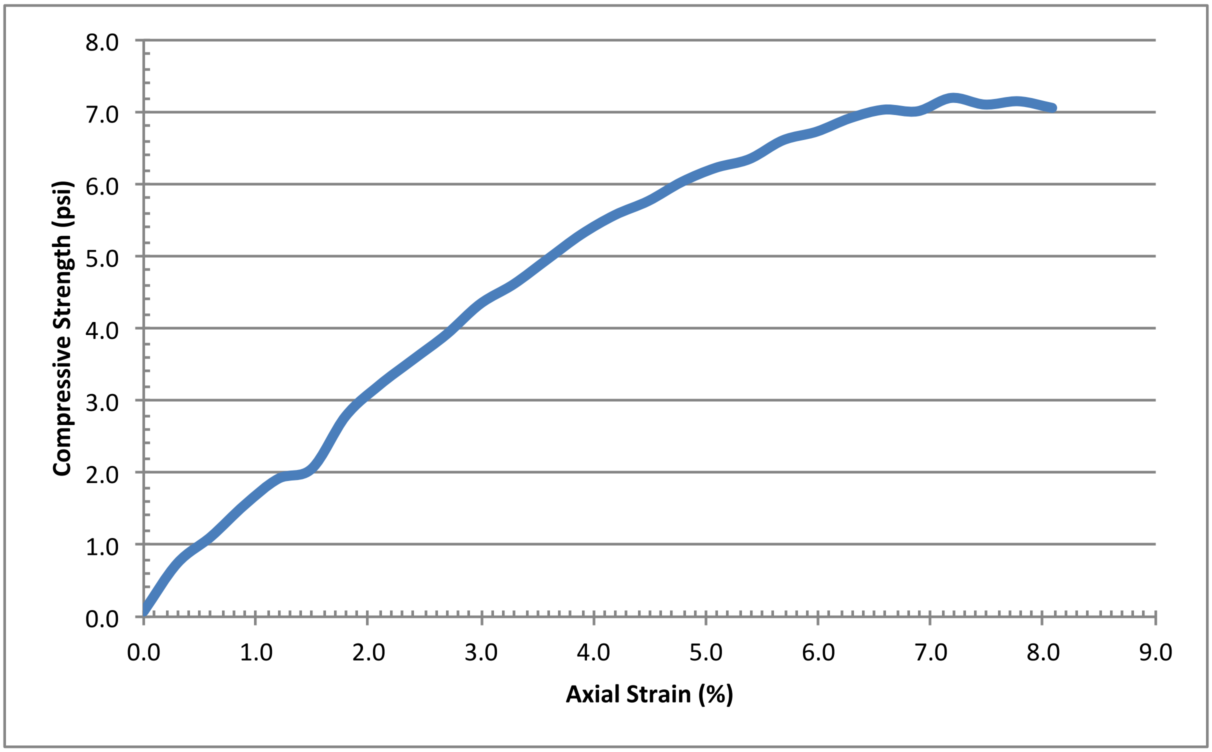
Geotechnical Engineering, Design and Construction Services

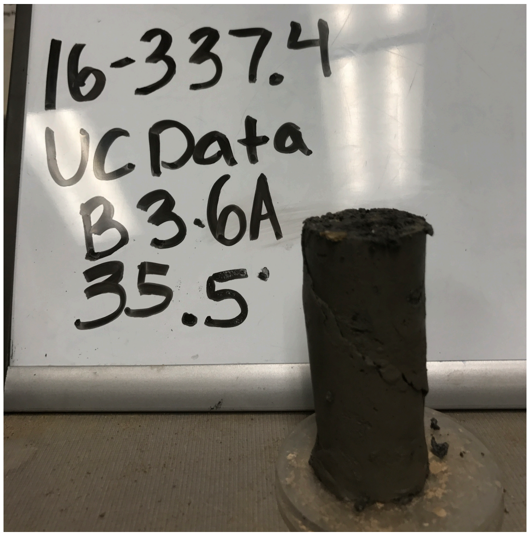
Project Name: Mountain View Road at MP 16.62
CAInc File No: 16-337.4
Date: 9/20/17
Technician: HFW
Sample ID: B3-6 Depth (ft): 35.5
USCS Classification: D. Rock

UNCONFINED COMPRESSION TEST - D2166



Dry Density (pcf)	**140.2**
Water Content (%)	**7.9**
Unconfined Compressive Strength (psi)	**7.2**
Unconfined Compressive Strength (psf)	**1037**
Shear Strength (psf)	**518.4**
Average Height (in)	3.363
Average Diameter (in)	1.406
Rate of strain (%)	1.0
Strain at Failure (%)	7.2

Notes:



Sunland Analytical
11419 Sunrise Gold Cir.#10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 07/28/17
Date Submitted 07/24/17

To: Hailey Wagenman
Crawford and Associates Inc.
4020 Rocklin Rd, Ste 1
Rocklin, CA, 95677

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following:
Location : 16-337.4 Site ID: B2-1 @ 6 FT
Thank you for your business.

* For future reference to this analysis please use SUN # 74863 - 156294

EVALUATION FOR SOIL CORROSION

Soil pH	4.77		
Minimum Resistivity	3.22	ohm-cm (x1000)	
Chloride	3.5 ppm	0.0004	%
Sulfate-S	13.3 ppm	0.0013	%

METHODS:
pH and Min.Resistivity CA DOT Test #643 Mod.(Sm.Cell)
Sulfate CA DOT Test #417, Chloride CA DOT Test #422