PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
FOR
GARDEN HIGHWAY (6237)
6237 Garden Highway
(APN 201-0270-061)
Sacramento, California

Project No. E18418.001
February 2022

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YOUNGDAHL CONSULTING GROUP, INC.
ESTABLISHED 1984
1234 Glenhaven Court, El Dorado Hills, CA 95762
4300 Anthony Court, Unit D, Rocklin, CA 95677
ph 916.933.0633 fx 916.933.6482
www.youngdahl.net

Jerry Bliatout
5200 Jilson Way
Elk Grove, California 95757

Project No. E18418.001
25 February 2022

Subject: **GARDEN HIGHWAY (6237)**
6237 Garden Highway, Sacramento, California
PRELIMINARY GEOTECHNICAL ENGINEERING STUDY

References:
1. Development Plans for 6237 Garden Highway, prepared by Architecture Solution Group, dated 10 October 2016 (Job No. 16105)
2. Proposal and Executed Contract for Garden Highway (6237), dated 10 March 2020 (executed 11 March 2020; Project No. E18418.001)
3. Change Order No. 1 for Garden Highway (6237), prepared by Youngdahl Consulting Group, Inc., dated 7 December 2021.

Dear Mr. Bliatout:

In accordance with your authorization, Youngdahl Consulting Group, Inc. has prepared this geotechnical engineering study for the project site located at 6237 Garden Highway in Sacramento, California. The purpose of this study was to prepare a preliminary geotechnical study for planning and preliminary development of the project site for a custom, single family residence. To complete this task, our firm completed a subsurface exploration, performed laboratory testing, reviewed the referenced documents, and prepared this report in accordance with the Reference 3 contract.

Based upon our observations and evaluation, the project site could be designed to support the proposed single-family residence. However, this operation is anticipated to incorporate design approaches which could have economical restrictions to development. The site is located immediately adjacent to the Sacramento River, on the inbound side of the levee, with liquefaction potential, and a significant potential for lateral spread. Historically, these conditions have been of interest but not specifically required by code which led to sporadic implementation; however, modern building codes and standards of practice require these to be analyzed and addressed in design. The recommendations and approaches in this preliminary report include elements which require coordination and design approaches with specialty design contractors, the structural engineer, and our firm. This report is not intended for use a design-level geotechnical study.

Due to the non-uniform nature of soils, other geotechnical issues may become more apparent during grading operations which are not listed above. The descriptions, findings, conclusions, and recommendations provided in this report are formulated as a whole; specific conclusions or recommendations should not be derived or used out of context. Please review the limitations and uniformity of conditions section of this report.

This report has been prepared for the exclusive use of the addressee of this report and their consultants, for specific application to this project, in accordance with generally accepted geotechnical engineering practice. Should you have any questions or require additional information, please contact our office at your convenience.

Very truly yours,
Youngdahl Consulting Group, Inc.

DRAFT

Matthew J. Gross, P.E., G.E.
Senior Geotechnical Engineer

Distribution: PDF to Client

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PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
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1.0 INTRODUCTION

This report presents the results of our preliminary geotechnical engineering study performed for the proposed improvements planned to be constructed at 6237 Garden Highway in Sacramento, California. The vicinity map provided on Figure A-1, Appendix A shows the approximate project location.

Project Understanding

We understand that the proposed development consists of the construction of a two to three story, custom single-family residence at the project site. Based on the referenced development plans (reference 1), the residence will have a footprint of approximately 5,625 square feet, be one to two stories, and of wood-frame construction. For the purposes of this report, we anticipate that the residence will be supported by deep foundations or the site soils be improved using ground improvement techniques.

Background

The project site is located directly adjacent to the Sacramento River in Sacramento, California. The Sacramento River is a meandering river that has historically held flood waters and spilled onto the adjacent low-lying areas on a seasonal basis. Due in part to rapid development of the Central Valley, an established flood control system was developed. In 1917, the federal government authorized the Sacramento River Flood Control Project consisting of a system of levees and bypasses through the Sacramento River basin. Since the authorization of this project, the Sacramento River and its tributaries have been bounded by levees of varying degrees, creating the modern-day river channels.

Historically, building codes including the California Building Code (CBC) and standards developed by ASCE, have been concerned primarily with general support of structures. The implementation of site-specific geotechnical engineering studies for sites associated with liquefaction and lateral spreading events has only been incorporated into modern day codes and standards. Evaluation of these seismic hazards were typically discretionary by the building official. Updates to building codes such as the 2007 CBC removed the discretionary status for certain conditions, requiring further review for liquefaction and lateral spreading events. Recent codes and standards have provided further guidance on the topic. These changes have impacted the design and construction of residences and buildings near waterways and areas where liquefaction mitigation was once not performed.

Aerial Photography Review

The project site consists of vacant land and based on a limited review of aerial photography; the site appears to have remained undeveloped as far back as 1993. If studies or plans pertaining to the site exist and are not cited as a reference in this report, we should be afforded the opportunity to review and modify our conclusions and recommendations as necessary.

Purpose and Scope

Youngdahl Consulting Group, Inc. has prepared this report to provide preliminary geotechnical engineering recommendations and considerations for incorporation into the design and development of the site. The following scope of services were developed and performed for preparation of this report:

- A review of geotechnical and geologic data available to us at the time of our study;
- Performance of a field study consisting of a site reconnaissance and subsurface explorations to observe and characterize the subsurface conditions;
- Laboratory testing on representative samples collected during our field study;
- Evaluation of the data and information obtained from our field study, laboratory testing, and literature review for geotechnical conditions;
- Development of the following geotechnical recommendations and considerations regarding earthwork construction including, site preparation and grading, engineered fill criteria, seasonal moisture conditions, and drainage;
- Development of geotechnical design criteria for code-based seismicity and foundations;
- Preparation of this report summarizing our findings, conclusions, and recommendations regarding the above-described information.

2.0 SITE CONDITIONS

The following section describes our findings regarding the site conditions that we observed during our site reconnaissance and subsequent subsurface explorations.

Surface Observations

The project site is located directly adjacent to the Sacramento River near the Sacramento International Airport. It is located on the east side of the river on its inboard side. The site consists of a relatively flat narrow strip of land approximately 75 to 90 feet wide (from the river bank to the toe of the levee). It is bounded by the Sacramento River to the west, by a levee to the east, and by single-family residences to the north and south. Vegetation at the site generally consists of a moderate to dense growth of trees and scattered bushes.

The levee was observed to have a slope of approximately 1.5H:1V (Horizontal:Vertical). At the time of our subsurface exploration, the water level of the river was approximately 13 to 15 feet below the existing surface grade of the site. Based on a review of nautical maps of the Sacramento River, the maximum depth of water adjacent to the site is approximately 11 feet; however, the nautical maps are not referenced to an elevation so their direct use in conjunction with the elevation of the site are limited.

Subsurface Conditions

Our field study included a site reconnaissance by a representative of our firm and a subsurface exploration program conducted on 31 January 2022. The exploration program included the advancement of a single exploratory boring and two cone penetration test (CPT) soundings to depths of 70 and 92 feet below ground surface (bgs), respectively. The approximate locations of the boring and CPT soundings are presented on Figure A-2, Appendix A.

The subsurface soils encountered generally consisted of sandy silts and silty clays to depths of approximately 25 to 30 feet bgs underlain by approximately 30 to 35 feet of silty sands and clean sands and subsequently underlain by finer grained clays and silts. The sandy silts and silty clays found near the surface were found to be in a soft to stiff and slightly moist to wet condition. The underlying silty sands and sands were found to be in a loose to medium dense and moist to wet condition. The finer grained materials found at depth were generally found to be in a stiff to very stiff condition.

Groundwater Conditions

Groundwater was encountered during our subsurface explorations at a depth of approximately 20 feet bgs. The depth at which groundwater is encountered in the area is generally dependent on the water level of the adjacent river. Based on our observations, the groundwater level was encountered approximately 5 to 8 feet below the water level in the river and will typically rise and fall with the water level.

3.0 GEOTECHNICAL SOIL CHARACTERISTICS

The geotechnical soil characteristics presented in this section of the report are based on laboratory testing and observation of samples collected from subsurface soils.

Laboratory Testing

Laboratory testing of the collected samples was directed towards determining the physical and engineering properties of the soil underlying the site. A description of the tests performed for this project and the associated test results are presented in Appendix B. In summary, the following tests were performed for the preparation of this report:

Table 1: Laboratory Tests

Laboratory Test	Test Standard	Summary of Results	
Direct Shear	ASTM D3080	B-1 @ 0-5 ft	Φ = 37.0°, c = 0 psf (90%RC)
Maximum Dry Density	ASTM D1557	B-1 @ 0-5 ft	DD = 101.7 pcf, MC = 18.7 %
Finer Than No. 200	ASTM D1140	B-1 @ 11 ft B-1 @ 21 ft B-1 @ 31 ft B-1 @ 46 ft	62.7% 98.5% 19.5% 5.8%
Corrosivity Suite	CA DOT Tests 417, 422 and 643	See Soil Corrosivity Section	

Soil Expansion Potential

The materials encountered in our explorations were generally non-plastic (sand and non-plastic silt) or had low plasticity. These materials are generally considered to have a low potential for expansive. Considering the mitigation measures for liquefaction (discussed later) and the low potential for expansion, we do not anticipate that special design considerations for expansive soils will be necessary for the design or construction of the proposed improvements. If necessary, recommendations can be made based on our observations at the time of construction should expansive soils be encountered at the project site which were not encountered during our study.

Soil Corrosivity

A corrosivity testing suite consisting of soil pH, resistivity, sulfate, and chloride content tests were performed on selected soil samples collected during our subsurface exploration. We are not corrosion specialists and recommend that the results be evaluated by a qualified corrosion expert. The laboratory test results (provided by Sunland Analytical, Inc.) are provided in Appendix B and are summarized in Table 2, below.

Table 2: Corrosivity Summary

Location	Depth (ft)	Soil pH	Minimum Resistivity ohm-cm (x1000)	Chloride (ppm)	Sulfate (ppm)	Caltrans Environment	ACI Environment
B-1	21	6.93	2.65	6.6	30.7	Non-Corrosive	S0 (Not a Concern)
B-1	66	8.17	9.94	1.9	8.7	Non-Corrosive	S0 (Not a Concern)

According to Caltrans Corrosion Guidelines Version 3.0, March 2018, the test results appear to indicate a non-corrosive environment. According to the 2019 California Building Code Section 1904.1 and ACI 318-14 Table 19.3.1.1, the test results indicate the onsite soils have a negligible potential for sulfide attack of concrete. A certified corrosion engineer should be consulted to review the above tests and site conditions in order to develop specific mitigation recommendations if metallic pipes or structural elements are designed to be in contact with or buried in soil.

4.0 GEOLOGY AND SEISMICITY

The geologic portion of this report includes a review of geologic data pertinent to the site based on an interpretation of our observations of the surface exposures and our observations in our exploratory test pits.

Geologic Conditions

The site is located within the Great Valley Geomorphic Province. The province is an approximately 50- by 400- mile alluvial plain that drains via the Sacramento and San Joaquin Rivers into the San Francisco Bay area. This valley is filled with sediments as thick as 20,000 to 40,000 feet and represents a fore-arc basin between the Sierra Nevada to the east and accretionary Coast Ranges to the west.

According to the Preliminary Geologic Map of The Sacramento 30' x 60' Quadrangle, California (Guitierrez, 2011), the site is underlain by stream channel deposits (Qhc). These deposits are relatively young deposits dating back less than 150 years (late Holocene) and typically consist of loose alluvial sands, gravels, and silts deposited by active rivers/streams.

Seismicity

Our evaluation of seismicity for the project site included reviewing existing fault maps, obtaining seismic design parameters from the USGS online calculators and databases, and the collection of seismic data during cone penetration testing. For the purpose of this study, we used a latitude and longitude of 38.679613, -121.630267 to identify the project site.

Alquist-Priolo Regulatory Faults

Based upon the records currently available from the California Department of Conservation, the project site is not located within an Alquist-Priolo Regulatory Review Zone and there are no known faults located at the subject site. We do not anticipate special design or construction requirements for faulting at this project site.

Code Based Seismic Criteria

Due to the potential for liquefaction, the site should be classified as Site Class F. The building code assumes that the project site would be developed using site-specific design criteria based on the methodologies described in ASCE 7-16, Chapter 21 unless the structural engineer can apply exceptions listed in ASCE 7-16 Section 11.4.8.e2. For the purpose of preparing the following table, our firm has assumed that these exceptions apply to this project as well as the exception for liquefaction given in ASCE 7-16 Section 20.3.1.1 to design for site class based on other parameters. As such, the value Fv was calculated using CBC Table 1613.2.3(2) since an evaluation of the site-specific ground motion response was not performed in accordance with ASCE 7-16 Chapter 21 and the design parameters were evaluated using Site Class D based on the seismic shear wave velocity from the CPT soundings. The structural engineer should review the conditions of the exception and final choice of design parameters remains the purview of the project structural engineer.

Table 3: Seismic Design Parameters*

	Reference	Seismic Parameter	Recommended Value
ASCE 7-16	Section 20.3.1	Site Class	F
	Table 20.3-1	Site Class (Exception 20.3.1.1)	D
	Figure 22-7	Maximum Considered Earthquake Geometric Mean (MCEC) PGA	0.282g
	Table 11.8-1	Site Coefficient F_{PGA}	1.318
	Equation 11.8-1	$PGA_M = F_{PGA}$ PGA	0.372g
2019 CBC	Figure 1613.2.1(1)	Short-Period MCE at 0.2s, S_S	0.669g
	Figure 1613.2.1(2)	1.0s Period MCE, S_1	0.278g
	Table 1613.2.3(1)	Site Coefficient, F_a	1.265
	Table 1613.2.3(2)	Site Coefficient, F_v	2.044
	Equation 16-36	Adjusted MCE Spectral Response Parameters, $S_{MS} = F_a S_s$	0.846g
	Equation 16-37	Adjusted MCE Spectral Response Parameters, $S_{M1} = F_v S_1$	0.568g
	Equation 16-38	Design Spectral Acceleration Parameters, $S_{DS} = \frac{2}{3} S_{MS}$	0.564g
	Equation 16-39	Design Spectral Acceleration Parameters, $S_{D1} = \frac{2}{3} S_{M1}$	0.379g
	Table 1613.2.5(1)	Seismic Design Category (Short Period), Occupancy I to III	D
	Table 1613.2.5(1)	Seismic Design Category (Short Period), Occupancy IV	D
	Table 1613.2.5(2)	Seismic Design Category (1-Sec Period), Occupancy I to IV	D

*Based on the online calculator available at https://earthquake.usgs.gov/ws/designmaps/

Earthquake Induced Liquefaction, Settlement, and Surface Rupture Potential

Liquefaction is the sudden loss of soil shear strength and sudden increase in porewater pressure caused by shear strains, as could result from an earthquake. Research has shown that saturated, loose to medium-dense sands with a silt content less than about 25 percent and located within the top 60 feet are most susceptible to liquefaction and surface rupture/lateral spreading. Typically, recent alluvial deposits, such as those present on site, are more susceptible to liquefaction.

Earthquake induced settlement associated with liquefaction could be separated into free-field settlements (i.e., settlement of the ground surface), and ejecta (e.g., sand boils). The total settlement of the buildings is the combination of the free-field settlement, liquefaction induced building settlement, and ejecta. The individual components of these settlements are discussed in the following sections.

Free-Field Settlement

An analysis of the liquefaction potential for these layers was performed using the computer-based program CLiq v2.3.1.15 developed by Geologismiki, Inc. As presented in the seismicity section of this report, we used a design earthquake moment magnitude of 6.50 and a peak ground acceleration of 0.37g based on the USGS deaggregation tool and ASCE 7-16, respectively. While groundwater was encountered during our field study at a depth of approximately 20 feet bgs, a depth of 15 feet was utilized in our analysis based upon groundwater fluctuation associated with changes in water elevation of the Sacramento River. During flood stages of the Sacramento River, it is possible that the groundwater elevation can be at or near the ground surface. Our analysis was not conducted for a flood stage and generally two extreme conditions are not considered at the same time.

The CPT analysis was performed using the methods presented by Boulanger & Idriss (2014). Based on the methods described, the calculated potential liquefaction settlement of the liquefiable zones is on the order of 9 to 11 inches, primarily occurring between a depth of 25 and 65 feet bgs. This method utilizes a summation approach throughout a soil profile. Although possible that liquefaction could occur at depth, the potential for manifestation of the entire calculated settlement at the ground surface becomes less with increasing depth. Therefore, the summation of settlements of all liquefiable layers, to the maximum depth explored of 92 feet bgs, is less likely to be propagated in its entirety at the surface.

Manifestation of Settlement
Considering the depth of the liquefiable layers, we evaluated the potential settlement using the weighting factor developed by Cetin (2008) and alternative settlement methods developed by Zhang (2002). The Cetin method recognized that the manifestation of liquefaction at the ground surface is dependent on depth and weights the settlement of individual layers by the depth from the ground surface to a depth of approximately 60 feet. Using a weighting average to 60 feet for all CPTs indicates that the potential liquefaction settlement may be on the order of 6 inches, if limited to the upper 60 feet. Based upon the available methods, we anticipate a potential of 3 to 4 inches of liquefaction settlement.

Liquefaction Induced Building Settlements
Based on recent findings, it may be possible for a building to experience settlement relative to the ground surface during a seismic/liquefaction event. Recommendations are presented in this report for ground improvement and deep foundations, which is expected to reduce the potential for this type of settlement; therefore, our scope did not include an evaluation of liquefaction induced building settlements.

Ejecta
The ejection of sands or materials from the ground surface following a seismic event is referred to as ejecta. We are not currently aware of a methodology for determining the volume of potential ejecta. Based on engineering judgement, ejecta is not anticipated to be significant provided the recommendations presented in this report are applied to the development of the project site.

Lateral Displacement
Lateral spreading is also a secondary consequence of a seismic event when adjacent to bodies of water and on slopes. Lateral spreading is the propensity of a soil mass to move laterally due to liquefaction of an underlying soil layer. It generally occurs on sloping ground or where there is a nearby descending slope (typically referred to as a “free face”) overlying the liquefied zone. The site is located on the inboard side of a levee, directly adjacent to a levee and consists of a narrow strip of land immediately adjacent to the Sacramento River. The depth of the river channel adjacent to the site is estimated to be 21 to 26 feet. Based on our analysis, it is estimated that lateral displacement could range from 87 to 125 feet which essentially indicates the loss of the river bank. Estimation of these values is based upon normalized parameters including soil type, groundwater depth, and topography.

5.0 DISCUSSION AND CONCLUSIONS
Based on our findings, the project site could be subject to static and seismically induced settlements, and seismically induced lateral displacements on the order of magnitude described in the previous sections. As such, the use of shallow conventional foundations alone is not a feasible option. We recommend that the chosen foundation system provide adequate support for the structure and address the identified geotechnical constraints. The scope of this report includes preliminary items and further evaluation and further review and recommendations may be performed. This report should not be used for final construction documents.

Mitigation of Static Settlement and Instability
Static settlement and instability are anticipated based on the relatively soft, near surface conditions. We have provided recommendations in the following sections of this report to overexcavate the near surface soils under the proposed working area and replace these materials with engineered fill.

Mitigation of Seismically Induced Settlements and Lateral Displacements
Due to the potential for liquefaction and lateral spreading, we recommend that mitigation measures be performed to address these conditions. Measures for liquefaction and lateral spreading have a range of costs and complexity and can vary between projects and area generally selected based on acceptable amounts of risk and damage for the structure. We recognize that some mitigation measures can be cost prohibitive; however, the selected measures should, at a minimum, provide protection for life safety. For the purposes of this report, we have included a discussion of the following mitigation options:

1. Deep Foundations
2. Ground Improvement

Once a mitigation option is determined suitable, additional recommendations can be provided by our firm under a separate cover, if necessary.

Deep Foundations
Due to the presence of soft, fine-grained soils and potentially liquefiable soils underlying the site, the use of conventional shallow foundations is not feasible due to excessive static settlement, potential for seismically induced settlement, and potential for seismically induced lateral displacement. Therefore, the proposed residence should be supported by deep foundations bearing within the stiff silts and clays approximately 60 to 65 feet below the existing surface grade. Possible deep foundations include augercast piles (ACP), drill displacement piles (DDP), and driven pipe piles. These foundation systems are designed and installed by specialty foundation contractors. The resulting depth of these foundations may extend tens of feet below the firm soil horizon to account for down drag settlements, liquefaction settlements, and bending by lateral spread.

Ground Improvement
In place of deep foundations, ground improvement methods may provide adequate mitigation against the identified geotechnical constraints. Conventional shallow or mat foundations may be used at the project site, provided that the selected ground improvement method(s) adequately addresses the geotechnical constraints. The use of conventional shallow or mat foundations would include overexcavation of the near surface soils and placement of engineered fills prior to ground improvement. These overexcavation and recompaction efforts may be necessary for site access by the ground improvement contractor. The structural engineer should work with the ground improvement design-build contractor to design the shallow or mat foundations to be sufficiently stiff to address the potential settlement of soil and ultimate, differential settlement damages to the structure. Section 12.13.9.2 of ASCE 7-161 provides commentary regarding flexural demands for liquefaction design. The overexcavation conditions may be revised depending upon the design-build ground improvement conditions.

6.0 SITE GRADING AND EARTHWORK IMPROVEMENTS
Prior to the installation of deep foundations or ground improvement, the site should be prepared as detailed in the following sections. Preparation of the site should take into consideration access and stability for large ground improvement and/or foundation installation equipment.

Soil Moisture Considerations
The compaction of soil to a desired relative compaction is dependent on conditioning the soil to a target range of moisture content. Moisture contents that are excessively dry or wet could limit the ability of the contractor to compact soils to the requirements for engineered fill. When dry, moisture should be added to the soil and the soils blended to improve consistency. Wet soil will need to be dried to become compactable. Generally, this includes blending and working the soil to avoid trapping moisture below a dryer surficial crust. Other options are available to reduce the time involved but typically have higher costs and require more evaluation prior to implementation.

The largest contributor to excessive soil moisture is generally precipitation and seepage during the rainy season. In recognition of this, we suggest that consideration be given to the seasonal limitations and costs of winter grading operations on the site. Special attention should be given regarding the drainage of the project site. If the project is expected to work through the wet season, the contractor should install appropriate temporary drainage systems at the construction site and should minimize traffic over exposed subgrades due to the moisture-sensitive nature of the on-site soils. During wet weather operations, the soil should be graded to drain and should be sealed by rubber tire rolling to minimize water infiltration.

Site Preparation
Preparation of the project site should involve site drainage controls, dust control, clearing and stripping, overexcavation and recompaction of loose native soils, and exposed grade compaction considerations. The following paragraphs state our geotechnical comments and recommendations concerning site preparation.

<u>Site Drainage Controls</u>
We recommend that initial site preparation involve intercepting and diverting any potential sources of surface or near-surface water within the construction zone. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and methods used by the contractor, final decisions regarding drainage systems are best made in the field at the time of construction. All drainage and/or water diversion performed for the site should be in accordance with the Clean Water Act and applicable Storm Water Pollution Prevention Plan.

<u>Dust Control</u>
Dust control provisions should be provided for as required by the local jurisdiction's grading ordinance (i.e., water truck or other adequate water supply during grading). Dust control is the purview of the grading contractor.

<u>Clearing and Stripping of Organic Materials</u>
Clearing and stripping operations should include the removal of all organic laden materials including trees, bushes, root balls, root systems, and any soft or loose soil generated by the removal operations. Short or mowed dry grasses may be pulverized and lost within fill materials provided no concentrated pockets of organics result. It is the responsibility of the grading contractor to remove excess organics from the fill materials. **No more than 2 percent of organic material, by weight, should be allowed within the fill materials at any given location.** Preserved trees may require tree root protection which should be addressed on an individual basis by a qualified arborist.

Our recommendations are based on limited windows into the surface and interpretations thereof; therefore, a representative of our firm should be present during site clearing operations to identify the location and depth of potential fills or loose soils, some of which may not have been found during our evaluation. We should also be present to observe removal of deleterious materials, and to identify any existing site conditions which may require mitigation or further recommendations prior to site development.

Overexcavation and Recompaction of Loose/Soft Soils
Following general site clearing, all existing loose/soft or saturated native soils within the development footprint should be overexcavated a minimum of 5 feet below the existing surface grade and backfilled with engineered fill as detailed in the engineered fill section below. Any depressions extending below final grade resulting from the removal of fill materials or other deleterious materials should be properly prepared as discussed below and backfilled with engineered fill.

Exposed Grade Compaction
Exposed soil grades following initial site preparation activities and overexcavation operations should be scarified to a minimum depth of 8 inches and compacted to the requirements for engineered fill. Generally, where rock conditions are exposed, no scarification should be necessary; however, these surfaces should be moisture conditioned and compacted to mitigate disturbance resulting from site preparation. Prior to placing fill, the exposed grades should be in a firm and unyielding state. Any localized zones of soft or pumping soils observed within the exposed grade should either be scarified and recompacted or be overexcavated and replaced with engineered fill as detailed in the engineered fill section below.

Engineered Fill Criteria
All materials placed as fills on the site should be placed as "Engineered Fill" which is observed, tested, and compacted as described in the following paragraphs.

Suitability of Onsite Materials
We expect that soil generated from excavations on the site, excluding deleterious material, may be used as engineered fill provided the material does not exceed 8 inches in maximum dimension.

Fill Placement and Compaction
Engineered fills should be placed in thin horizontal lifts not to exceed 8 inches in uncompacted thickness. If the contractor can achieve the recommended relative compaction using thicker lifts, the method may be judged acceptable based on field verification by a representative of our firm using standard density testing procedures. Lightweight compaction equipment may require thinner lifts to achieve the recommended relative compaction. Fills should have a maximum particle size of 8 inches unless approved by our firm.

The relative compaction of engineered fills is based on the maximum density and optimum moisture determined through the ASTM D1557 test method. We have considered the potential for differential settlement for this site and recommend that the engineered fills be placed at a relative compaction of 95 percent. Depending on the moisture condition of the soils, the engineered fills may require moisture conditioning to be within a suitable compaction range.

Our firm should be requested for consultation, observation, and testing for the earthwork operations prior to the placement of any fills. Fill soil compaction should be evaluated by means of in-place density tests performed during fill placement so that adequacy of soil compaction efforts may be determined as earthwork progresses.

Import Materials

The recommendations presented in this report are based on the assumption that the import materials will be similar to the materials present at the project site. High quality materials are preferred for import; however, these materials can be more dependent on source availability. Import material should be approved by our firm prior to transporting it to the project site.

Material for this project should consist of a material with the geotechnical characteristics presented below. If these requirements are not met, additional testing and evaluation may be necessary to determine the appropriate design parameters for foundations, pavement, and other improvements.

Table 3: Select Import Criteria

Behavior Property	Reference Document	Recommendation
Direct Shear Strength	ASTM D3080	≥ 32° when compacted
Plasticity Index	ASTM D4318	≤ 12
Expansion Index	ASTM D4829	≤ 20
Sieve Analysis	ASTM D1140	Not more than 30% Passing the No. 200 sieve

7.0 PRELIMINARY DESIGN RECOMMENDATIONS

The contents of this section include preliminary recommendations for ground improvement, foundations, slabs-on-grade, retaining walls, and drainage.

Deep Foundations

Due to the presence of soft, fine-grained soils and potentially liquefiable soils underlying the site, the use of conventional shallow foundations is not feasible without ground improvement due to excessive static settlement, potential for seismically induced settlement, and potential for seismically induced lateral displacement. Therefore, the proposed residence should be supported by deep foundations bearing within the stiff silts and clays approximately 60 to 65 feet below the existing surface grade.

In preparation of this report, we utilized CPeT-IT v.2.3.1.5 by GeoLogismiki to evaluation the potential capacity of cast in drilled hole (CIDH) piles. Based on the preliminary evaluation, an 18-inch diameter CIDH pile could have a potential skin friction capacity on the order of 120 kips at a depth of about 65 feet bgs and possible on the order of 150 kips a depth of about 90 feet bgs. These capacities included a factor of safety of 2.0 for the skin friction but do not account for downdrag generated by static or liquefaction settlement. In accordance with the recommendations in ASCE 7-16 Section 12.13.9.3.1, downdrag associated with liquefaction should be measured from the bottom of the liquefiable zones and the "ultimate capacity of the pile shall be the ultimate geotechnical capacity of the pile below the liquefiable layer, reduced by the downdrag load" and "shall be treated as a seismic load and factored accordingly." Due to the depth of liquefaction, this requirement is anticipated to generate long piles which may be tens of feet deeper than the liquefaction depth of about 65 feet. Additional evaluation should be performed to adequately account for such a condition.

Ground Improvement

Ground improvement is performed by a design-build contractor and is intended to densify or solidify the supporting soils through a specialized approach. The approach can be formulated to meet settlement and lateral spread limitations established by the 2019 California Building Code, the structural engineer, and the owner of the facility. Regionally, these approaches have consisted of stone columns installed by either pre-drilling or forcing aggregate into the subsurface soils to a design depth and width. Recent techniques have also incorporated the used of cement columns (drilled inclusions). This action densifies the soils around the installed element and provided resistance to liquefaction conditions. Another method which could be performed is by mixing the subsurface soils with a cementitious material to solidify the soils and provide the strength. Generally, this is performed through a technique called deep soil mixing (DSM) which included a large mixing bit and can be performed using different geometries to achieve the desired effect. Lateral spread appears to be the primary issue associated with the project site and should be considered when selecting the ground improvement method.

Shallow Conventional Foundations

Shallow conventional foundations are commonly incorporated with ground improvement approaches. Recommendations for bearing and lateral capacities are influenced by the ground improvement approach and the acceptable settlements generated by the design and provided by the structural engineer. The preliminary information provided below is for reference to anticipated configurations and should be revisited following further design.

The provided values do not constitute a structural design of foundations which should be performed by the structural engineer. In addition to the provided recommendations, foundation design and construction should conform to applicable sections of the 2019 California Building Code.

Foundation Capacities

The foundation bearing and lateral capacities are presented in the table below. The allowable bearing capacity is for support of dead plus live loads based on the foundation configuration presented in this report. The allowable capacity may be increased by 1/3 for short-term wind and seismic loads. Lateral forces on structures may be resisted by passive pressure acting against the sides of shallow footings and/or friction between the foundation bearing material and the bottom of the footing. Section 1806.3 of the 2019 CBC allows for the combination of the friction factor and passive resistance value to lateral resistance. Consideration should be given to ignoring passive resistance where soils could be disturbed later or within 6 feet horizontally of the slope face.

Table 4: Foundation Capacities

Soil Type	Design Condition	Estimated Design Value
Engineered Fill or Firm Native Soil	Allowable Bearing Capacity	2,000 psf
	Allowable Friction Factor	0.25
	Allowable Passive Resistance (if overexcavation is ≥ 10 feet beyond structure)	100 psf/ft

Foundation Configuration

Conventional shallow foundations should be a minimum of 15 inches wide and founded a minimum of 18 inches below the lowest adjacent soil grade. Isolated pad foundations should be a minimum of 24 inches in plan dimension. A grade beam, having the same depth as the continuous footings, should also be cast across the vehicle openings of the residence garage.

Foundation reinforcement should be provided by the structural engineer. The reinforcement schedule should account for typical construction issues such as load consideration, concrete cracking, and the presence of isolated irregularities. At a minimum, we recommend that continuous footing foundations be reinforced with four No. 4 reinforcing bars, two located near the bottom of the footing and two near the top of the stem wall.

Foundation Influence Line and Slope Setback
All footings should be founded below an imaginary 2H:1V plane projected up from the bottoms of adjacent footings and/or parallel utility trenches, or to a depth that achieves a minimum horizontal clearance of 6 feet from the outside toe of the footings to the slope face, whichever requires a deeper excavation.

Subgrade Conditions
Footings should never be cast atop soft, loose, organic, slough, debris, nor atop subgrades covered by ice or standing water. A representative of our firm should be retained to observe all subgrades during footing excavations and prior to concrete placement so that a determination as to the adequacy of subgrade preparation can be made.

Shallow Footing / Stemwall Backfill
All footing/stemwall backfill soil should be compacted to the criteria for engineered fill as recommended in Section 6.0 of this report.

Slab-on-Grade Construction
It is our opinion that soil-supported slab-on-grade floors could be used for the main floor of the structure, contingent on proper subgrade preparation. Often the geotechnical issues regarding the use of slab-on-grade floors include proper soil support and subgrade preparation, proper transfer of loads through the slab underlayment materials to the subgrade soils, and the anticipated presence or absence of moisture at or above the subgrade level. We offer the following comments and recommendations concerning support of slab-on-grade floors. The slab design (concrete mix design, curing procedures, reinforcement, joint spacing, moisture protection, and underlayment materials) is the purview of the project Structural Engineer.

Slab Subgrade Preparation
All subgrades proposed to support slab-on-grade floors should be prepared and compacted to the requirements of engineered fill as discussed in Section 6.0 of this report.

Slab Underlayment
As a minimum for slab support conditions, the slab should be underlain by a minimum 4-inch-thick crushed rock layer that is covered by a minimum 10-mil thick moisture retarding plastic membrane. The membrane may only be functional when it is above the vapor sources. The bottom of the crushed rock layer should be above the exterior grade to act as a capillary break and not a reservoir, unless it is provided with an underdrain system. The slab design and underlayment should be in accordance with ASTM E1643 and E1745.

An optional 1-inch blotter sand layer placed above the plastic membrane, is sometimes used to aid in curing of the concrete. Although historically common, this blotter layer is not currently included in slabs designed according to the 2019 Green Building Code. When omitted, special wet curing procedures will be necessary. If installed, the blotter layer can become a reservoir for excessive moisture if inclement weather occurs prior to pouring the slab, excessive water collects in it from the concrete pour, or an external source of water enters above or bypasses the membrane.

Our experience has shown that vapor transmission through concrete is controlled through proper concrete mix design. As such, proper control of moisture vapor transmission should be considered in the design of the slab as provided by the project architect, structural or civil engineer. It should be noted that placement of the recommended plastic membrane, proper mix design, and proper slab underlayment and detailing per ASTM E1643 and E1745 will not provide a waterproof condition. If a waterproof condition is desired, we recommend that a waterproofing expert be consulted for slab design.

Slab Thickness and Reinforcement

Geotechnical reports have historically provided minimums for slab thickness and reinforcement for general crack control. The concrete mix design and construction practices can additionally have a large impact on concrete crack control. All concrete should be anticipated to crack. As such, these minimums should not be considered to be standalone items to address crack control, but are suggested to be considered in the slab design methodology.

In order to help control the growth of cracks in interior concrete from becoming significant, we suggest the following minimums. Interior concrete slabs-on-grade not subject to heavy loads, should be a minimum of 6-inches thick and reinforced. A minimum of No. 4 deformed reinforcing bars placed at 18 inches on center both ways, at the center of the structural section is suggested. Joint spacing should be provided by the structural engineer. Troweled joints recovered with paste during finishing or "wet sawn" joints should be considered every 10 feet on center. Expansion joint felt should be provided to separate floating slabs from foundations and at least at every third joint. Cracks will tend to occur at recurrent corners, curved or triangular areas and at points of fixity. Trim bars can be utilized at right angle to the predicted crack extending 40 bar diameters past the predicted crack on each side.

Exterior Flatwork

Exterior concrete flatwork is recommended to have a 4-inch-thick rock cushion. This could consist of vibroplate compacted crushed rock or compacted ¾-inch aggregate baserock. If exterior flatwork concrete is against the floor slab edge without a moisture separator it may transfer moisture to the floor slab. Expansion joint felt should be provided to separate exterior flatwork from foundations and at least at every third joint. Contraction / groove joints should be provided to a depth of at least 1/4 of the slab thickness and at a spacing of less than 30 times the slab thickness for unreinforced flatwork, dividing the slab into nearly square sections. Cracks will tend to occur at recurrent corners, curved or triangular areas and at points of fixity. Trim bars can be utilized at right angle to the predicted crack extending 40 bar diameters past the predicted crack on each side.

Drainage

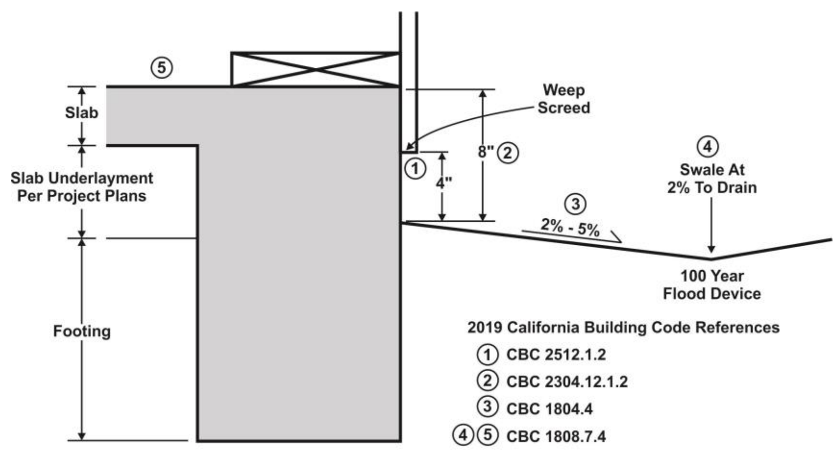
In order to maintain the engineering strength characteristics of the soil presented for use in this report, maintenance of the site will need to be performed. This maintenance generally includes, but is not limited to, proper drainage and control of surface and subsurface water which could affect structural support and fill integrity. A difficulty exists in determining which areas are prone to the negative impacts resulting from high moisture conditions due to the diverse nature of potential sources of water; some of which are outlined in the paragraph below. We suggest that measures be installed to minimize exposure to the adverse effects of moisture, but this will not guarantee that excessive moisture conditions will not affect the structure.

Some of the diverse sources of moisture could include water from landscape irrigation, annual rainfall, offsite construction activities, runoff from impermeable surfaces, collected and channeled water, and water perched in the subsurface soils. Some of these sources can be controlled through drainage features installed either by the owner or contractor. Others may not become evident until they, or the effects of the presence of excessive moisture, are visually observed on the property.

Some measures that can be employed to minimize the buildup of moisture include, but are not limited to proper backfill materials and compaction of utility trenches within the footprint of the proposed structures; grout plugs at foundation penetrations; collection and channeling of drained water from impermeable surfaces (i.e. roofs, concrete or asphalt paved areas); installation of subdrain/cut-off drain provisions; utilization of low flow irrigation systems; education to the proposed owners of proper design and maintenance of landscaping and drainage facilities that they or their landscaper installs.

Drainage Adjacent to Buildings

All grades should provide rapid removal of surface water runoff; ponding water should not be allowed on building pads or adjacent to foundations or other structural improvements (during and following construction). All soils placed against foundations during finish grading should be compacted to minimize water infiltration. Finish and landscape grading should include positive drainage away from all foundations. Section 1808.7.4 of the 2019 California Building Code (CBC) states that for graded soil sites, the top of any exterior foundation shall extend above the elevation of the street gutter at the point of discharge or the inlet of an approved drainage device a minimum of 12 inches plus 2 percent. If overland flow is not achieved adjacent to buildings, the drainage device should be designed to accept flows from a 100-year event. Grades directly adjacent to foundations should be no closer than 8 inches from the top of the slab (CBC 2304.12.1.2), and weep screeds are to be placed a minimum of 4 inches clear of soil grades and 2 inches clear of concrete or other hard surfacing (CBC 2512.1.2). From this point, surface grades should slope a minimum of 2 percent away from all foundations for at least 5 feet but preferably 10 feet, and then 2 percent along a drainage swale to the outlet (CBC 1804.4). Downspouts should be tight piped via an area drain network and discharged to an appropriate non-erosive outlet away from all foundations.



Typical 2019 California Building Code Drainage Requirements

The above referenced elements pertaining to drainage of the proposed structures is provided as general acknowledgement of the California Building Code requirements, restated and graphically illustrated for ease of understanding. Surface drainage design is the purview of the Project Architect/Civil Engineer. Review of drainage design and implementation adjacent to the building envelopes is recommended as performance of these improvements is crucial to the performance of the foundation and construction of rigid improvements.

8.0 DESIGN REVIEW AND CONSTRUCTION MONITORING

Geotechnical engineering can be affected by natural variability of soils and, as with many projects, the contents of this report could be used and interpreted by many design professionals for the application and development of their plans. For these reasons, we recommend that our firm provide support through plan reviews and construction monitoring to aid in the production of a successful project.

Plan Review

The design plans and specifications should be reviewed and accepted by Youngdahl Consulting Group, Inc. prior to contract bidding. A review should be performed to determine whether the recommendations contained within this report are still applicable and/or are properly interpreted and incorporated into the project plans and specifications. Modifications to the recommendations provided in this report or to the design may be necessary at the time of our review based on the proposed plans.

Construction Monitoring

Construction monitoring is a continuation of geotechnical engineering to confirm or enhance the findings and recommendations provided in this report. It is essential that our representative be involved with all grading activities in order for us to provide supplemental recommendations as field conditions dictate. Youngdahl Consulting Group, Inc. should be notified at least two working days before site clearing or grading operations commence, and should observe the stripping of deleterious material, overexcavation of soft soils and existing fills (if present), and provide consultation, observation, and testing services to the grading contractor in the field. At a minimum, Youngdahl Consulting Group, Inc. should be retained to provide services listed in Table 7 below.

The recommendations included in this report have been based in part on assumptions about strata variations that may be tested only during earthwork. Accordingly, these recommendations should not be applied in the field unless Youngdahl Consulting Group, Inc. is retained to perform construction observation and thereby provide a complete professional geotechnical engineering service through the observational method. Youngdahl Consulting Group, Inc. cannot assume responsibility or liability for the adequacy of its recommendations when they are used in the field without Youngdahl Consulting Group, Inc. being retained to observe construction.

Post Construction Drainage Monitoring

Due to the elusive nature of subsurface water, the alteration of water features for development, and the introduction of new water sources, all drainage related issues may not become known until after construction and landscaping are complete. Youngdahl Consulting Group, Inc. can provide consultation services upon request that relate to proper design and installation of drainage features during and following site development.

9.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. This report has been prepared for the exclusive use of the addressee of this report for specific application to this project. The addressee may provide their consultants authorized use of this report. Youngdahl Consulting Group, Inc. has endeavored to comply with generally accepted geotechnical engineering practice common to the local area. Youngdahl Consulting Group, Inc. makes no other warranty, expressed or implied.

2. As of the present date, the findings of this report are valid for the property studied. With the passage of time, changes in the conditions of a property can occur whether they be due to natural processes or to the works of man on this or adjacent properties. Legislation or the

broadening of knowledge may result in changes in applicable standards. Changes outside of our control may cause this report to be invalid, wholly or partially. Therefore, this report should not be relied upon after a period of three years without our review nor should it be used or is it applicable for any properties other than those studied.

3. Section [A] 107.3.4 of the 2019 California Building Code states that, in regard to the design professional in responsible charge, the building official shall be notified in writing by the owner if the registered design professional in responsible charge is changed or is unable to continue to perform the duties.

   WARNING: Do not apply any of this report's conclusions or recommendations if the nature, design, or location of the facilities is changed. If changes are contemplated, Youngdahl Consulting Group, Inc. must review them to assess their impact on this report's applicability. Also note that Youngdahl Consulting Group, Inc. is not responsible for any claims, damages, or liability associated with any other party's interpretation of this report's subsurface data or reuse of this report's subsurface data or engineering analyses without the express written authorization of Youngdahl Consulting Group, Inc.

4. The analyses and recommendations contained in this report are based on limited windows into the subsurface conditions and data obtained from subsurface exploration. The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any variations or undesirable conditions be encountered during the development of the site, Youngdahl Consulting Group, Inc. will provide supplemental recommendations as dictated by the field conditions.

Table 7: Checklist of Recommended Services

Item Description		Recommended	Not Anticipated
1	Provide foundation design parameters	Included	
2	Review grading plans and specifications	✓	
3	Review foundation plans and specifications	✓	
4	Observe and provide recommendations regarding demolition	✓	
5	Observe and provide recommendations regarding site stripping	✓	
6	Observe and provide recommendations on moisture conditioning removal, and/or recompaction of unsuitable existing soils	✓	
7	Observe and provide recommendations on the installation of subdrain facilities	✓	
8	Observe and provide testing services on fill areas and/or imported fill materials	✓	
9	Review as-graded plans and provide additional foundation recommendations, if necessary	✓	
10	Observe and provide compaction tests on storm drains, water lines and utility trenches		✓
11	Observe foundation excavations and provide supplemental recommendations, if necessary, prior to placing concrete	✓	
12	Observe and provide moisture conditioning recommendations for foundation areas and slab-on-grade areas prior to placing concrete		✓
13	Provide design parameters for retaining walls	Included	
14	Provide finish grading and drainage recommendations	Included	
15	Provide geologic observations and recommendations for keyway excavations and cut slopes during grading		✓
16	Excavate and recompact all test pits within structural areas		✓

APPENDIX A

Field Study

Vicinity Map
Site Plan
Log of Exploratory Boring
Soil Classification Chart and Log Explanation
CPT Sounding Interpretations

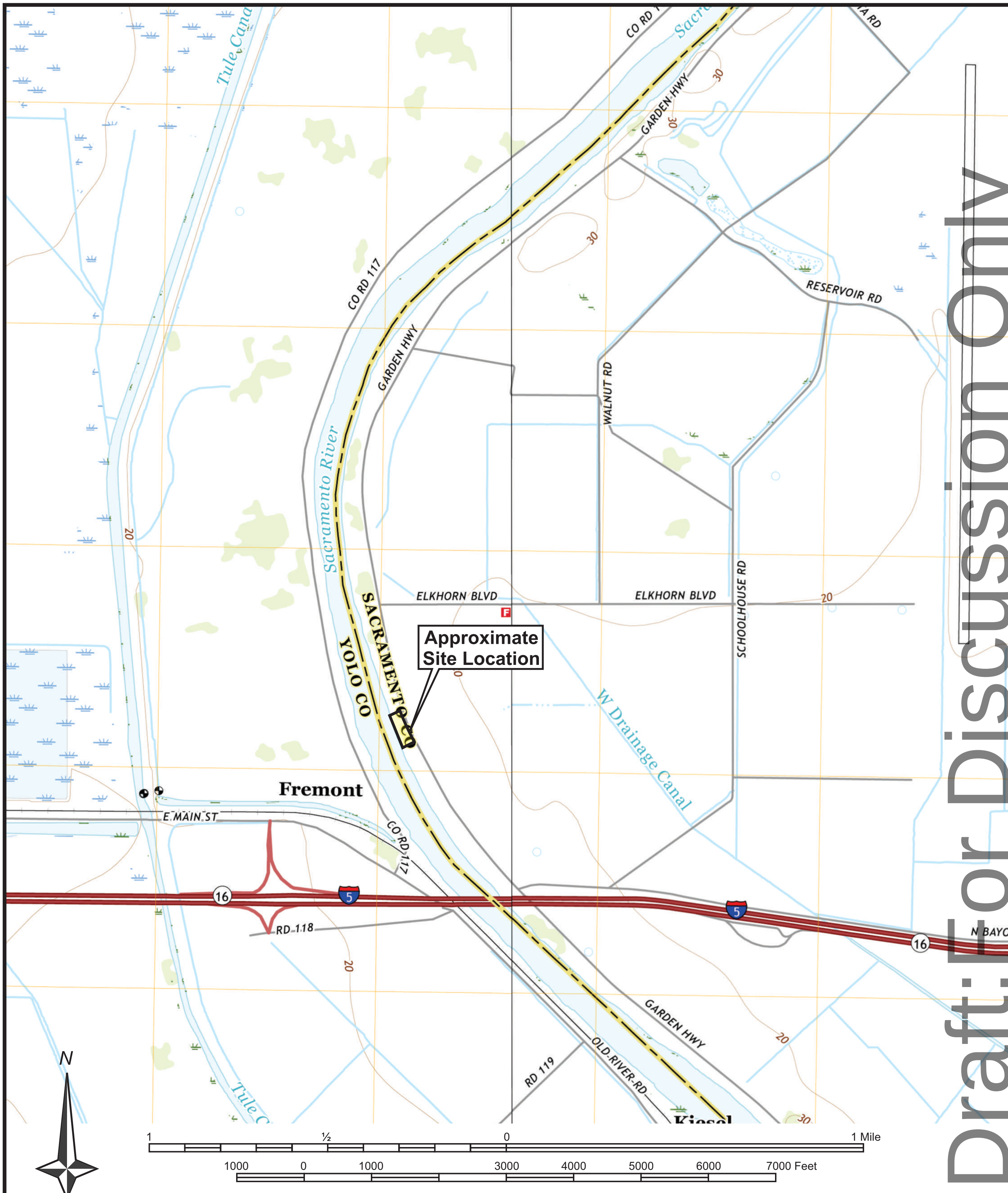
Introduction

The contents of this appendix shall be integrated with the Preliminary Geotechnical Engineering Study of which it is a part. They shall not be used in whole or in part as a sole source for information or recommendations regarding the subject site.

Our field study included a site reconnaissance by a Youngdahl Consulting Group, Inc. representative followed by a subsurface exploration program conducted on 1 February 2022, which included the advancement of one exploratory boring and two cone penetration (CPT) soundings at the approximate locations shown on Figure A-2, this appendix.

Throughout the drilling operation, soil samples were obtained at 5-foot depth intervals by means of a Modified California Sampler. This testing and sampling procedure consists of driving the steel sampler 18 inches into the soil with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded. If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance.

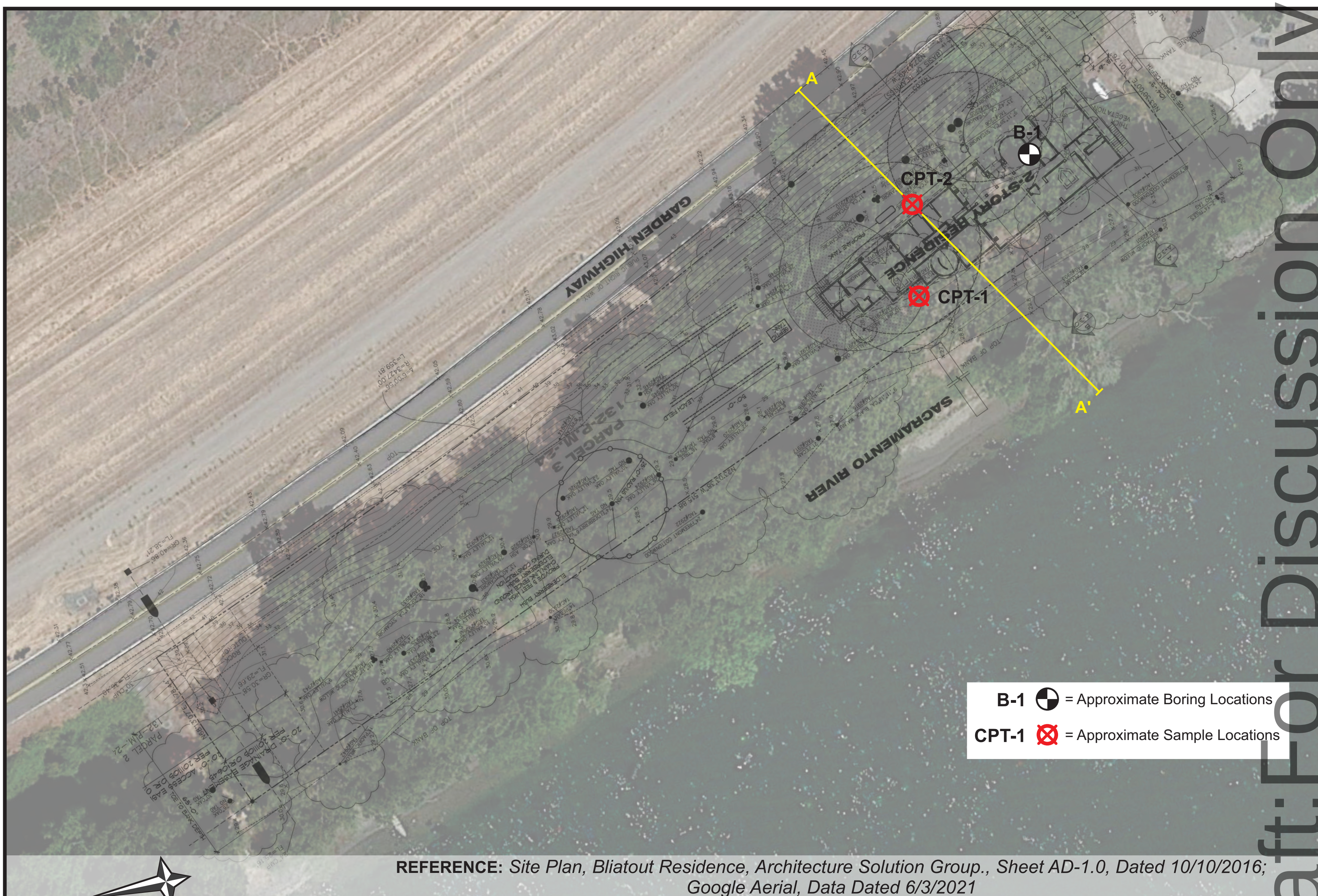
The soils encountered were logged during drilling and provide the basis for the "Boring Log," Figures A-4 this Appendix. The CPT data collected is also provided in this section, Figures A-5 through A-6. The enclosed Boring Logs describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth is depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted. The enclosed CPT data describes the vertical sequence of soil behavior which was encountered during exploration based on cone resistance, sleeve friction, and pore water pressure.



Scale: 1:24,000

BASE MAP REFERENCE: *U.S.G.S. 7.5 Minute Topographic Series, Grays Bend & Taylor Monument Quadrangles, Dated 2018*

YOUNGDAHL CONSULTING GROUP, INC. ESTABLISHED 1984	Project No.: E18418.001 **February 2022**	**VICINITY MAP** **Garden Highway (6237)** Sacramento, California	**FIGURE** **A-1**



REFERENCE: *Site Plan, Bliatout Residence, Architecture Solution Group., Sheet AD-1.0, Dated 10/10/2016; Google Aerial, Data Dated 6/3/2021*

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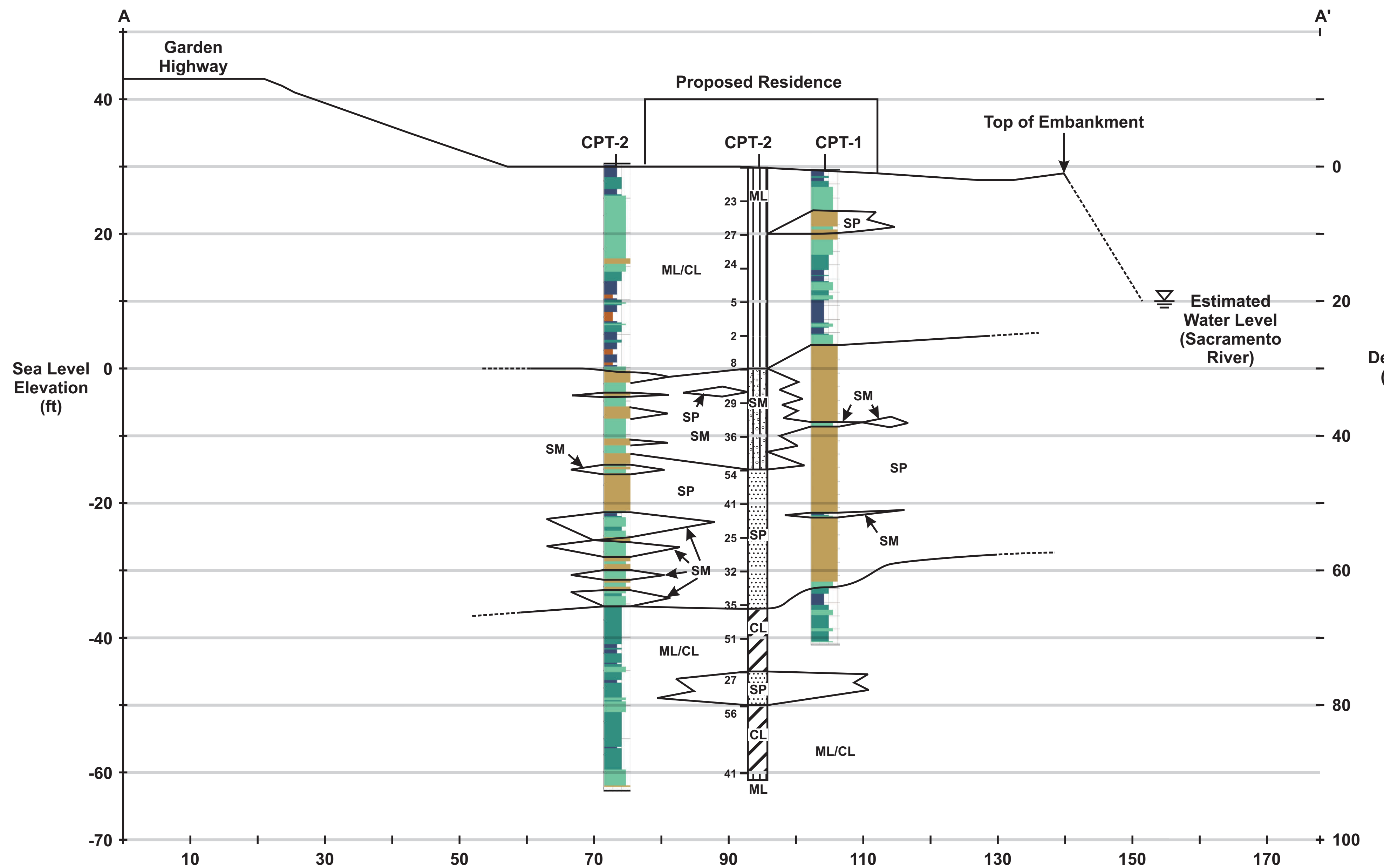
Project No.: E18418.001	SITE PLAN	FIGURE
February 2022	Garden Highway (6237) Sacramento, California	A-2

Cross Section A



Explanation

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

5 (cal mod)

W E

0 10 20 20

Approximate Scale: 1" = 20' Horizontal
1" = 20' Vertical

Draft: For Discussion Only

YOUNGDAHL CONSULTING GROUP, INC. ESTABLISHED 1984	Project No.: E18418.001 / February 2022	**SITE PLAN** Garden Highway (6237) Sacramento, California	FIGURE **A-3**

Logged By: **FJS**	Date: **31 January 2022**	Lat / Lon: **N 38.679361° / W 121.630064°**	Boring No. **B-1**
Equipment: **CME 75 Drill Rig - Mud Rotary**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
0			Olive sandy **SILT (ML)**, stiff, moist						**Bulk B-1** @ 0' - 5' DDmax = 101.7 pcf Mcopt = 18.7%
5			*Grades olive and light brown, very stiff, slightly moist*		23				
10			*Grades olive and light brown grey, stiff*		27		91.4	10.0	62.7% < No. 200
15			*Grades light brown grey and yellow brown, with trace clay, very stiff, with iron staining*		24				
20			*Grades olive, soft, wet*		5		69.6	52.7	98.5% < No. 200
23		▼							
25			*Boring Continued on Figure A-4b*						

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

Logged By: **FJS**	Date: **31 January 2022**	Lat / Lon: **N 38.679361° / W 121.630064°**	Boring No. **B-1**
Equipment: **CME 75 Drill Rig - Mud Rotary**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
25			*Grades very soft*		2				
30			Grey and green grey silty **SAND (SM)**, loose, wet		8		90.7	32.2	19.5% < No. 200
35					29				
40					36				
45			Olive and green grey medium to coarse **SAND (SP)** with trace gravel, medium dense, wet		54		114.7	18.0	5.8% < No. 200
47.5					18				
50			*Boring Continued on Figure A-4c*						

Draft: For Discussion Only

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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February 2022

EXPLORATORY BORING LOG

Garden Highway (6237)
Sacramento, California

FIGURE **A-4b**

Logged By: **FJS**	Date: **31 January 2022**	Lat / Lon: **N 38.679361° / W 121.630064°**	Boring No. **B-1**
Equipment: **CME 75 Drill Rig - Mud Rotary**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
51					41				
52									
53									
54									
55									
56					25				
57									
58									
59									
60			*Grades fine to medium grained*						
61					32				
62									
63			*Grades green grey*						
64					15				
65									
66			Olive sandy **CLAY (CL)**, very stiff, moist		35				
67									
68									
69									
70									
71					51				
72									
73									
74									
75			*Boring Continued on Figure A-4d*						

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

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Project No.: E18418.001

February 2022

EXPLORATORY BORING LOG

Garden Highway (6237)
Sacramento, California

FIGURE A-4c

Logged By: **FJS**	Date: **31 January 2022**	Lat / Lon: **N 38.679361° / W 121.630064°**	Boring No. **B-1**
Equipment: **CME 75 Drill Rig - Mud Rotary**		Elevation: **~**	

Depth (Feet)	Graphic Log	Ground Water	Geotechnical Description & Unified Soil Classification	Sample	Blow Counts	Pocket Pen (tsf)	Dry Density (pcf)	Moisture Content (%)	Tests & Comments
			Grades olive yellow, increasing sand						
76			Olive yellow **SAND (SP)** with silt, medium dense, wet		27				
77									
78									
79									
80			Olive **CLAY (CL)**, hard, slightly moist						
81					56				
82									Hard Drilling
83									
84									
85									
86									
87									
88									
89									
90			Olive yellow sandy **SILT (ML)** with trace clay, very stiff, moist						
91					41				
92			Boring terminated at 91.5' Groundwater encountered at 23'						
93									
94									
95									
96									
97									
98									
99									
100									
101									
102									

Note: The boring log indicates subsurface conditions only at the specific location and time noted. Subsurface conditions, including groundwater levels, at other locations of the subject site may differ significantly from conditions which, in the opinion of Youngdahl Consulting Group, Inc., exist at the sampling locations. Note, too, that the passage of time may affect conditions at the sampling locations.

YOUNGDAHL CONSULTING GROUP, INC.
ESTABLISHED 1984

Project No.: E18418.001

February 2022

EXPLORATORY BORING LOG

Garden Highway (6237)
Sacramento, California

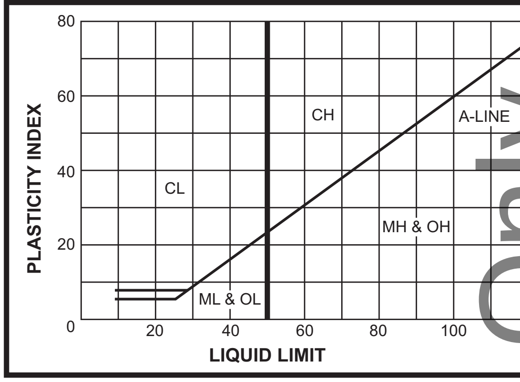
FIGURE **A-4d**

UNIFIED SOIL CLASSIFICATION SYSTEMS

MAJOR DIVISION			SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS Over 50% > #200 sieve	**GRAVELS** Over 50% > #4 sieve	Clean **GRAVELS** With Little Or No Fines	GW	Well graded **GRAVELS**, **GRAVEL-SAND** mixtures
			GP	Poorly graded **GRAVELS**, **GRAVEL-SAND** mixtures
		GRAVELS With Over 12% Fines	GM	Silty **GRAVELS**, poorly graded **GRAVEL-SAND-SILT** mixtures
			GC	Clayey **GRAVELS**, poorly graded **GRAVEL-SAND-CLAY** mixtures
	SANDS Over 50% < #4 sieve	Clean **SANDS** With Little Or No Fines	SW	Well graded **SANDS**, gravelly **SANDS**
			SP	Poorly graded **SANDS**, gravelly **SANDS**
		SANDS With Over 12% Fines	SM	Silty **SANDS**, poorly graded **SAND-SILT** mixtures
			SC	Clayey **SANDS**, poorly graded **SAND-CLAY** mixtures
FINE GRAINED SOILS Over 50% < #200 sieve	**SILTS & CLAYS** Liquid Limit < 50		ML	Inorganic **SILTS**, silty or clayey fine **SANDS**, or clayey **SILTS** with plasticity
			CL	Inorganic **CLAYS** of low to medium plasticity, gravelly, sandy, or silty **CLAYS**, lean **CLAYS**
			OL	Organic **CLAYS** and organic silty **CLAYS** of low plasticity
	SILTS & CLAYS Liquid Limit > 50		MH	Inorganic **SILTS**, micaceous or diamacious fine sandy or silty soils, elastic **SILTS**
			CH	Inorganic **CLAYS** of high plasticity, fat **CLAYS**
			OH	Organic **CLAYS** of medium to high plasticity, organic **SILTS**
HIGHLY ORGANIC CLAYS			PT	PEAT & other highly organic soils

PLASTICITY CHART

USED FOR CLASSIFICATION OF FINE GRAINED SOILS



SAMPLE DRIVING RECORD

BLOWS PER FOOT	DESCRIPTION
25	25 Blows drove sampler 12 inches, after initial 6 inches of seating
50/7"	50 Blows drove sampler 7 inches, after initial 6 inches of seating
50/3"	50 Blows drove sampler 3 inches during or after initial 6 inches of seating

Note: To avoid damage to sampling tools, driving is limited to 50 blows per 6 inches during or after seating interval.

SOIL GRAIN SIZE

U.S. STANDARD SIEVE		6"		3"		¾"		4		10		40		200		
	BOULDER		COBBLE		GRAVEL COARSE		GRAVEL FINE		SAND COARSE		SAND MEDIUM		SAND FINE		SILT	CLAY
SOIL GRAIN SIZE IN MILLIMETERS		150		75		19		4.75		2.0		.425		0.075		0.002

KEY TO PIT & BORING SYMBOLS

- Standard Penetration test
- 2.5" O.D. Modified California Sampler
- 3" O.D. Modified California Sampler
- Shelby Tube Sampler
- 2.5" Hand Driven Liner
- Bulk Sample
- Water Level At Time Of Drilling
- Water Level After Time Of Drilling
- P Perched Water

KEY TO PIT & BORING SYMBOLS

	Joint
	Foliation
	Water Seepage
NFWE	No Free Water Encountered
FWE	Free Water Encountered
REF	Sampling Refusal
DD	Dry Density (pcf)
MC	Moisture Content (%)
LL	Liquid Limit
PI	Plasticity Index
PP	Pocket Penetrometer
UCC	Unconfined Compression (ASTM D2166)
TVS	Pocket Torvane Shear
EI	Expansion Index (ASTM D4829)
Su	Undrained Shear Strength

YOUNGDAHL CONSULTING GROUP, INC. ESTABLISHED 1984	Project No.: E18418.001	**SOIL CLASSIFICATION CHART AND LOG EXPLANATION** **Garden Highway (6237)** Sacramento, California	**FIGURE**
	February 2022		**A-5**

YOUNGDAHL CONSULTING GROUP, INC.
Geotechnical • Geoscience • Materials Testing • Stormwater Compliance

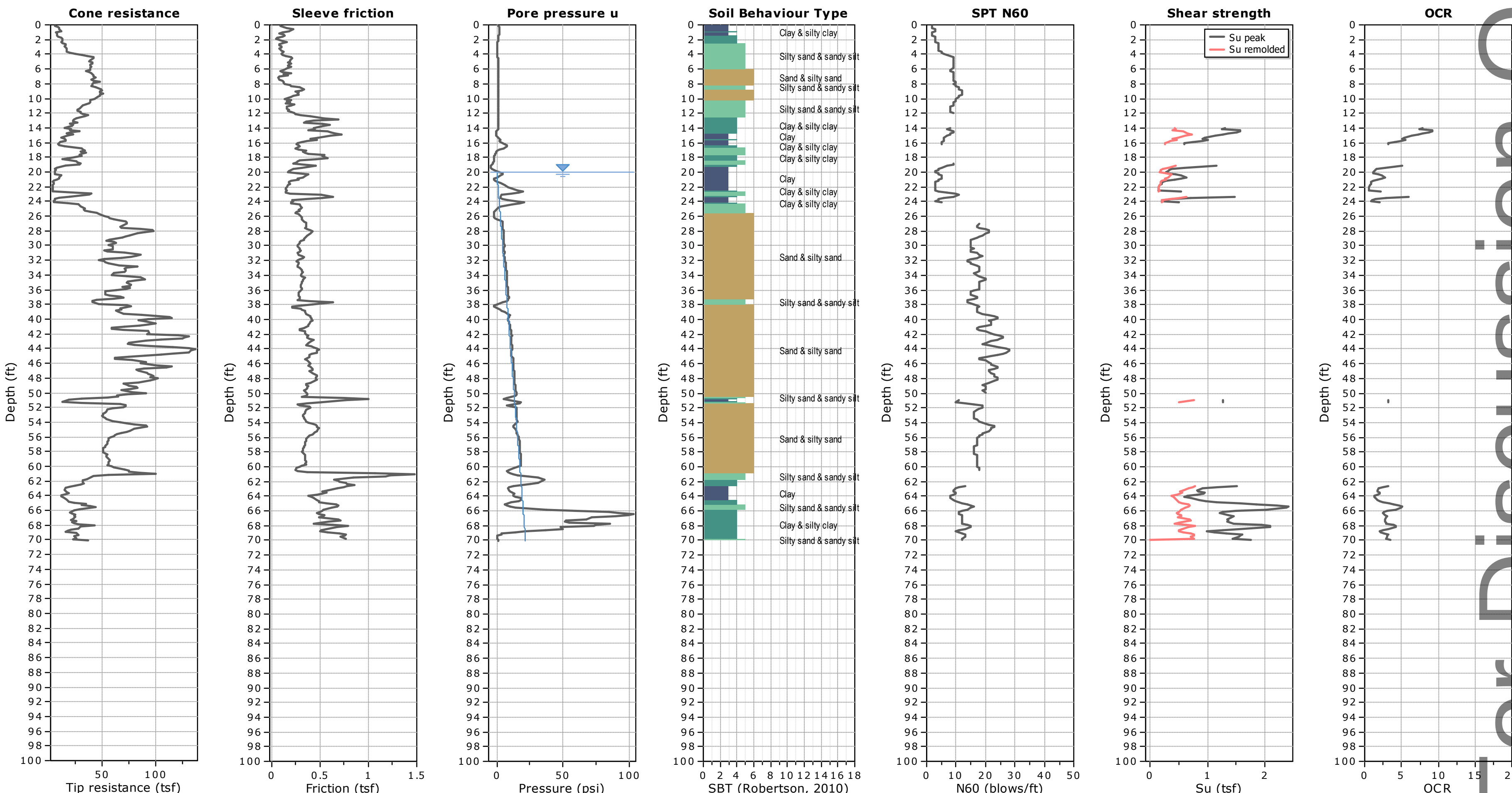
CPT: CPT-1

Project: Garden Highway (6237)

Location: 6237 Garden Highway, Sacramento, California

Total depth: 70.05 ft, Date: 12/31/2021

Coords: lat 38.679583° lon -121.630342°



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

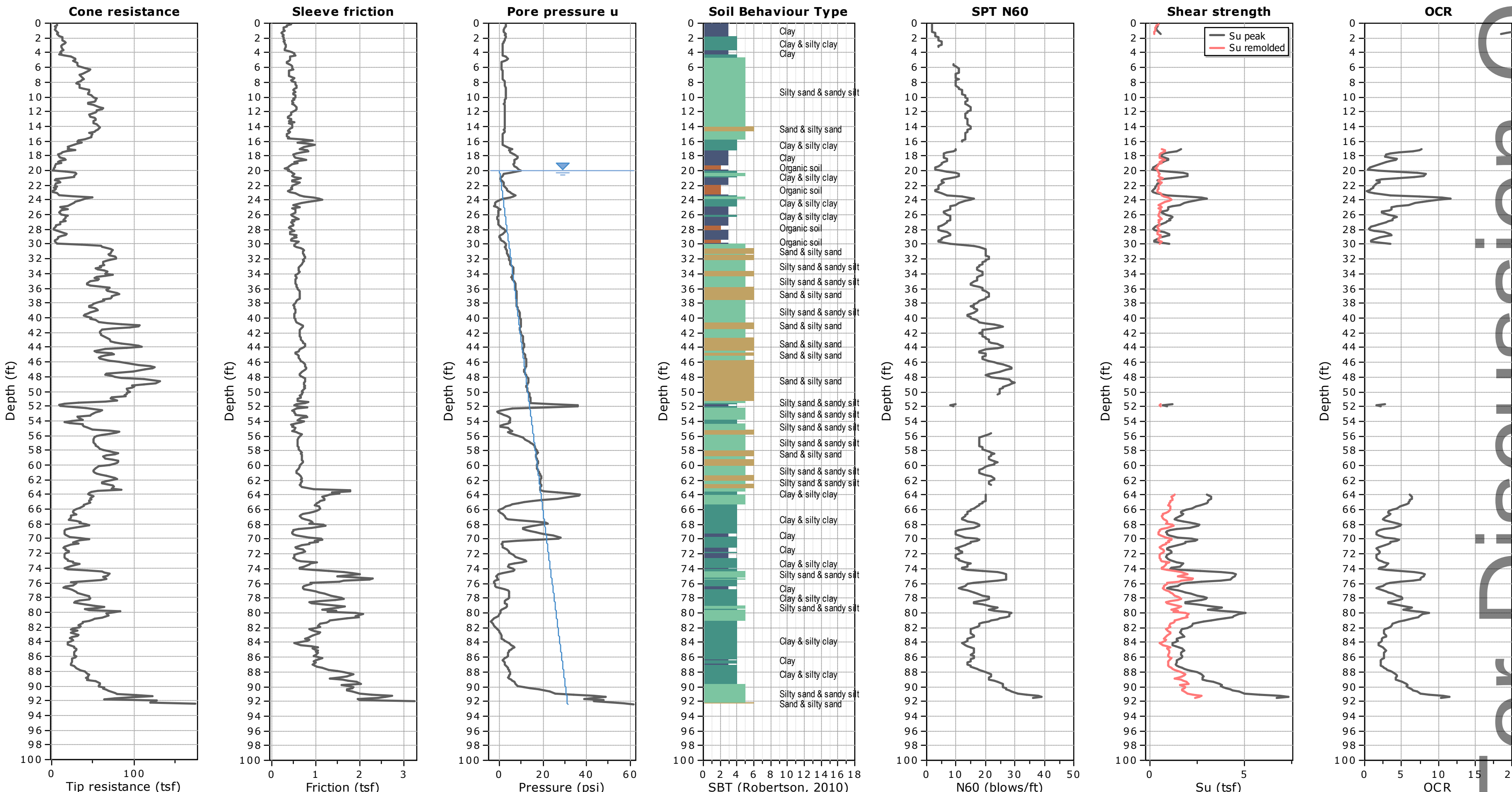
CPT: CPT-2

Total depth: 92.36 ft, Date: 1/31/2022

Coords: lat 38.679536° lon -121.630137°

Project: Garden Highway (6237)

Location: 6237 Garden Highway, Sacramento, California



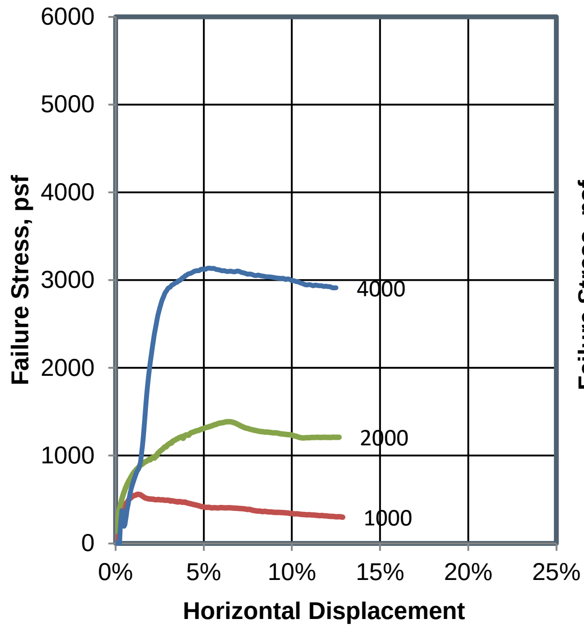
SBTn legend

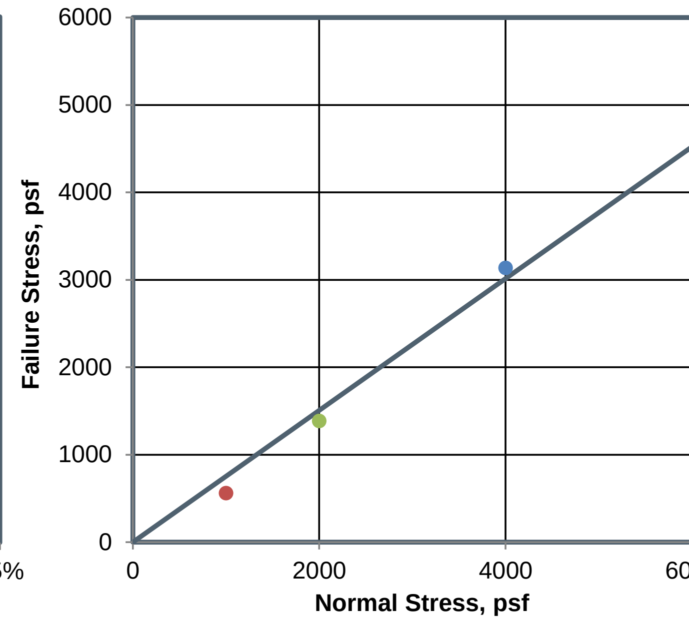
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

APPENDIX B
Laboratory Testing

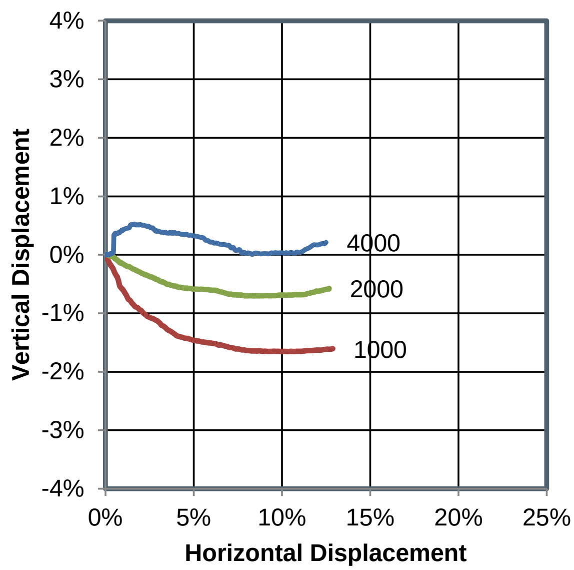
Direct Shear Test
Modified Proctor Test
Finer Than 200
Corrosivity Tests

Direct Shear Test of Soils Under Consolidated Drained Conditions, ASTM D3080





Direct Shearbox Results
Friction Angle
37.0°
Cohesion
0 psf



Test No.		1	2	3
Initial	Wet Density, pcf	108.6	108.6	108.6
	Dry Density, pcf	91.5	91.5	91.5
	Moisture Content, %	18.7	18.7	18.7
	Diameter, in	2.50	2.50	2.50
	Height, in	1.00	1.00	1.00
Pre Shear	Wet Density, pcf	126.5	128.4	126.9
	Dry Density, pcf	92.2	93.1	94.3
	Moisture Content, %*	37.3	37.9	34.6
	Diameter, in	2.50	2.50	2.50
	Height, in	0.99	0.98	0.97
Normal Stress, psf		1000	2000	4000
Failure Stress, psf		560	1386	3137
Failure Strain, %		1.24	6.41	5.32
Rate, in/min			0.002	

*Based on post shear moisture content

Sample Type:	Remolded to 90% RC
Material Description:	**Olive Sandy SILT**
Source:	
Notes:	Gravel removed from test sample.

Sample No./Depth: B-1 @ 0-5'		USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4	% Less than No. 200
Date Sampled: 1/31/2022	Date Test Started: 2/4/2022				1	

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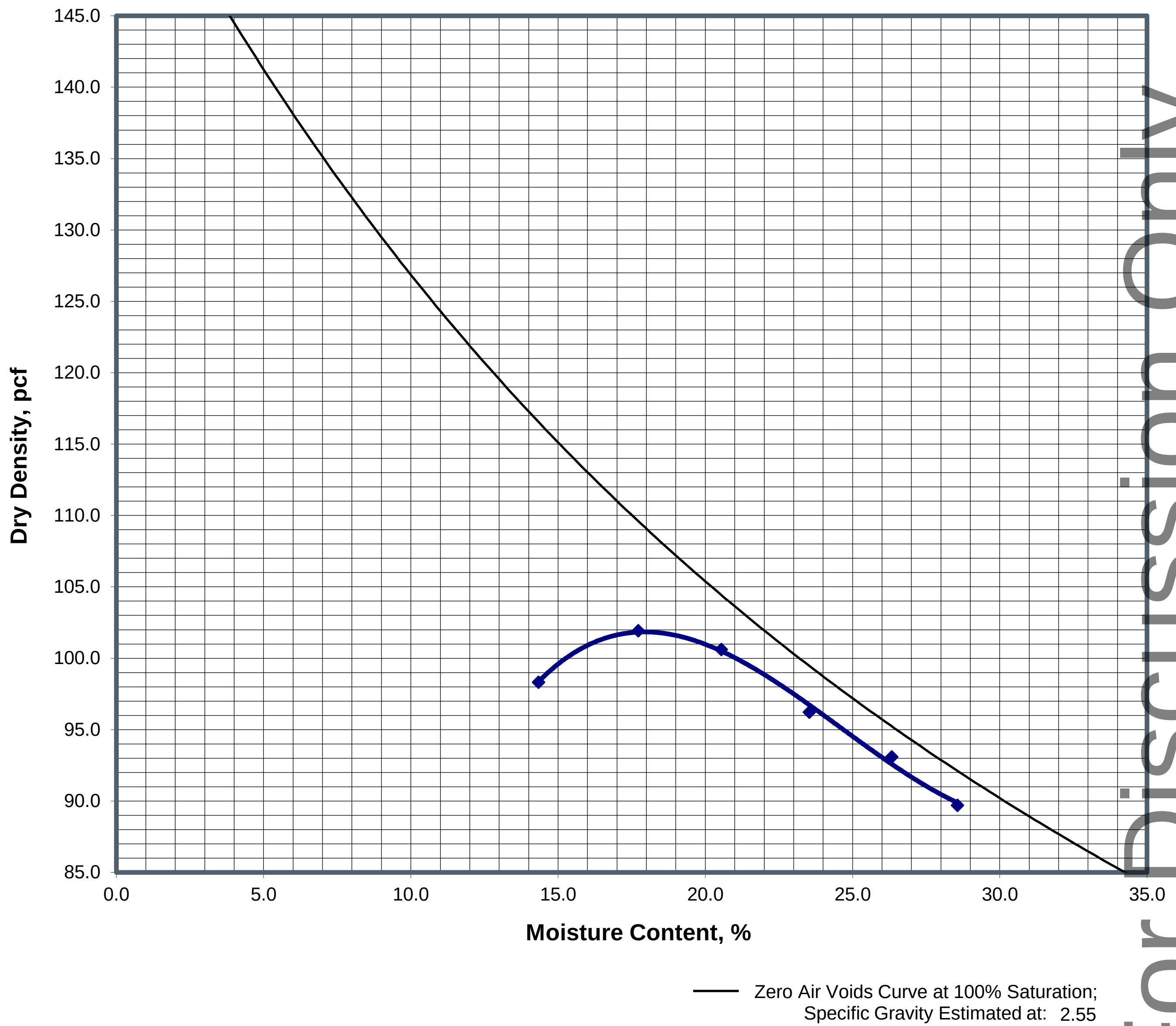
CONSULTING GROUP, INC.
ESTABLISHED 1984
1234 Glenhaven Court, El Dorado Hills, CA 95762
ph 916.933.0633 ▪ fx 916.933.6482 ▪ www.youngdahl.net

Project:	**Garden Highway (6237)**		
Project No.:	**E18418.001**		Figure
Reviewed By: DN	Date: 2/7/2022		**B-1**

Laboratory Compaction Characteristics of Soil
Using Modified Effort (56,000 lf-lbf/ft3), ASTM D1557, Method A



Maximum Dry Density, pcf:	**101.7**	Optimum Moisture Content, %:	**18.7**		
Material Description:	**Olive Sandy SILT**				
Source:	B-1 @ 0-5'				
Notes:					
Sample No./Depth: Curve 1		USCS Class.	Liquid Limit	Plasticity Index	% Greater than No. 4 :	% Less than No. 200
Date Sampled: 1/31/2022	Date Test Started: 2/2/2022				1	

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Project:	**Garden Highway (6237)**		
Project No.:	**E18418.001**		Figure
Reviewed By: JGR, JLC	Date: 2/4/2022		**B-2**

Amount of Material Finer than No. 200 (75-µm) Sieve in Soils by Washing, ASTM D1140, Method A

Sample No.	Depth	Sample Description	Material Finer than No. 200 Sieve, %
B-1	11'	Olive/Light Brown Gray Sandy SILT	62.7
B-1	21'	Olive SILT	98.5
B-1	31'	Gray/Green Gray Silty SAND	19.5
B-1	46'	Olive/Green Gray SAND	5.8

Notes:

Date Sampled:	1/31/2022	Date Test Started:	2/2/2022

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1234 Glenhaven Court, El Dorado Hills, CA 95762
ph 916.933.0633 ▪ fx 916.933.6482 ▪ www.youngdahl.net

Project:	Garden Highway (6237)			
Project No.:	**E18418.001**			Figure
Reviewed By:	DN	Date:	2/7/2022	**B-3**

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

RECEIVED FEB 1 4 2022

Date Reported 02/09/2022
Date Submitted 02/02/2022

To: Jeffry Cannon
Youngdahl Consulting Group
1234 Glenhaven Ct.
El Dorado Hills, CA 95630

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

The reported analysis was requested for the following location:
Location : E18418.001 GARDEN HY Site ID : B-1 @ 21.
Thank you for your business.

* For future reference to this analysis please use SUN # 86590-180269.

EVALUATION FOR SOIL CORROSION

Soil pH	6.93	
Minimum Resistivity	2.65 ohm-cm (x1000)	
Chloride	6.6 ppm	00.00066 %
Sulfate	30.7 ppm	00.00307 %

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m

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

Date Reported 02/09/2022
Date Submitted 02/02/2022

To: Jeffry Cannon
Youngdahl Consulting Group
1234 Glenhaven Ct.
El Dorado Hills, CA 95630

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

The reported analysis was requested for the following location:
Location : E18418.001 GARDEN HY Site ID : B-1 @ 66.
Thank you for your business.

* For future reference to this analysis please use SUN # 86590-180270.

EVALUATION FOR SOIL CORROSION

Soil pH	8.17		
Minimum Resistivity	9.94 ohm-cm (x1000)		
Chloride	1.9 ppm	00.00019	%
Sulfate	8.7 ppm	00.00087	%

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m