

---

# **Appendix D-1**

## Preliminary Geotechnical/Geologic Study



**REPORT OF PRELIMINARY  
GEOTECHNICAL / GEOLOGIC STUDY  
PROPOSED TWO WELL HEAD HOUSES, AN  
ABOVE-GROUND TREATMENT BUILDING  
WITH A WATER TANK AND  
APPURTENANCES  
APN 0335-141-06 OFF STATE HIGHWAY 173  
LAKE ARROWHEAD  
SAN BERNARDINO COUNTY, CALIFORNIA**

PROJECT NO.: 1666-01  
REPORT NO.: 1

SEPTEMBER 20, 2024

SUBMITTED TO:

**LAKE ARROHEAD COMMUNITY SERVICES DISTRICT  
27307 STATE HIGHWAY 189  
BLUE JAY, CA 92317**

PREPARED BY:

**HILLTOP GEOTECHNICAL, INC.  
786 SOUTH GIFFORD AVENUE  
SAN BERNARDINO, CA 92408**



**HILLTOP GEOTECHNICAL**  
INCORPORATED

786 S. GIFFORD AVENUE • SAN BERNARDINO • CA 92408  
Phone **909-890-9079** • FAX 909-890-9055  
[hilltopg@hgeotech.com](mailto:hilltopg@hgeotech.com)

September 20, 2024

**Lake Arrowhead Community Services District**  
27307 State Hwy 189  
Blue Jay, CA 92317

Project No.: 1666-01  
Report No.: 1

Attention: Mr. Scott Schroder, Engineering Manager

Subject: **Report of Preliminary Geotechnical / Geologic Study, Proposed Two Well Head Houses, a Treatment Building with a Water Tank, and Appurtenances, APN 0335-141-06 Off State Highway 173, Lake Arrowhead, San Bernardino County, CA 92352.**

- References:
1. *Proposed Groundwater Wells, CIP Project, Project 244, HWY 173 Groundwater Wells, a Portion of Parcel 1 PM 1232 MB 11/6 APN# 335-141-06, provided by LACSD.*
  2. Technical References – See Appendix ‘B.’

Gentleman:

According to your request, we have completed a preliminary geotechnical / geologic study for the design and construction of the proposed development at the subject site. We are presenting, herein, our findings and recommendations.

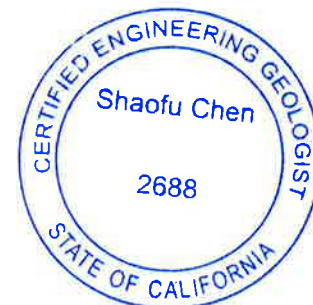
The findings of this study indicate that the proposed development at the subject site is feasible provided the recommendations presented in the attached report are complied with and incorporated into the design and construction of the project.

Copies of this report should be forwarded to the other consultants for the project (i.e., Civil Engineer, Architect, Structural Engineer, etc.) as needed to implement the recommendations presented. This report should be saved for submittal, and

the other required documentation to the appropriate agency having jurisdiction over the project for review and permitting purposes.

If you have any questions after reviewing the findings and recommendations contained in the attached report, please do not hesitate to contact this office. This opportunity to be of professional service is sincerely appreciated.

Respectfully Submitted,  
**HILLTOP GEOTECHNICAL, INC.**



S. Mack Chen, P.E. C76834/C.E.G. 2688  
Principal Engineer/Geologist

Distribution:           (1)   Addressee  
  Via Email  
  Scott Schroder: [sschroder@lakearrowheadcsd.com](mailto:sschroder@lakearrowheadcsd.com)

## TABLE OF CONTENTS

<u>Section Title</u>	<u>Page No.</u>
INTRODUCTION.....	1
AUTHORIZATION.....	1
PURPOSE AND SCOPE OF STUDY.....	1
PREVIOUS SITE STUDIES.....	4
PROJECT DESCRIPTION / PROPOSED DEVELOPMENT.....	4
FIELD EXPLORATION AND LAB TESTING.....	5
FINDINGS.....	6
SITE DESCRIPTION.....	6
ENGINEERING GEOTECHNICAL ANALYSIS.....	7
Regional Geological Setting.....	7
Local Subsurface Conditions.....	8
Earth Materials Description:.....	8
Groundwater.....	9
Surface Water.....	9
Site Variations.....	9
Faulting and Regional Seismicity.....	10
Secondary Seismic Hazards.....	11
Landslide.....	11
Liquefaction.....	11
Seismically Induced Subsidence.....	12
Seiching.....	12
Tsunamis.....	12
Lurching.....	13
OTHER GEOLOGIC HAZARDS.....	13
Flooding.....	13
CONCLUSIONS AND RECOMMENDATIONS.....	13
GENERAL.....	13
GRADING.....	14
General Grading Requirements.....	14
FILL MATERIALS.....	16

## TABLE OF CONTENTS

<u>Section Title</u>	<u>Page No.</u>
Onsite Earth Materials.....	16
Import Materials.....	17
TEMPORARY EXCAVATIONS.....	17
SEISMIC COEFFICIENTS.....	18
FOUNDATIONS.....	18
Structure and Foundation Setback from Slopes.....	18
Lateral Resistance .....	20
Estimated Settlement.....	20
RETAINING WALLS .....	20
FLOOR-ON-GROUND/HARDSCAPE.....	22
Moisture Sensitive Floor Covering.....	23
SURFACE DRAINAGE.....	23
UTILITY TRENCH BACKFILL .....	24
SOIL EXPANSIVITY AND COLLAPSIBILITY.....	25
SOIL CORROSIVITY .....	25
LIMITATIONS .....	26
REVIEW, OBSERVATION, AND TESTING .....	26
UNIFORMITY OF CONDITIONS.....	27
CHANGE IN SCOPE.....	27
TIME LIMITATIONS.....	27
PROFESSIONAL STANDARD .....	28
CLIENT'S RESPONSIBILITY.....	28

## TABLE OF CONTENTS

<u>Section Title</u>	<u>Page No.</u>
APPENDIX A.....	A-1
FIELD EXPLORATION .....	A-1
LABORATORY TESTING PROGRAM .....	A-2
CLASSIFICATION .....	A-3
IN-SITU MOISTURE CONTENT AND DRY DENSITY .....	A-3
CHEMICAL AND ELECTRICAL RESISTIVITY TESTS.....	A-3
SAND EQUIVALENT TEST .....	A-4
DIRECT SHEAR TEST .....	A-4
CONSOLIDATION TESTS .....	A-4
‘Exploratory Excavation Location Plan.....	Plate No. 1
‘Subsurface Exploration Legend’.....	Plate No. 2
‘Subsurface Exploration Log’.....	Plate Nos. 3 through 7
‘Summary of Laboratory Test Results’	
‘Chemical / Minimum Electrical Resistivity	
Test Results’ .....	Plate No. 8
‘Sand Equivalent Test Results ([California	
Test 217 Procedure] [ASTM D2419	
Test Method])’.....	Plate No. 8
‘Direct Shear Test Results’ (ASTM D3080	
Test Method) .....	Plate No. 9
‘Consolidation Test Results (ASTM D2435	
Test Method)’ .....	Plate Nos. 10-12
 APPENDIX B	
TECHNICAL REFERENCES .....	B-1

**REPORT OF PRELIMINARY  
GEOTECHNICAL / GEOLOGIC STUDY  
PROPOSED TWO WELL HEAD HOUSES, AN ABOVE-GROUND  
TREATMENT BUILDING WITH A WATER TANK, AND  
APPURTENANCES  
APN 0335-141-06 OFF STATE HIGHWAY 173  
LAKE ARROWHEAD  
SAN BERNARDINO COUNTY, CALIFORNIA**

PROJECT NO.: 1666-01  
REPORT NO.: 1

SEPTEMBER 20, 2024

## **INTRODUCTION**

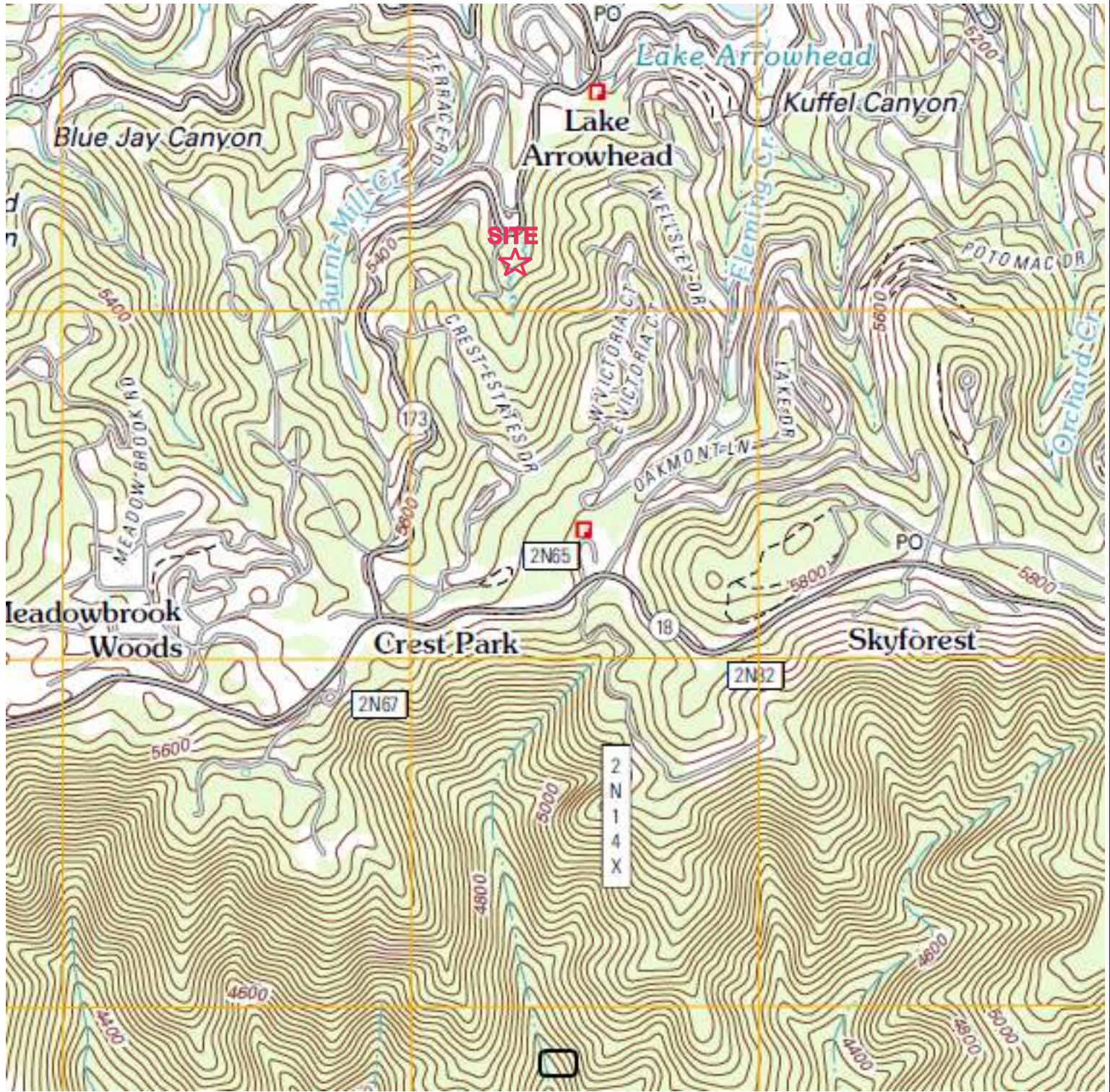
### **AUTHORIZATION**

This report presents results of the preliminary geotechnical / geologic study conducted on the subject site for the proposed development to be located on the northwestern portion of the site at APN 0335-141-06, off State Highway 173 in the Lake Arrowhead area of San Bernardino County, California. The general location of the subject site is indicated on the 'Site Location Map' Figure No. 1.

The authorization to perform this study was in the form of a signed proposal from **Hilltop Geotechnical, Inc. (HGI)** (Geotechnical / Geologic Consultant) to **Lake Arrowhead Community Services District** (Client), dated July 11, 2024, Proposal Number: P24126.

### **PURPOSE AND SCOPE OF STUDY**

The scope of work performed for this study was designed to determine and evaluate the surface and subsurface conditions in the vicinity of the proposed two well head houses, a treatment building with a water tank, and appurtenances on the subject site with respect to geotechnical characteristics, including potential geologic hazards that may affect the development of the site, and to provide



SCALE 1:24 000



Source: Copied from USGS Topo Map-  
Harrison Mtn Quadrangle 2012



### SITE LOCATION MAP

APN 0335-141-06 off State Highway 173,  
Lake Arrowhead, CA 92352

By: MC

Date: 9/2024

Project No.: 1666-01.1

**Figure 1**

geotechnical recommendations and criteria for use in the design and construction of the proposed development. The scope of work included the following:

- Review of locally and easily available published and unpublished soil, geologic, and seismologic reports, and data for the area (see References in Appendix 'B'), available photographs via Google Earth, flood hazard maps, well data, etc. to ascertain earth material, geologic, and hydrologic conditions of the area.
- Telephone conversations with the client.
- Site reconnaissance.
- Subsurface exploration by means of hand auger borings to characterize the earth materials, geologic, and groundwater conditions that could influence the proposed development.
- Sampling of on-site earth materials from the exploratory excavations.
- Laboratory testing of selected earth material samples considered representative of the subsurface conditions to determine the engineering properties and characteristics.
- Define the general geology of the subject site and evaluate potential geologic hazards which would have an effect on the proposed development.
- Determine seismic classification of the site to meet the requirements of the 2022 California Building Code (CBC), effective on January 1, 2023.
- Engineering and geologic analysis of field and laboratory data to provide a basis for geotechnical and geologic conclusions and recommendations regarding site grading and foundation, floor slab, etc. design parameters.
- Preparation of this report to present the geotechnical and geologic conclusions and recommendations for the proposed development at the site.

This report presents our conclusions and/or recommendations regarding:

- The geologic setting of the site.
- Potential geologic hazards (including landslides, seismicity, faulting, liquefaction potential, etc.)

- General subsurface earth conditions.
- The presence and effect of expansive, collapsible, and compressible earth materials.
- Groundwater conditions within the depth of our subsurface investigation.
- Excavation characteristics of the on-site earth materials.
- Characteristics and compaction requirements of proposed fill and backfill materials.
- Recommendations and guide specifications for earthwork.
- Seismic design coefficients for structural design purposes.
- Types and depths of foundations.
- Allowable bearing pressure and lateral resistance for foundations.
- Preliminary corrosion potential evaluation for concrete and buried metal in direct contact with the on-site earth materials.

The scope of work performed for this report did not include any testing of earth materials or groundwater for environmental purposes, an environmental assessment of the property, or opinions relating to the possibility of surface or subsurface contamination by hazardous or toxic substances. In addition, an evaluation of on-site private sewage disposal systems for the proposed development if any was not conducted as part of this study.

This study was prepared for the exclusive use of Lake Arrowhead Community Services District and their consultants for specific application to the proposed development in accordance with generally accepted standards of the geotechnical and geologic professions and generally accepted geotechnical (soil and foundation) engineering and geologic principles and practices at the time this report was prepared. Other warranties, implied or expressed, are not made. Although reasonable effort has been made to obtain information regarding geotechnical / geologic and subsurface conditions of the site, limitations exist with respect to

knowledge of unknown regional or localized off-site conditions which may have an impact at the site. The conclusions and recommendations presented in this report are valid as of the date of this report. However, changes in conditions of a property can occur with passage of time, whether they are due to natural processes or to works of man on this and/or adjacent properties.

If conditions are observed or information becomes available during the design and construction process which are not reflected in this report, **HGI**, as Geotechnical / Geologic Consultant of record for the project, should be notified so that supplemental evaluations can be performed and conclusions and recommendations presented in this report can be verified or modified in writing, as necessary. Changes in applicable or appropriate standards of care in the geologic / geotechnical professions occur, whether they result from legislation or the broadening of knowledge and experience. Accordingly, the conclusions and recommendations presented in this report may be invalidated, wholly or in part, by changes outside the influence of the project Geotechnical / Geologic Consultant which occurs in the future.

### **PREVIOUS SITE STUDIES**

No previous geotechnical and/or geological studies for the subject site are known to have been performed or were made available for review at the time of this study, if any had been performed.

### **PROJECT DESCRIPTION / PROPOSED DEVELOPMENT**

Based upon information presented to this firm by the client, it is our understanding that the proposed project will consist of two well houses, a water treatment building with a water tank, and appurtenances to the northwestern portion of the property.

The above project description and assumptions were used as the basis for the field exploration, laboratory testing program, the engineering analysis, and the conclusions and recommendations presented in this report. **HGI** should be notified if structures, foundation loads, grading, and/or details other than those represented herein are proposed for final development of the site so a review can be performed, a supplemental evaluation made, and revised recommendations submitted, if required.

### **FIELD EXPLORATION AND LAB TESTING**

The field study performed for this report included a visual and geologic reconnaissance of existing surface conditions of the subject site. A study of the property's subsurface condition was performed to evaluate underlying earth strata and the presence of groundwater. Surface and subsurface conditions were explored on August 22<sup>nd</sup>, 2024.

The subsurface exploration consisted of excavating five (5) exploratory hand auger borings on the subject property. The approximate locations of the exploratory excavations are shown on the 'Exploratory Excavation Location Plan,' Plate No. 1, presented in Appendix 'A' of this report. The exploratory excavations were observed and logged by a representative of **HGI**. Earth materials encountered in the exploratory excavations were visually described in the field in general accordance with the current Unified Soils Classification System (USCS), ASTM D2488, visual-manual procedures, as illustrated on the attached, simplified 'Subsurface Exploration Legend,' Plate No. 2, presented in Appendix 'A' of this report. The results of the borings are presented on the 'Subsurface Exploration Log,' Plate Nos. 3 through 7, presented in Appendix 'A' of this report. A more detailed explanation of the field study which was performed for this report is presented in Appendix 'A' of this report.

Representative bulk and ring samples of on-site colluvial and natural earth materials were collected during the field exploration and returned to the laboratory for testing. Laboratory tests were conducted to evaluate the engineering properties of on-site earth materials and included moisture density tests, a direct shear test, consolidation tests, and corrosivity tests. A more detailed explanation of laboratory tests performed for this study and test results are presented in Appendix 'A' of this report, Plate Nos. 3 through 7.

## **FINDINGS**

### **SITE DESCRIPTION**

The subject property comprises approximately 31 acres and was irregular in shape as shown on the Reference No. 1, 'Site Plan' noted on the first page of the cover letter for this report. The subject site was bounded by residences, S. State Highway 173, and vacant lot to the north and residences and vacant lots in other directions.

Per the referenced 'Site Plan,' a few existing buildings are located on graded flat areas. The property site generally descends from State Highway 173 to the south property line with various slope ratios.

At the time of the field investigation, the proposed two well head houses, a water treatment building with a water tank, and appurtenances are located at a valley area. The site was moderately to densely vegetated throughout the entirety of the property and some pine and cedar trees.

Utilities consisting of electric, telephone, gas, sewer, water, as well as other unknown underground and overhead lines, were observed to be present adjacent to the site and in the street right of way.

## **ENGINEERING GEOTECHNICAL ANALYSIS**

### **Regional Geological Setting**

The subject site is located at the east end of Transverse Ranges Geomorphic Province. The San Bernardino Mountains, the San Gabriel Mountains, and other ranges extending toward the west and east are portions of the Transverse Ranges Geomorphic Province, a nearly 300-mile-long belt of folded, faulted, and uplifted rocks of diverse lithologies. The east-west orientation of the Transverse Ranges markedly contrasts with the generally northwest-trending, structural grain of surrounding areas of California. The presence and orientation of these ranges are generally attributed to north-south directed compression and crustal shortening related to complications within the geometry of the San Andreas transform fault system. These complications are reflected in the kinematics of faults that bound virtually all sides of the San Bernardino Mountains block, faults that include right- and left-lateral strike-slip, normal, and reverse-slip displacements.

Basement rocks in the San Bernardino Mountains are like those observed in the Mojave Desert areas to the north and consist of Triassic through Cretaceous granitoid rocks of various compositions that have intruded prebatholithic orthogneiss (Proterozoic) and Late Proterozoic to Paleozoic metasedimentary rocks. The layered metasedimentary units consist of quartzites, marbles, pelitic schists, and gneisses, and are stratigraphic equivalents to widespread, marine sedimentary rocks in the eastern Mojave Desert and Great Basin regions. Deformed and undeformed suites of Mesozoic plutonic rocks predominate in the western San Bernardino Mountains. Least-common rock types around the margins of the range include banded and layered Mesozoic metasediments and several Tertiary sedimentary units, usually located within fault-bounded slivers and blocks.

Locally, the Lake Arrowhead area lies within the Northern Block of the San Bernardino Mountains, a broad plateau with relatively gentle highland

topography. This southwestern area of Lake Arrowhead is underlain by Monzogranite of City Creek (Kcc). The geology of the subject property and surrounding area is graphically depicted on the 'Regional Geologic Map,' Figure No. 2.

### **Local Subsurface Conditions**

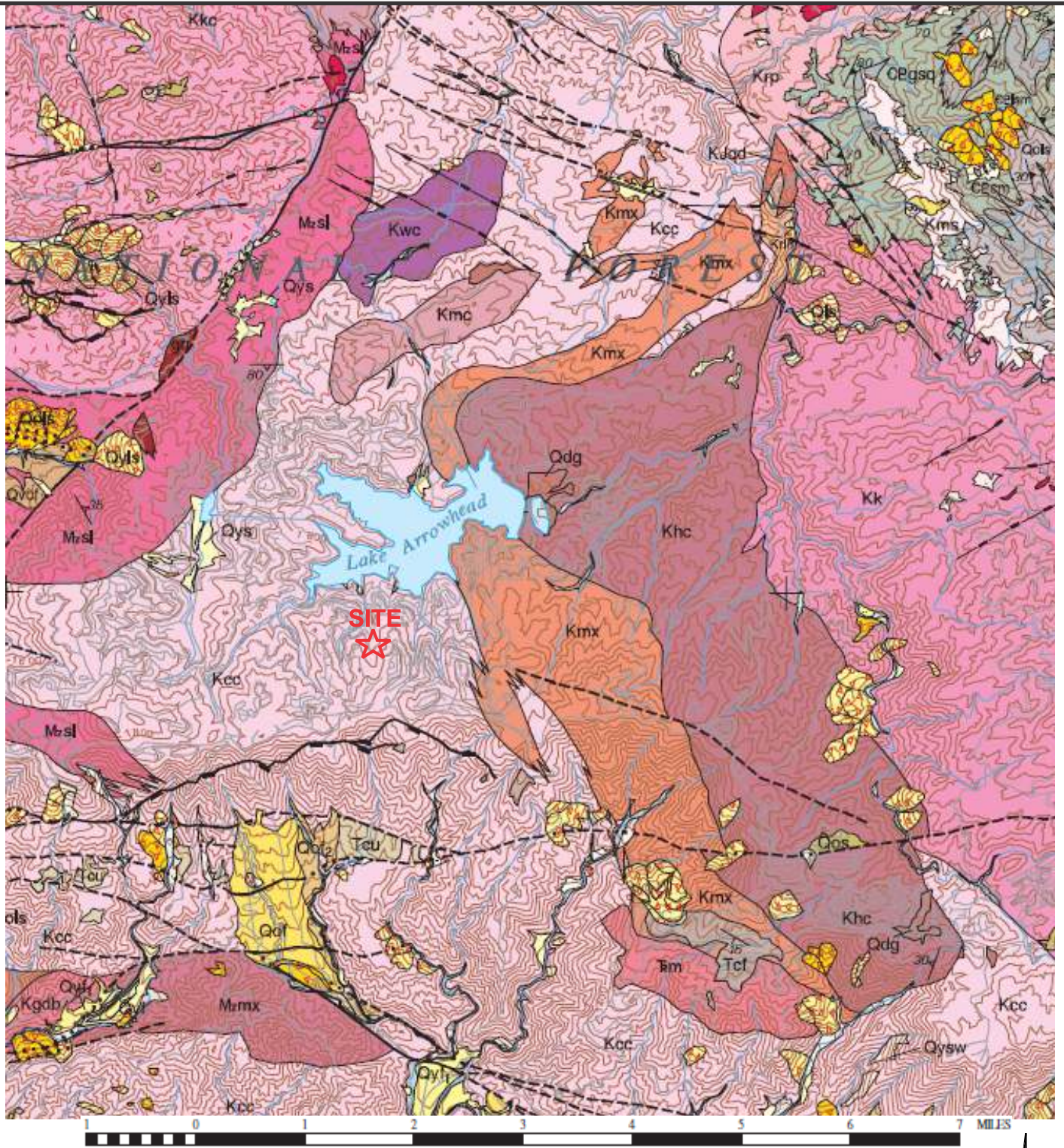
#### **Earth Materials Description:**

Presented as follows are brief descriptions of the earth materials encountered in the exploratory excavations. More detailed descriptions of encountered earth materials are presented on the 'Subsurface Exploration Logs,' Plate Nos. 3 through 7, presented in Appendix 'A' of this report. The earth material strata, as shown on the logs, represent conditions at the actual exploratory excavation locations. Other variations may occur beyond and/or between the excavations. Lines of demarcation between earth materials on the logs represented the approximate boundary between the material types; however, the transition may be gradual.

The earth materials encountered on the subject site during the field exploration were identified as artificial fill (Af), colluvium (Qc) and Cretaceous monzogranite of City Creek (Kcc).

Artificial fill was encountered in four of five borings. The artificial fill extended from the ground surface to approximately 6.0 feet below the ground surface (bgs). The artificial fill consisted of silty sand that was silty fine to medium grained sand. The fill was brown in color, was slightly moist to moist, and was loose to dense in consistency.

Colluvium was encountered in four of five borings and extended from the bottom of the artificial fill to approximately 12.5 feet bgs. Colluvium consisted of a silty fine to medium grained sand, trace gravels (SM), which was brown in color, lightly moist to moist, and medium dense to dense in consistency.



**Legend**

- Mzsl** Mixed granitic rocks of Silverwood Lake (Mesozoic)
- Kcc** - Monsogranite of City Creek (Cretaceous).



**REGIONAL GEOLOGIC MAP**

APN 0335-141-06 off State Highway 173,  
Lake Arrowhead, CA 92352

By: MC

Date: 9/2024

Project No.: 1666-01.1

**Figure 2**

Source: Copied from USGS: Geologic Map of The San Bernardino and Santa Ana 30'X60' Quadrangle, Sheet 1 of 4, Version 1.0, by D.M. Morton, F.K., Miller, Open File Report: 2006-1217, Scale 1:100,00

Monzogranite of City Creek bedrock at the subject site underlying colluvium was encountered in one of five borings. The bedrock was generally weathered near the contact with colluvial soil and became harder with depth. The bedrock when broken down was generally silty fine-grained sand and extended to a maximum explored depth of approximately 5 feet. The bedrock became less weathered with depth, moderately moist to moist, light brown in color, and hard to very hard in consistency with depth.

### **Groundwater**

Groundwater was not encountered in the exploratory excavations to the maximum explored depth of approximately 12.5 feet below the existing ground surface at the boring location at the time the field exploration was performed for this report.

No evidence of onsite springs or seeps was observed during our field study performed for this report. Though no groundwater was encountered during the field exploration performed for this report, a potential does exist that seeps and springs could occur during and following periods of heavy precipitation, snow melt, or prolonged landscape irrigation. Based on anticipated lot grading and the inferred groundwater depths, groundwater should not be an important factor for project design or long-term performance.

### **Surface Water**

Surface water was not observed on the subject site at the time the field exploration was performed for this report.

### **Site Variations**

Based on results of our subsurface exploration and experience, variations in the continuity and nature of surface and subsurface conditions should be anticipated. Due to uncertainty involved in the nature and depositional characteristics of

earth materials at the site, care should be exercised in extrapolating or interpolating subsurface conditions between and beyond the exploratory excavation locations.

Groundwater observations were made in the exploratory excavations at times and under conditions stated on the logs. However, it should be noted that fluctuations in levels of groundwater, springs, and/or perched water may occur due to variations in precipitation, temperature, and other factors.

### **Faulting and Regional Seismicity**

The site is situated in an area of active and potentially active faults, as is most of metropolitan southern California. Active faults present a variety of potential risks to structures, the most common of which are strong ground shaking, dynamic densification, liquefaction, mass wasting, and surface rupture at the fault plane. Generally speaking, the following four (4) factors are the principal determinants of seismic risk at a given location:

- Distance to seismogenically capable faults.
- The maximum or "characteristic" magnitude earthquake for a capable fault.
- Seismic recurrence interval, in turn related to tectonic slip rates.
- Nature of earth materials underlying the site.

Surface rupture represents the primary potential hazard to structures built in an active fault zone. A review of official maps delineating State of California earthquake fault zones found that no Alquist-Priolo fault study zones passed through or by the subject site. In addition, the site is not located within a zone of mandatory study for active faulting per the **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH23C Harrison Mtn, Plot Date: 03/09/2010, Scale: 1:14,400

([http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C\\_20100309.pdf](http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C_20100309.pdf)).

Ground shaking is judged to be the primary hazard most likely to affect the site, based upon proximity to regionally significant active faults. Per <https://maps.conservation.ca.gov/cgs/fam/>, the nearest regionally significant active fault is San Andrea fault which is approximately 6 miles to the southwest of the site. Another active fault, the Ord Mountain fault is approximately 8.7 miles to north of the site.

### **Secondary Seismic Hazards**

Secondary hazards include induced land sliding, liquefaction, subsidence as a result of soil densification, surface oscillations in larger lakes, or seismic sea waves, ground crack due to ground shaking, and flooding (from ruptured tanks and reservoirs).

### **Landslide**

The subject site is located within a designated low to moderate potential landslide area per **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH23C Harrison Mtn, Plot Date: 03/09/2010, Scale: 1:14,400 ([http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C\\_20100309.pdf](http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C_20100309.pdf)).

Field reconnaissance did not disclose the presence of older, existing landslides within or near the subject property.

### **Liquefaction**

Liquefaction describes a phenomenon in which cyclic stresses produced by ground shaking induced excess pore water pressures in the cohesionless soils, which may thereby acquire a high degree of mobility leading to damage or deformations. In general, this phenomenon only occurs below the water table, but after liquefaction has developed, it can propagate upward into overlying non-saturated soil as excess pore water pressure. Liquefaction susceptibility under a given earthquake is related to the gradation and relative density characteristics of the

soil, the in-situ stresses prior to ground motion, and the depth to the water table, as well as other factors.

The subject site is not located within a designated area as having a liquefaction potential per **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH23C Harrison Mtn, Plot Date: 03/09/2010, Scale: 1:14,400 ([http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C\\_20100309.pdf](http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23C_20100309.pdf)).

Moreover, the bedrock underneath the site is shallow. Therefore, the potential of liquefaction is low.

### **Seismically Induced Subsidence**

Loose sandy soils subjected to moderate to strong ground shaking can experience settlement. Experience from the Northridge Earthquake indicates that structural distress can result from such seismic settlement due to thick loose sandy soils. Based upon the findings of this investigation, no thick loose sandy soils underlie the subject site; and the proposed structures will be supported on engineered fill, settlement of structures induced by seismic event is considered insignificant.

### **Seiching**

Seiching involves an enclosed body of water oscillating due to ground shaking, usually following an earthquake. Lakes and water towers are typical bodies of water affected by seiching. However, the site does not appear to be under the influence of large bodies of water and, as such, seiching is considered insignificant for the development of the subject site.

### **Tsunamis**

Because of the inland geographic location of the site, tsunamis are not considered a geologic hazard for the development of the subject site.

**Lurching**

Lurching is a phenomenon in which ground cracking and/or secondary faulting occurs as a result of ground shaking. Generally, lurching primarily occurs in the immediate vicinity of faulting or steep slope areas. No known active or potential active faults pass through or by the subject site or its immediate vicinity, and granitic bedrock is shallow at the subject site as well as the footings of proposed structures will be founded into bedrock; therefore, the likelihood for lurching to impact the site is considered low.

**OTHER GEOLOGIC HAZARDS****Flooding**

The subject site is not located within a designated area as having a flooding potential per **San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Hazard Overlays*, Sheet FH23 B Harrison Mtn, Plot Date: 03/09/2010, Scale: 1:14,400 ([http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23B\\_20100309.pdf](http://www.sbcounty.gov/Uploads/lus/GeoHazMaps/FH23B_20100309.pdf))

**CONCLUSIONS AND RECOMMENDATIONS****GENERAL**

In our opinion, the proposed two well head houses, a water treatment building with a water tank, and appurtenances at the subject site are feasible from a geotechnical engineering viewpoint provided the geotechnical recommendations presented in this report are properly incorporated into design of the project and implemented during construction of the project.

The proposed structures can be supported on conventional shallow foundations. However, due to the anticipated high ground shaking and seismic settlement, all isolated footings should be tied to the strip footings or grade beams.

The following sections contain geotechnical recommendations for the design and construction of the subject development and include our recommendations and discussions about bearing capacity, settlement, flatworks, slabs-on-grade, temporary excavations, and site drainage.

## **GRADING**

Prior to grading, any existing vegetation, abandoned foundations and underground utilities, septic system, and other debris, if any, should be removed from the entire project area.

In general, the subgrade preparations including fill and backfill can be conducted as follows:

### **General Grading Requirements**

1. All undocumented fill, construction debris, organic matter, and other deleterious materials should be removed from the proposed structure areas.
2. Based on the laboratory test results and our field exploratory findings, the area for the proposed well head #1 should be excavated to a minimum of 10 feet bgs or competent native soil, whichever is deeper. The dry density of the competent native soil should be no less than 85 percent of the maximum dry density in accordance with the latest version of ASTM D1557. The excavation should be laterally extended to a minimum of 5 feet beyond the outlines of the proposed footprint. The excavation area should be filled with engineered fill.
3. The area for the proposed well head #2 should be excavated to a minimum of 7 feet bgs or competent native soil, whichever is deeper. The dry density of the competent native soil should be no less than 85 percent of the maximum dry density in accordance with the latest version of ASTM

D1557. The excavation should be laterally extended to a minimum of 5 feet beyond the outlines of the proposed structural footprint. The excavation area should be filled with engineered fill.

4. The areas for the proposed water treatment building and holding tank should be excavated to a minimum of 5 feet or a minimum of 2 feet below the bottom of the proposed footing, whichever is deeper. The excavated areas should be laterally extended to a minimum of 5 feet beyond the outlines of the proposed structural footprints. The excavated areas should be backfilled with engineered fill.
5. All engineered fill, unless otherwise specifically stated in the report, should be compacted to a minimum of 90 percent of the maximum dry density as determined by the latest version of ASTM D1557 Method.
6. No fill should be placed until the area to receive the fill has been adequately prepared, cleared of fill soil and/or loose native soil, and approved by the Geotechnical Consultant or his representative.
7. Fill soils should be kept free of debris and organic material.
8. Rocks or hard fragments larger than 3 inches may not be placed in the fill without the approval of the Geotechnical Consultant or his representative, and in a manner specified for each occurrence. There should not be any concentrations of particles sizes of 2 inches or greater; proper mixing should be performed.
9. The fill material should be placed in lifts which, when loose, should not exceed 8 inches per lift. Each lift should be spread evenly and should be thoroughly mixed during the spreading to obtain uniformity of material and moisture. Compaction tests should be conducted in accordance with

latest versions of the ASTM D1556 and/or D6938 in no more than 2 feet of vertical interval.

10. When the moisture content of the fill materials is lower than the specified value or is too low to obtain adequate compaction, water should be added and thoroughly dispersed until the soil has a moisture content within 2½ percent of optimum unless determined otherwise by the Geotechnical Consultant at the time of construction.
11. When the moisture content of the fill material is too high to obtain adequate compaction, the fill material should be aerated by blading or other satisfactory methods until the soil has a moisture content as specified herein.
12. Permanent fill slopes exceeding 5 feet in height should not be constructed at gradients steeper than 2: 1(H: V).

## **FILL MATERIALS**

### **Onsite Earth Materials**

The on-site soils are considered suitable for backfilling purpose, following proper processing, provided they are free of deleterious materials, construction debris, and oversize rocks. Imported materials may also be used for backfilling purposes.

Over excavation and re-compaction will induce fill shrinkage. Many factors such as mixing, relative compaction of the fill, and topographic approximations will affect shrinkage. We cannot estimate the exact amount of shrinkage; however, in our opinion, the shrinkage may be on the order of 6 to 14 percent for fill and alluvial material excavated and recompacted. This estimate does not include the material that will be required to fill in the excavations after the removal of any subsurface structures left in-place from prior to use of the site and removal of topsoil.

**Import Materials**

Any imported material should be observed and tested by HGI prior to use in fill or backfill areas.

Imported materials should be like the on-site soils with an expansion index of less than 20. Imported materials should be free from chemical or organic substances. The water-soluble sulfate content of the import materials should be less than 0.1% by weight.

**TEMPORARY EXCAVATIONS**

Cut and fill will be required for the proposed garage addition including slab-on-ground. The shallow undisturbed site soils are expected to be temporarily stable when excavated at a gradient of 1¼:1 (H:V) for un-surcharged excavations that are between 3 and 7 feet in depth. For excavations from 7 to 10 feet in depth, we recommend a gradient no steeper than 1½:1 (H:V) unless shoring is used.

The tops of slopes should be barricaded to prevent vehicles, and storage loads within 6 feet of the tops of slopes or 1 time of the excavation depth, whichever is greater. A greater setback may be necessary when considering heavy vehicles, such as concrete trucks and cranes; we should be advised of such heavy vehicle loadings so that specific setback requirements can be established. All regulations of the State and Federal OSHA should be followed. Some sloughing and caving of excavations should be anticipated.

Temporary excavations are assumed to be those that will remain un-shored for a period not exceeding one week. In dry weather, the excavation slopes should be kept moist, but not soaked. If excavations are made during the rainy season (normally from November through April), particular care should be taken to protect slopes against erosion. Mitigative measures, such as installation of berms, plastic sheeting, or other devices, may be warranted to prevent surface water from flowing over or ponding at the top of excavations.

## SEISMIC COEFFICIENTS

Based on the field investigation, the 2022 California Building Code (CBC), and ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16), the site could be designated as **Site Class D** per Table 20.3-1 of ASCE 7-16. The occupancy risk category can be designated as II. Other required seismic design parameters can be obtained from Section 1613 of the 2022 CBC or could be obtained from the California Structural Engineers Association website: <https://seismicmaps.org/> below by entering the coordinates of the project site (34.243943, -117.192057), the computer outputs are summarized in the following table:

**Table 1 Seismic Design Parameters**

<b>Spectral Response Accelerations <math>S_{MS}</math> and <math>S_{M1}</math></b>	
$S_s = 2.029 \text{ g}$ , $S_{MS} = F_a \times S_s$	$S_1 = 0.737 \text{ g}$ , $S_{M1} = F_v \times S_1$
Site Class D: $F_a = 1$ , $F_v = 1.7 \times 1.5$	
Period (Sec.)	$S_a$ (g)
0.2	2.029 ( $S_{MS}$ , Site Class D)
1.0	1.879 ( $S_{M1}$ , Site Class D)

<b>Design Spectral Response Accelerations <math>S_{DS}</math> and <math>S_{D1}</math></b>	
$S_{DS} = 2/3 \times S_{MS}$	$S_{D1} = 2/3 \times S_{M1}$
PGA=0.864 g, $F_{PGA}=1.1$ , $PGA_M=0.95 \text{ g}$	
Period (Sec.)	$S_a$ (g)
0.2	1.353 ( $S_{DS}$ , Site Class D)
1.0	1.253 ( $S_{D1}$ , Site Class D)
Seismic Design Category: D	

## FOUNDATIONS

### Structure and Foundation Setback from Slopes

The placement of the proposed structure on or adjacent to slopes steeper than three horizontals to one vertical should be in accordance with Section 1808.7 of

2022 California Building Code (2022 CBC). Building setback from an ascending slope should meet the minimum requirement regulated in Section 1808.7.2 of 2022 CBC, which is  $1/2H$  but not need exceed 15 feet nor less than a minimum of five feet horizontally from the building to the slope toe.

The proposed well head houses and water treatment building may be supported on continuous and pad footings.

Continuous footing should be designed for a minimum of 12 inches in width; and pad footing should be designed for a minimum of 18 inches in width. The bottom of footings should be located a minimum of 24 inches below the lowest adjacent finish grade, whichever is deeper. A net vertical bearing value of 2,000 pounds per square feet (psf) can be used to design the footings. A one-third increase in the bearing value can be used when considering wind or seismic loads.

The continuous footings should be reinforced with at least two # 4 re-bars near top and two # 4 re-bars near bottom or other reinforcement as determined by the Structural Engineer. Due to the potential seismic differential settlement, we recommend that any isolated footings be tied with the continuous footings and/or grade beams. The grade beams may be designed as bearing elements, like the footings.

The proposed tank may be supported on ring foundation. The stability of the tank should be evaluated by considering the bearing capacity and settlement of the circular ring foundation. Ring footing should be at least 24 inches in width and embedded at least 24 inches below the lowest adjacent soil grade. The footing reinforcement should be based on structural design. Footing placed at a depth of 24 inches below the lowest adjacent grade may be designed based on an allowable net bearing capacity of 2,000 psf. A one-third increase in the bearing value can be used when considering wind or seismic loads. The stresses in the ring foundation may be evaluated considering the ring as either a circular beam or a

mat on an elastic foundation. The modulus of subgrade reaction (Ks) for the properly compacted soil pad, may be taken as 200 kips per cubic foot (kcf).

### **Lateral Resistance**

Lateral load resistance can be derived from passive resistance along the vertical sides of the foundations, friction acting at the base of the foundations, or a combination of the two. A coefficient of friction of 0.35 can be used between the footings and the bedrock. The passive resistance of level properly competent bedrock or compacted fill in direct contact with the footings can be assumed to be equal to the pressure developed by a fluid with a density of 300 pounds per cubic foot (pcf), to a maximum pressure of 3,000 pcf. A one-third increase in the passive value can be used for wind or seismic loads. The frictional resistance and the passive resistance of the soils can be combined provided that the passive resistance is reduced by one-third. We recommend that the fill and native soil cover above bedrock be neglected in the passive resistance.

### **Estimated Settlement**

Based on the results of our analyses and our recommendations which will be incorporated into design and implemented during construction, we estimate that the total static settlement of isolated and/or strip footings under sustained loads will be on the order of  $\frac{3}{4}$  inch for the anticipated maximum structural loads. The maximum static differential settlement, over a horizontal distance of thirty feet, should be on the order of  $\frac{1}{2}$  inch for similarly loaded footings. The seismic differential settlement is expected to be on the order of  $\frac{3}{4}$  inch over a horizontal distance of thirty feet.

## **RETAINING WALLS**

Retaining walls may be required to accommodate the proposed structures. The pressure behind the retaining wall depends primarily on the allowable wall movement, wall inclination, type of backfill materials, backfill slopes, surcharge,

and drainage. Determination of whether the active or at-rest condition is appropriate for design will depend on the flexibility of the walls. Walls that are free to rotate at least 0.002 radians at the top (deflection at the top of the wall of at least  $0.002 \times H$ , where H is the unbalanced wall height) can be designed for free standing conditions; otherwise, it is considered as an at-rest condition. The recommended equivalent fluid weight (EFW) for free standing condition and at-rest conditions for the onsite soil retaining are presented in the following table.

**Table 2 - Earth Pressures for Retaining Walls**

Wall Movement	Backfill Condition (H:V)	Equivalent Fluid Weight (pcf)
Free Standing Condition	Level	30
	3:1	38
	2:1	43
At-rest Condition	Level	60
	3:1	79
	2:1	87

The above lateral earth pressures do not include the effects of surcharge (e.g., traffic, footings, hydrostatic pressure) or compaction. Any surcharge (live, including traffic, or dead load) located within a 1:1 plane drawn upward from the base of the excavation should be added to the lateral earth pressures. The lateral pressure addition of a uniform surcharge load located immediately behind walls may be calculated by multiplying the surcharge by 0.33 for cantilevered walls and 0.5 for restrained walls.

The retaining wall footings should be designed per Foundation Section above.

Foundations for the proposed structure and/or retaining walls on slopes that are steeper than 10H:1V (Horizontal to Vertical) (10 percent slope) should be

designed in accordance with the provisions of Section 1809.3, 'Stepped Footings,' in 2022 CBC. The top surface of the footings should be level or should be stepped on so that both the top and bottom of such foundations are in accordance with the provisions in Section 1809.3 in 2022 CBC. The stepped foundation should be suitably reinforced and designed by a qualified Civil or Structural Engineer.

A drainage system should be provided behind the walls to reduce the potential for development of hydrostatic pressure. If a drainage system is not installed, the walls should be designed to resist hydrostatic pressure in addition to the earth pressure.

Walls should be properly drained and waterproofed. Except for the upper two feet, the backfill immediately behind retaining walls (minimum horizontal distance of 12 inches) should consist of free-draining  $\frac{3}{4}$ -inch crushed rock wrapped with filter fabric. A 4-inch diameter Schedule 40 perforated PVC pipe, placed perforations down at the bottom of the crushed rock backfill, leading to a suitable gravity outlet should be installed.

### **FLOOR-ON-GROUND/HARDSCAPE**

Concrete slab-on-ground should consist of a nominal 4-inch thickness of concrete and contain at a minimum # 4 re-bars spaced a maximum of 16 inches on centers, both ways. Thicker slabs and additional reinforcement may be required depending on the floor loads and the structural requirements as determined by the Structural Engineer.

The subgrade preparations should follow the recommendations provided in the Grading Section above. It is recommended that the compacted subgrade be moistened prior to placement of the vapor retarder.

It is essential to minimize differential settlements, for each floor unit (room) to be founded entirely on compacted fill or competent bedrock or structurally supported (as raised floor).

### **Moisture Sensitive Floor Covering**

Water vapor transmitted through floor slabs is a common cause of floor covering problems. In areas where moisture-sensitive floor coverings (such as tile, hardwood floors, linoleum, or carpeting) are planned, a vapor retarder should be installed below the concrete slabs to reduce excess vapor transmission through the slab.

The function of the recommended relatively impermeable membrane (vapor retarder) is to reduce the amount of soil moisture or water vapor that is transmitted through the floor slab. The membrane should be 10-mil thick, Class A, and care should be taken to preserve the continuity and integrity of the membrane beneath the floor slab. The vapor retarder should conform to ASTM E1745. The vapor retarder should be installed in strict conformance with the manufacture recommendations.

If a capillary break is used, a 4-inch layer of  $\frac{1}{2}$ -  $\frac{3}{4}$  inch diameter gravels should be placed below the moisture barrier for capillary break to comply with the requirements of current California Green Building Code.

### **SURFACE DRAINAGE**

Foundation, slab, flatwork, and pavement performance depend greatly on proper drainage within and along the boundary of the improvements. Perimeter grades around the building should be sloped in a manner allowing water to drain away from the structure and not pond next to the foundations. Roof down drains should be connected to underground pipes carrying water away from the building area or have extenders, so water does not drain and pond next to the building. Per the 2022 CBC, landscape areas within 10 feet of the building should slope away at gradients of at least 5 percent. Paved areas within 10 feet of the building should slope away at gradients of at least 2 percent. Proper drainage is recommended for all surfaces to reduce the potential settlement due to water infiltration. We

recommend minimizing the size and number of planters adjacent to the building and other foundations and using drought resistant planting.

#### **UTILITY TRENCH BACKFILL**

It is anticipated that the natural soil will provide a firm foundation for site utilities. Any soft and/or unsuitable material encountered at the invert should be removed and replaced with an adequate bedding material.

Pipe bedding is defined as the material supporting the pipe up to midpoint of the pipe. Specifications for bedding materials including required backfill requirements surrounding the pipe should be specified by either the pipe manufacturer or design engineer.

To provide uniform and firm support for the pipeline, free-draining granular soil should be used as pipe bedding material. For flexible pipes, excavated sandy materials may be used as bedding material. Crushed rock or gravel may be used for rigid pipes. Bedding material for the pipes should be free from oversized particles (greater than one (1) inch).

Pipe design generally requires sand equivalent of 30 or greater for bedding materials. Laboratory test on one sample indicated sand equivalent of 20. Therefore, selective on-site soil may not be used for pipe bedding.

The pipe zone backfill refers to the soil envelope over the pipe extending from the pipe bedding up to about 12 inches above the pipe. The design of the pipe zone backfill depends on the type and the density of embedment materials and should be selected by a pipe designer.

Stiffness of the pipe zone backfill is the most important contributing factor to the deflection of flexible pipes. Clean sand may be used for flexible pipes, and gravel or ¾-inch crushed aggregate or crushed rock may be used for rigid pipes.

Pipe zone backfill should be vibrated in-place to achieve the compaction specified by the pipe designer. Flooding or jetting of the pipe zone material may be used at selective site soils with sand equivalent greater than 30. Long-term accumulation of water in the pipe trench from any sources should be avoided, and trenches should be pumped dry if water collects inside them during construction.

### **SOIL EXPANSIVITY AND COLLAPSIBILITY**

The subsurface soils encountered at shallow depths consist mostly of silty sand with trace amounts of gravel, which has very low expansive. These types of material generally have a low to medium susceptibility to collapse when facing seasonal cycles of saturation/desiccation. Consequently, the recommendations provided in this report regarding drainage, moisture content during compaction and other pertinent recommendations for site improvements should be incorporated into the design and construction.

### **SOIL CORROSIVITY**

The corrosion potential of the onsite materials to steel and buried concrete was preliminarily evaluated. Laboratory testing was performed on a selected soil sample to evaluate pH, minimum resistivity, chloride, and soluble sulfate content. The test results are presented in Appendix A, Plate No. 8.

These tests are only an indicator of soil corrosivity for the samples tested. Other soils found on site may be more, less, or of a similar corrosive nature. Imported fill materials should be tested to confirm their corrosion potential. Based on the minimum resistivity results from the soil tested, some of the near-surface site soils are mildly corrosive towards buried ferrous metals. The soluble sulfate concentration of 21 ppm indicates that the potential of sulfate attack on concrete

in contact with the onsite soils is classified as contact category “S0” based on ACI 318-19 Tables 19.3.1.1 and 19.3.2.1. Cement Type I or II may be used in concrete. Maximum water-cement ratios are not specified for the sulfate concentrations; however, the Structural Engineer should select a type of concrete with appropriate strength. The soluble chloride concentration of 11 ppm can be considered negligible for concrete per ACI 318-19 Tables 19.3.2.1. pH value measured in the soil sample is 7.53; and the resistivity value measured in the soil sample is 19,070 ohms-cm. The soil corrosion on the site is considered mild. Further interpretation of the corrosivity test results, including the resistivity value, and providing corrosion design and construction recommendations are the purview of corrosion specialists/consultants.

## **LIMITATIONS**

### **REVIEW, OBSERVATION, AND TESTING**

The recommendations presented in this report are contingent upon review of final plans and specifications for the project by **HGI**. The project Geotechnical / Geologic Consultant should review and verify in writing the compliance of the final grading plan and the final foundation plans with the recommendations presented in this report.

It is recommended that **HGI** be retained to provide continuous Geotechnical / Geologic Consulting services during the earthwork operations (i.e., rough grading, utility trench backfill, subgrade preparation for slabs-on-ground and pavement areas, finish grading, etc.) and foundation installation process. This is to observe compliance with the design concepts, specifications, and recommendations and to allow for design changes in the event that subsurface conditions differ from those anticipated prior to start of construction. If **HGI** is replaced as Geotechnical / Geologic Consultant of record for the project, the work on the project should be stopped until the replacement Geotechnical / Geologic Consultant has reviewed the previous reports and work performed for the project,

agreed in writing to accept the recommendations and prior work performed by **HGI** for the subject project, or has submitted their revised recommendations.

### **UNIFORMITY OF CONDITIONS**

The recommendations and opinions expressed in this report reflect our understanding of the project requirements based on an evaluation of subsurface earth material conditions encountered at the subsurface exploration locations and the assumption that earth material conditions do not deviate appreciably from those encountered. It should be recognized that the performance of the foundations may be influenced by undisclosed or unforeseen variations in earth material conditions that may occur in intermediate and unexplored areas. Any unusual conditions not covered in this report that may be encountered during site development should be brought to the attention of **HGI** so that we may make modifications, if necessary.

### **CHANGE IN SCOPE**

**HGI** should be advised of any changes in the project scope of proposed site grading so that it may be determined if recommendations contained herein are valid. This should be verified in writing or modified by a written addendum.

### **TIME LIMITATIONS**

The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the State-of-the-Art and/or government codes may occur. Due to such changes, the findings of this report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a period of two (2) years without a review by **HGI** verifying the validity of the conclusions and recommendations.

**PROFESSIONAL STANDARD**

In the performance of our professional services, we comply with the standard of care and skill ordinarily exercised under similar circumstances by members of the geologic/geotechnical professions currently practicing under similar conditions and in the same locality. The client recognizes that subsurface conditions may vary from those encountered at the locations where our surveys and exploratory excavations were made, and that our data, interpretations, and recommendations are based solely on information obtained by us. We will be responsible for those data, interpretations, and recommendations, but should not be responsible for interpretations by others of the information presented and/or developed. Our services consist of professional consultation and observation only, and other warranties, expressed or implied, are not made or intended in connection with work performed by **HGI** or by the proposal for consulting or other services or by the furnishing of oral or written reports or findings.

**CLIENT'S RESPONSIBILITY**

It is the responsibility of the client and/or the client's representatives to ensure that information and recommendations contained herein are brought to the attention of the Engineers and Architect for the project and incorporated into project plans and specifications. It is further their responsibility to take measures so that the contractor and his subcontractors carry out such recommendations during construction.

## **APPENDIX A**

## FIELD EXPLORATION

The field study performed for this report included a visual geologic reconnaissance of existing surface conditions of the subject site. Site observations and geologic mapping were conducted on August 22<sup>nd</sup>, 2024, by a representative of **HGI**.

A study of the property's subsurface condition was performed to evaluate underlying earth strata and the presence of groundwater. Five (5) exploratory hand auger excavations were performed on the subject site on August 22<sup>nd</sup>, 2024. The locations of the exploratory excavations were determined in the field by pacing, tape measuring, and sighting from the adjacent existing streets, adjacent structures, and topographic features as shown on Plate No. 1, presented in this appendix. Approximate locations of the exploratory excavations are denoted on the 'Exploratory Excavation Location Plan,' Plate No. 1, presented in this Appendix. Approximate elevations at the locations of the exploratory excavations were determined from the Google Earth Website (<http://www.google.com/earth>). Locations and elevations of the exploratory excavations should be considered accurate only to the degree implied by the method used in determining them.

The exploratory hand augers were excavated by using hand tools, hammers, rods, and a split spoon sampler. The depths explored in the borings vary from 2.5 to 12.5 feet below the existing ground surface at the excavation locations. Bulk and relatively undisturbed ring samples were obtained from cuttings developed during the excavation process and represent the earth materials within the depth indicated.

Groundwater observations were made during, and at the completion of the excavation process and are noted on the 'Subsurface Exploration Log' presented in this Appendix, if encountered.

The exploratory excavations were logged by a representative of **HGI** for fill material, natural earth material, and subsurface conditions encountered. Earth materials encountered in the exploratory excavations were visually described in the field in general accordance with the current Unified Soils Classification System (USCS), ASTM D2488, visual-manual procedures, as illustrated on the attached, simplified 'Subsurface Exploration Legend,' Plate No. 2, presented in this Appendix. The visual textural description, color of the earth material at natural moisture content, apparent moisture condition of the earth materials, and apparent relative density or consistency of the earth materials, etc., were recorded on the field logs. The 'Relative Density' of granular soils (SP, SW, SM, SC, GP, GW, GM, GC) is given as very loose, loose, moderately dense, dense, or very dense and is based on the number of blows to drive the sampler 1.0 foot or fraction thereof. The 'Consistency' of silts or clays (ML, CL, MH, CH) is given as very soft, soft, medium stiff, stiff, very stiff, or hard and is also based on the number of blows to drive the sampler 1.0 foot or fraction thereof. The field log for each excavation contains factual information and interpretation of earth material conditions between samples. The 'Subsurface Exploration Log' presented in this Appendix represents our interpretation of the field log contents and results of laboratory observations and tests performed on samples obtained in the field from the exploratory excavations.

### **LABORATORY TESTING PROGRAM**

Laboratory tests were performed on selected, relatively undisturbed ring and bulk samples obtained from exploratory excavations during field study. Tests were performed in general accordance with generally accepted American Society for Testing and Materials (ASTM), State of California - Department of Transportation (CALTRANS), Environmental Protection Agency (EPA) or other suitable test methods or procedures. The remaining samples obtained during the field study will be discarded 30 days after the date of this report. This office

should be notified immediately if retention of samples is needed beyond 30 days. A brief description of the tests performed is presented below:

### **CLASSIFICATION**

The field classification of earth material materials encountered in the exploratory excavations was verified in the laboratory in general accordance with the current Unified Soils Classification System, ASTM D2488, 'Standard Practice for Determination and Identification of Soils (Visual-Manual Procedures).' The final classification is shown on the 'Subsurface Exploration Log,' Plate Nos. 3 through 7, presented in this Appendix.

### **IN-SITU MOISTURE CONTENT AND DRY DENSITY**

The in-situ moisture content and dry density were determined in general accordance with current ASTM D2216 (Moisture Content) and D1188 (Bulk Specific Gravity and Density of Paraffin Coated Specimens) procedures, respectively, for selected undisturbed samples obtained. This information was an aid to classification and permitted recognition of variations in material consistency with depth. The dry density is determined in pounds per cubic foot and the moisture content is determined as a percentage of the oven dry weight of the earth material. Test results are shown on the 'Subsurface Exploration Log,' Plate Nos. 3 and 4, presented in this Appendix.

### **CHEMICAL AND ELECTRICAL RESISTIVITY TESTS**

The concentration of soluble chloride, pH, as well as other chemical constituents and the minimum electrical resistivity were determined for a selected sample of near-surface earth material. The pH test was performed in general accordance with current EPA 9045C procedures. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 8, presented in this Appendix.

**SAND EQUIVALENT TEST**

A sand equivalent test was performed on a sample of near-surface earth material in general accordance with current ASTM D2419 procedures. The Sand Equivalent is an indicator of the relative proportion of fine materials in samples of earth material or aggregate which pass a No. 4 sieve. The Sand Equivalent value is a unit less number and is the ratio of the height of sand to the height of flocculated fine material in a sedimentation cylinder. The ratio is multiplied by 100 to obtain the Sand Equivalent Value. The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 8, presented in this Appendix.

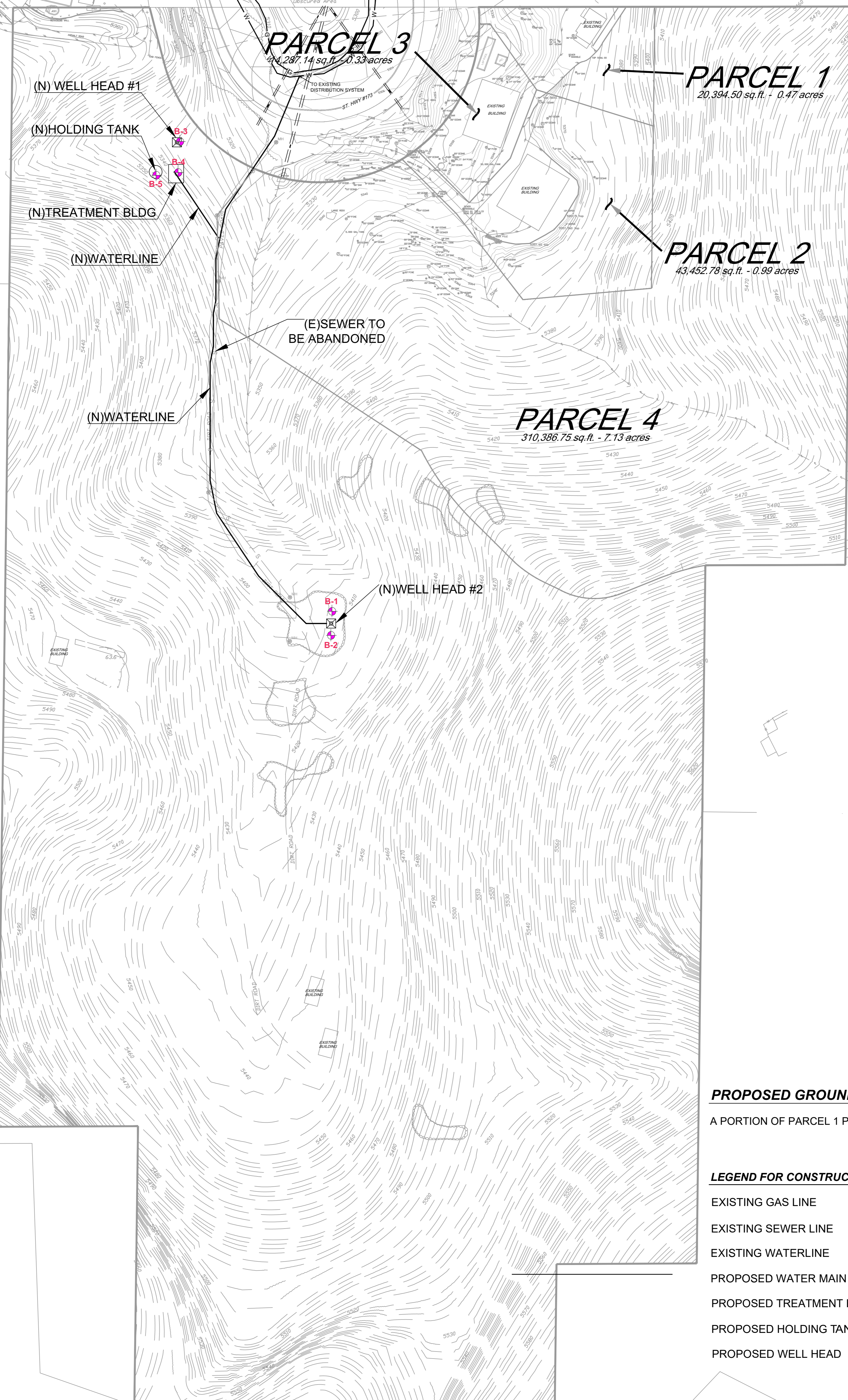
**DIRECT SHEAR TEST**

A direct shear test was performed on an undisturbed sample of near-surface earth materials obtained from the borings in general accordance with current ASTM D3080 procedures. The shear machine is of the constant strain type. The shear machine is designed to receive a 1-inch high, 2.416-inch diameter ring sample. Three (3) specimens from the selected sample of earth material were sheared at various pressures normal to the face of the specimens. The specimens were tested in a submerged condition. The peak and ultimate shear stresses were plotted versus the normal confining stresses to determine the shear strength (cohesion and angle of internal friction). The test results are summarized in the 'Summary of Laboratory Test Results,' Plate No. 9, presented in this Appendix.

**CONSOLIDATION TESTS**

Settlement predictions of the in-situ, on-site earth material behavior under load were made based on consolidation tests that were performed in general accordance with current ASTM D2435 procedures. The consolidation apparatus is designed to receive a 1-inch high, 2.416-inch diameter ring sample. Porous stones are placed in contact with the top and bottom of each specimen to permit addition and release of pore water and pore pressure. Loads normal to the face of the specimen are applied in several increments in a geometric progression under

both in-situ moisture and submerged conditions. The resulting changes in sample thickness are recorded at selected time intervals. Results are presented on the 'Consolidation Test Results,' Plate No. 10 through 12, presented in this Appendix.

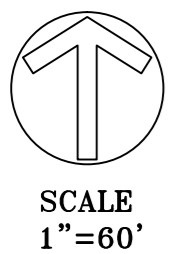


**PROPOSED GROUNDWATER WELLS**

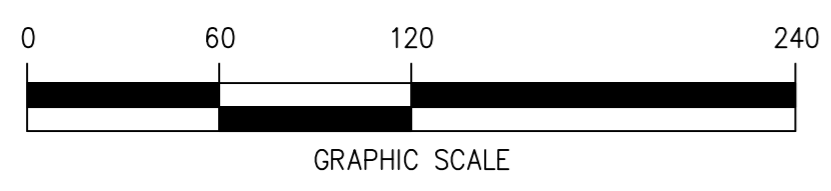
A PORTION OF PARCEL 1 PM 1232 MB 11/6

**LEGEND FOR CONSTRUCTION**

- EXISTING GAS LINE — G —
- EXISTING SEWER LINE — S —
- EXISTING WATERLINE — W —
- PROPOSED WATER MAIN ———
- PROPOSED TREATMENT BLDG □
- PROPOSED HOLDING TANK ○
- PROPOSED WELL HEAD ⊠



SCALE  
1"=60'



Legend  
⊠ B-1 Boring Location



**REGIONAL GEOLOGIC MAP**  
APN 0335-141-06 off State Highway 173,  
Lake Arrowhead, CA 92352  
By: MC Date: 9/2024  
Project No.: 1666-01.1 **Plate No. 1**

## SUBSURFACE EXPLORATION LEGEND

UNIFIED SOIL CLASSIFICATION SYSTEM Visual-Manual Procedure (ASTM D2488-09a)				CONSISTENCY / RELATIVE DENSITY		
MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES	CRITERIA		
Coarse-Grained Soils*	Gravels 50 % or more of Coarse Fraction Retained on No. 4 Sieve	Clean Gravels	GW	Well Graded Gravels and Gravel-Sand Mixtures, Little or no Fines		
		Gravels with Fines	GP	Poorly Graded Gravels and Gravel-Sand Mixtures, Little or no Fines		
			GM	Silty Gravels, Gravel-Sand-Silt Mixtures**		
		Sands More than 50 % of Coarse Fraction Passes No. 4 Sieve	Clean Sands	GC	Clayey Gravel, Gravel-Sand-Clay Mixtures**	
	SW			Well Graded Sands and Gravelly Sands, Little or no Fines		
	More than 50 % Retained on No. 200 Sieve	Sands with Fines	SP	Poorly Graded Sands and Gravelly Sands, Little or no Fines		
			SM	Silty Sands, Sand-Silt Mixtures**		
			SC	Clayey Sands, Sand-Clay Mixtures**		
				Inorganic Silts, Silty Silts, Rock Flour		
	Fine Grained Soils*	Silts and Clays Liquid Limits 50 % or less	ML	Inorganic Silts, Silty Silts, Rock Flour		
CL			Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Silty Clays, Lean Clays			
OL			Organic Silts and Organic silty Clays of Low Plasticity			
50 % or more Passes No. 200 Sieve		Silts and Clays Liquid Limits Greater than 50 %	MH	Inorganic Silts, Micaceous or Diatomaceous silts, Plastic Silts		
			CH	Inorganic Clays of High Plasticity, Fat Clays		
			OH	Organic Clays of Medium to High Plasticity		
Highly Organic Soils		PT	Peat, Muck, or Other Highly Organic Soils			
				<u>Standard Penetration Test</u> Cohesive Soils		
				Penetration Resistance, N, (Blows / Foot)	Consistency	Unconfined Compressive Strength, (Tons / Sq. Ft.)
				0 - 4	Very Loose	< 0.25
				5 - 10	Loose	0.25 - 0.5
				11 - 30	Medium Dense	0.5 - 1.0
				31 - 50	Dense	1.0 - 2.0
				> 50	Very Dense	2.0 - 4.0
				< 2	Very Soft	> 4.0
				2 - 4	Soft	
				5 - 8	Firm (Medium Stiff)	
				9 - 15	Stiff	
				16 - 30	Very Stiff	
				> 31	Hard	

\* Based on material passing the 3-inch sieve.

\*\* More than 12% passing the No. 200 sieve; 5% to 12% passing No. 200 sieve requires use of dual symbols (i.e., SP-SM., GP-GM, SP-SC, GP-GC, etc.); Border line classifications are designated as CH/CI, GM/SM, SP/SW, etc.

U.S. Standard Sieve Size	12"	3"	3/4"	#4	#10	#40	#200	
<b>Unified Soil Classification Designation</b>	Boulders	Cobbles	Gravel		Sand			Silt and Clay
			Coarse	Fine	Coarse	Medium	Fine	

<u>Moisture Condition</u>		<u>Material Quantity</u>		<u>Other Symbols</u>
Dry	Absence of moisture, dusty, dry to the touch.	Trace	< 5 %	C - Core Sample
Moist	Damp but no visible moisture.	Few	5 - 10%	S - SPT Sample
Wet	Visible free water, usually below the water table.	Little	15 - 25%	B - Bulk Sample
		Some	30 - 45 %	CK - Chunk Sample
		Mostly	50-100%	R - Ring Sample
				N - Nuclear Gauge Test
				∇ - Water Table



# Hilltop Geotechnical

786 S. Gifford Avenue, San Bernardino, California, 92408

Phone: 909 890 9079

Boring No.: B-1

**HILLTOP GEOTECHNICAL**  
INCORPORATED

Latitude : 34.242385	Drill Supplier : Hilltop Geotechnical	Job Number : 1666-01	Sheet : 1 OF 1
Longitude : -117.192326	Driller Company : Hilltop Geotechnical	Client : Example Client	
Elevation : Not Surveyed	Logged By : Albert Buffet	Project : Lake Arrowhead Community Services District	
Total Depth : 9.25 ft	Date : 08/22/2024	Location : Lake Arrowhead; APN 0335-141-06 off State Highway 173	

Depth (ft)	Samples		Blows per 6" (SPT)	Blows per 6" (ModCal)**	Graphic Log	Soil Origin	Classification Code	Material Description	Testing			
	Bulk	Mod Cal Sample							% Fines	Moisture %	Dry Density (pcf)	Other
1				100, ( N = 130 )	[Graphic Log: Yellowish-brown soil with small dark spots]	Fill	SM	SILTY SAND: silty fine to medium grained sand, loose, trace fine to medium sized gravel, moist, brown, some mulch .	7.8	109.2		
2												
3				16, 23, ( N = 25, 35 )								
4		NR										
5				50, 35, ( N = 55, 25 )					12.0	95.7		
6						Colluvium	SM	SILTY SAND: silty fine grained sand, medium dense to dense moist, trace fine sized gravel, dark yellowish brown.	12.8	97.5		
7				15, 16, ( N = 20, 15 )								
8												
9		NR		100/3in, ( N = 260 )				<b>B-1 refusal at 9.25ft (Refusal on large gravel). No Cave-in. No groundwater encountered.</b>				
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												



# Hilltop Geotechnical

786 S. Gifford Avenue, San Bernardino, California, 92408

Phone: 909 890 9079

Boring No.: B-2

**HILLTOP GEOTECHNICAL**  
INCORPORATED

Latitude : 34.242332	Drill Supplier : Hilltop Geotechnical	Job Number : 1666-01	Sheet : 1 OF 1
Longitude : -117.192401	Driller Company : Hilltop Geotechnical	Client : Example Client	
Elevation : Not Surveyed	Logged By : Albert Buffet	Project : Lake Arrowhead Community Services District	
Total Depth : 2.5 ft	Date : 08/22/2024	Location : Lake Arrowhead; APN 0335-141-06 off State Highway 173	

Depth (ft)	Samples		Blows per 6" (SPT)	Blows per 6" (ModCal)	Graphic Log	Soil Origin	Classification Code	Material Description	Testing			
	Mod Cal Sample								% Fines	Moisture %	Dry Density (pcf)	Other
1	NR			100/4in. (N = 195)		Fill	SM	SILTY SAND: silty fine grained sand, medium dense to dense, trace fine to medium sized gravel, moist to slightly moist, brown, trace of construction debris .				
2												
3								<b>B-2 refusal at 2.5ft (Refusal on large gravel. 4 attempts performed. *** N-value not calculated. Not to be used for density calculations). No Cave-in. No groundwater encountered.</b>				
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												



# Hilltop Geotechnical

786 S. Gifford Avenue, San Bernardino, California, 92408

Phone: 909 890 9079

Boring No.: B-3

**HILLTOP GEOTECHNICAL**  
INCORPORATED

Latitude : 34.243794	Drill Supplier : Hilltop Geotechnical	Job Number : 1666-01	Sheet : 1 OF 1
Longitude : -117.192817	Driller Company : Hilltop Geotechnical	Client : Example Client	
Elevation : Not Surveyed	Logged By : Albert Buffet	Project : Lake Arrowhead Community Services District	
Total Depth : 12.5 ft	Date : 08/22/2024	Location : Lake Arrowhead; APN 0335-141-06 off State Highway 173	

Depth (ft)	Samples		Blows per 6" (SPT)	Blows per 6" (ModCal)	Graphic Log	Soil Origin	Classification Code	Material Description	Testing			
	Bulk	Mod Cal Sample							% Fines	Moisture %	Dry Density (pcf)	Other
0.2						Non-Soil	PAV	Mulch				
1						Fill	SM	SILTY SAND: silty fine grained sand, medium dense, trace fine to medium sized gravel, moist to slightly moist, brown, trace of rootlets.				
2				60, ( N = 78 )					3.8	93.8		
3												
4												
5				60, ( N = 78 )					4.2	98.9		
6												
7				40, ( N = 52 )		Colluvium	SM	SILTY SAND: silty fine grained sand, medium dense, moist, trace fine sized gravel, brown.	4.9	86.0		
8												
9												
10												
11												
12				62, ( N = 80 )					8.8	87.4		
13								<b>B-3 Terminated at 12.5 ft. No cave-in. No groundwater encountered.</b>				
14												
15												
16												
17												
18												
19												



# Hilltop Geotechnical

786 S. Gifford Avenue, San Bernardino, California, 92408

Phone: 909 890 9079

Boring No.: B-4

**HILLTOP GEOTECHNICAL**  
INCORPORATED

Latitude : 34.243707	Drill Supplier : Hilltop Geotechnical	Job Number : 1666-01	Sheet : 1 OF 1
Longitude : -117.192712	Driller Company : Hilltop Geotechnical	Client : Example Client	
Elevation : Not Surveyed	Logged By : Albert Buffet	Project : Lake Arrowhead Community Services District	
Total Depth : 8 ft	Date : 08/22/2024	Location : Lake Arrowhead; APN 0335-141-06 off State Highway 173	

Depth (ft)	Samples		Blows per 6" (SPT)	Blows per 6" (ModCal)	Graphic Log	Soil Origin	Classification Code	Material Description	Testing			
	Bulk	Mod Cal Sample							% Fines	Moisture %	Dry Density (pcf)	Other
0.2						Non-Soil	PAV	Mulch				
1						Fill	SM	SILTY SAND: silty fine to medium grained sand, medium dense, trace fine to medium sized gravel, slightly moist, brown, trace of rootlets.				
2				20, 21, ( N = 26.65 )								
3.5		NR										
4						Colluvium	SM	SILTY SAND WITH GRAVEL: silty fine grained sand, fine grained gravel, medium dense, moist to slightly moist, brown, trace of rootlets.		2.1		
5				29, 35, ( N = 41.6 )								
6		NR										
8								B-4 refusal at 8ft (cobbles Encountered). No cave-in. No groundwater encountered.				
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												



# Hilltop Geotechnical

786 S. Gifford Avenue, San Bernardino, California, 92408

Phone: 909 890 9079

Boring No.: B-5

**HILLTOP GEOTECHNICAL**  
INCORPORATED

Latitude : 34.243713	Drill Supplier : Hilltop Geotechnical	Job Number : 1666-01	Sheet : 1 OF 1
Longitude : -117.192622	Driller Company : Hilltop Geotechnical	Client : Example Client	
Elevation : Not Surveyed	Logged By : Albert Buffet	Project : Lake Arrowhead Community Services District	
Total Depth : 5 ft	Date : 08/22/2024	Location : Lake Arrowhead; APN 0335-141-06 off State Highway 173	

Depth (ft)	Samples		Blows per 6" (SPT)	Blows per 6" (ModCal)	Graphic Log	Soil Origin	Classification Code	Material Description	Testing			
	Bulk	Mod Cal Sample							% Fines	Moisture %	Dry Density (pcf)	Other
0.2								Mulch				
1					Non-Soil Colluvium		PAV SM	SILTY SAND: silty fine grained sand, medium dense, moist to slightly moist, trace fine to medium sized gravel, brown, trace of rootlets.				
2.9				65, (N = 84.5)								
3					Plutonic Rocks Of Peninsular Ranges		GRA	GRANITE: distinctly weathered, medium hard to hard, light brown, fine grained, massive texture, distinct, moist.				
5								<b>B-5 refusal at 5 ft. No cave-in. No groundwater encountered.</b>				
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												

SEPTEMBER 19, 2024

1666-01

**SUMMARY OF LABORATORY TEST RESULTS**  
**APN 0335-141-06 off ST HWY 173**  
**LAKE ARROWHEAD, CA 92352**

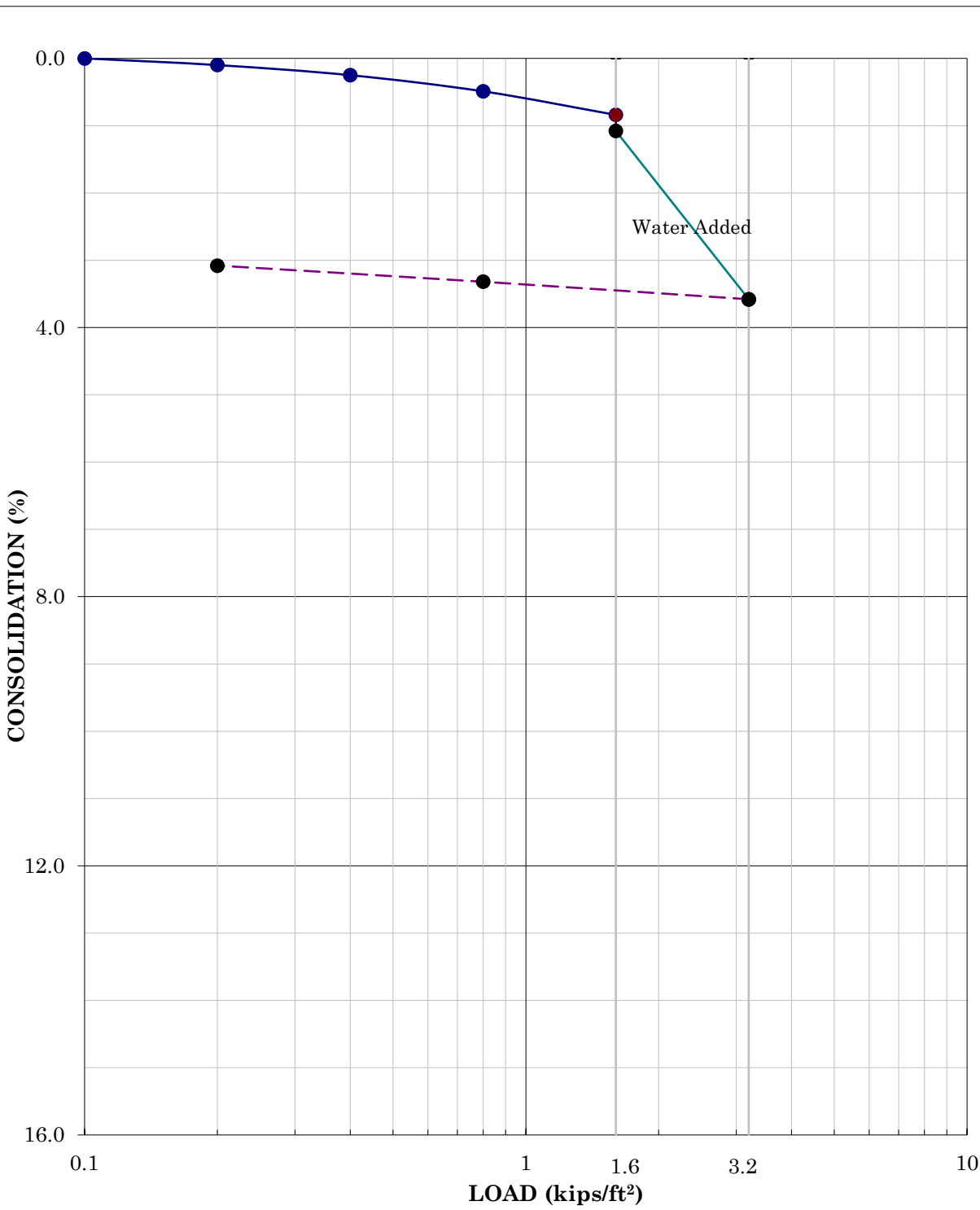
<b>CHEMICAL / MINIMUM ELECTRICAL RESISTIVITY TEST RESULTS</b>					
<b>SAMPLE</b>	<b>RESISTIVITY Minimum (ohm-cm)</b>	<b>pH*</b>	<b>SULFIDE</b>	<b>CHLORIDE (ppm)**</b>	<b>SOLUBLE SULFATE (%)**</b>
B-1, 0-9'	19070	7.53	Neg.***	11	0.0021
*	Test performed by <b>A &amp; R Laboratories</b> in accordance with EPA9045 C procedures.				
**	Test performed by <b>A &amp; R Laboratories</b> in accordance with EPA 300.0 procedures.				
***	Neg. - Negative.				

<b>SAND EQUIVALENT TEST RESULTS (ASTM D2419 Test Method)</b>	
<b>SAMPLE</b>	<b>SAND EQUIVALENT</b>
B1, 0-9'	20

PLATE NO. 8

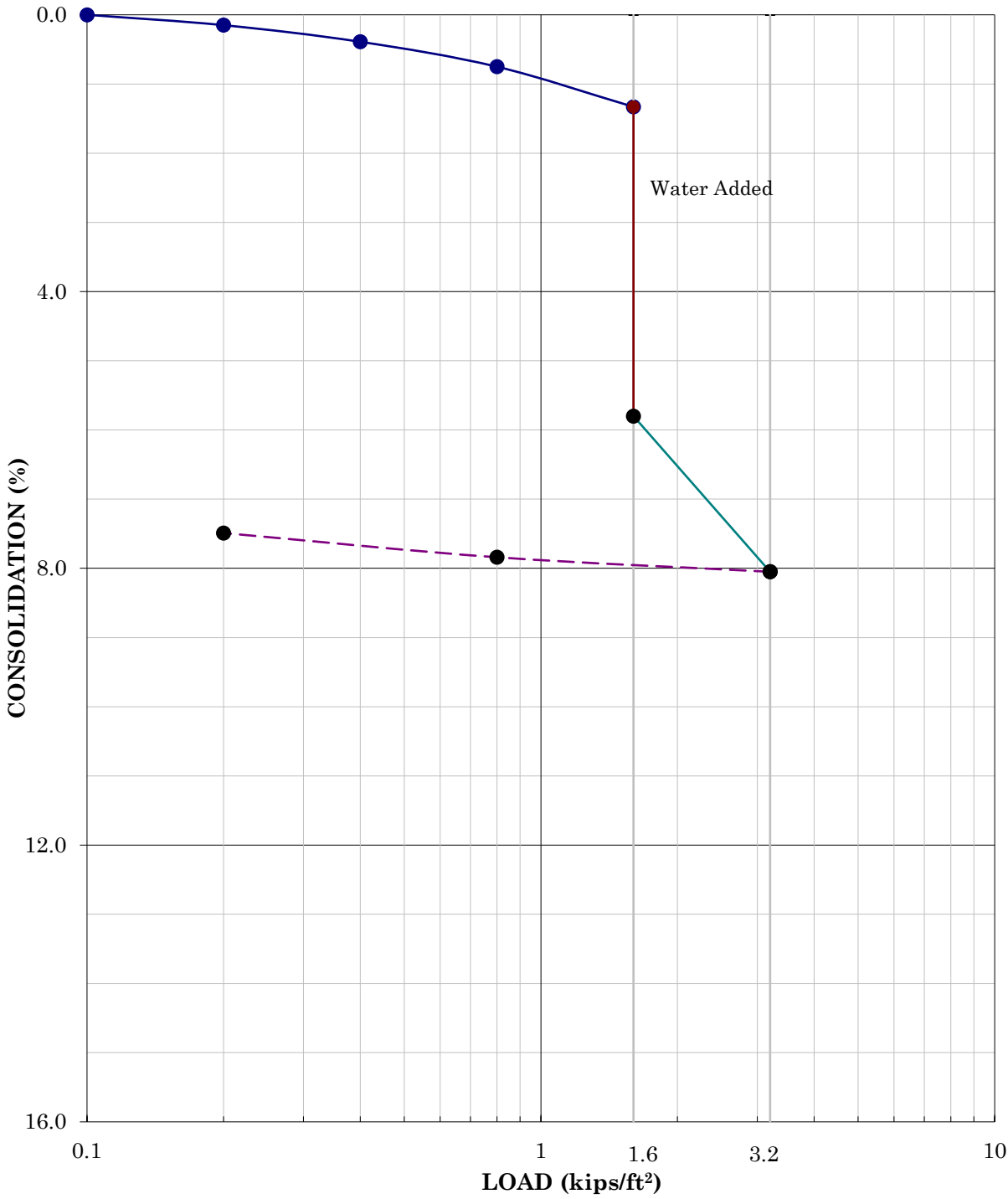
**HILLTOP GEOTECHNICAL, INC.**





**CONSOLIDATION TEST RESULTS  
(ASTM D2435 Test Method)**

SAMPLE: B1, 7.0'	
SOIL DESCRIPTION: Silty fine to medium sand, Dark yellowish brown (SM)	
BY: kb	DATE: 9-19-24
JOB NO.: 1666-01.1	PLATE NO. 10



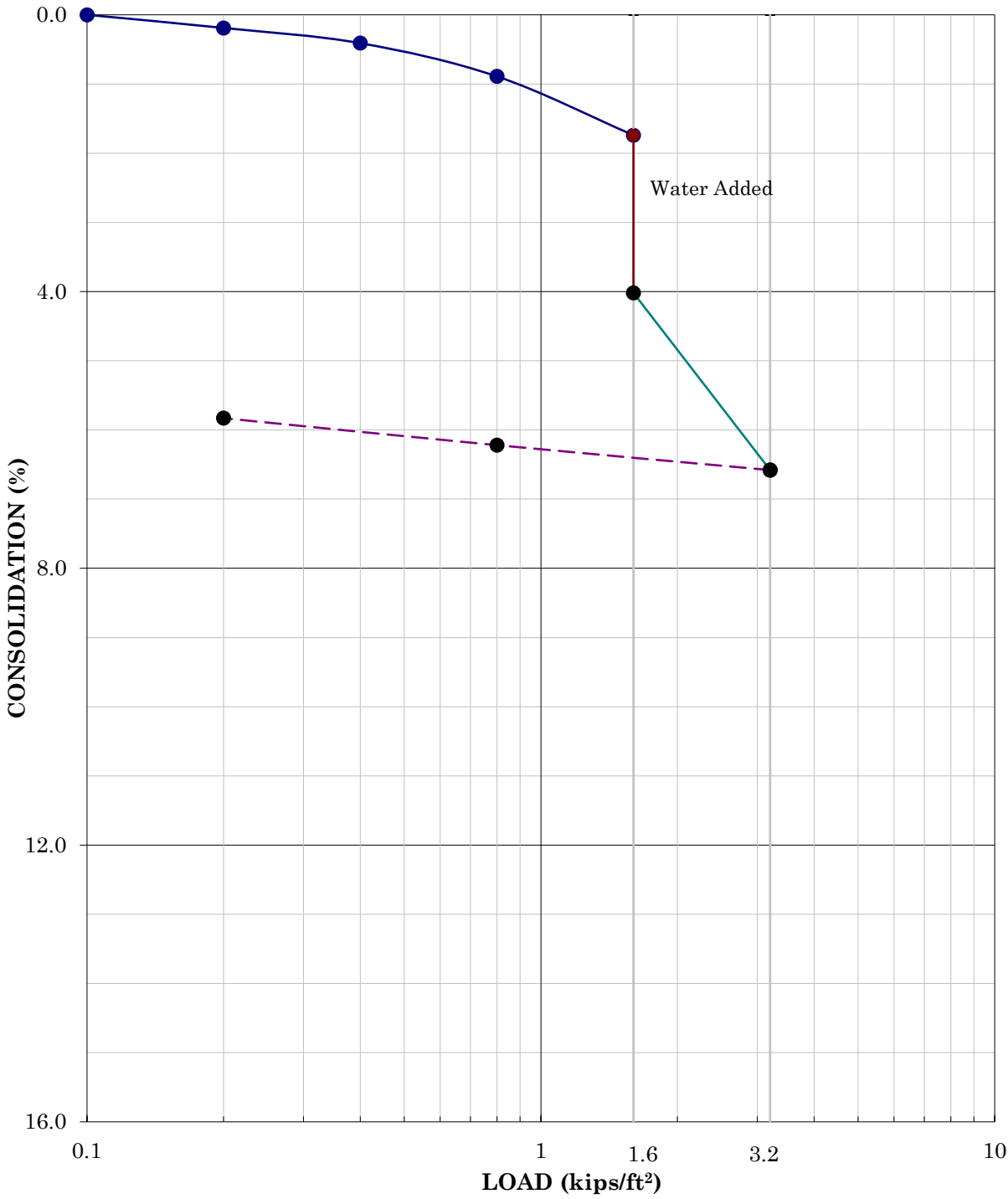
**CONSOLIDATION TEST RESULTS  
(ASTM D2435 Test Method)**

SAMPLE: B3, 7.0'

SOIL DESCRIPTION: Silty, fine sand, Brown (SM)

BY: kb	DATE: 9-19-24
--------	---------------

JOB NO.: 1666-01.1	PLATE NO. 11
--------------------	--------------



**CONSOLIDATION TEST RESULTS  
(ASTM D2435 Test Method)**

SAMPLE: B3, 7.0'

SOIL DESCRIPTION: Silty fine sand, Brown (SM)

BY: kb

DATE: 9-19-24

JOB NO.: 1666-01.1

PLATE NO. 12

## **APPENDIX B**

**TECHNICAL REFERENCES**

**American Concrete Institute**, 2019, Building Code Requirements for Structural Concrete, ACI 318-19, Chapter 19, Tables 19.3.1.1 and 19.3.2.1.

**American Society of Civil Engineers**, 2016, *Minimum Design Loads Associated Criteria for Buildings and Other Structures*: ASCE Standard No. 7-16.

**California Building Standards Commission**, Effective January 1, 2023, *California Building Code*: California Code of Regulations, Title 24, Part 2, Volume 1 of 2 and Volume 2 of 2.

**California Department of Conservation, Division of Mines and Geology**, *Guidelines to Geologic/Seismic Reports*: CDMG Note 42.

**California Department of Conservation, Division of Mines and Geology**, *Guidelines for Preparing Engineering Geologic Reports*: CDMG Note 44.

**California Department of Conservation, Division of Mines and Geology**, 1982, *Earthquake Planning Scenario for a Magnitude 8.3 Earthquake on the San Andreas Fault in Southern California*: Special Publication 60.

**California Department of Conservation, California Geological Survey**, 2008, *Guidelines for Evaluating and Mitigating Seismic Hazards in California*: Special Publication 117A.

**California Department of Conservation, Division of Mines and Geology**, 1992, *Quick Report on CSMIP Strong-Motion Records from the June 28, 1992, Earthquakes Near Landers and Big Bear, California*: CSMIP Report OSMS 92-06.

**California Department of Transportation**, March 20, 2020, *Highway Design Manual*, Chapter 630.

**Joseph E. Bowles**, 1997, *Foundation Analysis and Design*, Fifth Edition, McGraw-Hill Companies, Inc.

**Meisling, K.E. and Weldon, R.J.**, 1989, *Late Cenozoic Tectonics of the Northwestern San Bernardino Mountains, Southern Ca.*: Geologic Society of America, Bulletin 101, pp. 106-128.

**Public Works Standards, Inc.**, 2018, *The "Greenbook", Standard Specifications for Public Works Construction*.

**TECHNICAL REFERENCES**

**Robert W. Day**, 1999, *Geotechnical and Foundation Engineering*, McGraw-Hill.

**San Bernardino County Planning Department**, *San Bernardino County Land Use Plan, GENERAL PLAN, Geologic Hazard Overlays*, Sheet FH23 C Harrison Mtn, Plot Date:03/09/2010, Scale: 1:14,400 (<http://www.co.san-bernardino.ca.us/landuseservices/general>).

**Spotilla, J. and Sieh, K.**, 1997, *Characterizing Seismic Sources Associated with Uplift of the San Bernardino Mountains: Progress Report to Southern California Earthquake Center*: 4 p., (<http://www.scec.org/research/97progreports>).

**U.S. Department of the Interior, U.S. Geological Survey**, 2003, Morton, D.M., and Miller, F.K. (Digitally Prepared by Cossette, P.M. & Bovard, K.R.), *Preliminary Geologic Map of the San Bernardino 30'x60' Quadrangle, California: Digital Version 1.0*, U.S. Geological Survey Open-File Report 03-293, Scale: 1:100,000, Sheet 1 of 5 through Sheet 5 of 5.

**U.S. Department of the Interior, U.S. Geological Survey**, Design Maps Web Site (<https://earthquake.usgs.gov/designmaps/us/application.php>).

