GEOTECHNICAL ENGINEERING EXPLORATION
DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

W.O. 7611-00(C) SEPTEMBER 18, 2020

Prepared for

WSP

and

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

GEOLABS, INC.
Geotechnical Engineering and Drilling Services

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HIGHWAYS DIVISION

GERALD Y. SEKI
LICENSED PROFESSIONAL ENGINEER
No. 5635-C
HAWAII, U.S.A.

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

SIGNATURE   4-30-22
EXPIRATION DATE
OF THE LICENSE

GEOLABS, INC.
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GEOLABS, INC.

Geotechnical Engineering and Drilling Services

September 18, 2020
W.O. 7611-00(C)

Mr. Randall Urasaki
WSP USA
American Savings Bank Tower
1001 Bishop Street, Suite 2400
Honolulu, HI 96813

Dear **Mr. Urasaki:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Drywell Design for Hanato's Property, General Civil Engineering Services Statewide, Project No. HWY-DS-CE-2017-01, Island of Hawaii," prepared for the design of the project.

Our work was performed in general accordance with the scope of services outlined in our revised fee proposal dated June 6, 2019.

Please note that the soil and rock samples recovered during our field exploration (remaining after testing) will be stored for a period of two months from the date of this report. The samples will be discarded after that date unless arrangements are made for a longer sample storage period. Please contact our office for alternative sample storage requirements, if appropriate.

Detailed discussion and specific design recommendations are contained in the body of this report. If there is any point that is unclear, please contact our office.

Very truly yours,

GEOLABS, INC.

Gerald Y. Seki, P.E.
Vice President

GS:NK:sh

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GEOTECHNICAL ENGINEERING EXPLORATION

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GENERAL CIVIL ENGINEERING SERVICES STATEWIDE

PROJECT NO. HWY-DS-CE-2017-01

ISLAND OF HAWAII

W.O. 7611-00(C) SEPTEMBER 18, 2020

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Our field exploration generally encountered a surficial fill layer approximately 4 to 4.5 feet thick underlain by alternating layers of basalt formation and clinker extending to the maximum depth explored of about 40 feet below the existing ground surface. The basalt formation generally graded from severely to slightly fractured, moderately weathered to unweathered, and medium to very hard. The clinker generally consisted of silty gravel. We did not encounter groundwater in the borings at the time of our field exploration. However, it should be noted that groundwater levels are subject to change due to rainfall, time of year, seasonal precipitation, surface water runoff, and other factors.

Constant head percolation tests were performed in the borings drilled at the project site to assess the average permeability within an open interval of subsurface material. In both borings, constant head percolation tests were performed at open rock/clinker depth intervals of about 10 to 20 feet and 20 to 40 feet below the existing ground surface. It should be noted that after approximately 5 minutes of continual pumping, a hydrostatic head could not be established in our constant head tests. Therefore, the k-values for the selected test intervals may be greater than the values presented herein. Due to site and equipment constraints, the pumping capacity could not be increased.

Based on the information provided, we understand that the installation of two 30-inch diameter drywells is being considered for the project. The first drywell is planned at the southwest end of the intersection of Hawaii Belt Road and Mamalahoa Highway. The second drywell is planned further northwest along Hawaii Belt Road near the southern boundary of the Hanato property. For the first and second drywells, we recommend that the drywells be about 40 and 60 feet deep with the top 10 and 30 feet of the well cased, respectively. The deeper casing in the second drywell is to reduce the potential for stormwater flowing out of the existing slope below the roadway.

Based on our analysis, the estimated disposal rate of each drywell is 19 cubic feet per second. The estimated capacity does not account for head losses through well screens or gravel pack and do not allow for long term clogging. A suitable factor of safety should be included in the drywell design. Drywells should have a minimum spacing of 15 feet on-center.

The text of this report should be referred to for detailed discussion and specific design recommendations.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1. GENERAL

1.1 Introduction

This report presents the results of our geotechnical engineering exploration conducted for the *Drywell Design for Hanato's Property* project near the intersection of Kuakini Highway and Mamalahoa Highway on the Island of Hawaii. The project location and general vicinity are shown on the Project Location Map, Plate 1.

This report summarizes the findings and geotechnical recommendations resulting from our field exploration, laboratory testing, and engineering analyses for the project. These findings and geotechnical recommendations are intended for the design of drywells only. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.2 Project Considerations

The project site is located near the intersection of Hawaii Belt Road and Mamalahoa Highway on the Island of Hawaii. We understand that due to excessive stormwater runoff entering the Hanato Property, it is desired to install drywells on Hawaii Belt Road and Mamalahoa Highway to drain the stormwater runoff. A layout of the project site and the intersection of the two roadways are presented on the Site Plan, Plate 2.

In order to estimate the disposal capacity of the proposed drywell system planned at the site, in-situ permeability testing was conducted within two borings at depth intervals of about 10 to 20 feet, and 20 to 40 feet below the existing ground surface. One boring was drilled on the western shoulder of Hawaii Belt Road near where stormwater runoff has been observed to flow into Hanato's property. An additional boring was drilled within Hanato's property on an existing asphaltic concrete road below Hawaii Belt Road. The approximate boring locations are presented on the Site Plan, Plate 2.

1.3 Purpose and Scope

The purpose of our geotechnical engineering exploration was to obtain an overview of the surface and subsurface conditions at the drywell sites to formulate a summary of the soil/rock conditions for the drywell design. The work was performed in general accordance with the scope of services outlined in our revised fee proposal dated June 6, 2019. The scope of work for this exploration included the following tasks and work efforts:

1. Research and review of available in-house soil and geologic information related to the project area.
2. Boring stakeout and coordination of underground utility toning and site access by our engineer.
3. Application of the necessary excavation permits and utility clearance from the One Call System, State of Hawaii DOT, and various utility companies prior to drill crew mobilization.
4. Mobilization and demobilization of a truck-mounted drill rig and water truck on the Island of Hawaii, and two operators from Honolulu to the project site and back.
5. Drilling and sampling of two borings to a depth of approximately 40 feet below the existing ground surface.
6. Coordination of the field exploration and logging of the borings by our geologist.
7. Performance of in-situ permeability tests between about 10 to 20 feet and 20 to 40 feet deep in each boring to evaluate the subsurface material infiltration characteristics.
8. Laboratory testing of selected samples obtained during the field exploration as an aid in classifying the materials and evaluating their engineering properties.
9. Analysis of the field and laboratory data to formulate preliminary recommendations for the design of the proposed drywell systems planned for the project.
10. Preparation of this report summarizing our work on the project and presenting our findings and recommendations.
11. Coordination of our overall work on the project by our senior engineer.
12. Quality assurance of our work and client/design team consultation by our principal engineer.
13. Miscellaneous work efforts, such as drafting, word processing, and clerical support.

Detailed descriptions of our field exploration methodology and the Logs of Borings are presented in Appendix A. Results of the laboratory tests performed on selected soil samples are presented in Appendix B. Photographs of core samples recovered from our field exploration are provided in Appendix C. The results of our field percolation tests are presented in Appendix D.

END OF GENERAL

SECTION 2. SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Hawaii is the largest island in the Hawaiian Archipelago and covers an area of approximately 4,000 square miles. The island was formed by the activity of the following five shield volcanoes: Kohala (long extinct), Mauna Kea (activity during recent geologic time), Hualalai (last erupted in 1801 – 1803), Mauna Loa (active), and Kilauea (active).

The project site is situated on the western flank of Mauna Loa Mountain, which makes up the south-central portion of the island. The lava formation encountered at the site appears to be of both a'a and pahoehoe flows, which spread and ponded as they approached the ocean. A'a lava is typically characterized by a porous, rough, and irregular flow surface resembling a jagged accumulation of rock fragments including cobbles and boulders. Pahoehoe is characterized by a smooth, rope-like or billowy surface and an internal structure of vesicular (porous) rock.

Cavities are commonly encountered in basaltic lavas, especially pahoehoe type lava. Cavities form when lavas are still in a molten state, and they represent both lava tubes (intra-flow cavities) and blisters and pockets (inter-flow cavities). Lava tubes form when molten lava drains from the cooling flow, leaving a hollow tube-like structure which may extend for a large longitudinal distance along the flow. Blisters and pockets generally are smaller in horizontal extent.

Basalt is a relatively permeable rock and can transmit water quite readily in both the horizontal and vertical directions. In general, water is transmitted through the porous rock matrix, along joints, fractures and inter-flow contacts, cavities, and along clinker layers. Clinker and cavities serve as the primary water transmission features because of their high permeability.

2.2 Site Description

The project site is located near the intersection of Hawaii Belt Road and Mamalahoa Highway on the Island of Hawaii. The Hanato Property is to the west of the intersection, adjacent to Hawaii Belt Road, and is lower in elevation than the roadway.

Based on the information provided, we understand that most of the storm runoff water travels down Mamalahoa Highway from the north and around the bend that merges onto Hawaii Belt Road. Much of the runoff water then travels down into Hanato's property near the southeastern edge of the guardrail along Hawaii Belt Road.

Based on the topographic survey map provided, we understand that the section of Hawaii Belt Road adjacent to Hanato's property ranges in elevations from about +490 to about +520 feet Mean Sea Level (MSL). A relatively steep slope separates Hawaii Belt Road from Hanato's property, with an average slope inclination of about one-and-a-half horizontal to one vertical (1.5H:1V). The average slope height measures about 30 feet.

2.3 Subsurface Conditions

We explored the subsurface conditions at the project site by drilling and sampling two borings, designated as Boring Nos. 1 and 2, extending to a depth of about 40 feet below the existing ground surface. The approximate boring locations are shown on the Site Plan, Plate 2.

Our borings generally encountered a surficial fill layer, consisting of medium to very dense silty sand and gravel, extending to depths of about 4 to 4.5 feet below the existing ground surface. Boring No. 1 on Hawaii Belt Road also encountered a pavement structure consisting of 3 inches of asphaltic concrete. Beneath the fill, alternating layers of basalt formation and clinker were encountered extending to the maximum depth explored of about 40 feet below the existing ground surface. The basalt formation generally graded from severely to slightly fractured, moderately weathered to unweathered, and medium to very hard. The clinker generally consisted of silty gravel. It should be noted that a moderately fractured, slightly to moderately weathered, and soft to medium hard welded clinker layer was encountered from about 31 to 40 feet deep in Boring No. 1.

We did not encounter groundwater in the borings at the time of our field exploration. However, it should be noted that groundwater levels are subject to change due to rainfall, time of year, seasonal precipitation, surface water runoff, and other factors.

Detailed descriptions of the field exploration methodology are presented in Appendix A. Descriptions and graphic representations of the materials encountered in the borings are presented on the Logs of Borings in Appendix A. Results of the laboratory tests performed on selected soil samples are presented in Appendix B. Photographs of the core samples recovered from our field exploration are provided in Appendix C.

END OF SITE CHARACTERIZATION

SECTION 3. DISCUSSION AND RECOMMENDATIONS

Our field exploration generally encountered a surficial fill layer approximately 4 to 4.5 feet thick underlain by alternating layers of basalt formation and clinker extending to the maximum depth explored of about 40 feet below the existing ground surface. The basalt formation generally graded from medium to very hard. The clinker generally consisted of silty gravel. We did not encounter groundwater in the drilled borings at the time of our field exploration.

Constant head percolation tests were performed in the borings drilled at the project site to assess the average permeability within an open depth interval of subsurface material. For both borings, constant head tests were performed at open rock/clinker depth intervals of about 10 to 20 feet, and 20 to 40 feet below the existing ground surface. Detailed discussions and recommendations from the results of the percolation testing are presented in the following sections.

3.1 Percolation Test Methodology

Constant Head injection tests were performed in the borings drilled at the project site to assess the average permeability within an open interval of rock material.

In general, the borings were drilled using HQ wireline coring tools advanced to the scheduled test depths. Upon reaching the desired test depth, the HQ casing was pulled up to expose an open interval of basalt rock formation and/or clinker. The diameter of the open borehole was 3.5 inches. For Boring Nos. 1 and 2, constant head tests were performed at open rock/clinker depth intervals of about 10 to 20 feet, and 20 to 40 feet below the existing ground surface. The constant head tests were conducted using the discharge hose of a water truck, which could provide a flow rate of up to about 150 gallons per minute (gpm).

It should be noted that after approximately 5 minutes of continual pumping, a hydrostatic head could not be established in the constant head tests. Therefore, the k-values for the selected test intervals may be greater than the values presented herein. Due to site and equipment constraints, the pumping capacity during the test could not be increased.

3.2 Permeability Results

The field data for the constant head tests were analyzed using the Well Point - Filter in Uniform Soil equation presented in "Construction Dewatering and Groundwater Control, New Methods and Applications," 3rd Edition by Powers, Corwin, Schmall, and Kaeck (2007). The following table summarizes the permeability values (k) calculated from our field constant head tests.

CONSTANT HEAD PERCOLATION TEST RESULTS			
Test Location	**Test Interval** (feet)	**Flow Rate** (gpm)	**k** (ft/min)
B-1	10 to 20	147	0.05
	20 to 40	125	0.13
B-2	10 to 21.5	96	0.03
	20 to 40	102	0.11

3.3 Preliminary Well Capacity

Based on the initial information provided, we understand that the proposed drywells will be installed on the southwest side of the intersection of Hawaii Belt Road and Mamalahoa Highway near the existing residential lot in this area. The approximate location of the proposed drywell area is shown on the Site Plan, Plate 2.

We understand that the use of two 20-inch diameter drywells are being considered. The location of the first drywell is proposed at the southwest end of the intersection of Hawaii Belt Road and Mamalahoa Highway. The second drywell location is proposed further northwest along Hawaii Belt Road near the southern boundary of the Hanato property. For the proposed first and second drywells, we recommend that the drywells be about 40 and 60 feet in depth with the top 10 and 30 feet of the well cased, respectively. The deeper casing in the second drywell is to reduce the potential for stormwater flowing out of the existing slope below the roadway.

Using formula presented in "Groundwater and Wells, 2nd Edition", Driscoll, 1986, we have calculated the capacity for the planned 30-inch diameter wells. Based on our analysis, the estimated disposal rate of each drywell is 19 cubic feet per second. The estimated capacity does not account for head losses through well screens or gravel pack and do not allow for long term clogging. A suitable factor of safety should be included in the drywell design.

We understand that the design stormwater flow rate is 25 cubic feet per second (cfs). In addition, we understand that factors of safety of 1.5 and 2 are being considered. For factors of safety of 1.5 and 2, the design flows are 37.5 and 50 cfs. Based on the estimated disposal rate, the number of 30-inch diameter drywells needed for factors of safety of 1.5 and 2 are 2 and 3 drywells, respectively. Drywells should have a minimum spacing of 15 feet on-center.

It should be noted that there is a degree of uncertainty in the methods of calculation as the methods assume a stable groundwater table within the test depth of the well. For this project, the normal groundwater level is deep below the test depth; therefore, it was necessary to assume a groundwater level elevation. Based on the ground surface elevation of the project site and the geologic setting of the surrounding area, a groundwater level approximately 150 feet below the bottoms of the proposed drywells was assumed for our design.

3.4 Storm Water Treatment

Clogging can be a major factor in the loss of capacity and ultimate failure of dry wells and similar disposal systems. Clogging can result from sediment and debris entering the well and either blocking the permeable features, such as pores and fractures, or filling the interior of the well.

To reduce clogging in the final drywells, we recommend including a stormwater treatment system in the overall well system design. There are several commercially available systems that could be incorporated into the stormwater disposal systems for the new well sites.

3.5 Design Review

Preliminary and final drawings and specifications for the project should be forwarded to Geolabs for review and written comments prior to bid solicitation for construction. This review is necessary to evaluate the conformance of the plans and specifications with the intent of the foundation and utility trench recommendations provided herein. If this review is not made, Geolabs cannot be responsible for misinterpretation of our recommendations.

3.6 Construction Monitoring

Geolabs should be retained to provide geotechnical engineering services during construction of the project. The critical item of construction monitoring is that the Hawaii Department of Health requires new drywells (a.k.a. injection wells) to be logged by a geologist. If the actual exposed subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate design modifications should be made.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4. LIMITATIONS

The analyses and recommendations submitted herein are based, in part, upon information obtained from our field exploration. Variations of the subsurface conditions beyond the test borings may occur and the nature and extent of these variations may not become evident until construction is underway. If variations then appear evident, it will be necessary to re-evaluate the recommendations presented herein.

The test boring locations indicated herein is approximate, having been taped from visible features shown on the topographic plans received from WSP on August 3, 2020. The elevations of the borings were interpolated from the contour lines shown on the same plan. The field boring locations and elevations should be considered accurate only to the degree implied by the methods used.

The stratification breaks represented on the Logs of Borings show the approximate boundaries between soil and/or rock types and, as such, may denote a gradual transition. We did not encounter groundwater in the borings at the time of our field exploration. However, it should be noted that groundwater levels are subject to change due to rainfall, time of year, seasonal precipitation, surface water runoff, and other factors. The data has been reviewed and interpretation made in the formulation of this report.

This report has been prepared for the exclusive use of WSP and their client, the State of Hawaii, Department of Transportation – Highways Division, for specific application to the Drywell Design for Hanato’s Property project in accordance with generally accepted geotechnical engineering principles and practices. No warranty is expressed or implied.

This report has been prepared solely for the purpose of assisting the engineer in the design of drywells for the project. Therefore, this report may not contain sufficient data or the proper information to serve as the basis for construction cost estimates nor for bidding purposes. A contractor wishing to bid on this project should retain a competent geotechnical engineer to assist in the interpretation of this report and/or in the performance of additional site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated soil conditions are commonly encountered. Unforeseen subsurface conditions, such as perched groundwater, soft deposits, hard layers, or cavities may occur in localized areas and may require additional corrections in the field (which may result in construction delays) to attain a properly constructed project. Therefore, a sufficient contingency fund is recommended to accommodate these possible extra costs.

This geotechnical engineering exploration conducted at the project site was not intended to investigate the potential presence of hazardous materials existing at the project site. It should be noted that the equipment, techniques, and personnel used to conduct a geo-environmental exploration differ substantially from those applied in geotechnical engineering.

END OF LIMITATIONS

CLOSURE

The following plates and appendices are attached and complete this report:

Project Location Map .... Plate 1

Site Plan .... Plate 2

Field Exploration .... Appendix A

Laboratory Tests .... Appendix B

Photographs of Core Samples .... Appendix C

Field Percolation Tests .... Appendix D

-ΩΩΩΩΩΩΩΩΩ-

Respectfully submitted,

GEOLABS, INC.

By [signature]

Gerald Y. Seki, P.E.
Vice President

GS:NK:sh

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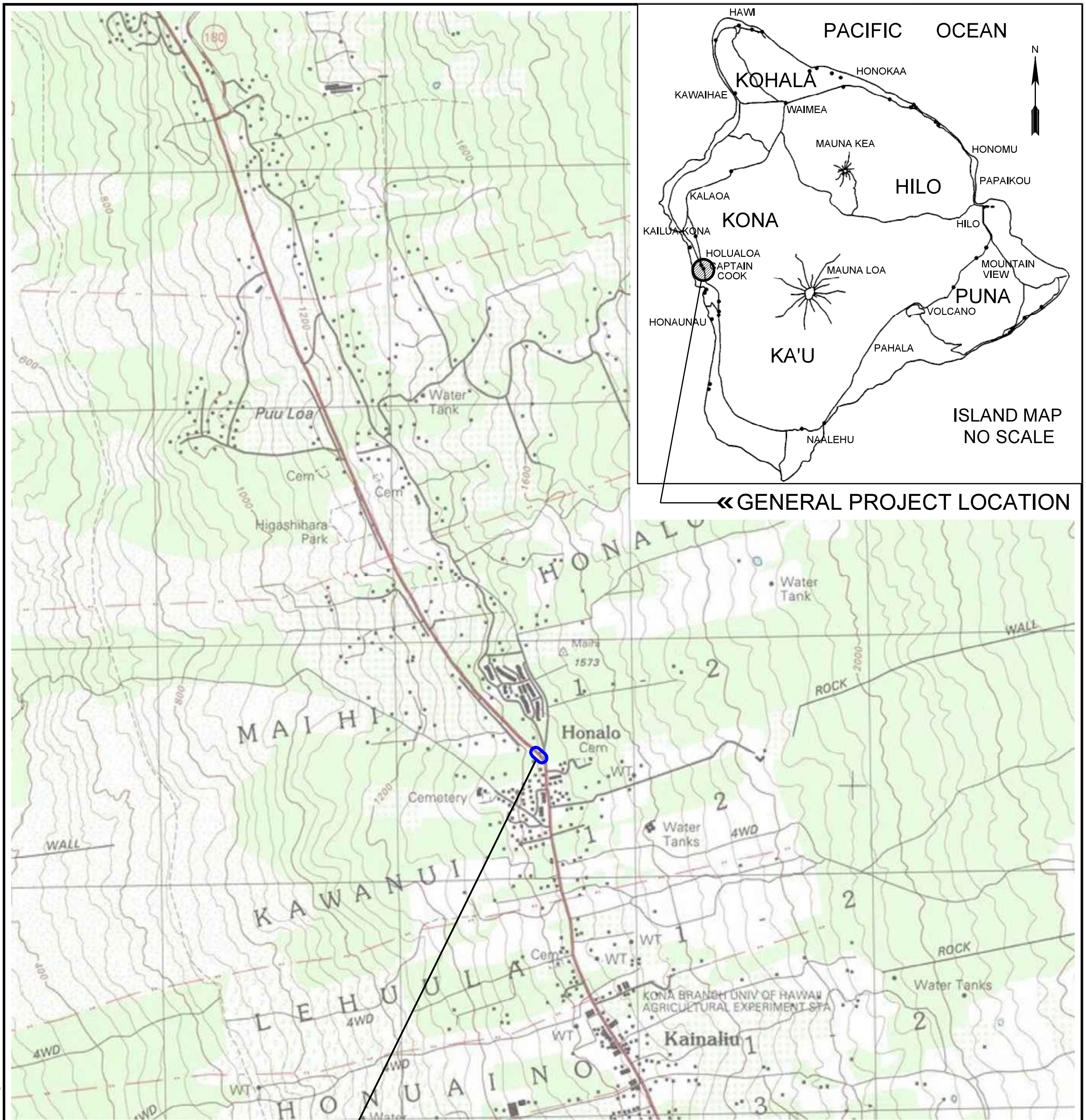
PLATES



PROJECT LOCATION

PROJECT LOCATION MAP

DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

2000 1000 0 2000 FT.

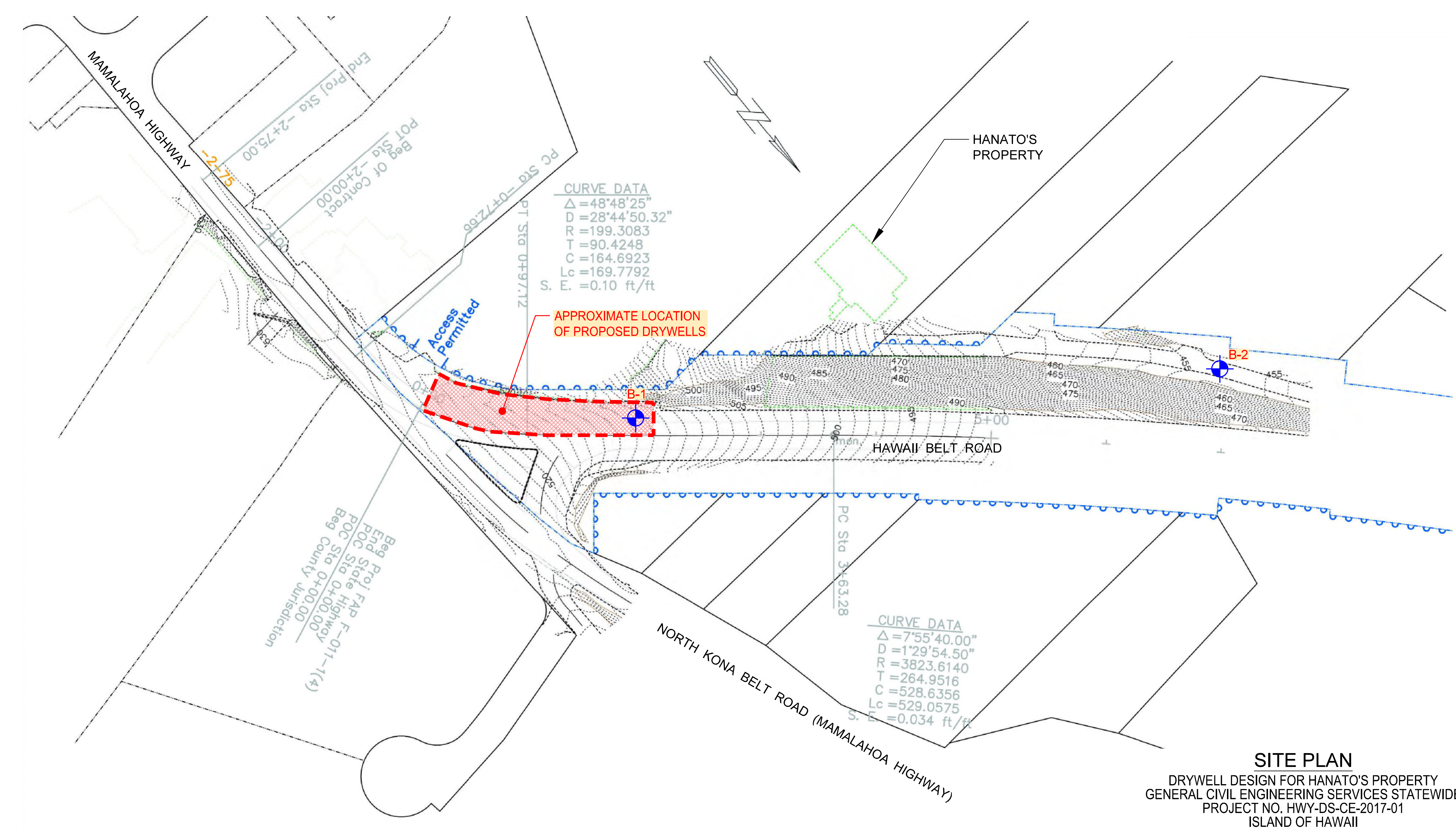
GRAPHIC SCALE

N

REFERENCE: MAP CREATED WITH TOPO!® ©2010 NATIONAL GEOGRAPHIC; ©2007 TELE ATLAS, REL. 1/2007.

GEOLABS, INC. Geotechnical Engineering		
DATE SEPTEMBER 2020	DRAWN BY HYC	PLATE
SCALE 1" = 2,000'	W.O. 7611-00(C)	1

CAD User: HENRY File Last Updated: September 08, 2020 3:52:51pm Plot Date: September 08, 2020 - 3:53:30pm
File: A:\Drafting\Drafting\Working\7611-00(C)_Hanatos_Property\7611-00(C)PLM.dwg\PLATE_1
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEO-No-Dithering-Blue-Boring.ctb



SITE PLAN

DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

LEGEND:

APPROXIMATE BORING LOCATION

0 40 80 160 240 FT.

GRAPHIC SCALE

REFERENCE: TOPOGRAPHY PLANS RECEIVED FROM WSP ON AUGUST 3, 2020.

GEOLABS, INC. Geotechnical Engineering		
DATE: SEPTEMBER 2020	DRAWN BY: HYC	PLATE
SCALE: 1" = 80'	W.O.: 7611-00(C)	2

APPENDIX A

A P P E N D I X A

Field Exploration

We explored the subsurface conditions at the project site by drilling and sampling two borings, designated as Boring Nos. 1 and 2, extending to a depth of about 40 feet below the existing ground surface. The approximate boring locations are shown on the Site Plan, Plate 2. The borings were drilled using a truck-mounted drill rig equipped with continuous flight augers and rotary coring tools.

Our geologist classified the materials encountered in the boring by visual and textural examination in the field in general accordance with ASTM D2488, Standard Practice for Description and Identification of Soils, and monitored the drilling operations on a near-continuous (full-time) basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general accordance with ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), as shown on the Soil Log Legend, Plate A-0.1. Deviations made to the soil classification in accordance with ASTM D2487 are described on the Soil Classification Log Key, Plate A-0.2. Graphic representation of the materials encountered is presented on the Logs of Borings, Plates A-1.1 through A-2.2.

Relatively “undisturbed” soil samples were obtained in general accordance with ASTM D3550, Ring-Lined Barrel Sampling of Soils, by driving a 3-inch OD Modified California sampler with a 140-pound hammer falling 30 inches. In addition, some samples were obtained from the drilled borings in general accordance with ASTM D1586, Penetration Test and Split-Barrel Sampling of Soils, by driving a 2-inch OD standard penetration sampler using the same hammer and drop. The blow counts needed to drive the sampler the second and third 6 inches of an 18-inch drive are shown as the “Penetration Resistance” on the Logs of Borings at the appropriate sample depths. The penetration resistance shown on the Logs of Borings indicates the number of blows required for the specific sampler type used. The blow counts may need to be factored to obtain the Standard Penetration Test (SPT) blow counts.

Core samples of the rock materials encountered at the project site were obtained by using diamond core drilling techniques in general accordance with ASTM D2113, Diamond Core Drilling for Site Investigation. Core drilling is a rotary drilling method that uses a hollow bit to cut into the rock formation. The rock material left in the hollow core of the bit is mechanically recovered for examination and description. Rock cores were described in general accordance with the Rock Description System, as shown on the Rock Log Legend, Plate A-0.3. The Rock Description System is based on the publication “Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses” by the International Society for Rock Mechanics (March 1977).

Recovery (REC) may be used as a subjective guide to the interpretation of the relative quality of rock masses, where appropriate. Recovery is defined as the actual length of material recovered from a coring attempt versus the length of the core attempt.

For example, if 3.7 feet of material is recovered from a 5.0-foot core run, the recovery would be 74 percent and would be shown on the Logs of Borings as REC = 74%.

The Rock Quality Designation (RQD) is also a subjective guide to the relative quality of rock masses. RQD is defined as the percentage of the core run in rock that is sound material in excess of 4 inches in length without any discontinuities, discounting any drilling, mechanical, and handling induced fractures or breaks. If 2.5 feet of sound material is recovered from a 5.0-foot core run in rock, the RQD would be 50 percent and would be shown on the Logs of Borings as RQD = 50%. Generally, the following is used to describe the relative quality of the rock based on the "Practical Handbook of Physical Properties of Rocks and Minerals" by Robert S. Carmichael (1989).

Rock Quality	RQD (%)
Very Poor	0 – 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 – 100

The excavation characteristic of a rock mass is a function of the relative hardness of the rock, its relative quality, brittleness, and fissile characteristics. A dense rock formation with a high RQD value would be very difficult to excavate and probably would require more arduous methods of excavation.

GEOLABS, INC.

Geotechnical Engineering

Soil Log Legend

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL RETAINED ON NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS LESS THAN 5% FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES MORE THAN 12% FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS 50% OR MORE OF COARSE FRACTION PASSING THROUGH NO. 4 SIEVE	CLEAN SANDS LESS THAN 5% FINES	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES MORE THAN 12% FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS 50% OR MORE OF MATERIAL PASSING THROUGH NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT 50 OR MORE	MH	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

LEGEND

- (2-INCH) O.D. STANDARD PENETRATION TEST
- (3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE
- SHELBY TUBE SAMPLE
- GRAB SAMPLE
- CORE SAMPLE
- WATER LEVEL OBSERVED IN BORING AT TIME OF DRILLING
- WATER LEVEL OBSERVED IN BORING AFTER DRILLING
- WATER LEVEL OBSERVED IN BORING OVERNIGHT

LL	LIQUID LIMIT (NP=NON-PLASTIC)
PI	PLASTICITY INDEX (NP=NON-PLASTIC)
TV	TORVANE SHEAR (tsf)
UC	UNCONFINED COMPRESSION OR UNIAXIAL COMPRESSIVE STRENGTH
TXUU	UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION (ksf)

Plate

A-0.1

GEOLABS, INC.

Geotechnical Engineering

Soil Classification Log Key

(with deviations from ASTM D2488)

GEOLABS, INC. CLASSIFICATION*

GRANULAR SOIL (- #200 <50%)	COHESIVE SOIL (- #200 ≥50%)
• **PRIMARY** constituents are composed of the largest percent of the soil mass. Primary constituents are capitalized and bold (i.e., **GRAVEL, SAND**)	• **PRIMARY** constituents are based on plasticity. Primary constituents are capitalized and bold (i.e., **CLAY, SILT**)
• **SECONDARY** constituents are composed of a percentage less than the primary constituent. If the soil mass consists of 12 percent or more fines content, a cohesive constituent is used (**SILTY** or **CLAYEY**); otherwise, a granular constituent is used (**GRAVELLY** or **SANDY**) provided that the secondary constituent consists of 20 percent or more of the soil mass. Secondary constituents are capitalized and bold (i.e., **SANDY** GRAVEL, **CLAYEY** SAND) and precede the primary constituent.	• **SECONDARY** constituents are composed of a percentage less than the primary constituent, but more than 20 percent of the soil mass. Secondary constituents are capitalized and bold (i.e., **SANDY** CLAY, **SILTY** CLAY, **CLAYEY** SILT) and precede the primary constituent.
• **accessory descriptions** compose of the following: with some: >12% with a little: 5 - 12% with traces of: <5% accessory descriptions are lower cased and follow the Primary and Secondary Constituents (i.e., SILTY GRAVEL **with a little sand**)	• **accessory descriptions** compose of the following: with some: >12% with a little: 5 - 12% with traces of: <5% accessory descriptions are lower cased and follow the Primary and Secondary Constituents (i.e., SILTY CLAY **with some sand**)

EXAMPLE: Soil Containing 60% Gravel, 25% Sand, 15% Fines. Described as: **SILTY GRAVEL** with some sand

RELATIVE DENSITY / CONSISTENCY

Granular Soils			Cohesive Soils			
N-Value (Blows/Foot)		Relative Density	N-Value (Blows/Foot)		PP Readings (tsf)	Consistency
SPT	MCS		SPT	MCS		
0 - 4	0 - 7	Very Loose	0 - 2	0 - 4		Very Soft
4 - 10	7 - 18	Loose	2 - 4	4 - 7	< 0.5	Soft
10 - 30	18 - 55	Medium Dense	4 - 8	7 - 15	0.5 - 1.0	Medium Stiff
30 - 50	55 - 91	Dense	8 - 15	15 - 27	1.0 - 2.0	Stiff
> 50	> 91	Very Dense	15 - 30	27 - 55	2.0 - 4.0	Very Stiff
			> 30	> 55	> 4.0	Hard

MOISTURE CONTENT DEFINITIONS

Dry: Absence of moisture, dry to the touch

Moist: Damp but no visible water

Wet: Visible free water

GRAIN SIZE DEFINITION

Description	Sieve Number and / or Size
Boulders	> 12 inches (305-mm)
Cobbles	3 to 12 inches (75-mm to 305-mm)
Gravel	3-inch to #4 (75-mm to 4.75-mm)
Coarse Gravel	3-inch to 3/4-inch (75-mm to 19-mm)
Fine Gravel	3/4-inch to #4 (19-mm to 4.75-mm)
Sand	#4 to #200 (4.75-mm to 0.075-mm)
Coarse Sand	#4 to #10 (4.75-mm to 2-mm)
Medium Sand	#10 to #40 (2-mm to 0.425-mm)
Fine Sand	#40 to #200 (0.425-mm to 0.075-mm)

ABBREVIATIONS

WOH: Weight of Hammer

WOR: Weight of Drill Rods

SPT: Standard Penetration Test Split-Spoon Sampler

MCS: Modified California Sampler

PP: Pocket Penetrometer

**Soil descriptions are based on ASTM D2488-09a, Visual-Manual Procedure, with the above modifications by Geolabs, Inc. to the Unified Soil Classification System (USCS).*

Plate

A-0.2

SOIL_CLASS_LOG_KEY 7611-00C.GPJ GEOLABS.GDT 9/3/20

ROCK DESCRIPTIONS

	BASALT		**CONGLOMERATE**
	BOULDERS		**LIMESTONE**
	BRECCIA		**SANDSTONE**
	CLINKER		**SILTSTONE**
	COBBLES		**TUFF**
	CORAL		**VOID/CAVITY**

ROCK DESCRIPTION SYSTEM

ROCK FRACTURE CHARACTERISTICS

The following terms describe general fracture spacing of a rock:

Massive: Greater than 24 inches apart

Slightly Fractured: 12 to 24 inches apart

Moderately Fractured: 6 to 12 inches apart

Closely Fractured: 3 to 6 inches apart

Severely Fractured: Less than 3 inches apart

DEGREE OF WEATHERING

The following terms describe the chemical weathering of a rock:

Unweathered: Rock shows no sign of discoloration or loss of strength.

Slightly Weathered: Slight discoloration inwards from open fractures.

Moderately Weathered: Discoloration throughout and noticeably weakened though not able to break by hand.

Highly Weathered: Most minerals decomposed with some corestones present in residual soil mass. Can be broken by hand.

Extremely Weathered: Saprolite. Mineral residue completely decomposed to soil but fabric and structure preserved.

HARDNESS

The following terms describe the resistance of a rock to indentation or scratching:

Very Hard: Specimen breaks with difficulty after several "pinging" hammer blows.
Example: Dense, fine grain volcanic rock

Hard: Specimen breaks with some difficulty after several hammer blows.
Example: Vesicular, vugular, coarse-grained rock

Medium Hard: Specimen can be broked by one hammer blow. Cannot be scraped by knife. SPT may penetrate by ~25 blows per inch with bounce.
Example: Porous rock such as clinker, cinder, and coral reef

Soft: Can be indented by one hammer blow. Can be scraped or peeled by knife. SPT can penetrate by ~100 blows per foot.
Example: Weathered rock, chalk-like coral reef

Very Soft: Crumbles under hammer blow. Can be peeled and carved by knife. Can be indented by finger pressure.
Example: Saprolite

GEOLABS, INC.	DRYWELL DESIGN FOR HANATO'S PROPERTY GENERAL CIVIL ENGINEERING SERVICES STATEWIDE PROJECT NO. HWY-DS-CE-2017-01 ISLAND OF HAWAII	Log of Boring 1
Geotechnical Engineering		

Approximate Ground Surface Elevation (feet MSL): 511.5 *

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
										SM	3-inch **ASPHALTIC CONCRETE**
			44	8	9/6" +50/0" Ref.						Brown to brownish gray **SILTY SAND** with gravel and a little clay, medium dense, moist (fill)
										GM	Light gray **SILTY GRAVEL AND COBBLES** with sand, moist (fill)
							5				Dark gray vesicular **BASALT**, severely to closely fractured, slightly to moderately weathered, medium hard (basalt formation)
UC= 4050 psi			90	43							
							10				
			30	0						GM	Brown, red and dark gray **SILTY GRAVEL** with sand and cobbles, slightly cemented in places, dense to very dense, dry to moist (clinker)
							15				
			63	7							
							20				Gray vesicular **BASALT**, moderately to slightly fractured, unweathered to slightly weathered, hard to very hard (basalt formation)
UC= 19690 psi			100	100							
											grades to massive
							25				
UC= 5100 psi			100	100							
UC= 4780 psi											
							30				
UC= 1370 psi			80	80							Purple to bluish gray **WELDED CLINKER** with silty sand matrix, moderately fractured, slightly to moderately weathered, soft to medium hard (clinker)
UC= 2730 psi							35				

Date Started:	June 16, 2020	Water Level:	Not Encountered	Plate
Date Completed:	June 17, 2020			
Logged By:	F. Sperberg	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*	A - 1.1
Total Depth:	40 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	7611-00(C)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 7611-00C.GPJ GEOLABS.GDT 9/17/20

GEOLABS, INC. Geotechnical Engineering	DRYWELL DESIGN FOR HANATO'S PROPERTY GENERAL CIVIL ENGINEERING SERVICES STATEWIDE PROJECT NO. HWY-DS-CE-2017-01 ISLAND OF HAWAII	Log of Boring 1

Laboratory			Field								(Continued from previous plate)
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
			50	11							grades to severely to closely fractued, moderately weathered
							40				Boring terminated at 40 feet
											* Elevations estimated from Topography Plans received from WSP on August 3, 2020.
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	June 16, 2020	Water Level:	Not Encountered	Plate A - 1.2
Date Completed:	June 17, 2020			
Logged By:	F. Sperberg	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*	
Total Depth:	40 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	7611-00(C)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	DRYWELL DESIGN FOR HANATO'S PROPERTY GENERAL CIVIL ENGINEERING SERVICES STATEWIDE PROJECT NO. HWY-DS-CE-2017-01 ISLAND OF HAWAII	Log of Boring 2

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Approximate Ground Surface Elevation (feet MSL): 455 * Description
										GP-GM	Brownish gray to brown **SANDY GRAVEL** with a little silt, dense to very dense, moist (fill)
Sieve - #200 = 9.0%	28	70			61						
	12				56						
			80	77							
							5				Gray **BASALT**, slightly fractured, unweathered to slightly weathered, hard to very hard
			100	68							
							10				
UC= 9610 psi			80	61							grades to moderately to slightly fractured
UC= 8620 psi							15				
UC= 10480 psi			72	53							
							20			GM	Red and dark gray **SILTY GRAVEL** with sand, dry to moist (clinker)
UC= 5910 psi			48	30							
							25				Dark gray vesicular **BASALT**, moderately fractured, slightly to moderately weathered, hard (basalt formation)
UC= 8360 psi UC= 2500 psi			92	92							grades to slightly fractured
							30				
			27	0						GM	Red **SILTY GRAVEL** with sand, dry to moist (clinker)
							35				

Date Started:	June 15, 2020	Water Level:	Not Encountered
Date Completed:	June 16, 2020		
Logged By:	F. Sperberg	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*
Total Depth:	40 feet	Drilling Method:	4" Auger & HQ Coring
Work Order:	7611-00(C)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 2.1

BORING_LOG 7611-00C.GPJ GEOLABS.GDT 9/17/20

GEOLABS, INC.

Geotechnical Engineering

DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

Log of Boring

2

(Continued from previous plate)

Other Tests (Laboratory)	Moisture Content (%) (Laboratory)	Dry Density (pcf) (Laboratory)	Core Recovery (%) (Field)	RQD (%) (Field)	Penetration Resistance (blows/foot) (Field)	Pocket Pen. (tsf) (Field)	Depth (feet)	Sample	Graphic	USCS	Description
										GM	
			100	0	50/3"						Dark gray **BASALT**, closely fractured, moderately to highly weathered, soft to medium hard (basalt formation)
					50/0" Ref.		40				Boring terminated at 40 feet
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	June 15, 2020
Date Completed:	June 16, 2020
Logged By:	F. Sperberg
Total Depth:	40 feet
Work Order:	7611-00(C)

Water Level:	Not Encountered
Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*
Drilling Method:	4" Auger & HQ Coring
Driving Energy:	140 lb. wt., 30 in. drop

APPENDIX B

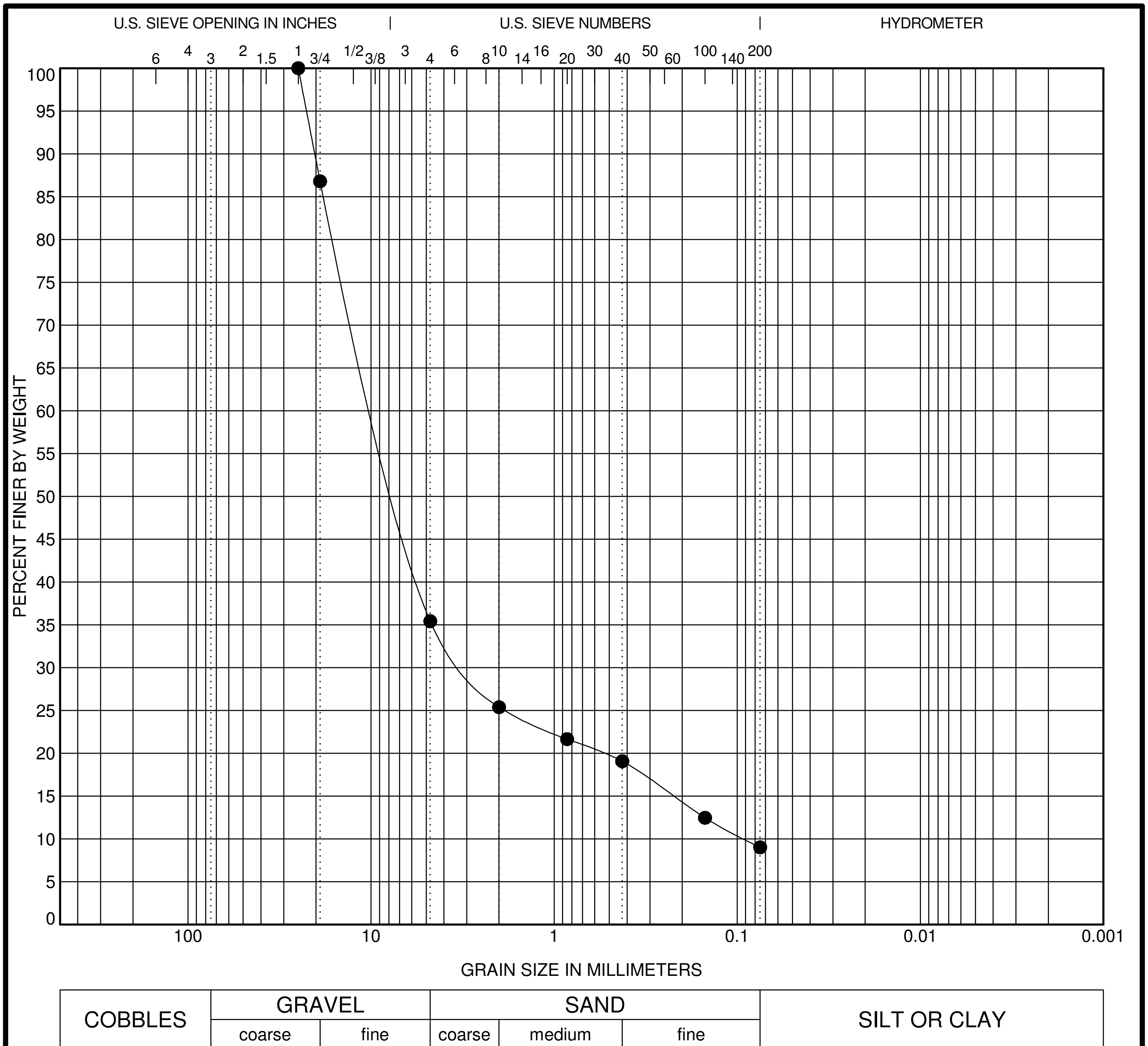
APPENDIX B

Laboratory Tests

Moisture Content (ASTM D2216) and Unit Weight (ASTM D2937) determinations were performed on selected samples as an aid in the classification and evaluation of soil properties. The test results are presented on the Logs of Borings at the appropriate sample depths.

One sieve analysis test (ASTM C117 & ASTM C136) was performed on a selected soil sample to evaluate the gradation characteristics of the soil and to aid in soil classification. Graphic presentation of the grain size distribution is provided on Plate B-1.

Twelve uniaxial compression tests (ASTM D7012 Method C) were performed on selected rock cores to evaluate their uniaxial compressive strengths of the rock formation encountered. Results of the uniaxial compression tests are presented on Plate B-2.



	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-2	1.0-2.5	Brownish gray to brown sandy gravel (GP-GM) with a little silt				10.5	100.8

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-2	1.0-2.5	25	9.22	2.979	0.091	64.6	26.4	9.0

G_GRAIN_SIZE_MOD 7611-00C.GPJ GEOLABS.GDT 9/17/20

GEOLABS, INC.
GEOTECHNICAL ENGINEERING

W.O. 7611-00(C)

GRAIN SIZE DISTRIBUTION - ASTM C117 & C136

DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

Plate
B - 1

Location	Depth	Length	Diameter	Length/ Diameter Ratio	Density	Load	Compressive Strength
	(feet)	(inches)	(inches)		(pcf)	(lbs)	(psi)
B-1	6 - 11	5.142	2.411	2.13	122.1	18,490	4,050
B-1	21 - 26	5.100	2.399	2.13	160.5	88,980	19,690
B-1	26 - 28.5	5.137	2.422	2.12	149.5	23,510	5,100
B-1	28.5 - 31	5.012	2.401	2.09	154.1	21,640	4,780
B-1	31 - 33.5	5.131	2.399	2.14	140.4	6,170	1,370
B-1	33.5 - 36	5.163	2.415	2.14	137.8	12,520	2,730
B-2	11.5 - 14.5	5.129	2.403	2.13	169.2	43,590	9,610
B-2	14.5 - 17.5	5.087	2.404	2.12	169.5	39,120	8,620
B-2	17.5 - 22.5	5.106	2.408	2.12	164.7	47,710	10,480
B-2	22.5 - 27.5	5.095	2.401	2.12	165.1	26,780	5,910
B-2	27.5 - 32.3	5.083	2.401	2.12	155.4	37,830	8,360
B-2	27.6 - 32.4	5.089	2.400	2.12	163.7	11,310	2,500

ASTM D7012 (METHOD C)

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W.O. 7611-00(C)

UNIAXIAL COMPRESSIVE STRENGTH TEST

DRYWELL DESIGN FOR HANATO'S PROPERTY
GENERAL CIVIL ENGINEERING SERVICES STATEWIDE
PROJECT NO. HWY-DS-CE-2017-01
ISLAND OF HAWAII

Plate
B - 2

G_ROCK_UC_TEST_PORTRAIT 7611-00C.GPJ GEOLABS.GDT 9/8/20

APPENDIX C

B-1 2.0' TO 27.75'

2.0' **20.0'**

20.0' **27.75'**

HANATO PROPERTY DRAINAGE IMPROVEMENTS
KONA, ISLAND OF HAWAII

B-1 27.75' TO 40.0'

27.75 **36.0**

36.0' **40.0'**

B-2 4.5' TO 21.0'

4.5' **11.5'**

11.5' **21.0'**

B-2 21.0’ TO 40.0’

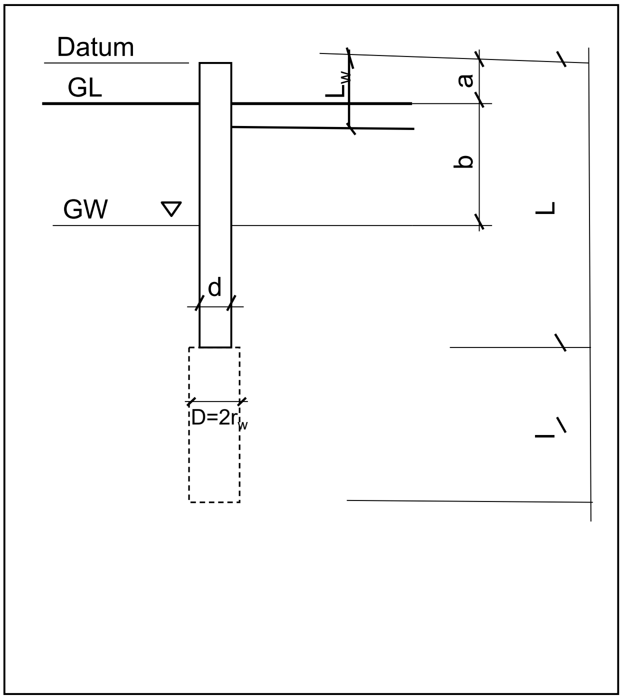
21.0’ 37.5’

37.5’ 40.0’

APPENDIX D

PERCOLATION TEST CALCULATION SHEET
(CONSTANT HEAD METHOD: WELL POINT-FILTER IN UNIFORM SOIL)

Drywell Design for Hanato's Property
General Civil Engineering Services Statewide
Project No. HWY-DS-CE-2017-01
Island of Hawaii



Boring:	**B-1**	
GW table, b (from ground):	**45.0**	feet
Datum, a (above ground):	**0.0**	feet
Depth of Boring:	**20.0**	feet
Length, L (from datum):	**10.0**	feet
Open hole Length, l:	**10.0**	feet
Diameter of open hole (D):	**3.5**	inches
Diameter of casing (d):	**3.0**	inches
Constant flow rate, Q:	**147.0**	gpm
Constant water level (L_w):	**20.0**	feet
Factor of m ($\sqrt{\frac{k_h}{k_v}}$ =	**1.0**	

Constant flow rate, Q =		147.0	gpm
	=	19.65	feet³/min
Piezometer head, H_c=		25.0	feet

Coefficient of Permeability

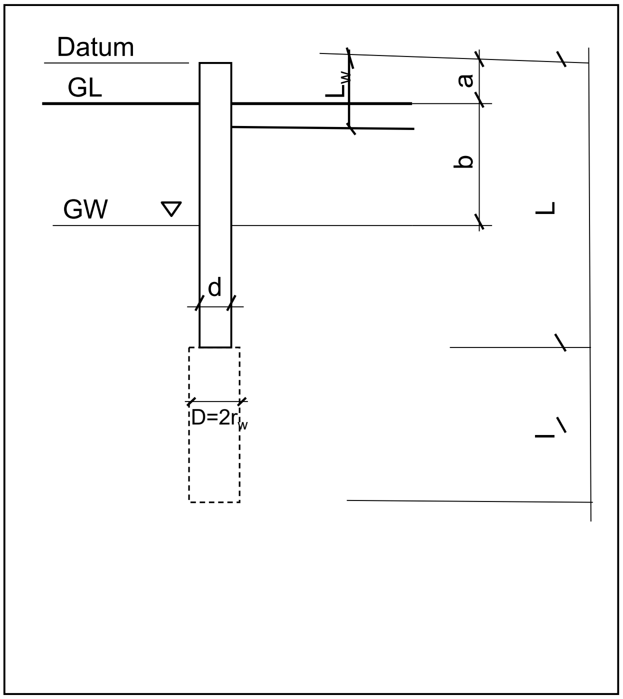
$$k = \frac{q \times \ln[\frac{mI}{D} + \sqrt{1 + (\frac{mI}{D})^2}\,]}{2 \times \pi \times I \times H_c}$$

5.29E-02	ft/min
2.69E-02	cm/s

PERCOLATION TEST CALCULATION SHEET

(CONSTANT HEAD METHOD: WELL POINT-FILTER IN UNIFORM SOIL)

Drywell Design for Hanato's Property
General Civil Engineering Services Statewide
Project No. HWY-DS-CE-2017-01
Island of Hawaii



Boring:	**B-1**	
GW table, b (from ground):	**45.0**	feet
Datum, a (above ground):	**0.0**	feet
Depth of Boring:	**40.0**	feet
Length, L (from datum):	**20.0**	feet
Open hole Length, l:	**20.0**	feet
Diameter of open hole (D):	**3.5**	inches
Diameter of casing (d):	**3.0**	inches
Constant flow rate, Q:	**125.0**	gpm
Constant water level (L_w):	**40.0**	feet
Factor of m ($\sqrt{\frac{k_h}{k_v}}$ =	**1.0**	

Constant flow rate, Q	=	125.0	gpm
	=	16.71	feet³/min
Piezometer head, H_c=		5.0	feet

Coefficient of Permeability

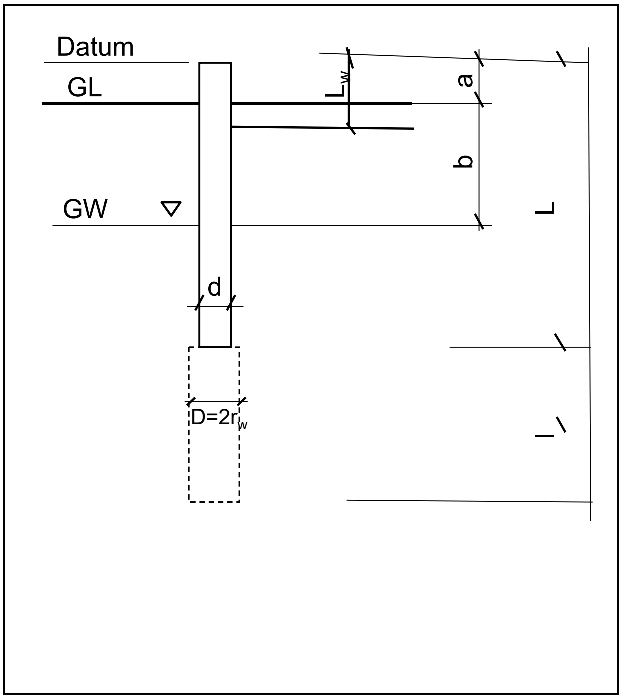
$$k = \frac{q \times \ln[\frac{mI}{D} + \sqrt{1+(\frac{mI}{D})^2}]}{2\times\pi \times I \times H_c}$$

1.31E-01	ft/min
6.65E-02	cm/s

PERCOLATION TEST CALCULATION SHEET

(CONSTANT HEAD METHOD: WELL POINT-FILTER IN UNIFORM SOIL)

Drywell Design for Hanato's Property
General Civil Engineering Services Statewide
Project No. HWY-DS-CE-2017-01
Island of Hawaii



Boring:	**B-2**	
GW table, b (from ground):	**45.0**	feet
Datum, a (above ground):	**0.0**	feet
Depth of Boring:	**21.5**	feet
Length, L (from datum):	**10.0**	feet
Open hole Length, l:	**11.5**	feet
Diameter of open hole (D):	**3.5**	inches
Diameter of casing (d):	**3.0**	inches
Constant flow rate, Q:	**96.0**	gpm
Constant water level (L_w):	**21.5**	feet
Factor of m ($\sqrt{\frac{k_h}{k_v}}$ =	**1.0**	

Constant flow rate, Q =	96.0	gpm
=	12.83	feet³/min
Piezometer head, H_c=	23.5	feet

Coefficient of Permeability

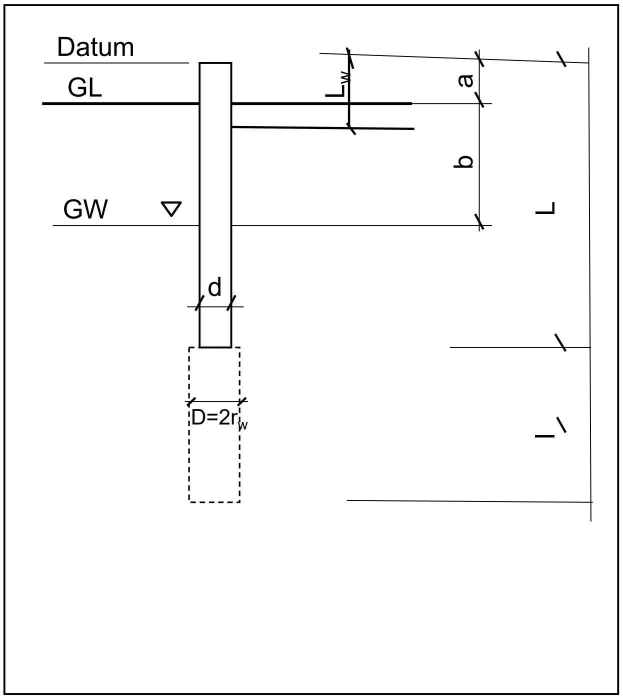
$$k = \frac{q \times \ln[\frac{mI}{D} + \sqrt{1 + (\frac{mI}{D})^2}]}{2 \times \pi \times I \times H_c}$$

3.30E-02	ft/min
1.68E-02	cm/s

PERCOLATION TEST CALCULATION SHEET

(CONSTANT HEAD METHOD: WELL POINT-FILTER IN UNIFORM SOIL)

Drywell Design for Hanato's Property
General Civil Engineering Services Statewide
Project No. HWY-DS-CE-2017-01
Island of Hawaii



Boring:	**B-2**	
GW table, b (from ground):	**45.0**	feet
Datum, a (above ground):	**0.0**	feet
Depth of Boring:	**40.0**	feet
Length, L (from datum):	**20.0**	feet
Open hole Length, l:	**20.0**	feet
Diameter of open hole (D):	**3.5**	inches
Diameter of casing (d):	**3.0**	inches
Constant flow rate, Q:	**102.0**	gpm
Constant water level (L_w):	**40.0**	feet
Factor of m ($\sqrt{\frac{k_h}{k_v}}$ =	**1.0**	

Constant flow rate, Q	=	102.0	gpm
	=	13.63	feet³/min
Piezometer head, H_c=		5.0	feet

Coefficient of Permeability

$$k = \frac{q \times \ln\left[\frac{mI}{D} + \sqrt{1+\left(\frac{mI}{D}\right)^2}\right]}{2\times\pi \times I \times H_c}$$

1.07E-01	ft/min
5.43E-02	cm/s

GEOLABS, INC.

Geotechnical Engineering and Drilling Services

TECHNICAL MEMORANDUM

DATE:	November 25, 2020	**TIME:**	10:46 AM
TO:	WSP	**FROM:**	Gerald Seki
ATTN:	Mr. Randall Urasaki	**W.O. No.:**	7611-00(C)
SUBJECT:	Bearing Capacity Recommendations for Drainage Inlet Structure Hanato Drainage Improvements Island of Hawaii	**NO. OF PAGES:**	1
E-MAIL:	Randall.Urasaki@wsp.com		
COPY TO:	KSF, Inc. (Mr. Russ Miyahara) RussM@ksfinc.us Original / File		

This technical memorandum provides our bearing capacity recommendations for the drainage inlet structure for the above project. The recommendations presented herein are based on our field exploration performed for the project.

We understand that new drainage inlet structures consisting of manholes with a grated cover are planned for the project. The new manhole inverts will be up to about 15 feet below the existing ground surface. Based on our borings, we anticipate that the inlet structure will be bearing on dense to very dense silty gravel or basalt rock formation.

Based on the anticipated subsurface conditions encountered and LRFD methods, an ultimate bearing capacity of up to 15,000 pounds per square foot (psf) may be used to evaluate the foundations bearing on the dense to very dense silty gravel or basalt rock formation based on an extreme event limit state. To evaluate the strength limit state of the foundations, a bearing pressure of up to 6,700 psf may be used based on a resistance factor of 0.45. For the service limit state, a bearing pressure of up to 5,000 psf may be used. If the footings are designed in accordance with our recommendations, total settlement of the structures are estimated to be on the order of 1 inch or less.

To provide uniform bearing support for the manhole structures, we recommend providing a 6-inch thick layer of No. 3B Fine Gravel (ASTM C33, No. 67 gradation) below the bottom of the structure. Alternately, a 6-inch layer of Controlled Low Strength Material (CLSM) or lean concrete may be placed in lieu of the No. 3B Fine gravel. Foundation subgrades should be recompacted to a firm and unyielding surface prior to the placement of the No. 3B Fine gravel for the manhole structures.

Soft and/or loose materials encountered at the bottom of the excavations should be over-excavated to expose the underlying firm materials. The over-excavation should be backfilled with fill materials compacted to a minimum of 90 percent relative compaction or lean concrete.

If you have questions or need additional information, please contact our office.