Geologic Hazards and Geotechnical Investigation Report–Revision 1

Proposed Health Center Building
Open Door Community Health Center
Foster and Sunset Avenues
Arcata, California

Prepared for:

Open Door Community Health Centers

SHN

October 2019

018011.200

812 W. Wabash Ave., Eureka, CA 95501-2138 707-441-8855
Civil Engineering, Environmental Services, Geosciences, Planning & Permitting, Surveying

Reference: 018011.200

October 15, 2019

Cheyenne Spetzler
Open Door Community Health Centers
670 9th Street
Arcata, CA 95521

Subject: Geologic Hazards and Geotechnical Investigation Report, Proposed Health Center Building, Open Door Community Health Center, Foster and Sunset Avenues, Arcata, California–Revision 1

Dear Cheyenne Spetzler:

As requested, SHN is providing this geologic hazards and geotechnical investigation report for the proposed health center building for Open Door Community Health Center between Foster and Sunset Avenues in Arcata, California. The enclosed report discusses geologic and geotechnical site characteristics and risks, and presents our findings, conclusions, and recommendations for site preparation and grading, and design of the proposed health center building and adjacent asphalt-paved parking and driveway areas.

If you have any questions, please call either of us at 707-441-8855.

Sincerely,

SHN

John H. Dailey, PE, GE 256
Senior Geotechnical Engineer

JHD:amg

Enclosure: Report

Reference: 019182.100

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Proposed Health Center Building
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Prepared for:

Open Door Community Health Centers

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October 2019

QA/QC:GDS___

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Abbreviations and Acronyms

mm	millimeter
pcf	pounds per cubic foot
pci	pounds per cubic inch
psf	pounds per square foot
psi	pounds per square inch
µm	micrometer
ASCE	American Society of Civil Engineers
ASTM	ASTM-International
BGS	below ground surface
CBC	California Building Code
H:V	horizontal to vertical
MD/TD	machined direction/transverse direction
NR	no reference
OSHA	Occupational Safety and Health Administration
SE	sand equivalent
SM	silty sand
TP-#	test pit-number
USGS	United States Geological Survey

1.0 Introduction

1.1 General

This report presents the results of a geotechnical investigation conducted by SHN to support the design and construction of the proposed health center at the subject site. The project is located on a vacant undeveloped property adjacent to and between Foster and Sunset Avenues in Arcata, California (see Figure 1, Site Plan). SHN previously performed a geotechnical investigation on the eastern portion of the site for a proposed new fire station and presented the results of that investigation in a report dated August 10, 2009 (SHN Project No. 009077). SHN supplemented the previous subsurface investigation with additional subsurface exploration on the western portion of the site in order to develop the recommendations provided in this report.

This report was prepared for the sole use of Open Door Community Health Centers and their design consultants. The report is intended to satisfy the requirements set forth by the Humboldt County Building Department and the criteria presented in Chapter 18 of the *2016 California Building Code* (CBC). Geologic conditions and conclusions regarding the risk of adverse effects from geologic hazards are also addressed, which were previously discussed in our 2009 report.

This report is based on a review of published geologic literature and mapping in the vicinity of the project site, the data obtained from our current field investigation, and data from the previous 2009 SHN investigation (SHN, 2009).

1.2 Project Description

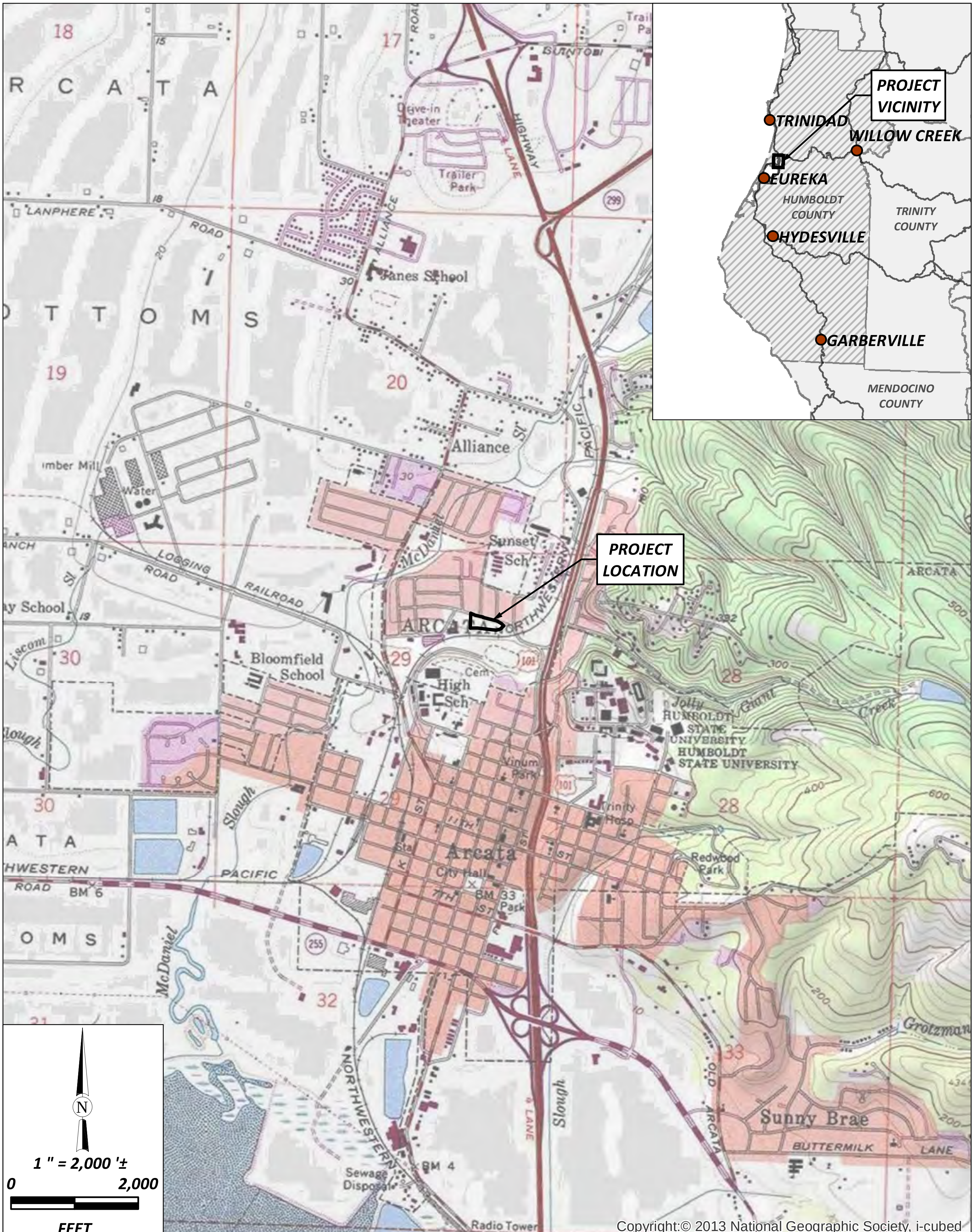
We understand the project will consist of the construction of a one- to two-story structure with a daylight basement in the southwest corner of the structure. Preliminary information indicates the first floor will be approximately 21,000 square feet in area, the second floor approximately 10,000 square feet, and the basement approximately 3,000 square feet. The basement will contain the HVAC equipment, with a retaining wall required for the north wall of the equipment room. A large parking lot is proposed on the eastern portion of the site with access from Foster Avenue, along with a small parking lot in the northwest corner with access from Sunset Avenue. We anticipate that the building structure will have moderately loaded perimeter footings and isolated column loads, and have slab-on-grade floors.

2.0 Scope of Work

The scope of SHN's services included reviewing available geologic and subsurface information, including SHN's 2009 investigation; supervising the excavation of three additional geotechnical test pits to supplement the previous subsurface exploration; and providing geotechnical recommendations to aid in project planning, design, and construction.

Specifically, the following information, recommendations, and design criteria are presented in this report:

- Description of site terrain
- Description of soil and groundwater conditions, interpreted based on our current and previous field exploration; laboratory testing; and review of existing geologic and geotechnical information
- Logs of the current geotechnical test pits (Appendix 1) and logs of previous borings, cone penetration tests (CPTs) and test pits excavated in 2009 by SHN for the Sunset Avenue Fire Station (Appendix 2)



Path: \\eureka\projects\2018\018011-ODCHC-Arcata\200-Geotech\GIS\PROJ_MXD\Figure1_ProjectLocationMap.mxd User Name: psundberg DATE: 10/24/19, 11:56AM

SHN	Pressey & Associates Proposed Health Center Building Arcata, California	Project Location Map SHN 018011.200
	October 2019 — Figure1_ProjectLocationMap	Figure 1

- Seismic design parameters in accordance with the applicable portions of the 2016 CBC and American Society of Civil Engineers (ASCE) 7-10 Standard, including site soil classification, seismic design category, and spectral response accelerations
- Recommendations for new site improvements, including site and subgrade preparation, fill material, placement and compaction requirements, slab-on-grade and foundation support, and design and construction of pavement areas
- Assessment of foundation load-bearing soil conditions, including:
  - Allowable bearing pressures or capacities (dead, live, and seismic loads)
  - Minimum foundation embedment
  - Estimates of settlement (total and differential)
  - Allowable lateral passive and sliding resistance characteristics for foundations
- Recommendations for observation of site grading and foundation installation, materials testing and inspection, and other construction considerations.

3.0 Field Investigation

On September 9, 2019, a project geologist from SHN logged three shallow backhoe test pits in the western portion the project site. The three test pits, TP-1 through TP-3 (Figure 2), were excavated to depths ranging from 10.5 feet to 11.5 feet below (existing) ground surface (BGS). Approximate test pit locations are shown on Figure 2. During our previous investigation (SHN, 2009) our subsurface exploration program was designed to evaluate soil and groundwater conditions underlying the eastern portion of the site and included six CPT borings, two geotechnical machine borings, and eight backhoe test pits; the location of those borings and test pits are also shown on Figure 2.

The soils encountered in the test pits were logged and field classified in general accordance with the Manual-Visual Classification Method (ASTM-International [ASTM] D 2488). During excavation, the project geologist evaluated the in situ soil consistency based on equipment performance and level of effort required to advance the test pit. After the test pits were logged, they were backfilled with the excavation spoils; however, the backfill was not compacted to the requirements for structural fill in the excavated test pits. Final test pit logs, presented in Appendix 1, were prepared based on the field logs. Logs from the previous investigation (2009) are included in Appendix 2.

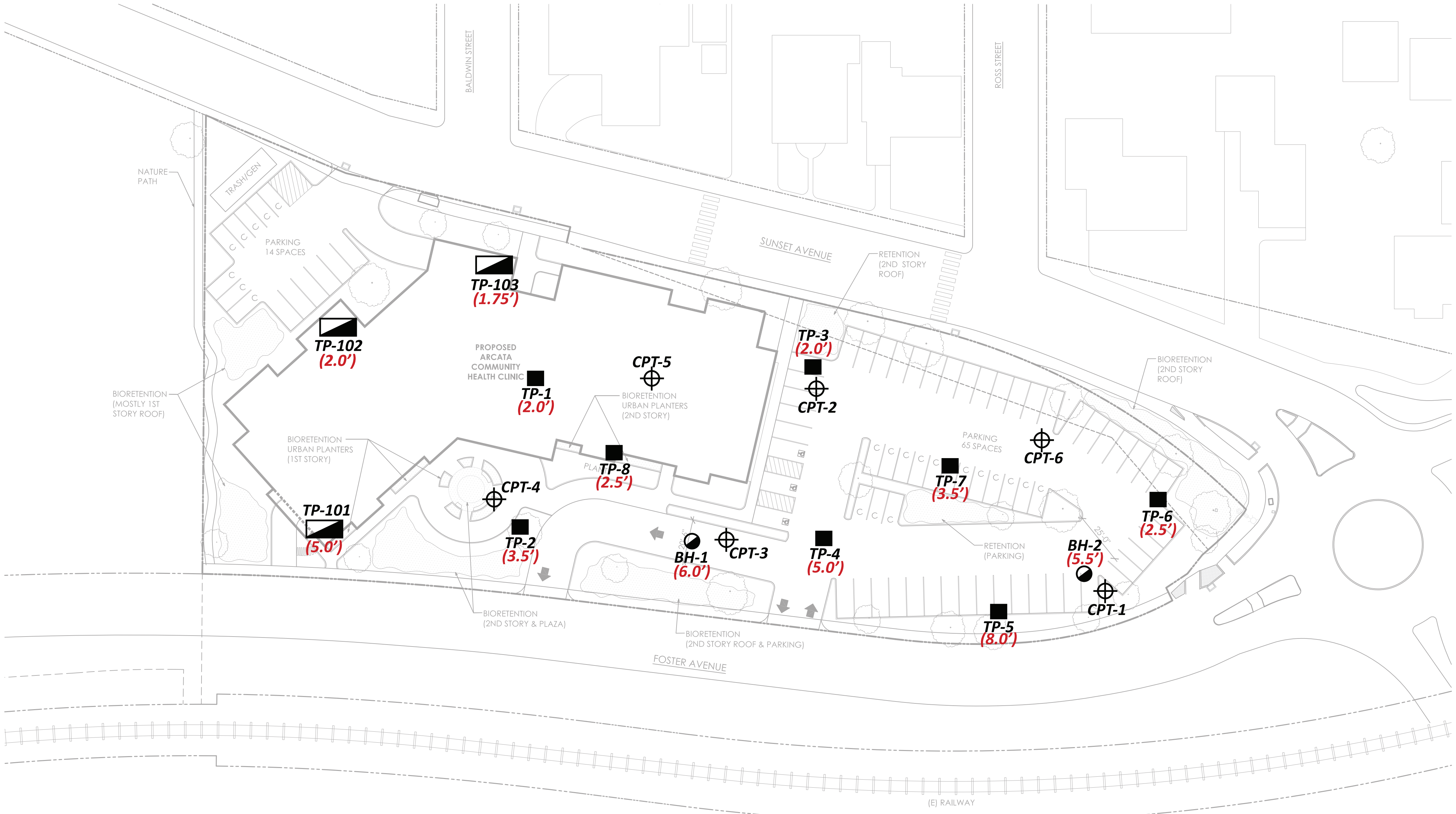
Selected soil samples were tested in SHN's certified soils-testing laboratory in Eureka, California, to determine index properties and characteristics of the subsurface materials. Selected relatively undisturbed samples were tested for in-place moisture content and dry density, and bulks samples of subgrade soils were tested for R-Value. Results of the moisture density and dry density tests are provided at the corresponding sample locations on the boring logs (Appendix 1) and included as Appendix 3.

4.0 Site Conditions

The following sections describe the site surface conditions and subsurface soil and groundwater conditions encountered at the time of our current and previous field explorations.

4.1 Site Description

The proposed development is planned for construction on a vacant parcel that is currently unimproved. The site has been graded relatively flat in the past by filling. We understand that the site was used in the past as



EXPLANATION

- SOIL TEST PIT - SHN, 2019
- GEOTECHNICAL BORING - SHN, 2009
- CONE PENETROMETER TEST - SHN, 2009
- SOIL TEST PIT - SHN, 2009

N

1"=60'±

0 60

FEET

NOTE: FILL THICKNESSES SHOWN IN PARENTHESES IN RED
LOCATIONS ARE APPROXIMATE

BASEMAP FROM PRESSEY & ASSOCIATES, ARCATA CONCEPTUAL DESIGN & FEASIBILITY, "SITE PLAN", SHEET AS-1.0, UNDATED

SHN	Pressey & Associates Proposed Health Center Building Arcata, California	Site Plan Map SHN 018011.200
	October 2019 / Figure2_SitePlanMap	Figure 2

a log deck and loading area in support of an adjacent mill facility. The proposed structure is situated within the western part of the parcel (Figure 2). Vegetation consists mainly of grasses with trees along the west boundary. Original topography (pre-fill) consisted of a gentle south-facing slope that made up the northern flank of a broad, low gradient swale within the Jolly Giant Creek drainage. A 20 to 30 percent slope is present along, and roughly parallel to the southern property line. The slope is heavily vegetated with brush and small trees.

4.2 Subsurface Soil

The subsurface materials consist of sedimentary deposits with stratified layers of fine-grained (silts and clays) and coarse-grained (sands and fine gravels) materials. The near surface soils consist of unengineered fill materials (discussed below). The native soil profile beneath the surgical fills, as observed in our backhoe pits, consists of a thin organic-rich silt (ML; native topsoil) that grades into a medium dense silty sand (SM) to the total depths explored with the backhoe (up to 11.5 feet). Soils at depth, as observed in our geotechnical boreholes and as indicated on CPT logs, consist primarily of soft to very stiff silt (ML) and clay (CL) with isolated intervals of loose to very dense silty sand (SM) and sand with silt (SP/SW). Below a depth of 30 to 35 feet, we encountered dense to very dense sand with gravel to the total depths explored in our boreholes (41.5 feet below grade).

Specific descriptions of the soils encountered within our current test pits are described on logs in Appendix 1, and the 2009 boreholes and test pits are described on the logs in Appendix 2. CPT logs from 2009 are included within Appendix 2.

4.3 Fills

Historic grading at the project site includes the placement of fill across most of the property. The original topography of the property was a gentle slope to the south. The site, as it exists today, is relatively flat, and as such, the fill prism forms a wedge that thickens toward the south. Thickness varies from less than 2 feet along the southern edge of Sunset Avenue to as much as 10 feet or more along the southern edge of the property (fill thicknesses at location of test pits are shown on Figure 2). As observed in our current and previous backhoe test pits, fill materials consist of a mixture of sands, silts, clays and gravels. In most of our sampling points, well-graded river run gravels and cobbles were observed within the upper 2 to 4 feet of the fill. In places, we observed concentrated layers of woody debris and organics. The presence of this material is consistent with the previous uses of the site as a log deck and truck loading area. The fill materials were placed on the original grade with little or no site preparation (removal of topsoil, benching). Native topsoil remains in place in most areas explored. The variability of the fill, and particularly the presence of soft compressible soils and layers of organic material, make the fill soils unsuitable for bearing structural loads. Foundation recommendations are provided below to mitigate the presence of the fill.

4.4 Groundwater

Groundwater was encountered within BH-1 and BH-2 at approximately 26 feet and 18 feet below grade, respectively. Perched groundwater was also encountered in TP-5 (2009) at approximately 9 feet below grade. Groundwater seeps have been observed at several locations at the site. Based on the variability of soil moisture in our boreholes and the interbedded fine and coarse grained soils, we expect that groundwater is locally perched on strata of lower permeability. We estimate the seasonal fluctuation of groundwater to vary from 5 to 30 feet below grade. We are not aware of any available records of historical groundwater levels at the project site. Groundwater conditions can be expected to fluctuate in response to seasons, storm events, and other factors. Note that the free face along the southwest margin of the site should allow groundwater “escape”; therefore we do not anticipate prolonged periods of very shallow groundwater. Wetlands are located at the base of this slope in the southwest corner of the site.

5.0 Geologic Setting

5.1 Regional Geology

Basement rock in the region is composed of late Jurassic to late Cretaceous age mélange of the Franciscan Complex (McLaughlin et al., 2000; Clarke, 1992). The mélange is part of the Central Belt subunit of the Franciscan Complex, and typically consists of blocks of conglomerate, graywacke sandstone, radiolarian chert, blueschist facies metamorphic rock, greenstone, and ophiolitic plutonic rock in an intensely sheared argillite matrix. Depth to Franciscan bedrock beneath the site is not known as it was not encountered in our subsurface investigation. The nearest surface exposures of Franciscan rocks are on the Humboldt State University campus to the east. In the Arcata area, Franciscan basement rock is unconformably overlain by early to middle Pleistocene age marine and continental deposits of the Falor formation (Carver et. al., 1985).

In coastal central Humboldt County, Franciscan basement rock and Falor formation deposits are overlain by a series of late Pleistocene marine terraces. These terraces typically consist of an abrasion platform cut across bedrock, and terrace cover sediments typically consisting of near-shore marine deposits and terrestrial alluvial, colluvial, and eolian deposits. No datable material has been recovered from the marine terraces, so age assignments have been based on elevation distributions and comparisons with global sea level chronologies, as well as comparisons of relative amounts of pedogenic soil development. Based on these analyses, the Arcata marine terrace is correlated to the Isotope Stage 7a interglacial period, about 176,000 years ago (Carver and Burke, 1992).

5.2 Seismic Setting

Northwestern California is located in a complex tectonic region dominated by northeast-southwest compression associated with collision of the Gorda and North American tectonic plates. The Gorda plate is being actively subducted beneath North America north of Cape Mendocino, along the southern part of what is commonly referred to as the Cascadia subduction zone. This plate convergence has resulted in a broad fold and thrust belt along the western edge of the accretionary margin of the North American plate. In the Humboldt Bay region, this fold and thrust belt is manifested as a series of northwest-trending, northeast-dipping thrust faults, including the Little Salmon fault and faults that comprise the Mad River fault zone (MRfz). These faults are active and are capable of generating large-magnitude earthquakes.

The project site is located within the MRfz. This zone consists of several major northwest-trending thrust faults and numerous minor, secondary synthetic and antithetic faults. Major faults within the MRfz include from north to south, the Trinidad, McKinleyville, Mad River, and Fickle Hill faults. The project site is located approximately 1200 feet northeast of the Alquist-Priolo Earthquake Fault Zone (APEFZ) for the Fickle Hill fault. Individual faults within the MRfz commonly exhibit variable strikes, which is common along thrust faults, and shallow to moderate dips ranging from as little as 10° to 55°. At least 3 miles of middle and late Pleistocene displacement has occurred across the MRfz since deposition of the Falor formation (Carver, 1987). In the Arcata area, the Fickle Hill fault crosses, and displaces, the marine terraces described above. The faults are typically well expressed across the terraces as west- and southwest-facing scarps separating the displaced, relatively flat terrace surfaces. Antithetic faults within the MRfz are typically associated with lesser amounts of cumulative displacement and form subtle northeast-facing scarps. Only one moderate historic earthquake may have been generated within the MRfz, but all the faults within the zone are considered active based on deformation of Holocene-age soils overlying the faults. The principal faults within the MRfz are considered active by the State and are included within APEFZ.

5.3 Regional Faults

Northwestern California is the most seismically active region in the continental United States. Over 60 earthquakes have produced discernable damage in the region since the mid-1800s (Dengler et al., 1992). Historic seismicity and paleoseismic studies in the area suggest there are six distinct sources of damaging earthquakes in the Humboldt Bay region:

1) **The Gorda Plate.** Gorda plate earthquakes account for the majority of historic seismicity. These earthquakes occur primarily offshore along left-lateral faults and are generated by the internal deformation within the plate as it moves toward the subduction zone. Significant historic Gorda plate earthquakes have ranged in magnitude from M5 to M7.5. The November 8, 1980 earthquake (M7.2) was generated on a left-lateral fault within the Gorda plate.

2) **The Mendocino Fault.** The Mendocino fault is the second most frequent source of earthquakes in the region. The fault represents the plate boundary between the Gorda and Pacific plates, and typically generates right lateral strike-slip displacement. Historic Mendocino fault events have ranged in magnitude from M5 to M7.5. The September 1, 1994 M7.2 event west of Petrolia was generated along the Mendocino fault.

3) **The Mendocino Triple Junction.** The Mendocino triple junction was identified as a separate seismic source only after the August 17, 1991 (M6.0) earthquake. Events associated with the triple junction are shallow onshore earthquakes that appear to range in magnitude from about M5 to M6. Raised Holocene terraces near Cape Mendocino suggest larger events are possible in this region.

4) **The northern end of the San Andreas Fault.** Northern San Andreas fault events are rare but can be very large. The northern San Andreas fault is a right lateral strike-slip fault that represents the plate boundary between the Pacific and North American plates. The fault extends through the Point Delgada region and terminating at the Mendocino triple junction. The 1906 San Francisco earthquake (M8.3) caused the most significant damage in the north coast region, with the possible exception of the 1992 Petrolia earthquake.

5) **Faults within the North American Plate**. Earthquakes within the North American plate can be anticipated from a number of intraplate sources, including the MRfz. There have been no large magnitude earthquakes associated with faults within the North American plate, although the December 21, 1954, M6.5 event may have occurred in the MRfz. Expected magnitudes for North American plate earthquakes are in the M6.5 to M8 range.

6) **The Cascadia Subduction Zone.** The Cascadia subduction zone represents the most significant potential seismic source in the north coast region. A great subduction event may rupture along 200 kilometers (km) or more of the coast from Cape Mendocino to British Columbia, may be up to M9.5, and could be associated with extensive tsunami inundation in low-lying coastal areas. The April 25, 1992, Petrolia earthquake (M7.1) appears to be the only documented historic earthquake involving slip along the subduction zone, but this event was confined to the southernmost portion of the fault. Paleoseismic studies along the subduction zone suggest that great earthquakes are generated along the zone every 300 to 500 years. The last large subduction earthquake occurred in 1700. A great subduction earthquake would generate long duration, very strong ground shaking throughout the Pacific Northwest.

Table 1 presents fault location and information data collected from the United States Quaternary Faults and Fold Database (U.S. Geological Survey, 2006).

Table 1. Summary of Nearby Active Faults

Fault Name	Approximate Distance to Surface Trace (kilometers)	Maximum Earthquake Magnitude (Mw)
Little Salmon	19	7.0
Mad River	4	7.1
Fickle Hill	<1	6.9
McKinleyville	4	7.0
Table Bluff	26	7.0
Trinidad	16	7.3
Big Lagoon/Bald Mountain Fault Zone	22	7.3
Cascadia Subduction Zone	64	8.3
Garberville/Briceland	82	6.9
Mendocino Fault Zone	4	7.4
San Andreas	90	7.6

5.4 Historical Seismicity

A search of historical earthquake records was performed using the USGS (United States Geological Survey) Preliminary Determinations of Epicenters Catalog on the web site http://neic.usgs.gov/neis/epic/epic_circ.html. Our historical search included years from 1865 to 2008.

A total of 66 earthquake records were identified with a magnitude greater than M5.0 within a 100-km radius around the site. The largest magnitude earthquakes within 100 km of the site were estimated M7.2 events that occurred in 1923 (78 km southwest of the project site), 1980 (29 km west of the project site) and 1992 (60 km southwest of the project site).

6.0 Evaluation of Potential Geologic Hazards

6.1 Surface Fault Rupture

A series of three northwest trending, northeast dipping sub-parallel thrust faults have been mapped through downtown Arcata (Carver, et. al., 1985; Kelley, 1984). These fault traces were mapped based on geomorphic features (scarps, topographic lineaments) and limited and/or undocumented exposures in road cuts. All three of these mapped traces terminate and/or become queried within the northwest portions of Arcata. Carver, et. al., maps the northernmost fault trace south of the site, extending into and terminating within the Jolly Giant Creek drainage, coming to within approximately 400 feet of the site. Kelley shows the same fault trace striking toward the subject property and terminating approximately 1000 feet southeast of the property. Both Carver and Kelley have not mapped any structures across the marine terrace surface on which the site is located. Additionally, this particular trace has not been determined to be sufficiently active and well-defined to warrant zoning under the provisions of the Alquist-Priolo Earthquake Fault Zoning Act (1972). The closest recognized active fault is an approximately 1.5 mile segment of the Fickle Hill fault (central trace), located south of the subject property, which comes to within approximately 1800 feet of the subject property on its northwest end.

A thorough investigation into the surface fault rupture hazard of the northern trace of the Fickle Hill fault zone was conducted by Geomatrix (2008) at Humboldt State University's site of a Student Housing Facility. Their report presented the results of approximately 300 feet of exploratory trench and a geophysical survey which focused on the mapped location of the northern trace of the Fickle Hill fault zone where it crossed the site. Gently folded sediments of Late Pleistocene aged deposits and a step in Franciscan bedrock (at depth) were documented, though no evidence of Holocene surface fault rupture was observed. Geomatrix concluded that at this location, "the potential for surface fault rupture associated with the northern trace of the Fickle Hill fault zone beneath the site is extremely low."

We found no evidence in our current or previous investigations that a previously unrecognized active fault may be present. Marine terraces, in general, are low relief topographic surfaces that would be anticipated to clearly express fault morphology, if active faults were present. The age of the undeformed marine terrace surface on which the site is located, as described above, is sufficient to preclude Holocene fault activity. The risk of surface fault rupture at the project site is considered remote.

6.2 Seismic Ground Shaking

Based on the subsurface conditions encountered at our exploration locations, laboratory test results, and our interpretation of soil conditions within 100 feet of the ground surface, we classify the site as a Site Class D consisting of a "stiff soil profile" in accordance with Chapter 20 of ASCE 7-10. On this basis, the mapped and design spectral response accelerations were determined using the Structural Engineers Association of California (SEAOC) and California Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps (Accessed 10/11/2019) in conjunction with the site class and the site coordinates (40.88799° N, -124.08644° W). Calculated values for ASCE 7-10 are presented in Table 2.

Table 2. ASCE 7-10 Standard Seismic Design Parameters
ODCHC, Foster and Sunset Avenues, Arcata, CA

Parameter	Calculated Value
S_S	2.773
S_1	1.091
F_a	1.0
F_v	1.5
S_{MS}	2.773
S_{M1}	1.663
S_{DS}	1.849
S_{D1}	1.091
Risk Category	II
Seismic Design Category	E

6.3 Liquefaction

Liquefaction is described as the sudden loss of soil shear strength due to a rapid increase of soil pore water pressures caused by cyclic loading from a seismic event. In simple terms, it means that a liquefied soil acts more like a fluid than a solid when shaken during an earthquake. In order for liquefaction to occur, the following are needed:

- granular soils (sand, silty sand, sandy silt, and some gravels);
- a high groundwater table; and
- a low density of the granular soils (usually associated with young geologic age).

The adverse effects of liquefaction include local and regional ground settlement, ground cracking and expulsion of water and sand, the partial or complete loss of bearing and confining forces used to support loads, amplification of seismic shaking, and lateral spreading. Lateral spreading is defined as lateral earth movement of liquefied soils, or competent strata riding on a liquefied soil layer, downslope toward an unsupported slope face, such as a creek bank, or an inclined slope face.

Liquefaction has been documented on numerous occasions in the greater Humboldt Bay area following historic moderate to large magnitude earthquakes. Specific accounts of historic ground failures are presented in a compilation prepared by Youd and Hoose (1978). Careful interpretation of the historic accounts, however, indicates that liquefaction events in the area are entirely confined to recent alluvial sediments in the Eel River Valley and late Holocene age bay margin sediments surrounding Humboldt Bay. There are no historic accounts of liquefaction on the Arcata marine terraces, on which the proposed development is situated.

Geologic materials most susceptible to liquefaction are geologically recent (i.e., late Holocene age) sand- and silt-rich deposits, located adjacent to streams, rivers, bays, or ocean shorelines. It should be noted that these 'most susceptible' conditions do not exist at the subject site. Susceptibility to liquefaction decreases with increasing geologic age, according to Youd and Perkins (1978). For example, Table 2 in Youd and Perkins' paper presents estimated liquefaction susceptibility of Holocene marine terraces as low, and Pleistocene marine terraces as very low. The subject site is a late Pleistocene age marine terrace.

On City of Arcata hazard mapping (City of Arcata, 1998), the low-lying swale south of the site has been mapped within a moderate liquefaction hazard zone due to the likely presence of young unconsolidated sediments associated with Jolly Giant Creek. The proposed structures are located outside the influence of these sediments. The Planning Scenario for a great earthquake on the Cascadia Subduction Zone (CDMG, 1995) shows the site to be outside any areas of liquefaction potential. At the subject site, we encountered some isolated and discontinuous soils in our geotechnical borings that meet the textural criteria for potentially liquefiable soils, although their age does not. Site-specific liquefaction potential and the associated risk to the proposed development are discussed below in Section 7.2.

6.4 Slope Stability

As described above, the project area has been historically graded flat. A 10 to 15 foot fill slope is aligned along the southwestern edge of the property. The slope has a moderate gradient and is heavily vegetated with brush and young trees. A plan for proposed grading was not available at the time of this writing. Additional review of site conditions may be necessary during the development of the grading plan. We provide general site preparation and grading recommendations below. Provided our recommendations are adhered to, there appears to be a negligible hazard associated with the risk of slope instability related to the proposed improvements.

6.5 Flooding

The site is located at an elevation of approximately 58 feet above mean sea level. According to the FEMA panel 0600610004E (Arcata South), revised by FEMA November 5, 1997 the subject property is not located within an identified flood hazard area. Additionally, the site is not located in the area of potential inundation resulting from a catastrophic failure of Matthews Dam.

6.6 Tsunami Hazard

The site is outside the Tsunami Run-up Zone on both City of Arcata hazard mapping (City of Arcata, 1998), and in the Planning Scenario for a great earthquake on the Cascadia Subduction Zone (CDMG, 1995). It is mapped as a No Hazard zone on other tsunami risk mapping (Patton and Dengler, 2004).

7.0 Geotechnical Conditions

7.1 Foundation Bearing Soils

Within our borings and backhoe pits we observed up to 6 feet of fill within the location of the proposed structure. As discussed above, the fill materials contain variable amounts of soft compressible soils and layers of organic material. The fill soils are therefore not considered suitable for bearing structural loads. The native olive brown to yellowish brown sandy silt ([ML] and silty sand[SM]) beneath the fill materials and the original native topsoil is considered suitably firm/dense to support structural loads. We make recommendations for foundation design and construction below in Section 8.2.

7.2 Liquefaction, Co-Seismic Settlement, Lateral Spreading

The liquefaction potential was evaluated quantitatively in 2009 based on sampler penetration resistance (SPT N-values) in the machine drilled borings. Penetration resistance indicates the existing relative density of the underlying sand deposits, which is related to liquefaction potential. The quantitative liquefaction analysis was conducted using the software program LiqIT, version 4.7.6.1, by GeoLogismiki, Inc. The calculation method used is in accordance with the procedures that were developed by consensus of participants of the recent National Center for Earthquake Engineering Research workshops (NCEER, 1997; Youd et al, 2001). The potential for liquefaction is estimated by calculation of the estimated Cyclic Stress Ratio (CSR) induced by the upper-bound earthquake, compared with the capacity of the soil to resist liquefaction, expressed in terms of the Cyclic Resistance Ratio (CRR). The risk of liquefaction is considered significant where the ratio of CRR to CSR, or factor of safety, approaches a value of about 1.2 or less.

The factor of safety for liquefaction was calculated at less than 1.0 for the 3’, 18’, 23’ and 36’ test locations within BH-1 and all test locations within the upper 26 feet of BH-2. It should be noted that the percent fines (silt and clay) in the soil profile are used by the software to adjust penetration values, but the software does not make a determination as to its potential for liquefaction based on the grain size distribution. This additional screening is required by the investigator, as the variability of factors and site conditions cannot be effectively modeled for use in the software. Of the soils within the anticipated depths of seasonal saturation (below 10 feet) all but the deepest (below 22 feet in BH-1 and below 26 feet in BH-2) are considered too cohesive to be liquefiable. Laboratory testing of representative samples from this interval indicate these soils have between 80 and 100% fines. The sandy soils encountered below the cohesive soils are suitably dense that the potential for liquefaction in these deposits is considered low.

Co-seismic settlement may occur within loose, cohesionless soil deposits due to soil densification from dynamic loading. In other words, shaking or vibration can densify loose to moderately consolidated granular soils, resulting in settlement of the ground surface. The magnitude of potential co-seismic settlement was evaluated in both of the borehole locations using the software program LiqIT. The total estimated co-seismic settlement is calculated at approximately 1 and 2 inches for the borehole locations BH-1 and BH-2, respectively.

Liquefaction, co-seismic settlement and lateral spreading are considered negligible risks for earthquakes of small to moderate magnitude. In relatively rare, great earthquakes, for example those with a moment magnitude of 7.5 or greater, there may be risk of liquefaction, co-seismic settlement, and lateral spreading. Risk of damage to the proposed structures from these soil behaviors, should they occur, is considered likely to be within building code criteria for upper bound (rare, great) earthquakes.

7.3 Settlement under Static Conditions

The project site is underlain by up to 10 feet, or more, of undocumented fill. Within the footprints of the proposed structure we observed up to 6 feet of fill. The fill materials contain variable amounts of soft, unconsolidated soils and layers of concentrated organics that have the potential to compress under loaded conditions associated with additional fill placement and structural foundations. We provide site preparation and foundation design recommendations that are intended to minimize the settlement potential.

In our opinion, under normal static conditions, the risk of significant post-construction foundation settlement will be mitigated to a low level if the recommended site preparation is completed, and if the structures are supported on foundations designed and constructed as recommended below. Due to the variability of soil deposits and the inherent limitations of current engineering and construction practices, some post-construction vertical settlement may occur. We estimate that with the project constructed in accordance with the following recommendations, and less than two feet of fill to raise site grade, total post construction settlement is not likely to exceed ¾ inch, and post-construction differential settlement is not likely to exceed ½ inch.

7.4 Expansive Soils

No high plasticity, potentially expansive soils were observed or are anticipated. Laboratory test results did not indicate significant potential for expansive soils behavior. No high plasticity clayey soils were encountered or are generally anticipated in the geologic formation comprising the site. Risk of adverse consequences to the structure from expansive soils is considered low. Recommendations are provided for geotechnical engineering review of the foundation excavations prior to pouring the foundations, and at this time the anticipated absence of high-plasticity, potentially expansive soils can be confirmed.

8.0 Conclusions and Recommendations

Based on the results of our current and previous field and laboratory investigations, it is our opinion that the project is feasible from a geotechnical standpoint, provided that our recommendations are implemented during design and construction, and that noted conditions and risks are acknowledged. The primary geotechnical site considerations for the proposed project is the presence of undocumented fills and the potential for settlement of structures founded on these or other unsuitable soils. The risk of adverse affects to the proposed structure due to liquefaction is low for earthquake events such as those that have occurred within the last 150 years.

In our opinion, the risk of significant post-construction static consolidation settlement is low, provided that the recommendations for site preparation and foundation support are followed. Due to the variability of soils deposits and the inherent limitations of current engineering and construction practices, some post-construction vertical consolidation settlement is likely to occur. We estimate that with the project constructed in accordance with the following recommendations, total post construction settlement is not likely to exceed ¾-inch, and post-construction differential settlement is not likely to exceed ½-inch within a distance of 30 feet under static conditions.

The site is likely to experience strong seismic ground shaking resulting from earthquakes on active faults in the region during the design life of the proposed structure. The intensity of ground shaking from earthquakes will depend on several factors, including the distance from the site to the earthquake focus, the magnitude and duration of the earthquake, and the response of the underlying soil and bedrock. At a minimum, it will be necessary to design and construct the proposed health center structure in accordance with the earthquake-resistant provisions of the governing code.

8.1 Site Preparation and Grading

As appropriate, notify Underground Service Alert prior to commencing site work, and use this location service and other methods to avoid injury or risk to life, and to avoid damaging underground and/or overhead utilities.

The following earthwork recommendations assume the work described herein will be completed during dry season conditions. Additional construction costs are likely to be incurred if the owner or their contractor chooses to conduct the work during or immediately following the wet season. If grading commences in the winter or spring, or after a period of excessive rainfall, the surficial soils will become saturated due to the presence of fine-grained material. Wet or saturated soil may cause difficulties in access with grading and trenching equipment and difficulties in loading, spreading, and compaction of fill material. An all-weather access road surfaced with 12 to 18 inches of 4-to-6-inch stabilization rock over a layer of heavy duty woven stabilization fabric (Mirafi® 600X or equivalent) for heavy construction equipment traffic should be constructed prior to the start of wet-weather work.

The contractor should be made aware that earthwork that is partially completed prior to the rainy season, but not fully completed, may need to be re-done and re-tested to achieve the compaction requirements specified in this report. Aerating of exposed subgrades in areas requiring over-excavation and replacement with engineered fill will likely be required.

The existing ground surface should be prepared in areas to receive fill and improvements. Site preparation includes stripping of vegetation and debris on the ground surface and removal of other unsuitable material. Where the removal of large trees is required, it will be necessary to remove all major root systems, then fill the excavations with properly placed engineered fill compacted to at least 90 percent relative compaction1.

The areas to contain the proposed building, and for a horizontal distance of at least 5 feet beyond, should be over-excavated to a minimum depth of 4 feet below proposed subgrade elevation for standard spread footing foundations. This will allow for the removal of a major portion of the non-engineered fill and underlying topsoil and organic rich soils with debris. The intent of these recommendations is to provide uniform foundation support with a minimum 4-foot layer of geogrid-reinforced engineered fill below proposed subgrade elevation for spread footing foundations.

If groundwater seeps or wet areas are present on the excavated subgrade surface, contact the geotechnical engineer. Additional mitigation recommendations may be applicable.

The overexcavated subgrade should be scarified to a depth of 6 inches, moisture conditioned or aerated and recompacted to 90 percent relative compaction. The Geotechnical Engineer or qualified representative

[1] Relative compaction refers to the in-place dry density of a soil expressed as a percentage of the maximum dry density of the same soil, as determined by the ASTM D1557-12 Test Method. Optimum moisture content is the water content (percentage by dry weight) corresponding to the maximum dry density.

should observe and approve the overexcavation, and prior to subgrade preparation and placement of fill or improvements. Following recompaction of the overexcavated subgrade, we recommend that a layer of geogrid (TenCate Mirafi® BXG120 or equivalent) be placed on the exposed subgrade prior to backfilling the overexcavated area with engineered fill. A second layer of geogrid should be placed at the midpoint of the 4 feet of replaced engineered fill. We, therefore, anticipate that approximately 4 feet of engineered fill, with 2 layers of geogrid, will be placed below the proposed building footprint. The placement of a geogrid–reinforced engineered-fill mat below the proposed structures is intended to minimize the estimated differential settlements caused by any settlement of the remaining unengineered fills, and the underlying topsoil and organic rich soils with debris.

Subsurface conditions in the southwestern corner of the site, which contain wetlands, were not investigated. We anticipate that soft compressible organic-rich silts may be encountered below the proposed daylight basement that will not have adequate support capacity. Therefore, the area to contain the proposed daylight basement, and a horizontal distance of at least 3 feet, should be over-excavated to a minimum depth of 2 feet below proposed subgrade elevation for the proposed mat foundation. The overexcavated subgrade should be scarified to a depth of 6 inches, moisture-conditioned or aerated and recompacted to 90 percent relative compaction. Following recompaction of the overexcavated subgrade, place 2 feet of engineered fill properly compacted to 90 percent relative compaction. Revised recommendations may be required in the field based on exposed subsurface conditions, i.e. the use of stabilization material over the exposed overexcavation subgrade.

The Geotechnical Engineer or qualified representative should check the subgrade surfaces exposed by over-excavation to determine if additional over-excavation is necessary to remove soft, wet, yielding, or otherwise unsuitable material. Proofrolling of the excavated surface may be employed to evaluate the suitability of the exposed ground. Approved excavated surfaces to support pavements should be scarified to a depth of 6 inches, moisture conditioned close to the optimum value, and compacted to at least 95 percent relative compaction.

8.2 Temporary Excavations

Temporary unbraced construction excavations should be made no steeper than 1.5H:1V (horizontal to vertical). This recommendation is applicable where construction loads are at least two times the excavation depth away and a minimum of 5 feet from the excavation.

Groundwater can be expected to be encountered at depths as shallow as about 5 feet, depending on the time of the year. Consideration should be given to performing the overexcavation during the summer or early fall months.

Excavated slopes encountering groundwater seepage into the excavation should be examined immediately by the Geotechnical Engineer or qualified representative to determine whether the slope should be flattened.

The top of unbraced excavations should not be subject to surcharge loads such as construction traffic, stockpiled building materials, or excavation spoils.

The contractor shall be responsible for the stability of all temporary excavations and should comply with applicable Occupational Safety and Health Administration (OSHA) regulations (California Construction Safety Orders, Title 8). All open excavations should be regularly monitored for evidence of incipient instability.

8.3 Engineered Fill

Fill placed in areas to support proposed foundations should meet the requirements for select engineered fill. Engineered fill should have less than 2 percent by dry weight of vegetation and deleterious material and should meet the gradation requirements presented in Table 3 below. In general, the upper gravel and cobble fill is suitable for reuse as select engineered fill. The underlying topsoil and organic rich silt and clay containing debris are not suitable for reuse as select engineered fill and should be removed from the site or stockpiled for use in non-structural areas. This may require importing replacement select engineered fill within the building pad area.

Table 3. Fill Gradation Criteria ODCHC, Arcata, California

Sieve Designation	Percent Passing by Dry Weight
3-inch (50 mm)[1]	100
1½-inch (37.5 mm)	90 minimum
¾-inch (19 mm)	70 minimum
No. 4 (4.75 mm)	60 minimum
No. 200 (75 µm)[2]	5 minimum; 30 maximum
1. mm: millimeters 2. µm: micrometers	

Fine-grained soil with a liquid limit greater than 40 and a plasticity index greater than 15 should not be used as engineered fill. If clayey soils do not meet the plasticity requirements, mixing of the clayey soils with sandier soils may be required. Crushing and/or removal of rock particles greater than 3 inches in size will be required.

All imported fill materials should be observed, tested, and approved by SHN prior to transportation to the site. Engineered fill should be placed in loose lifts not exceeding 8 inches in thickness and compacted to a minimum of 90 percent relative compaction. The Geotechnical Engineer should approve all fill prior to placement.

As required by the CBC, a qualified field technician should be present to observe fill placement and perform field density tests in accordance with ASTM D 6938 at random locations throughout each lift to verify the specified compaction is being achieved.

8.4 Surface Drainage Control

Surface drainage should be planned to prevent ponding and enable water to drain away from foundations, slabs-on-grade, and edges of pavements toward suitable collection or discharge facilities.
A positive surface drainage of at least 4 percent is recommended within 10 feet of all building foundations in landscaped areas.

Pavements and sidewalks should be designed with minimum gradients of about 2 percent in their principal direction of drainage, unless drainage reaches are short or specifically designed for flatter gradients.
Roof drainage systems should be planned to direct rainwater away from building foundations and into the sites and/or City of Arcata storm drain system.

8.5 Foundations

8.5.1 Spread Footing Foundation

Foundation support for the new building can be achieved with a standard spread footing foundation founded in a 4-foot layer of properly compacted geogrid-reinforced engineered fill placed on a prepared subgrade in accordance with the recommendations in Sections 8.1 and 8.3.

All footings should be founded at least 18 inches below the lowest adjacent finished grade. Footings meeting the foregoing requirements may be designed for the following bearing pressures:

Dead plus long-term live load	2,500 psf (pounds per square foot)
All loads, including wind and seismic	3,325 psf

SHN should check foundation subgrades before reinforcing steel and concrete is placed. Exposed soil that becomes disturbed may require compaction or removal/replacement.

Any new footing excavations or slab-on-ground subgrade should be maintained in a wetted condition prior to pouring concrete to avoid soil shrinkage.

Provided any new foundations are constructed in accordance with these recommendations, we estimate that total post-construction settlement will be ¾ inch or less under static conditions; and post-construction differential settlement should be less than ½ inch.

8.5.2 Basement Foundation

We recommend that the basement be supported on a reinforced mat slab foundation bearing on the underlying firm native soil or properly compacted engineered fill. The mat foundation may be designed using an allowable bearing capacity of 1,500 psf for dead plus long-term live loads. This allowable bearing capacity may be increased by one-third for total load conditions, including wind and seismic.

For mat design, we recommend using the following equation to estimate the subgrade modulus:

$$K_s = k_1 \left\{ \frac{(B+1)}{2B} \right\}^2$$

where:
k_1 = coefficient of subgrade reaction for 1 foot square plate = 200 pci (pounds per cubic inch)
B = width beneath column or bearing wall, in feet, where stresses are imposed on ground

The value of B and the corresponding K_s value should be consistent with the calculated deflected shape of the foundation beneath columns and bearing walls.

The mat foundation should be reinforced with grids of reinforcing steel bars. The project structural engineer should determine actual mat reinforcing based on anticipated loading and the design criteria presented in this report.

We recommend that the basement mat foundation be provided with a subdrain system integrally designed with the basement retaining wall drainage. We recommend that the mat slab be underlain by a minimum of

8 inches of ½- to ¾-inch clean crushed rock underlain by filter fabric. To facilitate drainage below the slab, the subgrade soil beneath the mat should be sloped at an inclination of 1.5 percent to a perimeter trench where the retaining wall drainage pipe will be located.

We recommend that the bottom of the mat foundation be waterproofed and that the waterproofing be designed and constructed by qualified professionals.

In planning the location for any temporary basement access ramp, the contractor should consider the future location of any at-grade structures or hardscape. If possible, we recommend that the ramp excavation be kept approximately 5 feet away from proposed at-grade structures and hardscape. If placement of the ramp within this zone is unavoidable, it is imperative that the backfilled soils be compacted in accordance with the specifications outlined in Sections 8.1 and 8.3 of this report. A representative from SHN should observe and test the compaction of the ramp backfill. In addition, we recommend that a note be included on the structural plans referencing these recommendations.

8.5.3 Lateral Resistance

Base friction resistance may be calculated using a friction coefficient of 0.35 (ultimate value for concrete on soil). The ultimate friction coefficient may be as low as 0.15 if waterproofing is used, depending on the waterproofing. Passive resistance may be calculated using an equivalent fluid unit weight of 250 pounds per cubic foot (pcf). This value is reduced by a factor of 1.5 from the ultimate value to limit movement required to mobilize ultimate passive pressure. Both the ultimate base friction and allowable passive pressure may be combined in calculating total lateral resistance.

The passive resistance contributed by fill material within 1 foot of the ground surface should be neglected unless these materials are protected and confined by a slab-on-grade or pavement.

The foundations should be cast neat against the engineered fill to develop the design passive resistance. Alternatively, any gap between the footing and the adjacent ground should be completely backfilled using lean concrete.

8.6 Utility Trench Backfill

New utility trenches excavated parallel to foundations should be set back from the footings such that the trench bottoms lie above a projected hypothetical 1.5:1 H:V line extending downward from the foundation bottom.

Unless concrete bedding is required around utilities, bedding should consist of sand having a sand equivalent (SE) of at least 30. The bedding should extend from 6 inches below to 1 foot above the conduit or pipe. Sand bedding should not be jetted or ponded into place and should be mechanically compacted to a minimum of 90 percent relative compaction.

In areas to support improvements such as slabs and pavements adjacent to structure foundations, backfill placed above the bedding in utility trenches (including culvert and sprinkler lines) should be properly placed and adequately compacted to minimize settlement and provide a stable subgrade. If possible, the trench backfill should be compacted following rough grading but prior to final grading and compaction. Onsite inorganic soils meeting the requirements for engineered fill may be used as trench backfill. Backfill consisting of onsite soils should be placed in layers not exceeding 8 inches in loose thickness, moisture-conditioned, and compacted to at least 90 percent relative compaction as described for engineered fill.

Trench backfill needs to be compacted to 85 percent relative compaction in landscape areas or in areas more than 5 feet beyond the limits of buildings, pavements, concrete slabs-on-grade, sidewalks, or other flatwork. The upper 6 inches of trench backfill under pavements should be surface compacted to at least 95 percent relative compaction.

Where utility trenches cross underneath buildings, we recommend that a plug be placed within the trench backfill to minimize the normally granular backfill from acting as a conduit for water to enter beneath the building. The plug should be constructed using a sand cement slurry (minimum 28-day compressive strength of 500 pounds per square inch [psi]) or relatively impermeable native soil for pipe bedding or backfill. We recommend the plug extend a distance of at least 3 feet in each direction from the point where the utility enters the building perimeter.

8.7 Slabs-on-Grade

Concrete slabs-on-grade should be supported by engineered fill prepared in accordance with our recommendations for earthwork.

To reduce water vapor transmission upward through floor slabs, concrete slabs-on-grade should be constructed on a minimum 4-inch thick layer of capillary break material covered with a vapor retarder. The capillary break material should be free-draining, clean gravel or rock, such as No. 4 by ¾-inch pea gravel or permeable aggregate complying with Caltrans Standard Specification, Section 68, Class 1, Type B Permeable Material. The vapor retarder should be at least 10 mil in thickness and meet the material requirements for Class C vapor retarders presented in ASTM E1745, and should be installed according to ASTM E1643. These installation requirements include overlapping seams by 6 inches, taping seams, and sealing penetrations in the vapor retarder.

The field of moisture vapor transmission is a specialty field and we suggest that qualified experts be contacted to assist in the design and construction of measures related to moisture transmission through slabs-on-grade.

The American Concrete Institute (ACI) Committee document “Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials” (ACI 302.2R-06) provides guidelines for reducing moisture migration through slabs-on-grade. This document advises that concrete slabs be cast directly on the vapor retarder (ACI 302.2R-06, Section 9.3) and provides guidelines for selecting vapor permeance, tensile strength, and puncture resistance. When casting the slab directly on the vapor retarder, a reduced joint spacing, low shrinkage mix design, or other appropriate measures should be used to control slab curl. The ACI guide also notes that a maximum water-cement ratio of 0.5 has yielded satisfactory performance on many slab-on-grade projects. Water-reducing admixtures may be useful in achieving workability at low water-cement ratios. Control joints should be provided at appropriate intervals to control the location of shrinkage cracks. After proper curing, the slab should be allowed to dry and then should be tested to check that the moisture transmission rate is appropriate for the intended floor covering.

For exterior flatwork and other slabs-on-grade where water vapor transmission through slabs is not a concern, the vapor barrier and capillary break material described in this section may be omitted. However, a minimum of 4 inches of Class 2 Aggregate Base rock, compacted to a minimum of 90 percent relative compaction, should be provided beneath exterior flatwork and other slabs-on-grade where vapor transmission is not a concern.

It is important that the subgrade be moist and free of desiccation cracks at the time the slab is cast. Recommendations for slab reinforcement, strength, thickness, control and construction joints, etc., should be provided by others. Although cracks in concrete slabs are common and should be expected, the following measures may help to reduce cracking of slabs.

- Slabs should be cast using concrete with a maximum slump of 4 inches or less.
- Add a water-reducing agent or plasticizer to the concrete to increase slump while maintaining a low water-cement ratio to reduce concrete shrinkage. (Concrete having a high water-cement ratio is a major cause of concrete cracking.)

Control joints should be provided at appropriate intervals to control the location of shrinkage cracks.

8.8 Retaining Walls

Retaining walls should be designed to resist static earth pressures, seismic earth pressures, and surcharge pressures. Retaining wall backfill should be placed and compacted according to the recommendations above in Sections 8.1 and 8.3 of this report, and drainage should be provided behind walls according to the recommendations that follow. Retaining wall foundations should be designed according to the recommendations above in Section 8.5.1 of this report.

Active earth pressures may be used for design of unrestrained retaining walls where the top of the wall is free to translate or rotate. To develop active earth pressures, the walls should be capable of deflecting by at least 0.004H (where H is the height of the wall). At-rest earth pressures should be used for design of retaining walls where the wall top is restrained such that the deflections required to develop active soil pressures cannot occur or are undesirable. Cantilever walls retaining firm native soil or engineered fill may be designed for active or at-rest lateral earth pressures for various backfill slopes using the equivalent fluid unit weights presented in Table 4, Equivalent Fluid Unit Weight (pcf).

Table 4. Equivalent Fluid Unit Weight (pcf)

Backfill Slope	At-Rest Conditions	Active Conditions
Level	62	36
3H:1V	81	46
2H:1V	89	55

Lateral earth pressures for backfill slopes other than those given above can be estimated by interpolation. The lateral earth pressures should be applied to a plane extending vertically upward from the base of the heel of the retaining wall to the ground surface.

The lateral earth pressures given above apply where the wall backfill is fully drained, is not subject to traffic or other surcharge loads, and the backfill is not subject to heavy compaction equipment within a distance of one-third the height of the backfill. Lateral surcharge pressures are discussed later in this section.

If retaining wall backfill will be subject to passenger vehicle or light truck traffic loading within a distance of H/2 from the top of the wall (where H is the wall height), the wall should be designed to resist an additional uniform lateral pressure of 72 psf applied to the back of yielding walls (active conditions), or 124 psf applied to the back of non-yielding walls (at-rest conditions). Surcharge loads imposed by greater loads or unusual loads within a distance of H of the back of the wall should be considered on a case-by-case basis.

Surcharge loads on retaining walls resulting from proposed adjacent building foundations parallel to the proposed retaining wall can be approximated by the following expression:

$$\Delta p_h = (4p/\pi)(x^2z/R^4)$$

Where:
Δp_h = the lateral stress on the wall at depth z
p = magnitude of the footing load (lbs/ft)
x = centerline distance from the footing load to the wall
z = depth below surface
$R^4 = x^4 + z^4$ = the radius from the location on the wall where Δp is, measured to the footing load on the surface)

Surcharge loads imposed by greater loads or unusual loads within a distance of H of the back of the wall should be considered on a case-by-case basis.

In addition to the active or at-rest lateral soil pressures, retaining walls should be designed to resist additional dynamic earth pressures during earthquake loading. The additional dynamic pressure increment may be calculated using an additional equivalent fluid pressure of 13 pcf for back slopes up to 3H:1V. The dynamic pressure increment should be applied to the wall as a triangular distribution so the resultant force acts at a distance of 0.33H above the base of the wall (where H is the height of the wall). Under the combined effects of static and dynamic loading, a safety factor of 1.1 against sliding or overturning is acceptable. The dynamic component of the lateral earth pressure was calculated using the Mononabe-Okabe equation and, therefore, assumes that sufficient deformation of the wall will occur during seismic loading to develop active soil conditions. For walls that are restrained at the top, the walls should be designed using the most critical condition, either at-rest lateral pressure or the combined effects of static active and seismic loading.

A drainage system should be constructed on the backside of all retaining walls. The drainage system for backfilled walls should consist of a 4-inch diameter perforated pipe surrounded by Class 2 permeable material complying with Section 68 of the Caltrans Standard Specifications, latest edition. Alternatively, the perforated pipe may be surrounded by clean coarse gravel or drain rock, provided the gravel or rock is completely separated from the surrounding soil by an engineering filter fabric (such as, Mirafi® 140N or similar fabric). The section of permeable material should be at least 12 inches wide and should extend up the back of the wall to within about 18 inches of finished grade. The drainage material should be capped with compacted fine-grained soil, soil-cement, or other relatively impermeable material or barrier. The pipe should be polyvinyl chloride (PVC) Schedule 40 or acrylonitrile butadiene styrene (ABS) with a standard dimension ratio (SDR) of 35 or better. Perforations in the drainpipe should be ¼ inch in diameter. The perforated pipe should be placed holes-down near the bottom of the section of permeable material and should discharge by gravity to a suitable outlet. Accessible subdrain cleanouts should be provided and maintained on a regular basis.

Waterproofing or damp-proofing of retaining walls should be included in areas where wall moisture would be undesirable (such as, living space or where wall finishes could be impacted by moisture). The project architect or a waterproofing consultant should provide detailed recommendations for waterproofing or damp proofing, as necessary. As noted above, the basement mat slab waterproofing should be designed and constructed to be integral with the basement wall waterproofing.

8.9 Pavements

The existing gravel and cobble fill within at least the upper 1 ½ to 2 feet as encountered in the borings and test pits appears to have adequate density and strength to support anticipated traffic loading for either flexible or rigid pavement systems. Therefore, if site grade is to be raised in pavement areas, we don't anticipate that over-excavating the gravel and cobble fill will be required. However, the underlying organic topsoil and fill do not have this support capacity. If site grade is to be lowered, for all pavement areas, we recommend a subgrade thickness that consists of at least two feet of properly compacted engineered fill. Regardless of site grade, there may be some risk of long-term degradation of the ground surface, especially where flexible pavements are located. This risk can be reduced by providing at least two feet of properly compacted engineered fill (including the gravel and cobble fill) within all pavement areas.

Pavement construction should conform to the requirements of the Caltrans Standard Specifications, latest edition. Recommendations for both asphalt concrete and Portland cement concrete pavements are given in this section.

Recommended minimum pavement sections for standard flexible asphalt concrete are given below in Table 5 for several traffic loading conditions. These values are based on the R-Value of 14 for silt with sand and may be used for preliminary design purposes. Pavement sections for other traffic loading should be designed on a case-by-case basis.

Table 5. Recommended Pavement Sections, Standard Flexible Asphalt Concrete Pavement ODCHC, Foster and Sunset Avenues, Arcata, California

Traffic Index	Asphalt Concrete Thickness (feet)	Class 2 Aggregate Base Thickness (feet)
4 and below	0.20	0.55
5	0.20	0.80
6	0.25	1.00

Crushed aggregate base should consist of ¾-inch maximum-sized aggregate. The coarse aggregate portion (the portion retained on the US Standard #4 sieve) must have a minimum of 50 percent by weight of particles with at least two fractured faces, as determined by California Test 205. Additionally, the material shall meet the aggregate gradation and quality characteristics of Class 2 Aggregate Base specified in Section 26-1.02B of the California Department of Transportation's Standard Specifications (Current Edition) and should be compacted to at least 95 percent relative compaction.

We recommend that exterior concrete pavements consist of at least 6 inches of aggregate baserock beneath at least 6 inches of concrete. For durability and wear resistance, all Portland cement concrete pavements should have a minimum compressive strength of 4,000 pounds per square inch (psi). A modulus of subgrade reaction, k_v (30-inch circular plate) of 150 psi may be used for design of Portland cement concrete pavements.

Paved areas should be sloped and adequately drained to prevent surface water or subsurface seepage from saturating the pavement subgrade soil. All curbs surrounding landscape areas should be embedded at least 6 inches into the soil subgrade to minimize the migration of water beneath pavements

9.0 Additional Services

We suggest communications be maintained during the design phase between the design team and SHN to optimize compatibility between the design and soil conditions. We also recommend that SHN be retained during the construction phase to verify the implementation of our recommendations related to earthwork.

9.1 Plan and Specification Review

We have assumed, in preparing our recommendations, that SHN will be retained to review those portions of the plans and specifications that pertain to earthwork and foundations, if prepared by others. The purpose of this review is to confirm that our earthwork and foundation recommendations have been properly interpreted and implemented during design. If we are not provided this opportunity for review of the plans and specifications, our recommendations could be misinterpreted.

9.2 Construction-Phase Monitoring

In order to assess construction conformance with the intent of our recommendations, it is important that a representative of SHN perform the following tasks:

1. Monitor site stripping, including removal of the undocumented fill material and debris, and any other unsuitable material if it is determined this is required.
2. Monitor subgrade preparation.
3. Observe and test placement of structural fill and backfill.
4. Observe foundation excavations.
5. Observe placement and compaction of subgrade and aggregate base in asphalt-paved areas.

This construction-phase monitoring is important, because it provides the stakeholders and SHN the opportunity to verify anticipated site conditions and recommend appropriate changes in design or construction procedures if site conditions encountered during construction vary from those described in this report. It also allows SHN to recommend appropriate changes in design or construction procedures if construction methods adversely affect the competence of onsite soils to support the structural improvements.

10.0 Limitations

The geotechnical conclusions and recommendations presented in this report are intended for planning and design of the new building and related improvements at the project site as described in this report. These conclusions and recommendations may not apply if:

- changes are made to the proposed construction,
- the report is used for a different site,
- the recommendations given in this report are not followed, or
- any other change is made that materially alters the proposed project.

The analyses and recommendations presented in this report are based upon interpretation of data obtained from the exploration locations located approximately, as shown on Figure 2 and on general field observations made during the site investigation. Subsurface exploration of any site is necessarily confined to selected locations and subsurface conditions may, and usually do, vary between and around these locations. Any person associated with this project who observes conditions or features of the site or its surrounding areas that are different from those described in the report should report them immediately to SHN for evaluation. If varied conditions come to light during project development, SHN should be given the opportunity to evaluate the need for additional exploration, testing, or analysis.

The geotechnical recommendations and design criteria given in this report are sensitive to the location, design details, and any special requirements of the new construction. For this reason, we recommend SHN be given the opportunity to review the geotechnical elements of project grading, foundation plans, and specifications to check that the intent of our recommendations have been incorporated into these project documents. If SHN does not review the geotechnical elements of the plans and specifications, the reviewing geotechnical engineer should thoroughly review this report and should agree with its conclusions and recommendations or otherwise provide alternative recommendations. Furthermore, if another geotechnical consultant is retained for follow-up service to this report, SHN will at that time cease to be the Geotechnical Engineer-of-Record. SHN cannot assume responsibility or liability for the adequacy of our geotechnical recommendations unless SHN is retained to observe the soil-related portions of the construction.

This report was prepared in accordance with the generally accepted standards of geotechnical engineering practice in Humboldt County at the time this report was written. No other warranty, express or implied, is made. It is the owner's responsibility to see that all parties to the project, including the designers, contractors, and subcontractors, are made aware of this report in its entirety.

It should be noted that changes in the standards of practice in the field of geotechnical engineering, changes in site conditions (such as new excavations or fills, new agency regulations, or modifications to the proposed project) are grounds for this report to be professionally reviewed. In light of this, there is a practical limit to the usefulness of this report without critical professional review. It is suggested that two years be considered a reasonable time for the usefulness of this report.

11.0 References

American Society of Civil Engineers. (2010). "ASCE 7-10: Minimum Design Loads for Buildings and Other Structures." Reston, VA:ASCE.

California Building Standards Commission. (July 1, 2016). 2016 California Building Standards Code (Cal. Code Regs., Title 24). Based on International Building Code (2015) by the International Code Council. Sacramento, CA: California Building Standards Commission.

California Division of Mines and Geology (1995). "Planning Scenario in Humboldt and Del Norte Counties, California, for a Great Earthquake on the Cascadia Subduction Zone", California Division of Mines and Geology, Special Publication 115, Sacramento, California.

City of Arcata (1998). Figure PS-a, Arcata General Plan 2020, Hazards Map. City of Arcata, California.

Carver, G.A. (1987). Late Cenozoic Tectonics of The Eel River Basin Region, Coastal Northern California, in Schymiczek, H. and Suchsland, R. (Eds): Tectonics, Sedimentation and Evolution of the Eel River and Associated Coastal Basins of Northern California. pp. 61-72. Bakersfield: San Joaquin Geological Society.

Carver, B. A., and R. M. Burke. (1992). Late Cenozoic deformation on the Cascadia Subduction Zone in the region of the Mendocino Triple Junction. Prepared by Humboldt State University, Department of Geology, Arcata, California.

Carver, G.A., Stephens, T.A., and Young, J.C. (1985). "Quaternary Geology of a portion of the Arcata South 7.5' Quadrangle," California Division of Mines and Geology open file report.

Clarke, S.H., Jr. (1992). Geology of the Eel River Basin and Adjacent Region: Implications for Late Cenozoic Tectonics of the Southern Cascadia Subduction Zone and Mendocino Triple Junction: AAPG Bulletin, v. 76, no. 2, p. 199-224.

Dengler, L., R. McPherson, and G.A. Carver. (1992). "Historic Seismicity and Potential Source Areas of Large Earthquakes in North Coast California," *1992 Friends of the Pleistocene Guidebook, Pacific Cell*, p. 112-118. NR: Friends of the Pleistocene.

Geomatrix (2008). "Assessment of the Potential for Surface Fault Rupture, Proposed Student Housing Facility, Humboldt State University, Arcata, California," an unpublished consultant report for Humboldt State University, dated February 2008.

Kelley, F.R. (1984). "Geology and Geomorphic Features Related to Landsliding, Arcata North 7.5" Quadrangle, Humboldt County, California." NR: CDMG Open File Report 84-39 SF.

Kramer, S. L. (1996) Geotechnical Earthquake Engineering, Prentice-Hall international series in civil engineering and engineering mechanics, Prentice Hall, Upper Saddle River, N.J.

McLaughlin, R.J., et al. (2000). "Geology of the Cape Mendocino, Eureka, Garberville, and Southwestern Part of the Hayfork 30 x 60 Minute Quadrangles and Adjacent Offshore Area, Northern California," *U.S. Geological Survey Miscellaneous Field Studies MF-2336*. NR: USGS.

NCEER, December, 1997. *Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils,* Edited by Youd, T.L. and Idriss, I.M., National Center for Earthquake Engineering Research, Buffalo, NY.

Patton, J. R. , Dengler, L. (2004). Tsunami Safety Map. Humboldt Earthquake Education Center, Humboldt State University, Arcata, California (Later Versions Marked Draft, Not for Distribution or Planning).

SHN. (2009). *Geologic Hazard and Geotechnical Investigation Report, Arcata Volunteer Fire Department, Proposed Sunset Avenue Fire Station, Arcata, CA*. Eureka, CA:SHN.

Structural Engineers Association of California [SEAOC]. (Accessed October 2019). "Seismic Design Maps." NR:SEAOC. Accessed at: https://seismicmaps.org

U.S. Geological Survey and California Geological Society, 2006, Quaternary fault and fold database for the United States, accessed July 15, 2009, from USGS web site: http//earthquakes.usgs.gov/regional/qfaults/

Youd, T.L. and Idriss, I.M., Andrus, R.D., Arango, I., Castro, G., Christian, J.T., Dobry, R., Finn, W.D., Harder, L.F. Jr., Hynes, M.E., Ishihara, K., Koester, J.P., Liao, S.S.C., Marcuson, W.F. III, Martin, G.R., Mitchell, J.K., Moriwaki, Y., Power, M.S., Robertson, P.K., Seed, R.B., Stokoe, K.H. II (2001), Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, October 2001.

Youd, T.L., and Perkins (1978). "Mapping Liquefaction-Induced Ground Failure Potential", American Society of Civil Engineers, Journal of the Geotechnical Engineering Division, Volume 104, No. GT4, April, 1978

Youd, T.L. and S.N. Hoose. (1978). *Geological Survey Professional Paper Number 993: Historic Ground Failures in Northern California Triggered by Earthquakes*. Washington, D.C.: United States Government Printing Office.

Test Pit Logs 2019 **1**

PROJECT: Arcata Open Door
LOCATION: Arcata
GROUND SURFACE ELEVATION: ~55 Feet
EXCAVATION METHOD: Mini Excavator
LOGGED BY: AC

JOB NUMBER: 018011.200
DATE DRILLED: 9/11/19
TOTAL DEPTH OF TEST PIT: 11.5 Feet BGS
SAMPLER TYPE: Hand-driven tube

TEST PIT NUMBER TP-101

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	U.C. (psf) by P.P.	% Passing 200	Atterberg: Liquid Limit	Atterberg: Plastic Index	REMARKS
0.0			ML		SANDY SILT with GRAVEL; Brown, medium stiff, dry, concrete chunks, scrap metal, wood fragments, roots, plants (FILL).							FILL
-1.0			GP		POORLY GRADED GRAVEL with SAND; Brown, dense, dry, subrounded clasts to 4 inch maximum diameter, 60% coarse gravel, cobbles (FILL).							
-2.0			ML		SANDY SILT with GRAVEL; Brown, medium stiff, damp, subrounded gravel to 2 inch maximum diameter, 30% gravel (FILL).							
-3.0			ML/ CL		SANDY SILT with GRAVEL; Dark brown, and LEAN CLAY with SAND; Bluish-gray and yellowish-brown, medium stiff/ medium dense, moist, wood fragments (FILL).							
-5.0			SP-SM		POORLY GRADED SAND with SILT; Greenish-gray, loose to medium dense, moist, fine sand.							NATIVE
-5.5 to -6.0		X				14.2	109					5 blows/ 6 inches.
-7.0 to -7.5		X				15.1	109					5 blows/ 6 inches.
-8.0			GW-GC		WELL-GRADED GRAVEL with CLAY AND SAND; Brown to reddish-brown, medium dense, moist, subrounded gravel to 1.5 inch maximum diameter, 50% gravel, fine to coarse sand.							
-9.0 to -9.5		X	CL		SANDY LEAN CLAY; Light reddish-brown and yellowish-brown, medium stiff, saturated, fine to coarse sand. Becomes less sandy, stiff.							14 blows/ 6 inches.
-11.0 to -11.5	X											
-11.5					Excavation terminated at a depth of 11.5 feet. Groundwater not encountered. Test pit backfilled with excavated spoils.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

LOG OF TEST PIT

PROJECT: Arcata Open Door
LOCATION: Arcata
GROUND SURFACE ELEVATION: ~ 58 Feet
EXCAVATION METHOD: Mini Excavator
LOGGED BY: AC

JOB NUMBER: 018011.200
DATE DRILLED: 9/11/19
TOTAL DEPTH OF TEST PIT: 11.0 Feet BGS
SAMPLER TYPE: Hand-driven tube

TEST PIT NUMBER
TP-102

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	U.C. (psf) by P.P.	% Passing 200	Atterberg Liquid Limit	Atterberg Plastic Index	REMARKS
0.0					ROOTS							FILL
-1.0			ML		SANDY SILT with GRAVEL: Brown, medium stiff, damp to dry, rounded gravel to 3 inches maximum diameter, 20% gravel (FILL).							
-2.0		X	SC		CLAYEY SAND; Yellowish-brown, medium dense, damp, occasional coarse sand and fine rounded gravel. Becomes mottled yellowish brown and brownish gray.	16.1	100					NATIVE 14 blows/ 6 inches.
-4.0		X			Becomes fine sand, (CLAYEY SAND TO POORLY GRADED SAND with CLAY; Gray and yellowish-brown, medium dense to dense, damp), no coarse sand or gravel.	11.9	109					20 blows/ 6 inches.
-6.0		X			Becomes gravelly, 1 inch maximum diameter rounded gravel, 30% gravel.							20 blows/ 6 inches.
-7.5			CL		GRAVELLY LEAN CLAY with SAND; Reddish-brown and olive gray (mottled), stiff, damp, 30% gravel, leisegeng banding. reduction in gravel							
-8.0	X											
-8.5			ML		SILT; Olive gray and reddish-brown (mottled), stiff, damp to moist.							
-9.0	X											
-11.0					Excavation terminated at a depth of 11 feet. Groundwater not encountered. Test pit backfilled with excavated spoils.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location Subsurface conditions may differ at other locations and with the passage of time

LOG OF TEST PIT

PROJECT: Arcata Open Door
LOCATION: Arcata
GROUND SURFACE ELEVATION: ~60 Feet
EXCAVATION METHOD: Mini Excavator
LOGGED BY: AC

JOB NUMBER: 018011.200
DATE DRILLED: 9/11/19
TOTAL DEPTH OF TEST PIT: 10.5 Feet BGS
SAMPLER TYPE: Hand-driven tube

TEST PIT NUMBER
TP-103

DEPTH (FT)	BULK SAMPLES	TUBE SAMPLES	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	U.C. (psf) by P.P.	% Passing 200	Atterberg: Liquid Limit	Atterberg: Plastic Index	REMARKS
0.0 -1.0			GW-GM		WELL-GRADED GRAVEL with SAND (Aggregate Base Rock); Gray, dense, dry, subrounded gravel to 3 inch maximum diameter, 60% gravel (FILL).							FILL
-2.0			ML ML		SILT with SAND; Brown, soft, damp, woody debris (FILL).							NATIVE 5 blows/ 6 inches. Attempted two sample tubes at 2.0 to 2.5 feet BGS (A and B). Both attempts resulted in 1/2 filled sample tube.
-3.0			ML		SILT; Brown, soft to medium stiff, damp to moist.	25.2	95					
-4.0 -5.0					SILT with SAND; Reddish-brown, soft, damp. Becomes mottled greenish-gray and olive gray. Becomes light greenish-gray, not mottled. Becomes mottled greenish-gray and olive brown.	23.2	99					9 blows/ 6 inches.
-6.0 -7.0			SM		SILTY SAND; Reddish-brown and gray (mottled), medium dense, damp to moist. Becomes dense, thin film of water observed on parting fracture faces.	18.5	103					15 blows/ 6 inches.
-8.0 -9.0 -10.0			SW		WELL-GRADED SAND with GRAVEL; Olive gray, medium dense to dense, moist, fine to coarse sand, fine subrounded gravel, 25% gravel. Approximately 6-inch thick alternating gravelly and sandy (without gravel) layers to bottom of excavation.							Encountered void space at 8 feet BGS. Elongate void space trending north-south, gently arched, approximately 4 feet long, 1 foot wide and 1 foot deep, cause unknown.
-11.0 -12.0 -13.0 -14.0 -15.0					Excavation terminated at a depth of 10.5 feet. Groundwater not encountered. Test pit backfilled with excavated spoils.							

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF TEST PIT

Subsurface Exploration Logs 2009

2

SHN Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave, Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: 6" Hollow Stem Auger
LOGGED BY: AC

JOB NUMBER: 009077
DATE DRILLED: 06/29/09
TOTAL DEPTH OF BORING: 40.5 Feet
SAMPLER TYPE: CA, SPT, Shelby Bulk

BORING NUMBER BH-1

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0				GW		FILL:WELL GRADED GRAVEL, with sand, dense, damp, gray.							
-1.0													
-2.0				ML		FILL: SILT, with sand, fine, medium stiff, damp, dark gray, mixed browns.							
			10										
-3.0			11										
			11							61			
-4.0													
-5.0			1										
			18	SM		SILTY SAND, fine, medium dense, damp, mottled yellowish-brown and light gray.							
-6.0			21				15	116					
-7.0													
-8.0													
-9.0													
-10.0			Push	SM		SILTY SAND, fine, loose, moist, brownish-gray.	33	93		77			Direct Shear
-11.0													
-12.0													
-13.0				ML		SILT, with sand, fine, soft, moist, brown.							
-14.0													
-15.0													

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

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812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave, Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: 6" Hollow Stem Auger
LOGGED BY: AC

JOB NUMBER: 009077
DATE DRILLED: 06/29/09
TOTAL DEPTH OF BORING: 40.5 Feet
SAMPLER TYPE: CA, SPT, Shelby
Bulk

BORING NUMBER BH-1

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
-15.0				ML		SILT, with sand, fine, soft, moist, brown.							
-17.0			3, 4, 5	CH		CLAY, soft, plastic, damp, bluish-gray.	25	99					
-22.0			3, 4, 7								27	10	
-26.0				SW-SM		WELL GRADED SAND, with silt and gravel, dense, wet, bluish-gray.							
-27.0			22, 31, 32							10			
-30.0			26	SW									

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FIELD LOG

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PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave, Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: 6" Hollow Stem Auger
LOGGED BY: AC

JOB NUMBER: 009077
DATE DRILLED: 06/29/09
TOTAL DEPTH OF BORING: 40.5 Feet
SAMPLER TYPE: CA, SPT, Shelby
Bulk

BORING NUMBER BH-1

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
-30.0			50/ 5"	SM		WELL GRADED SAND, with silt and gravel, dense, wet, bluish-gray							
-31.0													
-32.0													
-33.0													
-34.0													
-35.0			6 17 13										
-36.0													
-37.0													
-38.0													
-39.0			26 29 33										
-40.0													
-41.0						Bottom of boring at 40.5 feet. Groundwater encountered at 26 feet. Boring backfilled with grout.							
-42.0													
-43.0													
-44.0													
-45.0													

FIELD LOG

SHN Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department

LOCATION: 1138 Sunset Ave, Arcata

GROUND SURFACE ELEVATION: --

EXCAVATION METHOD: 6" Hollow Stem Auger

LOGGED BY: AC

JOB NUMBER: 009077

DATE DRILLED: 06/29/09

TOTAL DEPTH OF BORING: 40.5 Feet

SAMPLER TYPE: CA, SPT, Shelby

Bulk

BORING NUMBER BH-2

DEPTH (FT)	BLOWS PER 0.5'	USCS	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0		GW	FILL:WELL GRADED GRAVEL, with sand, dense, damp, gray.							
-2.0	13, 8, 8, 5, 4, 7	SP/SM	FILL: POORLY GRADED SAND, with silt and gravel, medium dense, damp, dark gray. Woody Debris	19	105					
-5.5	8, 10, 10	SM	SILTY SAND, fine, with gravel, medium dense, damp, greenish-gray.	15	113		19			
-10.0	5, 7, 9	ML	SILT, medium stiff, damp, mottled yellowish-brown and gray.				88			
-13.0	Push	ML	SILT, medium stiff, moist, gray.	28	99		97			Direct Shear

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

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812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
JOB NUMBER: 009077
LOCATION: 1138 Sunset Ave, Arcata
DATE DRILLED: 06/29/09
GROUND SURFACE ELEVATION: --
TOTAL DEPTH OF BORING: 40.5 Feet
EXCAVATION METHOD: 6" Hollow Stem Auger
SAMPLER TYPE: CA, SPT, Shelby Bulk
LOGGED BY: AC

BORING NUMBER BH-2

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
-15.0				ML		SILT, medium stiff, moist, gray.							
-16.0													
-17.0			4, 4, 4	ML		SILT, soft, wet, gray.	27				24	4	
-18.0													
-19.0													
-20.0													
-21.0			Push				19	113.2					
-22.0				SP/SM		POORLY GRADED SAND, with silt, medium dense, moist, gray.							
-23.0													
-24.0													
-25.0			6, 11, 18	SM		WELL GRADED SAND, with silt and gravel, dense, moist, bluish-gray.	15						
-26.0													
-27.0													
-28.0													
-29.0													
-30.0			Push	ML			24	104					

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FIELD LOG

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812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave, Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: 6" Hollow Stem Auger
LOGGED BY: AC

JOB NUMBER: 009077
DATE DRILLED: 06/29/09
TOTAL DEPTH OF BORING: 40.5 Feet
SAMPLER TYPE: CA, SPT, Shelby
Bulk

BORING NUMBER BH-2

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
-30.0						SILT, with gravel, soft, wet, gray							
-31.0													
-32.0													
-33.0													
-34.0													
-35.0			35 41 50/ 5"	SW		WELL GRADED SAND, with gravel, dense, wet, bluish-gray							
-36.0													
-37.0													
-38.0													
-39.0													
-40.0			43 50 50/ 5"										
-41.0													
-42.0						Bottom of boring at 41.5 feet. Groundwater encountered at 18 feet. Boring backfilled with grout.							
-43.0													
-44.0													
-45.0													

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

SHN Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 9.0 Feet
SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER TP-1

DEPTH (FT)	USCS	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0	GW	FILL: SANDY GRAVEL, dense, dry, gray.							
-1.0	ML	FILL: SANDY SILT, medium stiff, dry, mixed brown and gray, organics.							
-2.0	ML	SILT WITH SAND, fine, medium stiff, damp, dark brown, original native topsoil.	20	102					Shelby tube sample recovered from test pit wall at an angle
-2.5	ML	SILT, medium stiff, damp, olive brown.							
-3.0	SM	SILTY SAND, fine, medium dense, damp, mottled yellowish-brown and reddish-brown.							
-6.5		Slightly less sandy intervals interfingered with thin discontinuous lenses of medium sand with silt.							
-9.0		Bottom of test pit at 9.0 feet. No free groundwater observed.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

Columns: BULK SAMPLES | SHELBY TUBE | BLOWS PER 0.5' | PROFILE

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department

LOCATION: 1138 Sunset Ave., Arcata

GROUND SURFACE ELEVATION: --

EXCAVATION METHOD: Backhoe

LOGGED BY: AC

JOB NUMBER: 009077

DATE EXCAVATED: 07/15/09

TOTAL DEPTH OF TEST PIT: 8.5 Feet

SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER **TP-2**

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0				GW		FILL: SANDY GRAVEL, dense, dry, gray.							
				SW		FILL: GRAVELY SAND, with silt, medium dense, damp, mixed browns.							
-1.0				GW		FILL: SANDY GRAVEL, dense, damp, gray.							
-2.0				ML		FILL: SILT, medium stiff, damp, dark brown, prominent large woody debris.							Increasing woody content to 3.5 feet
-3.0				ML		SILT, medium stiff, damp, dark brown, common fine roots along preexisting fractures, original native topsoil.	23	102			27	8	Shelby tube sample recovered from test pit wall at an angle
-4.0				ML		SILT WITH SAND, fine, medium stiff, damp, mottled yellowish-brown and reddish-brown							
-5.0 to -8.0				SM		SILTY SAND, medium dense, damp, mottled yellowish-brown and gray.							
-9.0						Bottom of test pit at 8.5 feet. No free groundwater observed.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

SHN Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 9.0 Feet
SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER TP-3

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0 to -2.0				GW		FILL: SANDY GRAVEL, dense, dry, gray.							
-2.0 to -2.5	X			ML		SANDY SILT, medium stiff, damp, olive gray.							
-2.5 to -3.0				ML									
-3.0		■		SM		SANDY SILT, medium stiff, damp, dark brown, original native topsoil.	17	107.9		32			Shelby tube sample recovered from test pit wall at an angle
-3.0 to -9.0						SILTY SAND, medium dense, damp, mottled yellowish-brown and gray.							
-9.0						Bottom of test pit at 9.0 feet. No free groundwater observed.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

FIELD LOG

SHN Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 8.5 Feet
SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER TP-4

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0 – -1.8				GW		FILL: SANDY GRAVEL, medium dense, dry, gray.							
-1.8 – -4.8	X (at ~-4.3 to -4.8)			ML		FILL: SANDY SILT, with occasional fine gravel, organics, medium stiff, damp, mixed browns, large woody debris.							Zones of yellowish-brown silty sand
-4.8 – -5.6		■ (at ~-5.0 to -5.5)		ML		SANDY SILT, soft-medium stiff, damp, brown, charcoal, original native topsoil.	17	114					Shelby tube sample recovered from test pit wall at an angle
-5.6 – -8.5				SM		SILTY SAND, medium dense, damp, olive brown to greenish-gray.							
-8.5						Bottom of test pit at 8.5 feet. No free groundwater observed.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 10.5 Feet
SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER TP-5

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0 to -1.5				GW		FILL: SANDY GRAVEL, medium dense, dry, gray.							
-1.5 to -8.0				ML		FILL: SANDY SILT, with occasional fine gravel, medium stiff, damp, mixed browns, large woody debris, organics.							Zones of yellowish-brown silty sand
-8.0 to -8.7				ML		SANDY SILT, soft, moist, dark brown, original native topsoil.							
-8.7 to -10.0 (groundwater ▽ -9.0)	X (-9.0 to -9.5)			SM		SILTY SAND, medium dense, wet, mottled olive brown and reddish-brown.				65			
-10.0						Bottom of test pit at 10.0 feet. Groundwater encountered at 9.0 feet.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

SHN Consulting Engineers & Geologists, Inc.
812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 7.5 Feet
SAMPLER TYPE: Bulk, 2.5" I.D Shelby hand hammer drive

TEST PIT NUMBER TP-6

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0				GW		FILL: SANDY GRAVEL, medium dense, dry, gray.							
				ML		FILL: SILT, with sand and occasional gravel, medium stiff, damp, dark brown, organics.					29	7	Shelby tube sample recovered from test pit wall at an angle
				ML		SILT, with sand, soft, damp, dark brown, charcoal, original native topsoil.							
				SM		SILTY SAND, medium dense, damp, olive brown. Becomes mottled olive brown and reddish-brown.							
						Bottom of test pit at 7.5 feet. No free groundwater observed.							

Depth scale: 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

FIELD LOG

Consulting Engineers & Geologists, Inc.

812 West Wabash, Eureka, CA 95501 ph. (707) 441-8855 fax. (707) 441-8877

PROJECT: Arcata Volunteer Fire Department

LOCATION: 1138 Sunset Ave., Arcata

GROUND SURFACE ELEVATION: --

EXCAVATION METHOD: Backhoe

LOGGED BY: AC

JOB NUMBER: 009077

DATE EXCAVATED: 07/15/09

TOTAL DEPTH OF TEST PIT: 5.5 Feet

SAMPLER TYPE: N/A

TEST PIT NUMBER TP-7

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0				GW		FILL: SANDY GRAVEL, medium dense, dry, gray.							
-1.0				ML		FILL: SANDY SILT, medium stiff, damp, mixed browns.							Scrap metal, zones of yellowish-brown silty sand
-2.0													
-3.0				SM		FILL: SILTY SAND, medium dense, damp, yellowish-brown.							
				ML		SILT, soft, damp, dark brown, original native topsoil.							
-4.0				SM/ML		SILTY SAND to SANDY SILT, medium dense, damp, mottled yellowish-brown and reddish-brown.							
-5.0													
-6.0						Bottom of test pit at 5.5 feet. No free groundwater observed.							
-7.0													
-8.0													
-9.0													
-10.0													
-11.0													
-12.0													
-13.0													
-14.0													
-15.0													

FIELD LOG

Consulting Engineers & Geologists, Inc.
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PROJECT: Arcata Volunteer Fire Department
LOCATION: 1138 Sunset Ave., Arcata
GROUND SURFACE ELEVATION: --
EXCAVATION METHOD: Backhoe
LOGGED BY: AC

JOB NUMBER: 009077
DATE EXCAVATED: 07/15/09
TOTAL DEPTH OF TEST PIT: 4.5 Feet
SAMPLER TYPE: N/A

TEST PIT NUMBER TP-8

DEPTH (FT)	BULK SAMPLES	SHELBY TUBE	BLOWS PER 0.5'	USCS	PROFILE	DESCRIPTION	% Moisture	Dry Density (pcf)	Unc. Com. (psf)	% Passing 200	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Index	REMARKS
0.0 to -2.5				GW		FILL: SANDY GRAVEL, medium dense, dry, gray.							Scrap metal, zones of yellowish-brown silty sand
-2.5 to -4.5				ML		SANDY SILT, medium stiff, damp, mottled yellowish-brown, reddish-brown and light grayish-brown, original native topsoil.							
-4.5						Bottom of test pit at 4.5 feet. No free groundwater observed.							

Depth scale (ft): 0.0, -1.0, -2.0, -3.0, -4.0, -5.0, -6.0, -7.0, -8.0, -9.0, -10.0, -11.0, -12.0, -13.0, -14.0, -15.0

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time

FIELD LOG

Laboratory Test Results 3

Phone: (707) 441-8855 Email: info@shn-engr.com Web: shn-engr.com
812 W. Wabash Avenue, Eureka, CA 95501-2138

DENSITY BY DRIVE- CYLINDER METHOD (ASTM D2937)

Project Name:	Arcata ODHC	Project Number:	018011.200
Performed By:	JMA	Date:	10/10/2019
Checked By:	NAN	Date:	10/10/19
Project Manager:	GDS		

Lab Sample Number	19-884	19-885	19-888	19-889	
Boring Label	TP-101	TP-101	TP-102	TP-102	
Sample Depth (ft)	5.5-6.0	7-7.5	2-2.5	4-4.5	
Diameter of Cylinder, in	2.38	2.38	2.38	2.38	
Total Length of Cylinder, in.	7.90	6.90	7.95	7.90	
Length of Empty Cylinder A, in.	1.70	0.00	0.00	2.33	
Length of Empty Cylinder B, in.	0.31	1.67	2.65	0.00	
Length of Cylinder Filled, in	5.89	5.23	5.30	5.57	
Volume of Sample, in^3	26.20	23.27	23.58	24.78	
Volume of Sample, cc.	429.40	381.28	386.38	406.07	

Pan #	ss3	SS15	ss14	ss11	
Weight of Wet Soil and Pan	1054.5	963.5	911.3	984.5	
Weight of Dry Soil and Pan	948.2	862.5	811.5	900.3	
Weight of Water	106.3	101.0	99.8	84.2	
Weight of Pan	197.0	194.3	192.8	192.6	
Weight of Dry Soil	751.2	668.2	618.7	707.7	
Percent Moisture	14.2	15.1	16.1	11.9	
Dry Density, g/cc	1.75	1.75	1.60	1.74	
Dry Density, lb/ft^3	109.2	109.4	100.0	108.8	

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812 W. Wabash Avenue, Eureka, CA 95501-2138

DENSITY BY DRIVE- CYLINDER METHOD (ASTM D2937)

Project Name:	Arcata ODHC	Project Number:	018011.200
Performed By:	JMA	Date:	10/10/2019
Checked By:	NAN	Date:	10/10/19
Project Manager:	GDS		

Lab Sample Number	19-893	19-895	19-896		
Boring Label	TP-103	TP-103	TP-103		
Sample Depth (ft)	2.3-2.8	4-4.5	5.5-6		
Diameter of Cylinder, in	2.38	2.38	2.38		
Total Length of Cylinder, in.	6.71	8.00	13.50		
Length of Empty Cylinder A, in.	3.35	0.00	0.00		
Length of Empty Cylinder B, in.	0.21	2.14	6.77		
Length of Cylinder Filled, in	3.15	5.86	6.73		
Volume of Sample, in^3	14.01	26.07	29.94		
Volume of Sample, cc.	229.64	427.21	490.63		

Pan #	ss10	ss7	ss7		
Weight of Wet Soil and Pan	634.8	1026.2	1157.6		
Weight of Dry Soil and Pan	546.3	869.2	1007.4		
Weight of Water	88.5	157.0	150.2		
Weight of Pan	195.4	193.1	196.5		
Weight of Dry Soil	350.9	676.1	810.9		
Percent Moisture	25.2	23.2	18.5		
Dry Density, g/cc	1.53	1.58	1.65		
Dry Density, lb/ft^3	95.4	98.8	103.2		

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