APPENDIX F: GEOTECHNICAL ENGINEERING REPORT FOR THE PALMDALE DITCH CONVERSION PROJECT

GEOTECHNICAL ENGINEERING REPORT

Prepared For
Hazen and Sawyer

Proposed
Palmdale Ditch Conversion Project
Littlerock Reservoir to Lake Palmdale
Palmdale, Los Angeles County, California

Job No.: 23-314
March 15, 2023

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SOIL AND MATERIAL TESTING AND INSPECTIONS

March 15, 2024 Job No.: 23-314

Ms. Jessica Mamos
Hazen and Sawyer
498 Seventh Avenue, 11th Floor
New York, NY 10018

Subject: **Geotechnical Engineering Report for Palmdale Ditch Conversion Project, Littlerock Reservoir to Lake Palmdale, Palmdale, Los Angeles County, California**

Dear Ms. Mamos:

Presented herewith in is our Geotechnical Engineering Report for the subject project. Our work was performed in accordance with the scope of work outlined in our original proposal dated July 28, 2023.

This report presents the results of our field investigation, laboratory testing, along with our engineering judgment, opinions, conclusions, and recommendations pertaining to the proposed development.

It has been a pleasure to be of service to you on this project. Should you have any questions regarding the contents of this report, or should you require additional information, please contact the undersigned at (661) 273-9078.

Respectfully submitted,

BRUIN GEOTECHNICAL SERVICES, INC.

Ryan D. Duke, P.E.
RDD/mes

GEOTECHNICAL ENGINEERING REPORT
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GEOTECHNICAL ENGINEERING REPORT
PALMDALE DITCH CONVERSION PROJECT
LITTLEROCK RESERVOIR TO LAKE PALMDALE
PALMDALE, LOS ANGELES COUNTY, CALIFORNIA

1.0 INTRODUCTION

This report presents the results of our geotechnical investigation performed by Bruin Geotechnical Services, Inc. for the proposed construction of buried pipe to convey water from the Littlerock Reservoir to Palmdale Lake for Palmdale Water District (PWD or District), based on discussions and preliminary site plans provided by the client. This report is specific to the proposed design and construction of the new proposed buried pipeline.

The purpose of this investigation was to evaluate the on-site subsurface soil conditions relative to geotechnical engineering characteristics and to provide geotechnical recommendations relative to proposed buried pipe.

The scope of the authorized geotechnical investigation included the following tasks:

- Performing a site reconnaissance
- Conducting field subsurface exploration through soil borings and sampling
- Laboratory testing program of selected soil samples
- Performing engineering analyses of the data
- Preparing this Geotechnical Engineering Report

This study also includes a review of published and unpublished literature and geotechnical maps with respect to active and potentially active faults located in proximity to the site which may have impact on the seismic design of the proposed structure.

2.0 SITE LOCATION AND DESCRIPTION

The subject site, herein after referred to as Site, is a corridor located between the Littlerock Reservoir extending to Lake Palmdale, in Palmdale, Los Angeles County, California. The Site currently contains an open ditch to convey the water and begins at the Littlerock Reservoir, traversing approximately seven (7) miles. The open ditch and corridor originates near the intersection of Cheseboro Road and Mt. Emma Road, winding northeast towards 47th Street East. The ditch is then enclosed and crosses beneath 47th Street east and generally parallels Barrel Springs Road from 47th Street East to 40th Street East, crossing over the California Aqueduct near Bear Creek Road, and parallels the north side of the aqueduct, beneath Pearblossom Highway, and again generally parallels Barrel Springs Road, turning south towards Alpine and Sierra Highway, connecting to existing underground pipeline to

Palmdale lake, approximately 2,100 feet southeast of Lake Palmdale. The Site is located in a semi-rural area of Palmdale, with a few residential developments along the subject corridor.

At the time of our investigation, the Site corridor contained an open ditch which conveys water. Vegetation varied along the alignment and consisted of sparse, low annual weeds and brush to heavy brush and shrubs. The Site topography is undulating, as the corridor travels along the north side of the foothills of the San Garbiel Mountains. The corridor has a general slope to the south/southwest, with drainage by sheet flow to drainage gullies. The topography varies from relatively flat and gentle to slope gradients of up to 20 percent. The elevation of the Site ranges from approximately 3,200 feet above mean sea level at the eastern origin to approximately 2,850 feet above mean sea level at the west terminus.

The aforementioned site description is intended to be illustrative and is specifically not intended for use as a legal description of the Site.

The subject site corridor contains many access points, both paved and unpaved. Access points are achieved through open land, dirt and paved roads as well as gated areas owned by (PWD).

The general location of the subject site and access points is shown on Figure 1.

3.0 PROPOSED GRADING AND CONSTRUCTION

Based on our review of the preliminary site plans and discussions, Bruin GSI understands that the development will consist of 36” to 48” diameter reinforced concrete pipe (RCP) or high-density polyethylene (HDPE) pipe. As it is a gravity flow system, the depth of cover over the pipeline is anticipated to be approximately four to ten (4-10) feet thick with a maximum cover of approximately eighteen (18) feet thick. Concrete thrust blocks and trenchless horizontal borings are anticipated.

Due to the undulating topography of the pipe alignment, it appears the proposed excavation to pipe depth will include areas requiring terracing and/or shoring.

4.0 GEOTECHNICAL INVESTIGATION

The geotechnical investigation included a field subsurface exploration program and a laboratory testing program on soil samples collected. These programs were performed in accordance with our proposal for Geotechnical Investigation Report dated July 28, 2023. The scope of work did not include environmental assessment or investigation for the presence or absence of hazardous substances or toxic materials in structures, soil, surface

Vicinity Map

N.T.S.

= Denotes approximate pipeline alignment

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water, groundwater, or air, below or around the site. The field subsurface exploration and laboratory testing programs are described below.

4.1 Field Exploration Program

A site reconnaissance was made by our representative prior to instigating the field exploration program. The Site was observed, and boundaries roughly located for purposes of underground utility locating. As required by law, Bruin GSI contacted Underground Service Alert (one-call notification service) to attain underground utility marking and clearance, a minimum of 72 hours prior to performing the field subsurface investigation.

The field exploration program was initiated on November 9, 2023, and was performed intermittently through December 20, 2023, under the technical supervision of our engineer. A total of thirty-six (36) exploratory borings were drilled using a CME 65 truck mounted drill rig and CME 55 limited access rig, both equipped with eight (8) inch hollow stem auger, in accordance with generally accepted geotechnical exploration procedures (ASTM D 1452). The borings were advanced to maximum depths of thirty (30) feet below ground surface (bgs).

The approximate locations of the borings within the area of the proposed pipeline alignment were determined by sighting and pacing from existing site improvements, such as streets, and hand-held GPS accurate to approximately ten (10) feet and should be only considered accurate to the degree implied by the method used. The borings were located in approximate 2,000 feet intervals along the proposed preliminary pipeline alignment. Actual distances varied depending on accessibility, terrain and vegetation. The boring locations are presented on Figure 2.

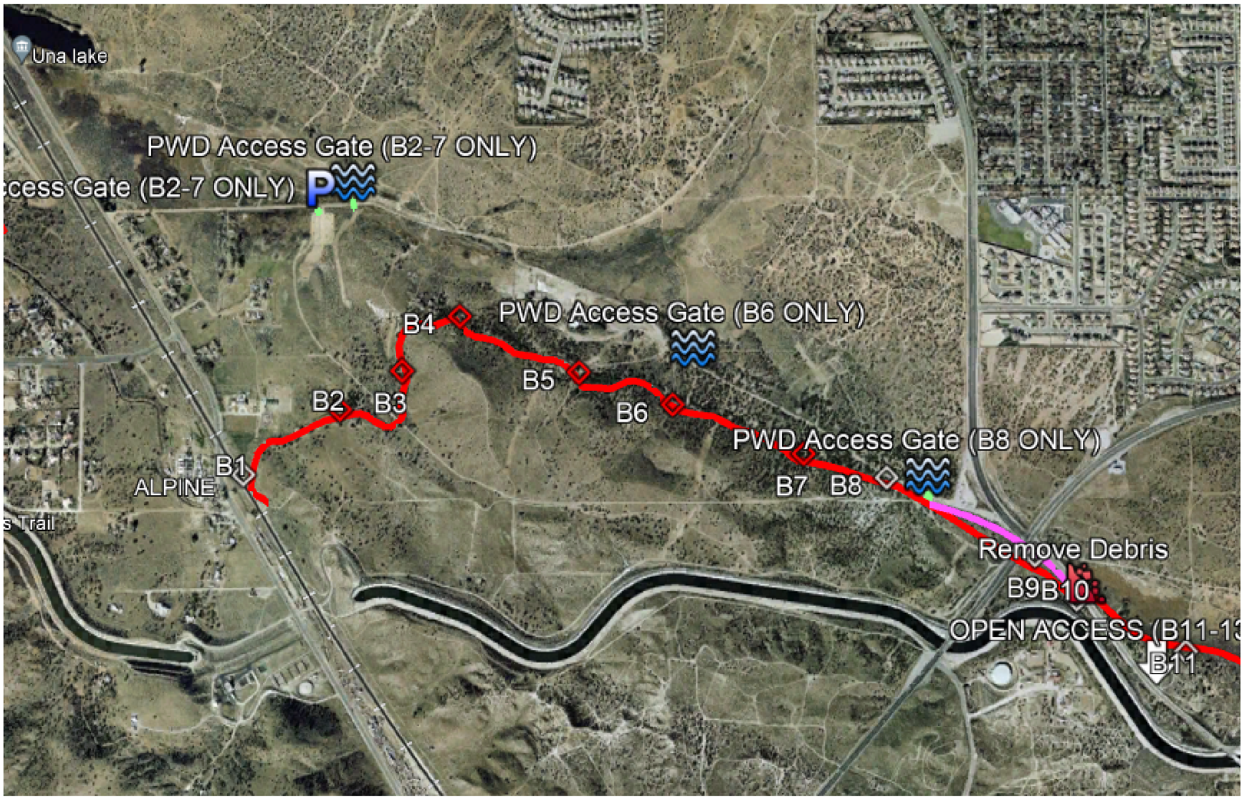
Soil samples were obtained at various depth intervals, consisting of relatively undisturbed brass ring samples (Modified California split-spoon sampler) and Standard Penetration Test (SPT) samples driven by a 140-pound hammer falling 30 inches. After seating of the sampler, the number of blows required to drive the sampler one foot was recorded in six (6) inch increments, in general accordance with procedures presented in ASTM D 1586.

Bulk samples were also collected at various depths from auger cuttings during drilling and represent a mixture of soils within the noted depths. The soil samples were returned to the laboratory for analysis and testing.

Final boring logs presented in Appendix A are Bruin GSI's interpretation of the field logs prepared by our representative during drilling, as well as laboratory test results. The stratification lines represent approximate boundaries between soil types. The actual soil transitions may be gradual.

Boring Location Map

N.T.S.



B1 = Denotes Approximate Boring Location

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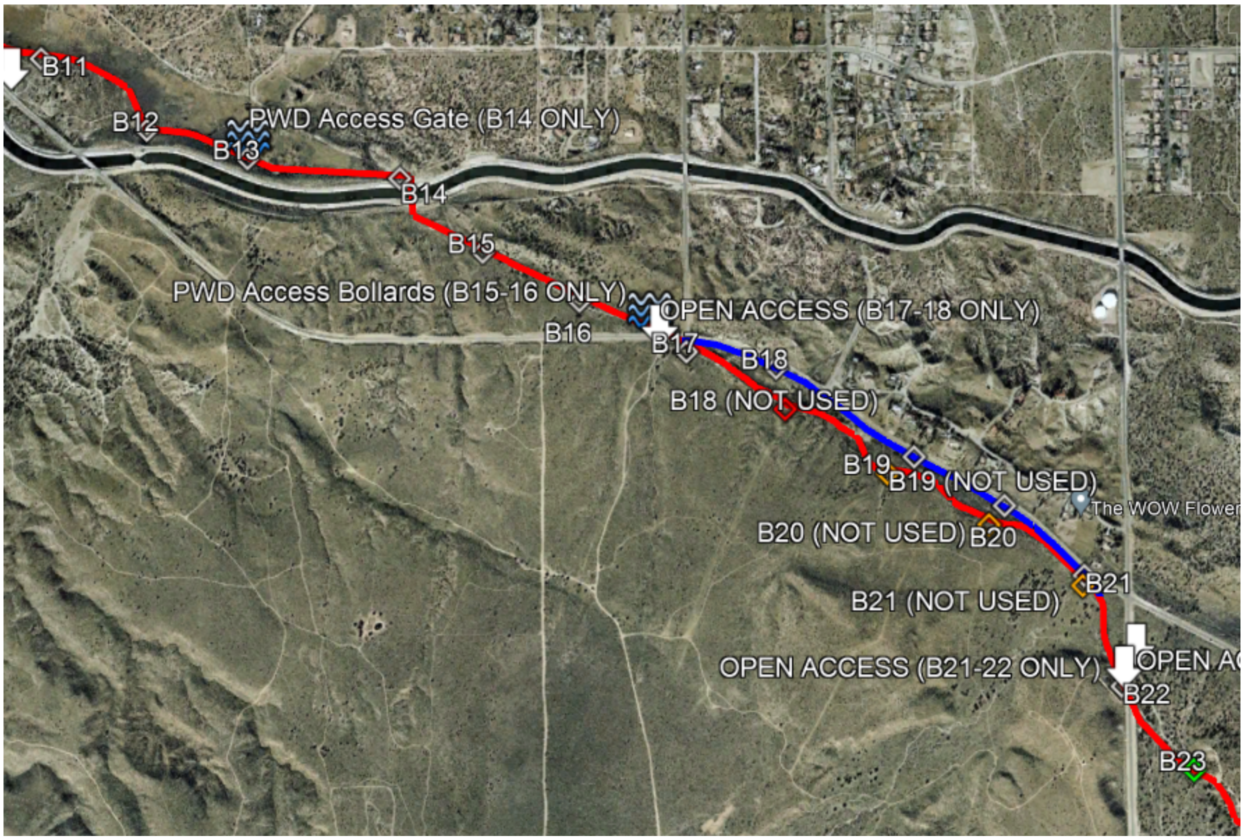
Figure 2

Boring Location Map

N.T.S.



B11 = Denotes Approximate Boring Location

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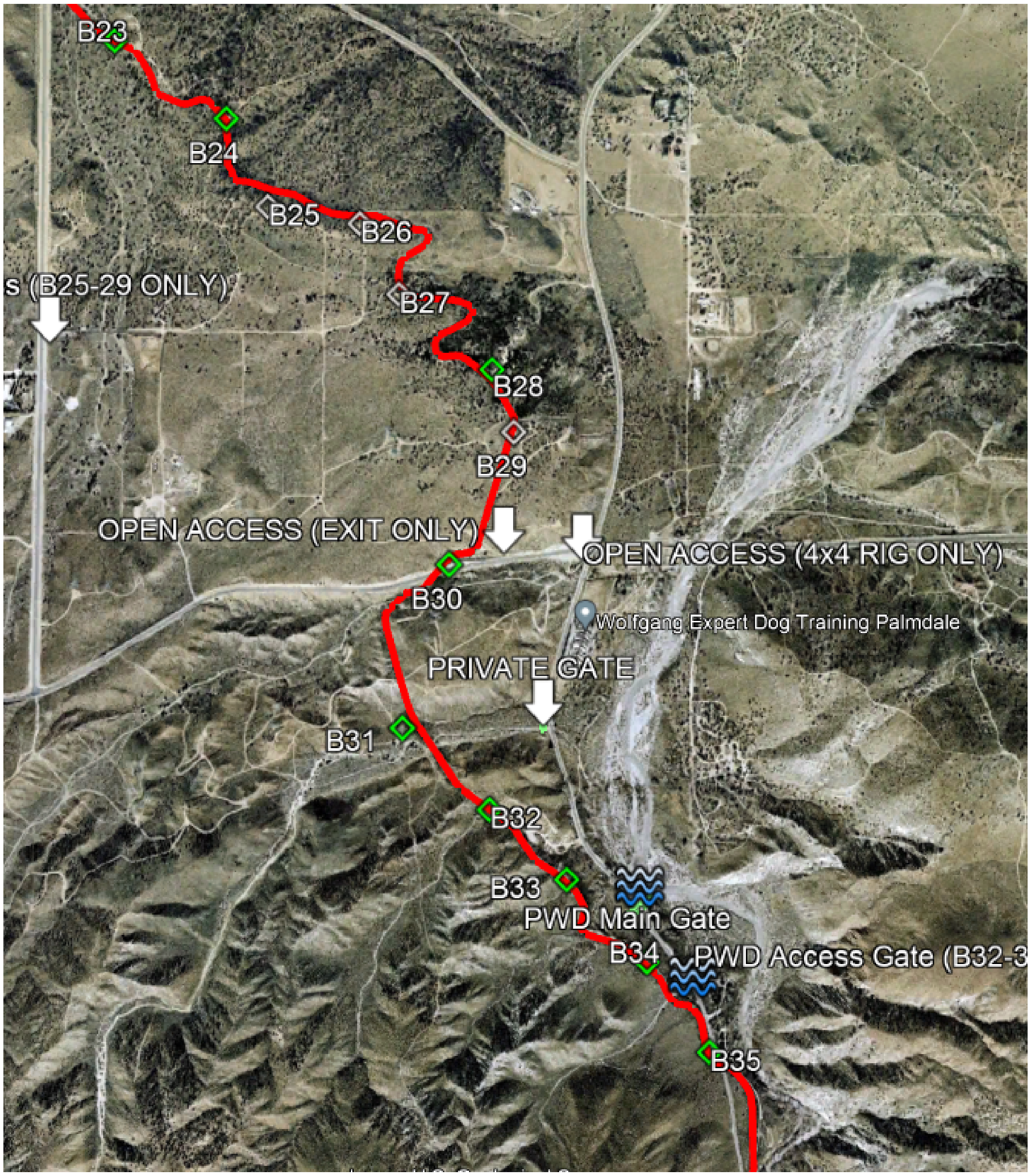

B23 = Denotes Approximate Boring Location

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4.2 Site and Subsurface Conditions

Native alluvial materials and bedrock were encountered within all our exploratory trenches. The native materials were noted to be slightly moist to moist and loose, medium dense to very dense. Drilling refusal was encountered in some borings due to the dense bedrock material encountered.

The soil strata encountered consisted predominately of silty sand (SM) with poorly-graded sand (SP) and clayey sand (SC), occasional sandy silt (ML) and clay (CL). Free groundwater was encountered in three of the borings: B17, B18 and B19, at depths from 12 to 29 feet bgs.

It is our understanding that horizontal boring will be necessary at Pearblossom Highway crossing. Based on our review of the borings performed at this location (Borings B8 and B9) the soil types consist of silty sands (SM), clayey silts (ML), and silty clays (CL).

Boring 8 was drilled to a depth of 15 feet below ground surface, consisting of medium dense to dense material, ranging from slightly moist to moist. Poorly-graded sand (SP) in the upper 10 feet of soil, while the remaining depth to 15 feet contains clayey sand (SC).

Boring 9 was drilled to a depth of 30 feet below ground surface, consisting of loose to dense material, ranging from moist to very moist. Silty sand (SM) was encountered in the upper 12 feet of soil, while the remaining depth to 30 feet contains fine to medium sandy silt with coarse sand and clay binder.

No groundwater or caving was encountered within B8 or B9.

For more detailed descriptions of the subsurface materials refer to the boring logs and classification profile of all borings in graphic form of the materials encountered is presented in Appendix A.

4.3 Groundwater Conditions

Bruin GSI reviewed available reports and electronic databases to assess historic water level conditions in the vicinity of the Site. Sources reviewed included the historically highest groundwater contours prepared by State of California Department of Water Resources SGMA electronic database, historically highest groundwater levels in the immediate site vicinity indicate that groundwater level at the site are between 20 to 68 feet bgs. (refer to Appendix D for groundwater well locations and depths). However, as previously mentioned, free groundwater was encountered in borings B17, B18 and B19 at depths from 12 to 29 feet below ground surface (bgs).

4.4 Laboratory Testing

The field boring logs and soil samples were reviewed to assess which samples would be analyzed further. The selected soil samples collected during trenching activities at the Site were then tested in the laboratory to assist in evaluating engineering properties of subsurface materials deemed within structural influence.

The soil samples were classified in accordance with the Unified Soils Classification System and a testing program was established. The samples were tested to determine the following:

- In-situ moisture and dry unit weight determinations were determined in accordance with ASTM D 2937.

- Relative strength characteristics were estimated from results of direct shear tests (ASTM D 3080) performed on in-place and bulk soil samples remolded to approximately 90% of the maximum dry density as determined by ASTM D 1557 test method.

- Consolidation potential was determined on select soil samples in accordance with ASTM D 2435.

- Soil chemical analysis on a soil sample from the site was performed by Anaheim Test Lab, which included pH, resistivity, soluble sulfates and soluble chlorides as well as other chemical contents.

The following additional tests were performed:

- Identification of soils — ASTM D 2488
- Expansion Index — ASTM D 4829
- Maximum density – Optimum moisture — ASTM D 1557
- Material Finer than the No. 200 Sieve — ASTM D 1140
- Sand Equivalent Value — ASTM D 2419

Pertinent tabular and graphic test results are presented in Appendix B.

5.0 REGIONAL GEOLOGY AND SEISMIC HAZARDS

The Site is located in a seismically active area typical of Southern California and likely to be subjected to a strong ground shaking due to earthquakes on nearby faults.

The San Andreas Fault zone is the largest active fault rift zone, which is several miles wide, and passes through the Antelope Valley, extending from the Gulf of Mexico through the western portion of the State of California to a point at Cape Mendocino in northern California. The San Andreas Fault is predicted to have an event every 100-200 years based on geologic records. The San Andreas Fault has had two major eruptions in the last 150 years: 1) in the Southern California area in 1857, and 2) in San Francisco in 1906. In each event, approximately 199 miles of surface rupture has taken place, as well as a horizontal displacement of approximately 29.5 feet. Additional faulting has occurred adjacent to the San Andreas Fault causing numerous events of various magnitudes throughout the length of the San Andreas Fault.

The Site is located in an area in which active seismic occurrences are recorded on a yearly basis. Seismic studies conducted show a major break along the San Andreas Fault could be responsible for an event of approximately 8.4 on the Richter scale. A seismic event of this magnitude could cause bedrock accelerations as large as 0.5g. Events of this magnitude are anticipated to occur approximately every 150 years. The last occurrence of this magnitude was in 1857.

The San Andreas Fault has been mapped through a majority of the Site. The potential hazards due to active fault ground rupture are considered highly likely in the next 30 years. A seismic event along this section of the San Andreas Fault could result in permanent ground deformation and excessive ground shaking. According to current publications by the State of California, the project site is located within the Alquist-Priolo special studies zone.

According to the California Department of Conservation (CDC) and California Geological Survey (CGS) online database for Zones of Required Investigation, portions of the Site area are located within a Liquefaction, Landslide, or Earthquake Zone.

A map detailing the location of the San Andreas Fault, Liquefaction zones, and Landslide Zones can be found in Figure 3.

5.1 CBC Design Parameters

The following coefficients have been estimated in accordance with the requirements of the 2022 CBC, utilizing the Structural Engineers Association of California and California's Office of Statewide Health Planning and Development Seismic Design Maps Application:

Fault-Liquefaction Map

N.T.S.

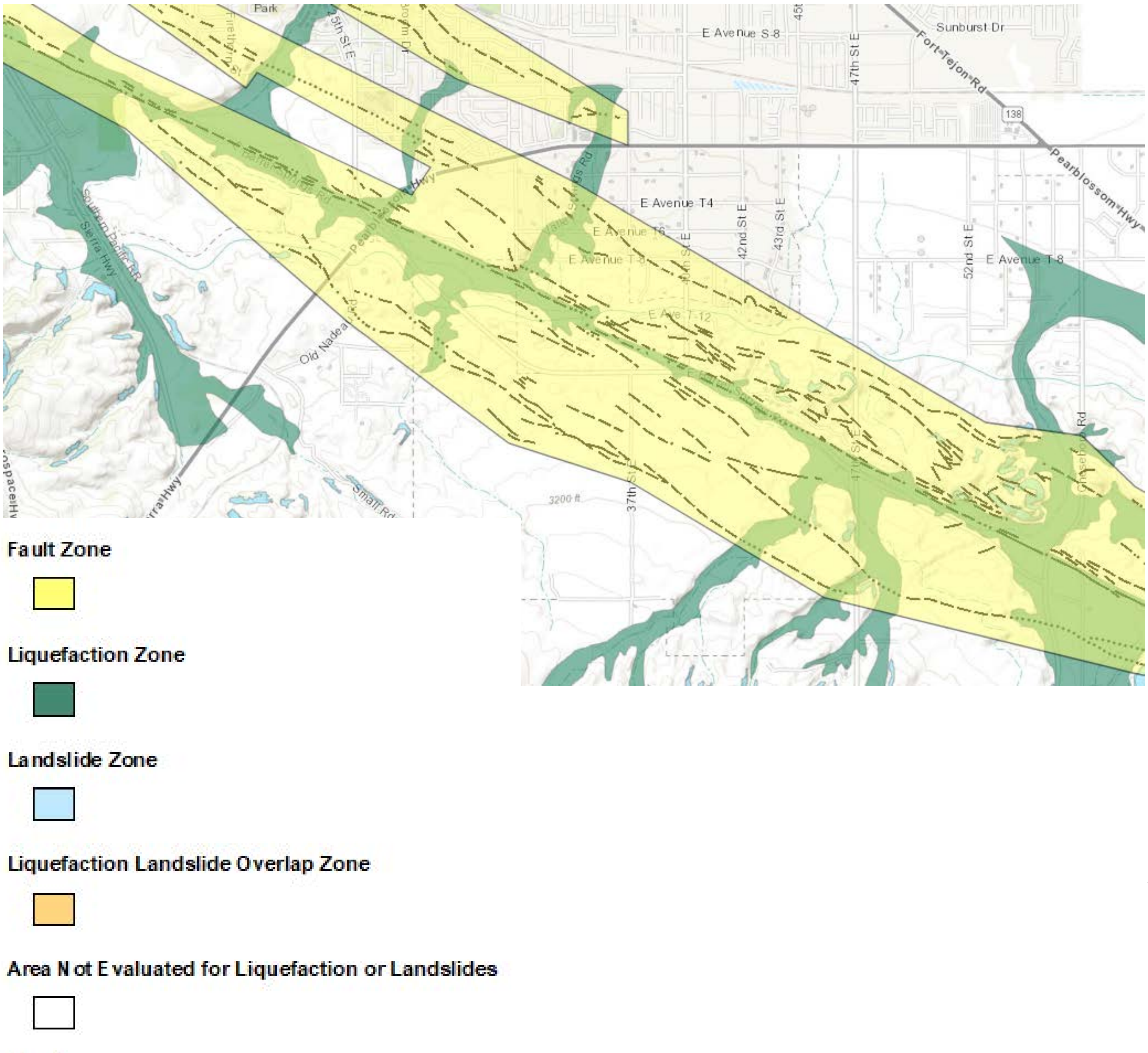

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Figure 3

https://seismicmaps.org/

As the pipeline alignment parallels the San Andreas Fault Zone, the following seismic parameters are the most conservative values, based on the approximate latitude and longitude shown (approximately 216 feet north of Barrel Springs Road and 0.5 miles west of Bear Creek Road):

Latitude 34.52907964°
Longitude -118.07011524°

Spectral Response Acceleration, Short Period) - S_s	2.5g	0.2(sec)
Spectral Response Acceleration at 1 sec. - S_1	1.065g	1.0(sec)
Mapped Spectral Response, Short period - S_{DS}	1.667g	0.2(sec)
Mapped Spectral Response at 1 sec. - S_{D1}	*	1.0(sec)
Site Coefficient – F_A	1.0	
Site Coefficient – F_V	*	
Site Modified Spectral Response Acceleration, Short period -S_{MS}	2.5g	
Site Modified Spectral Response Acceleration, Short period -S_{M1}	*	

Site Classification (2022 CBC, further defined in ASCE7-16 Chapter 20) = D Stiff Soil

* The actual method of seismic design should be determined by the Structural Engineer in accordance with Section 11.4.8 Site-Specific Ground Motion Procedures of the ASCE 7-16. Refer to Appendix E for the Design Maps Summary Report provided by the Structural Engineers Association of California and California's Office of Statewide Health Planning and Development website.

5.2 Liquefaction Potential

Liquefaction is a seismic phenomenon in which loose, saturated, granular (non-cohesive) soils react as a fluid when subject to high-intensity ground shaking. Research and historical data indicate loose granular soils with a specific range of grain size distribution, saturated by a relatively shallow groundwater table are most susceptible to liquefaction.

The effects of liquefaction on level ground include settlement, sand boils and bearing capacity failures below structures.

A liquefaction analysis was not a part of our scope of work. However, in view of the relatively loose to dense silty sand encountered in the exploratory borings, relative densities, and depth to static groundwater, it is Bruin GSI's opinion that the potential for on-site liquefaction or seismically induced dynamic settlement is probable.

5.2.1 Other Liquefaction Associated Hazards

Potential hazards associated with liquefaction include lateral spreading and slow slides, foundation bearing failure, and ground surface settlement. Considering the upper native soils may liquefy, these hazards should be considered as design factors for this project.

5.3 Other Secondary Seismic Hazards

Seismic hazards relative to earthquakes include landslides, ground lurching, tsunamis, seiches and seismic-induced settlement. As site topography is relatively flat, hazards from landslides are considered negligible. Ground lurching is generally associated with fault rupture and liquefaction. As these hazards are considered likely, it is Bruin GSI's opinion that the potential for ground lurching is moderate. Tsunami hazards are considered nonexistent due to the site location.

5.4 Erosion

The subject site drainage occurs by minor sheet flow and some concentrated ravines and erosion could occur. Appropriate analysis, grading and drainage design and site maintenance should minimize the erosion potential.

6.0 DISCUSSIONS AND CONCLUSIONS

Based upon the results of our investigation, it is Bruin GSI's opinion that the proposed pipeline project is considered feasible from a geotechnical standpoint provided the recommendations presented herein are incorporated into the design and construction. If changes in the design of the pipeline are made or variations of changed conditions are encountered during construction, Bruin GSI should be contacted to evaluate their effects on these recommendations.

6.1 Soil Engineering Properties

Physical tests were performed on bulk and relatively undisturbed samples to characterize the engineering properties of the native soils.

Moisture content and dry unit weight determinations were performed on samples to evaluate the in-situ unit weights of the different materials. Moisture contents ranged from five to thirty one (5-31) percent. In-place dry densities ranged generally from 98 pounds per cubic foot (pcf) to 129 pcf. Moisture content and dry unit weight results are shown on the Boring Logs in Appendix A.

Direct shear test data indicates some of the native soils were found to have low cohesive strength.

The expansion index tests (ASTM D 4829) indicate that the surficial soils are within the “very low” expansion category.

Consolidation test results reveal that some samples tested soil has a moderate potential to hydro-consolidate.

Refer to Appendix B for graphic results of laboratory tests.

6.2 Seismic Considerations

The proposed pipeline alignment lies within the San Andreas Fault Zone. Based on our investigation and research, it is our recommendation that the proposed water line should be classified by the Design Engineer in accordance with the Liquefaction and Landslide Transverse information found in Table 1 and designed per Table 3, Table 7, and Table 11 provided in the “Design Guideline for Seismic Resistant Water Pipeline Installations”, found in Appendix F.

6.3 Groundwater Considerations

Groundwater was encountered in Borings B17, B18 and B19 from thirteen to twenty nine (13-29) feet bgs. Anticipated trench excavation depths in these areas are estimated to be from ten to seventeen (10-17) feet bgs. Considerations for pumping free groundwater and trench stabilization are likely to be required during construction. It is possible that free groundwater is encountered in other areas of the proposed trench alignment.

Refer to Appendix C for the Boring Classification Profile that indicate groundwater depths.

7.0 GEOTECHNICAL RECOMMENDATIONS

The following geotechnical engineering recommendations for the proposed pipeline are based on observations from the field investigation program and the laboratory test results and our experience with sites of similar conditions.

The Authority Having Jurisdiction (AHJ) should be contacted prior to start of construction to assure the project is properly permitted and inspected during construction. Any grading performed at the site shall be in compliance with the recommendations provided in this report.

Field observations and testing during pipe construction operations should be provided by a qualified professional so a decision can be formed regarding the adequacy of the site preparation, the acceptability of fill materials, and the extent to which the earthwork construction and the degree of compaction comply with the project geotechnical specifications. **Any work related to grading performed without the full knowledge of, and under the supervision of the Geotechnical Consultant, may render the recommendations of this report invalid.**

7.1 Earthwork

Prior to any grading, the site should be cleared and grubbed of all vegetation. All pavements, vegetation, trash, debris and abandoned underground utilities shall be removed from the area of pipeline construction and should not be incorporated into trench backfill.

Any depressions resulting from removals during grubbing process (trees etc.) shall be observed by the Geotechnical Consultant. Depressions requiring backfill within structural areas will require placement of engineered fill, observed, and tested by the Geotechnical Consultant.

7.2 Pipeline Trench Excavations

It is Bruin GSI's opinion that standard construction techniques and excavation equipment may be used. However, Bedrock was encountered between ten to twelve (10-12) feet below ground surface from Boring 27 to Boring 29. The bedrock was dense and drilling refusal was encountered. Trench depths in this area should be verified, as special excavation techniques may be necessary.

The soils encountered in the exploratory borings consist mainly of "non-cohesive" loose to medium silty sands (SM) and poorly-graded sands (SP) soil types based on the Unified Soil Classification System. Sloughing of sidewalls is likely to occur. The soils encountered in the exploratory borings can be classified as Type "C" soils according to CAL/OSHA. Trench excavations shall comply with CAL/OSHA Construction Safety Orders for Excavation, Trenches, and Earthwork.

Shoring Is likely to be necessary, even for shallow trenches. If space permits, sloping of the trench sidewalls from the base of the excavation is recommended.

As trenches are exposed and soils dry out, additional sloughing of sidewalls will likely occur.

Caving was not noted in any of our eight-inch borings, however the chances of caving will increase within larger scale excavations and should be anticipated particularly in coarse-grained material and under groundwater table, and saturated fine-grained material may cave as well.

Trench depths greater than 20 feet are not anticipated. However, if trenches exceed 20 feet, a registered professional engineer must design protective systems for trenches. The contractor should provide their own design for trench shoring and retaining and submit their design to the project engineer prior to construction.

No heavy equipment or other surcharge loads (i.e., excavation spoils) should be allowed within the top of slope a distance equal to the depth of the excavation, both measured from the top of the excavation. *(Note: lateral support shall be considered removed when the excavation extends below a plane projected downward at an angle of 45 degrees from the bottom of an excavation of an existing structure, from the edge of the public way or an adjacent property)*.

7.3 Temporary Shoring

Proper installation of shoring is the responsibility of the contractor. The adjacent property owners must be advised of the risks and the owner and builder should provide arrangements to repair any possible damages.

The following information on the design and installation of the shoring is as complete as possible at this time. It is suggested that a review of the final shoring plans and specifications be made by this office prior to bidding or negotiating with a shoring contractor be made.

The cantilevered restrained shoring shall be designed per the following table. A trapezoidal distribution of lateral earth pressure would be appropriate where shoring is to be restrained at the top by bracing or tie backs. In addition to lateral earth pressure, the shoring should be designed to resist the surcharge imposed by the proposed structures, footings, and any adjacent buildings. The design values provided in the following table assuming that water table will be maintained below the bottom of the cut.

Depth of Shoring (feet)	Cantilever Shoring System Equivalent Fluid Pressure (p.c.f.) *Triangular Distribution of Pressure*	Restrained Shoring System Lateral Earth Pressure (p.s.f./ft)* *Trapezoidal Distribution of Pressure*
Up to 6	20	13
Up to 8	24	16
Up to 12	30	20
Up to 18	36	24

In addition to lateral earth pressure, these retaining walls should be designed to resist the surcharge imposed by the proposed structures, footings, any adjacent buildings, or by adjacent traffic surcharge.

It is very important to note that active pressures can only be achieved when movement in the soil (earth wall) occurs. If movement in the soil is not acceptable, such as adjacent to an existing structure, an at-rest pressure of 60 pcf should be considered for design purposes.

Where a combination of sloped embankment and shoring is utilized, the pressure will be greater and must be determined for each combination. Additional active pressures should be applied where the shoring will be surcharged by adjacent traffic or structures.

Construction excavations shall be made under the supervision of a qualified "competent person" along with periodic review performed by this office. A "competent person" as defined by California/OSHA, is one who is capable of identifying existing and predictable hazards that are unsanitary or dangerous to employees. The competent person has the authority to impose prompt corrective measures to eliminate these hazards.

Water should not be allowed to pond on top of the excavation, nor to flow toward it. **All excavations should be protected from inclement weather**. This is required to keep the surface of the open excavation from becoming saturated during rainfall. Saturation of the excavation may result in a relaxation of the soils which may result in failures. Excavations should be kept moist, not saturated, to reduce the potential for raveling and sloughing during construction.

7.4 Trench Subgrade (Bottom) Stabilization and Bedding

Due to the granular nature of the soil encountered, the majority of the trench bottoms are anticipated to require only minor stabilization. Although some loose and very dense exposures should be anticipated.

Trench subgrade (bottom) should be firm and unyielding. If the trench excavation is excavated below the design invert elevation, it should be backfilled to the design elevation with compacted bedding material.

Trench bottoms (subgrade) should be scarified a minimum of eight (8) to twelve (12) inches, moisture conditioned or aerated to near optimum moisture content and compacted to minimum 90% relative compaction as determined by ASTM D1557 test method. Unstable soils, excessive moisture or free-standing water, or loose soils should be observed by the Geotechnical Consultant for the opportunity to provide recommendations prior to pipe placement.

The sand equivalent value of the soils tests ranged from two to sixty-eight (2-68).

Refer to Appendix B for a summary of sand equivalent values.

the Standard specifications for pipeline construction call for pipe bedding material to have a sand equivalent value of 30 or higher. Some materials having this minimum sand equivalent were encountered along the proposed alignment. If material meeting the minimum sand equivalent requirement is encountered it may be possible to stockpile the acceptable pipe bedding material for use along the alignment. However, care will have to be utilized in collecting and segregating these materials to prevent possible contamination with other undesirable soil encountered with sand equivalents of less than 30.

Pipeline installed as recommended on compacted subgrade, based on our investigation, boring data and laboratory test results in combination with the "Modulus of Soil Reaction (E') Values for Buried Flexible Pipe" from the Engineering and Research Center Bureau of Reclamation as well as the "Handbook of Ductile Iron Pipe" Sixth Edition, by Ductile Iron Pipe Research Association, an E' value of 1,000 psi be used.

Refer to Appendix C for the Boring Classification Profile and corresponding E' Values.

7.5 Trenchless Horizontal Drilling (Pearblossom Highway)

Based on the materials encountered at Pearblossom Highway (silty sand and poorly-graded sand), it is our opinion that trenchless shoring is feasible. Due to some of the loose and non-cohesive soil encountered, casing may be needed to advance the horizontal boring to prevent caving. No large rocks or boulders or otherwise impenetrable soils were encountered in our exploratory borings.

7.6 Pipe Bedding

For purposes of this section of the report, “bedding” is defined as material placed in a trench up to one (1) foot above a utility pipe, and “backfill” is all material placed in the trench above the bedding.

Unless concrete-slurry bedding is required around utility pipes, free-draining sand should be used as bedding. Pipe bedding shall be clean sand or site soil with a sand equivalent value of 30 or higher, free of gravel. Sand or on-site soils proposed for use as bedding should be tested in our laboratory to verify its suitability and measure its compaction characteristics. The pipe bedding shall be placed in lifts not exceeding eight (8) inches, moisture conditioned to near optimum moisture content and compacted to a minimum relative compaction of 90% as determined in accordance with Test Method ASTM D 1557.

It is recommended that bedding material be placed to an elevation equal to one (1) foot over the top of the pipe.

Jetting will not be allowed unless approved by the Project Engineer and Geotechnical Consultant.

7.7 Fill Placement and Compaction Requirements

The excavated native soils may be used as engineered fill to backfill the excavation. Materials for engineered fill should be free of organic material, debris, and other deleterious substances, and should not contain rocks greater than two (2) inches in maximum dimension.

All native soil shall be moisture conditioned or air dried as necessary to achieve near optimum moisture condition, placed in lifts (eight to ten inches, measured loose) and then compacted in place by mechanical compaction equipment to a minimum relative compaction of 90% as determined in accordance with Test Method ASTM D 1557.

All import soil fill (meeting the requirements of Section 7.9) should be placed in lifts eight to ten inches, measure loose), moisture conditioned or air dried as necessary to near optimum moisture condition, and then compacted in place to a minimum relative compaction of 90% as determined in accordance with Test Method ASTM D 1557.

A representative of the project consultant should be present on-site during grading operations to verify proper placement and compaction of all fill, as well as to verify compliance with the other geotechnical recommendations presented herein.

7.8 Native Soil Shrinkage

A shrinkage factor of the upper site soils will vary along the trench and is dependent on many factors such as depth of trench, material encountered, in-situ density and degree of compaction. Overall, shrinkage is estimated at five to ten (5-10) percent. Areas excavated into dense bedrock will yield a much lower shrinkage factor and will affect quantities. This estimate is based on the limited data collected from the subsurface exploration and laboratory test data with an average degree of compaction of 92% and will vary depending on contractor methods.

7.9 Imported Soils for Backfill

If imported soils are required to complete the planned grading, these soils shall be free of organic matter and deleterious substances, meeting the following criteria:

- 100% passing a 2-inch sieve
- 60% to 100% passing the #4 sieve
- no more than 20% passing a #200 sieve
- expansion index less than 20
- liquid limit less than 35
- plasticity index less than 12
- Low corrosion potential
    - Soluble Sulfates less than 1,500 ppm
    - Soluble Chlorides less than 150 ppm
    - Minimum Resistivity greater than 8,000 ohm-cm

Prospective import soils should be observed, tested and pre-approved prior to importing the soils to the site. The Geotechnical Consultant shall monitor the pre-approved import soil as it is delivered to the site in order to provide final approval of the import soil on site either in place or adequate quantities to finish the grading.

7.10 Soil Settlement

Soil settlement behind shoring and of the backfill material can occur in trenches at the site. The soil behind shoring can settle from two primary sources:

1. The soil can "yield" laterally and downward toward the shoring. This is often referred to as "ground loss".
2. Dewatering can increase stresses in dewatered soils, which results in consolidation.

Some ground loss will occur with a shield and other shoring systems. The magnitude of this loss varies widely and is difficult to predict. For the medium dense to dense sands encountered in the borings, it is estimated that the ground loss will be in a range of one (1) percent near the trench, in the range of 0.5 percent at a distance "H" from the excavation, and to be negligible to a distance of "2H" from the excavation: "H" is equal to the trench depth and ground loss is expressed as a percent of the trench depth.

Settlement of deep trench backfill is possible, even when the backfill is properly placed and compacted. Occasional reworking or resurfacing of the trench areas where the backfill exceeds approximately ten feet may be necessary.

7.11 Observations and Testing

The pipeline construction shall be observed and tested by the Geotechnical Consultant to verify compliance with the recommendations. Any pipe placement or backfill performed without full knowledge of the Geotechnical Consultant may render the recommendations of this report invalid.

8.0 DESIGN CONSIDERATIONS

8.1 Foundation Design Recommendations

Provided the recommendations in this report are incorporated into site development, foundations and thrust blocks constructed on compacted fill and dense native soil may be designed as follows:

8.1.1 Allowable Bearing Capacity

An allowable "net" bearing capacity of 1,500 psf. can be utilized for dead and sustained live loads. This value includes a minimum safety factor of three (3) and may be increased by one-third (1/3) for total loads, including seismic forces.

8.1.2 Lateral Load Resistance

Lateral load resistance for the footings or thrust blocks will be developed by passive soil pressure against sides of footings or thrust blocks. This passive pressure was estimated to be 300 Z PSF, where Z = Depth (in feet) below adjacent soil elevation. In passive pressure calculations, the upper one (1) foot of soil should be subtracted from the depth, “Z”, unless confined by pavement or slab. This is an ultimate value. An appropriate safety factor should be used for design calculations. Passive resistance may be combined with frictional resistance without reduction.

Friction along the footing or thrust block base may provide resistance to lateral loading. The coefficient of friction was estimated to be 0.31 for undisturbed soils or site soils compacted to 90% of the maximum dry density as determined by ASTM D 1557 test method, and may be used for dead load forces and includes a reduction factor of one-third (1/3).

9.0 CORROSION AND CHEMICAL ATTACK

Soluble sulfate, pH, resistivity and chloride concentration test results are presented in Appendix B. The Resistivity (CTM 643) test results on bulk soil samples from the site indicated that on-site soils range from **extremely-corrosive** to **moderately-corrosive** when in contact with ferrous material (<500 to 10,500 ohm-cm). Corrosion test results also indicate that the surficial soils at the site have negligible sulfate attack potential (0.0123% to .0967% by weight) on concrete.

Based on the preliminary chemical analysis performed on a sample of the native soil, foundation concrete shall consist of type II cement with a minimum compressive strength of 2,500 psi as indicated in the ACI 318-19 Table 19.3.2.1. A higher compressive strength may be required by the structural engineer. Additional soil chemical analysis during grading is recommended. The minimum concrete compressive strength should be determined by the structural engineer.

The chemical test results should be distributed to the project design team for their interpretations pertaining to the corrosivity or reactivity of the construction materials (ferrous metals, and piping).

10.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report is based on the preliminary pipeline .kmz plans provided to our office. If the pipeline alignment changes or pipeline location changes occur, the conclusion and recommendations in this report may not be considered valid unless the changes are reviewed, and the conclusions of this report are modified or approved by the Geotechnical Consultant.

The subsurface conditions and characteristics described herein have been projected from individual borings or test pits placed across the project Site. Actual variations in the subsurface conditions and characteristics may occur.

If conditions encountered during construction differ from those described in this report, this office should be notified so as to consider the necessity for modifications. No responsibility for construction compliance with the design concepts, specifications, or recommendations is assumed unless on-site construction review is performed during the course of construction, which pertains to the specific recommendations contained herein.

It is recommended that Bruin GSI be provided the opportunity for a general review of final design and specifications in order that earthwork recommendations may be properly interpreted and implemented in the design specifications. If Bruin GSI is not accorded the privilege of making this recommended review, Bruin GSI can assume no responsibility for misinterpretation of the recommendations contained in this report.

This report has been prepared in accordance with generally accepted practice and standards in this community at this time. No warranties, either expressed or implied, are made as to the professional advice provided under the terms of the agreement and included in this report. This report has been prepared for the exclusive use of Hazen and Sawyer and their authorized agents. Unauthorized reproduction of any portion of this report without expressed written permission is prohibited.

If parties other than Bruin GSI are engaged to provide construction geotechnical services, they must be notified that they will be required to assume complete responsibility for the geotechnical phase of the project by concurring with the findings and recommendations in this report or providing alternate recommendations.

11.0 CLOSURE

The conclusions, recommendations, and opinions presented herein are: (1) based upon our evaluation and interpretations of the limited data obtained from our field and laboratory programs; (2) based upon an interpolation of soil conditions between and beyond the borings; (3) are subject to confirmation of the actual conditions encountered during construction; and, (4) are based upon the assumption that sufficient observation and testing will be provided during the grading, infrastructure installation and building phases of pipeline construction.

APPENDIX A

Boring Logs Classification Profile and Key

Date(s) drilled	11/9/2023	**LOG OF BORING 1**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	ML	Dark Brown fine to medium sandy silt w/ occ. coarse sand to #3/8" gravel Firm, slightly moist	8-8	117.2	7.7
	ML	Brown fine to medium sandy silt w/ occ. coarse sand to 3/8" gravel & clay binder Very stiff, slightly moist	7-10	98.3	8.7
5'	ML	Brown fine to coarse sanyd silt w/ occ. #4 gravel (slighlty cemtented) Moderately firm, slightly moist	6-8	103.9	7.1
	ML	Brown fine to medium sandy silt w/ occ. coarse sand to 1/2" gravel Stiff, moist	5-8	101.9	11.0
10'	SM	Brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel Loose, slightly moist	3-4-3		5.9
15'	SM	Brown silty fine to coarse sand w/ occ. #4 to 1/2" gravel Medium dense, slightly moist	6-8-8		5.4
		Boring terminated @ 15' bgs No groundwater No caving			
20'					
25'					
30'					

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Date(s) drilled	12/20/2023	**LOG OF BORING 2**	
Drilling Contractor	Choice Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 55 Mini LAR	Logged By:	AM
Drill Bit Size/Type	6"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	12'
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client:	Hazen & Sawyer
Project Number:	23-314
Project Location:	Palmdale

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SC	Moderate brown very clayley fine to medium sand w/ coarse sand & occ. #4 gravel Dense, moist	6-12	121.8	11.2
5'	SC	Dark yellowish brown very clayley fine to medium sand w/ coarse sand & occ. #4-1/2" gra Dense, moist	7-13	114.5	9.6
	SM	Yellowish brown silty very fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Dense, moist	16-11-10		7.8
10'	SM	Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, slightly moist	4-5-6		6.5
15'					
		Boring terminated @ 12' bgs No groundwater No caving			
20'					
25'					
30'					

Date(s) drilled	12/20/2023	**LOG OF BORING 3**
Drilling Contractor	Choice Drilling	**Page 1 of 1**
Drilling Method	Hollow Stem Auger	
Drill Rig Type	CME 55 Mini LAR	Logged By: AM
Drill Bit Size/Type	6"	Checked By: MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole: 15'
Groundwater	None Encountered	Boring Location: See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:
Hammer Data	140#, 30" drop	

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Reddish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel and clay bi	3-8-16		10.3
				Medium dense, moist			
		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-1"gravel	16-36-43		6.4
				Very dense, moist			
5'							
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel & slight clay binder	12-21-24		8.2
				Dense, moist			
10'		SM		Yellowish brown slightly silty fine to coarse sand w/ occ. #4 to 2" gravel & clay binder	15-30		9.8
				Dense, moist			
15'		SM		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel	26-50/6"	128.1	7.7
				Very dense, moist			
				Boring terminated @ 15' bgs			
				No groundwater			
20'				No caving			
25'							
30'							

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Date(s) drilled	12/20/2023	**LOG OF BORING 4**	
Drilling Contractor	Choice Drilling		
Drilling Method	Hollow Stem Auger	**Page 1 of 1**	
Drill Rig Type	CME 55 Mini LAR	Logged By:	AM
Drill Bit Size/Type	6"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15'
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty medium to coarse sand w/ fine sand & occ. #4-1" gravel Very dense, moist	27-50/6"	126.1	7.7
5'		SM		Yellowish brown silty fine to medium sand w/ coarse sand occ. #4-1/2" gravel & slight clay Dense, very moist	16-25	107.9	14.4
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel Very dense, moist	50/5"		10.4
10'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel Very dense, moist	16-30-34		8.7
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Very dense, slightly moist	23-28-50/5"		5.8
15'		SM		Pale yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Very dense, moist	15-50/5"		9.5
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	12/20/2023	**LOG OF BORING 6**	
Drilling Contractor	Choice Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 55 Mini LAR	Logged By:	AM
Drill Bit Size/Type	6"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15'
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-3" gravel & slight clay binder Medium dense, slightly moist	8-16	109.6	6.2
5'		SC		Brown clayley medium to coarse sand w/ fine sand & occ. #4-3" gravel Dense, moist	16-20	129.2	11.4
		SC		Yellowish brown clayley fine to medium sand w/ coarse sand & occ. #4-3" gravel Dense, moist	14-24		15.3
10'							
		SM		Greyish brown silty fine to coarse sand w/ occ. #4-4" cobble Very dense, moist	26-37		8.8
15'		SM		Greyish brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel (Decompose Very dense, slightly moist	22-50/6"		6.4
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	12/20/2023	**LOG OF BORING 7**	
Drilling Contractor	Choice Drilling		
Drilling Method	Hollow Stem Auger	Page 1 of 1	
Drill Rig Type	CME 55 Mini LAR	Logged By:	AM
Drill Bit Size/Type	6"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	15'
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SC		Brown clayley fine to medium sand w/ coarse sand & occ. #4-3" gravel Medium dense, slightly moist	5-14		
5'		SC		Brown clayley fine to medium sand w/ coarse sand & occ. #4-3" gravel Medium dense, moist	6-13	108.3	10.4
10'		SC		Brown clayley fine to medium sand w/ coarse sand & occ. #4-3" gravel Dense, moist	12-18	103.2	14.8
		CL		Moderate brown clayley fine to coarse sand w/ occ. #4-4" cobble Hard, moist	22-34		11.1
15'		SM		Pale brown silty fine to coarse sand w/ occ. #4 gravel & slight clay binder (Decomposed Gr Very dense, moist	25-50/5"		8.6
20'							
25'							
30'							

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Date(s) drilled	**11/16/2023**	**LOG OF BORING 8**	
Drilling Contractor	**GP Drilling**	**Page 1 of 1**	
Drilling Method	**Hollow Stem Auger**		
Drill Rig Type	**CME 65**	Logged By:	**AM**
Drill Bit Size/Type	**8"**	Checked By:	**MS**
Sampling Method(s)	**CSS/SPT/Bulk**	Total Depth of Borehole	**15' bgs**
Groundwater	**None Encountered**	Boring Location:	**See Figure 2**
Borehole Backfill	**Native/ Cuttings**	Notes:	
Hammer Data	**140#, 30" drop**		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		ML		Yellowish brown fine to medium sandy silt w/ coarse sand & calcium carbonate Very stiff, slightly moist	13-24	120.7	5.7
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4 gravel (slightly cemen Dense, moist	19-29	120.1	6.3
5'		SM		Reddish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Very dense, moist	28-48	119.6	7.3
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand & #4 gravel Dense, moist	12-11-11		
10'		SC		Yellowish brown clayey fine to medium sand w/ coarse sand & occ. #4 gravel Dense, very moist	7-13-20		12.0
15'		SC		Moderate brown clayey fine to medium sand w/ occ. coarse sand - #4 gravel Medium dense, moist	7-11-13		8.6
20'				Boring terminated @ 15' bgs No groundwater No caving			
25'							
30'							

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LOG OF BORING 9

Date(s) drilled	**11/17/2023**		
Drilling Contractor	**GP Drilling**		
Drilling Method	**Hollow Stem Auger**		
Drill Rig Type	**CME 65**	Logged By:	**AM**
Drill Bit Size/Type	**8"**	Checked By:	**MS**
Sampling Method(s)	**CSS/SPT/Bulk**	Total Depth of Borehole	**30' bgs**
Client: **Hazen & Sawyer**	Groundwater: **None Encountered**	Boring Location:	**See Figure 2**
Project Number: **23-314**	Borehole Backfill: **Native/ Cuttings**	Notes:	
Project Location: **Palmdale**	Hammer Data: **140#, 30" drop**		

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	ML	Light brown fine to medium sandy silt w/ coarse sand & occ. #4 gravel & slightly cemented Stiff, moist	5-7	107.6	9.1
	SM	Brown silty fine to medium sand w/ coarse sand & occ. #4 gravel Loose, moist	2-2	106.6	8.5
5'					
	SM	Brown very silty fine to coarse sand w/ occ. #4 gravel & slight clay binder Loose, moist	2-2	102.3	12.4
	SM	Brown silty fine to coarse sand w/ occ. #4 gravel & clay binder Loose, moist	3-2	106.0	9.2
10'					
	SM	Yellowish brown very silty fine to medium sand w/ occ. coarse sand to #4 gravel Dense, very moist	10-26	120.8	12.0
15'	SM	Brown very silty fine to medium sand w/ occ. coarse sand (slightly cemented) Dense, moist	15-31-35		9.6
20'	SM/ML	Dark yellowish brown very silty f-m sand w/ coarse sand & clay binder Dense, moist	8-14-28		7.9
25'	ML	Brown fine to medium sandy silt w/ occ. coarse sand & 1/2" gravel & clay binder Firm, moist	8-9-13		17.2
30'	ML	Olive Brown fine to medium sandy silt w/ occ. coarse sand & 1/2" gravel & clay binder	10-14-31		15.2
		Boring terminated @ 30' bgs, No groundwater, No caving			

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Date(s) drilled	11/17/2023	**LOG OF BORING 10**	
Drilling Contractor	GP Drilling		
Drilling Method	Hollow Stem Auger	**Page 1 of 1**	
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client:	Hazen & Sawyer
Project Number:	23-314
Project Location:	Palmdale

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4 gravel w/ slight clay binder Medium dense, slightly moist	5-7-13		3.5
5'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4 gravel Dense, slightly moist	18-20-18		4.1
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4 gravel Very dense, slightly moist	50/6"		3.2
10'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4 gravel Very dense, slightly moist	50/5"	100.3	4.2
		SM		Yellowish brown silty very fine to coarse sand w/ occ. #4 gravel Very dense, slightly moist	50/5"		
15'		SM		Yellowish brown silty very fine to coarse sand w/ occ. #4 gravel Very dense, slightly moist	50/4"	98.2	4.9
20'				Boring terminated @ 15' bgs No groundwater No caving			
25'							
30'							

Date(s) drilled	11/16/2023	**LOG OF BORING 11**	
Drilling Contractor	GP Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand Loose, slightly moist	3-2-1		2.9
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand to 1/2" gravel Loose, slightly moist	2-3-3		5.0
5'		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand to #4 gravel Loose, moist	2-3-3		6.7
		SM		Yellowish brown very silty fine to medium sand w/ occ. coarse sand & clay binder Loose, saturated	3-4	102.5	15.8
10'		SC		Yellowish brown clayey fine to coarse sand w/ occ. #4 gravel Very loose, saturated	1-2	103.4	21.8
15'		SC		Yellowish brown clayey fine to coarse sand w/ occ. #4 gravel Very loose, saturated	2-2	106.9	19.8
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

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Date(s) drilled	11/16/2023	**LOG OF BORING 12**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	Refusal @ 13' bgs
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SM	Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, slightly moist	12-13	116.3	4.3
5'	SM	Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel Very dense, slightly moist	18-33	121.0	4.2
	SP	Yellowish brown slightly silty medium to coarse sand w/ fine sand & occ. #4-2" gravel (DG) Very dense, slightly moist	21-50/6"	116.3	2.9
10'	SP	Greenish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel (weathered bedrock) Very dense, moist	24-50/6"		
	SP	Pale brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel & slight clay binder (we Very dense, moist	50/6"		6.4
15'		Refusal @ 13' bgs No groundwater No caving			
20'					
25'					
30'					

BRUIN GEOTECHNICAL SERVICES INC. est. 2004

Date(s) drilled	11/16/2023	**LOG OF BORING 13**	
Drilling Contractor	GP Drilling		
Drilling Method	Hollow Stem Auger	Page 1 of 1	
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	13' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	Refusal @ 13' bgs
Hammer Data	140#, 30" drop		

Client: Hazen & Sawyer

Project Number: 23-314

Project Location: Palmdale

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SC		Olive brown clayey fine to coarse sand w/ occ. #4 gravel Loose, saturated	2-2-2		16.8
		SC		Olive brown clayey fine to coarse sand w/ occ. #4-1" gravel Loose, very moist	2-2-3		9.3
5'		SC		Olive brown clayey fine to medium sand w/ coarse sand & occ. #4 gravel Loose, very moist	1-2-2		15.3
		SC		Olive brown clayey fine to medium sand w/coarse sand & occ. #4 gravel Medium dense, very moist	6-14	121.1	14.2
10'		SP		Olive brown slightly silty fine to coarse sand w/ occ. #4-1" gravel (DG) Medium dense, moist	18-22	129.9	9.5
		SP		Olive brown slightly silty fine to coarse sand w/ occ. #4-1" gravel (DG) Very dense, moist	50/6"		8.9
15'				Refusal @ 13' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	11/16/2023
Drilling Contractor	GP Drilling
Drilling Method	Hollow Stem Auger
Drill Rig Type	CME 65
Drill Bit Size/Type	8"
Sampling Method(s)	CSS/SPT
Groundwater	None Encountered
Borehole Backfill	Native/ Cuttings
Hammer Data	140#, 30" drop

LOG OF BORING 14

Logged By:	AM
Checked By:	MS
Total Depth of Borehole	15' bgs
Boring Location:	See Figure 2
Notes:	

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SM/ML	Light brown very silty fine to medium sand w/ coarse sand & slight clay binder Medium dense, very moist	9-11	123.7	11.3
5'	SM	Light brown silty fine to medium sand w/ coarse sand & clay binder Loose, very moist	4-4	104.4	13.2
	CL	Light brown clayey fine to medium sand w/ coarse sand & occ/ #4 gravel Loose, saturated	4-6	97.2	26.3
	CL	Reddish brown fine to medium sandy clay w/ occ. coarse sand to #4 gravel Firm, saturated	3-5-6		19.5
10'	CL	Yellowish brown fine to medium sandy clay Firm, moist	4-6-8		11.2
15'	CL	Yellowish brown fine to medium sandy clay Very firm, moist	10-12-16		18.8
20'		Boring terminated @ 15' bgs No groundwater No caving			
25'					
30'					

LOG OF BORING 15

Date(s) drilled	11/16/2023
Drilling Contractor	GP Drilling
Drilling Method	Hollow Stem Auger
Drill Rig Type	CME 65
Drill Bit Size/Type	8"
Sampling Method(s)	CSS/SPT/Bulk
Groundwater	None Encountered
Borehole Backfill	Native/ Cuttings
Hammer Data	140#, 30" drop
Logged By:	AM
Checked By:	MS
Total Depth of Borehole	15' bgs
Boring Location:	See Figure 2
Notes:	
Client:	Hazen & Sawyer
Project Number:	23-314
Project Location:	Palmdale

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to medium sand w/ occ. coarse sand & slight clay binder Medium dense, moist	4-7-11		8.9
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand to #4 gravel Medium dense, moist	8-11-12		8.1
5'		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1" gravel Medium dense, moist	8-9-12		7.8
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1" gravel Dense, slightly moist	17-27	122.7	4.4
10'		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand to #4 gravel Dense, moist	15-28	118.4	10.6
15'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel Dense, moist	18-32	119.4	4.8
				Boring terminated @ 15' bgs No groundwater No Caving			
20'							
25'							
30'							

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Date(s) drilled	11/16/2023	**LOG OF BORING 16**	
Drilling Contractor	GP Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown very silty fine to medium sand w/ occ. coarse sand to 3/8" gravel (slightly Medium dense, moist	10-16	105.0	7.9
5'		SM		Yellowish brown silty very fine to medium sand w/ occ. coarse sand to 3/8" gravel Medium dense, slightly moist	10-15	110.5	4.0
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand & #4 gravel Medium dense, slightly moist	10-15	97.9	2.4
10'		SM		Yellowish brown slightly silty fine to medium sand w/ occ. coarse sand & #4 gravel Medium dense, slightly moist	8-12-14		3.3
		SM		Yellowish brown silty fine to medium sand w/ occ. coarse sand Dense, moist	12-22-25		
15'		SM/ML		Light yellowish brown very silty fine to medium sand w/ occ. coarse sand Dense, slightly moist	13-15-15		11.5
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	11/16/2023	**LOG OF BORING 17**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	30' bgs
Groundwater	29'	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	Groundwater @ 29'
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Light yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, slightly moist	10-13	113.9	5.4
		SM		Light yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, slightly moist	8-12	114.5	7.0
5'		SM		Moderate brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Loose, moist	4-5	115.4	5.5
		SM		Moderate brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, moist	5-10	108.4	6.7
10'		SM		Moderate brown silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, moist	5-7	112.5	7.3
15'		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, moist	8-10-11		
20'		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, moist	13-15-18		10.8
25'		SM		Moderate brown very silty fine to medium sand w/ occ. coarse sand to 1/2" gravel Firm, saturated	9-14-18		15.1
			∇	Groundwater encountered			
30'		CL		Moderate brown fine to medium sandy clay w/ occ. coarse sand	6-8-9		25.0
				Boring terminated @ 30', Groundwater @ 29' bgs, No caving			

Date(s) drilled	11/17/2023	**LOG OF BORING 18**
Drilling Contractor	GP Drilling	**Page 1 of 1**
Drilling Method	Hollow Stem Auger	
Drill Rig Type	CME 65	Logged By: **AM**
Drill Bit Size/Type	8"	Checked By: **MS**
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole: **15' bgs**
Groundwater	12.5'	Boring Location: **See Figure 2**
Borehole Backfill	Native/ Cuttings	Notes: **Groundwater @ 12.5' bgs**
Hammer Data	140#, 30" drop	

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Light brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel & clay binder Medium dense, moist	8-19	111.8	12.3
5'		SM		Light yellowish brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, moist	8-12	110.7	12.0
		SM		Light olive brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, very moist	5-7	113.3	15.4
10'		SM		Olive brown fine to medium sandy silt w/ occ. coarse sand & clay binder Firm, saturated	3-4-6		16.5
		SM		Olive brown silty fine to coarse sand w/ occ. #4 gravel & clay binder	5-8-6		12.5
			∇	Groundwater @ 12.5'			
15'		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel (DG in last 3") Medium dense, very moist	9-16-16		12.3
				Boring terminated @ 15' bgs Groundwater @ 12.5' bgs No caving			
20'							
25'							
30'							

Date(s) drilled	11/17/2023	**LOG OF BORING 19**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	15' bgs
Groundwater	12'	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	Groundwater @ 12' bgs
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to medium sand w/ coarse sand Loose, moist	2-3-3		6.8
		SM		Dark yellowish brown silty fine to medium sand w/ occ. coarse sand to #4 gravel Loose, moist	3-3-3		8.6
5'							
		SM		Dark yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel & slight clay binder Very loose, very moist	1-1-1		14.1
		SC		Dark yellowish brown clayey fine to medium sand w/ coarse sand Loose, over saturated	2-3	111.7	17.9
10'		SC		Yellowish brown clayey fine to medium sand w/ coarse sand Loose, over saturated	2-2	DIST	22.6
			∇	Groundwater @ 12'			
15'		SM		Moderate brown silty fine to coarse sand w/ occ. #4 gravel & clay binder Medium dense, very moist	10-15	122.1	13.1
				Boring terminated @ 15' bgs Groundwater @ 12' bgs No caving			
20'							
25'							
30'							

Date(s) drilled	11/17/2023	**LOG OF BORING 20**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client:	Hazen & Sawyer
Project Number:	23-314
Project Location:	Palmdale

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to medium sand w/ occ. coarse sand & #4 gravel Loose, moist	3-4	105.4	8.2
		SM		Brown silty fine to medium sand w/ occ. coarse sand to 3/8" gravel Loose, very moist	2-3	106.0	14.0
5'		SM		Brown silty fine to medium sand w/ coarse sand & slight clay binder Loose, over saturated	2-2	100.1	21.5
		CL		Brown fine to medium sandy clay Very soft, over saturated	1-1-1		31.6
10'		CL		Brown fine to medium sandy clay Very soft, over saturated	1-1-1		14.0
15'		CL		Brown fine to medium sandy clay w/ coarse sand Very soft, over saturated	1-1-1		23.6
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

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Date(s) drilled	11/17/2023	**LOG OF BORING 21**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Loose, slightly moist	2-3-3		5.8
		SM		Brown silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	6-5-5		5.2
5'		SM		Moderate brown silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, moist	3-3-5		9.3
		SM		Moderate brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	7-9	117.7	5.6
10'		SM		Moderate brown silty very fine to medium sand w/ occ. coarse sand & #4 gravel Medium dense, very moist	5-7	103.8	11.1
15'		SP		Moderate brown slightly silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, moist	12-19	113.1	6.3
				Boring terminated @ 15' bgs No groundwater			
20'				No caving			
25'							
30'							

Date(s) drilled	11/9/2023
Drilling Contractor	GP Drilling
Drilling Method	Hollow Stem Auger
Drill Rig Type	CME 65
Drill Bit Size/Type	8"
Sampling Method(s)	CSS/SPT/Bulk
Groundwater	None Encountered
Borehole Backfill	Native/ Cuttings
Hammer Data	140#, 30" drop

LOG OF BORING 22

Logged By:	AM
Checked By:	MS
Total Depth of Borehole	25' bgs
Boring Location:	See Figure 2
Notes:	Refusal @ 26' bgs

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel Dense, moist	20-31	124.3	6.5
5'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel Very dense, slightly moist	22-50/5"	96.2	4.3
		ML		Light yellowish brown fine to medium sandy silt w/ occ. coarse sand & 2" gravel Very stiff, slightly moist	17-50/6"		5.4
		SM		Pale brown silty fine to coarse sand w/ occ. #4 gravel (DG) Very dense, dry	23-50/5"		2.6
10'		SM		Pale brown silty fine to coarse sand w/ occ. #4 gravel (DG) Very dense, dry	50/6"		
15'		SM		Pale brown silty fine to medium sand w/ coarse sand & occ. #4 gravel (DG) Very dense, slightly moist	50/5"		3.5
20'		SM		Pale brown silty fine to coarse sand w/ occ. #4 gravel (DG) Very dense, slightly moist	50/5"		4.4
25'		SP		Light greyish brown slightly silty fine to coarse sand w/ occ. #4 gravel (DG) Very dense, dry	50/3"		1.0
				Bedrock refusal @ 26' bgs No groundwater No caving			
30'							

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Date(s) drilled	11/30/2023	**LOG OF BORING 23**	
Drilling Contractor	GP Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, dry	5-7-7		1.6
		SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	7-8-7		5.2
5'		SM		Yellowish brown very silty fine to medium sand w/ occ. coarse sand to 1/2' gravel Loose, moist	3-3-4		8.6
		SM		Olive brown very silty fine to medium sand w/ occ. coarse sand to #4 gravel (calcium carb Dense, moist	10-21	128.5	7.4
10'		ML		Greenish grey fine to medium sandy silt w/ occ. coarse sand Dense, moist	15-22	120.7	11.1
15'		SM/ML		Olive brown very silty fine to medium sand w/ occ. coarse sand Dense, saturated	13-19	108.8	17.0
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

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Date(s) drilled	**11/30/2023**	**LOG OF BORING 24**	
Drilling Contractor	**GP Drilling**	**Page 1 of 1**	
Drilling Method	**Hollow Stem Auger**		
Drill Rig Type	**CME 65**	Logged By:	**AM**
Drill Bit Size/Type	**8"**	Checked By:	**MS**
Sampling Method(s)	**CSS/SPT**	Total Depth of Borehole	**15' bgs**
Groundwater	**None Encountered**	Boring Location:	**See Figure 2**
Borehole Backfill	**Native/ Cuttings**	Notes:	
Hammer Data	**140#, 30" drop**		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SP		Brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	7-14	117.5	2.7
5'		SP		Brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	8-17	114.2	5.5
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4 gravel Medium dense, moist	3-7	107.1	9.3
10'		SM/ML		Pale olive brown silty fine to medium sand w/ occ. coarse sand to #4 gravel (calcium carbo Dense, moist	12-15-19		8.4
		SM		Olive brown silty fine to medium sand w/ coarse sand & occ. #4 gravel (calcium carbonate Dense, moist	12-21-27		8.2
15'		SM/ML		Olive brown very silty fine to medium sand w/ occ. coarse sand to #4 gravel (calcium carbo Dense, moist	13-16-24		8.1
20'				Boring terminated @ 15' bgs No groundwater No caving			
25'							
30'							

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Date(s) drilled	11/9/2023	**LOG OF BORING 25**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to coarse sand w/ occ. #4-1/2" gravel Dense, slightly moist	14-18-16		4.4
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, slightly moist	7-8-8		3.0
5'		SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	6-7-7		3.0
		SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, dry	11-20	DIST	1.2
10'		SP		Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Dense, dry	14-20	DIST	2.1
15'		SP		Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Dense, slightly moist	11-25	117.1	3.2
				Boring termianted @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

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Date(s) drilled	11/9/2023	**LOG OF BORING 26**	
Drilling Contractor	GP Drilling		
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	20' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to medium sand w/ occ. Coarse sand to 1" gravel Medium dense, dry	11-15	113.3	1.5
5'		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, slightly moist	7-15	112	4.1
		SM/SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	12-17-20		1.9
10'		SM/SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	16-21-22		3.7
		SM/SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	9-17-30		
15'		SM/SP		Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel (DG) Very dense, dry	26-50/6"		1.4
20'		SM/SP		Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel (DG) Very dense, dry	24-39-50/4"		2.5
				Boring terminated @ 20' bgs No groundwater No caving			
25'							
30'							

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Date(s) drilled	11/9/2023	**LOG OF BORING 27**	
Drilling Contractor	GP Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	10' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	Refusal @ 10' bgs
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel	5-6-9		3.1
				Medium dense, slightly moist			
		SM		Yellowish brown very silty fine to medium sand w/ occ. coarse sand to #4 gravel	8-12-19		15.3
				Dense, saturated			
5'		SM		Yellowish brown very silty fine to medium sand w/ coarse sand & occ. #4 gravel	18-21-15		2.1
				Dense, slightly moist			
		SM		Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel	50/5"	DIST	3.4
				Very dense, slightly moist			
10'		SM		(Large rock refusal/no recovery) Yellowish brown silty fine to coarse sand w/ occ. #4-4" co	50/1"		8.2
				Very dense, dry			
				Refusal @ 10' bgs			
				No groundwater			
15'				No caving			
20'							
25'							
30'							

Date(s) drilled	11/9/2023	**LOG OF BORING 28**
Drilling Contractor	GP Drilling	
Drilling Method	Hollow Stem Auger	Page 1 of 1
Drill Rig Type	CME 65	Logged By: AM
Drill Bit Size/Type	8"	Checked By: MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole: 12' bgs
Groundwater	None Encountered	Boring Location: See Figure 2
Borehole Backfill	Native/ Cuttings	Notes: Refusal @ 12' bgs
Hammer Data	140#, 30" drop	

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Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SM	Yellowish brown silty fine to medium sand w/ fine sand & occ. #4 gravel Very dense, moist	25-42	94.3	8.2
	SM	Yellowish brown silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, slightly moist	15-21	118.5	4.3
5'	SP	Light yellowish brown slightly silty fine to medium sand w/ occ. coarse sand Medium dense, dry	5-11	91.1	2.2
	SP	Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, dry	17-12-16		1.8
10'	SP	Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-5" cobble Very dense, dry	18-31-50/6"		1.2
	SP	(Bedrock refusal) Light yellowish brown slightly silty fine to coarse sand w/ occ. #4-5" cobb Very dense, dry	50/4"		1.3
15'		Refusal @ 12' bgs No groundwater No caving			
20'					
25'					
30'					

Date(s) drilled	11/9/2023	**LOG OF BORING 29**	
Drilling Contractor	GP Drilling	**Page 1 of 1**	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Client: Hazen & Sawyer	Groundwater: None Encountered	Boring Location:	See Figure 2
Project Number: 23-314	Borehole Backfill: Native/ Cuttings	Notes:	Refusal @ 12' bgs
Project Location: Palmdale	Hammer Data: 140#, 30" drop		

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Dense, slightly moist	9-9-18		2.6
		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Dense, slightly moist	14-14-19		3.1
5'		SM		Brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Very dense, slightly moist	13-17-30		5.0
		SP		Brown slightly silty fine to coarse sand w/ occ. #4-1/2" gravel Very dense, slightly moist	19-45		2.5
10'		SP		Brown slightly silty fine to coarse sand w/ occ. #4-2" gravel (DG) Dense, moist	13-31	127.6	6.6
		SP		Brown slightly silty fine to coarse sand w/ occ. #4-2" gravel (Bedrock Refusal) Very dense, moist	50/4"		
15'				Refusal @ 12' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	11/30/2023	LOG OF BORING 30	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	30' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

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Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Pale brown silty fine to coarse sand w/ occ. #4-3" gravel Dense, slightly moist	17-19	122.8	2.6
		SM		Pale brown silty fine to coarse sand w/ occ. #4-3" gravel Medium dense, slightly moist	11-13	DIST	2.6
5'		SM		Light Olive brown silty fine to coarse sand w/ occ. #4-4" cobble Medium dense, slightly moist	7-10	112.4	3.1
		SM		Pale brown very silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, slightly moist	10-11	110.3	4.2
10'		SM		Pale brown very silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, slightly moist	6-7	114.0	4.4
15'		SM		Light brown silty fine to medium sand w/ coarse sand & occ. #4-1" gravel Medium dense, slightly moist	3-3-6		4.2
20'		SM		Light brown silty fine to medium sand w/ occ. coarse sand & 1/2" gravel Medium dense, slightly moist	8-10-11		5.7
25'		SM		Yellowish brown silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, moist	4-4-6		8.4
30'		SC		Moderate brown clayey fine to coarse sand w/ occ. #4-1" gravel	5-13-9		11.1
				Boring terminated @ 30' bgs, No groundwater, No caving			

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LOG OF BORING 31

Date(s) drilled	12/1/2023		
Drilling Contractor	GP Drilling		
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SM		Brown silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, slightly moist	8-9	113.5	2.9
		SM		Brown silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, slightly moist	8-8	110.4	2.6
5'		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-2" gravel Loose, slightly moist	4-3	108.1	3.1
		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, dry	10-11-13		1.5
10'		SP/SM		Light brown slightly silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, dry	11-13-13		1.5
15'		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, dry	11-14-15		1.8
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

Date(s) drilled	12/1/2023
Drilling Contractor	GP Drilling
Drilling Method	Hollow Stem Auger
Drill Rig Type	CME 65
Drill Bit Size/Type	8"
Sampling Method(s)	CSS/SPT
Groundwater	None Encountered
Borehole Backfill	Native/ Cuttings
Hammer Data	140#, 30" drop

LOG OF BORING 32

Logged By:	AM
Checked By:	MS
Total Depth of Borehole	15' bgs
Boring Location:	See Figure 2
Notes:	

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	3-3-3		3.5
5'		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	2-3-4		2.6
		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	4-5-6		2.1
10'		SP/SM		Brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	6-10	112.9	3.2
		SP		Greyish brown slightly silty fine to coarse sand w/ occ. #4-4" cobble Very dense, dry	50/6"		
15'		SP		Greenish grey slightly silty fine to coarse sand w/ occ. #4-4" cobble (weathered bedrock) Very dense, slightly moist	33-40	122.9	7.1
20'				Boring terminated @ 15' bgs No groundwater No caving			
25'							
30'							

Date(s) drilled	12/1/2023	**LOG OF BORING 33**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		SP		Pale brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	6-10-14		0.1
		SP		Light olive brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	9-13-15		0.8
5'		SP		Pale olive brown brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	31-19-19		1.0
		SP		Pale olive brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, dry	11-25	110.2	1.8
		SP		Olive brown slightly silty fine to coarse sand w/ occ. #4-3" cobble	16-25	DIST	3.0
10'				Dense, slightly moist			
15'		SP		Olive brown slightly silty fine to coarse sand w/ occ. #4-6" cobble Very dense, slightly moist	50/5"		
				Boring terminated @ 15' bgs No groundwater			
20'				No caving			
25'							
30'							

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Date(s) drilled	12/1/2023	**LOG OF BORING 34**	
Drilling Contractor	GP Drilling		
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SM	Pale brown very silty fine to medium sand w/ coarse sand & occ. #4-2" gravel Loose, dry	4-5	104.0	2.2
5'	SM	Pale brown very silty fine to medium sand w/ coarse sand & occ. #4-2" gravel Loose, dry	3-3	97.4	1.3
	SP	Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	5-6	110.3	6.5
10'	SP	Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	4-5-8		5.0
	SP	Brown slightly silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, slightly moist	4-4-4		
15'	SM	Brown silty fine to coarse sand w/ occ. #4-1" gravel Medium dense, moist	4-5-7		5.9
		Boring terminated @ 15' bgs No groundwater No caving			
20'					
25'					
30'					

LOG OF BORING 35

BRUIN GEOTECHNICAL SERVICES INC. est. 2004

Date(s) drilled	**12/1/2023**
Drilling Contractor	**GP Drilling**
Drilling Method	**Hollow Stem Auger**
Drill Rig Type	**CME 65**
Drill Bit Size/Type	**8"**
Sampling Method(s)	**CSS/SPT/Bulk**
Groundwater	**None Encountered**
Borehole Backfill	**Native/ Cuttings**
Hammer Data	**140#, 30" drop**
Logged By:	**AM**
Checked By:	**MS**
Total Depth of Borehole	**20' bgs**
Boring Location:	**See Figure 2**
Notes:	

Client: **Hazen & Sawyer**
Project Number: **23-314**
Project Location: **Palmdale**

Depth	USCS	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
	SP	Light yellowish brown fine to coarse sand w/ occ. #4-1/2" gravel Medium dense, dry	6-6	DIST	1.7
	SP	Light yellowish brown fine to coarse sand w/ occ. #4-1" gravel Loose, slightly moist	2-4		3.5
5'	SM	Yellowish brown silty fine to coarse sand w/ frequent #4 gravel & occ. 3/5"-1" gravel Loose, slightly moist	3-5	99.7	3.5
	SM	Brown very silty fine to medium sand w/ coarse sand & occ. #4-1/2" gravel Medium dense, moist	5-7	117.9	6.5
10'	SM	Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel Medium dense, moist	12-16	117.7	3.2
15'	CL/ML	Dark yellowish brown fine to medium sandy silt w/ occ. Coarse sand & clay binder Firm, very moist	2-4-7		12.9
20'	SP	Greenish brown slightly silty fine to coarse sand w/ occ. #4-3" gravel Very dense, slightly moist	50/2"		
25'		Boring terminated @ 20' bgs No groundwater No caving			
30'					

Date(s) drilled	12/1/2023	**LOG OF BORING 36**	
Drilling Contractor	GP Drilling	Page 1 of 1	
Drilling Method	Hollow Stem Auger		
Drill Rig Type	CME 65	Logged By:	AM
Drill Bit Size/Type	8"	Checked By:	MS
Sampling Method(s)	CSS/SPT/Bulk	Total Depth of Borehole	15' bgs
Groundwater	None Encountered	Boring Location:	See Figure 2
Borehole Backfill	Native/ Cuttings	Notes:	
Hammer Data	140#, 30" drop		

Client: **Hazen & Sawyer**

Project Number: **23-314**

Project Location: **Palmdale**

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
		ML		Moderate brown fine to medium sandy silt w/ occ. coarse sand-#4 gravel & very slight clay Soft, moist	3-4	102.4	12.4
		SM		Moderate brown silty fine to medium sand w/ occ. coarse sand-#4 gravel & clay binder Loose, saturated	3-3	94.7	20.9
5'							
		SM		Moderate brown very silty very fine to medium sand w/ occ. coarse-1/2" gravel Loose, saturated	2-3	105.8	21.5
		CL		Moderate brown fine to medium sandy clay Firm, very moist	4-6-9		14.9
10'							
		SM		Moderate brown silty fine to medium sand w/ occ. coarse sand-1" gravel & slight clay bind Medium dense, very moist	8-11-12		13.5
15'		SC		Moderate brown clayey fine to medium sand w/ occ. coarse sand-1" gravel Medium dense, over saturated	5-9-7		14.2
				Boring terminated @ 15' bgs No groundwater No caving			
20'							
25'							
30'							

SOIL CLASSIFICATION KEY

MAJOR DIVISIONS			SYMBOL	TYPICAL NAMES
Coarse Grained Soils 50% or more larger than #200 sieve	**Gravels** More than half coarse-fraction is larger than No. 4 sieve size	Clean gravels with little or no fines	GW	Well graded gravels, gravel-sand mixtures
			GP	Poorly graded gravels, gravel-sand mixtures
		Gravel with over 12% fines	GM	Silty gravels, poorly graded gravel-sand-silt mixtures
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures
	Sands More than half coarse-fraction is smaller than No. 4 sieve size	Clean sands with little or no fines	SW	Well graded sands, gravelly sands
			SP	Poorly graded sands, gravelly sands
		Sands with over 12% fines	SM	Silty sands, poorly graded sand-silt mixtures
			SC	Clayey sands, poorly graded sand-clay mixtures
Fine Grained Soils 50% or more smaller than #200 sieve	**Silts and Clays** Liquid limit less than 50		ML	Inorganic silts, rock flour, clayey silts
			CL	Inorganic clays of low to medium plasticity, sandy clays, silty clays
			OL	Organic clays and organic silty clays of low plasticity
	Silts and Clays Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy/silty soils, elastic silts
			CH	Inorganic clays with high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly Organic Soils			Pt	Peat and other highly organic soils

CLASSIFICATION SYSTEM BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM

44732 Yucca Avenue
Tel (661) 273-9078

Lancaster, California 93534
www.bruingsi.net

Boring Log Key

Depth	Sample	USCS	Graphic Log	Material Description	Penetration Resistance (Blows/6")	Dry Unit Weight pcf	Water Content %
1	2	3	4	5	6	7	8

COLUMN DESCRIPTIONS

1	Depth in feet below the ground surface	5	Description of the material encountered. May include consistency, moisture, color, and other descriptors
2	Sampling Method see "symbols" below	6	Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval
3	USCS symbol	7	Dry weight per unit volume of soil sample measured in laboratory units in pounds per cubic foot
4	Graphic depiction of the subsurface material	8	Water content of the sample expressed as a percentage of the dry weight of the sample

ABBREVIATIONS

DIST = Disturbed Sample

N/R = No Recovery

CHEM = Chemical Test

N/A = Not Analyzed

SAMPLING METHOD SYMBOLS

California Split Spoon (CSS)

Standard Penetration Test (SPT)

Bulk Sample

Grab Sample

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

APPENDIX B

Laboratory Test Data

SUMMARY OF LABORATORY TEST RESULTS

SIEVE ANALYSIS

Percent passing individual sieves

Sample I.D.	1/2"	3/8"	#4	#10	#40	#100	#200
B1@1	100	99	94	86	74	64	53
B1@7	99	99	98	96	87	76	63
B1@15	97	94	88	75	37	20	14
B2@2	0	100	98	90	60	47	41
B3@1	97	97	95	90	66	50	44
B3@7	96	94	90	77	45	27	19
B3@15	99	97	95	81	44	26	20
B4@1	99	98	94	83	50	32	25
B4@15	98	98	96	88	63	48	38
B6@2	99	96	88	72	39	23	18
B6@12	97	97	92	82	59	37	27
B7@4	100	98	93	80	42	24	20
B7@9	96	94	88	80	55	38	30
B8@2	0	100	99	95	70	63	42
B8@4	0	100	99	93	61	42	32
B8@6	99	99	98	90	59	38	26

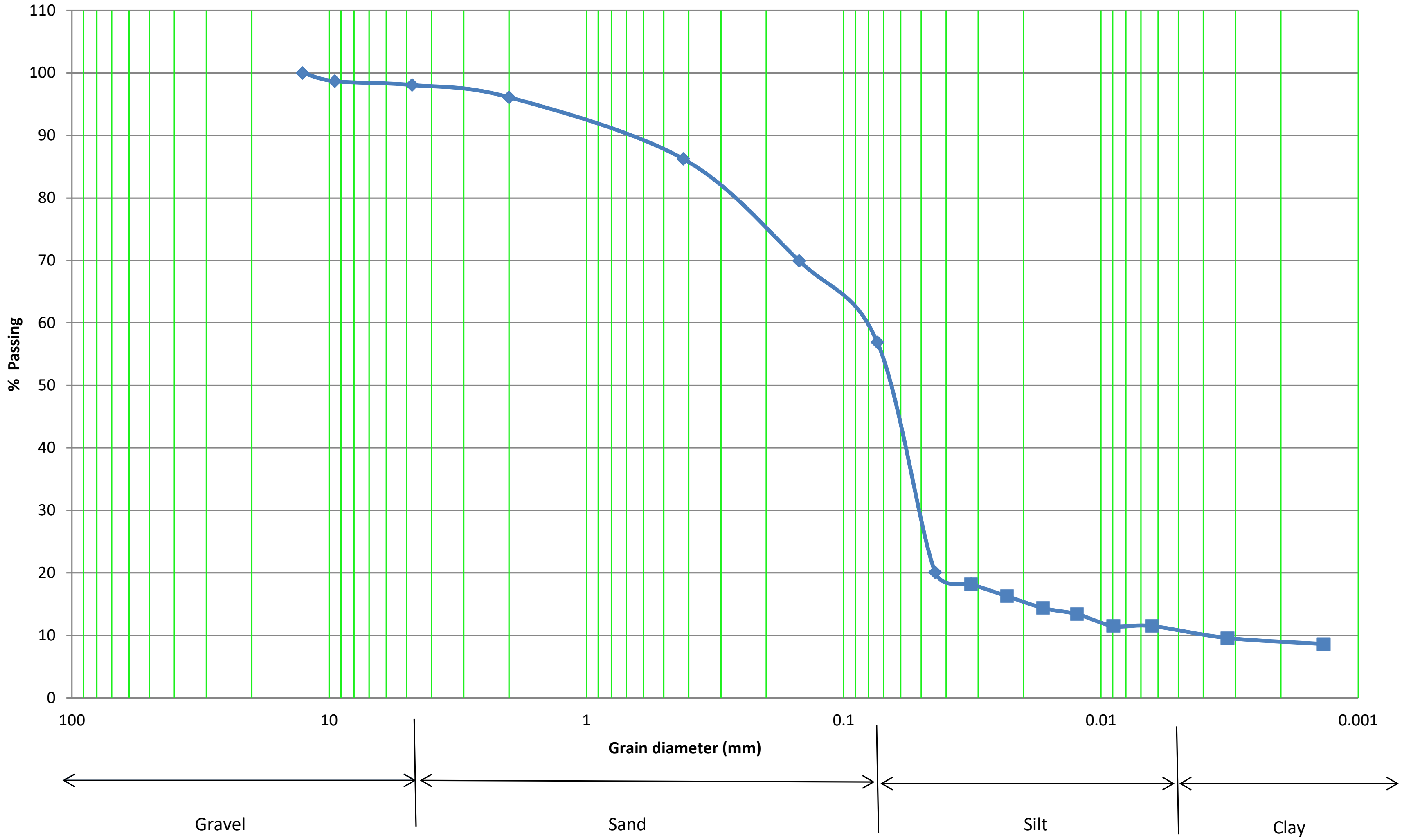
SAND EQUIVALENT

Sample I.D.	Sand Equivalent
B2@6	11
B9@6’	14
B10@7’	19
B11@5’	20
B12@4’	47
B13@5	11
B14@10’	2
B15@5’	41
B16@4’	39
B17@9’	33
B20@6’	11

B20@12’	11
B21@3’	23
B21@10’	32
B23@6’	34
B24@4’	28
B25@5’	58
B26@12’	30
B28@8’	54
B29@5’	28
B30@6’	40
B31@5’	31
B32@2’	43
B33@5’	68

EXPANSION INDEX

Sample I.D.	Expansion Index	Classification
B1@0-5’	0	Non-Expansive
B11@3-8’	0	Non-Expansive
B14@6-11’	0	Non-Expansive
B22@6-11’	0	Non-Expansive
B36@0-5’	0	Non-Expansive



Grain Size Distribution Curve (ASTM D422)

Job Number: 23-314

Client Name: Hazen & Sawyer

Sample I.D.: B1@1'

Coefficient of Uniformity, Cu: 24.67

Particle range, mm: 12.699

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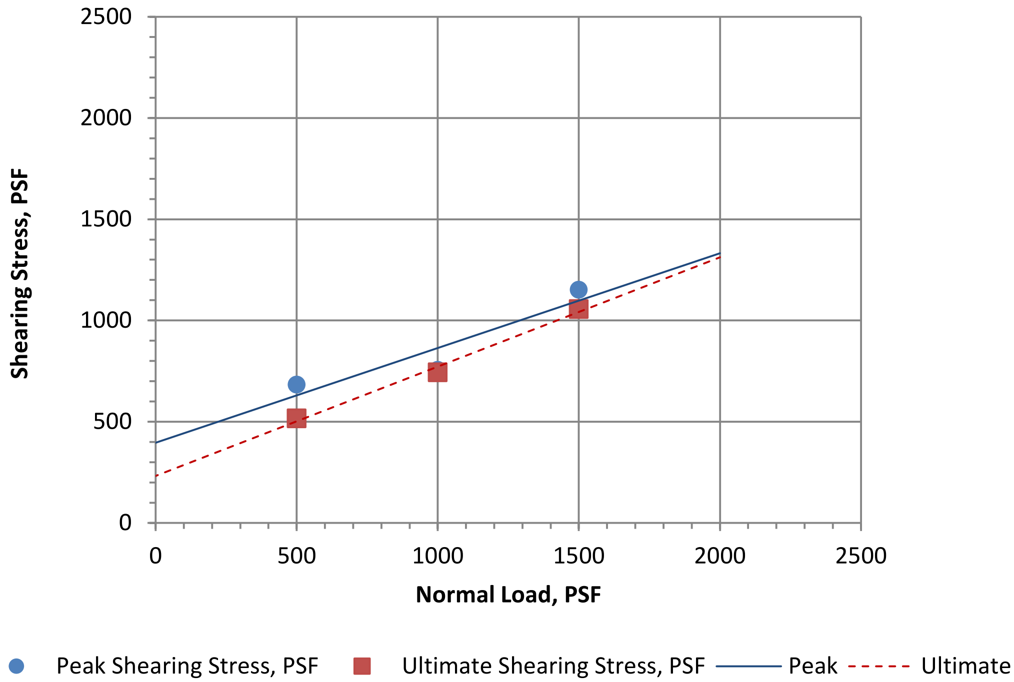
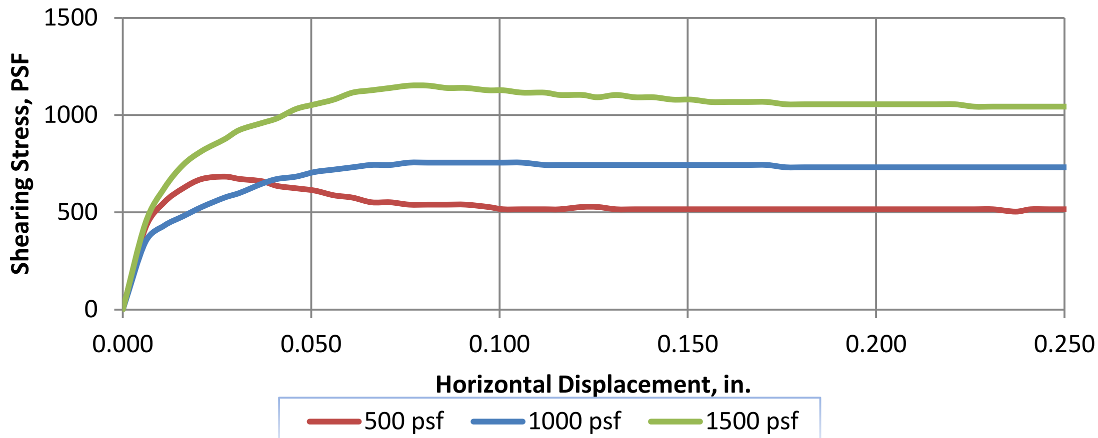




Sample Description: (SM) - Brown silty fine to medium sand w/ coarse sand & occ. #4 gravel

Direct Shear Test

Hazen and Sawyer

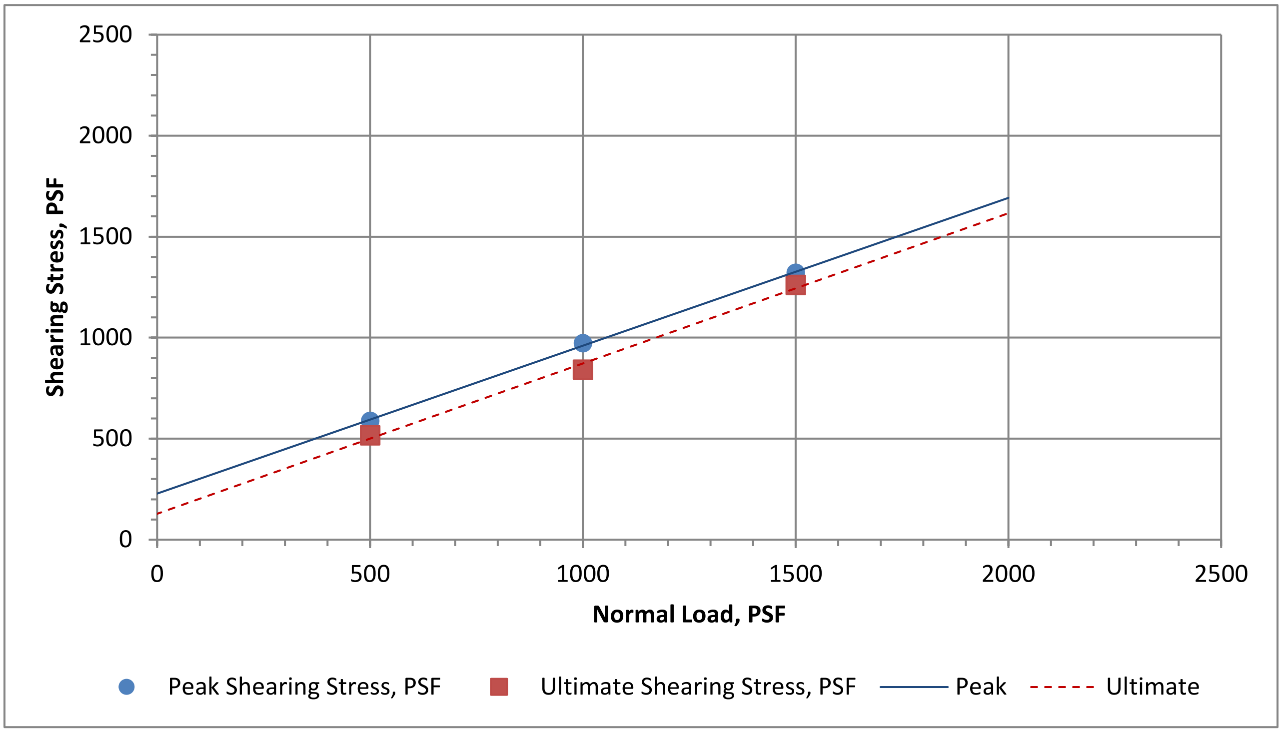
23-314

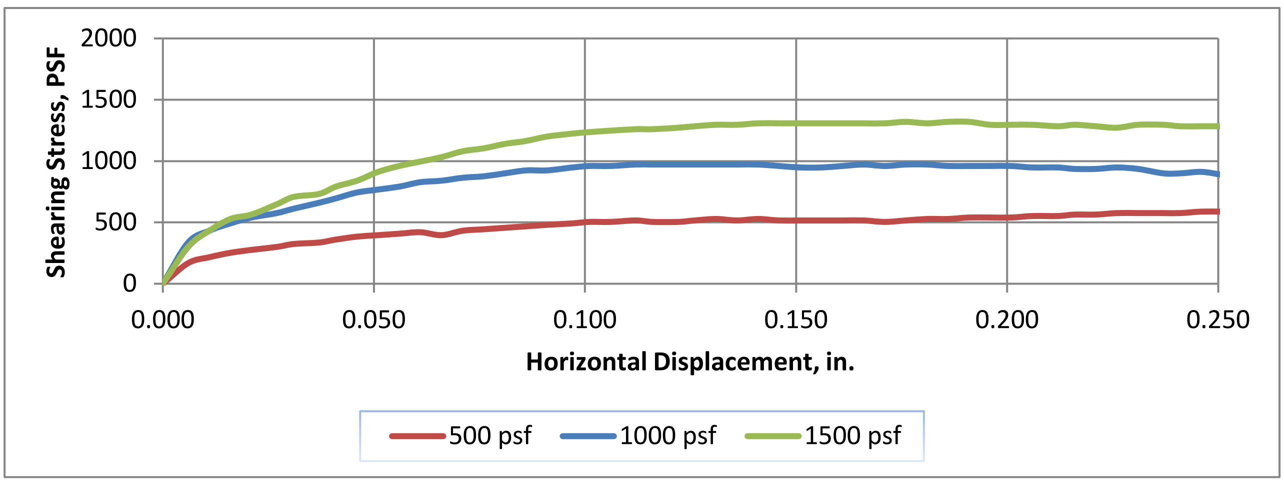
DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B1	●	0-5'	108	101

* Sample remolded to 90% relative compaction as determined by ASTM D-1557 Test Method

	Peak	Ultimate
Angle of friction, (degrees)	25	28
Cohesive Strength (PSF)	396	232





Sample Description: (SC) - Dark yellowish red clayey medium to coarse sand w/ occ. #4 gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B4	●	4	108	83

	Peak	Ultimate
Angle of friction, (degrees)	36	37
Cohesive Strength (PSF)	228	128

Direct Shear Test

Hazen and Sawyer

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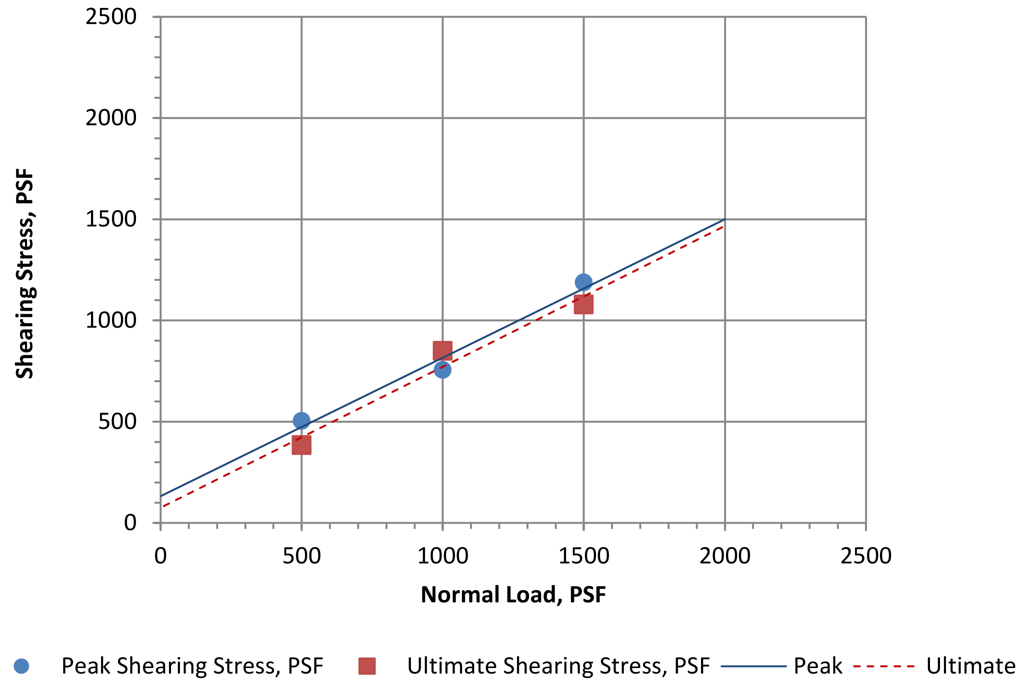
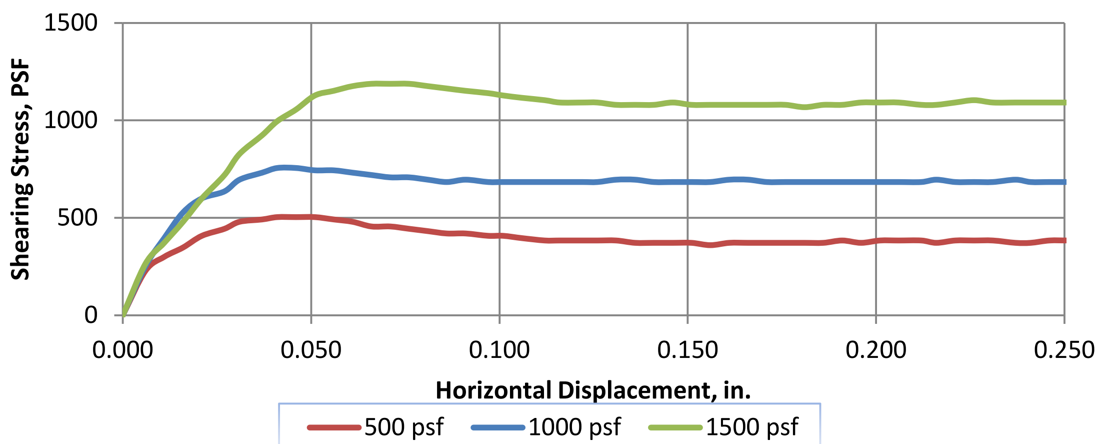
J.N. 23-314





Sample Description: (SP) - Yellowish brown slightly silty fine to coarse sand w/ occ. #4 gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B11	●	3-8'	114	84

* Sample remolded to 90% relative compaction as determined by ASTM D-1557 Test Method

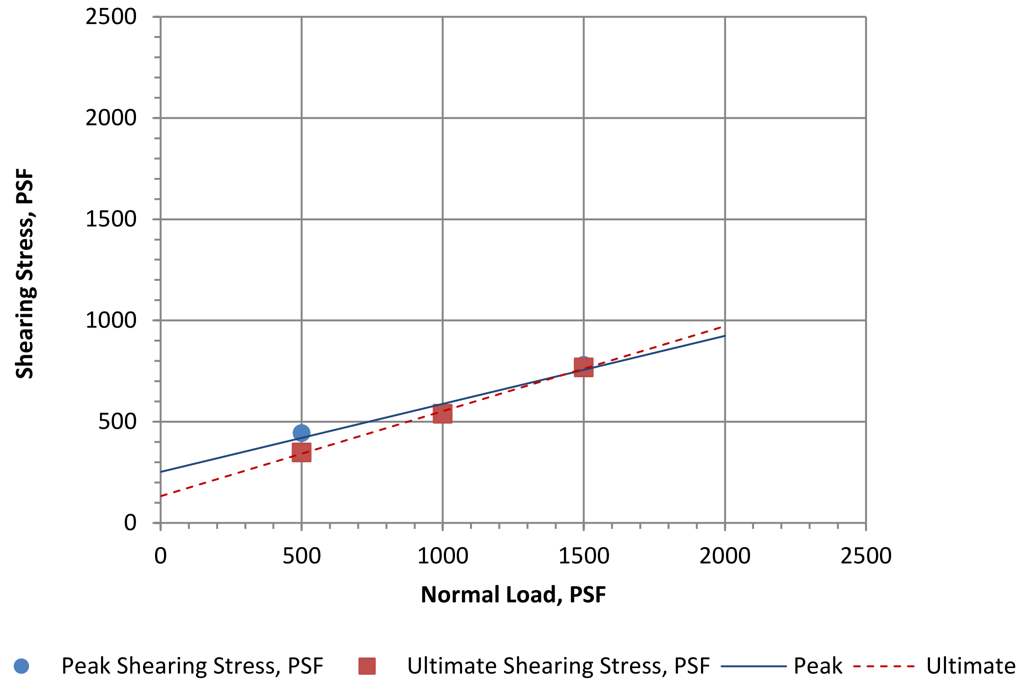
	Peak	Ultimate
Angle of friction, (degrees)	34	35
Cohesive Strength (PSF)	132	75

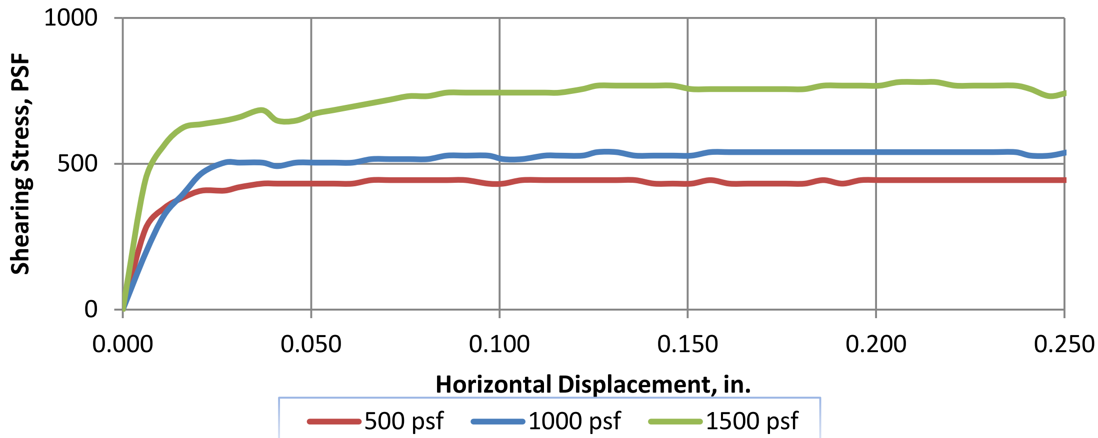
Direct Shear Test

Hazen and Sawyer

BRUIN GEOTECHNICAL SERVICES INC.

23-314





Sample Description: (SP) - Moderate brown silty fine to medium sandy clay

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B14	●	6-11'	106	124

* Sample remolded to 90% relative compaction as determined by ASTM D-1557 Test Method

	Peak	Ultimate
Angle of friction, (degrees)	19	23
Cohesive Strength (PSF)	252	132

Direct Shear Test

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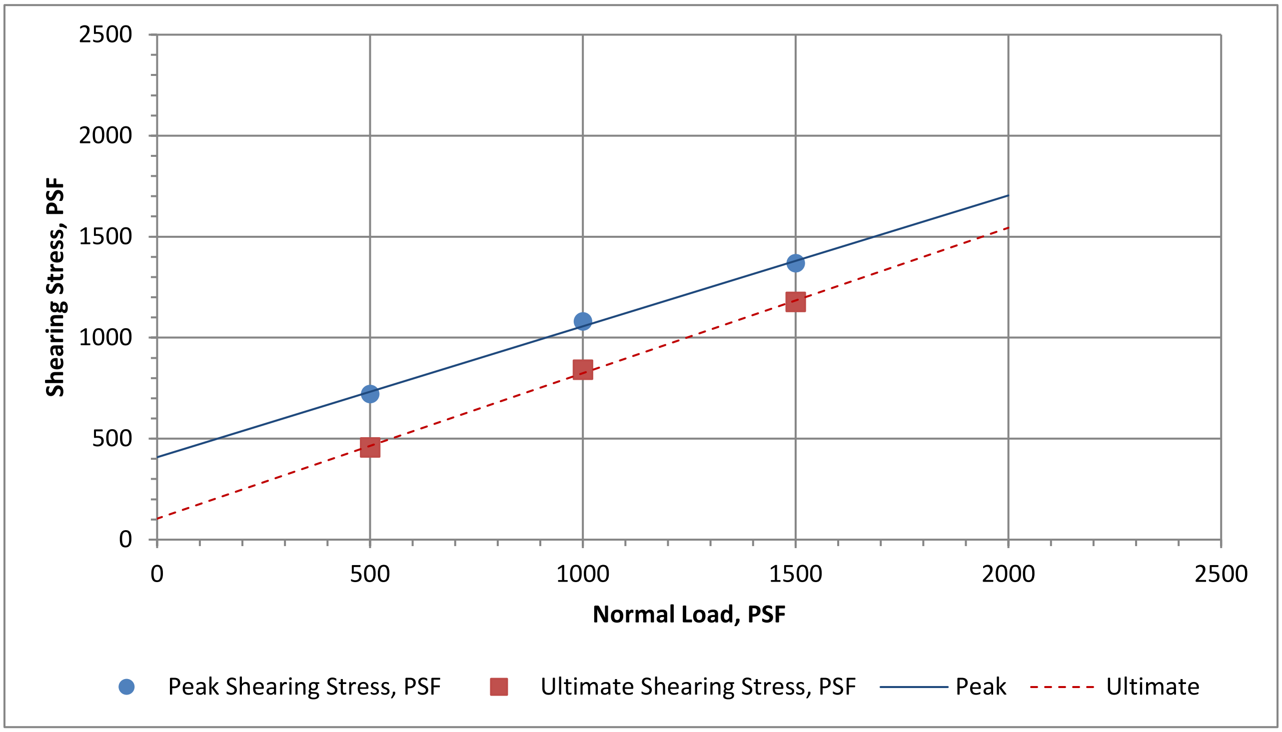
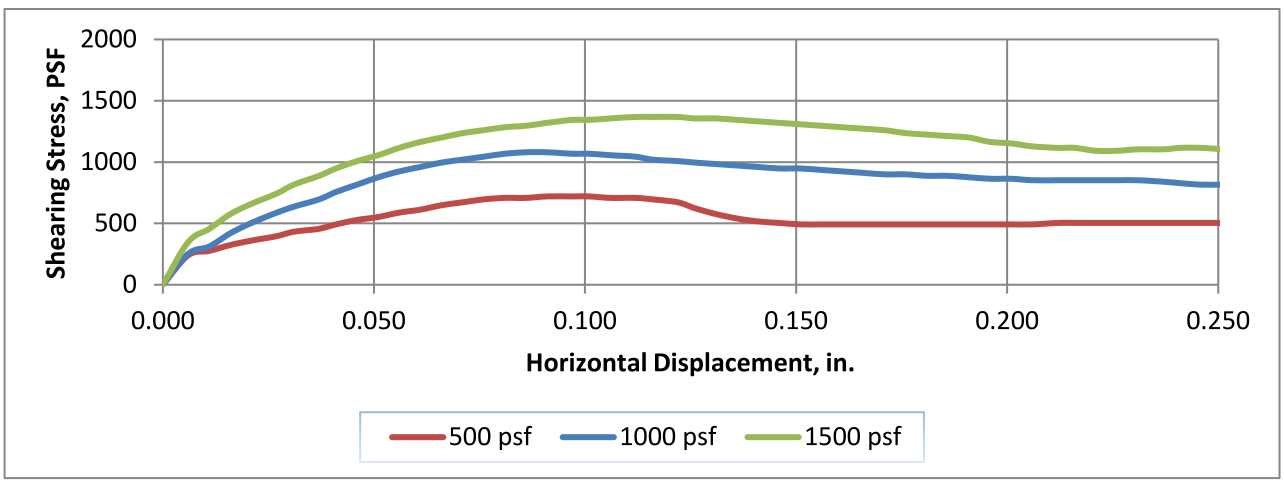
23-314





Sample Description: (ML) - Yellowish brown silty fine to coarse sand w/ occ. #4-1" gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B15	●	8	122.7	92

	Peak	Ultimate
Angle of friction, (degrees)	33	36
Cohesive Strength (PSF)	408	104

Direct Shear Test

Hazen and Sawyer

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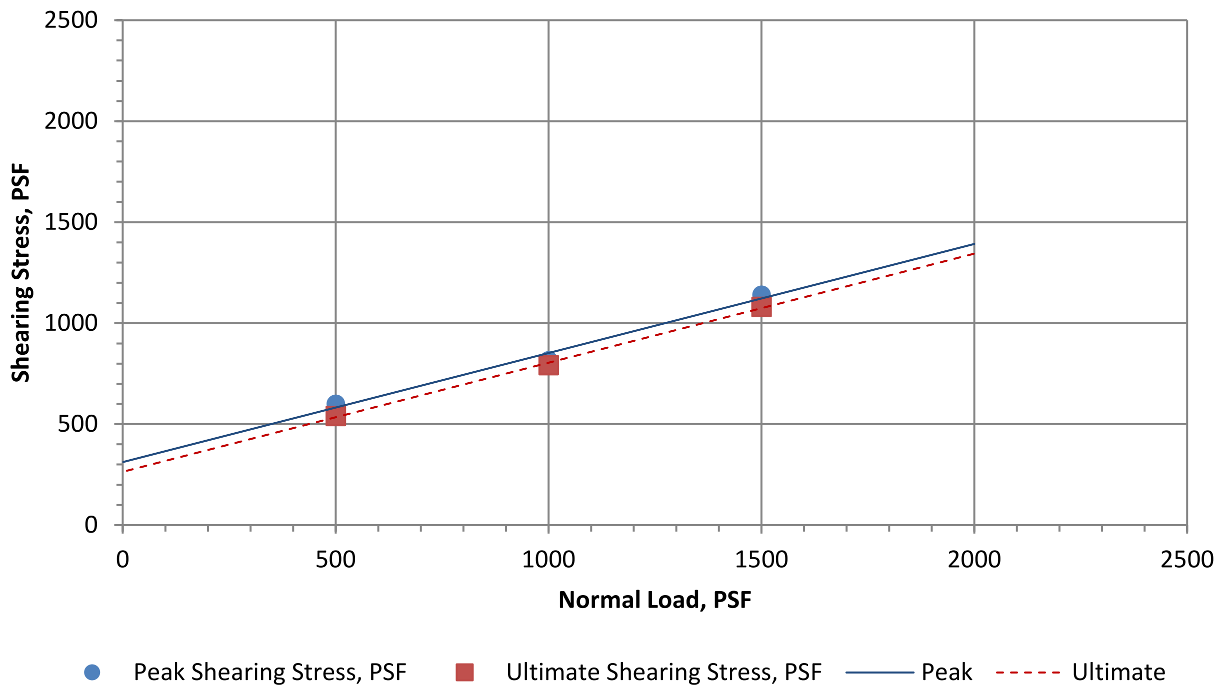
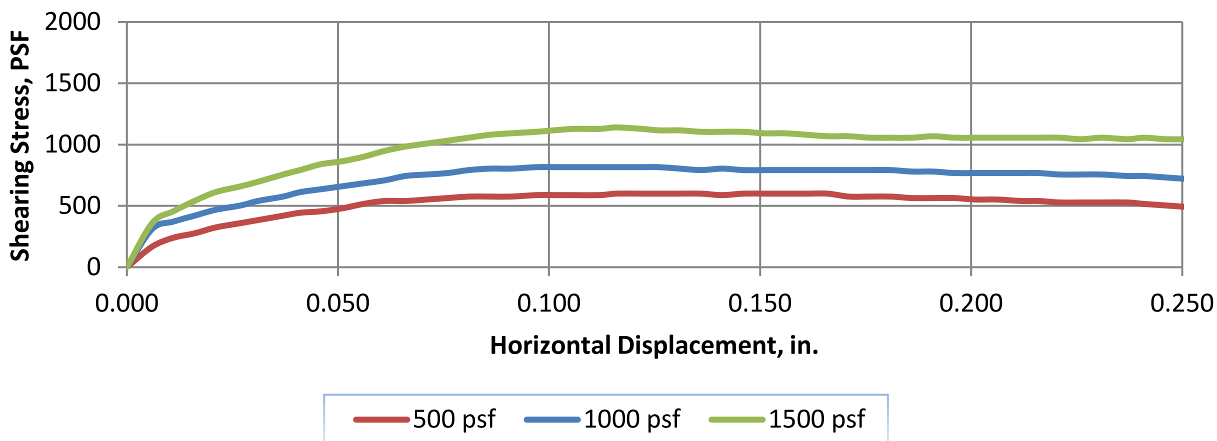
GEOTECHNICAL SERVICES INC.
est. 2004

J.N. 23-314





Sample Description: (ML) - Dark yellowish brown clayey silty w/ fine sand & clay binder

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B17	●	3	114.5	92
			Peak	Ultimate
Angle of friction, (degrees)			28	28
Cohesive Strength (PSF)			312	264

Direct Shear Test

Hazen and Sawyer

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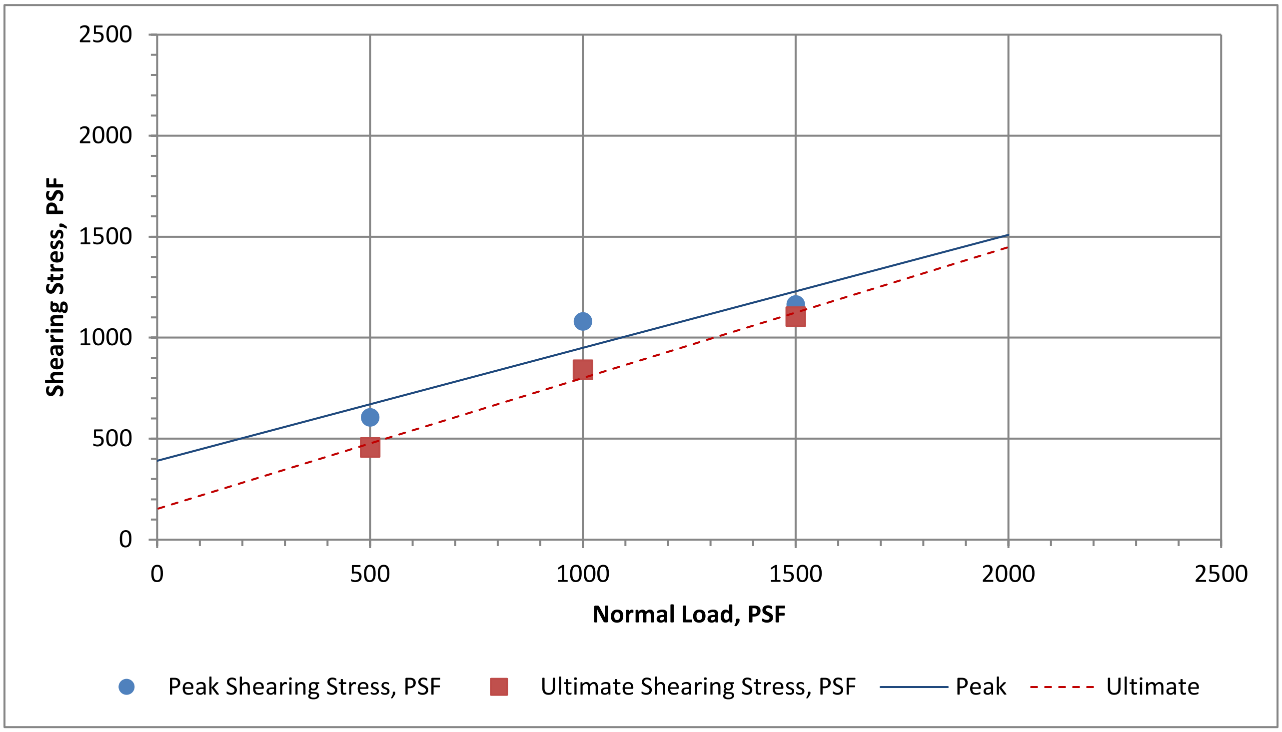
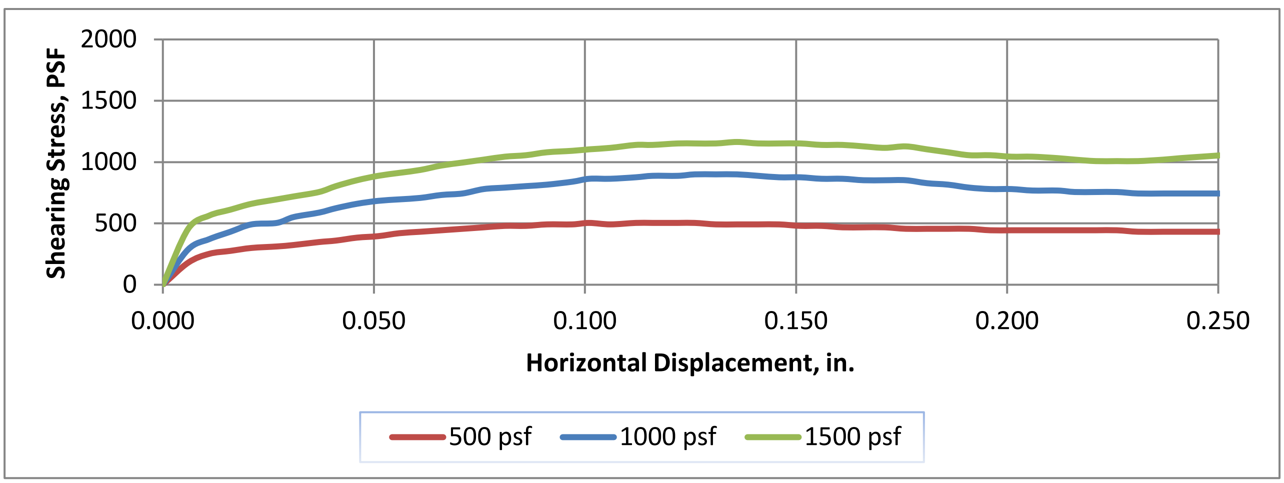
J.N. 23-314





Sample Description: (ML) - Dark brown clayey silt w/ fine sand & clay binder

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B19	●	8'	111.7	84

	Peak	Ultimate
Angle of friction, (degrees)	29	33
Cohesive Strength (PSF)	390	152

Direct Shear Test

Hazen and Sawyer

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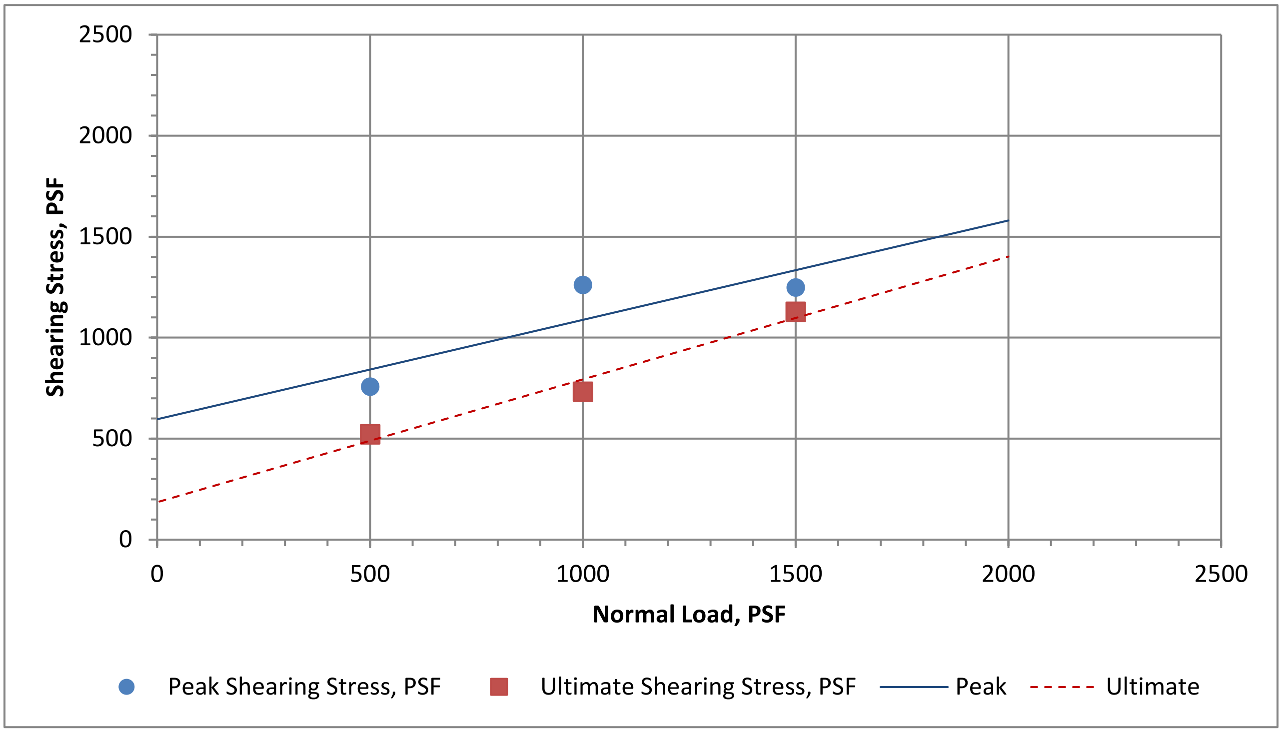
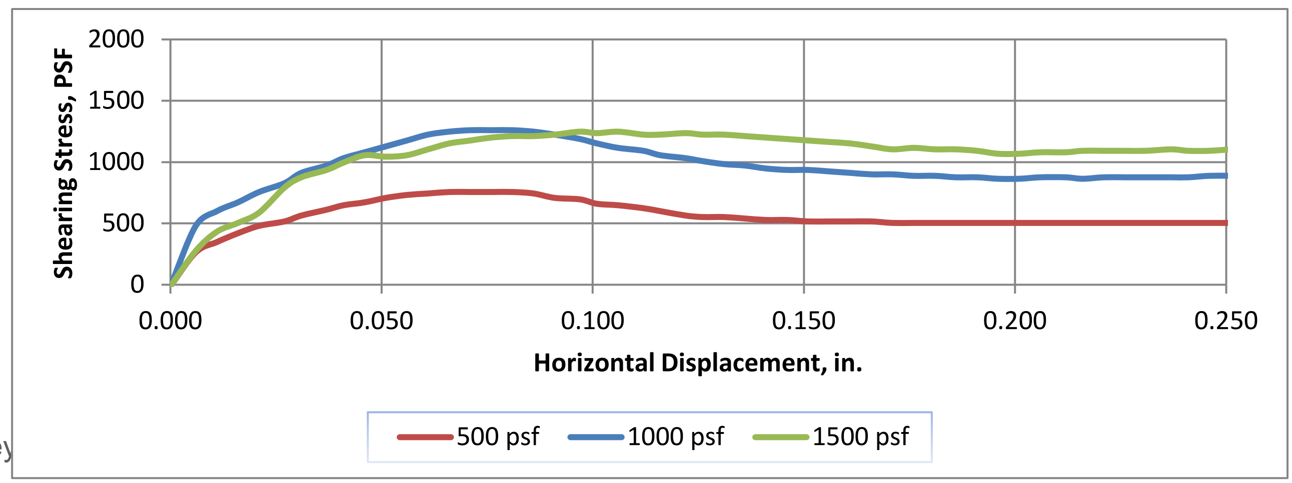
J.N. 23-314





Sample Description: (SM) - Light yellowish brown silty fine to coarse sand (cemented)

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B22	●	2	124.3	90
			Peak	Ultimate
Angle of friction, (degrees)			26	31
Cohesive Strength (PSF)			596	185

Direct Shear Test

Hazen and Sawyer

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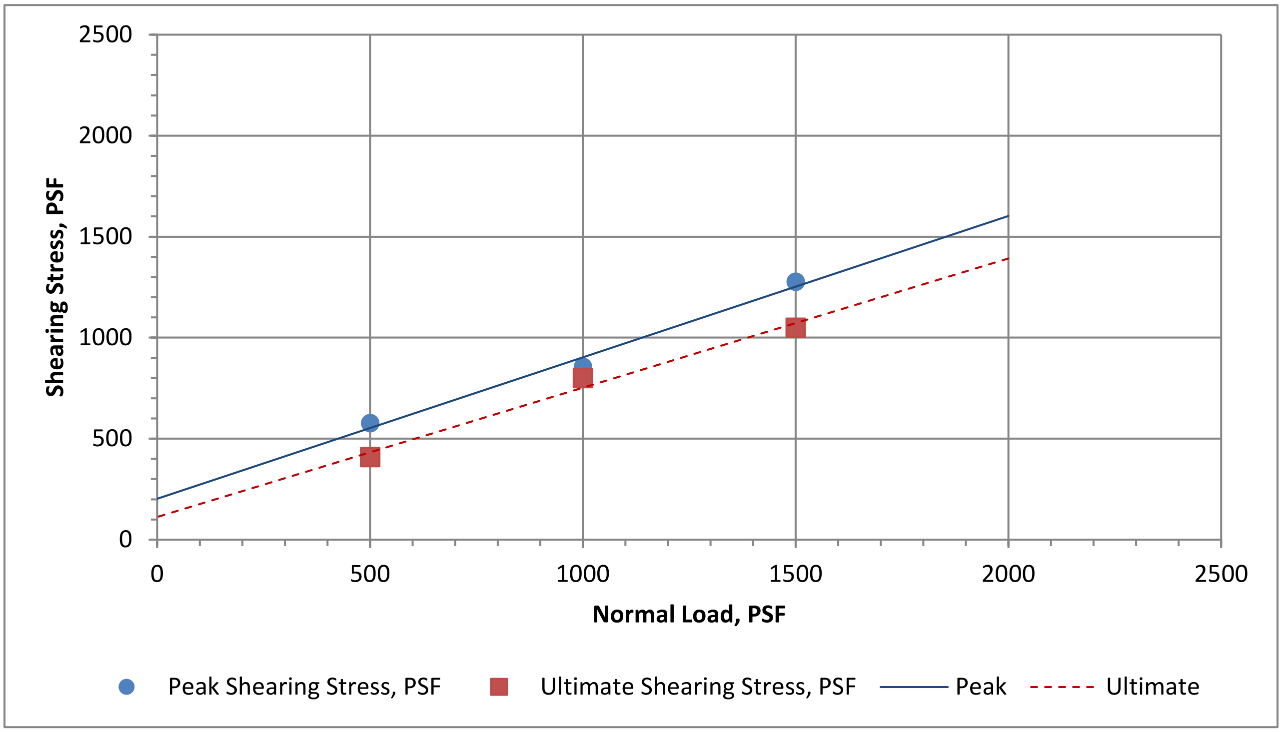
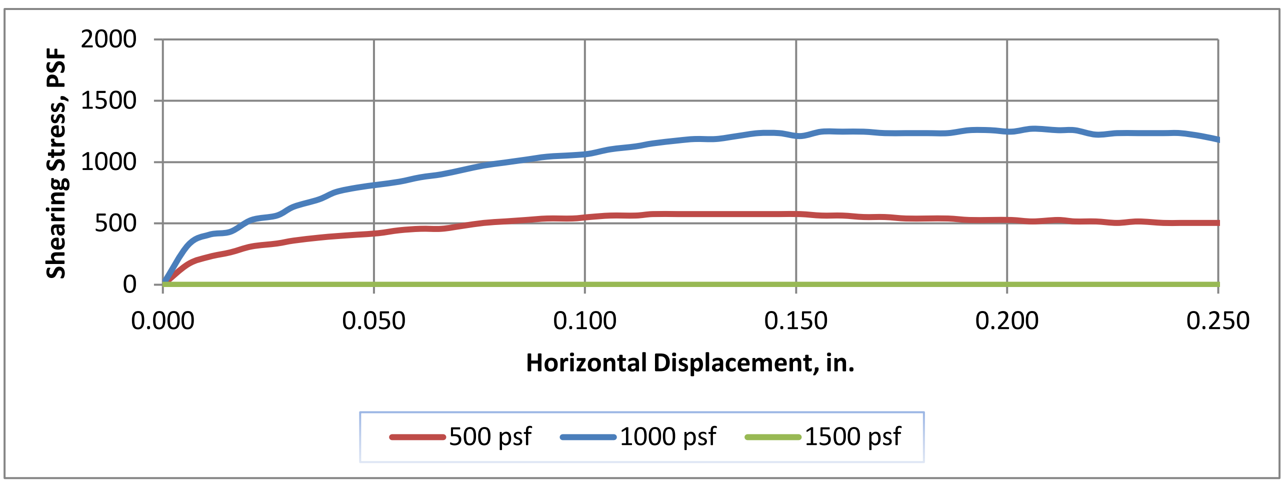
J.N. 23-314





Sample Description: (SM) - Yellowish brown silty fine to coarse sand w/ occ. #4-2" gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B26	●	5	112	76

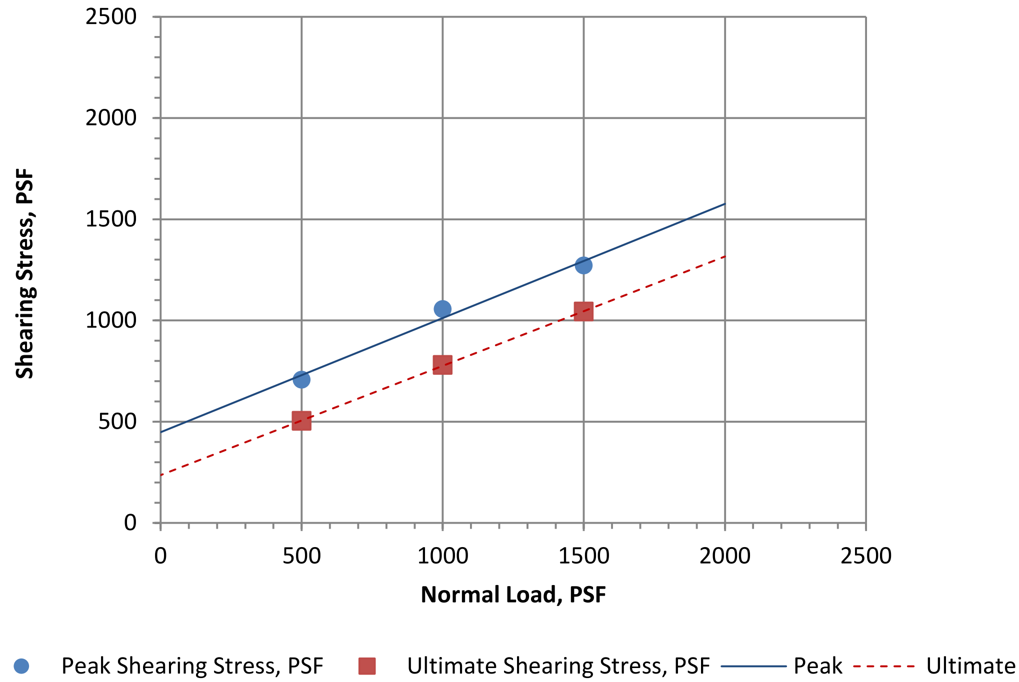
	Peak	Ultimate
Angle of friction, (degrees)	35	33
Cohesive Strength (PSF)	202	112

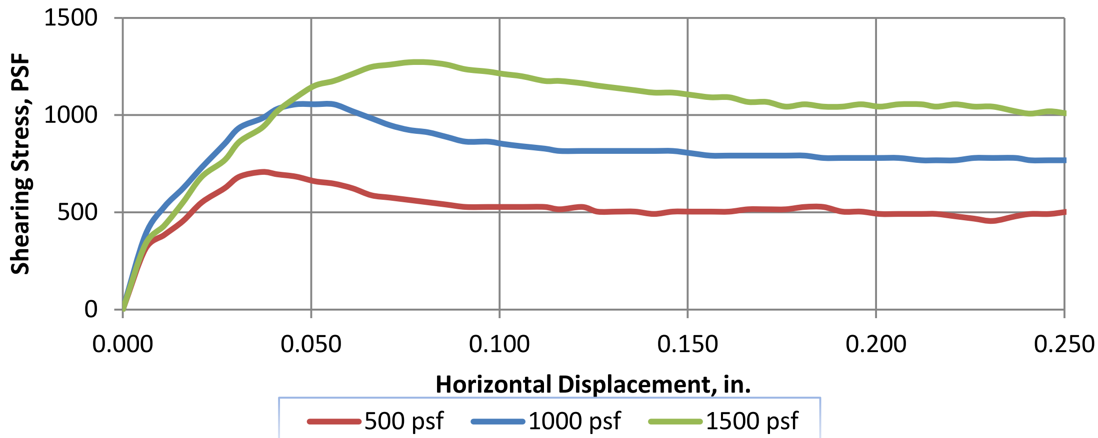
Direct Shear Test

Hazen and Sawyer

BRUIN GEOTECHNICAL SERVICES INC. est. 2004

J.N. 23-314





Sample Description: (SP) - Yellowish brown slightly silty fine to coarse sand w/ occ. #4-1" gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B26	●	6-11'	120	94

* Sample remolded to 90% relative compaction as determined by ASTM D-1557 Test Method

	Peak	Ultimate
Angle of friction, (degrees)	29	28
Cohesive Strength (PSF)	448	236

Direct Shear Test

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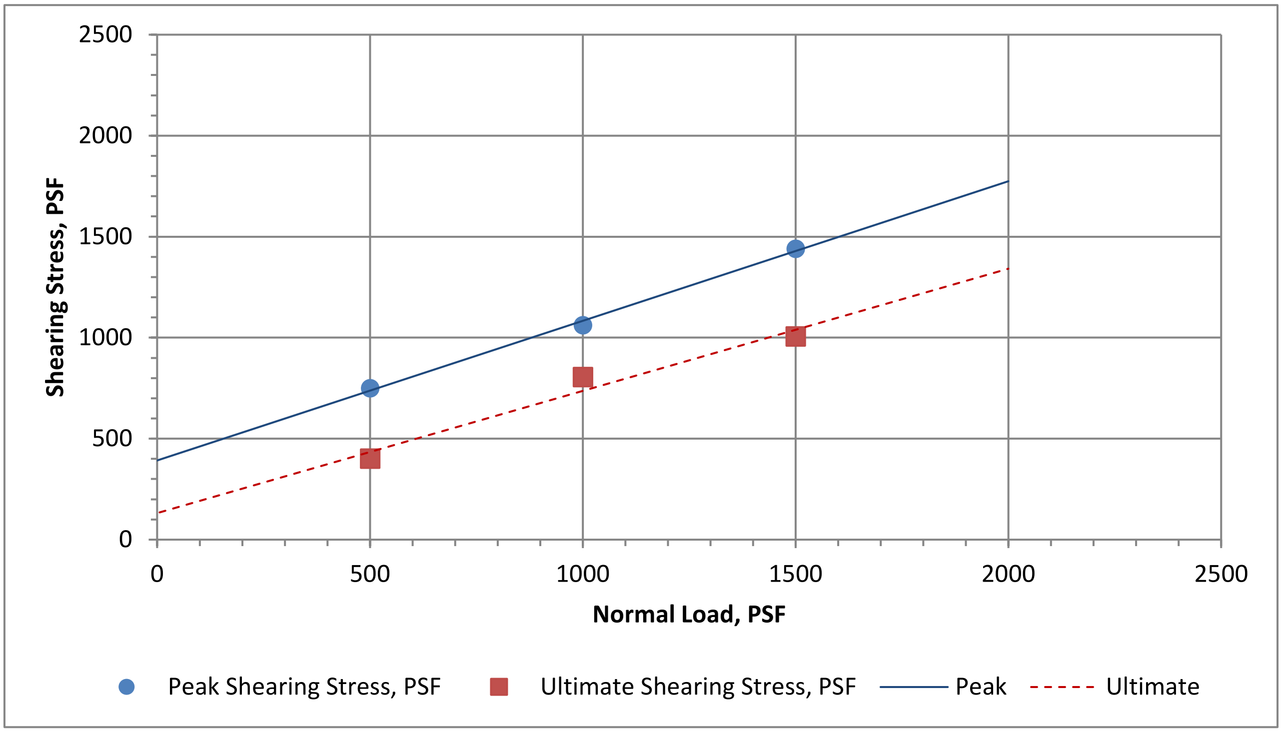
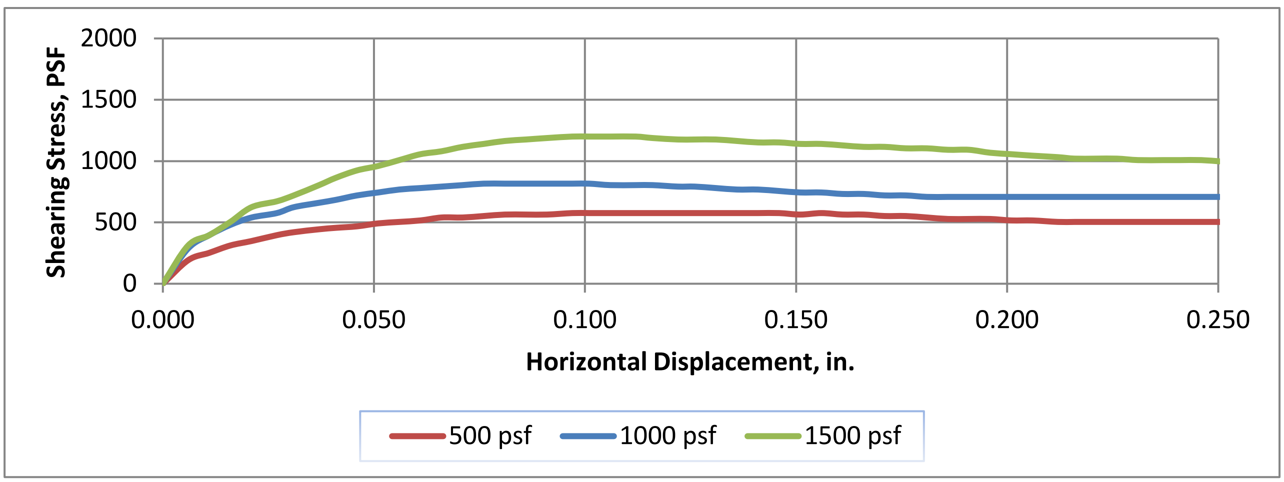
23-314





Sample Description: (SP) - Yellowish brown slightly silty fine to medium sand w/ coarse sand & occ. #4 gravel

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B28	●	6	91	100
			Peak	Ultimate
Angle of friction, (degrees)			35	31
Cohesive Strength (PSF)			392	131

Direct Shear Test

Hazen and Sawyer

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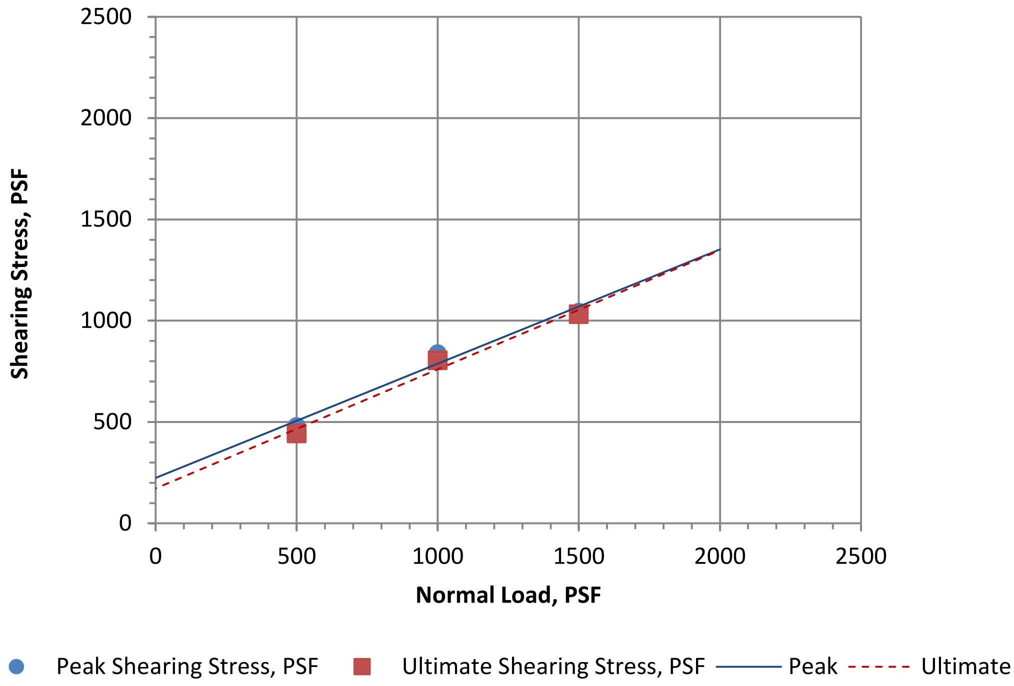
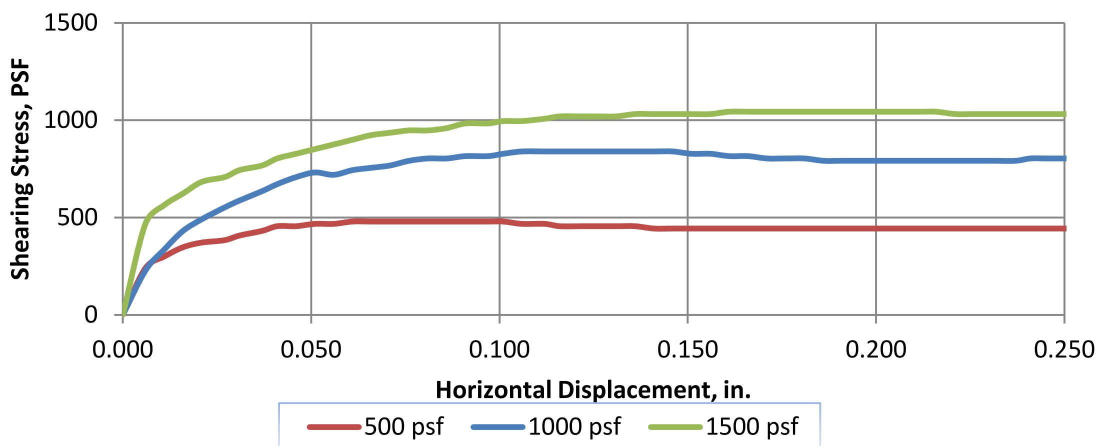
est. 2004

J.N. 23-314





Sample Description: (SP) - Moderate brown silty fine to medium sand w/ coarse sand & clay binder

Direct Shear Test

Hazen and Sawyer

BRUIN GEOTECHNICAL SERVICES INC.

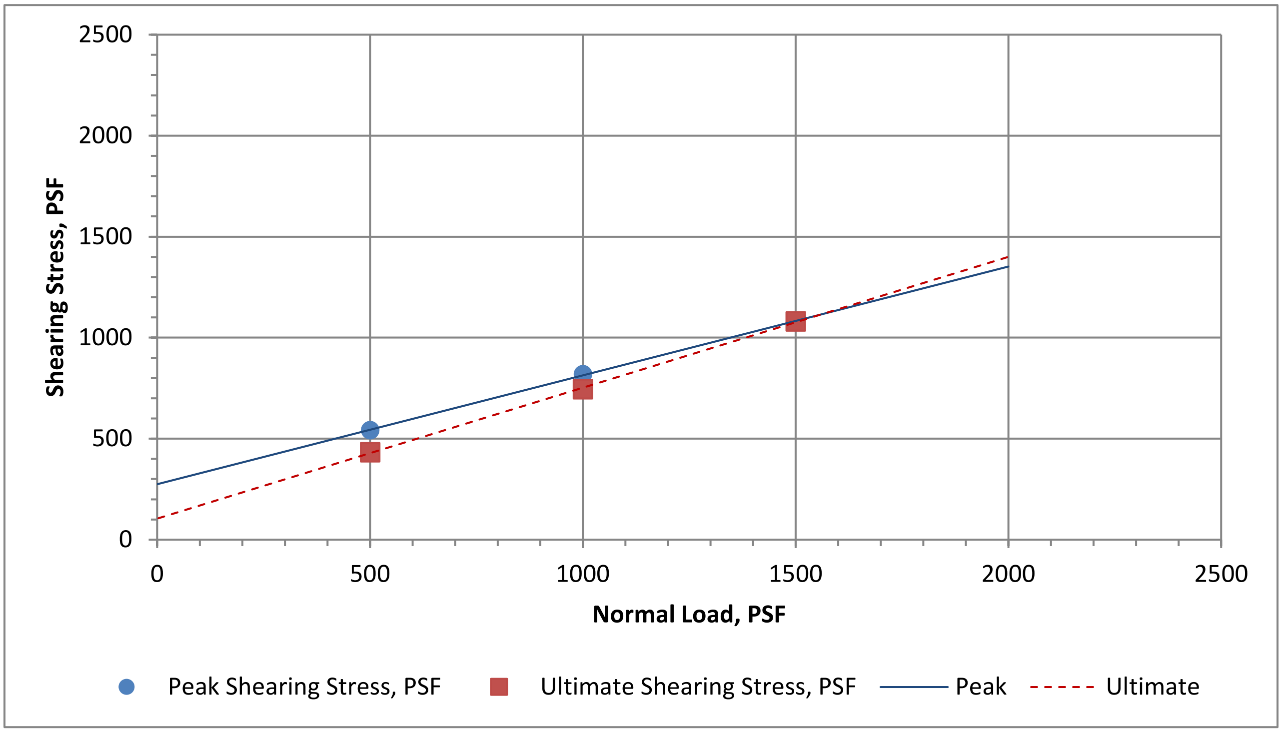
23-314

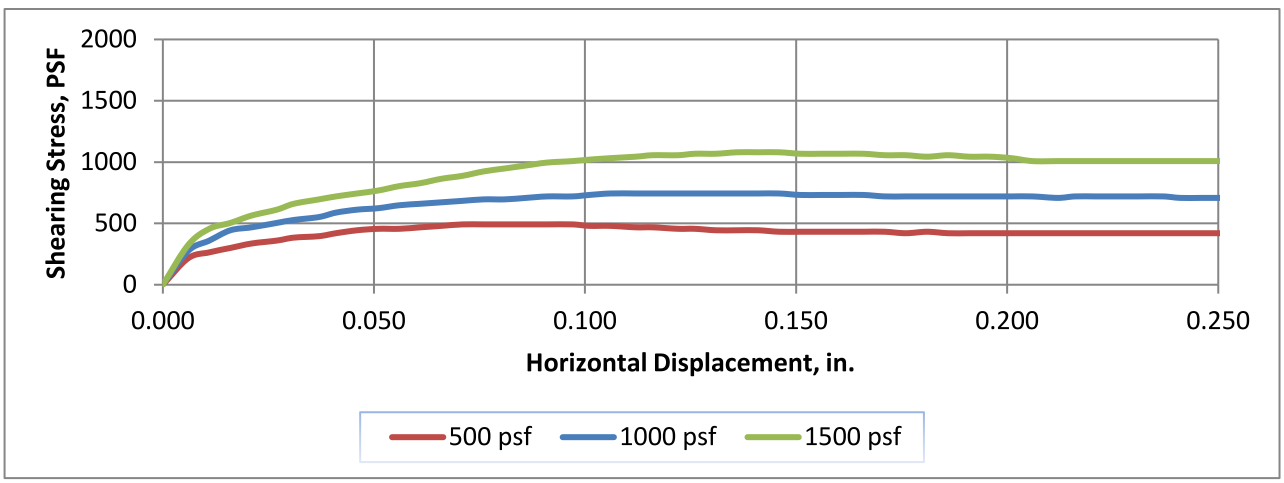
DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B36	●	0-5'	107	99

* Sample remolded to 90% relative compaction as determined by ASTM D-1557 Test Method

	Peak	Ultimate
Angle of friction, (degrees)	29	30
Cohesive Strength (PSF)	224	172





Sample Description: (SM) - Moderate brown silty fine to medium sand w/ coarse sand

DIRECT SHEAR DATA (ASTM D-3080)

Sample ID	Symbol	Depth, feet	Dry Density, PCF	Average deg. of saturation
B36	●	4	94.7	86
			Peak	Ultimate
Angle of friction, (degrees)			28	33
Cohesive Strength (PSF)			274	104

Direct Shear Test

Hazen and Sawyer

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GEOTECHNICAL SERVICES INC.
est. 2004

J.N. 23-314

ANAHEIM TEST LAB, INC

196 Technology Drive, Unit D
Irvine, CA 92618
Phone (949) 336-6544

Bruin Geotechnical Services, Inc.
44732 Yucca Avenue
Lancaster, CA 93534

DATE: 1/2/2024

P.O. NO.: Transmittal

LAB NO.: C-7587, 1-2

SPECIFICATION: CTM-643/417/422

MATERIAL: Soil

Project No.: 23-314
Project: Hazen & Sawyer
Littlerock Reservoir, Littlerock, CA

ANALYTICAL REPORT

CORROSION SERIES
SUMMARY OF DATA

	pH	MIN. RESISTIVITY per CT. 643 ohm-cm	SOLUBLE SULFATES per CT. 417 (% by weight)	SOLUBLE CHLORIDES per CT. 422 ppm
1) B1 @ 0-5'	7.5	1,900	0.0164%	39
2) B11 @ 3-8'	7.4	2,200	0.0123%	47

RESPECTFULLY SUBMITTED

WES BRIDGER, LAB MANAGER

ANAHEIM TEST LAB, INC
196 Technology Drive, Unit D
Irvine, CA 92618
Phone (949) 336-6544

DATE: 1/8/2024

Bruin Geotechnical Services, Inc.
44732 Yucca Avenue
Lancaster, CA 93534

P.O. NO.: Transmittal

LAB NO.: C-7602, 1-5

SPECIFICATION: CTM-643/417/422

MATERIAL: Soil

Project No.: 23-314
Project: Hazen & Sawyer
Littlerock Reservoir, Palmdale, CA

ANALYTICAL REPORT

CORROSION SERIES
SUMMARY OF DATA

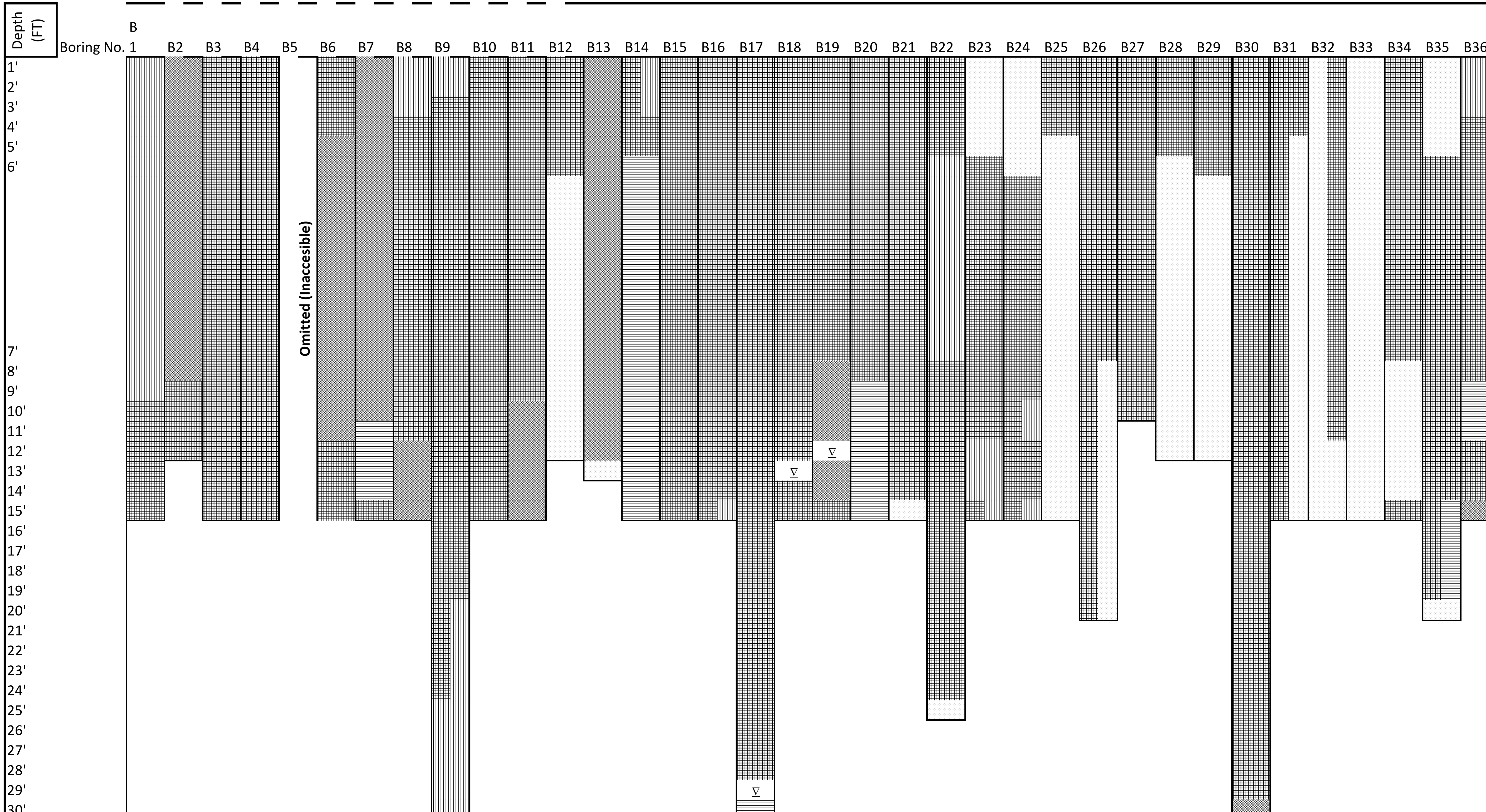
	pH	MIN. RESISTIVITY per CT. 643 ohm-cm	SOLUBLE SULFATES per CT. 417 (% by weight)	SOLUBLE CHLORIDES per CT. 422 ppm
1) B14 @ 6-11'	7.5	<500	0.0967%	291
2) B22 @ 6-11'	7.7	5,000	0.0193%	34
3) B26 @ 6-11'	7.3	10,500	0.0181%	81
4) B31 @ 0-5'	7.4	10,200	0.0209%	61
5) B36 @ 0-5'	7.5	900	0.0246%	153

RESPECTFULLY SUBMITTED

WES BRIDGER, LAB MANAGER

APPENDIX C

Boring Soil Classification Profile



Borings	B4&B5	B6	B8 to B12	B15&B16	B17&B18	B23&B24	B27&B28
Est. Pipe Depth	11'-14' bgs	14' bgs	10'-16' bgs	10'-13' bgs	10'-17' bgs	10'-18' bgs	10'-14' bgs
Est. E'	700	700	500-700	500	500	700	700

Soil Graphic Legend

SM: ML: SP: CL: SC:

Other Graphic Legend

Ground Water: ∇

Note: Refer to boring logs for detailed information

Palmdale Ditch Conversion Project

Boring Soil Classification Profile

BRUIN GEOTECHNICAL SERVICES INC. est. 2004

JN: 23-314

14-Feb-24

APPENDIX D

Groundwater Well Locations

Vicinity of Borings 1 to 6 (Location 1 & 2)
Site Code: 345353N1181046W001
Local Well Name: 05N12W11B001S
Latitude: 34.53530
Longitude: -118.10460
Last test: 1986
Groundwater: 50’ bgs

Vicinity of Borings 7 to 16 (Location 3 & 4)
Site Code: 345356N1180793W001
Local Well Name: 05N11W07E002S
Latitude: 34.53560
Longitude: -118.07930
Last test: 1977
Groundwater: 20’ bgs

Vicinity of Borings 17 to 20 (Location 5)
Site Code: 345292N1180335W001
Local Well Name: 05N11W09Q001S
Latitude: 34.52920
Longitude: -118.03350
Last test: 1971
Groundwater: 68’ bgs

Vicinity of Borings 21 to 30 (Location 6 & 7)
Site Code: 345147N1180301W001
Local Well Name: 05N11W16R001S
Latitude: 34.51470
Longitude: -118.03010
Last test: 1978
Groundwater: 60’ bgs

Vicinity of Borings 31 to 35
Site Code: 345086N1180299W001
Local Well Name: 05N11W21H002S
Latitude: 34.50860
Longitude: -118.02990
Last test: 1986
Groundwater: 27’ bgs

Reference: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

APPENDIX E

USGS Seismic Design Summary Report

OSHPD

23-314 Hazen and Sawyer

Latitude, Longitude: 34.53822615, -118.10193376

Date	2/2/2024, 3:00:27 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	2.465	MCE_R ground motion. (for 0.2 second period)
S_1	1.05	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.465	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	1.643	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	null -See Section 11.4.8	Site amplification factor at 1.0 second
PGA	1.059	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	1.165	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	2.975	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	3.4	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.465	Factored deterministic acceleration value. (0.2 second)
S1RT	1.278	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	1.467	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	1.05	Factored deterministic acceleration value. (1.0 second)
PGAd	1.059	Factored deterministic acceleration value. (Peak Ground Acceleration)

Type	Value	Description
PGA_{UH}	1.366	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.875	Mapped value of the risk coefficient at short periods
C_{R1}	0.871	Mapped value of the risk coefficient at a period of 1 s
C_V	1.5	Vertical coefficient

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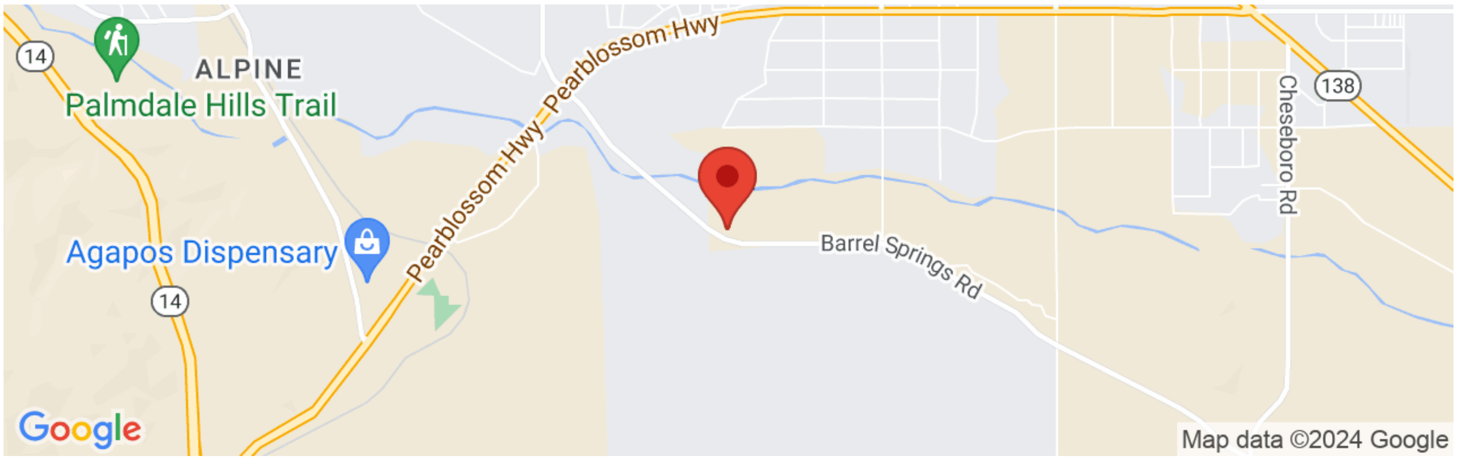
23-314 Hazen and Sawyer

Latitude, Longitude: 34.52907964, -118.07011524



Date	2/2/2024, 3:00:57 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	2.5	MCE_R ground motion. (for 0.2 second period)
S_1	1.065	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.5	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	1.667	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	null -See Section 11.4.8	Site amplification factor at 1.0 second
PGA	1.074	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	1.181	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	2.868	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	3.251	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.5	Factored deterministic acceleration value. (0.2 second)
S1RT	1.23	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	1.416	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	1.065	Factored deterministic acceleration value. (1.0 second)
PGAd	1.074	Factored deterministic acceleration value. (Peak Ground Acceleration)

Type	Value	Description
PGA_{UH}	1.303	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.882	Mapped value of the risk coefficient at short periods
C_{R1}	0.869	Mapped value of the risk coefficient at a period of 1 s
C_V	1.5	Vertical coefficient

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USGS web services are now operational so this tool should work as expected.

23-314 Hazen and Sawyer

Latitude, Longitude: 34.50941976, -118.03561130

Date	2/2/2024, 3:01:47 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	2.457	MCE_R ground motion. (for 0.2 second period)
S_1	1.046	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.457	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	1.638	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	null -See Section 11.4.8	Site amplification factor at 1.0 second
PGA	1.056	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	1.162	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	2.953	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	3.336	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.457	Factored deterministic acceleration value. (0.2 second)
S1RT	1.259	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	1.448	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	1.046	Factored deterministic acceleration value. (1.0 second)
PGAd	1.056	Factored deterministic acceleration value. (Peak Ground Acceleration)

Type	Value	Description
PGA_{UH}	1.334	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.885	Mapped value of the risk coefficient at short periods
C_{R1}	0.87	Mapped value of the risk coefficient at a period of 1 s
C_V	1.5	Vertical coefficient

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23-314 Hazen and Sawyer

Latitude, Longitude: 34.49300941, -118.02496829

Date	2/2/2024, 3:02:07 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	2.307	MCE_R ground motion. (for 0.2 second period)
S_1	0.98	MCE_R ground motion. (for 1.0s period)
S_{MS}	2.307	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	1.538	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	null -See Section 11.4.8	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	null -See Section 11.4.8	Site amplification factor at 1.0 second
PGA	0.993	MCE_G peak ground acceleration
F_{PGA}	1.1	Site amplification factor at PGA
PGA_M	1.092	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	2.966	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	3.349	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	2.307	Factored deterministic acceleration value. (0.2 second)
S1RT	1.257	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	1.439	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.98	Factored deterministic acceleration value. (1.0 second)
PGAd	0.993	Factored deterministic acceleration value. (Peak Ground Acceleration)

Type	Value	Description
PGA_{UH}	1.338	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.886	Mapped value of the risk coefficient at short periods
C_{R1}	0.874	Mapped value of the risk coefficient at a period of 1 s
C_V	1.5	Vertical coefficient

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APPENDIX F

Design Guideline for Seismic Resistant Water Pipeline Installations

DESIGN GUIDELINE FOR SEISMIC RESISTANT WATER PIPELINE INSTALLATIONS

John Eidinger[1]

ABSTRACT

Seismic design for water pipelines is not explicitly included in current AWWA standards. Compounding this problem, standard water pipeline materials and installation techniques are prone to high damage rates whenever there is significant permanent ground deformations or excessively high levels of ground shaking.

To help improve this situation, a new Design Guideline for Seismic Resistant Water Pipeline Installations (the Guidelines) has been developed. It is intended that the Guidelines be issued in March 2005. For the period from November 2004 through January 2005, the Guidelines are available in draft form for public comment. Comments from U.S., Japanese, Canadian and all other water utilities, pipeline manufacturers, AWWA, JWWA and other interested parties are welcomed.

The Guidelines provide direction for three situations:

- When the pipeline engineer has just rough estimates of the earthquake hazard, does not have the resources to do design by analysis, and wishes to rely on standardized pipeline components. The Guidelines provide the Chart Method. This is the preferred approach for common pipeline installations like 6-inch to 8-inch diameter pipes, fire hydrants and service laterals.

- When the pipeline engineer wishes to perform a limited design by analysis. The Guidelines provide the Equivalent Static Method. This is the preferred approach for medium important pipelines like 12-inch to 24-inch installations, or as a preliminary approach for major transmission pipelines.

- When the pipeline engineer has the resources to perform detailed subsurface investigations, geotechnical engineering and pipe stress analyses. The Guidelines provide the Finite Element Method. This is the preferred approach for essential non-redundant installations, like 36-inch to 120-inch pipelines.

INTRODUCTION

In most every severe earthquake, the largest negative impact to water utilities has been the damage to buried water pipelines. At the past three JWWA-AWWARF workshops (Oakland

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2000, Tokyo 2001, Los Angeles 2003), a great emphasis was placed by many participants on the rate of pipe damage, the causes of pipe damage, and the improved earthquake performance of new types of pipe.

After the Los Angeles workshop, many US participants got together and decided something ought to be done about this. Accordingly, in concert with FEMA, NIBS and the ALA, a team of engineers was assembled to put together the first ever US seismic design guideline for buried water pipelines. The American Lifelines Alliance (ALA) was formed by the Federal Emergency Management Agency (FEMA) in 1998 as a public-private partnership whose goal is to reduce risk to utility and transportation systems from natural hazards and manmade threats. In 2002, FEMA contracted with the National Institute of Building Sciences (NIBS) through its Multihazard Mitigation Council (MMC) to, among other things, assist FEMA in developing these Guidelines. The ALA sponsors this work through funding from NIBS and FEMA.

AmericanLifelinesAlliance

AUTHORS

The following people and their affiliations contributed to the Guidelines.

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Mr. Luke Cheng	San Francisco Public Utilities Commission
Mr. Frank Collins	Parsons
Mr. Mike Conner	San Diego Water Department
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Mr. Alex Tang	Nortel Networks, Retired
Mr. Doug Honegger	Consultant (Technical Oversight)
Mr. Joseph Steller	NIBS (Project Management)

The Guidelines would not have been possible without the contributions from numerous staff of the San Francisco Public Utilities Commission, East Bay Municipal Utilities District, City of San Diego Water Department, the Los Angeles Department of Water and Power, and many other participating agencies.

OUTLINE OF THE GUIDELINES

The Guidelines describe the various steps in seismic water pipeline design, with commentary. The main topics included are: Goals; Performance Objectives; Earthquake Hazards; Subsurface Investigations; General Pipeline Design; Analytical Models; Transmission Pipelines; Bypass Pipelines; Distribution Pipelines; Service and Hydrant Laterals; Distribution Pipelines; and Other Components. The Guidelines are meant to be a self-standing document that can be used by pipeline designers in water utilities; as such, it is geared to provide simple procedures to achieve the overall goal. The Guidelines always allow for more detailed procedures to be used by geologists, geotechnical engineers and pipeline engineers when suitable. A link to obtain the entire draft Guidelines is listed in the Conclusions.

For the 4th AWWARF-JWWA workshop, four papers cover the major topic areas of the Guidelines. This paper describes performance goals and the design-by-chart method. The paper by Dr. Craig Davis covers reliability goals and definition of geotechnical hazards. The paper by Mr. Luke Cheng covers design issues for transmission pipelines. The paper by Mr. Bruce Maison covers the two design-by-analysis models and design issues for service laterals.

GOAL OF SEISMIC DESIGN FOR WATER PIPELINES

The goal of the Guidelines is to improve the capability of water pipelines to function and operate during and following design earthquakes for life safety and economic reasons. This is accomplished using a performance based design methodology that provides cost-effective solutions and alternatives to problems resulting from seismic hazards. Improved water pipeline performance will help create a more resilient community for post-earthquake recovery; therefore portions of the Guidelines inherently consider the community impacts if pipeline damage were to occur. The Guidelines do not intend to prevent all pipelines from being damaged.

To achieve this goal, the fundamental intent of the Guidelines is to assure a reasonably low rate of water pipeline damage throughout a water utility system, such that about 90% of customers in a system can be restored with piped water service within about three days after a design basis earthquake.

To achieve this level of performance, an acceptable damage rate will be about 0.03 to 0.06 breaks per 1,000 feet (0.1 to 0.2 breaks per kilometer) of equivalent 6-inch diameter pipe. The commentary of the Guidelines provides a calculation to convert a network of pipes of different diameters that may suffer both breaks and leaks, in conjunction with network redundancy, into a single equivalent break rate per equivalent 6-inch diameter pipe. By minimizing pipeline damage after earthquakes to this level of damage, a typical water utility serving a population of 150,000 people could expect to:

- Deliver water at serviceable pressure to 65% to 90% of all hydrants within the first hours after the earthquake, as long as there are adequate supply sources; and

- Deliver water via the pipe network to at least 90% of all customers within 3 days following an earthquake;

as long as the utility can isolate most of the leaking and broken pipes within one day or so, and repair equivalent 6-inch diameter pipes at a rate of about 20 within the first three days after the earthquake, and 20 per day thereafter.

For water utilities with limited post-earthquake repair capability, or serving pipe networks with limited or no redundancy, it is important to limit the damage rate to the lower range. For water utilities with much greater post-earthquake repair capability, it might be acceptable to sustain damage to the higher range.

NEW INSTALLATIONS AND REPLACEMENT / RETROFIT

It is the intent of the Guidelines that they be used for all new pipeline installations. Over a period of many years, a sufficiently high percentage of pipelines in a network will eventually have been designed per these Guidelines. Thus, it may take decades for some utilities to ultimately achieve the goals, unless a pipeline replacement / retrofit program is also adopted.

The decision to replace older pipes is a complex one. In many networks, many existing pipelines (such as cast iron pipe with caulked joints) will not meet the seismic design capability recommended by the Guidelines. Still, the Guidelines do not recommend replacing older 4-inch to 10-inch diameter cast iron pipes solely on the basis of earthquake improvement, since this is not thought to be cost effective. However, as old pipeline are thought to need replacement because they no longer provide adequate fire flows, or have been observed to require repair at a rate of more than once every 5 years, then the added benefit of improved seismic performance may justify pipe replacement. When replaced, the new pipes should be designed per the Guidelines.

Replacement of larger diameter pipelines (12-inch diameter and upwards) may be cost effective just from a seismic point of view, in areas prone to PGDs.

PIPELINE FUNCTION CLASSES

A pipeline's function within the system identifies its importance in achieving the system performance goal. Table 1 provides the 4 function classes. A pipe function identifies a performance objective of an individual pipe, but not that of an entire system.

Function	Seismic Importance	Description
I	Very Low to None	Pipelines that represent very low hazard to human life in the event of failure. Not needed for post earthquake system performance, response, or recovery. Widespread damage resulting in long restoration times (weeks or longer) will not materially harm the economic well being of the community.
II	Ordinary, Normal	Normal and ordinary pipeline use, common pipelines in most water systems. All pipes not identified as Function I, III, or IV.
III	Critical	Critical pipelines and appurtenances serving large numbers of customers and present significant economic impact to the community or a substantial hazard to human life and property in the event of failure.
IV	Essential	Essential pipelines required for post-earthquake response and recovery and intended to remain functional and operational during and following a design earthquake.

Table 1. Pipe Function Classifications

THREE DESIGN APPROACHES

The Guidelines provide three approaches can be used in the design of buried pipelines.

- Chart method. The simplest approach. Avoids all mathematical models, and allows the designed to pick a style of pipe installation based on parameters such as regional maps for PGV and PGD hazards, and the pipeline function class.

- Equivalent static method. Uses simple quantifiable models to predict the amount of stress, strain and displacement on a pipe for a particular level of earthquake loading. The pipeline can then be designed to meet these quantified values, or pipe styles can be selected that presumably meet these quantified values without a formal capacity to demand check. Pipe selection is usually made by specification from available manufacturer's catalogs.

- Finite element method. This method uses finite element models to examine the seismic loads (whether PGA, PGV or PGD) over the length of the pipeline, and then uses beam on inelastic foundation finite element models (or sometimes use two- or three-dimensional mesh models) to examine the state of stress and strain and displacement within the pipeline and pipeline joints. Pipe design is often shown on contract drawings, covering material selection, joint preparation, trench design and other factors.

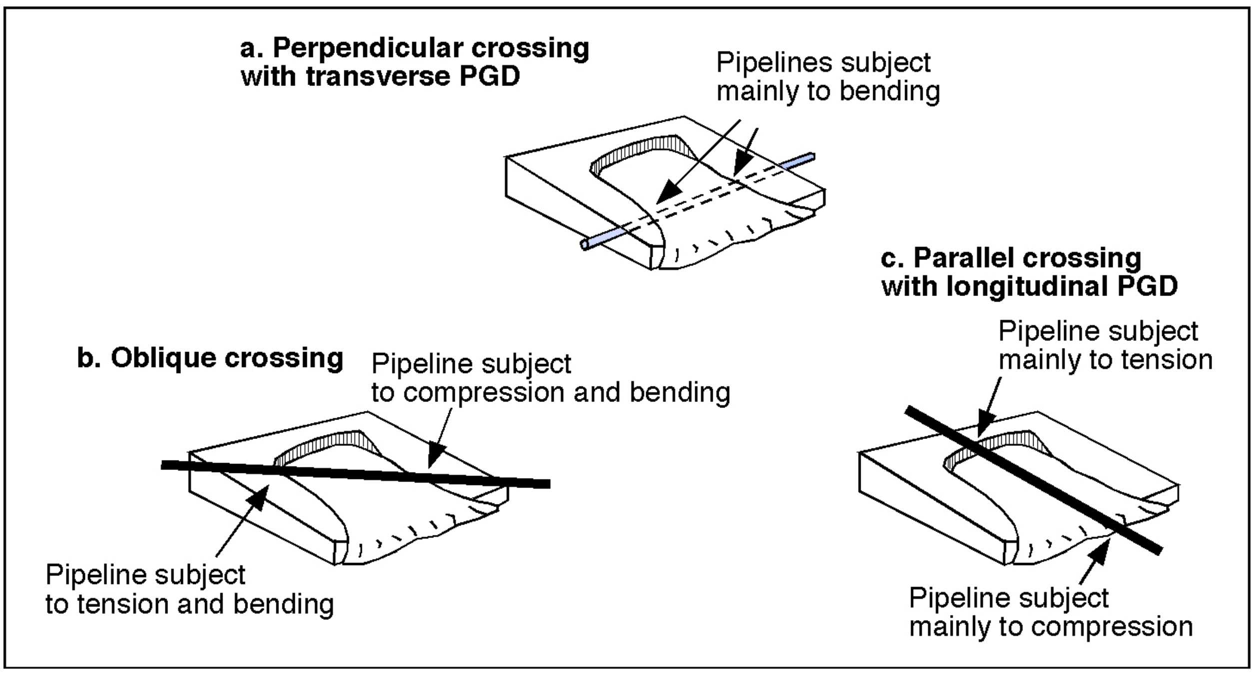


Figure 1. Direction of Permanent Ground Deformation (PGD)

CHART METHOD

Transmission Pipelines

Transmission pipelines may carry raw or treated water. Due to their importance to a great number of people, Function Class I is generally to be avoided except for those pipes whose failure would not impact any customer for 30 days or more.

Tables 2 to 5 set the pipeline design category (A, B, C, D or E). Figure 1 shows the meaning of perpendicular (transverse) and parallel (along the axis) orientations. If a portion of a pipeline has two or more categories for the various hazards (ground shaking, transverse PGDs, parallel PGDs, fault offset PGDs), then the highest category controls.

Inch/sec	Function I	Function II	Function III	Function IV
0 < PGV ≤ 10	A	A	A	A
10 < PGV ≤ 20	A	A	A	B
20 < PGV ≤ 30	A	A	B	C
30 < PGV	A	B	C	D

Table 2. Transmission Pipelines – Ground Shaking

Inches	Function I	Function II	Function III	Function IV
0 < PGD ≤ 2	A	A	A	A – welded steel B - segmented
2 < PGD ≤ 6	A	A	A	B
6 < PGD ≤ 12	A	A	B	C
12 < PGD	A	B	C	D

Table 3. Transmission Pipelines – Liquefaction and Landslide Transverse to Pipeline Alignment

Inches	Function I	Function II	Function III	Function IV
0 < PGD ≤ 2	A	A	B	B
2 < PGD ≤ 6	A	B	B	C
6 < PGD ≤ 12	C	C	C	D
12 < PGD	D	D	D	E

Table 4. Transmission Pipelines – Liquefaction (Lateral Spread) and Landslide Along Axis of Pipeline

Inches	Function I	Function II	Function III	Function IV
0 < PGD ≤ 2	A	A	B	B
2 < PGD ≤ 6	A	B	B	C
6 < PGD ≤ 12	A	C	C	D
12 < PGD ≤ 24	A	D	D	E
24 < PGD	A	D	E	E

Table 5. Transmission Pipelines – Fault Offset

Distribution Pipelines, Service Laterals and Fire Hydrant Laterals

In most cases, distribution pipelines are in networks. Failure of a single distribution pipeline will not fail the entire network (once the broken pipe is valved out), but the customers on the broken distribution pipeline will have no piped water service until the pipe is repaired. The engineer can assume that distribution pipelines are Function Class II, except in the following cases:

- The pipeline is the only pipe between lower elevation pump station and upper elevation pump station / reservoir in a pressure zone, and the failure of that pipeline will lead to complete loss of supply to the pump station serving a higher zone, or loss of the water in the reservoir for fire fighting purposes. For example, a 12-inch diameter pipe from lower elevation pump station that delivers water to a higher elevation tank within a pressure zone, and that also serves water to higher elevation pump stations.

- The pipeline is the only pipe delivering water to particularly important customers, such as critical care hospitals. For example, an 8-inch diameter pipe that has a service connection to a 200 bed hospital.

Past earthquakes have shown that there can be great quantity of damage to distribution pipelines, especially in areas prone to PGDs or high velocity pulses. While no single distribution pipeline is as important as a transmission pipeline, the large quantity of distribution pipe damage can lead to rapid system-wide depressurization, loss of fire fighting capability, and long outage times due to the great amount of repair work needed. Accordingly, we recommend that most distribution pipes be classified as Function Class II and very few as Function Class I (under ~5% of total pipeline inventory). A few distribution pipes serving essential facilities could be classified as Function III or IV; or they could be designated in suitable emergency response plans as prioritized for prioritized and rapid repair (generally under one day or two days at most). Once the Function Class is set, Tables 6 to 11 define the Design Category.

Inch/sec	Function I	Function II	Function III, IV
$0 < PGV \leq 10$	A	A	A
$10 < PGV \leq 20$	A	A	A
$20 < PGV \leq 30$	A	A	A (with additional valves)
$30 < PGV$	A	A (with additional valves)	B

Table 6. Distribution Pipelines – Ground Shaking

Inches	Function I	Function II	Function III, IV
$0 < PGD \leq 2$	A	A	A (with additional valves)
$2 < PGD \leq 6$	A	A (with additional valves)	B
$6 < PGD \leq 12$	A	B	C
$12 < PGD$	A	C	C

Table 7. Distribution Pipelines – Liquefaction and Landslide Transverse to Pipeline Alignment

Inches	Function I	Function II	Function III, IV
0 < PGD ≤ 2	A	A	B (with additional valves)
2 < PGD ≤ 6	A	B	C
6 < PGD ≤ 12	A	C	D
12 < PGD	A	D	D

Table 8. Distribution Pipelines – Lateral Spread and Landslide Along Axis of Pipeline

Inches	Function I	Function II	Function III, IV
0 < PGD ≤ 2	A	B	B
2 < PGD ≤ 6	A	B	C
6 < PGD ≤ 12	A	C	D
12 < PGD ≤ 24	A	D	E
24 < PGD	A	E	E

Table 9. Distribution Pipelines – Fault Offset

Service Laterals and Hydrant Laterals

Inch/sec	Any Lateral
0 < PGV ≤ 10	A
10 < PGV ≤ 30	A
30 < PGV	B

Table 10. Laterals – Ground Shaking

Inches	Any Lateral
0 < PGD ≤ 2	A
2 < PGD ≤ 12	B
12 < PGD	C

Table 11. Laterals – Liquefaction, Landslide and Surface Faulting

Design Categories

There are five design categories. Category A denotes standard (non-seismic) design. The following summarizes the general design approach for Categories B, C, D and E:

- B = restrained with extra valves
- C = B + better pipe materials
- D = C + quantified seismic design; or provide bypass system.
- E = D + peer review (it is strongly recommended that FEM method be used for any pipe with Classification E)

Tables 12 to 19 provide guidance for seismic pipe design using the chart method based on the categories A through E. Note. This guidance is based on commonly available pipe and joinery as of 2004. As new pipe products become available, they can be used in the chart method as long as suitable justification (FEM, test, etc.) is provided to show that the pipe meets the intended reliability of the pipe and performance of the pipe network as a whole.

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Extended Joints	
C	Restrained Joints	
D	Extended and Restrained Joints	Standard with bypass
E	Special Joints	Standard with bypass

Table 12. Ductile Iron Pipe

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Standard with extra insertion	
C	Restrained Joints	
D	Extended and Restrained Joints	Standard with bypass
E	Not recommended	Standard with bypass

Table 13. PVC Pipe

Design Category	Cost Effective Design Approach	Notes
A	Single Lap Weld	
B	Single Lap Weld	Weld t = pipe t
C	Double Lap Weld	Weld t = pipe t
D	Double Lap Weld / Butt Weld	D/t max 110 in PGD zones
E	Butt Weld	D/t max 95 in PGD zones

Table 14. Welded Steel Pipe

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Extended Joints	
C	Restrained Joints	
D	Extended and Restrained Joints	Standard with bypass
E	Not recommended	Standard with bypass

Table 15. Gasketed Steel Pipe

Design Category	Cost Effective Design Approach	Notes
A	Gasketed or Single Lap weld	
B	Single Lap Weld	Weld t = pipe t
C	Double Lap Weld	Weld t = pipe t
D	Not recommended	Standard with bypass
E	Not recommended	Standard with bypass

Table 16. CCP & RCCP Pipe

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Butt Fusion Joints	
C	Butt Fusion Joints	
D	Butt Fusion Joints	
E	Butt Fusion Joints	

Table 17. HDPE Pipe

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Soldered joints	
C	Soldered joints	Expansion loop / Christie box / Other box

Table 18. Copper Pipe

Design Category	Cost Effective Design Approach	Notes
A	Standard	
B	Dresser-type coupling	
C	Multiple dresser couplings	
D	EBAA flextend type couplings	
E	Not recommended	Relocate hydrant

Table 19. Segmented Pipelines Used as Hydrant Laterals

Design Category	Cost Effective Design Approach	Notes
A	Bolted, Single Lap Weld, Fusion Weld	
B	Bolted, Single Lap Weld, Fusion Weld	Weld t = pipe t
C	Bolted, Double Lap Weld, Single Lap Weld with fiber wrap, Fusion Weld	Weld t = pipe t
D	Bolted, Double Lap Weld, Single Lap Weld with fiber wrap, Butt Weld, Fusion Weld	Bolted, Double Lap Weld, Single Lap Weld with fiber wrap, Fusion Weld
E	Bolted, Double Lap Weld, Single Lap Weld with fiber wrap, Butt Weld, Fusion Weld	Bolted, Double Lap Weld, Single Lap Weld with fiber wrap, Fusion Weld

Table 20. Continuous Pipelines Used as Hydrant Laterals

In addition to the design categories in Tables 12 to 20, the following additional requirements are made. These recommendations are cumulative (For C, include B and C recommendations).

- B. Add isolation valves on all pipes within 50 feet of every intersection, for example, four valves on a four-way cross.
- C. Maximum pipe length between connections for segmented pipe is 16 feet, or as otherwise justified by ESM or FEM.
- D. Maximum pipe length between connections for segmented pipe is 12 feet, or as otherwise justified by ESM or FEM.

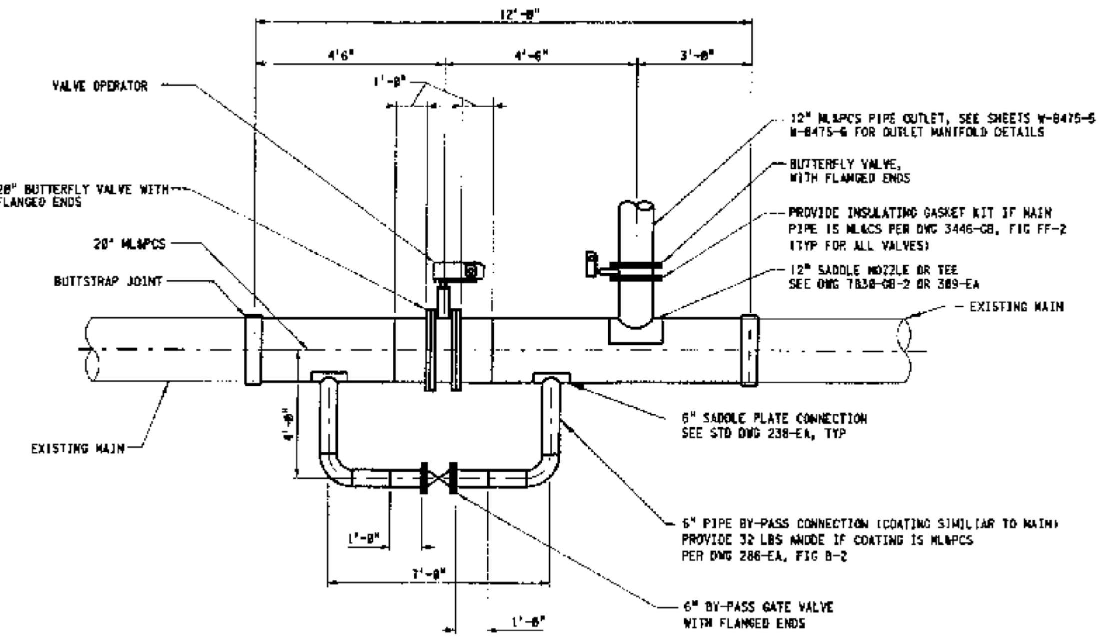
Bypass Pipelines

During design of a pipeline, it is typical to perform some preliminary seismic and hazard investigation. A geotechnical engineer can perform literature search of available publications and assess the seismic setting of the pipeline and identify potential hazards such as fault crossings, landslides, and zones of potential liquefaction.

With this information, the pipeline design engineer can often times route the pipeline to avoid well-defined hazards. This is the most cost-effective approach for minimizing seismic-related damage to a pipeline. However, sometimes there is no feasible way to avoid a hazard and the pipeline must be routed through the hazard.

Instead of using a higher Category Design (such as D or E), the owner can elect to provide a bypass capability, as long as the owner has the ability to install the bypass within about 1 day after the earthquake, and in consideration of the entire post-earthquake response. Bypass capability might be the most cost effective approach to mitigate many fault and landslide crossings for Function Class III pipelines. Bypasses can be used in retrofitting existing pipelines or for new construction where loss of service cannot be tolerated for more than one day.

A typical bypass is illustrated in Figure 2, consisting of a line isolation valve, if none previously existed, and a 12-inch diameter connection and manifold assembly on either side of the defined hazard. In order for the bypass to be used effectively, the hazard must be relatively well defined. Each of the manifolds is configured to accept one or multiple large diameter hose connections. In the event of a seismic event that results in a pipeline failure within the bounds of the hazard, the hazard isolation valves are closed, thereby stopping leakage at the point of failure. The hose is then deployed across the ground between the two manifold assemblies and serves as a temporary pipe bypass, allowing restoration of flows through the system. Figure 3 shows a deployed bypass system at a fault crossing where deployment of three flex hoses was possible.



Typical Isolation Valve with Bypass

Figure 2. Bypass Manifold Assembly

Figure 3. Flex Hose Attached to Manifold Outlets

The criteria for the bypass system components are included in Table 21. So called "large diameter flex hose" (diameter ~5-inches) will generally not provide sufficient flow rate at a reasonable pressure drop, for distances on the order of 1,000 feet between manifolds. So called "ultra large diameter flex hose" (diameter ~12-inches) can provide high flow rates at separation distances of 1,000 feet (or more). There are pros and cons with using either 5-inch or 12-inch hose, including: flow rate and pressure drop; cost; storage life; deployment effort and time; hose breakage and resultant pipe whip; etc.

Description	**Criteria**
Pipe Materials	Mortar-lined and mortar- or tape/epoxy-coated steel pipe Field joints shall be flanged, welded, or mechanically coupled with suitable restraint Design for anticipated internal, external, and transient loading conditions Provide cathodic protection as needed
Manifold Pit	Precast reinforced concrete with seismic design factors suitable for site Traffic rated steel plate cover Sized for easy hose deployment
12-inch Valves and Smaller	Butterfly or Gate
Flexible Hose	12 -inch flex hose, burst pressure ~ 400 psi, operating pressure ~150 psi. Distances up to 1,000 feet or more at flow rates of up to 5,000 gpm 5-inch fire hose from local Fire Department. Distances up to 1,000 feet at flow rates of up to 500 gpm Connections to be coordinated with manifold configuration

Table 21. Bypass System Components Criteria

CONCLUSIONS

It is the intent of these Guidelines to provide a unified, comprehensive and simple approach that can be readily adopted by water utilities for the design of new pipeline installations. The draft Guidelines are available for public comment through January 2005. They may be obtained via the Internet at: http://homepage.mac.com/eidinger/ (follow the link to downloads, and then download Seismic Guidelines.doc.) Comments should be sent to any of the authors.

The Guidelines may result in changes in pipeline installations in moderate and high seismic areas throughout the United States. Given the large economic consequences of widespread pipeline damage, the authors believe that the extra reliability afforded by these changes is worthwhile and cost effective. We hope that the Guidelines will spur water utilities to procure better pipelines in high hazard locations; in turn, the pipeline manufacturers will manufacture and supply better products. This is, in part, a "chicken and egg" process, since prior to the current moment (late 2004 – early 2005) we have not had the Guidelines for water utilities; nor have we always had suitable cost effective pipelines provided by manufacturers to meet the Guidelines.

ABBREVIATIONS AND UNITS

Customary US units (inches, pounds, gallons) are used in this paper. Conversions to SI units are provided below. All pipe sizes are in customary US units; conversion of a customary pipe size (such as 12-inch diameter) to SI units has no precision, as a 12-inch pipe may often have outside diameter anywhere from ~12-inches to ~13-inches.

ALA	American Lifelines Alliance
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
ESM	Equivalent Static Method
FEM	Finite Element Method
FEMA	Federal Emergency Management Agency
JWWA	Japan Water Works Association
MMC	Multihazard Mitigation Council
NIBS	National Institute of Building Sciences
PGA	Peak Ground Acceleration (g)
PGD	Permanent Ground Deformation (1 inch = 2.54 cm)
PGV	Peak Ground Velocity (1 inch/sec = 2.54 cm/sec)

inch	inch (1 inch = 2.54 cm)
feet	feet (1 foot = 12 inches = 30.48 cm)
g	gravity constant (1g = 386.4 inch/sec^2 = 981 cm/sec^2)
gpm	gallons per minute (1 gpm = 3.785 liters per minute)
psi	pounds per square inch (1 psi = 6.895 kilopascals)
sec	second

APPENDIX G

General Earthwork and Grading Guidelines

Earthwork and Grading Specifications for Rough Grading

1.0 General

1.1 Intent: These General Earthwork and Grading Specifications are for the grading and earthwork shown on the approved grading plan(s) and/or indicated in the geotechnical report(s). These Specifications are a part of the recommendations contained in the geotechnical report(s). In case of conflict, the specific recommendations in the geotechnical report shall supersede these more general Specifications. Observations of the earthwork by the project Geotechnical Consultant during the course of grading may result in new or revised recommendations that could supersede these specifications or the recommendations in the geotechnical report(s).

1.2 The Geotechnical Consultant of Record: Prior to commencement of work, the owner shall employ a qualified Geotechnical Consultant of Record (Geotechnical Consultant). The Geotechnical Consultant shall be responsible for reviewing the approved geotechnical report(s) and accepting the adequacy of the preliminary geotechnical findings, conclusions, and recommendations prior to the commencement of the grading.

Prior to commencement of grading, the Geotechnical Consultant shall review the "work plan" prepared by the Earthwork Contractor (Contractor) and schedule sufficient personnel to perform the appropriate level of observations, mapping, and compaction testing.

During the grading and earthwork operations, the Geotechnical Consultant shall observe, map, and document the subsurface exposures to verify the geotechnical design assumptions. If the observed conditions are found to be significantly different than the interpreted assumptions during the design phase, the Geotechnical Consultant shall inform the owner, recommend appropriate changes in design to accommodate the observed conditions, and notify the review agency where required.

The Geotechnical Consultant shall observe the moisture-conditioning and processing of the subgrade and fill materials and perform relative compaction testing of fill to confirm that the attained level of compaction is being accomplished as specified. The Geotechnical Consultant shall provide the test results to the owner and the Contractor on a routine and frequent basis.

1.3 The Earthwork Contractor: The Earthwork Contractor (Contractor) shall be qualified, experienced, and knowledgeable in earthwork logistics, preparation and processing of ground to receive fill, moisture-conditioning and processing of fill, and compacting fill. The Contractor shall review and accept plans, geotechnical report(s), and these Specifications prior to commencement of grading. The Contractor shall be solely responsible for performing the grading in accordance with the project plans and specifications. The Contractor shall prepare and submit to the owner and the Geotechnical Consultant a work plan that indicates the sequence of earthwork grading, the number of "equipment" of work and the estimated quantities of daily earthwork contemplated for the site prior to commencement of grading. The Contractor shall inform the owner and the Geotechnical Consultant of changes in work schedules and updates to the work plan at least 24 hours in advance of such changes so that appropriate personnel will be available for observation and testing. The Contractor shall not assume that the Geotechnical Consultant is aware of all grading operations.

The Contractor shall have the sole responsibility to provide adequate equipment and methods to accomplish the earthwork in accordance with the applicable grading codes and agency ordinances, these Specifications, and the recommendations in the approved geotechnical report(s) and grading plan(s). If, in the opinion of the Geotechnical Consultants, unsatisfactory conditions, such as unsuitable soil, improper moisture-condition, inadequate compaction, insufficient buttress key size, adverse weather, etc., are resulting in a quality of work less than required in the specifications, the Geotechnical Consultant shall reject the work and may recommend to the owner that construction be stopped until the conditions are rectified. It is the contractor's sole responsibility to provide proper fill compaction.

2.0 Preparation of Areas to be Filled

2.1 **Clearing and Grubbing:** Vegetation, such as brush, grass, roots, and other deleterious material shall be sufficiently removed and properly disposed of in a method acceptable to the owner, governing agencies, and the Geotechnical Consultant.

The Geotechnical Consultant shall evaluate the extent of these removals depending on specific site conditions. Earth fill material shall not contain more than 1 percent of organic materials (by volume). No fill lift shall contain more than 10 percent of organic matter. Nesting of the organic materials shall not be allowed.

If potentially hazardous materials are encountered, the Contractor shall stop work in the affected area, and a hazardous material specialist shall be informed immediately for proper evaluation and handling of these materials prior to continuing to work in that area.

As presently defined by the State of California, most refined petroleum products (gasoline, diesel fuel, motor oil, grease, coolant, etc.) have chemical constituents that are considered to be hazardous waste. As such, the indiscriminant dumping or spillage of these fluids onto the ground may constitute a misdemeanor, punishable by fines and/or imprisonment, and shall not be allowed. The contractor is responsible for all hazardous waste relating to his work. The Geotechnical Consultant does not have expertise in this area. If hazardous waste is a concern, then the Client should acquire the services of a qualified environmental assessor.

2.2 **Processing:** Existing ground that has been declared satisfactory for support of fill by the Geotechnical Consultant shall be scarified to a minimum depth of 6 inches. Existing ground that is not satisfactory shall be overexcavated as specified in the following section. Scarification shall continue until soils are broken down and free from oversize material and the working surface is reasonably uniform, flat, and free from uneven features that would inhibit uniform compaction.

2.3 **Overexcavation:** In addition to removals and overexcavations recommended in the approved geotechnical report(s) and the grading pan, soft, loose, dry, saturated, spongy, organic-rich, highly fractured or otherwise unsuitable ground shall be overexcavated to competent ground as evaluated by the Geotechnical Consultant during grading.

2.4 **Benching:** Where fills are to be places on ground with slopes steeper than 5:1 (horizontal to vertical units), the ground shall be stepped or benched. The lowest bench or key shall be a minimum of 15 feet wide and at least 2 feet deep, into competent material as evaluated by the Geotechnical Consultant. Other benches shall be excavated a minimum height of 4 feet into competent material or as otherwise recommended by the Geotechnical Consultant. Fill placed on ground sloping flatter that 5:1 shall also be benched or otherwise overexcavated to provide a flat subgrade for the fill.

2.5 **Evaluation/Acceptance of Fill Areas:** All areas to receive fill, including removal and processed areas, key bottoms, and benches, shall be observes, mapped, elevations recorded, and/or tested prior to being accepted by the Geotechnical Consultant as suitable to receive fill. The Contractor shall obtain a written acceptance from the Geotechnical Consultant prior to fill placement. A licensed surveyor shall provide the survey control for determining elevations of processed areas, keys, and benches.

3.0 **Fill Material**

3.1 **General:** Material to be used as fill shall be essentially free of organic matter and other deleterious substances evaluated and accepted by the Geotechnical Consultant prior to placement. Soils of poor quality, such as those with unacceptable gradation, high expansion potential, or low strength shall be placed in areas acceptable to the Geotechnical Consultant or mixed with other soils to achieve satisfactory fill material.

3.2 **Oversize:** Oversize material defined as rock, or other irreducible material with a maximum dimension greater than 8 inches, shall not be buried or placed in fill unless location, materials, and placement methods are specifically accepted by the Geotechnical Consultant. Placement operations shall be such that nesting of oversized material does not occur and such that oversize material is completely surrounded by compacted or densified fill. Oversize material shall not be placed within 10 vertical feet of finish grade or within 2 feet of future utilities or underground construction.

3.3 **Import:** If importing of fill material is required for grading, proposed import material shall meet the requirements of the geotechnical report(s). The potential import source shall be given to the Geotechnical Consultant at least 48 hours (2 working days) before importing begins so the suitability can be determined and appropriate tests performed.

4.0 Fill Placement and Compaction

4.1 **Fill Layers:** Approved fill material shall be placed in areas prepared to receive fill in near-horizontal layers not exceeding 8 inches in loose thickness. The Geotechnical Consultant may accept thicker layers if testing indicates that grading procedures can adequately compact the thicker layers. Each layer shall be spread evenly and mixed thoroughly to attain relative uniformity of material and moisture throughout.

4.2 **Fill Moisture Conditioning:** Fill soils shall be watered, dried back, blended, and/or mixed, as necessary to attain relatively uniform moisture content within 2% of optimum. Maximum density and optimum soil moisture content tests shall be performed in accordance with the American Society of Testing and Materials (ASTM Test Method D1557-91).

4.3 **Compaction of Fill:** After each layer has been moisture-conditioned, mixed, and evenly spread, it shall be uniformly compacted to not less than 90 percent of maximum dry density (ASTM Test Method D1557-91). Compaction equipment shall be adequately sized and be either specifically designed for soil compaction or of proven reliability to efficiently achieve the specified level of compaction with uniformity.

4.4 **Compaction of Fill Slopes:** In addition to normal compaction procedures specified above, compaction of slopes, shall be accomplished by backrolling of slopes with sheepfoot rollers at increments of 3 to 4 feet in fill elevation, or by other methods producing satisfactory results acceptable to the Geotechnical Consultant. Upon completion of grading, relative compaction of the fill, out to the slope face, shall be at least 90 percent of maximum density per ASTM Test Method D1557-91.

4.5 **Compaction Testing:** Field tests for moisture content and relative compaction of the fill soils shall be performed by the Geotechnical Consultant. Location and frequency of tests shall be at the Consultant's discretion based on field conditions encountered. Compaction test locations will not necessarily be selected on a random basis. Test locations shall be selected to verify adequacy of compaction levels in areas that are judged to be prone to inadequate compaction (such as close to slope faces and at the fill/bedrock benches).

4.6 **Frequency of Compaction Testing:** Tests shall be taken at intervals not exceeding 2 feet in vertical rise and/or 1,000 cubic yards of compacted fill soils embankment. In addition, as a guideline, at least one test shall be taken on slope faces for each 5,000 square feet of slope face and/or each 10 feet of vertical height of slope. The Contractor shall assure that fill construction is such that the testing schedule can be accomplished by the Geotechnical Consultant. The Contractor shall stop or slow down the earthwork construction if these minimum standards are not met.

4.7 **Compaction Test Locations:** The Geotechnical Consultant shall document the approximate elevation and horizontal coordinates of each test location. The Contractor shall coordinate with the project surveyor to assure that sufficient grade stakes are established so that the Geotechnical Consultant can determine the test locations with sufficient accuracy. At a minimum, two grade stakes within a horizontal distance of 100 feet and vertically less then 5 feet apart from potential test locations shall be provided.

5.0 Subdrain Installation

Subdrain systems shall be installed in accordance with the approved geotechnical repot(s), the grading plan, and the Standard Details. The Geotechnical Consultant may recommend additional subdrains and/or changes in subdrain extent, location, grade, or material depending on conditions encountered during grading. All subdrains shall be surveyed by a land survey/civil engineer for line and grade after installation and prior to burial. Sufficient time should be allowed by the Contractor for these surveys.

6.0 Excavation

Excavations, as well we over-excavation for remedial purposes, shall be evaluated by the Geotechnical Consultant during grading. Remedial removal depths shown on geotechnical plans are estimates only. The actual extent of removal shall be determined by the Geotechnical Consultant based on the field evaluation of exposed conditions during grading. Where fill-over-cut slopes are to be graded, the cut portion of the slope shall be made, evaluated, and accepted by the Geotechnical Consultant prior to placement of materials for construction of the fill portion of the slope, unless otherwise recommended by the Geotechnical Consultant.

7.0 Trench Backfills

7.1 The Contractor shall follow all OHSA and Cal/OSHA requirements for safety of trench excavations.

7.2 All bedding and backfill of utility trenches shall be done in accordance with the applicable provisions of Standard Specifications of Public Works Construction. Bedding Material shall have a Sand Equivalent greater then 30 (SE>30). The bedding shall be placed to 1 foot over the top of the conduit and densified by jetting. Backfill shall be placed and densified to a minimum of 90 percent of maximum from 1 foot above the top of the conduit to the surface.

7.3 The jetting of the bedding around the conduits shall be observed by the Geotechnical Consultant.

7.4 The Geotechnical Consultant shall test the trench backfill for relative compaction. At least one test should be made for every 300 feet of trench and 2 feet of fill.

7.5 Lift thickness of trench backfill shall not exceed those allowed in the Standard Specifications of Public Works Construction unless the Contractor can demonstrate to the Geotechnical Consultant that the fill lift can be compacted to the minimum relative compaction by his alternative equipment and method.