GEOTECHNICAL ENGINEERING EXPLORATION

POHOIKI BOAT RAMP MAINTENANCE DREDGING

PUNA DISTRICT, ISLAND OF HAWAII

W.O. 8271-00 JULY 7, 2022

Prepared for

THE LIMTIACO CONSULTING GROUP

GEOLABS, INC.
Geotechnical Engineering and Drilling Services

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THE LIMTIACO CONSULTING GROUP

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

THIS WORK WAS PREPARED BY
ME OR UNDER MY SUPERVISION.

DRAFT

4-30-24

SIGNATURE EXPIRATION DATE OF THE LICENSE

GEOLABS, INC.
Geotechnical Engineering and Drilling Services
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Hawaii • California

GEOLABS, INC.

Geotechnical Engineering and Drilling Services

July 7, 2022
W.O. 8271-00

Mr. Kyle Kaneshiro
The Limtiaco Consulting Group
1622 Kanakanui Street
Honolulu, HI 96817

Dear **Mr. Kaneshiro:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Pohoiki Boat Ramp Maintenance Dredging, Puna District, 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 May 14, 2021.

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 not clear, please contact our office.

Very truly yours,

GEOLABS, INC.

DRAFT

Gerald Y. Seki, P.E.
Vice President

GS:sh

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Hawaii • California

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PUNA DISTRICT, ISLAND OF HAWAII
W.O. 8271-00 JULY 7, 2022

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Our field exploration generally encountered a beach deposit surface layer, about 18 feet thick, underlain by shallow marine deposit, clinker, and basalt rock formation extending to the maximum depth explored of 27 feet below the existing ground surface. The beach deposit consisted of loose to very dense sandy gravel with some cobbles. The shallow marine deposit was composed of medium dense silty sand. The clinker deposit consisted of very dense sandy gravel. The basalt rock formation was hard. We encountered groundwater in the boring at about 8.5 feet below the existing ground surface.

Recent activity along the Kilauea Volcano's east rift zone created lava flows just above the Pohoiki Boat Ramp area. These lava flows started in May of 2018 and entered the ocean just north of Pohoiki Bay from July to August of 2018. Subsequent to the recent lava flows, a large amount of sand, gravel, and cobbles was transported down the coast and closing off the existing Pohoiki Bay at the Isaac Hale Park. The sand, gravel, and cobbles were generated from the erosion of the new friable lava north of the bay from the ocean waves. We understand that the beach deposit along the shoreline is more than 20 feet in height and more than 200 feet wide.

Several ridges were observed on the surface of the beach deposit due to heavy wave events that occurred. We anticipate that numerous cobbles and some boulders may be encountered in the beach deposit below these ridges where the old shoreline existed previously.

Therefore, we anticipate that the dredged materials may consist of sand, gravel, and some cobbles. In addition, we anticipate that occasional boulders may be encountered.

Based on our slope stability analysis, we recommend that a dredged slope of 4H:1V or flatter may be used for the cut slopes below the water and up to about +2 feet Mean Sea Level (MSL). From +2 feet MSL, a dredged slope of 3H:1V or flatter may be used. Our analysis does not take fully into account the slope under wave loading. Therefore, some sloughing of the dredged slope may occur.

Due to the limited budget for the project, the slopes were not designed for seismic loading. If seismic loading conditions were considered, the finished slopes would need to be flattened significantly and the amount of dredging required would also increase significantly.

The new lava material from the recent flows is generally friable and protrusions in the coastline may provide material for deposition down current. The erosion and deposition may be the greatest during heavy wave events. Therefore, future deposition of beach material within the dredged area may occur subsequent to the maintenance dredging.

We understand that the dredged materials from the project will be stockpiled in an open lava field area adjacent to the project site. It is desired to determine if the dredged material can be used as construction fill material.

Based on the laboratory test results, the beach deposit material qualifies for use as Aggregate Subbase, Structural Backfill Material A, Structural Material B, Trench Backfill Material B, and Granular Material for Embankment in accordance with the 2005 State of Hawaii Department of Transportation Standard Specifications. In addition, the beach deposit qualifies for use as Select Borrow for Subbase and Borrow in accordance with the County of Hawaii Standard Specifications for Public Works Construction, dated September 1986.

It should be noted that some cobbles were observed within the beach deposit. In addition, we anticipate some boulders may be encountered in the beach deposit. Therefore, some screening of these larger size materials will be required.

The text of this report should be referred to for detailed discussions and specific geotechnical recommendations.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1. GENERAL

This report presents the results of our geotechnical engineering exploration performed for the *Pohoiki Boat Ramp Maintenance Dredging* project in the Puna District 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. The findings and recommendations presented herein are subject to the limitations noted at the end of this report.

1.1 Project Considerations

The project site is located along the southeast coast of the Puna District on the Island of Hawaii. We understand that subsequent to the recent lava flows immediately adjacent to Pohoiki Bay, a large deposit of sand, gravel, and cobbles was transported down the coast and closing off the existing Puna Boat Ramp at the Isaac Hale Park. The sand, gravel, and cobbles were generated from the erosion of the new friable lava from the ocean waves. The sand, gravel, and cobbles deposit along the shoreline is more than 20 feet in height and more than 200 feet wide.

We understand that it is desired to provide access from the ocean to the existing boat ramp. In addition, we understand that removal of the deposited materials down to Elevation -6 feet Mean Sea Level (MSL) is being considered. Due to the limited budget on this project, we understand that only the grading option for the maintenance dredging is feasible. Typically, the exposed cut channel slopes are protected from erosion by wave action by an armoring layer. Therefore, some amount of erosion should be expected from the wave action.

1.2 Purpose and Scope

The purpose of our exploration was to obtain information on the subsurface conditions to develop an idealized soil/rock data set to formulate geotechnical engineering recommendations for the maintenance dredging project. The work was performed in general accordance with our revised fee proposal dated May 14, 2021 with the following exception. Due to accessibility for our truck-mounted drill rig at the project site, drilling of a boring was performed instead of the Dynamic Cone Penetration and nuclear gage testing to obtain better subsurface information. The scope of work for this exploration included the following tasks and work efforts:

1. Boring stakeout and utility clearance by our engineer.
2. Mobilization and demobilization of a truck-mounted drill rig on the Island of Hawaii, a water truck, and two operators from Honolulu to the project site and back.
3. Drilling and sampling of one borehole extending to a depth of about 27 feet below the existing ground surface. In addition, a bulk sample was obtained for testing.
4. Coordination of the field exploration and logging of the boring by our field engineer/geologist.
5. Laboratory testing of selected samples obtained during the field exploration as an aid in classifying the materials and evaluating their engineering properties.
6. Analysis of the field and laboratory data to formulate geotechnical recommendations for the design of the maintenance dredging cut slopes and potential uses of the dredge materials.
7. Preparation of this report summarizing our work on the project and presenting the findings and geotechnical recommendations.
8. Coordination of our overall work on the project by our senior engineer.
9. Quality assurance of our work and client/design team consultation by our principal engineer.
10. 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. Photograph of the core samples are presented in Appendix C.

END OF GENERAL

SECTION 2. SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Hawaii is the largest in the Hawaiian Archipelago and covers an area of approximately 4,030 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), and Mauna Loa and Kilauea (both still active).

The project site is situated on the eastern flank of the Kilauea Volcano, which has been built up by basaltic lava flows. These flows are of the Pleistocene Epoch (Ice Age) and of the Recent Age, and belong to the Puna Volcanic Series.

Recent activity from Kilauea Volcano's east rift zone created lava flows just north of the Pohoiki area. These lava flows started in May 2018.

2.2 Existing Site Conditions

The project site is located along the southeast coast of the Puna District on the Island of Hawaii. The project site is covered by dark gray to black sands, gravels and cobbles. The abundance of cobbles was observed along the shoreline.

Remanence of the recent lava flow is located east of the project site. An existing lifeguard tower was noted just south of the boat ramp. Natural ocean thermal ponds were noted in several areas at the project site.

Several ridges were noted on the surface of the beach deposit. We believe that these ridges were formed during heavy wave events and the deposition of the beach deposits.

The project site is fairly level and slopes down near the existing boat ramp structure and at the coastline. The existing ground surface elevations at the fairly level area range from about +10 to +15 feet MSL.

2.3 Subsurface Conditions

We explored the subsurface conditions at the project site by drilling and sampling one boring, designated as Boring No. 1, extending to a depth about 27 feet below the existing ground surface. In addition, one bulk sample of the near-surface soils, designated as Bulk-1, was obtained to evaluate the characteristics of the near-surface soils. The approximate boring and bulk sample locations are shown on the Site Plan, Plate 2.

The boring generally encountered a beach deposit surface layer about 18 feet thick, underlain by a shallow marine deposit extending to about 20.5 feet deep. Below the shallow marine deposit, a clinker deposit about 4 feet thick was encountered, underlain by a basalt rock formation extending to the maximum depth explored of 27 feet below the existing ground surface.

The beach deposit layer consisted of loose to very dense sandy gravel with some cobbles. The shallow marine deposit was composed of medium dense silty sand. The clinker deposit consisted of very dense sandy gravel. The basalt rock formation was hard.

We encountered groundwater in the drilled boring at about 8.5 feet below the existing ground surface at the time of our field exploration. However, it should be noted that the groundwater levels are subject to change due to tidal fluctuations, rainfall, time of year, seasonal precipitation, surface water runoff, and other factors.

END OF SITE CHARACTERIZATION

SECTION 3. DISCUSSION AND RECOMMENDATIONS

Based on our field exploration, the project site is generally underlain by a beach deposit about 18 feet thick, followed by a shallow marine deposit, clinker, and basalt rock formation extending to the maximum depth explored of 27 feet below the existing ground surface.

The anticipated dredged materials, dredged slope recommendations, and potential uses for the dredged materials are presented in the following sections.

3.1 Anticipated Dredged Materials

As indicated previously, recent activity along the Kilauea Volcano's east rift zone created lava flows just above the Pohoiki Boat Ramp area. These lava flows started in May of 2018 and entered the ocean just north of Pohoiki Bay from July to August of 2018.

Subsequent to the recent lava flows, a large amount of sand, gravel, and cobbles was transported down the coast and closing off the existing Pohoiki Bay at the Isaac Hale Park. The sand, gravel, and cobbles were generated from the erosion of the new friable lava north of the bay from the ocean waves. We understand that the beach deposit along the shoreline is more than 20 feet in height and more than 200 feet wide.

Based on the boring drilled at the project site, the site is generally underlain by a beach deposit surface layer consisting of loose to very dense sandy gravel with some cobbles extending about 18 feet below the existing ground surface. The beach deposit was underlain by a shallow marine deposit, clinker, and basalt rock formation extending to the maximum depth explored of 27 feet below the existing ground surface.

Several ridges were observed on the surface of the beach deposit due to heavy wave events that occurred. We anticipate that numerous cobbles and some boulders may be encountered in the beach deposit below these ridges where the old shoreline existed previously.

Therefore, we anticipate that the dredged materials may consist of sand, gravel, and some cobbles. In addition, we anticipate that occasional boulders may be encountered.

3.2 Dredged Slopes

Based on our literature search, recommended finished slopes under wave loading could not be found. In the report by Lee, Torresan, and McArthur entitled "Stability of Submerged Slopes on the Flanks of the Hawaiian Island, a Simplified Approach" for the U.S. Department of the Interior, U.S. Geological Survey, some guidelines are provided for volcaniclastic sands similar to the beach deposits encountered at the project site. For static conditions, submerged slope inclinations between 1H:1V and 2H:1V were recommended.

In our slope stability analysis, a differential hydraulic head of 2 feet was used for the static condition. To try and simulate some of the effects of wave loading, a differential head of 5 feet was used in our analysis.

Based on our slope stability analysis, we recommend that a dredged slope of 4H:1V or flatter may be used for the cut slopes below the water and up to about +2 feet MSL. From +2 feet MSL, a dredged slope of 3H:1V or flatter may be used. As indicated above, our analysis does not take fully into account the slope under wave loading. Therefore, some sloughing of the dredged slope may occur.

Due to the limited budget for the project, the slopes were not designed for seismic loading. If seismic loading conditions were considered, the finished slopes would need to be flattened significantly and the amount of dredging required would also increase significantly.

The new lava material from the recent flows is generally friable and protrusions in the coastline may provide material for deposition down current. The erosion and deposition may be the greatest during heavy wave events. Therefore, future deposition of beach material within the dredged area may occur subsequent to the maintenance dredging.

3.3 Potential Uses for Dredged Materials

We understand that the dredged materials from the project will be stockpiled in an open lava field area adjacent to the project site. It is desired to determine if the dredged material can be used as construction fill material.

Laboratory testing consisting of gradation, sand equivalent, plasticity index, and California Bearing Ratio (CBR) tests was performed on a bulk sample of the beach deposit material recovered at the project site. The laboratory test results are provided in Appendix B.

Based on the laboratory test results, the beach deposit material qualifies for use as Aggregate Subbase, Structural Backfill Material A, Structural Material B, Trench Backfill Material B, and Granular Material for Embankment in accordance with the 2005 State of Hawaii Department of Transportation Standard Specifications. In addition, the beach deposit qualifies for use as Select Borrow for Subbase and Borrow in accordance with the County of Hawaii Standard Specifications for Public Works Construction, dated September 1986. A summary of the material requirements for the different agencies and the project sample results is provided on the Potential Uses of the Dredged Materials, Plates 3.1 and 3.2.

It should be noted that some cobbles were observed within the beach deposit. In addition, we anticipate some boulders may be encountered in the beach deposit. Therefore, some screening of these larger size materials will be required.

3.4 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 earthwork recommendations provided herein. If this review is not made, Geolabs cannot be responsible for misinterpretation of our recommendations.

3.5 Post-Design Services/Services During Construction

Geolabs should be retained to provide geotechnical engineering services during construction. The critical items of construction monitoring consist of the observation of the excavated dredge material and the temporary slope conditions.

A Geolabs representative also should monitor other aspects of earthwork construction to observe compliance with the design concepts, specifications, or recommendations and to expedite suggestions for design changes that may be required in the event that subsurface conditions differ from those anticipated at the time this report was prepared. Geolabs should be accorded the opportunity to provide geotechnical engineering services during construction to confirm our assumptions in providing the recommendations presented herein.

If the actual exposed subsurface conditions encountered during construction differ from those assumed or considered herein, Geolabs should be contacted to review and/or revise the geotechnical recommendations presented herein.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4. LIMITATIONS

The analyses and recommendations submitted herein are based in part upon information obtained from the field boring and bulk sample. Variations of the subsurface conditions between and beyond the field boring and bulk sample 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 field boring and bulk sample locations indicated herein are approximate, having been estimated by taping from visible features shown on the Topographic Plan received from The Limtiaco Consulting Group on May 31, 2022. Elevations of the boring was estimated from contours shown on the same plan. The field boring location and elevation should be considered accurate only to the degree implied by the methods used.

The stratification breaks shown on the graphic representations of the boring depict the approximate boundaries between soil types and, as such, may denote a gradual transition. Water level data from the boring were measured at the times shown on the graphic representations and/or presented in the text of this report. These data have been reviewed and interpretations made in the formulation of this report. It should be noted that the groundwater levels are subject to change due to tidal fluctuation, rainfall, seasonal precipitation, surface water runoff, and other factors.

Due to the limited budget on this project, we understand that only the grading option for the maintenance dredging is feasible. Typically, the exposed cut channel slopes are protected from erosion by wave action by an armoring layer. Therefore, some amount of erosion should be expected from the wave action.

This report has been prepared for the exclusive use of The Limtiaco Consulting Group and their project consultants for specific application to the *Pohoiki Boat Ramp Maintenance Dredging* 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 design engineers in the design of the proposed project. Therefore, this report may not contain sufficient data, or the proper information, to serve as a basis for detailed construction cost estimates.

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 probing or 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:

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Respectfully submitted,

GEOLABS, INC.

DRAFT

By ______________________________

Gerald Y. Seki, P.E.
Vice President

GS:sh

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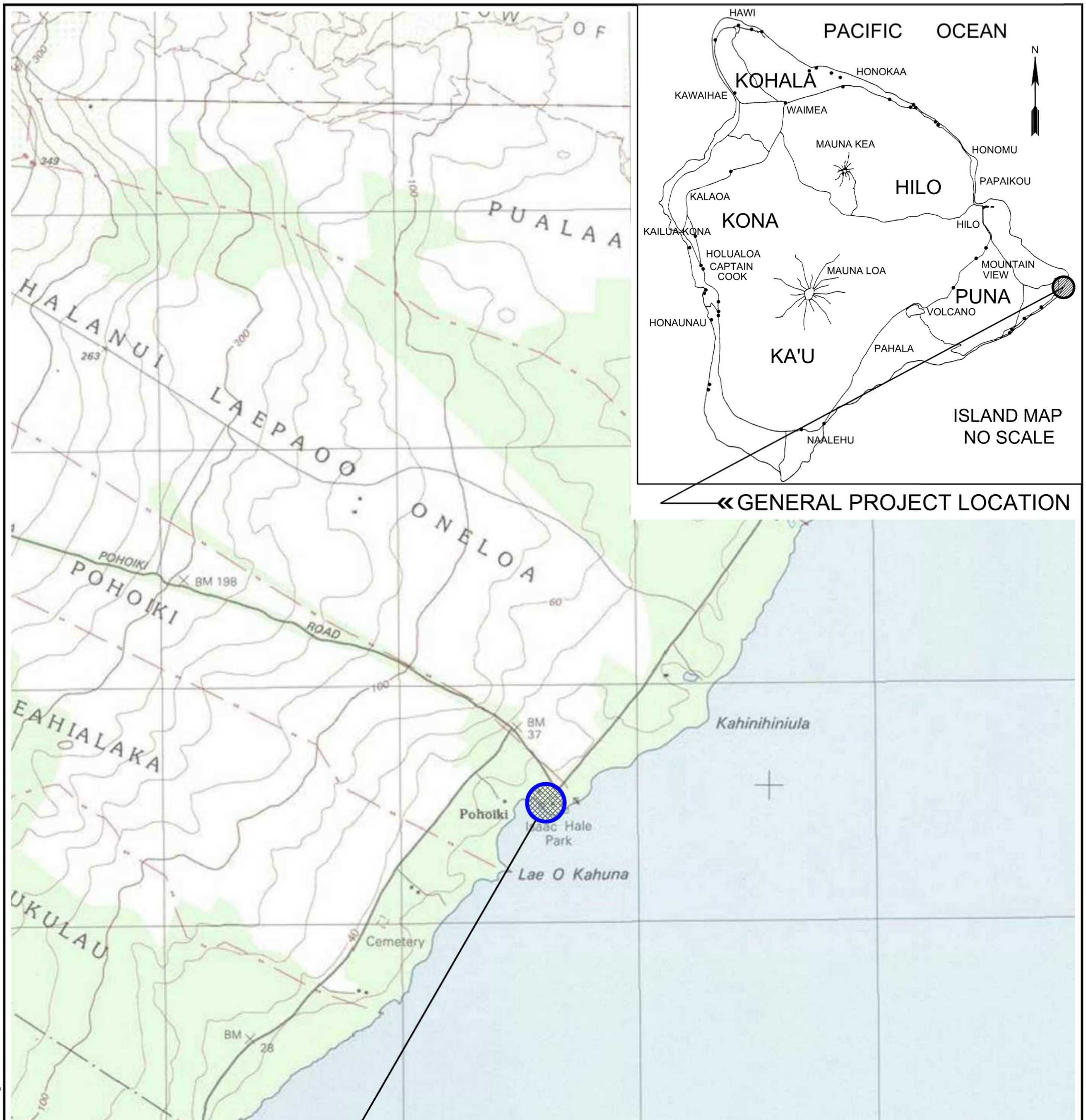
PLATES



PROJECT LOCATION

PROJECT LOCATION MAP

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

2000 1000 0 2000 FT.

GRAPHIC SCALE

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

GEOLABS, INC. Geotechnical Engineering		
DATE: MAY 2022	DRAWN BY: HYC	PLATE
SCALE: 1" = 2,000'	W.O.: 8271-00	1

CAD User: HENRY File Last Updated: June 17, 2022 5:45:53pm Plot Date: June 17, 2022 - 5:47:21pm
File: A:\Drafting\Drafting\Working\8271-00_Pohoiki_Boat_Ramp\8271-00PLM.dwg\1
Plotter: DWG To PDF-GEO.pc3 Plotstyle: GEO-No-Dithering-Blue-Boring.ctb

POHOIKI BOAT
PUNA D

OCATION

TEST	HDOT REQUIREMENTS	CITY & COUNTY REQUIREMENTS	PROJECT SAMPLE RESULTS	QUALITY/DOES NOT QUALIFY
Gradation				DOES NOT QUALIFY
2 Inch	100	100	100	
1-1/2 Inch	90 - 100	90 - 100	98	
3/4 inch	50 - 90	50 - 90	92	
No. 4	25 - 50	25 - 50	49	
No. 200	3 - 9	3 - 9	0	
Gradation				QUALIFY
2-1/2 Inch	100	100	100	
No. 4	20 - 60		49	
No. 200	0 - 15	<15	0	
Sand Equivalent	>=25	NA	100	
Plasticity Index	<=15	NA	Non-Plastic	
Gradation				QUALIFY
3 Inch	100	NA	100	
No. 4	20-75	NA	49	
No. 200	0 - 15	NA	0	
Gradation				QUALIFY
3 Inch	100	NA	100	
No. 4	20 - 100	NA	49	
Gradation				DOES NOT QUALIFY
3 Inch	100		100	
1 Inch	100	NA	96	
No. 4	75 - 100	NA	49	
No. 200	0 - 15	NA	0	
SW, SP, SM, SW-SM, SP-SM			GW	
Gradation				QUALIFY
3 Inch	100	NA	100	
1 Inch		NA		
No. 4	20 - 100	NA	49	
No. 200		NA		

TEST	HDOT REQUIREMENTS	CITY & COUNTY REQUIREMENTS	PROJECT SAMPLE RESULTS	QUALITY/DOES NOT QUALIFY
Gradation				QUALIFY
6 Inch	100	NA	100	
3 Inch	75 - 100	NA	100	
No. 4	20 - 75	NA	49	
No. 200	0 - 15	NA	0	
CBR				QUALIFY
Expansion	NA	<3	0	
Value	NA	>=8	26	
SAND EQUIVALENT	NA	>=10	100	

APPENDIX A

APPENDIX A

Field Exploration

We explored the subsurface conditions at the project site by drilling and sampling one boring, designated as Boring No. 1, extending to a depth of about 27 feet below the existing ground surface. In addition, one bulk sample of the near-surface soils, designated as Bulk-1, was obtained to evaluate the pavement support characteristics of the near-surface soils. The approximate boring and bulk sample locations are shown on the Site Plan, Plate 2. The boring was drilled using a truck-mounted drill rig equipped with continuous flight augers and HQ coring.

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 representations of the materials encountered are presented on the Log of Boring, Plate A-1.

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 boring 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 Log of Boring at the appropriate sample depths. The penetration resistance shown on the log of boring 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). “Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses” by the International Society for Rock Mechanics (March 1977).

Recovery (REC) is used as a subjective guide to the interpretation of the relative quality of rock masses. 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 discontinuities, discounting drilling 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."

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

The rippability of a rock mass is a function of the relative hardness of the rock, its relative quality, brittleness, and fissile characteristics. A dense basalt with a high RQD value would be very difficult to rip and would probably 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

GEOLABS, INC.

Geotechnical Engineering

Rock Log Legend

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

LOG LEGEND FOR ROCK 8271-00.GPJ GEOLABS.GDT 5/23/22

GEOLABS, INC. Geotechnical Engineering	POHOIKI BOAT RAMP MAINTENANCE DREDGING PUNA DISTRICT, ISLAND OF HAWAII	Log of Boring 1

Approximate Ground Surface Elevation (feet MSL): 12 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)
Direct Shear	4	109			23	
	4				39	
Direct Shear	5	131			97	
			3			
Sieve - #200 = 0.2%	5				47	
			58			
	7				23	
			25			
	18				56	
			90	24		

USCS	Description
GW	Dark gray to black medium to coarse angular **SANDY GRAVEL (BASALTIC)** with some cobbles, loose to medium dense, dry to moist (beach deposit)
GP	Dark gray **SANDY GRAVEL (BASALTIC)** with some cobbles, dense to very dense, moist to wet (beach deposit)
SM	Dark gray with trace tan **SILTY SAND (BASALTIC)** with a little sand (coralline) and a little gravel (basaltic), medium dense (shallow marine deposit)
GW	Gray with some brown **SANDY GRAVEL (BASALTIC)** with a little cobbles and traces of silt, very dense (clinker)
	Gray vugular **BASALT**, moderately to closely fractured, unweathered to slightly weathered, hard (a'a basalt)

Boring terminated at 27 feet

* Elevation estimated from Topographic Plan received from The Limtiaco Consulting Group on May 31, 2022.

Date Started:	May 19, 2022	Water Level: ▽	9.5 ft. 05/19/2022 1435 HRS	Plate A - 1
Date Completed:	May 19, 2022	▼	8.5 ft. 05/19/2022 1655 HRS	
Logged By:	S. Latronic	Drill Rig:	MOBILE B-53.1	
Total Depth:	27 feet	Drilling Method:	4" Solid-Stem Auger & HQ Coring	
Work Order:	8271-00	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.

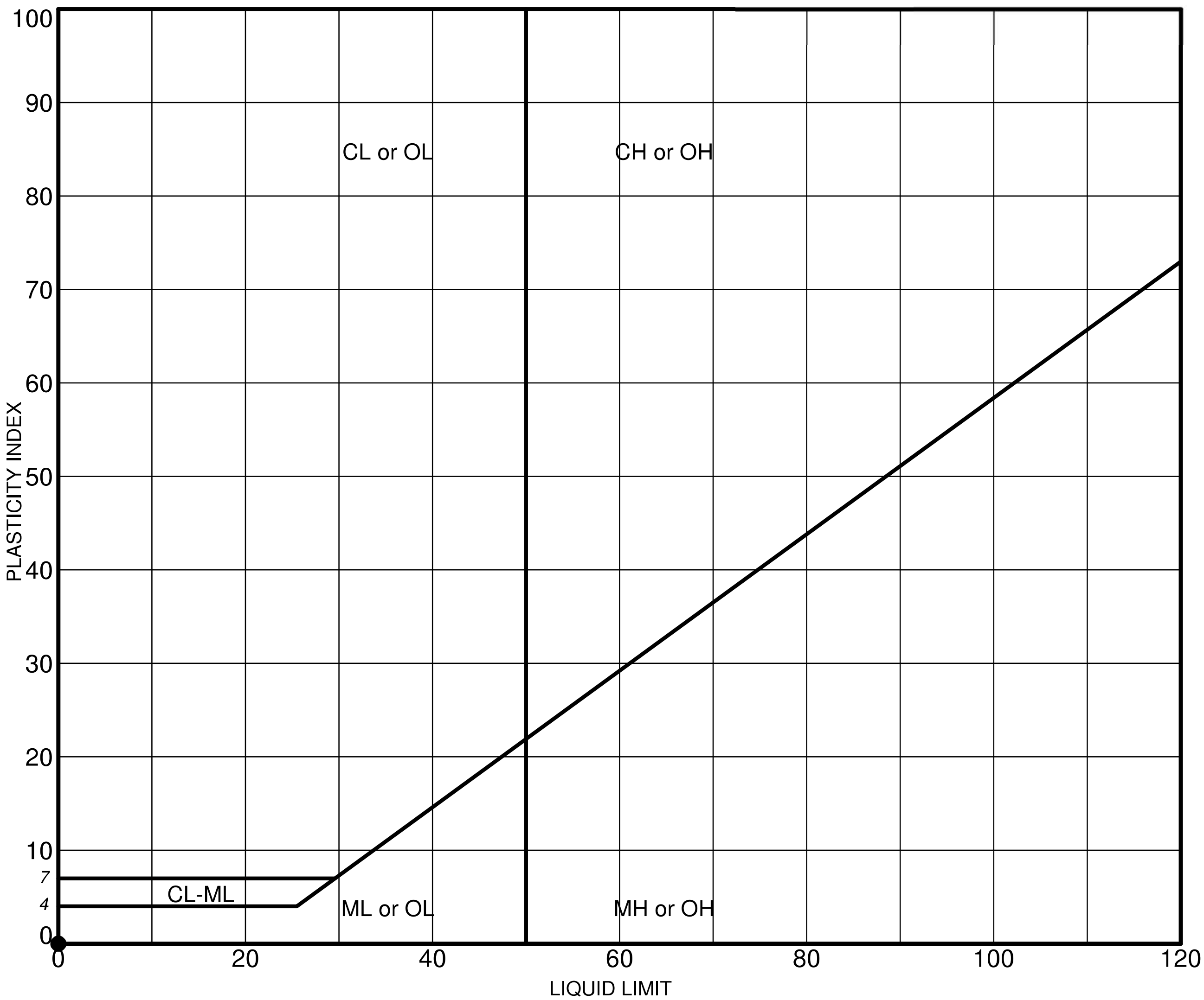
One Atterberg Limits test (ASTM D4318) was performed on a selected soil sample to evaluate the liquid and plastic limits. The test results are summarized on the Log of Boring at the appropriate sample depth. Graphic presentation of the test results is provided on Plate B-1.

Two Sieve Analysis tests (ASTM D6913) were performed on selected samples to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentation of the grain size distributions is provided on Plate B-2.

Two Direct Shear tests (ASTM D3080) were performed on selected samples to evaluate the shear strength characteristics of the material tested. The test results are presented on Plates B-3 and B-4.

One laboratory California Bearing Ratio test (ASTM D1883) was performed on a bulk sample of the near-surface soils to evaluate the characteristics of the soils. The test results are presented on Plate B-5.

One Sand Equivalent test (ASTM D2419) was performed on a bulk sample of the near-surface soils to evaluate the characteristics of the soils. The test results are presented on Plate B-6.



	Sample	Depth (ft)	LL	PL	PI	Description
●	Bulk-1	0.0-1.0	NP	NP	NP	Dark gray to black sandy gravel (NP)

NP = NON-PLASTIC

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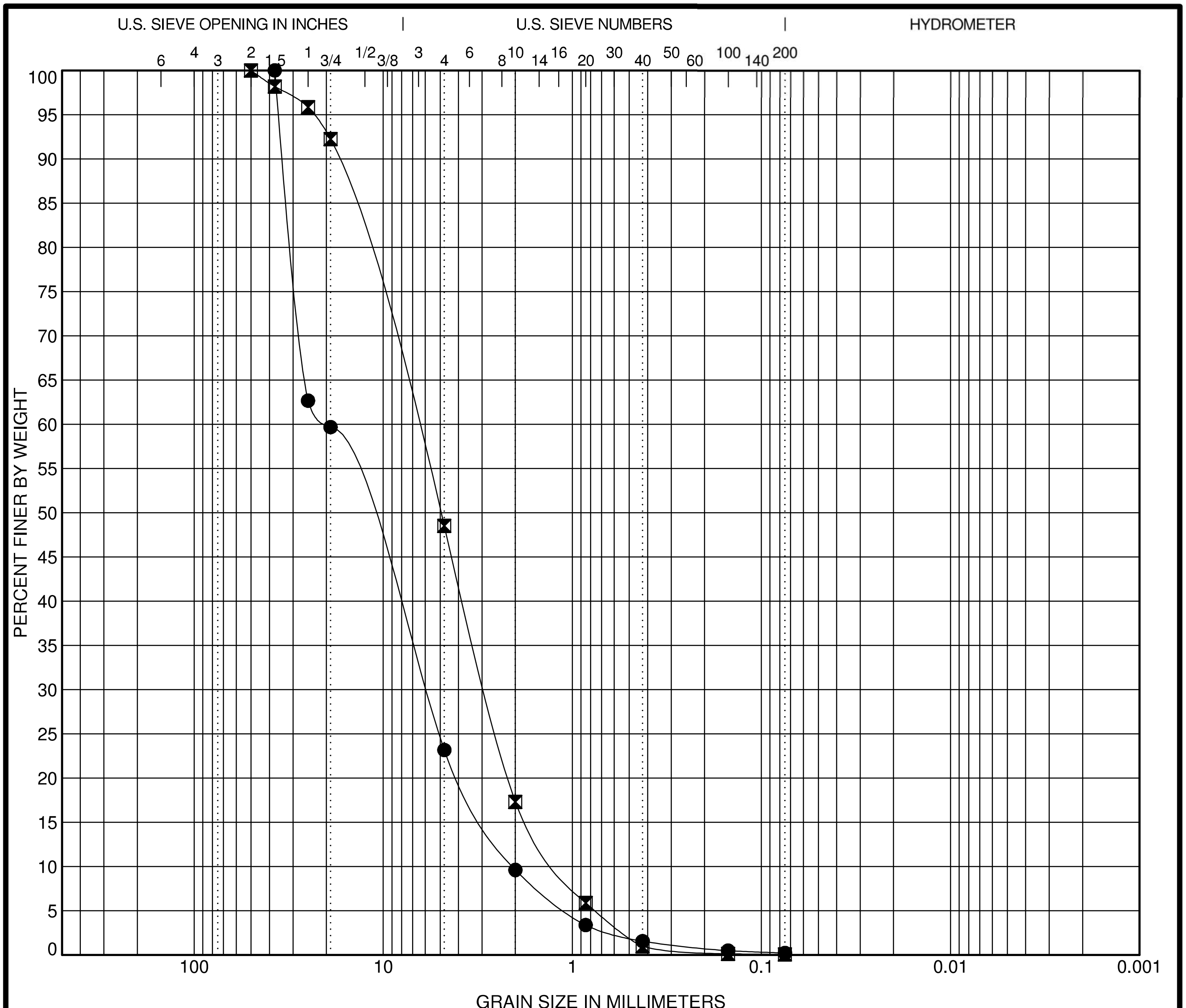
W.O. 8271-00

ATTERBERG LIMITS TEST RESULTS - ASTM D4318

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

Plate
B - 1

G ATTERBERG PI-100 LL-120 8271-00.GPJ GEOLABS.GDT 6/17/22



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-1	12.0-14.0	Dark gray to black sandy gravel (GP)				0.9	9.5
⊠	Bulk-1	0.0-1.0	Dark gray to black sandy gravel (GW)	NP	NP	NP	1.0	5.9

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-1	12.0-14.0	37.5	19.577	6.158	2.051	76.8	22.9	0.2
⊠	Bulk-1	0.0-1.0	50	6.838	2.844	1.158	51.5	48.5	0.0

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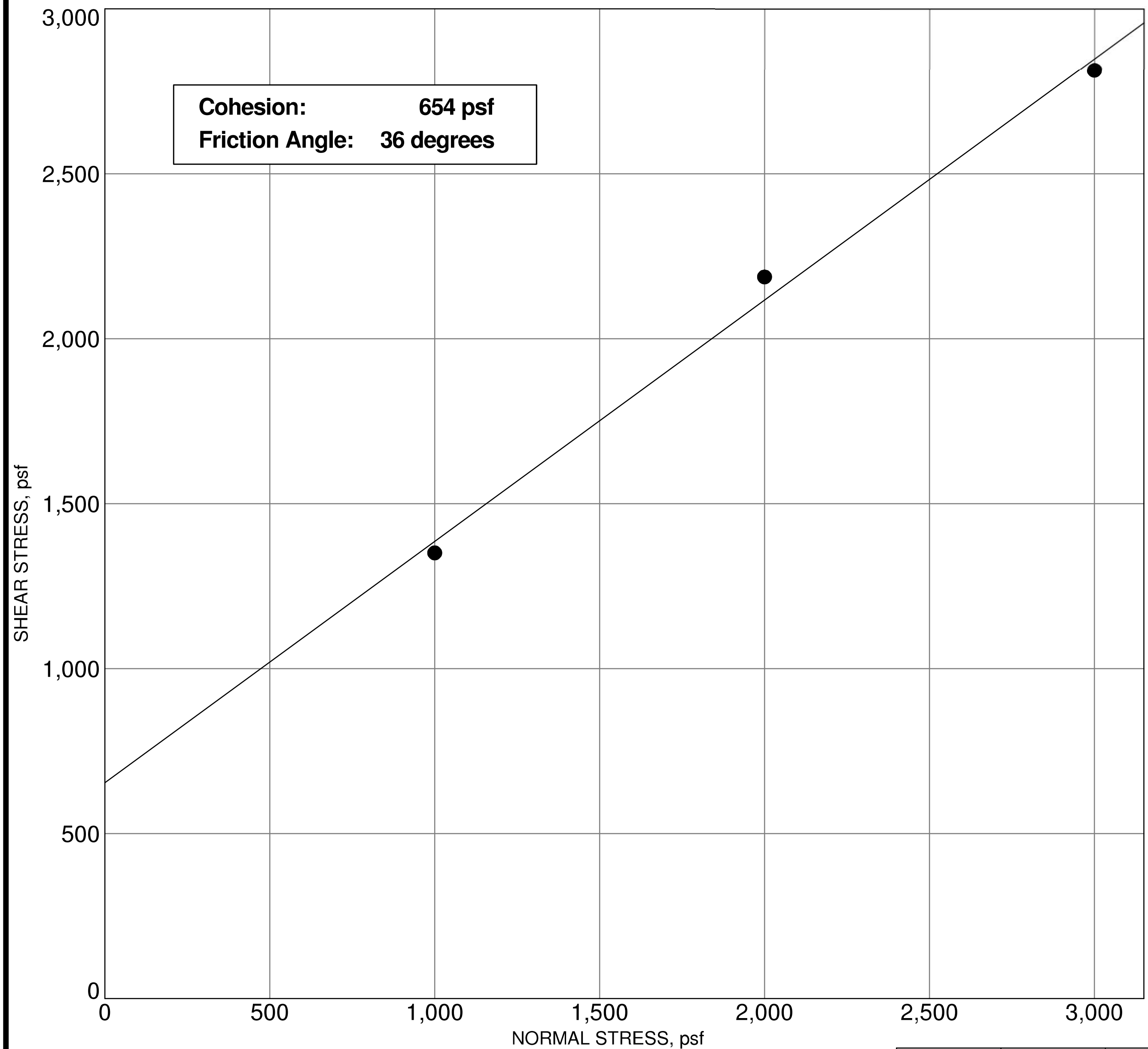
GRAIN SIZE DISTRIBUTION - ASTM D6913

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

Plate
B - 2

G_GRAIN_SIZE_MOD 8271-00.GPJ GEOLABS.GDT 7/7/22



		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	7.7	13.3	8.8
	Dry Density, pcf	94.3	91.9	96.1
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	21.2	19.8	19.7
	Dry Density, pcf	91.9	93.7	96.1
	Height, inches	1.027	0.980	1.000
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0024	0.0021	0.0023
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1351**	**2187**	**2814**
	Shear Displacement, inches	0.43	0.41	0.41

Sample: B-1
Depth: 2.0 - 3.5 feet
Description: Dark gray to black sandy gravel with some cobbles

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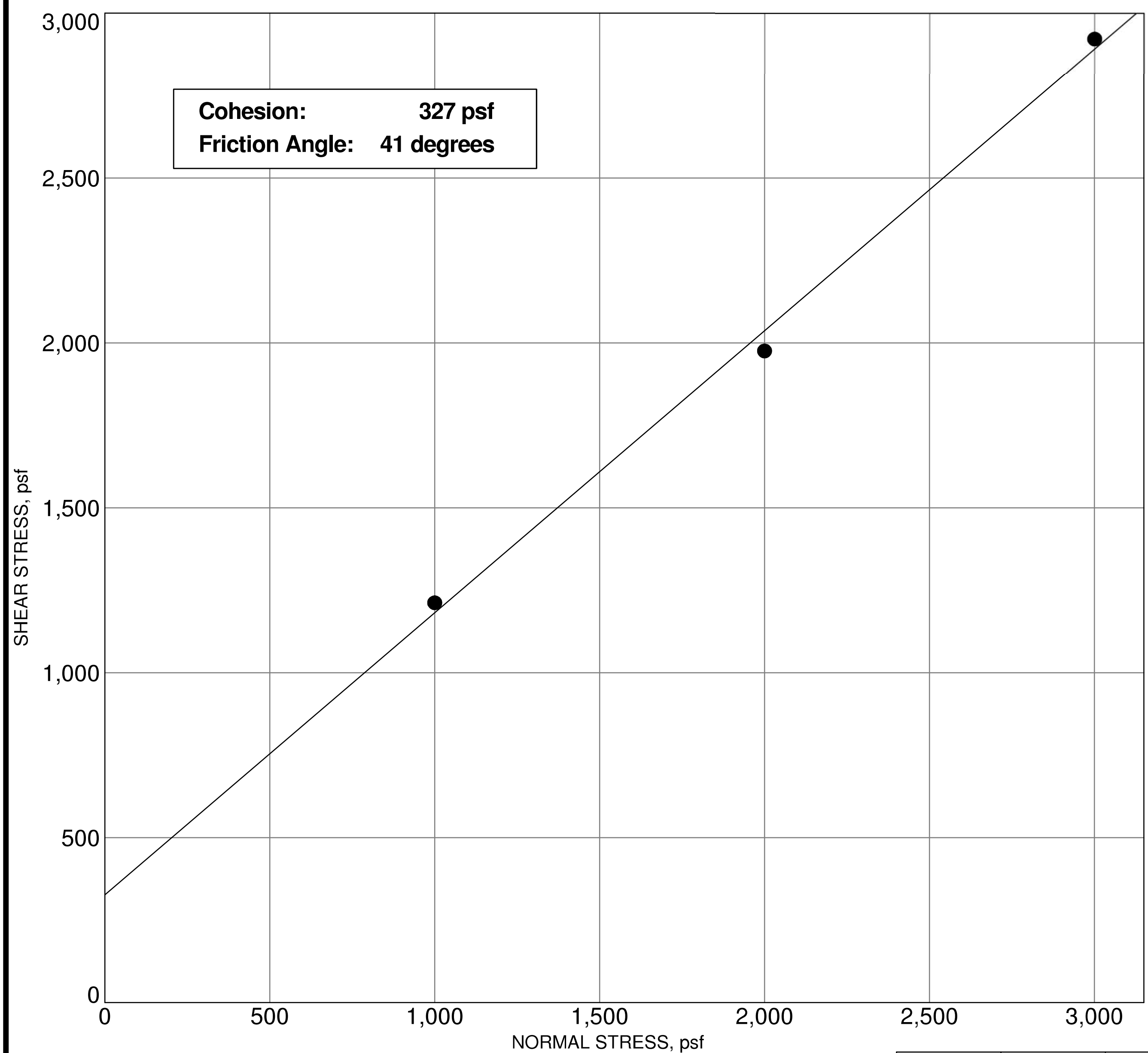
W.O. 8271-00

DIRECT SHEAR TEST - ASTM D3080

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

Plate
B - 3



Sample: B-1
Depth: 5.5 - 7.0 feet
Description: Dark gray sandy gravel with some cobbles

		Sample #1	Sample #2	Sample #3
INITIAL	Moisture Content, %	9.1	9.9	12.2
	Dry Density, pcf	104.3	105.1	105.8
	Height, inches	1.00	1.00	1.00
FINAL	Moisture Content, %	18.7	17.6	16.9
	Dry Density, pcf	101.0	105.6	106.0
	Height, inches	1.033	0.995	0.998
	Diameter, inches	2.42	2.42	2.42
	Deformation Rate, inch/minute	0.0024	0.0020	0.0023
	Normal Stress, psf	**1000**	**2000**	**3000**
	Peak Shear Stress, psf	**1212**	**1976**	**2922**
	Shear Displacement, inches	0.43	0.40	0.41

G DIRECT SHEAR 8271-00.GPJ GEOLABS.GDT 6/17/22

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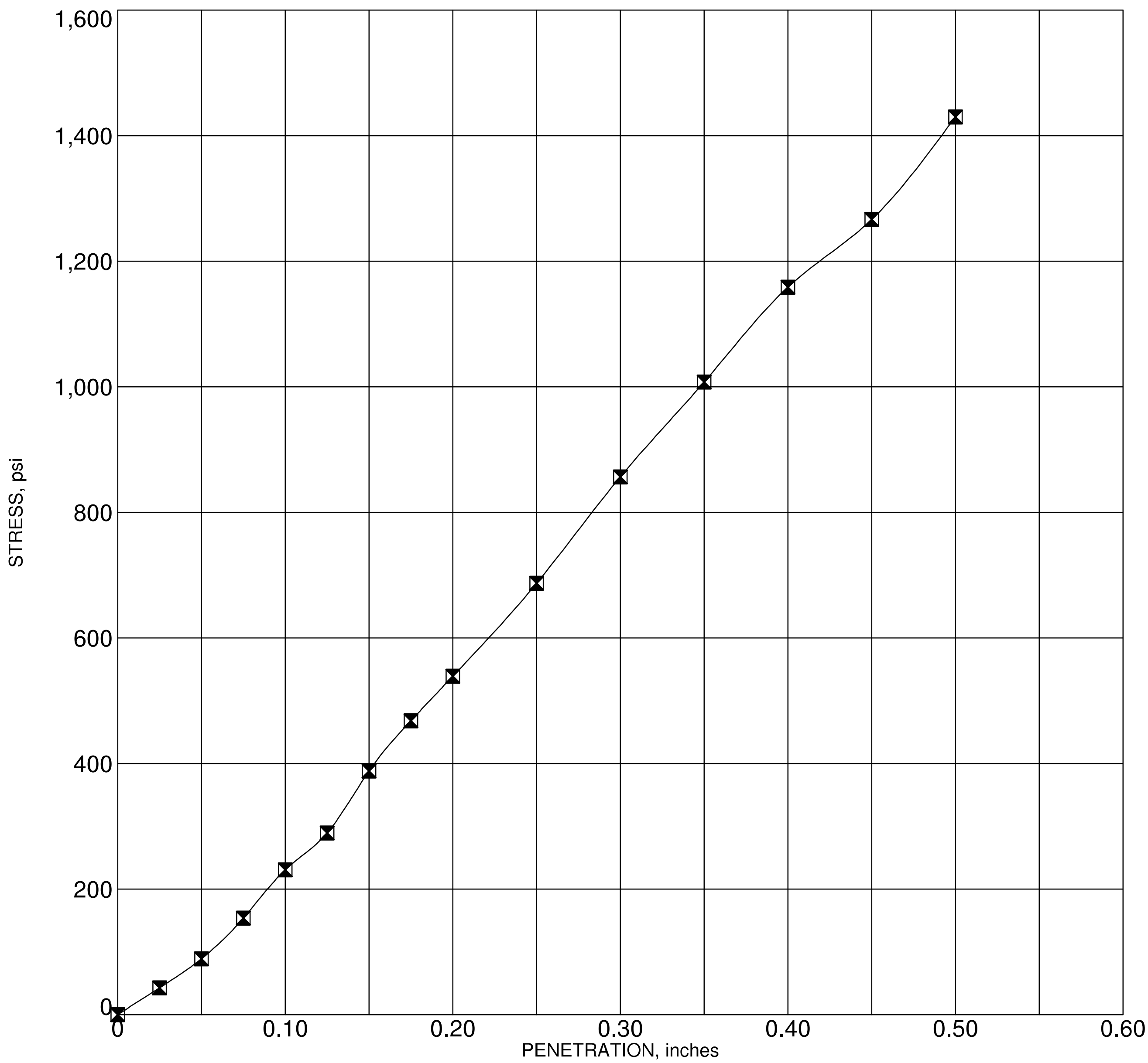
W.O. 8271-00

DIRECT SHEAR TEST - ASTM D3080

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

Plate
B - 4



Corr. CBR @ 0.1"	26.7
Corr. CBR @ 0.2"	39.0
Swell (%)	0.00

Sample: Bulk-1
Depth: 0.0 - 1.0 feet
Description: Dark gray to black sandy gravel (NP)

Molding Dry Density (pcf)	117.3	Hammer Wt. (lbs)	10
Molding Moisture (%)	1.3	Hammer Drop (inches)	18
Days Soaked	4	No. of Blows	56
Aggregate	3/4 inch minus	No. of Layers	5

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CALIFORNIA BEARING RATIO - ASTM D1883

POHOIKI BOAT RAMP MAINTENANCE DREDGING
PUNA DISTRICT, ISLAND OF HAWAII

Plate
B - 5

SAND EQUIVALENT VALUE OF SOILS AND FINE AGGREGATE ASTM D 2419

W.O. 8271-00 PROJECT: Pohoiki Boat Ramp Maintenance Dredging

DATE TESTED: 6/3/22 BY: SA
SAMPLE: Bulk-1 Engineer: GS

SOIL DESCRIPTION: Dark gray to black sandy gravel

SEDIMENTATION TIME: 20 MINUTES

SAND EQUIVALENT = SAND READING / CLAY READING X 100

SAND READING	CLAY READING	SAND EQUIVALENT
3.6	0.0	100
3.8	0.0	100
3.9	0.0	100
	AVERAGE SAND EQUIVALENT	**100**

APPENDIX C

B-1 7.0' TO 27.0'

7.0'

27.0'