GEOTECHNICAL INVESTIGATION REPORT
SONOMA COUNTY VALLEY SANITATION DISTRICT
SONOMA COUNTY WATER AGENCY
SEWER TRUNK REPLACEMENT PROJECT
REACH A
RAMON STREET AND SONOMA HIGHWAY AREA
SONOMA COUNTY, CALIFORNIA
KLEINFELDER PROJECT NO.: 20143780.001A

FEBRUARY 6, 2015

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February 6, 2015
Kleinfelder Project No. 20143780.001A

Mr. Victor Swift
Sonoma Valley County Sanitation District
Sonoma County Water Agency
404 Aviation Boulevard
Santa Rosa, California 95403-9019

SUBJECT: Geotechnical Investigation Report
Sewer Trunk Replacement Project - Reach A
Ramon Street and Sonoma Highway Area
Sonoma County, California

Mr. Swift:

Submitted herewith is a report of our geotechnical investigation for the subject Sewer Trunk Replacement Project. This report contains geotechnical recommendations and conclusions specifically related to Reach A; Reaches B & C are addressed in separate reports. Although this report specifically addresses geotechnical issues for Reach A, in order to provide geographic context and to assist in a complete understanding of the project, this report also includes a discussion of subsurface conditions encountered in Reaches B and C. Our services were authorized by your contract entitled "Agreement for Geotechnical Engineering Services for Replacement of Sonoma Valley Trunk Main," dated April 15, 2014.

In general, the site is well suited to either trenching or trenchless construction. Beneath surficial fills the majority of soils consist of stiff to hard clays and dense to very dense sands and gravel. However, soils at this site are alluvial deposits and as such are variable. The primary geotechnical concerns related to the design and construction of the proposed pipeline include the presence of occasional areas of recent (Holocene) stream deposits that may contain localized area of soft clay or loose sand. Groundwater depths encountered during our initial explorations were generally below the proposed pipeline invert, however our explorations were drilled in July following an extremely dry winter. A supplemental exploration drilled in December, 2014 (KB-6) encountered a groundwater level that was more than 10 feet above the proposed pipeline invert and piezometer readings in December, 2014 recorded a groundwater level (KB-4) that was approximately 5 feet above the pipeline invert. Groundwater levels will continue to be monitored during the coming winter and a supplementary report will be provided when this data is available.

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We appreciate the opportunity to be of service on this project. Please contact the undersigned at 707.571.1883 if you have any questions regarding this report.

Sincerely,

KLEINFELDER, INC.

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SONOMA COUNTY VALLEY SANITATION DISTRICT
SONOMA COUNTY WATER AGENCY
SEWER TRUNK REPLACEMENT PROJECT - REACH A
RAMON STREET AND SONOMA HIGHWAY AREA
SONOMA COUNTY, CALIFORNIA

1 INTRODUCTION

This report presents findings, conclusions and recommendations resulting from our geotechnical investigation for Reach A of the Sewer Trunk Replacement Project, Ramon Street and Sonoma Highway Area, Sonoma County, California. The approximate location of the site is shown on Plate 1, Site Location. Our understanding of the project is based on information received from the Sonoma Valley County Sanitation District / Sonoma County Water Agency (SVCSD/SCWA – herein referred to as the District) in email correspondence, telephone conversations and in meetings at the District's office. Information received from the District included the following:

- Topographic Map and surveyed elevations of current and proposed alignment, *7365TOPO_4*, received in June, 2014.
- Groundwater Level Hydrographs – Agua Caliente/El Verano Area, January 2012 through March 2014.
- Ground Elevations, Preliminary Trunk Inverts, and Bore Hole Depths to Inverts, June 11, 2014.
- Geotechnical Investigation, West Napa Street Water System Improvement Project, Sonoma, California, by Miller Pacific Engineering Group, June 28, 2013.
- Geotechnical Report, Effluent and I/I Relief Pipelines, Sonoma County, California, by John K. Lowney & Associates, dated September 27, 1977.
- Geotechnical Investigation, Sonoma Valley County Sanitation District, Agua Caliente Creek, Bore and Jack Crossing, El Verano, Sonoma County, California, by Brunsing Associates, August 30, 2012.
- Technical Memorandum, Limited Phase II-West Napa Street Hazardous Materials Investigation, by GHD, dated May 20, 2014.

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- Initial and ongoing piezometer readings: Borings KB-4, KB-10, Aqua Caliente 1 (AC1) and Agua Caliente 2 (AC2).

These documents were reviewed during the project scope development and during the development of conclusions and recommendations for the current investigation. Discussions of the current project and our scope of services are provided below.

1.1 PROJECT DESCRIPTION

The project consists of approximately 9,250 lineal feet of new sewer pipeline. The pipeline alignment is divided into three reaches, as shown on Plate 2, Site Plan. This report describes geotechnical conditions along the entire proposed alignment (Reaches A, B and C) with specific conclusions and recommendations pertaining to Reach A. Conclusions and recommendations for Reaches B and C are contained in separate stand-alone reports.

- Reach A consists of approximately 3,700 lineal feet of new, approximately 27-inch ID (inside diameter) by 30-inch OD (outside diameter), thermoplastic (HDPE, PVC or similar) trunk sewer pipe and appurtenances. The pipeline will be installed at depths ranging from about 15 to 30 feet below site grades. Reach A is largely located beneath areas of heavily travelled city streets and within Caltrans and City of Sonoma rights-of-ways. The proposed alignment is roughly parallel to an existing 21-inch-diameter, reinforced concrete pipe (RCP) trunk sewer main.
- Reach B consists of approximately 3,300 lineal feet of new, approximately 27-inch ID (inside diameter) by 30-inch OD (outside diameter), thermoplastic trunk sewer pipe and appurtenances. The pipeline will be installed at depths ranging from about 10 to 30 feet below site grades. This reach replaces an existing 21-inch-diameter RCP trunk sewer main. Within this reach, this sewer line begins at a private mobile home park on the south end of the alignment and then is primarily located beneath the (public) Maxwell Recreational Park. The north end of this alignment crosses the County roadway at Verano Avenue and connects to an inverted siphon sewer that passes beneath Agua Caliente Creek. The crossing of Agua Caliente Creek has been investigated by others (Brunsing Associates) and is not included in this project.

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- Reach C will replace approximately 2,500 lineal feet of existing 21-inch-diameter RCP trunk sewer pipeline and appurtenances with a new thermoplastic trunk sewer pipe that will be 27-inch ID (inside diameter) by 30-inch OD (outside diameter). This reach begins at the northern end of the Agua Caliente Creek crossing and follows public roadways and obtained public sewer easements through primarily residential neighborhoods within unincorporated Sonoma County, ending on Happy Lane.

Although it is the County's preference to install as much of the sewer as possible using conventional open-cut construction methods, trenchless construction may be required in some areas potentially including:

- Major portions of Reach A will be located beneath Highway 12 within the Caltrans right-of-way. The need to maintain traffic flow on this street and to provide access to local businesses may require portions of trenchless construction.
- The southern end of Reach B will be located beneath a private mobile home park. There may be insufficient horizontal clearance at this location to allow conventional open-cut construction.
- The southern portion of Reach C may cross an area of private property where access for trenching may not be available.
- Other areas of trenchless construction may be identified in the future to maintain access to properties or to avoid blocking streets or intersections or to pass under drainage courses.
- If areas of soft, loose or saturated soil conditions are identified that could make trenching difficult due to flowing conditions, and/or have the potential to cause difficult dewatering and/or risk of excessive trench bottom heave, trenchless construction may need to be considered.

It is our understanding that the project is in the preliminary design phase at this time. Information from the results of this geotechnical investigation will be used to develop preliminary and final phases of design plans, specifications and construction cost estimates.

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The information described above represents our understanding of the project. If this information is to be modified, we will need to review our conclusions and recommendations for applicability.

1.2 PURPOSE AND SCOPE OF SERVICES

The purposes of this study were to explore subsurface conditions along the proposed pipeline alignments, characterize the geologic and geotechnical conditions at the site and provide geotechnical recommendations for conceptual design and construction of the sewer, as described above.

Our geotechnical exploration program was specifically designed to assist the District and their contractor in the consideration and selection of appropriate sewer installation methods including open trenching, horizontal directional drilling (HDD), jack and bore (J&B), pipe ramming (PR), guided auger boring (GAB) and microtunneling.

Kleinfelder's Scope of work for this project included a geologic reconnaissance, review of published geologic literature and other geotechnical reports in the project vicinity, exploration of subsurface conditions by means of 16 exploratory borings (6 explorations in Reach A), installation of two piezometers (to be read by County staff), geotechnical laboratory testing, geotechnical engineering analyses and preparation of this report.

Environmental evaluations and analyses including hazardous materials evaluations and storm water pollution plans are outside the scope of this study. We understand a concurrent environmental assessment for the project was conducted by others.

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2 FIELD EXPLORATION

2.1 GENERAL

Prior to beginning subsurface explorations, an Engineering Geologist from our firm reviewed relevant published geologic data regarding the site as well as previous geotechnical reports (by others) that were furnished to us by the District. Our geologist then performed a geologic site reconnaissance to identify evidence or surface expressions of geologic conditions, with particular emphasis on exposed soils in slopes, creek banks or areas of apparent instability. Combining the information from available geologic maps with the results of the surface mapping, a tentative geologic cross section along the proposed alignment was prepared. This cross section was updated during exploration and testing phases of the project and is presented in its current version on Plates 3A and 3B, Subsurface Profile.

The field exploration program for this project was focused on obtaining information related to the following: 1) soil classification, 2) soil shear strength, 3) groundwater levels, and 4) stratigraphy. The field exploration program included drilling sixteen (16) exploratory borings within Reaches A, B, and C. The explorations included thirteen hollow stem auger borings and three direct push borings (direct push borings were performed at the request of the District to obtain samples for environmental testing by others). Four hollow stem auger borings and two direct push borings were performed in Reach A. The approximate locations of the borings are shown on Plate 2. The initial field exploration program was conducted in July of 2014; two supplemental explorations were performed in December of 2014. Two piezometers were installed at Borings KB-4 and KB-10. A summary of information regarding the borings drilled for this study is provided in Table 1 below.

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TABLE 1
SOIL BORINGS DRILLED FOR REPLACEMENT OF SONOMA VALLEY TRUNK MAIN

REACH A

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-1	38.29243°	-122.47052°	79.7	7/15/2014	31½	16
KDP-2	38.29288°	-122.47042°	82.3	7/23/2014	7[2]	19
KB-2	38.29288°	-122.47042°	82.3	12/17/14	31½	19
KB-3	38.29338°	-122.47280°	82.8	7/17/2014	26½	18
KB-4	38.29372°	-122.47550°	82.4	7/16/2014	51½	16
KB-5	38.29615°	-122.47558°	98	7/18/2014	31½	23
KDP-6	38.29817°	-122.47540°	101.6	7/24/2014	10[2]	26
KB-6	38.29817°	-122.47540°	101.6	12/18/2014	31½	26

REACH B

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-7	38.29922°	-122.47731°	92	7/18/2014	26[2]	15
KB-8	38.30074°	-122.47823	99	7/18/2014	26½	21
KB-9	38.30059°	-122.47919°	90	7/17/2014	21½	12
KB-10	38.30156°	-122.48159°	94	7/18/2014	51½	14
KB-11	38.30295°	-122.48162°	104.5	7/17/2014	26	23

REACH C

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-12	38.30505°	-122.48190°	102	7/17/2014	16½	10
KB-13	38.30632°	-122.48169°	108	7/16/2014	21½	16
KB-14	38.30716°	-122.48271°	100.7	7/15/2014	15	8
KDP-15	38.30841°	-122.48336°	105	7/24/2014	28	12
KB-16	38.31003°	-122.48421°	106.8	7/15/2014	21½	12

[1] Borings designated KB were drilled using Hollow Stem Auger methods. Borings designated KDP were drilled using direct push methods to aid in obtaining environmental samples. Ground elevations approximate.
[2] Boring terminated short of scheduled depth due to practical refusal of drilling method. Supplemental borings (KB-2 and KB-6) were later drilled at the locations of KDP-2 and KDP-6.

Boring coordinates were based on locating the drilling locations on Google Earth. Boring elevations were estimated from the topographic map provided by the District following completion of the drilling. The horizontal datum is North American Datum (NAD) 1983 Zone 3,

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and the vertical datum is North American Vertical Datum (NAVD) 1988. All references to elevation in this report are based on NAVD88.

Before drilling, Kleinfelder obtained drilling permits from Sonoma County Permit and Resource Management Department (PRMD). A City of Sonoma encroachment permit was obtained for all borings in Reach A. A California Department of Transportation (Caltrans) encroachment permit was obtained for Borings KB-3, KB-4, KB-5, KDP-6 and KB-6. A County of Sonoma encroachment permit was obtained for Borings KB-13, KB-14, KDP-15, and KB-16. License agreements were obtained by the District for entry and permission to drill Borings KB-7 through KB-12. Five well permits were obtained from the PRMD to comply with regulations. Boring locations were cleared through Underground Service Alert (USA-North), and a subcontracted utility locator service was used to mark known existing utilities at boring locations where deemed necessary.

2.2 DRILLING AND SAMPLING METHODS

For the entire project (Reaches A, B, and C), a total of 18 borings were drilled/advanced for this investigation by Woodward Drilling of Rio Vista, California. Of those, 15 of the borings (6 in Reach A) were drilled using a truck-mounted drill rig equipped with 8-inch-diameter hollow-stem augers. Hollow-stem auger borings were drilled in accordance with ASTM D-6151 (Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling). This drilling method avoids the need to use drilling mud, which can seal the sides of the explorations and prevent observations of groundwater levels during drilling. Three borings were advanced using direct push methods (two in Reach A) in general accordance with ASTM D6282 (Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations).

A Kleinfelder engineer maintained logs of the borings, visually classified the soils encountered according to the Unified Soil Classification System presented in Appendix A, and obtained relatively undisturbed and bulk samples of the subsurface materials. Soil classifications made in the field from samples and auger cuttings were in accordance with relevant portions of ASTM D2488. These classifications were re-evaluated in the laboratory after further examination and testing in accordance with ASTM D2487. Sample classifications, blow counts recorded during sampling, and other related information were recorded on the boring logs. Boring logs are presented in Appendix A, together with a soil description key and an explanation of the symbols

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used on the logs. The approximate boring locations are shown on Plate 2. In addition to the borings performed by Kleinfelder, we also attached boring logs by other firms that were drilled in the vicinity of the project. Logs of these Borings are presented in Appendix B. Approximate locations of the borings by others are shown on Plate 2.

Samples were obtained from the hollow-stem-auger borings at depth intervals of about 2 to 3 feet in the upper 10 feet and at approximate 5-foot depth intervals thereafter. Soils were sampled using a 1.4-inch inner diameter (ID) split-barrel (Standard Penetration Test) sampler in accordance with ASTM D-1586 (Test Method for Penetration Test and Split-Barrel Sampling of Soils) or using a 2.5-inch inner diameter (ID) split-barrel (California) sampler with stainless steel liners and in general conformance with ASTM D3550 (Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils). Both samplers were driven with a 140-pound automatic-trip hammer free-falling a distance of 30 inches.

Blow counts were recorded at 6-inch intervals for each sample attempt and are reported on the boring logs. Blow counts shown on the logs have not been corrected for the effects of overburden pressure, rod length, sampler size, or hammer efficiency. The terminology used in soil descriptions is based on field observations of the samples recovered and on the results of the laboratory testing.

Samples were obtained from the direct push borings continuously, beginning at a depth below the pavement section and continuing to the near planned exploration depth, or refusal. The maximum length of each incremental push (run) was a maximum 4 feet long, however many runs were shorter than 4 feet when hard/dense materials were encountered. Soils were sampled using 2.75-inch outside diameter (O.D.) rods attached to a 2.75-inch O.D. shoe that was driven by push/percussion into the subsurface. During the driving, soil enters inside the shoe and into a plastic sleeve with a 1.5-inch O.D.

During direct push operations, and during hollow-stem auger borings drilled to environmental sampling standards, a representative from Environmental Resources Management (ERM) was onsite to passively test for potential hydrocarbons and to collect soil and water samples for specific laboratory testing. The soil samples that ERM did not retain were sealed, labeled and returned to our laboratory.

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2.3 DEPTH TO GROUNDWATER MEASUREMENTS

During drilling in July of 2014, free groundwater was observed in Borings KB-4, KB-9, KB-10, KB-11, KDP-15, and KB-16. Free groundwater was also observed in boring KB-6 at the time of drilling in December of 2014. In addition, groundwater readings are being periodically obtained by the District in the piezometers installed at Borings KB-4 and KB-10. Groundwater measurements are summarized in Table 2.

TABLE 2
GROUNDWATER LEVEL MEASUREMENTS

Boring Number	Approx. Ground Surface Elevation (feet)	Depth of Boring (feet)	Circumstance & Date	Approx. Depth to Pipeline Invert (feet)	Depth to Ground-water (feet)	Approx. Ground-water Elevation (feet)
KB-4	82.4	51.5	During drilling 7-16-14	16	41	41
KB-4	82.4	51.5	Piezometer 7-29-14	16	22	60
KB-4	82.4	51.5	Piezometer 12-20-14	16	11	71
KB-6	101.6	31.5	During Drilling 12-18-14	26	14.5	87
KB-9	90.0	21.5	During drilling 7-17-14	12	14	76
KB-10	94.0	51.5	During drilling 7-18-14	14	35	59
KB-10	94.0	51.5	Piezometer 7-29-14	14	22	72
KB-10	94.0	51.5	Piezometer 12-20-14	14	9.5	84.5
KB-11	104.5	26.0	During drilling 7-17-14	16	15	90
KDP-15	105.0	28	During drilling 7-24-14	12	16.5	89
KDP-16	106.8	21.5	During drilling 7-15-14	12	15.0	92

Additionally, the District provided us with water level readings from three piezometers during the period from January 2012 through January 2015. Readings from those piezometers are summarized in Table 3.

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TABLE 3
DISTRICT PIEZOMETER READINGS

Location	Approx. Ground Surface Elevation (feet)	Minimum Elevation (feet)	Maximum Sustained Elevation (feet)
Agua Caliente 1	102.9	80	88
Agua Caliente 2	99.5	69	86
W. Thompson	61.6	42	54

Additional discussion of groundwater depth is provided in Sections 5.3 and 7.5.

2.4 BORING COMPLETION AND ABANDONMENT

Upon completion of drilling, the borings were backfilled with bentonite chips in accordance with Sonoma County requirements. The drill cuttings were contained in 55-gallon steel drums and temporarily stored at the District's Treatment Plant while awaiting the results of sample testing. After receipt of test results the drums were disposed of by Woodward drilling. Borings in the City and Caltrans right-of-way were finished at the surface with the pavement core replaced and secured with epoxy, over the top of an (approximate) five foot thick plug of sand cement grout.

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3 LABORATORY TESTING

Laboratory testing was performed on selected soil samples for use in our analyses, to provide contractor information for bidding, and to confirm field soil classifications in general accordance with ASTM D-2487 (Test Method for Classification of Soils for Engineering Purposes). Laboratory tests were performed by our accredited laboratory in accordance with relevant ASTM standards. Laboratory Tests included:

- Moisture content and dry density tests determine the weight of water contained in a given weight of soil in accordance with ASTM Methods D-2216 and D-2937, respectively. Tests were used in estimating loads on buried pipe, for determining the percent saturation of soils, and for general correlation and classification purposes.
- Particle-size analyses (sieve and hydrometer) were performed to estimate soil permeability in dewatering analyses and aid in soil classification and for use in liquefaction analyses. Tests are performed in general accordance with ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.
- Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) and are used to assist in soil classification, identify soil consistency (when compared to natural or existing moisture content), and provide correlation to soil properties, including expansion, compressibility, liquefaction and strength. Atterberg Limits were evaluated in accordance with ASTM Method D-4318.
- Strength tests were performed for use in design of shoring systems and evaluation of trenchless pipeline installation systems. Tests were conducted in accordance with ASTM D2850, Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils (TxUU).
- Corrosivity testing of two selected soil samples was performed by an outside laboratory (Sunland Analytical). Tests include pH, resistivity, sulfate content and chloride content.

Geotechnical laboratory test results are included in Appendix C and are summarized, where appropriate, on the boring logs. Corrosivity results are provided in Appendix D.

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4 GEOLOGIC AND SEISMIC SETTING

4.1 REGIONAL GEOLOGY

The reaches are located within the Coast Range Geomorphic Province of Northern California. This province is generally characterized by northwest-trending mountain ranges and intervening valleys, which are a reflection of the dominant northwest structural trend of the bedrock in the region. The basement rock in the northern portion of this province consists of the Great Valley Sequence, a Jurassic (200 to 145 million years old) volcanic ophiolite sequence with associated Jurassic to Cretaceous (200 to 65 million years old) sedimentary rocks and the Franciscan Complex, a subduction complex of diverse groups of igneous, sedimentary and metamorphic rocks of late Jurassic to early Tertiary age (161 to 34 million years old). The Great Valley Sequence was tectonically juxtaposed with the Franciscan Complex most likely during subduction accretion of the Franciscan and these ancient fault boundaries are truncated by a modern right-lateral fault system that includes the San Andreas, Hayward-Rodgers Creek, Maacama and West Napa faults. The San Andreas fault defines the westernmost boundary of the local bedrock and is located approximately 24.1 miles southwest of the reaches. In the site vicinity, the Franciscan Complex is unconformably overlain by Tertiary age continental and marine sedimentary and volcanic rocks. These Tertiary age rocks are locally overlain by younger Quaternary alluvial, colluvial and landslide deposits.

4.2 LOCAL GEOLOGY

The local geology has been mapped by Huffman and Armstrong (1980) and Wagner, et al. (2004). These references generally agree that the three (3) reaches and surrounding vicinity are underlain by Pleistocene and Holocene alluvial deposits. The low hills northeast of the reaches are mapped as being underlain by early Pliocene to late Miocene Sonoma Volcanics (andesite, basalt, rhyolite flows and tuff). Wagner et al. (2004) identify localized areas 500 to 1,000 feet southwest of the reaches underlain by early Pleistocene to Pliocene Glen Ellen Formation bedrock (claystone, sandstone, siltstone and gravel).

According to Huffman and Armstrong (1980), the three (3) reaches are located within Slope Stability Zone A, described as areas of greatest relative stability due to low slope inclination.

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4.3 FAULTS AND SEISMICITY

The site is located within the seismically active North Bay/North Coast Area of California. Several faults have been mapped in the general site vicinity. The San Andreas fault zone, located southwest of the site, is the boundary between two tectonic plates, the Pacific Plate (west of the fault) and the North American Plate (east of the fault). At this boundary, the Pacific Plate is moving north relative to the North American Plate. In the North Coast region of California, this movement is distributed across a complex system of predominantly strike-slip, right-lateral parallel and sub-parallel faults which include the San Andreas, Hayward-Rodgers Creek and the Maacama-Garberville, among others.

The site is not located within an Earthquake Fault Zone as defined by the California Geological Survey (CGS, 2010) in accordance with the Alquist–Priolo Earthquake Fault Zone Act of 1972 (AP Zone).

The nearest known active fault is the Hayward-Rodgers Creek fault, located approximately 3.8 miles southwest of the site, which is capable of producing a maximum earthquake magnitude event of 7.3. Moderate to major earthquakes generated on the Rodgers Creek fault can be expected to cause strong ground shaking at the site. In addition, strong ground shaking can be expected from moderate to major earthquakes generated on other faults in the region such as the San Andreas fault (located 24.1 miles southwest), the Maacama-Garberville fault (located 22.4 miles north of the site), the Concord-Green Valley fault (located 15.2 miles northeast of the site) and the West Napa fault (located 8 miles northeast of the site).

Table 4 below identifies the significant faults in the area and their corresponding parameters.

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TABLE 4: SIGNIFICANT FAULTS

Fault Name	Closest Distance to Site* (mi)	Magnitude of Characteristic Earthquake**	Slip Rate (millimeters/year)
Hayward-Rodgers Creek-SH+NH+RC	3.4	7.3	9
West Napa	7.3	6.7	1
Concord-Green Valley (connected)	15.2	6.8	5
Maacama-Garberville	22.4	7.3	9
San Andreas-SAS+SAP+SAN+SAO	24.1	8.1	17-24

* Closest distance to the potential rupture.

** *Moment magnitude*: An estimate of an earthquake's magnitude based on the seismic moment (measure of an earthquake's size utilizing rock rigidity, amount of slip, and area of rupture).

According to Petersen et al. (2008), characterization of the Hayward-Rodgers Creek and San Andreas faults are based on the following fault rupture segments and fault rupture scenarios:

- The Hayward-Rodgers Creek fault has been characterized by three segments and six rupture scenarios plus a floating earthquake. The three segments are the Rodgers Creek fault (RC), the Hayward North (HN), and the Hayward South (HS).
- The Concord-Green Valley fault has been characterized by three segments and six rupture scenarios plus a floating earthquake. The three segments are the Concord fault (CON), the Green Valley South (GVS), and the Green Valley North (GVN).
- The San Andreas Fault has been characterized by four segments and nine rupture scenarios, plus a floating earthquake. The four segments are Santa Cruz Mountains (SAS), Peninsula (SAP), North Coast (SAN), and Offshore (SAO).

A number of large earthquakes have occurred within this region in the historic past. Some of the significant nearby events include the 2000 Napa earthquake (M5.0), two (2) 1969 Santa Rosa earthquakes (M5.6, 5.7), the 2014 Napa earthquake (M6.0) and the 1906 San Francisco earthquake (M8+). Future seismic events in this region can be expected to produce strong seismic ground shaking at this site. The intensity of future shaking will depend on the distance

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from the site to the earthquake focus, magnitude of the earthquake and the response of the underlying soil and bedrock.

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5 SITE AND SUBSURFACE CONDITIONS

The following sections of this report describe general site conditions, subsurface stratigraphy, and groundwater depth. Our descriptions and conclusions are based on information from the field exploration conducted for this study.

5.1 SITE DESCRIPTION (REACHES A, B AND C)

The proposed SVCSD/SCWA Trunk Sewer Replacement Project will be located north and west of downtown Sonoma in Sonoma County. The proposed pipeline begins in the vicinity of 6th Street West and Studley Street and extends generally north and west to its terminus on Happy Lane. The ground surface along the proposed alignment is generally flat, rising from elevation +80 feet msl to approximately elevation +107 feet msl, with minor variations along its length. The depth to the sewer invert varies from approximately 8 to 26 feet below the existing ground surface. After a short section beneath 6th Street West, the alignment includes approximately 3,500 linear feet of sewer beneath Sonoma Highway (State Highway 12). It then passes beneath a private manufactured home park and then extends for more than 2,000 feet beneath Maxwell Farms Regional Park (Maxwell Park) before crossing Verano Avenue and connecting with a proposed inverted siphon sewer that passes beneath Agua Caliente Creek. The crossing of Agua Caliente Creek has been investigated by others (Brunsing Associates) and is not included in this project. At the northern end of the Agua Caliente Creek crossing, the sewer generally follows minor streets and obtained public sewer easements through residential neighborhoods to the terminus on Happy Lane.

5.2 STRATIGRAPHY

Based on the available geologic information and on the results of our field explorations, the site soils consist of variable alluvial soils ranging from plastic clays to clayey gravels. Stratigraphic boundaries and engineering properties within the strata vary along the proposed pipeline route, as is typical of alluvial environments. With the exception of occasional surficial layers of fill and recent alluvium, most soils encountered consist of Pleistocene age alluvium (11,000 years old to 1.8 million years old) or Glen Ellen Formation Plio-Pleistocene age bedrock (greater than 1 million years old). Although the Glen Ellen Formation is usually classified as bedrock, it generally has the consistency of a very dense to hard soil and is extremely difficult to distinguish

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from the slightly younger Pleistocene alluvium. The general material types, as encountered in our borings, are described below. Please refer to the boring logs for detailed soil descriptions at particular locations.

5.2.1 Surficial Fill and Holocene Alluvium

In many locations the near surface soils have been extensively disturbed by previous earthwork. In roadway areas pavement thicknesses varied from as little as 1.5 inches of asphalt concrete (AC) (on 6th Street West) to as much as 9 inches of AC overlying 7 inches of Portland cement concrete (PCC) (within Caltrans right-of-way). Beneath pavement sections, or at the ground surface in areas where no pavement was present, borings encountered undocumented fill to depths ranging from zero to as much as nine feet. Beneath the fills, native soils generally consist of Pleistocene or Plio-Pleistocene alluvium as discussed in Sections 5.2.2 and 5.2.3. In some locations the explorations encountered relatively thin overlying layers of more recent Holocene age alluvium (less than 11,000 years old). These younger soils typically are soft to medium stiff clay with undrained shear strengths of less than 1000 psf and with California sampler blow counts that are less than about 10 (blows per foot). In most areas the Holocene deposits do not extend deeper than 5 or 6 feet below the existing ground surface. However, borings KB-9 and KB-10, which are located in a broad flood plain of Sonoma Creek (within Maxwell Park), have soft to medium stiff soil with blow counts of 10 or less to depths of approximately 15 feet and 40 feet respectively. Additionally, in KB-10 some wood fragments and organic matter were encountered at a depth of 30 feet. These soils appear to be Holocene alluvium and it should be anticipated that some areas of deep Holocene alluvium may be encountered in the Maxwell Park area (for more detail see geotechnical report for Reach B).

5.2.2 Fine Grained Alluvium (Pleistocene or Plio-Pleistocene)

The majority of soils at this site consist of low plasticity (lean) to high plasticity (fat) clay with varying amounts of silt, sand and gravel. Clays were encountered in all of our borings except KB-7, KB-12, and KB-13, where soils were slightly coarser. The clays that we encountered are generally firm to very hard, with uncorrected California sampler blow counts that range from 7 to more than 50 blows per foot. Field indicator tests on these soils generally recorded undrained shear strengths in excess of 3000 psf; laboratory tests (under saturated conditions) measured undrained shear strengths in these soils ranging from 1300 to 4300 psf. As discussed in the preceding section, layers of soft to medium stiff clay (typically indicating an undrained shear

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strength of less than approximately 1000 psf) were encountered near the proposed pipeline invert in borings KB-9 and KB-10 (Reach B). It should be anticipated that localized areas of softer clay may be encountered in some locations along the sewer alignment.

The clays that were encountered along the proposed alignment are moderately plastic, with liquid limits (LL) that range from 36 to 44 and plasticity indices (PI) that range from 16 to 29. Based on the Atterberg Limit testing the clays appear to have low to moderate expansion potential. In most cases, the natural water content was found to be near the plastic limit of the soil when the water table was five feet or more below the sample tested. When the groundwater table was within five feet of the sample tested the natural moisture contents exceeded the PL and in one case (KB-16) the natural moisture content was close to the LL.

5.2.3 Granular Alluvium (Pleistocene or Plio-Pleistocene)

Intermixed with the clayey alluvial deposits, the borings encountered layered alluvial deposits of clayey gravel, clayey sand and occasionally silty sand and sandy silt. These granular alluvial deposits are highly variable, but generally have a significant clay content and moderate plasticity. They are interlayered with the clays and below the upper few feet (below ground surface) they tend to be dense to very dense, with uncorrected California sampler blow counts typically exceeding 40 to 50 blows per foot. One hollow stem auger boring (KB-7) met practical refusal at a depth of 26 feet, approximately 10 to 11 feet below the planned invert depth. Soil conditions at the bottom of this boring appeared to consist of a very dense sand or sandstone. Two direct push borings met refusal at depths shorter than scheduled (KDP-2 and KDP-6). These areas were re-explored in December of 2014 using a hollow stem auger (KB-2 and KB-6).

5.3 GROUNDWATER

As discussed in Section 2.3 of this report, six borings encountered groundwater at the time of drilling. Depths to groundwater that were recorded during drilling varied from about 14 feet to 41 feet below the ground surface. Due to the high clay content of the soils, the groundwater depths that were recorded during drilling may not be representative of the true, stabilized groundwater levels. In Boring KB-4 groundwater was recorded at a depth of about 41 feet at the time of drilling, but at a depth of about 22 feet in a piezometer at this location approximately

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two weeks later. In Boring KB-10, a wet sample was noted at a depth of about 35 feet, indicating groundwater near that depth at the time of drilling. However, a groundwater depth of 22 feet was measured in a piezometer at this location approximately two weeks later. The groundwater readings that were recorded during drilling probably represent a lower bound on groundwater levels. If given more time to stabilize, groundwater levels in the borings may have risen higher than shown on the boring logs.

The depth to groundwater is expected to vary with seasonal changes in rainfall and surface runoff. The borings for this study were drilled in the middle of summer during a period of extreme drought. In Boring KB-4 groundwater was recorded at a depth of about 41 feet at the time of drilling and at a depth of about 22 feet in a piezometer at this location approximately two weeks later. But in December, 2014 (following a period of relatively heavy rainfall) the recorded groundwater depth was only 11 feet. In Boring KB-10, a wet sample was noted at a depth of about 35 feet, indicating groundwater near that depth at the time of drilling. A groundwater depth of 22 feet was measured in a piezometer at this location approximately two weeks later but a groundwater depth of only 9.5 feet was recorded in December, 2014, again following a period of relatively heavy rainfall. It should be anticipated that groundwater levels may be higher than shown on the boring logs during summers following more typical rainfall patterns and may be considerably higher during prolonged wet winter weather. In addition, perched groundwater can develop in granular soils above less permeable soil layers, particularly during periods of prolonged wet weather. Water levels will continue to be monitored in the piezometers that were installed during this study as well as those at Agua Caliente Creek. A report addendum discussing groundwater will be provided in the late spring of 2015 after the end of the rainy season.

During periods of extended rainfall the space between a shoring system and retained soils can fill with water unless proper drainage is provided. See Section 7.5 for further discussion of groundwater conditions for design and construction.

5.4 CORROSION

Two samples of near surface soils were sent to an outside laboratory for testing to screen for corrosivity potential. Test results are presented in Appendix D of this report. The test results are tabulated in Table 5.

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TABLE 5
SUMMARY OF CORROSION TEST RESULTS

Boring /Sample No.	Sample Depth (feet)	Minimum Resistivity (Ohm-Cm)	pH	Water Soluble Sulfates (ppm)	Water Soluble Chlorides (ppm)
KB2/ 3C	16	1,530	6.72	5.1	14.6
KB14/ 2B&C	6	1,880	6.39	29.1	17.1

Based on the Caltrans Corrosion Guidelines (2003 version 1.0), a site is considered corrosive if one or more of the following conditions exist for the representative soil and/or water samples taken at the site: Chloride concentration is 500 ppm or greater, sulfate concentration is 2000 ppm or greater, or the pH is 5.5 or less. A minimum resistivity value for soil and/or water less than 1000 ohm-cm indicates the presence of high quantities of soluble salts and a higher propensity for corrosion. Based on the above results and the Caltrans Corrosion Guidelines, the tested sample is considered non-corrosive.

According to ACI 318 Section 4.3, Table 4.3.1, a sulfate concentration below 0.10 percent by weight (1,000 ppm) is negligible. A water-soluble chloride content of less than 500 ppm is generally considered non-corrosive to reinforced concrete. Based on these guidelines and the above test results the sample tested is considered non-corrosive to concrete.

Another factor for evaluating soil corrosivity to buried metal is electrical resistivity. The electrical resistivity of a soil is a measure of resistance to the flow of electrical current. Corrosion of buried metal is an electrochemical process in which the amount of metal loss due to corrosion is directly proportional to the flow of electrical current (DC) from the metal into the soil. As the resistivity of the soil decreases, the corrosivity generally increases. A common correlation between soil resistivity and corrosivity towards ferrous metals (NACE 1984) is provided below:

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Minimum Resistivity (ohm-cm)		Corrosion Potential
0 to 1,000	-	Severely Corrosive
1,000 to 2,000	-	Corrosive
2,000 to 10,000	-	Moderately Corrosive
Over 10,000	-	Mildly Corrosive

Based on this correlation the soil samples tested would be considered corrosive to buried metal.

The above corrosion tests are preliminary only and are an indicator of potential soil corrosivity for the sample tested. Other soils found on the site may be more, less, or of a similar corrosive nature. If corrosion is a concern to you, we recommend that a competent corrosion engineer be retained to evaluate the corrosion potential of the site to proposed improvements, to recommend further testing as required, and to provide specific corrosion mitigation methods appropriate for the project.

5.5 VARIATIONS IN SUBSURFACE CONDITIONS

Our interpretations of soil and groundwater conditions in this report are based on data obtained from widely-spaced borings, geologic research and laboratory test data collected for this study. The conclusions and recommendations that follow are based on interpretations and extrapolation of that data. It is likely that undetected variations in subsurface conditions exist at the site and that seasonal variations in groundwater levels will occur.

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6 GEOLOGIC HAZARDS AND SEISMIC DESIGN CONSIDERATIONS

Potential geologic hazards reviewed for this project include seismic shaking, fault ground rupture, liquefaction and seismically-induced slope failures. Each of these items is discussed below.

6.1 SEISMIC SHAKING

The site will likely be subjected to at least one moderate to severe earthquake and associated seismic shaking during the pipeline lifetime. Some degree of structural damage due to strong seismic shaking can be expected at the site. Periodic slight to moderate earthquakes should also be expected.

6.2 FAULT GROUND RUPTURE

As discussed in Section 4.3, no active faults are mapped at or in the immediate vicinity of the proposed pipeline alignment. Based on our literature review and site visits, we believe that the potential for fault-related surface rupture along the pipeline route is low.

6.3 LIQUEFACTION AND LATERAL SPREADING

Soil liquefaction is a condition where saturated, granular soils undergo a substantial loss of strength due to pore pressure increase resulting from cyclic stress application induced by earthquakes. In the process, the soil may acquire a mobility sufficient to permit both horizontal and vertical movement if the soil mass is not confined. Soils most susceptible to liquefaction are saturated, loose, clean, uniformly graded, Holocene age, and fine-grained sand deposits located below the groundwater table. In order for soil liquefaction and possible associated effects due to ground shaking to occur, it is generally accepted that four conditions are necessary:

- The subsurface soils are in a relatively loose state
- The soils are saturated
- The soils have very low plasticity
- Ground shaking is of sufficient intensity and duration to act as a triggering mechanism

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Along this alignment, the factors controlling liquefaction potential are primarily the soil plasticity and soil density, as discussed below.

Soil Plasticity

Researchers generally agree that soils with a sufficiently high plasticity will not liquefy, although there is not universal consensus on the level of plasticity required. Boulanger and Idriss (2006) conclude that soils with a fines content exceeding about 35% should be considered non-liquefiable when the Plasticity Index (PI) exceeds 7. Seed et al (2003) set the limit at a PI of 12.

As discussed in Section 5.2, the majority of soils at this site consist of low to high plasticity clay. For the soils tested at this site we recorded PI values between 16 and 29. Based on these values, the soils at this site with fines contents greater than 35% are judged to have a low liquefaction potential.

Soil Density

For granular soils with less than 35% fines, liquefaction susceptibility is usually controlled by the soil fabric and density. As discussed in Section 5.2, most of the soils that we encountered at this site are Pleistocene age or older. Due to the soil fabric (and density) developed during their stress history (having been subjected to numerous previous cycles of seismic shaking over a period of tens of thousands of years), Pleistocene age deposits have consistently been determined to have low to very low liquefaction potential (Idriss & Boulanger 2008). The "Final Technical Report, Characterization of Subsurface Sediments, Northern San Francisco Bay Area, U.S. Geologic Survey, National Earthquake Reduction Program, Award No. 02HQ-GR0038," (Lettis, 2007) states: "In general, the 'top of Pleistocene' represents the probable base of potentially liquefiable deposits within the Bay area." Typically this resistance to liquefaction is reflected by relatively high blow counts during sampling.

Based on Youd (2001), $(N_1)_{60}$ blow counts (blows per foot) exceeding 21 indicate low liquefaction potential (regardless of the Peak Ground Acceleration, PGA) for soils with a fines content of 35% or more and $(N_1)_{60}$ blow counts exceeding 29 indicate low liquefaction potential (regardless of PGA) in soils with a fines content as low as 5%. Disregarding soils in the upper 5 feet (which will not affect sewer performance) we obtained 14 samples of sands and gravels,

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all but one of which had fines content between 12% and 50%. The granular soils sampled had uncorrected California sampler blow counts ranging from 28 to 100+, with an average blow count of approximately 80. Using methods developed by Youd, these correlate to $(N_1)_{60}$ blow counts ranging from 21 to 50+, with an average of approximately 45. Based on these considerations, the granular soils at this site (below a depth of 5 feet) were classified as Pleistocene or older and should have low liquefaction potential.

Summary

The soils along the pipeline alignment (below a depth of approximately five feet) generally have low liquefaction potential, as discussed above. However, alluvial deposits can vary significantly and there is a possibility of localized areas of potentially liquefiable soil, particularly in the area of deeper Holocene deposits beneath Maxwell Park (Reach B). As a general design guideline, we recommend the pipeline be designed to accommodate up to 2 inches of liquefaction settlement in isolated locations. The estimated differential settlement would be as much as 2 inches in 50 feet following major seismic events.

Lateral spreading is a potential hazard commonly associated with liquefaction where extensional ground cracking and settlement occur as a response to lateral migration of subsurface liquefiable material. Because no large or continuous zones of potentially liquefiable soil were encountered, and because the ground surface is relatively level, we consider that the potential for lateral spreading to take place along this alignment is low.

6.4 LANDSLIDES AND SEISMICALLY-INDUCED SLOPE FAILURES

Areas along the pipeline alignment are relatively flat and are generally not susceptible to landslide and seismically-induced slope failures.

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7 PIPELINE DESIGN AND INSTALLATION RECOMMENDATIONS - REACH A

7.1 GENERAL

The previous sections of this report discussed geotechnical conditions along the entire proposed alignment (Reaches A, B, and C). The remainder of this report pertains only to Reach A.

Based on our review of the field exploration and laboratory data collected to date, we conclude the project as currently proposed is feasible from a geotechnical standpoint, provided the recommendations presented in this report are incorporated in design and construction. This report section includes discussion of open-trench construction recommendations, trench backfill recommendations, soil loads on buried pipe, and other aspects of geotechnical design as well as construction considerations for the pipeline.

We understand the District is currently deciding whether to employ open-trench construction methods for the majority of the pipeline, with trenchless crossings at selected locations, or to employ trenchless construction methods throughout the pipeline alignment. Section 7.2 and 7.3 provide recommendations for open-trench construction and Section 7.4 provides general recommendations for trenchless construction.

7.2 OPEN-TRENCH CONSTRUCTION

Sections 7.2 and 7.3 of this report present our recommendations for open trench construction for the pipeline. Our discussions include general recommendations regarding excavation planning, anticipated subsurface conditions in open-cut trenches, and a discussion of surcharging adjacent to open trenches. Trenchless construction methods are discussed in Section 7.4.

7.2.1 Excavations and Shoring

Construction site safety should be the sole responsibility of the Contractor, who should also be solely responsible for the means, methods, and sequencing of construction operations. We are providing the information below solely for consideration in design and specification development. Under no circumstances should the information provided herein be interpreted to

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mean that Kleinfelder is assuming responsibility for construction site safety or the Contractor's activities. Such responsibility is not implied and should not be inferred.

Excavations should comply with applicable local, state and federal safety regulations including the current OSHA Excavation and Trench Safety Standards. Shoring and bracing should be designed by a California-registered professional engineer.

Appropriate trench excavation and shoring methods will depend on the various soil and groundwater conditions encountered. We emphasize that most of Reach A is located in developed urban areas and that near-surface soils may vary in composition and quality. We expect the soils that will be encountered in trench excavations will be subject to random caving and sloughing. We recommend that trench excavations and shoring be designed to accommodate significant variability in subsurface material quality and composition. Shoring should extend sufficiently below the bottom of the trench to provide the required lateral resistance. Where trenches are excavated more than about 3 feet below groundwater levels, upwelling of seepage, especially in soft or cohesionless soils, can cause bottom heave and/or sand boils, which loosen the trench bottom materials. Sheet pile shoring systems, if used, can be used to reduce the upward groundwater seepage gradient if they are driven to a sufficient depth below the trench bottom. Alternatively, external well or well point dewatering systems could be used to lower external groundwater levels to acceptable levels. In any case, shoring and dewatering systems should be compatible. In developed areas, positive restraint of trench walls is recommended. Use of trench boxes and similar systems that do not provide positive restraint of trench walls can cause lateral movement and/or caving of trench walls and resulting distress to adjacent structures and/or pavements.

In addition to the soil and groundwater conditions, the restraint condition at the top of the shoring system will affect the magnitude of lateral pressures. Our experience indicates that cantilevered or unbraced sheeting is typically limited to excavations less than about 10 to 12 feet deep. Because of the depth of the proposed sewer in Reach A (approximately 16 to 26 feet) we expect that braced sheeting will be necessary.

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Although the design of shoring should be the responsibility of the contractor, if requested we can provide approximate pressures for use by the owner in alternatives analysis or for use in preparing construction cost estimates.

7.2.2 Lateral Shoring Pressures

At the request of the District this section contains preliminary estimated lateral earth pressures for shoring. These pressures do not contain a factor of safety and are provided for estimating purposes only. Shoring pressures will depend on specific soil and groundwater conditions encountered at the shoring location, as well as upon the type of shoring used, the method of shoring placement and the dewatering systems employed. Shoring design is the sole responsibility of the contractor and the pressures provided herein should not be used for final design unless independently arrived at by the contractor.

7.2.2.1 Active Earth Pressures

Cantilevered shoring systems, i.e., soldier piles, sheet piles, or similar shoring systems should be designed to resist an active earth pressure equivalent to a fluid weighing 40 pounds per cubic foot (pcf). Braced excavations should be designed to resist a uniform horizontal soil pressure of 25H (in pounds per square foot, psf), where H is the height of the shoring in feet. These values are applicable to the medium dense to very dense sandy soils and stiff to very hard silts and clays encountered at the site. For combined vertical and sloping trenches, an additional lateral force due to the sloping trench wall behind the shoring will be imparted to shoring systems. This value will be dependent on the trench slope angle and should be determined by the designer once the desired trench slope configuration is chosen.

Lateral deflection of the shored excavation will depend on the relative stiffness of the shoring system selected and mobilization of the active earth pressure. The limiting condition of maximum active earth pressure for stiff to hard silts and clays is generally reached when the shoring tilts or deflects laterally about 1 percent of the shoring wall height. The limiting condition of active earth pressure for medium dense to dense sands and gravels is generally reached when the shoring tilts or deflects laterally about 0.2 percent of the shoring wall height. If the shoring tilts or deflects less than the limiting condition, the lateral earth pressure will lie between the active and at-rest earth pressures. This soil movement has been observed extending horizontally as far back as 2H from the top of cantilever retaining structures with vertical

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movements approximately equal to the horizontal. The movement tends to be greatest close to the excavation and becomes less with increasing distance.

The shoring designer should perform a deflection analysis of the shoring system. If movements are greater than the tolerance of existing project features (utilities, pavements, structures, etc.) tie-backs, dead-man anchors, or cross bracing may be needed to reduce deflections. Design using the at-rest pressure and more stringent tie-back or bracing requirements may be required in the vicinity of improvements that cannot withstand lateral movements.

7.2.2.2 At-Rest Earth Pressures

Sheet pile, soldier pile, or similar shoring systems either incapable of deflection or which are fully constrained against deflection may be designed for an equivalent fluid at-rest pressure of 60 pcf for level backfill.

7.2.2.3 Surcharge Pressures

Shoring systems should be designed to resist forces resulting from surface loads placed at or near the walls. A Surcharge Factor (ratio of horizontal pressure to applied vertical load) of 0.50 should be used for design when evaluating surcharge pressures in level backfill.

7.2.3 Anticipated Shallow Trench Soil Conditions

Refer to Section 5 of this report and the boring logs (Appendix A) for detailed descriptions of the subsurface soil and groundwater conditions encountered during our field exploration. A brief summary tailored to a discussion of shallow excavations is provided below.

Near-surface soil conditions are variable, in part due to past earthwork activities. About 1½ to 6 feet of fill was encountered in the six borings drilled within Reach A. The maximum fill depth was recorded in Boring KB-4. Beneath the fill in Boring KB-4, approximately five feet of soft to firm clay (probable Holocene deposits) was encountered. Below the Holocene deposits in Boring KB-4, and below the fill in the other borings in Reach A, firm to hard clay with occasional layers of clayey gravel was encountered to depths exceeding the pipeline invert.

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We understand the new approximately 27-inch ID (inside diameter) by 30-inch OD (outside diameter) pipeline will be installed at invert depths of about 16 to 26 feet. At the trenchless crossings, the pipe jacking and receiving pits will need to extend about 3 to 4 feet below the pipe invert. As shown in Section 2.3, measured groundwater depths in our borings and piezometers are below the pipeline invert throughout Reach A. However, as discussed in Section 5.3, the depth to groundwater is expected to vary with seasonal changes in rainfall and surface runoff. Readings from the piezometer on the north side of Agua Caliente Creek (Agua Caliente 2) fluctuated by 16 feet over the course of the last two years. The borings for this study were drilled in the middle of summer during a period of extreme drought. It should be anticipated that groundwater levels will be significantly higher during a year of more typical rainfall conditions. In addition, perched groundwater can develop in granular soils above less permeable soil layers, particularly during periods of prolonged wet weather. Water levels will continue to be monitored in the piezometers that were installed during this exploration as well as the piezometer installed by others on the south bank of Agua Caliente Creek, and a report addendum will be provided when this data is available. For additional discussion of groundwater conditions refer to Sections 5.3 and 7.5.

7.2.4 Surcharges

The contractor should avoid stockpiling excavated materials adjacent to open trench excavations. We recommend that stockpiled materials, building materials, vehicular traffic and heavy construction equipment be kept back from the excavation a distance of at least half the excavation depth to reduce surcharges on shoring and open cuts. If this is impractical due to space constraints, the trench shoring system must be designed for the anticipated surcharge loading by a California-registered Professional Engineer.

7.2.5 Excavation Conditions

Soil conditions in Reach A are described elsewhere in this report and more detailed information is presented on the boring logs. Although some material encountered in our borings may be geologically classified as bedrock, borings that were drilled with a truck mounted hollow stem were advanced to below the pipeline invert with low to moderate difficulty. The two borings in Reach A that were drilled with light weight direct push equipment (KDP-2 and KDP-6) met refusal at relatively shallow depths (7’ and 10’ respectively). We expect that subsurface material encountered in Reach A can be excavated with a moderate sized excavator (Caterpillar

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235 or equal). However it is possible that more resistant cemented soil or bedrock could be encountered that could require the use of larger equipment or a hydraulic hammer.

7.2.6 Bedding and Backfill

The following paragraphs present our recommendations for trench width, bottom preparation and trench backfill under vehicle pavements and under undeveloped areas.

7.2.6.1 Bottom Preparation

The contractor should evaluate appropriate dewatering methods based on the soil and groundwater conditions described in this report. Dewatering methods should assume that conditions will include interlayered clays, silts, sands, and gravels, with the possibility of both confined and perched aquifers. In addition, the contractor should monitor groundwater levels well in advance of the start of construction in order to plan for an appropriate dewatering system. If shallow groundwater occurs in the excavations, we suggest that a component of a dewatering plan could include an over-excavated trench about 12 inches deep below the pipe bedding, which could be backfilled with crushed stone or other granular material to provide, 1) a stable working base for pipe installation and 2) a drainage conduit under the trench bottom. Trench dams and sumps could be included in the over-excavated trench to help direct water to interceptor sumps where the water can be pumped out of the trench. Note, however, that use of shallow dewatering systems such as sumps can lead to bottom heave and boils if the groundwater is more than a few feet above the trench bottom. Where groundwater levels are more than 2 feet above the bottoms of the excavations, dewatering wells or well points should be used instead of sumps and pumps within the excavations. The contractor should be aware that significant groundwater may be encountered during excavation. In cases with significant water infiltration, additional over-excavation and other groundwater controls may be warranted.

The trench width and pipe bedding should be prepared in accordance with the pipe manufacturer's recommendations. Loose, soft or disturbed soils lying at the sides or bottom of pipeline trenches should be removed to prepare a firm, uniform subgrade. Soft, weak or pumping soils are not anticipated at the bottom of the trench, if the trench is properly dewatered. However, if weak or otherwise unsuitable soils are encountered at the base of the trench and over-excavation is required, the over-excavation should be backfilled with ¾-inch clean, crushed rock. It has been our experience that up to about 2 feet of over-excavation can be needed to

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stabilize soft and wet trench bottoms. The actual depth of over-excavation needed will depend on the field conditions and should be evaluated by the geotechnical engineer on a case-by-case bases during construction. Clean crushed rock should be hard, durable, clean gravel and should be free from significant organic material, clay balls, or other deleterious materials. Clean crushed rock backfill for over-excavated material should be surrounded by (encapsulated within) a nonwoven filter fabric to prevent migration of surrounding fine soils into the crushed rock zone. Fabrics such as Mirafi 140 N or equal are generally appropriate for this use.

7.2.6.2 Pipe Bedding and Pipe Zone Backfill Placement

In general, the trench width should be at least 1.5 times the pipe diameter, leaving a minimum of 10 inches on either side of the pipe, plus the shoring width. Pipe bedding and pipe zone backfill materials should meet District and pipeline manufacturer's specifications for material gradation and thickness. If used, clean crushed rock bedding and initial backfill materials should be surrounded by a non-woven filter fabric to prevent migration of fines into the voids in the material. If washed sand or compacted Caltrans Class 2 aggregate base material is used, a filter fabric wrap will not be necessary. Bedding materials should be placed and compacted to a firm condition prior to installing pipes in a manner to eliminate voids beneath the pipe. Care should be taken to place the side fill soil in such a manner that it will be in intimate contact with the sides of the pipeline. Crushed rock materials should be placed in lifts no greater than 12 inches in thickness and be compacted until no further consolidation occurs under the compaction equipment. Aggregate base materials should be compacted to at least 90 percent relative compaction, based on ASTM D1557. If used, washed sand should be placed wet such that it is able to flow completely around the pipe and/or be shovel sliced under the haunch areas. The sand should either be compacted by tamping or by placing and compacting a thin lift (about 8 inches or less) of trench backfill over it.

7.2.6.3 Backfill under Pavements

Unless the City, County or Caltrans have other requirements, we recommend trench backfill placed between the initial pipe zone backfill and the subgrade elevation be nearly free of organic materials, debris, or other deleterious materials, be essentially non-plastic, and have a maximum particle size less than 3 inches in maximum dimension. In general, well-graded mixtures of gravel, sand, non-plastic silt, and small quantities of clay are acceptable for use as

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engineered fill. Specific requirements for engineered fill, as well as applicable test procedures to verify material suitability are provided in Table 5.

TABLE 6
ENGINEERED FILL REQUIREMENTS

		Test Procedures	
Fill Requirement		**ASTM[1]**	**Caltrans[2]**
Gradation			
Sieve Size	**Percent Passing**		
3 inch	100	C136	202
¾ inch	70-100	C136	202
No. 200	15-70	C136	202
Plasticity			
Liquid Limit	**Plasticity Index**		
<30	<12	D4318	204

Notes: 1. American Society for Testing and Materials Standards (latest edition)
2. State of California, Department of Transportation, Standard Test Methods (latest edition)

Alternatively, Caltrans Class 2 aggregate base material can be used for trench backfill. Trench backfill should be uniformly moisture conditioned to 0 to 2 percent above the optimum moisture content, placed in lifts that do not exceed 8 inches in loose thickness, and be compacted to at least 90 percent relative compaction based on ASTM D1557. Trench backfill should not contain corrosive agents or soft, friable, or thin elongated particles in quantities considered deleterious by Kleinfelder. The trench backfill should extend to a depth of 12 inches below the bottom of the existing aggregate base that is beneath the asphalt surfacing. The final 12 inches of trench backfill should be Caltrans Class 2 aggregate base material. Aggregate base materials should be uniformly moisture conditioned to 0 to 2 percent above the optimum moisture content, placed in lifts that do not exceed 8 inches in loose thickness, and be compacted to at least 95 percent relative compaction based on ASTM D1557.

With the possible exception of some existing pavement base course, excavated materials from the trench will not generally be suitable for use as backfill beneath pavements, sidewalks or structures due to their high fines content and high plasticity.

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To expedite backfilling and to eliminate the need for compaction, controlled density fill (CDF) may be used as backfill to a depth of 12 inches below pavement base materials. CDF should have a 48-hour compressive strength of about 50 to 100 psi. CDF is a slurry,therefore, measures should be taken to eliminate the potential for pipe flotation. In addition, the slurry mixture will need to set sufficiently prior to allowing traffic on it, as it may become unstable if not sufficiently cured.

7.2.6.4 Undeveloped Areas

In undeveloped areas, away from roadways or other construction, where surface settlement is acceptable to the property owner, general fill consisting of excavated materials may be used. General fill should be placed in loose lifts not exceeding 8 inches and should be compacted to at least 90 percent of the ASTM D1557 maximum dry density at a moisture content between 2 and 4 percent above the optimum moisture content.

7.3 PIPELINE DESIGN CRITERIA

7.3.1 Trench Installations

Flexible pipes constructed in open trenches typically derive part of their resistance to ring deflection from the stiffness of initial backfill and trench wall soils. Evaluation of ring deflection of buried pipes under soil and live loads may be determined using the Iowa Formula. The elastic modulus of the soils surrounding the pipe, or E', may be evaluated by knowing the trench width, the pipe diameter, the elastic modulus of the initial backfill (E'_b), and the elastic modulus of the native trench wall soils (E'_n - also termed Constrained Modulus). Recommendations for pipe design using the Iowa Formula are presented in Tables 6 and 7.

Table 6 presents recommended E'_b values for use in the Iowa Formula for proposed initial backfill materials placed and compacted in accordance with our recommendations. The value of E'_b is a lateral modulus of subgrade reaction for the initial backfill material. For E'_b values at depths between the intervals presented below, the E'_b value between data points may be determined by linear interpolation.

The recommended E'_b values presented in Table 6 apply to clean crushed rock or washed sand bedding and initial backfill material along the sides of the pipe at the recommended level of

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compaction. These values are applicable for pipe design where the initial backfill width is at least 2 times the pipe diameter (D) on each side of the pipe (trench width of 5D). Since trenches are normally not that wide, the values require adjustment based on the actual trench width and depth. That methodology is discussed below. Alternatively, we can provide more specific design values if we are provided with specific trench widths.

TABLE 7
E'_B VALUES FOR DESIGN OF BURIED FLEXIBLE PIPES

Soil Type	Depth to Springline of Pipe (ft)	Recommended E'_b (psi)
Pipe Bedding and Initial Backfill (clean crushed rock or washed sand)	5 10 15 20+	1000 1500 1600 1700

Notes:
1. The above design values are based on "Evaluation of the Modulus of Soil Reaction, E', and its Variation With Depth," by Hartley & Duncan, dated June 1982.
2. Based on providing at least 2 pipe diameters of backfill on each side of pipes. For narrower trenches use composite E' based on Soil Support Combining Factors.

Where the zone of backfill beside the pipe is less than 2D, the E'_b values presented above may not be applicable and the constrained soil modulus E'_n will affect flexible pipe design. The actual lateral soil modulus at the pipe depth will lie somewhere between E'_b and E'_n depending on the trench width.

Based on the field and laboratory data obtained along the pipeline alignments, we recommend an E'_n value of 3,000 psi (Howard, 1996) be used for design of flexible pipes. This value is applicable to the undisturbed native soils encountered at the site.

For trench widths less than 5D, the design E' may be calculated by multiplying E'_b by the Soil Support Combining Factors (S_c) presented in Table 7, where B_d is the trench width at pipe springline and D is the diameter of the pipe.

$$\text{Design } E' = S_c(E'_b)$$

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TABLE 8
SC VALUES FOR DESIGN OF BURIED FLEXIBLE PIPES
(SOIL SUPPORT COMBINING FACTOR)

E'_n/E'_b	B_d /D 1.5	B_d /D 2.0	B_d /D 2.5	B_d /D 3.0	B_d /D 4.0	B_d /D 5.0
0.1	0.15	0.30	0.60	0.80	0.90	1.00
0.2	0.30	0.45	0.70	0.85	0.92	1.00
0.4	0.50	0.60	0.80	0.90	0.95	1.00
0.6	0.70	0.80	0.90	0.95	1.00	1.00
0.8	0.85	0.90	0.95	0.98	1.00	1.00
1.0	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.30	1.15	1.10	1.05	1.00	1.00
2.0	1.50	1.30	1.15	1.10	1.05	1.00
3.0	1.75	1.45	1.30	1.20	1.08	1.00
5.0	2.00	1.60	1.40	1.25	1.10	1.00
Source: "Pipeline Installation," A. Howard, 1996.						

If CLSM is utilized around the pipe for this trench configuration, E'_n should be used for the E'_b value.

7.3.2 Flexible Pipe Trench Width Recommendations

According to ASTM D 2321, "Standard Practice for Underground Installation of Thermoplastic Pipes for Sewers and other Gravity-Flow Applications", the minimum trench width for flexible pipes should be the greater of 16 inches greater than the pipe diameter or 1.25 times the pipe diameter plus 12 inches. For flexible pipes, the trench width should be kept to a minimum to reduce the soil loading on the pipes. Wider trenches will generally impart higher soil loads on buried flexible pipes.

Where granular pipe zone backfill is used, the trench should be wide enough to accommodate compaction equipment and shoring along the sides of the pipe. Where CLSM or CDF is used, the minimum trench width should be sufficient to allow proper placement of the material and provide the required lateral pipe support.

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7.3.3 Flexible Pipe Construction Considerations

Flexible pipes generally require uniform support from bedding and initial backfill materials, especially in haunch areas, to prevent excessive ring deflection or other deformations. Care should be taken during installation of the bedding and initial backfill beneath the haunches of the pipe (i.e., from the bottom of the pipe to springline) such that voids or loose zones are eliminated and the backfill material is firm and unyielding. The initial backfill placed above the springline of the pipe should be placed evenly on both sides of the pipe in a manner to avoid deforming the top of the pipe.

The pipeline designers should evaluate the proximity of adjacent pipelines, excavations, and their related effects on the proposed construction. If proper trench wall support cannot be provided in a portion of the pipe trench, we recommend consideration be given to the use of controlled low strength material (CLSM) or controlled density fill (CDF) bedding and initial backfill around the pipes. The CLSM is normally made using local soils, cement, water and various additives, as relatively low strength and has good flowability characteristics. The CDF is made at a concrete batch plant and is designed for relatively low strength and good flowability. In general, we recommend CLSM or CDF materials have a 28-day compressive strength between 50 and 150 psi.

7.4 TRENCHLESS CONSTRUCTION METHODS

7.4.1 General Discussion

In its current alignment, Reach A is comprised of 5 straight-line segments.

- Approximately 300 feet along West 6th street, from Studley Street to West Napa Street, 16 to 19 feet deep.
- Approximately 1,400 feet along West Napa Street to the beginning of the curve onto Sonoma Hwy., 16 to 19 feet deep.
- A short section approximately 250 feet long at the intersection of West Napa Street and Sonoma Hwy., approximately 16 feet deep.
- Approximately 1,600 feet along Sonoma Hwy from the intersection with West Napa Street to Ramon Street, 16 to 26 feet deep.

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The selection of an appropriate trenchless pipeline installation method will depend on factors including drive length, subsurface conditions (stratigraphy and groundwater), external casing requirements, geometric constraints at the ground surface (i.e., construction laydown area requirements), grade and alignment tolerances for pipe to be installed, and constraints of the different excavation and pit shoring methods. Because of the varied lengths of these five segments, different trenchless construction methods may be appropriate for the shorter and longer tunnel drives in this reach. If the entire pipeline were to be installed using the same trenchless method, guided auger boring or microtunneling would probably offer the most flexibility for all portions of the alignment and provide the required line and grade control. Shorter segments (i.e., less than about 300 feet) could be accomplished by jack and bore or pipe ramming provided some misalignment of the casing pipe is tolerable and the sewer pipe can be placed at the desired grade within the casing. For these short crossings, the external casing pipe would likely be about 12 to 18 inches larger than the inside diameter of the trunk sewer pipe. That leaves several inches of tolerance if the casing pipe is not exactly on its proposed line and grade. However, with these methods the risk of bore misalignment is high and is often unpredictable depending upon variations in soil conditions between the borings and on the contractor's equipment and expertise. For these reasons we generally recommend a steerable system such as guided auger boring or microtunneling be used for gravity flow sewers. In this report we have limited our discussions to steerable tunneling methods, however we can provide additional information on systems such as jack and bore or pipe ramming, if requested. Both guided auger boring and microtunneling methods would likely require intermediate jacking shafts between individual drive segments unless microtunneling with intermediate jacking stations is used. More discussion of the trenchless methods, including the use of intermediate jacking stations is provided in subsequent sections.

7.4.2 Microtunneling

Where tunnel drive lengths are longer than about 300 to 400 feet, microtunneling methods should be considered for trenchless pipeline installation. Microtunneling uses a remote-controlled Microtunnel Boring Machine (MTBM) that provides continuous support to the tunnel face. Sections of jacking pipe or a steel casing are jacked into place behind the MTBM and the sewer is later installed through this casing. The excavated materials are conveyed through the MTBM and jacked pipes and are removed at the entry pit. Spoil removal methods may employ

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auger, conveyor, or slurry systems. Slurry systems typically require more space as a slurry/spoil separation system is needed.

The MTBM is launched and recovered from access shafts on either end of the crossing. This method can be used in most soil conditions above or below groundwater, except that cobbles and boulders can be problematic depending on their size in relation to the MTBM diameter. Microtunneling provides excellent control of line and grade and is the most common choice for the trenchless installation of long gravity sewers. Because it requires jacking and receiving shafts (to accommodate the MTBM) and very specialized equipment, it is often more expensive than other trenchless methods of construction.

Microtunneling methods are steerable and can be installed using methods that provide balanced earth pressures at the tunneling face, which reduces the potential for ground settlement and heave. During microtunneling, the microtunnel bore diameter is generally slightly larger than the diameter of the installed pipe. Radial overcut is typically on the order of 1 inch to permit advancement and steering of the MTBM. At that level of overcut and using a minimum pipe depth of about 16 feet, the potential for ground surface settlement exists and that settlement should be on the order of ¾ to 1 inch or less in the absence of a grout backfill of the annular space. If the annular space is contact grouted immediately following tunneling, the magnitude of ground surface settlement can generally be reduced to ½ inch or less. This grouting is normally done through a series of grout ports installed in the steel casing pipe. The actual settlement will depend on the ground conditions, contact grouting program, and the contractor's means and methods.

The launching and recovery shafts (to insert and recover the MTBM) typically measure about 40 feet long by 20 feet wide but will depend on the contractor's equipment. Jacking pipe may consist of steel, reinforced concrete, polymer concrete or vitrified clay jacking pipe. Microtunneling machines are available in various sizes and configurations from about 12 inches to over 60 inches in diameter, and should be available in a size to accommodate advancement of a 42- to 48-inch-diameter steel casing within which the a 30-inch O.D. diameter sewer pipe can be installed.

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Maximum drive lengths for a 42-inch or 48-inch-diameter steel casing pipe generally range from about 600 to 800 feet depending on equipment and soil conditions. For a longer trenchless alignment using typical microtunneling equipment, intermediate jacking shafts or jacking stations would be needed at maximum drive length intervals. Using the intermediate jacking shaft approach, the MTBM would be launched from the launching shaft into an intermediate shaft constructed near the anticipated maximum drive length. After entering the intermediate shaft, the MTBM would be re-launched again to the next shaft, and so on until reaching the end of the trenchless alignment where it would enter a recovery shaft and be removed.

To reduce the number of microtunneling shafts on a relatively long trenchless alignment, intermediate jacking stations can be used. The method uses a hydraulic jacking ring installed within the pipe string being jacked. The unit is placed at a joint along the pipe string where needed to provide the required jacking forces. In this manner, the MTBM is jacked forward as far as possible (limited by friction and jacking force limitations), and an intermediate jacking station unit is installed on the pipe string. As that unit is expanded, it jacks the forward pipe string forward. As the unit is retracted, the rear pipe string is jacked forward as much as possible using the jacking frame in the launching shaft. Then the intermediate jacking station is expanded again to move the front pipe string further forward, followed by jacking the rear station forward again from the launching shaft, and so on until the drive is completed and the TMBM is removed from the recovery shaft. Using this method, the drive length can be increased to accommodate the 1,400 and 1,600 foot segments thereby reducing the number of shaft exaction needed. Since the intermediate jacking station units have limited throw and several jacking units must be operated, this process can be slower than using shorter drive lengths with intermediate shafts.

7.4.3 Guided Auger Boring

A method to improve the precision of horizontal auger boring is through use of a guided boring machine (GBM) often referred to as guided auger boring (GAB) or pilot tube microtunneling (PTMT). The GBM employs a laser-guided steering head which is used to install a small-diameter pilot tube from the entrance pit to the exit pit. Next, the boring head is attached to the pilot tube and advanced by jacking pipe or casing segments behind it. The GBM method typically is applicable for pipe sizes up to about 55 inches in diameter. GBM methods generally do not work well in very dense or cemented soils due to pilot tube penetration and equipment

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torque limitations. Such soils were not encountered in the borings drilled along this reach. However, coarse gravel layers are present in some areas that could affect the ability to advance the pilot tube. This method should be able to produce bore drive lengths in the 400-foot range in most of the soil units encountered at the site.

Similar to microtunneling, the GAB bore diameter is generally slightly larger than the diameter of the installed pipe but the overcut can be less as the GAB boring unit does not have to turn to steer. Radial overcut is typically on the order of ½ inch. At that level of overcut and using a pipe depth of about 16 feet, the potential for ground surface settlement exists and that settlement should be on the order of ½ inch or less in the absence of a grout backfill of the annular space. If the annular space is contact grouted immediately following tunneling, the magnitude of ground surface settlement can generally be reduced below ½ inch. This grouting is normally done through a series of grout ports installed in the steel casing pipe. The actual settlement will depend on the ground conditions, contact grouting program, and the contractor's means and methods. It has been our experience with Caltrans that the normal settlement tolerance for a roadway section being crossed is ½ inch or less. The Caltrans Encroachment Permit Manual, Chapter 600 (Caltrans 2008) provides submittal requirements for trenchless applications but does not provide specific settlement criteria.

Guided auger boring and/or pilot tube microtunneling can be configured for work above or below the groundwater table. Groundwater was not encountered in the borings drilled along Reach A (KB-1 through KB-6). However, groundwater levels could change in some areas of sewer construction, depending on weather conditions and the time of year that the work is performed. Additional information on dewatering will be provided in a supplemental report in 2015.

7.4.4 Horizontal Directional Drilling (HDD)

HDD is a steerable trenchless method of installing underground pipes in a shallow arc along a prescribed bore path by using a surface-launched drilling rig. It has historically not been able to produce sufficient accuracy for gravity sewers and has left sags and humps in completed sewers. However, new techniques are evolving and there have been recent cases of gravity sewers with slopes as flat as 0.5% being installed using this technique. This installation method is particularly sensitive to the presence of gravels, cobbles or more resistant soil layers which can deflect the drill head from its desired alignment. Horizontal directional drilling (HDD)

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methods are well suited to sites with relatively long drive lengths and do not require launching and receiving pits. However, HDD in this size range requires a drill staging area (to accommodate the drilling rig, a separation plant and a drill control area) of about 200 by 200 feet (not necessarily square), and sufficient laydown area is needed at the exit side of the bore to accommodate laying out and assembling the pipeline for the entire length of HDD crossing. Because of these staging area requirements we do not believe that HDD is suitable for the proposed project and it is not discussed further in this report. We can provide additional information on HDD, if requested.

7.4.5 Summary of Trenchless Method Feasibility

In summary, HDD methods are probably not suitable for this project due to staging and lay-down area requirements. Jack and bore and pipe ramming methods are not steerable and generally are only suitable for crossings less than about 300 feet in length where some misalignment of the bore is tolerable.

Of the methods discussed above, microtunneling and GAB methods appear most suitable for this reach of the project. Table 8 summarizes major comparisons between these two methods.

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TABLE 9
COMPARISON OF APPROPRIATE TRENCHLESS INSTALLATION METHODS

Method	Drive Length	Typical Work Area	Relative Cost	Other Considerations
Microtunneling	600 to 800 ft. between shafts or up to 1600 ft. with intermediate jacking stations	100x100 ft. equipment area, shape can vary. 20x40 ft. launch shaft. 20x30 ft. recovery shaft.	More costly than open-cut or GAB	Requires launching a microtunneling machine from one shaft to another. Pipe sections are inserted and jacked behind the MTBM from the launch shaft, so suitable jacking pipe is needed or place pipeline in external steel casing. Minimum depth typically at least 2 to 3 pipe diameters. Contact grout required for annular space created by overcut around pipe or casing. Can be configured for above or below groundwater conditions but working below groundwater is more difficult and expensive. Can handle coarse gravel and small cobbles in the bore path. Ground surface settlement on the order of ½ to 1 inch is possible and can be reduced using contact grouting of the annular space around the casing.
GAB	Maximum 400ft. between shafts	100x100 ft. equipment area, shape can vary. 20x30 ft. launch shaft. 20x20 ft. recovery shaft.	Less costly than microtunneling, but more costly than open-cut	Requires launching a guided boring machine from one shaft to another. Pipe sections are inserted and jacked behind the GBM from the launch shaft. So suitable jacking pipe is needed or the pipeline can be installed in an external steel casing that is jacked into place. Minimum depth typically at least 2 to 3 pipe diameters. Can be configured for work above or below groundwater levels. Can have difficulty advancing the pilot tube in coarse gravels and cobbles. Ground surface settlement on the order of ½ inch is possible and can be reduced using contact grouting of the annular space around the casing.

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7.4.6 Bore Pit Shoring

Where trenchless pipeline installation methods are used, relatively deep excavations will be required to construct the launching and receiving shafts, typically 3 to 4 feet below the pipe invert. We expect that shoring and possibly dewatering systems will be required to construct the shafts. Shoring design for bore pits typically is the responsibility of the contractor. We expect that suitable alternatives for conventional shoring systems include soldier piles with lagging and tied-back or braced sheet piles. As discussed previously, the contractor should consider the presence of medium dense to very dense sands and gravels when evaluating installation of appropriate shoring system alternatives. We recommend that required embedment depths for shoring be determined using methods for evaluating sheet pile walls and based on the principles of force and moment equilibrium. We recommend that Kleinfelder be given the opportunity to review proposed excavation and shoring designs for consistency with the information contained in this report.

7.5 GROUNDWATER AND CONSTRUCTION DEWATERING

Explorations for this project were performed in the middle of summer, following a prolonged period of drought. Piezometers that were installed for this project, as well as a nearby piezometer at Agua Caliente Creek have been monitored for several months and that data is summarized in Section 5.3. It appears that groundwater levels fluctuate fairly rapidly in response to rainfall events. The observed seasonal groundwater fluctuations in the available monitoring wells show a water level rise of 12 to 16 feet. The need for dewatering may be significantly reduced if construction can be performed during dry summer and early fall weather. Piezometers will continue to be monitored over the upcoming winter and a more detailed dewatering section will be provided at that time. Groundwater pressure contributes to soil raveling and can cause flowing ground conditions in cohesionless soils. Construction dewatering will reduce the effects of water pressure on ground behavior and reduce the amount of water flowing into bored tunnels and excavations. In sands, no passive resistance should be relied upon for support of bracing materials or resistance to uplift forces without first depressurizing the sand by dewatering.

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7.5.1 Groundwater Considerations During Construction

The contractor should retain the services of a dewatering expert to assist with the evaluation of an appropriate combination of dewatering methods for trenching and trenchless construction methods. An effective dewatering program takes time to dewater a site, so dewatering systems should be installed well in advance of construction. It has been our experience that several weeks may be needed to lower groundwater levels to acceptable levels. Piezometers should be installed and monitored to verify that groundwater levels have been lowered to acceptable levels before construction begins. Localized granular soil layers below or near the trench bottoms may also need to be dewatered.

Particularly during rainy months, heavy rainfall or the malfunction of a dewatering system could cause the void behind a braced or cantilevered wall to become filled with water. Therefore, if construction takes place during rainy months we recommend the groundwater level be assumed at the ground surface for purposes of shoring design and construction. During dry seasons the groundwater depth for shoring design purposes may be taken at a depth of 10 feet.

We recommend that during wet weather, earthen berms or other controls be used to prevent surface runoff from entering excavations. Surface runoff water and groundwater pumped from excavations should be collected and disposed of outside of the construction limits.

7.5.2 Groundwater Level for Buoyancy Design

For preliminary planning purposes we recommend the long-term groundwater level for buoyancy design be taken at a depth of 10 feet below the ground surface.

7.5.3 Trench Dams

Trench dams are often used within the pipe zone to block the flow of groundwater in relatively permeable trench bedding and initial backfill materials. This reduces the amount of water that has to be removed from a trench section during future maintenance and/or repairs and helps to prevent internal scour where clean crushed rock materials are used for bedding and initial backfill. Trench dams, if used, should be constructed of lean concrete or controlled density fill (low strength cementitious slurry) that is at least 12-inches-thick. The dams should extend into the trench bottom and wall soils at least 12 inches. They should also extend at least 12 inches

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above the pipe, through any initial backfill above the pipe, and engage the overlying trench backfill soils.

Unless trench backfill consists of highly-permeable, clean, crushed rock we do not expect that trench dams will be required to control hydraulic gradients in the bedding and trench zone, and seepage rates through sand or aggregate base materials should be slow enough to handle with sumps and pumps. However, to further reduce seepage into the trench, trench dams could still be used.

7.6 CONSTRUCTION PERFORMANCE MONITORING

We recommend that a survey of all existing utilities, pavements and any other above-ground and underground structures be completed for locations adjacent to proposed shored excavations. The purpose of this review will be to evaluate the ability of existing pipelines and conduits to withstand horizontal movements associated with a shored excavation. If existing utility lines are not capable of withstanding anticipated lateral movements, alternative shoring systems may be required. Lateral movement of shored excavations should be expected. Therefore, cracks may open in sidewalks and pavements adjacent to shored portions of the excavations.

Construction-related settlement around the excavations may occur due to shoring deflection and construction dewatering. Settlement adjacent to shoring due to shoring deflections can usually be limited to less than ½" to 1" if the contractor designs and installs the shoring system to keep lateral deformations to less than ½". Lateral shoring deflection should be monitored to confirm that performance is within design expectations. Because seasonal groundwater levels appear to (at least periodically) be below the proposed pipeline invert, construction dewatering should not induce significant settlement as long as the contractor provides adequate filtration to avoid loss of ground due to piping (internal soil erosion).

Horizontal and vertical movements of the shoring system and at points outside of the immediate construction area should be monitored regularly by a surveyor and the results reviewed by Kleinfelder.

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During trenchless installation activities we recommend the ground surface be monitored to ensure that ground surface movements are within tolerable limits, typically less than about ½ inch over a horizontal distance of about 100 feet. This can be accomplished using surface settlement monitoring points at appropriate locations along the bore paths. This may be a condition of the Caltrans permit for boring beneath the roadway.

During the final design phase, Kleinfelder should be retained to provide detailed recommendations for construction monitoring after a review of the proposed trenchless construction, shoring and dewatering systems.

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8 ADDITIONAL SERVICES

8.1 PLANS AND SPECIFICATIONS

We recommend Kleinfelder conduct a general review of final plans, specifications and contractor submittals to evaluate that our geotechnical recommendations have been properly interpreted and implemented during design. In the event Kleinfelder is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

8.2 PROJECT BID DOCUMENTS

All contractor questions concerning this Geotechnical Report should be submitted to the Owner. After consultation with Kleinfelder, the project owner (or their representative) should provide clarifications or additional information to all contractors bidding the job. Kleinfelder has been instructed to respond to questions only through the project owner.

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9 LIMITATIONS

This report presents information for planning, permitting, design, and construction of the Reach A of the Ramon Street and Sonoma Highway Area Sewer Trunk Replacement Project, prepared for the Sonoma County Valley Sanitation District/Sonoma County Water Agency in Sonoma County, California. It is expected that information contained in this report will be used to help other design professionals select the ultimate location, length, and depth of the proposed pipeline crossings. However, this report should not be used to define site conditions for contractual purposes, and Kleinfelder will accept no liability for changed conditions claims based on this report.

Recommendations contained in this report are based on materials encountered in the borings drilled for this study and during previous studies along the project alignment, evaluation of existing geotechnical data from the project vicinity, geologic interpretation based on published articles and geologic literature, and our present knowledge of the proposed construction.

It is possible and likely that soil and groundwater conditions could vary between or beyond the points explored. If the scope of the proposed construction, including the proposed alignment locations, changes from that described in this report, we should be notified immediately in order that a review may be made and any supplemental recommendations provided.

We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the site area at the time of our study. No warranty is expressed or implied.

This report may be used only by the client and only for the purposes stated, within a reasonable time (3 years) from its issuance. Land use, site conditions (both on site and off site) or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party.

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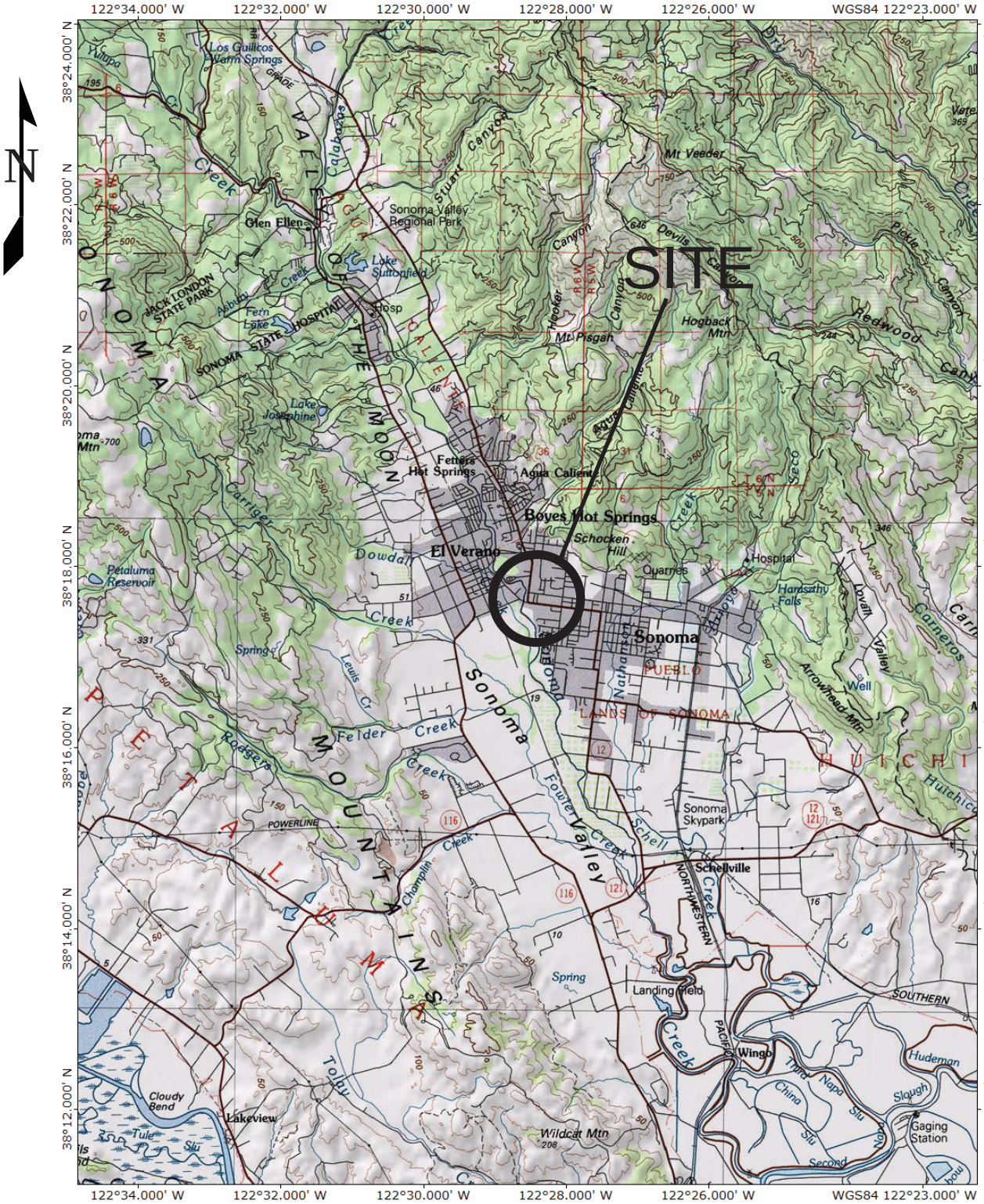
Plates



Reference: TOPO! National Geographic Holdings, 2001

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APPROXIMATE SCALE (feet)

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Santa Rosa

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PROJECT NO.	20143780
DRAWN	JAN 2015
DRAWN BY	MP
CHECKED BY	TC
FILE NAME	Site Location_A.ai

SITE LOCATION

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA COUNTY, CALIFORNIA

PLATE

1

SOIL BORINGS DRILLED FOR REPLACEMENT OF SONOMA VALLEY TRUNK MAIN

REACH A

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-1	38.29243°	-122.47052°	79.7	7/15/2014	31½	16
KDP-2	38.29288°	-122.47042°	82.3	7/23/2014	7[2]	19
KB-2	38.29288°	-122.47042°	82.3	12/17/14	31½	19
KB-3	38.29338°	-122.47280°	82.8	7/17/2014	26½	18
KB-4	38.29372°	-122.47550°	82.4	7/16/2014	51½	16
KB-5	38.29615°	-122.47558°	98	7/18/2014	31½	23
KDP-6	38.29817°	-122.47540°	101.6	7/24/2014	10[2]	26
KB-6	38.29817°	-122.47540°	101.6	12/18/2014	31½	26

REACH B

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-7	38.29922°	-122.47731°	92	7/18/2014	26[2]	15
KB-8	38.30074°	-122.47823	99	7/18/2014	26½	21
KB-9	38.30059°	-122.47919°	90	7/17/2014	21½	12
KB-10	38.30156°	-122.48159°	94	7/18/2014	51½	14
KB-11	38.30295°	-122.48162°	104.5	7/17/2014	26	23

REACH C

Boring Number[1]	Latitude	Longitude	Ground Surface Elevation (feet)	Date Drilled	Boring Depth (feet)	Approx. Depth to Sewer Invert (feet)
KB-12	38.30505°	-122.48190°	102	7/17/2014	16½	10
KB-13	38.30632°	-122.48169°	108	7/16/2014	21½	16
KB-14	38.30716°	-122.48271°	100.7	7/15/2014	15	8
KDP-15	38.30841°	-122.48336°	105	7/24/2014	28	12
KB-16	38.31003°	-122.48421°	106.8	7/15/2014	21½	12

[1] Borings designated KB were drilled using Hollow Stem Auger methods. Borings designated KDP were drilled using direct push methods to aid in obtaining environmental samples. Ground elevations approximate.

[2] Boring terminated short of scheduled depth due to practical refusal of drilling method. Supplemental borings (KB-2 and KB-6) were later drilled at the locations of KDP-2 and KDP-6.

Reach A
Reach B
Reach C
Existing Sewer Main
Agua Caliente Creek Crossing
KB-1 Hollow-Stem Auger Boring Location: Kleinfelder, 2014
KDP-2 Direct Push Boring Location: Kleinfelder, 2014
Miller Pacific: B-1 Miller Pacific Boring Location, 2013
Brunsing: B-1 Brunsing Boring Location, 2012
Lowney: B-18 Lowney Boring Location, 1977

200 100 0 200
APPROXIMATE SCALE (feet)

Basemap: Google Earth Pro
Alignment Locations provided by SCWA

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PROJECT NO.	20143780
DRAWN	JAN 2015
DRAWN BY	EJ
CHECKED BY	MP
FILE NAME	Site Plan.ai

SITE PLAN

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE 2

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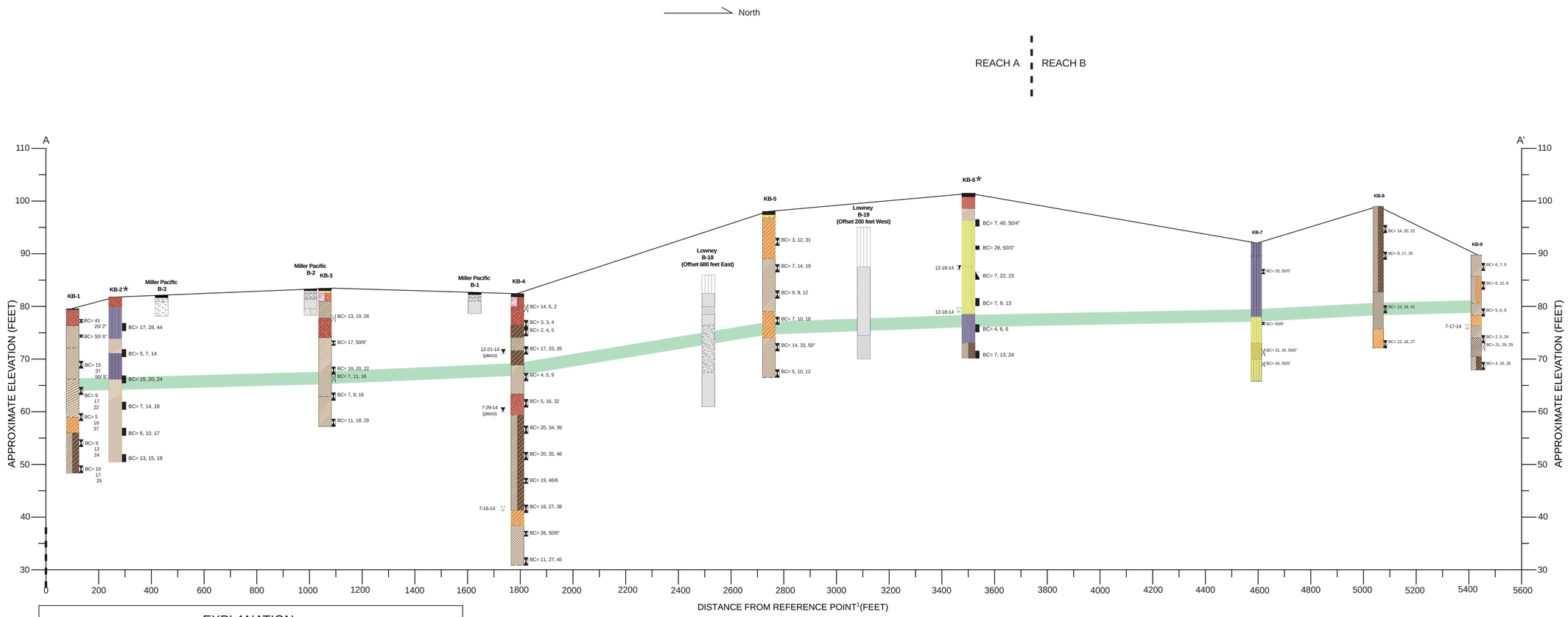

Ground Surface
Proposed Trunk

First Water Level Reading (during drilling)
Static Water Level Reading (short-term)
Static Water Level Reading (post-drilling)

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- Standard California Sampler
- Modified California Sampler
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

EXPLANATION

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		

* The graphics for direct push borings KDP-2 and KDP-6 have been removed from this cross section. These two borings encountered refusal at 7-feet and 10-feet-deep, respectively. Borings KB-2 and KB-6 were drilled to the planned depth of approximately 30-feet-deep after the direct push borings encountered refusal. See Appendix A for detailed logs of all borings.

Surface Elevations based on SCWA Cad File 7365TOPO_4
[1]Reference point: Survey Monument 20157 79.29 MON157

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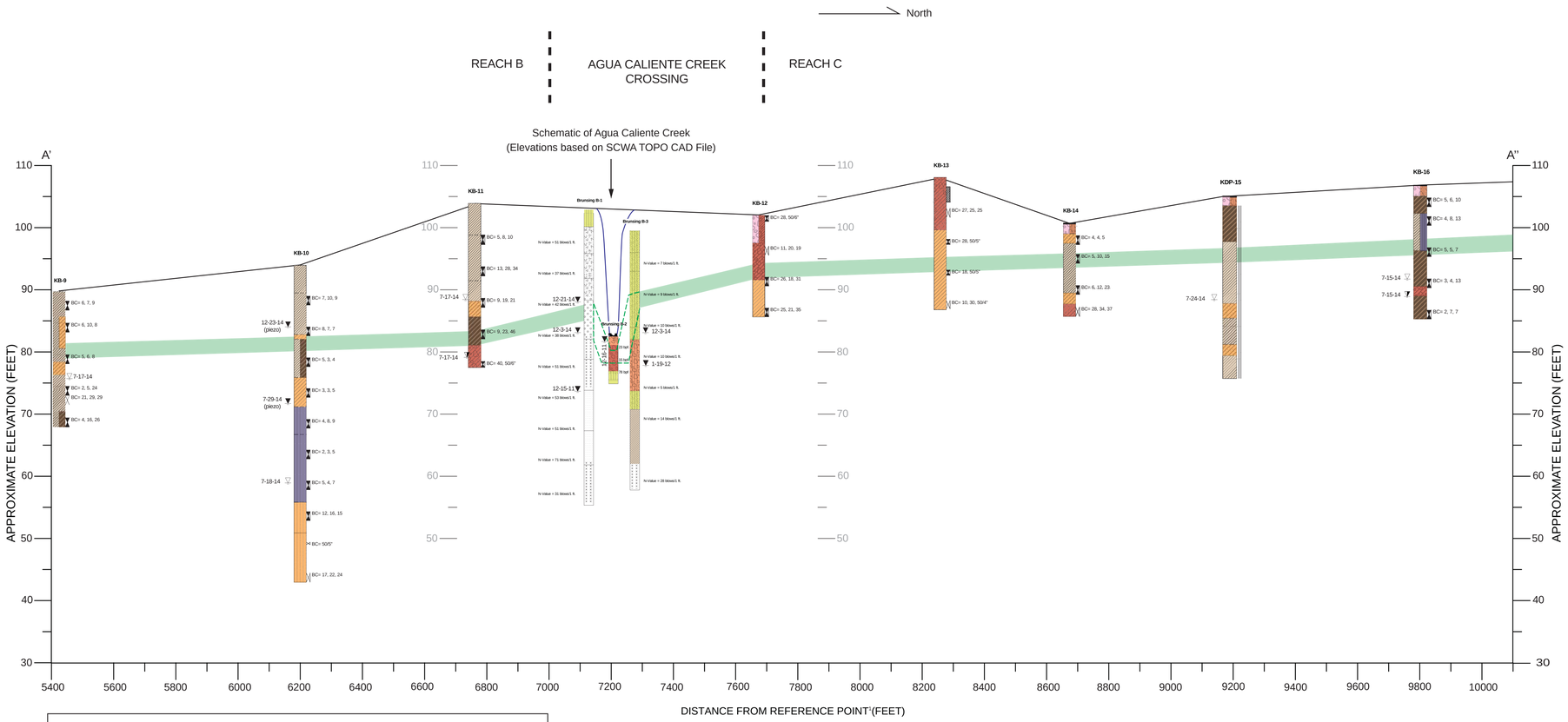
PROJECT NO.	20143780
DRAWN	JAN 2015
DRAWN BY	JC
CHECKED BY	TC
FILE NAME	Cross Section (3A and 3B).ai

CROSS SECTION OF PLANNED ALIGNMENT

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
3A



EXPLANATION

Ground Surface
Proposed Trunk

First Water Level Reading (during drilling)
Static Water Level Reading (short-term)
Static Water Level Reading (post-drilling)

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- Standard California Sampler
- Modified California Sampler
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

Direct Push Refusal

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		

Surface Elevations based on SCWA Cad File 7365TOPO_4
[1]Reference point: Survey Monument 20157 79.29 MON157

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PROJECT NO.	20143780
DRAWN	JAN 2015
DRAWN BY	JC
CHECKED BY	TC
FILE NAME	Cross Section (3A and 3B).ai

CROSS SECTION OF PLANNED ALIGNMENT

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE 3B

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Appendix A

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL 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
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
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GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
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)
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)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic / Symbol	Group Names
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
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
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT 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
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
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
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
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
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
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

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435-04)
CL	Collapse Potential (ASTM D 5333-03)
CP	Compaction Curve (CTM 216 - 06)
CR	Corrosion, Sulfates, Chlorides (CTM 643 - 99; CTM 417 - 06; CTM 422 - 06)
CU	Consolidated Undrained Triaxial (ASTM D 4767-02)
DS	Direct Shear (ASTM D 3080-04)
EI	Expansion Index (ASTM D 4829-03)
H	Hydrometer (ASTM D 422-63 [2007])
M	Moisture Content (ASTM D 2216-05)
P	Permeability (CTM 220 - 05)
PA	Particle Size Analysis (ASTM D 422-63 [2007])
PI	Liquid Limit (LL), Plastic Limit, Plasticity Index (PI) (AASHTO T 89-02, AASHTO T 90-00)
PL	Point Load Index (ASTM D 5731-05)
PP	Pocket Penetrometer
R	R-Value (CTM 301 - 00)
SE	Sand Equivalent (CTM 217 - 99)
SG	Specific Gravity (AASHTO T 100-06)
SL	Shrinkage Limit (ASTM D 427-04)
Su	Undrained Shear Strength from UU Triaxial Test
TV	Pocket Torvane
UC	Unconfined Compression - Soil (ASTM D 2166-06) Unconfined Compression - Rock (ASTM D 2938-95)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850-03)
UW	Unit Weight (ASTM D 4767-04)
VS	Vane Shear (AASHTO T 223-96 [2004])
WA	Minus #200 Sieve Wash (ASTM D 1140 [2006])

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- Standard California Sampler
- Modified California Sampler
- 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)

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REPORT TITLE
BORING RECORD LEGEND

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME
SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-			1 of 2

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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} - Value (blows / foot)
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE

Descriptor	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

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.

NOTE: This legend sheet provides descriptors and associated criteria for required soil description components only. Refer to Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010), Section 2, for tables of additional soil description components and discussion of soil description and identification.

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REPORT TITLE				
BORING RECORD LEGEND				
DIST. 04	COUNTY Sonoma	ROUTE -	POSTMILE -	EA -
PROJECT OR BRIDGE NAME SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A				
BRIDGE NUMBER -	PREPARED BY	DATE	SHEET 2 of 2	

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-15-14	7-15-14	38.29243° / -122.47052° NAD83	KB-1
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~79.7 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 30.0 ft; AFTER DRILLING (DATE) Not Applicable	TOTAL DEPTH OF BORING: 31.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	ASPHALT CONCRETE; 2".												
		CLAYEY GRAVEL with SAND (GC); dense; olive brown; moist; subangular gravel, max..75 in. dia.; fine sand; (AGGREGATE BASE).												
				S01	41 20/2"	20/2	100							
		subangular gravel, max.1.5 in. dia.; less fines (FILL).												change in drilling at 3'
		GRAVELLY CLAY with SAND (CL); hard; yellowish brown; moist; subangular to subrounded gravel, max.1 in. dia.; coarse to fine sand.												
75.00	5			S02	50 -		100							
		LEAN CLAY with SAND (CL); hard; light olive brown to olive brown; moist; fine sand with trace coarse sand.												consistent drilling at 7' to 8'
70.00	10			S03	15 37 50/5"	87/11	88							
		LEAN CLAY with SAND (CL); very stiff; olive brown to brown; higher moisture content; fine sand; increased structure.												
65.00	15			S04	9 17 22	39	94		26 26	97 97				LL = 44 PI = 29 Su = 2.0 KSF M, UW M, UW, PI
		Pipe Invert (16').												
60.00	20			S05	5 19 37	56	89				PP=3.5-4.0			
		stiff; pale olive; moist.												
		CLAYEY SAND (SC); dense/ hard; orangish brown; moist; medium to fine sand.												
		LEAN/FAT CLAY with SAND (CL-CH); very stiff; orangish brown; moist; fine sand.												
55.00	25			S06	6 12 24	36	94							
50.00	30			S07	10 17 25	42	94							
		orangish brown with olive mottling.												
		Bottom of borehole at 31.5 ft bgs 6th Street West at Studley												
45.00	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-1

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	12-17-14	12-17-14	38.29288° / -122.47042° NAD83	KB-2
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~82.3 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Mod Cal (2.0")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 31.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	Asphalt Concrete (18").												
		CLAYEY GRAVEL (GC); medium dense; brown; moist; subangular to subrounded gravel, max.1 in. dia.; coarse to fine sand; (FILL).												
80.00		SANDY SILT (ML); hard; brown to yellowish brown; dry; fine sand.												change in cuttings at 2'
	5		X	S01	17 28 44	72	100							
75.00		SANDY LEAN CLAY (CL); firm to hard; yellowish brown; moist; fine sand.												
	10		X	S02	5 7 14	21	78							
		SILTY SAND with GRAVEL (SM); medium dense; yellowish brown; moist; trace subrounded gravel, max.0.5 in. dia.; coarse to fine sand.							15	79				M, UW, WA
70.00														
	15		X	S03	15 20 24	44	78							
		LEAN CLAY (CL); hard; yellow to olive brown; moist; trace fine sand.												
65.00		Pipe Invert (19').												
	20	increase in sand content, some fine to medium sand.	X	S04	7 14 18	32	83							
60.00														
	25	becomes stiff to hard.	X	S05	6 10 17	27	100							
55.00														
	30	increase in sand content.	X	S06	13 15 19	34	100							
50.00		Bottom of borehole at 31.5 ft bgs 6th Street West at Highway 12												
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-2

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma			-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-17-14	7-17-14	38.29338° / -122.47280° NAD83	KB-3
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~82.8 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 26.5 ft

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		ASPHALT CONCRETE; 6".												
			CONCRETE; 6".												
			POORLY-GRADED GRAVEL with SILT (GP-GM); (Fill).												
80.00			SANDY LEAN CLAY (CL); stiff; brown; moist; medium to fine sand.												smoother drilling at 3'
	5				S01	13 19 26	45								
75.00			CLAYEY GRAVEL (GC); dense; gray to yellowish brown; dry to moist; subangular to subrounded gravel, max.> 1.5 in. dia.; coarse to fine sand.												
	10		SANDY LEAN CLAY with GRAVEL (CL); stiff; brown; moist; subrounded gravel, max.0.5 in. dia.; fine sand.		S02	17 50/6"	50/6	67							
70.00															
	15		subrounded gravel, max.1.25 in. dia..		S03	18 20 22	42	28							
					S04	7 11 16	27	6							
65.00			Pipe Invert (18').												
	20				S05	7 8 16	24	67				PP=> 4.5			
			SANDY LEAN CLAY (CL); stiff to very stiff; brown; moist; fine sand.												
60.00															
	25				S06	11 18 29	47	67				PP=> 4.5			
			Bottom of borehole at 26.5 ft bgs West Napa at 7th Street West												
55.00															
	30														
50.00															
	35														

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REPORT TITLE	HOLE ID
BORING RECORD	KB-3

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	12	36.73	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-16-14	7-16-14	38.29372° / -122.47550° NAD83	KB-4
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~82.4 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Piezometer			GROUNDWATER READINGS: DURING DRILLING 41.0 ft; AFTER DRILLING (DATE) 11.4 ft on 12-21-14	TOTAL DEPTH OF BORING: 51.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	ASPHALT CONCRETE; 7.5".												
80.00		POORLY-GRADED GRAVEL with CLAY AND SAND (GP-GC); medium dense; grayish brown; moist; subangular to subrounded gravel, max.0.75 in. dia.; coarse to fine sand; (AGGREGATE BASE).		S01	14 5 2	7	39							
		CLAYEY GRAVEL with SAND (GC); loose; reddish brown; moist; subangular gravel, max.0.50 in. dia.; coarse to fine sand; rock fragments; (probable fill).												some rig chatter at ~4'
	5			S02	3 3 4	7	11							
75.00		SANDY FAT CLAY (CH); soft; orangish brown to brown; moist; trace max.0.50 in. dia.; coarse to fine sand.		S03	2 4 5	9	17							stiffer drilling at ~7' to 8'
		LEAN CLAY with SAND (CL); stiff; black; moist; fine sand; slightly porous.												
	10			S04	17 23 26	49	83				PP=3.75			
70.00		SANDY FAT CLAY with GRAVEL (CH); very stiff; brown, yellowish brown; moist; subangular to subrounded gravel, max.1.25 in. dia.; coarse to fine sand.												
		SANDY LEAN CLAY (CL); stiff; brown; moist; medium to fine sand; medium to high plasticity.												
	15			S05	4 5 9	14	94		26	99	PP=1.5			LL = 36
		Pipe Invert (16').							26	99				PI = 23
65.00		increasing sand content with depth.												Su = 1.3 KSF M, UW M, UW, PI
		CLAYEY GRAVEL with SAND (GC); dense; brown to orangish brown; moist; subrounded gravel, max.2.5+ in. dia.; coarse to fine sand; high plasticity.												rig chatter at ~19'
	20			S06	5 16 32	48	89							
60.00		LEAN/FAT CLAY (CL-CH); very stiff to hard; olive yellowish brown; dry to moist; some fine sand.												
	25			S07	20 34 39	73	100							
55.00														some rig chatter at 28'
	30			S08	20 35 48	83	78							
50.00														
	35													

(continued)

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REPORT TITLE	HOLE ID
BORING RECORD	KB-4

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	12	36.57	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 2

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ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	35		LEAN/FAT CLAY (CL-CH); very stiff to hard; olive yellowish brown; dry to moist; some fine sand. trace.		S09	19 46/6"	46/6	100							
45.00															
	40		yellowish brown.		S10	16 27 38	65	100							sampler wet at 41'
			CLAYEY SAND (SC); very dense; yellowish brown; moist; medium to fine sand; lightly cemented.												
40.00															
			SANDY LEAN CLAY (CL); hard; yellowish brown; moist; fine sand.												
	45				S11	26 50/6"	50/6	75							
35.00															
	50				S12	11 27 45	72								
			Bottom of borehole at 51.5 ft bgs West Napa at Highway 12												
30.00															
	55														
25.00															
	60														
20.00															
	65														
15.00															
	70														
10.00															
	75														

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REPORT TITLE				HOLE ID
BORING RECORD				**KB-4**
DIST. **04**	COUNTY **Sonoma**	ROUTE **12**	POSTMILE **36.57**	EA **-**
PROJECT OR BRIDGE NAME **SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A**				
BRIDGE NUMBER **-**	PREPARED BY **Amanda May**		DATE	SHEET **2 of 2**

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-18-14	7-18-14	38.29615° / -122.47558° NAD83	KB-5
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line):	SURFACE ELEVATION: ~98.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 31.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	8" ASPHALT.												
		7" CONCRETE.												
		CLAYEY SAND (SC); dense; brown; dry; medium to fine sand; low plasticity.												
95.00														
	5			S01	3 12 31	43	83				PP=3.5			
90.00														
		LEAN CLAY (CL); stiff to very stiff; brown to olive brown; dry to moist; trace fine sand; medium plasticity.												
	10			S02	7 14 19	33	83							
85.00														
	15	firm; dark brown; slight increase in sand content.		S03	9 9 12	21	100							
80.00														
		CLAYEY SAND (SC); medium dense; dark brown; dry to moist; medium to fine sand; low plasticity.												
	20			S04	7 10 18	28	100							
75.00		Pipe Invert (23').												
		LEAN CLAY with SAND (CL); very stiff; dark brown; moist; medium to fine sand; low plasticity.												
	25			S05	14 33 50	83	100							
70.00														
	30	stiff; fine sand; decrease in sand content.		S06	5 10 12	22	100							
		Bottom of borehole at 31.5 ft bgs Highway 12 at Lyon Street												
65.00	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-5

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	12	36.37	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	12-18-14	12-18-14	38.29817° / -122.47540° NAD83	KB-6
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~101.6 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Mod Cal (2.0")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 20-25 ft; AFTER DRILLING (DATE) 14.5 ft on 12-18-14	TOTAL DEPTH OF BORING: 31.5 ft

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		Asphalt Concrete (9").												
100.00			CLAYEY GRAVEL (GC); medium dense; grayish brown; moist; coarse to fine, subangular gravel; coarse to fine sand; (FILL).												
			SANDY LEAN CLAY (CL); medium stiff; brown; moist; coarse to fine sand.												
	5		SILTY SAND/SANDY SILT (SM); hard; olive gray to brown; moist; fine sand.		S01	7 40 50/4"	90/10	94							
95.00															
	10		becomes yellow, very hard/dense, lightly cemented, fine to coarse sand.		S02	28 50/3"	50/3	100							
90.00															very slow advancement of auger from 11.5' to 14' (approximately 10 minutes)
			SILTY SAND (SM); dense; yellowish brown; moist; fine sand.												easier drilling from 14'-15' (less than 30 seconds)
	15				S03	7 22 23	45	67							
85.00															PA, H (composite sample - S03/S04)
	20		moist to wet medium dense.		S04	7 9 13	22	100		35	83				M, UW
80.00															
			SILT with SAND (ML); soft; yellowish brown; wet; fine sand.												
	25				S05	4 6 6	12	100		35	88				M, UW, PA, H
75.00			Pipe Invert (26').												
			LEAN/FAT CLAY (CL-CH); hard; yellowish brown; moist; fine sand.												
	30				S06	7 13 24	37	89							
70.00			Bottom of borehole at 31.5 ft bgs Highway 12 at Ramon Street												
	35														

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REPORT TITLE	HOLE ID
BORING RECORD	KB-6

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	12	36.26	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
	C Ewing		1 of 1

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gINT FILE: \\santarosa\santarosa-Data\users\geotech_projects\projects\active\20143780.001a Scwa Happy Lane\gint\20143780 Trunk Main.gpj
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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-18-14	7-18-14	38.29922° / -122.47731° NAD83	KB-7
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~92.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 26.0 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	SILT with SAND (ML); soft; light brown to brown; dry to moist; non-plastic to low plasticity.												
90.00		SANDY SILT (ML); hard; grayish brown; dry; coarse to fine sand; non-plastic.												
	5			S01	20 50/5"	50/5	82							
85.00														
	10													
80.00		brown to dark brown.												
	15	SILTY SAND with GRAVEL (SM); very dense; brown to dark brown; dry; subrounded gravel, max.1.5 in. dia.; coarse to fine sand; non-plastic.		S02	50/6" -	REF	67							
75.00														
	20	POORLY-GRADED SAND with SILT (SP); very dense; light brown to black; dry; coarse to fine sand; non-plastic.		S03	31 34 50/5"	84/11	82							
70.00		SILTY SAND (SM); very dense; black; dry; coarse to fine sand; non-plastic.		S04	44 50/5"	50/5	91							very hard drilling at 22'
	25													
65.00		Pipe Invert (26'). Bottom of borehole at 26.0 ft bgs Maxwell Park (south end)												
	30													
60.00														
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-7

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-18-14	7-18-14	38.30074° / -122.47823° NAD83	KB-8
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~99.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS — DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 26.5 ft

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		SANDY LEAN/FAT CLAY (CL-CH); hard; light brown yellowish brown; dry; trace max.0.75 in. dia.; coarse to fine sand; rootlets.												
95.00	5				S01	14 20 22	42	50							
90.00	10		olive; some wet faces; lightly cemented zone in shoe.		S02	9 17 33	50	100							consistent drilling from 10' to 13.5'
85.00	15														
			LEAN CLAY with SAND/ SANDY LEAN CLAY (CL); hard; brown; moist; coarse to fine sand; some lenses of clayey sand.												easier drilling from 16'-18.5'
80.00	20				S03	13 19 41	60	89							
			Pipe Invert (21').												
			SILTY CLAY (CL-ML); very stiff; dark brown; moist.												
75.00	25				S04	13 18 27	45	100		28	95				M, UW, PA
			Bottom of borehole at 26.5 ft bgs Maxwell Park (east end)												
70.00	30														
65.00	35														

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REPORT TITLE	HOLE ID
BORING RECORD	KB-8

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-17-14	7-17-14	38.30059° / -122.47919° NAD83	KB-9
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~90.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 14.0 ft; AFTER DRILLING (DATE) Not Applicable	TOTAL DEPTH OF BORING: 21.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	SANDY LEAN CLAY (CL); very stiff; brown; dry to moist; trace subrounded gravel, max.0.5 in. dia.; coarse to fine sand; slightly pourous; trace rootlets (Qal).												
				S01	6 7 9	16	100							
85.00	5	CLAYEY SAND (SC); medium dense/stiff; brown; moist; trace subrounded gravel, max.0.5 in. dia.; coarse to fine sand; (borders Sandy Lean Clay).												
				S02	6 10 8	18	100							
		SANDY LEAN CLAY (CL); stiff; light brown to brown; moist; medium to fine sand.												softer drilling at 9'
80.00	10			S03	5 6 8	14	100				PP=2.0			LL = 36 PI = 17 PA, PI, H PA, H
		CLAYEY SAND (SC); medium dense; orangish brown; moist; coarse to fine sand; (predominantly coarse). Pipe Invert (12').												
		SANDY LEAN CLAY (CL); soft to medium stiff; brown; wet; medium to fine sand.												
75.00	15			S04	2 5 24	29	11							
		becomes very stiff.		S05	21 29 29	58	83							
														very hard drilling at 18.5' softer drilling at 19'
70.00	20	SANDY LEAN/FAT CLAY (CL-CH); very stiff; brown; moist.												
				S06	4 16 26	42	22							
		Bottom of borehole at 21.5 ft bgs Maxwell Park (central)												
65.00	25													
60.00	30													
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-9

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-18-14	7-18-14	38.30156° / -122.48159° NAD83	KB-10
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~94.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Piezometer			GROUNDWATER READINGS: DURING DRILLING 35.5 ft; AFTER DRILLING (DATE) 10.0 ft on 12-22-14	TOTAL DEPTH OF BORING: 51.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	GRAVELLY CLAY with SAND (CL); brown; dry to moist; coarse to fine sand.												
90.00														
	5	SANDY LEAN CLAY with GRAVEL (CL); stiff to very stiff; brown; moist; subrounded gravel, max.1.0 in. dia.; coarse to fine sand; (Qal).		S01	7 10 9	19	78							
85.00														
	10	increased coarse sand.		S02	8 7 7	14	100							
		CLAYEY SAND LENSE (SC); medium dense; brown; moist; fine sand.												
		SANDY LEAN/FAT CLAY (CL-CH); soft to stiff; brown; moist; fine sand.												
80.00		Pipe Invert (14').												
	15			S03	5 3 4	7	83				PP=1.5-1.25			
		SANDY LEAN CLAY (CL); stiff; brown, orangish brown; moist; medium to fine sand.												
75.00														
	20			S04	3 3 5	8	89		32	87				M, UW
									32	87				M, UW, PA, H
		SANDY CLAYEY SILT (CL-ML); stiff; brown to gray; moist to wet; fine sand; slightly cemented in shoe.												
70.00														
	25			S05	4 8 9	17	94							
		CLAYEY SILT with SAND (CL-ML); soft; dark gray to black; wet; fine sand; some wood debris; slight organic decay odor.												
65.00														
	30			S06	2 3 5	8	83				PP=0.5			
60.00	35													

(continued)

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REPORT TITLE	HOLE ID
BORING RECORD	KB-10

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 2

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ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	35	CLAYEY SILT with SAND (CL-ML); soft; dark gray to black; wet; fine sand; some wood debris; slight organic decay odor.		S07	5 4 7	11	83							
55.00		SANDY SILTY CLAY (CL-ML); medium stiff to stiff; dark gray; wet; some subrounded gravel, max.1.0 in. dia.; medium to fine sand.												
	40			S08	12 16 15	31	94		42 42	80 80				M, UW M, UW, PA, H
50.00		SILTY SAND with GRAVEL (SM); medium dense; dark gray; wet; subrounded gravel, max.>1.5" in. dia.; coarse to fine sand.												
	45			S09	50/5" -	REF	80							
45.00														
	50			S10	17 22 24	46	67							
		Bottom of borehole at 51.5 ft bgs Maxwell Park (northwest end)												
40.00	55													
35.00	60													
30.00	65													
25.00	70													
20.00	75													

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REPORT TITLE **BORING RECORD**			HOLE ID **KB-10**
DIST. **04**	COUNTY **Sonoma**	ROUTE **-**	POSTMILE **-**	EA **-**
PROJECT OR BRIDGE NAME **SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A**			
BRIDGE NUMBER **-**	PREPARED BY **C Ewing**	DATE	SHEET **2 of 2**

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-17-14	7-17-14	38.30295° / -122.48162° NAD83	KB-11
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line):	SURFACE ELEVATION: ~104.5 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 15.0 ft; AFTER DRILLING (DATE) Not Applicable	TOTAL DEPTH OF BORING: 26.0 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	SANDY LEAN CLAY (CL); stiff to very stiff; reddish brown; dry to moist; coarse to fine sand.												
100.00	5	LEAN CLAY with SAND (CL); very stiff; brown; moist; trace subangular to subrounded gravel, max.0.75 in. dia.; coarse to fine sand; (Qal).		S01	5 8 10	18	61							
95.00	10	hard; olive brown; increased sand content.		S02	13 28 34	62	78		32 32	89 89				LL = 40 PI - 16 Su = 4.3 KSF M, UW M, UW, PI
		SANDY LEAN CLAY (CL); stiff; brown; moist; medium to fine sand.												
90.00	15	SILTY SAND with GRAVEL (SM); medium dense to dense; orange to yellowish brown; moist; coarse to fine sand; (predominantly coarse). Pipe Invert (16').		S03	9 19 21	40	89		27 27	96 96				softer dilling at 12' to 15' M, UW M, UW, PA, H
		SANDY FAT CLAY (CH); stiff to very stiff; brown to olive; moist; medium to fine sand.												
85.00	20			S04	9 23 46	69	89							
80.00	25	CLAYEY GRAVEL with SAND (GC); very dense; yellowish brown; wet; subangular to subrounded gravel, max.>2.5 in. dia.; coarse to fine sand.		S05	40 50/6"	50/6	67							
		Bottom of borehole at 26.0 ft bgs Maxwell Park (north end)												
75.00	30													
70.00	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-11

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-17-14	7-17-14	38.30505° / -122.48190° NAD83	KB-12
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~102.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 16.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	POORLY-GRADED GRAVEL with CLAY (GP-GC); brown to yellowish brown; dry to moist; max.0.5 in. dia..		S01	28 50/6"	50/6	42							
100.00														
	5	CLAYEY GRAVEL with SAND (GC); dense; brown to yellowish brown; moist; subangular to subrounded gravel, max.1.0 in. dia.; coarse to medium sand.		S02	11 20 19	39	67							harder drilling at 4'
95.00														
	10	Pipe Invert (10').		S03	26 18 31	49	50		36	81				M, UW
		SILTY SAND (SM); dense; yellowish brown; moist; trace subrounded gravel, max.0.75 in. dia.; fine sand; moisture in shoe.							36	81				M, UW, PA, H
90.00														
	15	lightly cemented.		S04	25 21 35	56	94							
85.00		Bottom of borehole at 16.5 ft bgs West of Buena Vida Drive Cul-de-sac												
	20													
80.00														
	25													
75.00														
	30													
70.00														
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-12

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-16-14	7-16-14	38.30632° / -122.48169° NAD83	KB-13
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~108.0 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 21.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	CLAYEY GRAVEL with SAND (GC); dense; brown, orange & olive brown; moist; subangular gravel, max.1.0 in. dia.; coarse to fine sand; rock fragments; (FILL).												
105.00				B01										
	5			S02	27 25 25	50	39							
100.00														very hard drilling at 7.5'
		SANDY SILT (ML); very dense/hard; yellowish brown; moist; coarse to fine sand; clay matrix.												
	10			S03	28 50/5"	50/5	91		35 35	81 81				M, UW M, UW, PA
95.00														
	15			S04	18 50/5"	50/5	82							
		Pipe Invert (16'). increased gravel; same clay matrix.												
90.00														
	20			S05	10 30 50/4"	80/10	88							
		Bottom of borehole at 21.5 ft bgs Buena Vida Drive and Academy Lane												
85.00														
	25													
80.00														
	30													
75.00														
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-13

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-15-14	7-15-14	38.30716° / -122.48271° NAD83	KB-14
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~100.7 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 15.0 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
100.00	0	ASPHALT CONCRETE; 2".												
		POORLY-GRADED GRAVEL with SILT AND SAND (GP-GM); medium dense; brown; moist; subangular to subrounded gravel, max.0.75 in. dia.; coarse to fine sand; (AGGREGATE BASE).												
		CLAYEY SAND (SC); loose; brown; moist; fine sand; trace rootlets; increase in fines with depth.		S01	4 4 5	9	83							
		SANDY LEAN CLAY/CLAYEY SAND (CL); stiff/medium dense; brown; moist; medium to fine sand.												
95.00	5			S02	5 10 15	25	83							
		Pipe Invert (8').												
90.00	10	slightly porous.		S03	6 12 23	35	89		98	47				M, UW
		SILTY SAND (SM); dense; grayish brown, yellowish brown; moist; subrounded gravel, max.0.5 in. dia.; coarse to fine sand; (Qal).							19	108				M, UW, PA
		CLAYEY GRAVEL with SAND (GC); very dense; yellowish brown, reddish brown; moist; subangular gravel, max.>1.5 in. dia.; coarse to fine sand; (old Qal).		S04	28 34 37	71	61							rig chatter at 13'
85.00	15	Bottom of borehole at 15.0 ft bgs Happy Lane Cul-de-sac												
80.00	20													
75.00	25													
70.00	30													
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-14

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-15-14	7-15-14	38.31003° / -122.48421° NAD83	KB-16
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~106.80 ft NAVD88
DRILLING METHOD: Hollow Stem Auger			DRILL RIG: Mobile B-57	BOREHOLE DIAMETER: 8 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4"), Cal (2.5")			SPT HAMMER TYPE: Auto; 140 lbs / 30-inch drop	HAMMER EFFICIENCY, ERi: 65%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 15.0 ft; AFTER DRILLING (DATE) Not Applicable	TOTAL DEPTH OF BORING: 21.5 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0	ASPHALT CONCRETE; 1.5".												
105.00		POORLY-GRADED GRAVEL with SILT AND SAND (GP-GM); medium dense to dense; brown to orangish brown; moist; subangular to subrounded gravel, max.1.0 in. dia.; coarse to fine sand; (AGGREGATE BASE).		S01	5 6 10	16	89				PP=3.0			
		FAT CLAY with SAND (CH); stiff; black; moist; medium to fine sand; trace coarse sand; (Qal).												
	5	SANDY LEAN CLAY/SANDY SILT (CL-ML); stiff to very stiff; grayish brown to black; moist; coarse to fine sand.		S02	4 8 13	21	94				PP=4.5+			
100.00														
	10	LEAN CLAY with SAND (CL); stiff; light gray with olive brown mottling; moist; medium to fine sand.		S03	5 5 7	12	89		36 36	85 85	PP=2.25			LL = 42 PI = 24 Su = 2.0 KSF M, UW M, UW, PI
95.00		Pipe Invert (12').												
	15			S04	3 4 13	17	83							
90.00		CLAYEY GRAVEL with SAND (GC); medium dense; gray; wet; subangular to subrounded gravel, max.1.0 in. dia.; coarse to fine sand.												
		FAT CLAY (CH); soft to stiff; dark gray; moist; trace fine sand.												
	20			S05	2 7 7	14	89							
85.00		Bottom of borehole at 21.5 ft bgs Happy Lane at Anthony Court												
80.00	25													
75.00	30													
	35													

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REPORT TITLE	HOLE ID
BORING RECORD	KB-16

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	C Ewing		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-23-14	7-23-14	38.29288° / -122.47042° NAD83	KDP-2
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~82.3 ft NAVD88
DRILLING METHOD			DRILL RIG: Powerprobe 9500	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID)			SPT HAMMER TYPE	HAMMER EFFICIENCY, ERi: N/A%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS — DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 7.0 ft

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		ASPHALT CONCRETE; 2".												
			CLAYEY GRAVEL with SAND (GC); medium dense; orangish brown; moist; subangular to subrounded gravel, max.0.75 in. dia.; coarse to fine sand.												
80.00			SANDY LEAN CLAY (CL); hard; brown; moist; medium to fine sand.		R01			67							
					R02			100							
	5				R03			25							
					R04			50							
75.00			Bottom of borehole at 7.0 ft bgs 6th Street West at West Napa												
	10														
70.00															
	15														
65.00			Pipe Invert (19')												
	20														
60.00															
	25														
55.00															
	30														
50.00															
	35														

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REPORT TITLE	HOLE ID
BORING RECORD	KDP-2

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-24-14	7-24-14	38.29817° / -122.47540° NAD83	KDP-6
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~101.6 ft NAVD88
DRILLING METHOD			DRILL RIG: Powerprobe 9500	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID)			SPT HAMMER TYPE	HAMMER EFFICIENCY, ERi: N/A%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS — DURING DRILLING: Not Applicable; AFTER DRILLING (DATE): Not Applicable	TOTAL DEPTH OF BORING: 10.0 ft

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	RQD (%)	Moisture Content (%)	Dry Unit Weight (pcf)	Shear Strength (tsf)	Drilling Method	Casing Depth	Remarks
	0		ASPHALT CONCRETE; 9".												
			CONCRETE; 7".												
100.00			CLAYEY GRAVEL with SAND (GC); medium dense; brown; dry to moist; subangular gravel, max.1.0 in. dia.; coarse to fine sand; (FILL).		R01										
			olive gray.												
	5		SANDY LEAN CLAY (CL); stiff to hard; orangish brown; moist; some subrounded gravel, max.0.25 in. dia.; coarse to fine sand; (ALLUVIUM).		R02										
95.00			CLAYEY SAND (SC); dense; brown; dry to moist; some subrounded to subangular gravel, max.0.5 in. dia.; coarse to fine sand.												
			CLAYEY GRAVEL with SAND (GC); hard/very dense; light olive brown; dry to moist; subangular to subrounded gravel, max.1.0 in. dia.; coarse to fine sand.		R03										
	10		Bottom of borehole at 10.0 ft bgs Highway 12 at Ramon Street												
90.00															
	15														
85.00															
	20														
80.00															
	25		Note: Pipe Invert (26')												
75.00															
	30														
70.00															
	35														

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REPORT TITLE	HOLE ID
BORING RECORD	KDP-6

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 1

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LOGGED BY	BEGIN DATE	COMPLETION DATE	BOREHOLE LOCATION (Lat/Long or North/East and Datum)	HOLE ID
M. Pucci	7-24-14	7-24-14	38.30841° / -122.48336° NAD83	KDP-15
DRILLING CONTRACTOR: Woodward Drilling			BOREHOLE LOCATION (Offset, Station, Line)	SURFACE ELEVATION: ~105.0 ft NAVD88
DRILLING METHOD			DRILL RIG: Powerprobe 9500	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID)			SPT HAMMER TYPE	HAMMER EFFICIENCY, ERi: N/A%
BOREHOLE BACKFILL AND COMPLETION: Bentonite chips			GROUNDWATER READINGS: DURING DRILLING 16.5 ft; AFTER DRILLING (DATE) Not Applicable	TOTAL DEPTH OF BORING: 28.0 ft

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Recovery (%)	Remarks
	0	ASPHALT CONCRETE; 3".				
		POORLY-GRADED GRAVEL with SILT AND SAND (GP-GM); grayish brown; dry; subangular to subrounded gravel, max.0.75 in. dia.; coarse to fine sand; (AGGREGATE BASE).		R01	87	
		FAT CLAY with SAND (CH); stiff to very stiff; brown; moist; medium to fine sand; (ALLUVIUM).		R02	75	
100.00	5	less plasticity.				
		SANDY LEAN CLAY (CL); stiff to hard; olive brown, yellowish brown; moist; coarse to fine sand; some clayey sand lenses.		R03	79	
95.00	10	Pipe Invert (12').				
		some subangular to subrounded gravel, max.1.0 in. dia..		R04		
90.00	15	gravel, max. 2.0 in. diameter.				very hard drilling at 14.5'
		CLAYEY SAND (SC); olive brown; wet; some subangular to subrounded gravel, max.1.0 in. dia.; coarse to fine sand.		R05	100	
85.00	20	SANDY LEAN CLAY (CL); very stiff; olive brown; moist; some subrounded gravel, max.0.75 in. dia.; coarse to fine sand.				
		some clayey sand lenses.		R06		
		CLAYEY SAND (SC); olive brown; wet; coarse to fine sand; lightly cemented.				
80.00	25	bluish gray. SANDY LEAN CLAY (CL); hard; bluish gray; moist; fine sand.		R07		
		Bottom of borehole at 28.0 ft bgs Happy Lane at West Thompson				
75.00	30					
	35					

Material Graphics | RQD (%) | Moisture Content (%) | Dry Unit Weight (pcf) | Shear Strength (tsf) | Drilling Method | Casing Depth | Blows per 6 in. | Blows per foot

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REPORT TITLE	HOLE ID
BORING RECORD	KDP-15

DIST.	COUNTY	ROUTE	POSTMILE	EA
04	Sonoma	-	-	-

PROJECT OR BRIDGE NAME: SONOMA VALLEY TRUNK MAIN REPLACEMENT - REACH A

BRIDGE NUMBER	PREPARED BY	DATE	SHEET
-	Amanda May		1 of 1

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Appendix B

BORING 1

EQUIPMENT: Truck mounted Mobile B-53 drill head with 6 inch solid flight augers.

DATE: 6/18/13

ELEVATION: 85-Feet*

*REFERENCE: Google Earth used for Elevation

OTHER TEST DATA	OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
						0	0			5 inches ASPHALTIC CONCRETE
							1			15 inches AGGREGATE BASEROCK
		2500 UC	34	15.5	109	1	2, 3	■		CLAYEY SAND WITH GRAVEL (SC) Dark to medium brown, moist, medium dense, fine to coarse sand, ~15-25% low plasticity clay, ~5-15% fine to coarse sub-rounded gravel up to 2 inches. [Alluvium]
							4			Bottom of boring at 4.0 feet. No groundwater observed during drilling.
						2	5, 6			
							7			
							8			
						3	9, 10			

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

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ENGINEERING GROUP

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FILE: 1635.10 BL.dwg

BORING LOG

West Napa Street
Water System Improvements
Sonoma, California

Project No. 1635.10 Date: 6/19/13

Drawn JBG
Checked

A-3
FIGURE

BORING 2

EQUIPMENT: Truck mounted Mobile B-53 drill head with 6 inch solid flight augers.

DATE: 6/18/13

ELEVATION: 87-Feet*

*REFERENCE: Google Earth used for Elevation

OTHER TEST DATA	OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
						0	0			4 inches ASPHALTIC CONCRETE
							1			21 inches AGGREGATE BASEROCK
							2			CLAYEY SAND (SC) Dark brown, moist, loose, fine to medium sand, ~30% medium plasticity clay. [Alluvium]
						1	3			
		600 UC	23	19.0	105		4			GRAVELLY SAND WITH CLAY (SW/SC) Light brown, moist, medium dense, fine to coarse sand, ~20% fine to medium gravel, ~10% low plasticity clay. [Alluvium]
							5			Bottom of boring at 5.0 feet. No groundwater observed during drilling.
							6			
						2	7			
							8			
							9			
						3	10			

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

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BORING LOG

West Napa Street
Water System Improvements
Sonoma, California

Project No. 1635.10 Date: 6/19/13

Drawn JBG
Checked

A-4
FIGURE

BORING 3

EQUIPMENT: Truck mounted Mobile B-53 drill head with 6 inch solid flight augers.

DATE: 6/18/13

ELEVATION: 86-Feet*

*REFERENCE: Google Earth used for Elevation

OTHER TEST DATA	OTHER TEST DATA	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
						0	0			6 inches ASPHALTIC CONCRETE
							1			9 inches CONCRETE
		1100 UC	86	25.2	95	1	2	■		LAPILLI ASH TUFF Light brown, thickly bedded, low hardness, weak to moderate strength, slightly weathered, [Bedrock] Drill rate ~30 sec/ft
							3			
							4			Bottom of boring at 4.0 feet. No groundwater observed during drilling.
						2	5			
							6			
							7			
							8			
						3	9			
							10			

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

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BORING LOG

West Napa Street
Water System Improvements
Sonoma, California

Project No. 1635.10 Date: 6/19/13

Drawn JBG
Checked

A-5
FIGURE

Log of Boring B-1

Equipment: Deeprock DR8K

Date: 12/15/11

Logged By: SCL **Elevation:** 102.9 feet ***

Laboratory Tests	Sampler Type*	Moisture Content (%)	Dry Density (pcf)	Blows/foot	Depth (ft.)	Sample	
					1		BROWN SILTY GRAVELLY SAND (SM) medium dense, damp to moist large cobbles of rhyolite, andesite
					2		
					3		BROWNISH-RED TUFF BRECCIA little fracturing,moderately hard to hard, little weathering
					4		
					5		
	CA	12.4	94	51**	6		
					7		BROWNISH-RED TUFF little fracturing, moderately hard, deep weathering
					8		
					9		
Tx 5488 (1440)		17.5 15.8	102 103		10		
	CA			37**	11		GRAY TUFF little fracturing, moderately hard to hard, moderate weathering
					12		
					13		
					14		REDDISH BROWN CONGLOMERATE little fracturing, moderate hardness, little weathering cobbles of volcanics, clast-supported in a sandy-clayey matrix
Tx 1112 (2160)		16.6	101		15		
	CA			42**	16		
					17		
					18		
					19		
					20		
	CA			38**			GRAY AND YELLOW SILTSTONE little fracturing, moderate hardness, little weathering
Tx 5896 (3600)		31.1	91		21		
					22		

Fill

?

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

Brunsing Associates, Inc.
5468 Skylane Blvd., Suite 201
Santa Rosa, California 95403
Tel: (707) 838-3027

Job No.: 11027.04
Appr.: EEO
Date: 08/30/12

LOG OF BORING B-1
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 3

Log of Boring B-1

Equipment: Deeprock DR8K
Date: 12/15/11
Logged By: SCL **Elevation:** 102.9 feet ***

Laboratory Tests	Sampler Type*	Moisture Content (%)	Dry Density (pcf)	Blows/foot	Depth (ft.)	Sample
54% Passing #200		29.6	90		25	
	CA			51/10"***	26	
					27	
Bottom Elev. of Jacking Pit					30	
22% Passing #200		33.2	88			
97% Passing #4	CA	19.6	107	53/10"***	31	
	CA			51/11"**	36	
	SPT			71	41	

Casing

TAN SILTSTONE
little fracturing, moderate hardness, little weathering

TAN TO RED SILTY SANDSTONE
little fracturing, moderate hardness, little weathering, coarse, rounded sands

BLUE-GRAY SANDSTONE
little fracturing,moderate hardness, little weathering
coarse rounded sands entrained

BLUE-GRAY SILTSTONE-SHALE
little fracturing, low to moderate hardness,
little weathering
contains coarse rounded sands

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

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Tel: (707) 838-3027

Job No.: 11027.04
Appr.: EEO
Date: 08/30/12

LOG OF BORING B-1
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 3
SHEET 2 of 3

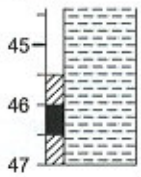
Log of Boring B-1

Equipment: Deeprock DR8K

Date: 12/15/11

Logged By: SCL **Elevation:** 102.9 feet ***

Laboratory Tests	Sampler Type*	Moisture Content (%)	Dry Density (pcf)	Blows/foot	Depth (ft.)	Sample
					45	
	SPT			31	46	
					47	



Notes:
1. Water encountered at about 30 feet during drilling
2. 4-inch diameter well installed to 45.3 feet, see well construction detail

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

Brunsing Associates, Inc.
5468 Skylane Blvd., Suite 201
Santa Rosa, California 95403
Tel: (707) 838-3027

Job No.: 11027.04
Appr.: EEO
Date: 08/30/12

LOG OF BORING B-1
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 3
SHEET 3 of 3

Log of Boring B-2

Equipment: Light Portable Drill Rig (Little Beaver)

Date: 12/16/11

Logged By: SCL **Elevation:** 83 feet ***

Sampler Type*	Blows/foot	Depth (ft.)	Sample
		1	
SPT	23**	2	
		3	
SPT	15**	4	
		5	
SPT	78**	6	
		7	

Casings

COBBLES, 6-inch diameter

BROWN SILTY SANDY GRAVEL (GP-GM)
medium dense, saturated

COBBLES & SILTY SANDY GRAVEL (SP-GP)
medium dense to dense, saturated

BROWN GRAVELLY SILTY SAND (SM)
dense, saturated

Notes:
1. Water encountered at 0.8 feet during drilling.
2. Material "glory holed" during drilling, hole would not stay open. Hole was hand dug to 2 feet.

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

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LOG OF BORING B-2
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 4
SHEET 1 of 1

Log of Boring B-3

Equipment: Deeprock DR8K
Date: 1/9/12
Logged By: SCL **Elevation:** 99.5 feet ***

Laboratory Tests	Sampler Type*	Moisture Content (%)	Dry Density (pcf)	Blows/foot	Depth (ft.)	Sample	
							BROWN SILTY SAND (SM) loose, porous, dry to damp (fill)
					1		
					2		
					3		
					4		BROWN SILTY SAND (SM) loose, porous, dry to damp with rootlets (topsoil)
	CA			7**	5		
					6		
					7		BROWN WITH GRAY SILTY SAND (SM) loose, porous, dry with roots
					8		
					9		
	CA			9**	10		
Tx 2168 (1440)		15.1	69		11		
					12		
					13		
					14		
	CA			10**	15		
Tx 2690 (2160)		11.9	71		16		REDDISH BROWN SILTY COARSE SAND (SM) with rounded gravels loose, dry
					17		
					18		REDDISH-BROWN SILTY SANDY GRAVEL (GM) loose to very loose, wet to saturated large gravels to small cobbles
					19		
	CA			10**	20		
11% Passing #200 49% Passing #4					21		
					22		

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

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Job No.: 11027.04
Appr.: EEO
Date: 08/30/12

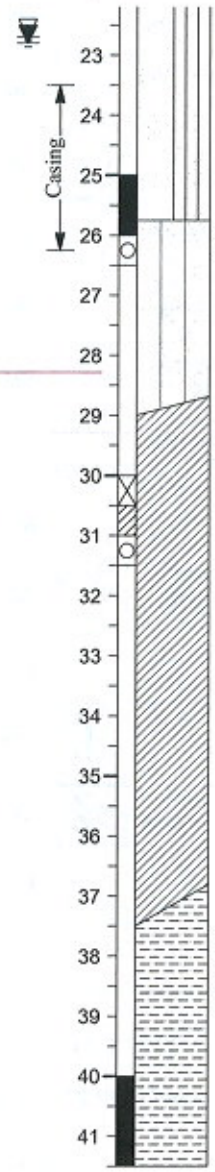
LOG OF BORING B-3
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 5
SHEET 1 of 2

Log of Boring B-3

Equipment: Deeprock DR8K
Date: 1/9/12
Logged By: SCL **Elevation:** 99.5 feet ***

Laboratory Tests	Sampler Type*	Moisture Content (%)	Dry Density (pcf)	Blows/foot	Depth (ft.)	Sample
15% Passing #200 47% Passing #4	CA			5**	25	
	CA			14**	30	
	CA			28**	40	



Bottom Elev. of Receiving Pit

BROWN SILTY FINE SAND (SM)
very loose, saturated

BLUE-GRAY CLAY (CL)
medium stiff, saturated

BLUE-GREEN TO OLIVE-TAN SILTSTONE
little fracturing, weakly indurated, low to moderate hardness, little weathering
contains coarse rounded sands

Notes:
1. Water encountered at about 23 feet bgs during drilling
2. 4-inch diameter well installed to 40 feet, see well construction detail

*CA - California Modified Split Barrel Sampler 3.0-inch O.D.
CM - California Modified Split Barrel Sampler 2.5-inch O.D.
SPT - California Split Barrel Sampler 2.0-inch O.D.
** Equivalent "Standard Penetration" Blow Counts.
*** Elevations interpolated from Sheet C-1, Alternate 2, dated 8-3-11 by SCVSD, See Plate 2

Scale: 1" = 3'

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Tel: (707) 838-3027

Job No.: 11027.04
Appr.: EEO
Date: 08/30/12

LOG OF BORING B-3
SVCSD AGUA CALIENTE CREEK
BORE AND JACK CROSSING
Agua Caliente Creek
El Verano, Sonoma County, California

PLATE 5
SHEET 2 of 2

DRILL RIG CME-55	SURFACE ELEVATION	LOGGED BY DF
DEPTH TO GROUNDWATER Not Encountered	BORING DIAMETER 6 Inches	DATE DRILLED 6/23/77

DESCRIPTION AND CLASSIFICATION					DEPTH (FEET)	SAMPLER	PENETRATION RESISTANCE (BLOWS/FT.)	WATER CONTENT (%)	SHEAR STRENGTH BY TORVANE (KSF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)
DESCRIPTION AND REMARKS	SYMBOL	COLOR	CONSIST.	SOIL TYPE						
SANDY SILT, fine grained *Passing No. 200 Sieve = 60%		light brown	stiff to very stiff	ML	1, 2, 3	*	30 28	4		
CLAYEY SAND, with gravel		brown	medium dense	SC	4, 5		13			
SANDY CLAY		brown	firm	CL	6, 7					
CLAYEY SAND, with gravel		brown	dense	SC	8, 9		60/10"	12		
CLAYEY SANDY GRAVEL becoming CLAYEY SAND, with gravel		brown yellow brown	dense dense	GC SC	10, 11, 12, 13, 14, 15, 16, 17, 18		32			
CLAYEY SAND, fine grained		brown	dense	SC	19, 20		35	17		

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EXPLORATORY BORING LOG

EFFLUENT AND I/I RELIEF PIPELINES
Sonoma County, California

PROJECT NO.	DATE	BORING NO.
266-4	August 1977	18

B&V 000075

DRILL RIG CME-55	SURFACE ELEVATION	LOGGED BY DF
DEPTH TO GROUNDWATER Not Encountered	BORING DIAMETER 6 Inches	DATE DRILLED 6/24/77

DESCRIPTION AND CLASSIFICATION					DEPTH (FEET)	SAMPLER	PENETRATION RESISTANCE (BLOWS/FT.)	WATER CONTENT (%)	SHEAR STRENGTH BY TORVANE (KSF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)
DESCRIPTION AND REMARKS	SYMBOL	COLOR	CONSIST.	SOIL TYPE						
CLAYEY SAND, fine grained (continued)		brown	dense	SC						
					21					
					22					
becoming					23					
SANDY CLAY, fine grained		brown	very stiff	CL	24		58			
					25					
Bottom of Boring = 25.0 Feet					26					
Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.					27					
					28					
					29					
					30					
					31					
					32					
					33					
					34					
					35					
					36					
					37					
					38					
					39					
					40					

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EXPLORATORY BORING LOG

EFFLUENT AND I/I RELIEF PIPELINES
Sonoma County, California

PROJECT NO.	DATE	BORING NO.
266-4	August 1977	18

B&V 000576

DRILL RIG CME-55	SURFACE ELEVATION	LOGGED BY DF
DEPTH TO GROUNDWATER Not Encountered	BORING DIAMETER 6 Inches	DATE DRILLED 6/24/77

DESCRIPTION AND CLASSIFICATION					DEPTH (FEET)	SAMPLER	PENETRATION RESISTANCE (BLOWS/FT.)	WATER CONTENT (%)	SHEAR STRENGTH BY TORVANE (KSF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)
DESCRIPTION AND REMARKS	SYMBOL	COLOR	CONSIST.	SOIL TYPE						
SANDY SILT, fine grained with scattered small gravel		gray-brown	very stiff	ML	1		30	9		
grading to					2		60			
SANDY CLAY, fine grained with silt and scattered small gravel		light brown	very stiff	CL	3					
					4		64	21		
					5					
					6					
					7					
CLAYEY SAND, medium to coarse grained		yellow brown	medium dense to dense	SC	8					
					9		32	23		
					10					
					11					
					12					
					13					
					14		20			
					15					
					16					
					17					
					18					
increasing clay					19		44			
					20					

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EXPLORATORY BORING LOG

EFFLUENT AND I/I RELIEF PIPELINES
Sonoma County, California

PROJECT NO.	DATE	BORING NO.
266-4	August 1977	19

B&V 000057

DRILL RIG CME-55	SURFACE ELEVATION	LOGGED BY DF
DEPTH TO GROUNDWATER Not Encountered	BORING DIAMETER 6 Inches	DATE DRILLED 6/24/77

DESCRIPTION AND CLASSIFICATION					DEPTH (FEET)	SAMPLER	PENETRATION RESISTANCE (BLOWS/FT.)	WATER CONTENT (%)	SHEAR STRENGTH BY TORVANE (KSF)	UNCONFINED COMPRESSIVE STRENGTH (KSF)
DESCRIPTION AND REMARKS	SYMBOL	COLOR	CONSIST.	SOIL TYPE						
SANDY CLAY, fine grained		brown	very stiff	CL	21					
					22					
					23					
					24		37	23		
					25					
Bottom of Boring = 25.0 Feet					26					
Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.					27					
					28					
					29					
					30					
					31					
					32					
					33					
					34					
					35					
					36					
					37					
					38					
					39					
					40					

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EXPLORATORY BORING LOG

EFFLUENT AND I/I RELIEF PIPELINES
Sonoma County, California

PROJECT NO.	DATE	BORING NO.
266-4	August 1977	19

B&V 000057

KLEINFELDER

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Appendix C

Exploration ID	Depth (ft.)	Sample No.	Sample Description	Water Content (%)	Dry Unit Wt. (pcf)	Sieve Analysis (%)			Atterberg Limits			Additional Tests
						Passing 3/4"	Passing #4	Passing #200	Liquid Limit	Plastic Limit	Plasticity Index	
KB-1	15.0	S04	LEAN CLAY WITH SAND (CL)	26.0	97.0							
KB-1	15.5		LEAN CLAY WITH SAND (CL)	26.0	97.3				44	15	29	
KB-2	11.0		SILTY SAND WITH GRAVEL (SM)	15.3	79.3			22				
KB-4	15.0	S05	SANDY LEAN CLAY (CL)	26.0	99.0							
KB-4	16.0		SANDY LEAN CLAY (CL)	26.1	98.8				36	13	23	
KB-6	18.0		SILTY SAND (SM)			100	95	48.5				**Hydrometer**
KB-6	21.0		SILTY SAND (SM)	35.2	83.0							
KB-6	26.0		SILT WITH SAND (ML)	35.0	87.7			85.2				**Hydrometer**
KB-8	26.0		SILTY CLAY (CL-ML)	28.2	95.4		100	99				
KB-9	11.0		SANDY LEAN CLAY (CL)				99	62.3	36	19	17	**Hydrometer**
KB-9	11.25		CLAYEY SAND (SC)				97	27.0				**Hydrometer**
KB-10	20.0	S04	SANDY LEAN CLAY (CL)	32.0	87.0							
KB-10	21.0		SANDY LEAN CLAY (CL)	31.8	87.3		100	64.8				**Hydrometer**
KB-10	40.0	S08	SANDY SILTY CLAY (CL-ML)	42.0	80.0							
KB-10	41.0		SANDY SILTY CLAY (CL-ML)	41.8	80.4		100	70.0				**Hydrometer**
KB-11	10.0	S02	LEAN CLAY WITH SAND (CL)	32.0	89.0							
KB-11	11.0		LEAN CLAY WITH SAND (CL)	32.2	88.9				40	24	16	
KB-11	15.0	S03	SANDY LEAN CLAY (CL)	27.0	96.0							
KB-11	15.5		SILTY SAND WITH GRAVEL (SM)	26.7	95.8	100	85	21.9				**Hydrometer**
KB-12	10.0	S03	CLAYEY GRAVEL WITH SAND (GC)	36.0	81.0							
KB-12	11.0		SILTY SAND (SM)	35.7	81.0	100	94	38.7				**Hydrometer**
KB-13	10.0	S03	SANDY SILT (ML)	35.0	81.0							
KB-13	10.5		SANDY SILT (ML)	34.9	80.5	100	94	53				
KB-14	10.0	S03	SANDY LEAN CLAY (CL)	98.0	47.0							
KB-14	11.0		SILTY SAND (SM)	18.8	107.7	100	98	47				
KB-16	10.0	S03	SANDY LEAN CLAY (CL)	36.0	85.0							
KB-16	11.0		LEAN CLAY WITH SAND (CL)	36.4	84.9				42	18	24	

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = NonPlastic
NA = Not Available

KLEINFELDER
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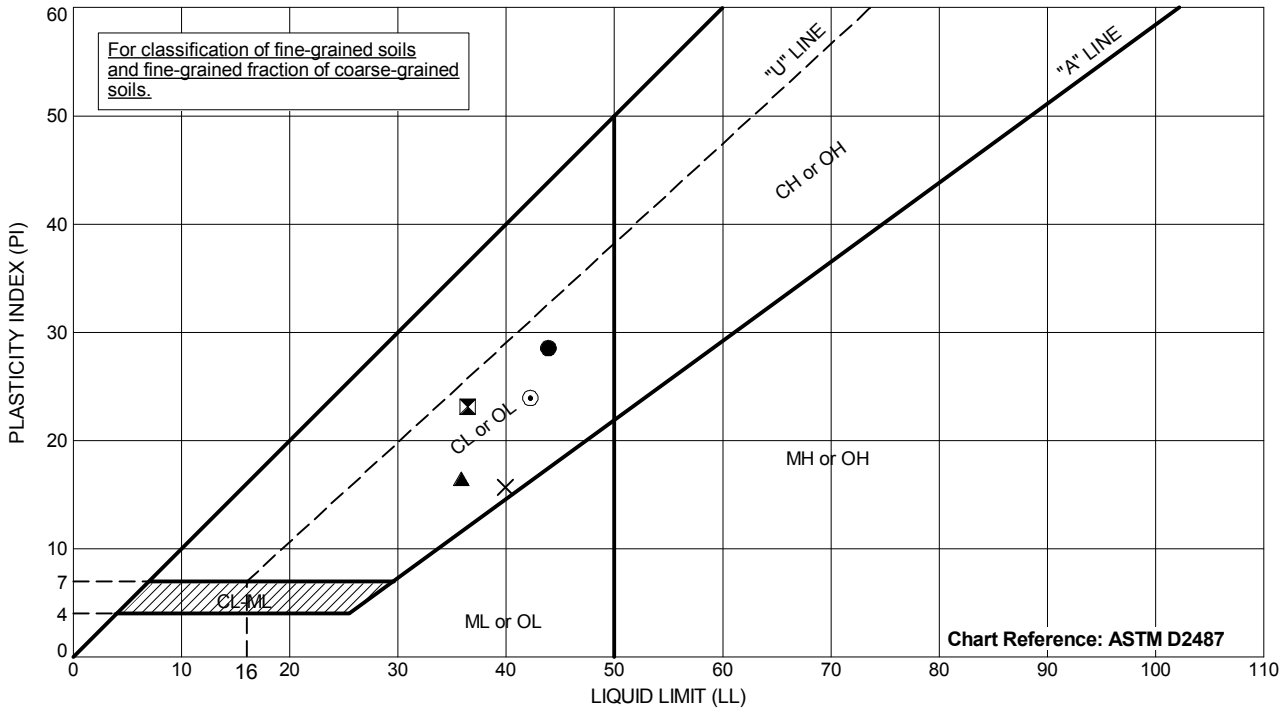
PROJECT NO.: 20143780
DRAWN BY: 1/27/15
CHECKED BY: 1/27/15
DATE: 1/27/2015
REVISED: -

LABORATORY TEST RESULT SUMMARY

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

TABLE
C-1



	Exploration ID	Depth (ft.)	Sample Number	Sample Description	Passing #200	LL	PL	PI
●	KB-1	15.5	NA	LEAN CLAY WITH SAND (CL)	NM	44	15	29
⊠	KB-4	16	NA	SANDY LEAN CLAY (CL)	NM	36	13	23
▲	KB-9	11	NA	SANDY LEAN CLAY (CL)	62.3	36	19	17
×	KB-11	11	NA	LEAN CLAY WITH SAND (CL)	NM	40	24	16
⊙	KB-16	11	NA	LEAN CLAY WITH SAND (CL)	NM	42	18	24

Testing perfomed in general accordance with ASTM D4318.
NP = Nonplastic
NA = Not Available
NM = Not Measured

KLEINFELDER
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PROJECT NO.: 20143780
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ATTERBERG LIMITS

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-2

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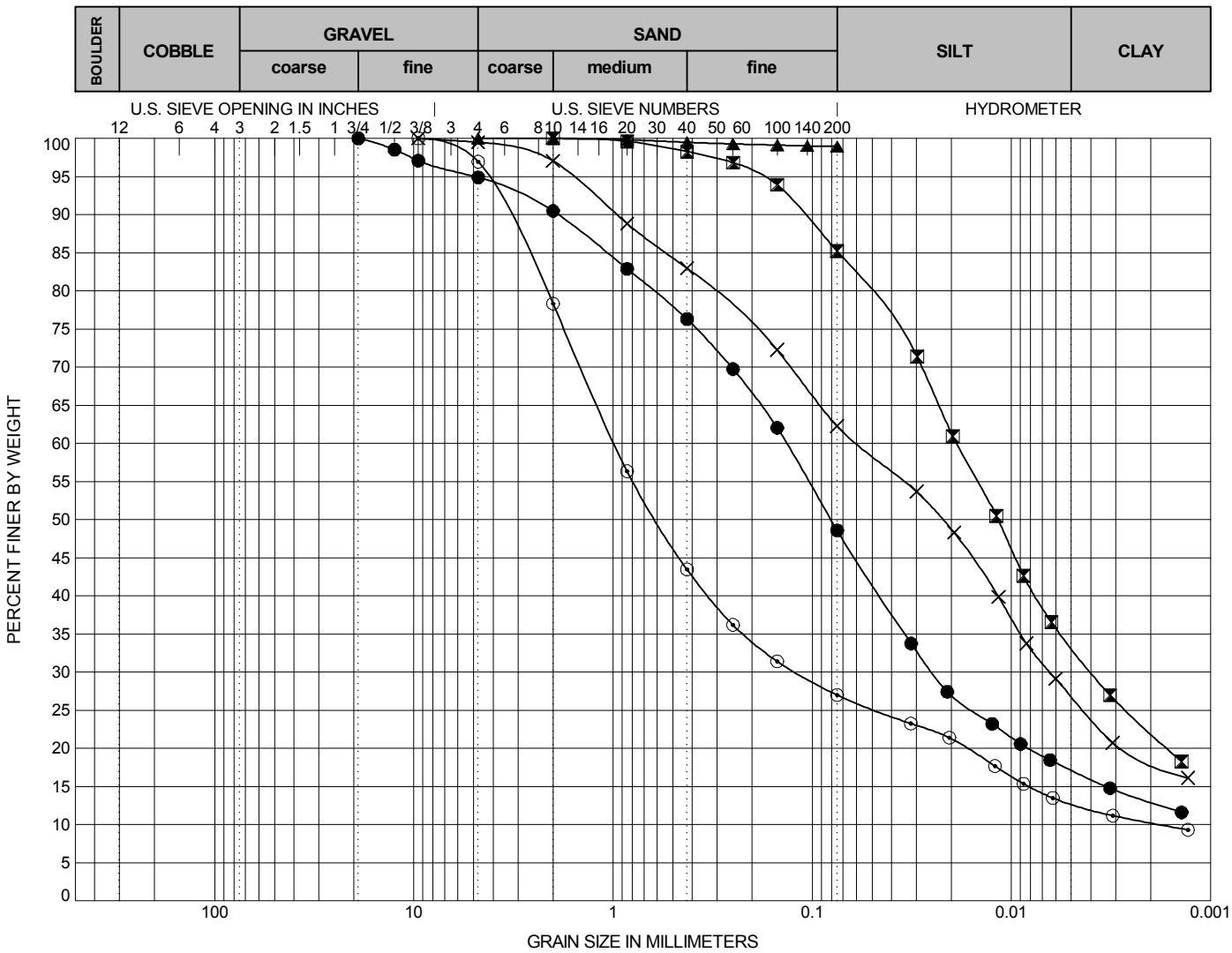

	Exploration ID	Depth (ft.)	Sample Number	Sample Description	LL	PL	PI
●	KB-6	18 - 21	NA	SILTY SAND (SM)	NM	NM	NM
⊠	KB-6	26	NA	SILT WITH SAND (ML)	NM	NM	NM
▲	KB-8	26	NA	SILTY CLAY (CL-ML)	NM	NM	NM
×	KB-9	11	NA	SANDY LEAN CLAY (CL)	36	19	17
⊙	KB-9	11.25	NA	CLAYEY SAND (SC)	NM	NM	NM

	Exploration ID	Depth (ft.)	D_{100}	D_{60}	D_{30}	D_{10}	Cc	Cu	Passing 3/4"	Passing #4	Passing #200	%Silt	%Clay
●	KB-6	18 - 21	19	0.135	0.025	NM	NM	NM	100	95	48.5	31.4	17.1
⊠	KB-6	26	2	0.019	0.004	NM	NM	NM			85.2	51.9	33.3
▲	KB-8	26	4.75	NM	NM	NM	NM	NM		100	99	NM	NM
×	KB-9	11	9.5	0.059	0.006	NM	NM	NM		99	62.3	35.5	26.8
⊙	KB-9	11.25	9.5	0.98	0.12	0.002	8.19	542.46		97	27.0	14.2	12.8

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$

Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60}\, D_{10}$

Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D422

D_{60} = Grain diameter at 60% passing

D_{30} = Grain diameter at 30% passing

D_{10} = Grain diameter at 10% passing

NP = Nonplastic
NA = Not Available
NM = Not Measured

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SIEVE ANALYSIS

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-3

PLOTTED: 01/27/2015 11:38 AM BY: Mpucci
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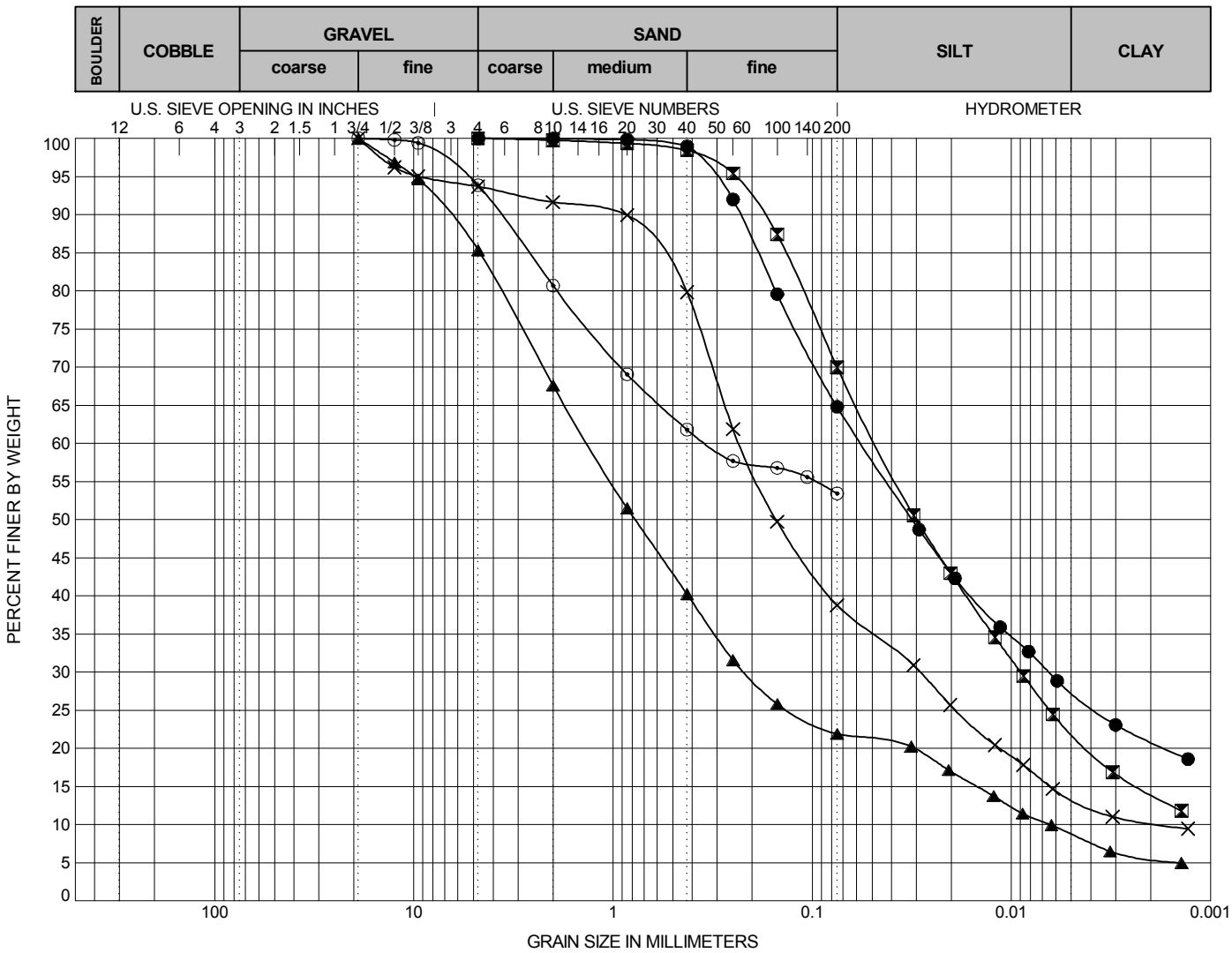

	Exploration ID	Depth (ft.)	Sample Number	Sample Description	LL	PL	PI
●	KB-10	21	NA	SANDY LEAN CLAY (CL)	NM	NM	NM
⊠	KB-10	41	NA	SANDY SILTY CLAY (CL-ML)	NM	NM	NM
▲	KB-11	15.5	NA	SILTY SAND WITH GRAVEL (SM)	NM	NM	NM
×	KB-12	11	NA	SILTY SAND (SM)	NM	NM	NM
⊙	KB-13	10.5	NA	SANDY SILT (ML)	NM	NM	NM

	Exploration ID	Depth (ft.)	D_{100}	D_{60}	D_{30}	D_{10}	Cc	Cu	Passing 3/4"	Passing #4	Passing #200	%Silt	%Clay
●	KB-10	21	4.75	0.057	0.007	NM	NM	NM		100	64.8	37.4	27.4
⊠	KB-10	41	4.75	0.048	0.009	NM	NM	NM		100	70.0	47.9	22.1
▲	KB-11	15.5	19	1.337	0.218	0.006	5.52	208.11	100	85	21.9	13.2	8.7
×	KB-12	11	19	0.231	0.029	0.002	2.01	129.53	100	94	38.7	25.2	13.5
⊙	KB-13	10.5	19	0.337	NM	NM	NM	NM	100	94	53	NM	NM

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$

Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60}\, D_{10}$

Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D422

D_{60} = Grain diameter at 60% passing

D_{30} = Grain diameter at 30% passing

D_{10} = Grain diameter at 10% passing

NP = Nonplastic
NA = Not Available
NM = Not Measured

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SIEVE ANALYSIS

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-4

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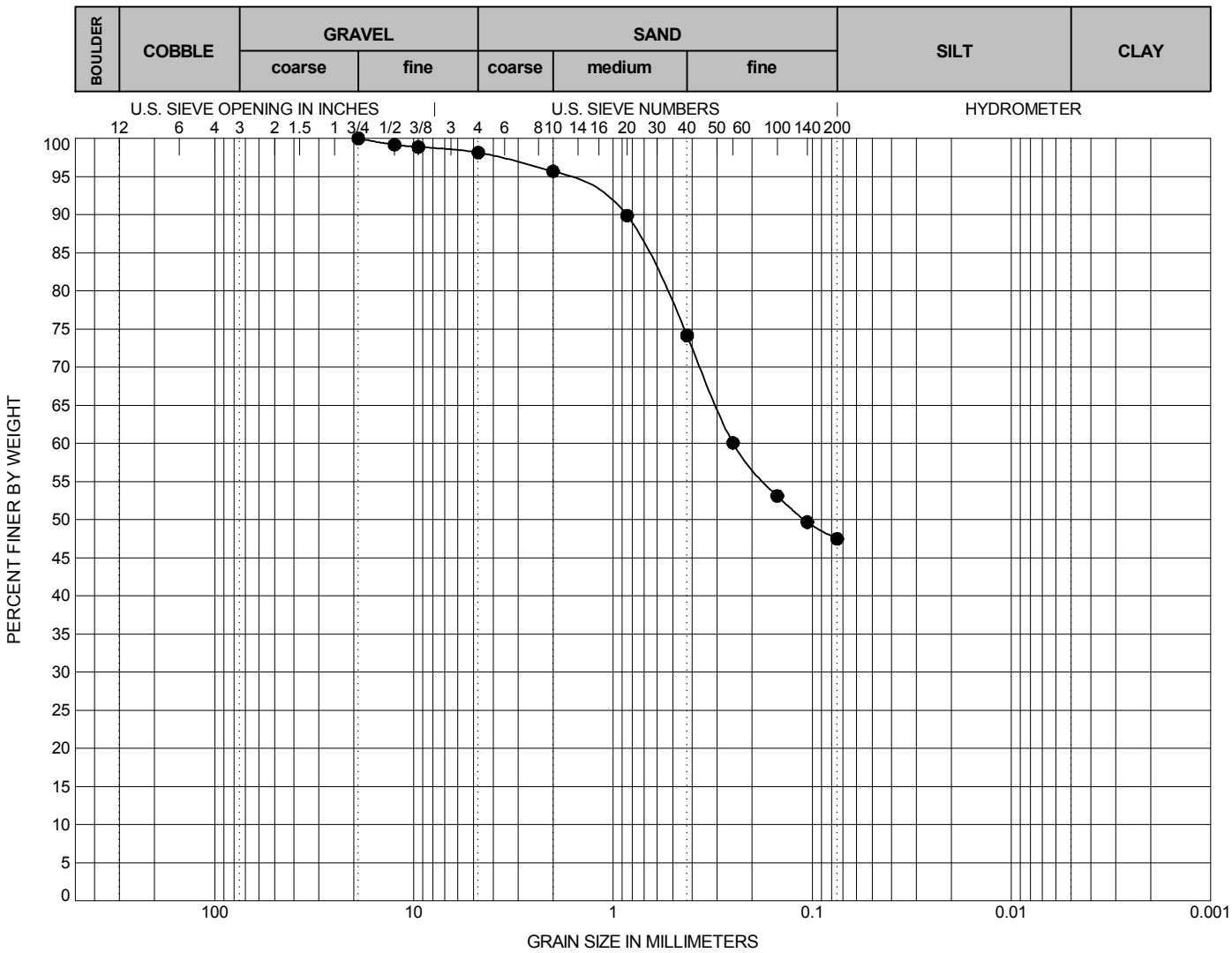

	Exploration ID	Depth (ft.)	Sample Number	Sample Description	LL	PL	PI
●	KB-14	11	NA	SILTY SAND (SM)	NM	NM	NM

	Exploration ID	Depth (ft.)	D_{100}	D_{60}	D_{30}	D_{10}	Cc	Cu	Passing 3/4"	Passing #4	Passing #200	%Silt	%Clay
●	KB-14	11	19	0.249	NM	NM	NM	NM	100	98	47	NM	NM

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$

Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60}\, D_{10}$

D_{60} = Grain diameter at 60% passing

D_{30} = Grain diameter at 30% passing

D_{10} = Grain diameter at 10% passing

Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D422
NP = Nonplastic
NA = Not Available
NM = Not Measured

KLEINFELDER
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SIEVE ANALYSIS

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-5

PLOTTED: 01/27/2015 11:38 AM BY: Mpucci
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gINT TEMPLATE: PROJECTWISE: KLF_STANDARD_GINT_LIBRARY_2015.GLB [KLF_SIEVE ANALYSIS]

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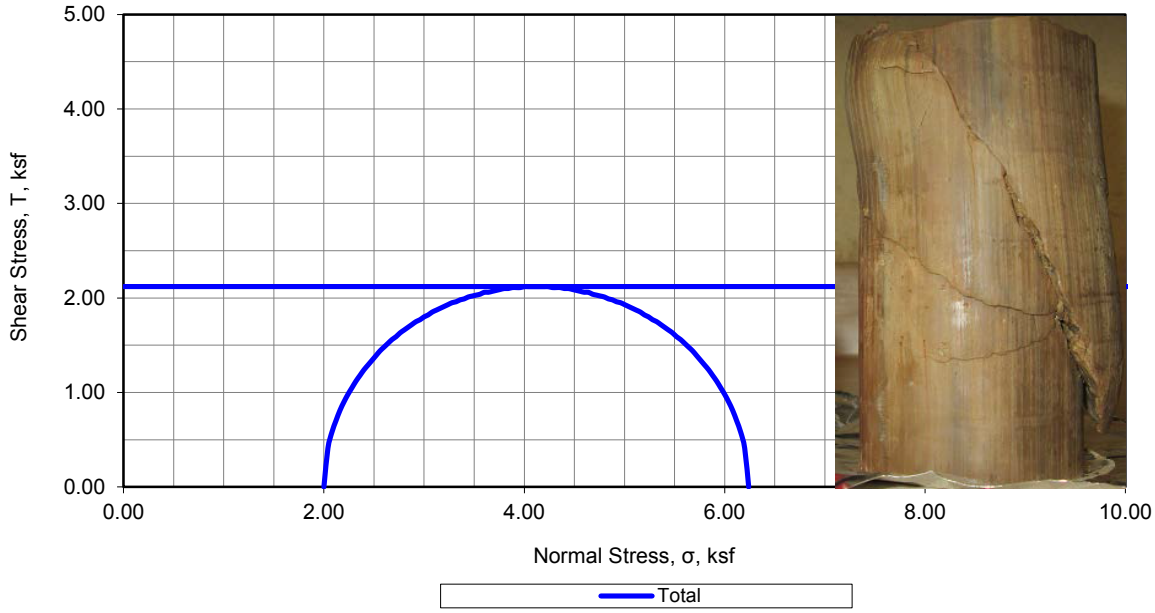
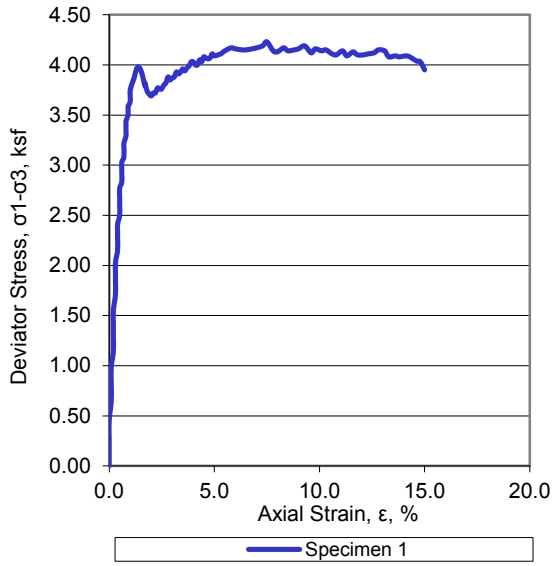


Specimen Shear Picture



Specimen No.			1
Initial	Diameter, in	D_O	2.39
	Height, in	H_O	5.58
	Water Content, %	ω_O	26.0
	Dry Density, lbs/ft3	$^{\gamma}d_o$	97.3
	Saturation, %	S_O	98
	Void Ratio	e_O	0.699
Minor Principal Stress, ksf		σ_3	2.00
Maximum Deviator Stress, ksf		$(\sigma 1-\sigma 3)_{max}$	4.23
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	7.55
Deviator Stress @ 15% Axial Strain, ksf		$(\sigma_1-\sigma_3)_{15\%}$	3.95
Ultimate Deviator Stress, ksf		$(\sigma_1-\sigma_3)_{ult}$	na
Rate of strain, %/min		'ε	1.00
Axial Strain at Failure, %		ε_f	7.55

Description of Specimen: Olive Brown Lean Clay with Sand (CL)

Amount of Material Finer than the No. 200, %: nm

LL: 44	PL: 15	PI: 29	G_S: 2.65 Assumed	Specimen Type: Undisturbed	Test Method: ASTM D2850

Membrane correction applied

Boring:	KB-1
Sample:	4B
Depth, ft:	15.5
Test Date:	7/31/14

Remarks: nm= not measured, na = not applicable

KLEINFELDER
Bright People. Right Solutions.

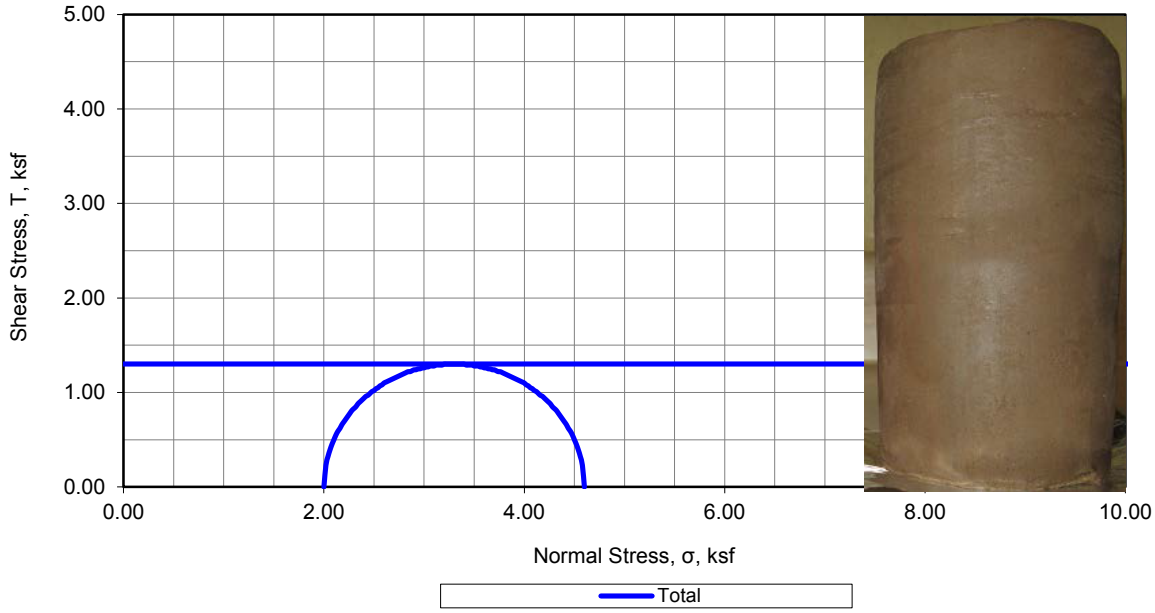
PROJECT NO.: 134751
DRAWN BY:
CHECKED BY:
DATE: 8/1/2014
REVISED: -

TRIAXIAL COMPRESSION TEST (UU)

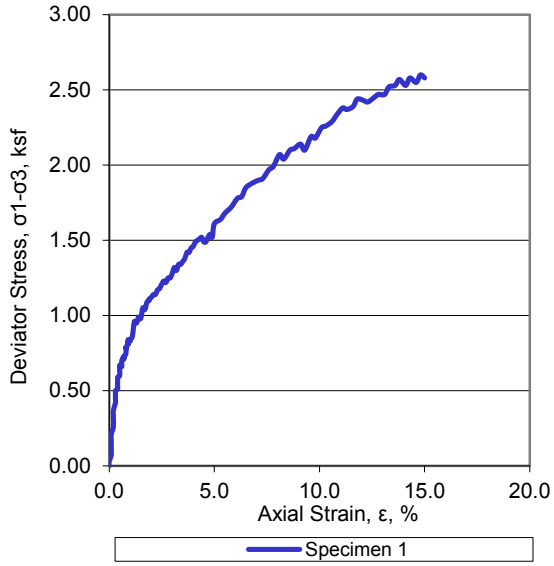
SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-6

Total	
c = 1.30	ksf



Specimen Shear Picture



Specimen No.			1
Initial	Diameter, in	D_O	2.40
	Height, in	H_O	5.46
	Water Content, %	ω_O	26.1
	Dry Density, lbs/ft3	γd_o	98.8
	Saturation, %	S_O	103
	Void Ratio	e_O	0.674
Minor Principal Stress, ksf		σ_3	2.00
Maximum Deviator Stress, ksf		$(\sigma 1-\sigma 3)_{max}$	2.60
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	14.85
Deviator Stress @ 15% Axial Strain, ksf		$(\sigma_1-\sigma_3)_{15\%}$	2.58
Ultimate Deviator Stress, ksf		$(\sigma_1-\sigma_3)_{ult}$	na
Rate of strain, %/min		$'\varepsilon$	1.00
Axial Strain at Failure, %		ε_f	14.85

Description of Specimen: Dark Yellowish Brown Clayey Sand (SC)

Amount of Material Finer than the No. 200, %: nm

LL: 36	PL: 13	PI: 23	G_S: 2.65 Assumed	Specimen Type: Undisturbed	Test Method: ASTM D2850

Membrane correction applied

Boring:	KB-4
Sample:	5C
Depth, ft:	16.0
Test Date:	7/31/14

Remarks: nm= not measured, na = not applicable

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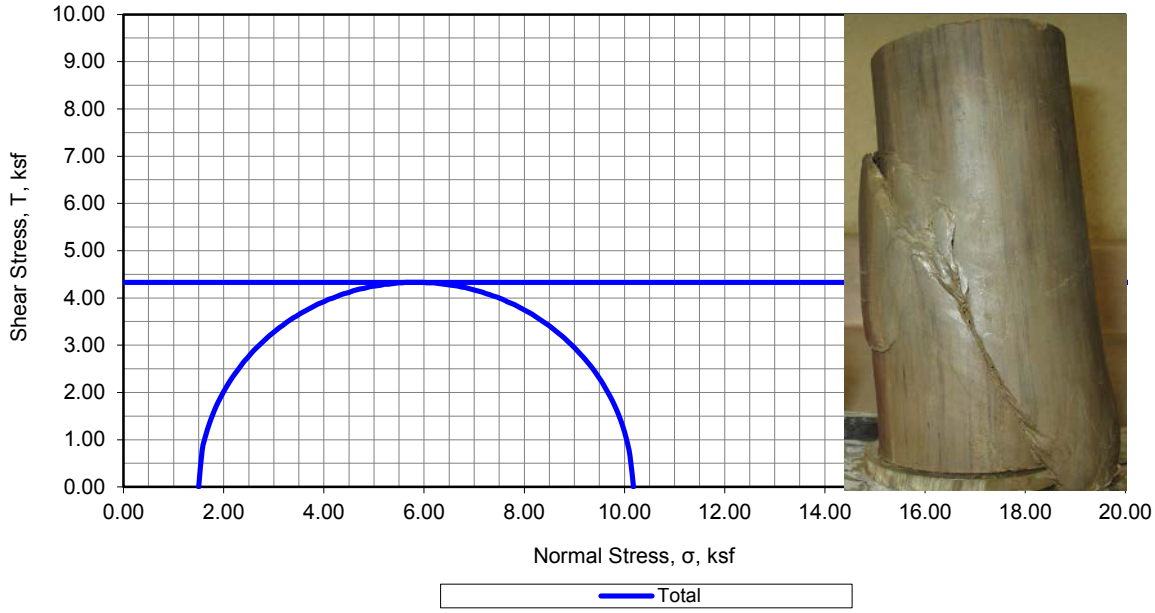
PROJECT NO.: 134751
DRAWN BY:
CHECKED BY:
DATE: 8/1/2014
REVISED: -

TRIAXIAL COMPRESSION TEST (UU)

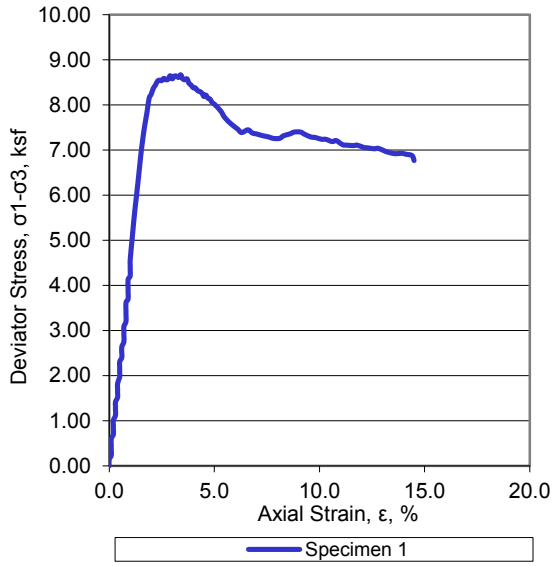
SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

PLATE
C-7

Total	
c = 4.33	ksf



Specimen Shear Picture



Specimen No.			1
Initial	Diameter, in	D_O	2.40
	Height, in	H_O	5.99
	Water Content, %	ω_O	32.2
	Dry Density, lbs/ft3	$^{\gamma}d_o$	88.9
	Saturation, %	S_O	99
	Void Ratio	e_O	0.860
Minor Principal Stress, ksf		σ_3	1.50
Maximum Deviator Stress, ksf		$(\sigma 1-\sigma 3)_{max}$	8.67
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	3.45
Deviator Stress @ 15% Axial Strain, ksf		$(\sigma_1-\sigma_3)_{15\%}$	6.77
Ultimate Deviator Stress, ksf		$(\sigma_1-\sigma_3)_{ult}$	na
Rate of strain, %/min		$'\varepsilon$	1.00
Axial Strain at Failure, %		ε_f	3.45

Description of Specimen: Olive Brown Sandy Lean Clay (CL)

Amount of Material Finer than the No. 200, %: nm

LL: 40.24	PL: 24	PI: 16.24	G_S: 2.65 Assumed	Specimen Type: Undisturbed	Test Method: ASTM D2850

Membrane correction applied

Boring:	KB-11
Sample:	2C
Depth, ft:	11.0
Test Date:	7/31/14

Remarks: nm= not measured, na = not applicable

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PROJECT NO.:	134751
DRAWN BY:	
CHECKED BY:	
DATE:	8/1/2014
REVISED:	-

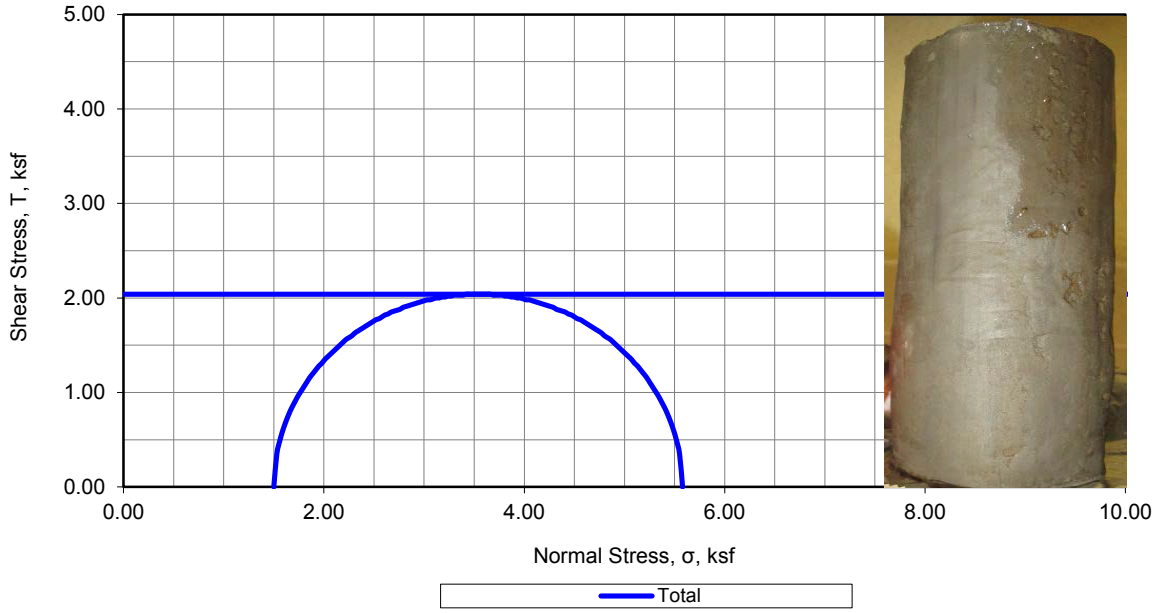
TRIAXIAL COMPRESSION TEST (UU)

SONOMA VALLEY TRUNK MAIN REPLACEMENT
REACH A
SONOMA, CALIFORNIA

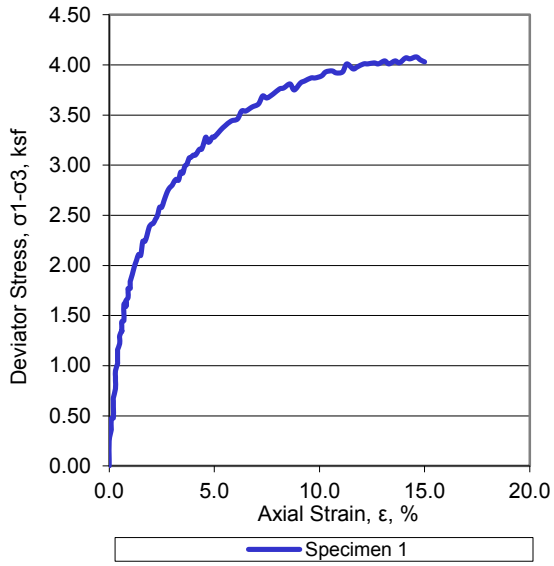
PLATE

C-8

Total	
c = 2.04	ksf



Specimen Shear Picture



Specimen No.			1
Initial	Diameter, in	D_O	2.40
	Height, in	H_O	5.85
	Water Content, %	ω_O	36.4
	Dry Density, lbs/ft3	$^{\gamma}d_o$	84.9
	Saturation, %	S_O	102
	Void Ratio	e_O	0.948
Minor Principal Stress, ksf		σ_3	1.50
Maximum Deviator Stress, ksf		$(\sigma 1-\sigma 3)_{max}$	4.08
Time to $(\sigma_1-\sigma_3)_{max}$, min		t_f	14.58
Deviator Stress @ 15% Axial Strain, ksf		$(\sigma_1-\sigma_3)_{15\%}$	4.03
Ultimate Deviator Stress, ksf		$(\sigma_1-\sigma_3)_{ult}$	na
Rate of strain, %/min		$'\varepsilon$	1.00
Axial Strain at Failure, %		ε_f	14.58

Description of Specimen: Dark Grayish Brown Sandy Lean Clay (CL)

Amount of Material Finer than the No. 200, %: nm

LL: 42	PL: 18	PI: 24	G_S: 2.65 Assumed	Specimen Type: Undisturbed	Test Method: ASTM D2850

Membrane correction applied

Boring:	KB-16
Sample:	3C
Depth, ft:	11.0
Test Date:	8/3/14

Remarks: nm= not measured, na = not applicable

KLEINFELDER
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PROJECT NO.: 134751	TRIAXIAL COMPRESSION TEST (UU)	PLATE
DRAWN BY:		
CHECKED BY:	SONOMA VALLEY TRUNK MAIN REPLACEMENT REACH A SONOMA, CALIFORNIA	C-9
DATE: 8/1/2014		
REVISED: -		

KLEINFELDER

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Appendix D

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

Date Reported 01/30/15
Date Submitted 01/26/15

To: Martin Pucci
Kleinfelder
2240 Northpoint Pkwy
Santa Rosa, CA, 95407

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

The reported analysis was requested for the following:
Location : 20143780.001A-SVCSD1 Site ID: KB-2-3C @ 16 FT
Thank you for your business.

* For future reference to this analysis please use SUN # 68644 - 142605

EVALUATION FOR SOIL CORROSION

Soil pH	6.72			
Minimum Resistivity	1.53	ohm-cm (x1000)		
Chloride	14.6	ppm	0.0015	%
Sulfate-S	5.1	ppm	0.0005	%

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

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

Date Reported 01/30/15
Date Submitted 01/26/15

To: Martin Pucci
Kleinfelder
2240 Northpoint Pkwy
Santa Rosa, CA, 95407

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

The reported analysis was requested for the following:
Location : 20143780.001A-SVCSD3 Site ID: KB-14-2B+C COMP
Thank you for your business.

* For future reference to this analysis please use SUN # 68645 - 142606

EVALUATION FOR SOIL CORROSION

Soil pH	6.39			
Minimum Resistivity	1.88	ohm-cm (x1000)		
Chloride	17.1	ppm	0.0017	%
Sulfate-S	29.1	ppm	0.0029	%

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

KLEINFELDER

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Appendix E

Important Information about Your

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical-Engineering Report Is Based on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical-engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical-engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold-prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical-engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold-prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your GBA-Member Geotechncial Engineer for Additional Assistance

Membership in the GEOPROFESSIONAL BUSINESS ASSOCIATION exposes geotechnical engineers to a wide array of risk confrontaton techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your GBA-member geotechnical engineer for more information.

GEOPROFESSIONAL BUSINESS ASSOCIATION

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

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