GEOTECHNICAL ENGINEERING EXPLORATION
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

JANUARY 22, 2003

Prepared for

R.M. TOWILL CORPORATION

and

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

W.O. 4850-00(B)

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GEOLABS, INC.

Geotechnical Engineering and Drilling Services

January 22, 2003
W.O. 4850-00(B)

Mr. Greg Hiyakumoto
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Dear **Mr. Hiyakumoto:**

Geolabs, Inc. is pleased to submit our report entitled "Geotechnical Engineering Exploration, Interstate Route H-1 Widening, Waimalu Viaduct Westbound, Pearl City Off-Ramp to Kaonohi Street, Pearl City to Aiea, Oahu, Hawaii" prepared for the design of the highway widening project.

Our work was performed in general accordance with the scope of services outlined in our fee proposal, dated October 19, 2001.

Detailed discussion and specific recommendations for design of the project are contained in the body of the report. If there is any point that is not clear, please contact our office.

Very truly yours,

GEOLABS, INC.

Robin M. Lim P.E.
Vice President

RML:JC:as

(h:\4800 Series\4850-00B.jc2.pg2)

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GEOTECHNICAL ENGINEERING EXPLORATION

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

Based on our field exploration and review of the site history, the Interstate Route H-1 Widening, Waimalu Viaduct Westbound project site is generally underlain by highly variable and complex subsurface conditions. Our field exploration at the viaduct bridge site generally encountered a surface fill layer placed over soft to medium stiff recent alluvium and stiff to hard old alluvium. It should be noted that dense to very dense layers of conglomerate (mixture of cobbles and boulders in a cemented soil matrix) of about 7 to 15 feet thick were encountered in our borings drilled near the boundary of the recent alluvium and old alluvium. Below the alluvial soil layers, our borings encountered weathered basalt formation. It should be noted that the soft recent alluvium encountered at the project site appears to be under-consolidated based on our laboratory consolidation tests. Groundwater was encountered in the borings at depths of about 8 to 64 feet below the existing ground surface during our field exploration. The measured groundwater levels generally correspond to about Elevations +1 to +16 feet MSL.

Based on subsurface conditions encountered in the borings and the structural load demands of the bridge structure, we recommend that the new bridge structure be supported by a deep foundation system. Because of the complex subsurface conditions encountered at the site and other construction considerations, we recommend that the new bridge structure be supported on a combination of 4-foot and 5-foot diameter cast-in-place concrete drilled shaft foundations. Because of the competent subsurface conditions encountered at the eastern portion of the new bridge structure, Bent 11 may be supported on a shallow foundation system consisting of spread footings. In general, the drilled shafts for the new bridge structure should extend to depths of about 46 to 119 feet below the bottom of footing elevations in order to achieve the design load capacities. The ultimate compressive load capacities of the drilled shaft foundations are on the order of about 1,530 to 3,100 kips per drilled shaft.

Considering the diameters and structural load capacities of the drilled shafts, we recommend that a trial shaft and load test program be implemented for this project. The trial shaft program should consist of drilling and installing one 5-foot diameter trial shaft near Bent 9 of the new bridge footing. The trial shaft should be extended to a minimum depth of about 130 feet below the ground level. In addition, we recommend that two bi-directional static load tests be conducted for the project (near Bent 2 and Bent 6).

The subsurface conditions underlying the approach fills leading to the Waimalu Viaduct structure (on the west side) are highly variable and just as complex. In general, the approach fill site consists of embankment fills placed over soft recent alluvium and/or weathered basalt formation. The maximum thickness of soft soils encountered in the recent borings is about 44 feet. Based on our laboratory consolidation tests, the relatively thick layer of soft recent alluvium encountered at the site appears to be under-consolidated. Based on our evaluation of the laboratory consolidation tests, the soft recent alluvium layer appears to have achieved about 60 to 80 percent consolidation. However, continuing settlements on the order of about 12 inches may be expected to occur over time and in the future. To stabilize the on-going settlements of the under-consolidated recent alluvium and to reduce the potential for significant ground settlement in the future, we recommend that the under-consolidated recent alluvium below the highway embankment be stabilized by jet-grouting methods. In general, the tips of the jet-grouted columns should be extended until the stiff/dense materials are encountered at each jet-grouted column location.

Based on our analyses, we recommend that the soil stabilization consist of 3-foot diameter jet-grouted columns. The jet-grouted columns should be spaced at about 6 feet on-center in a triangular grid pattern. Based on the recommended configuration, each of the jet-grouted columns would need to be able to support approximately 100 kips of load (weight of the embankment fill above the jet-grouted column). As a minimum, we recommend that the grout mix have a specific gravity of at least 1.6 and should be able to produce jet-grouted columns with a 7-day unconfined compressive strength of at least 200 psi and a 28-day unconfined compressive strength of at least 400 psi.

Our field exploration at the retaining wall (retaining a cut condition) site generally encountered a surface fill layer over residual soils and weathered basalt formation. Based on the generally competent subsurface conditions at the site, we believe that the retaining walls should consist of soil nail retaining walls. In general, we recommend that an average bond stress of 1,000 psf and 2,500 psf be used for the on-site clayey silt soils and the basalt rock formation, respectively. In addition, we recommend that the lengths of the soil nails range from about 120 to 190 percent of the height of the wall. It should be noted that the soil nail reinforcing bars should consist of a fully encapsulated double corrosion protection system.

We anticipate that segmental retaining wall systems will be installed on the west side of the existing viaduct structure near the existing three 162-inch diameter drainage culverts and at other locations to provide for grade separation. In general, we recommend that an ultimate bearing capacity of up to 10,000 psf be used to evaluate the foundations bearing on the on-site clayey silts and/or compacted aggregate subbase based on an extreme event limit state. To evaluate the strength limit state and service limit state of the foundations, bearing pressures of up to 6,000 and 3,000 psf, respectively, may be used. In general, the retaining wall foundations should be embedded a minimum of 24 inches below the lowest adjacent finished grade.

We anticipate that steepened slopes retaining a fill condition would be required for grade separation on the west side of the existing viaduct structure. In general, we believe that steepened fill slopes may be designed with slope inclinations up to one horizontal to one vertical (1H:1V) provided that the earth materials are reinforced with geogrids (or geotextiles) to strengthen the fill soils. Due to the limited space for placement of long reinforcing elements, we recommend that imported select granular fill soils be used for the reinforced earth fill embankment. We also recommend that erosion control matting be used for erosion control of the steepened slope faces.

Due to the highway widening at the Austin Bishop Separation structure, we recommend that a permanent tieback anchor system be used to provide the lateral restraint for the proposed widening project and to underpin the existing north abutment footing of the Austin Bishop Separation structure. The permanent tieback anchor system will consist of the installation of two rows of tiebacks (top and bottom) and should be post tensioned to counteract the active lateral forces acting on the existing abutment structure.

We anticipate that noise barrier walls will be constructed near the edge of the State right-of-way adjacent to private properties or on the cut slopes on the north (mauka) side of the highway. In general, we recommend that the noise barrier walls be supported on 24-inch diameter cast-in-place concrete drilled shafts to resist the relatively high loading and to accommodate the limited space for a wide footing at the top of the slope. The drilled shafts would provide the necessary support for vertical and lateral loads imposed on the noise barrier wall foundations.

The text of this report should be referred to for detailed discussion and specific recommendations for design of the highway and viaduct widening project.

END OF SUMMARY OF FINDINGS AND RECOMMENDATIONS

SECTION 1.0 - GENERAL

1.1 Introduction

This report presents the results of our geotechnical engineering exploration and engineering analyses performed for the proposed Interstate Route H-1 Widening, Waimalu Viaduct Westbound project in the Pearl City to Aiea area on the Island of Oahu, Hawaii. The general location and vicinity of the project site are shown on the Project Location Map, Plate 1.

This report summarizes the findings and geotechnical recommendations based on our field exploration, laboratory testing, and engineering analyses performed for the proposed highway and viaduct widening project. The recommendations presented in this report are intended for the design of foundations, soil stabilization, retaining structures (including specialty retaining structures), site grading, and pavements 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 consists of widening the westbound lane of the existing Interstate Route H-1 Highway from the Pearl City Off-Ramp to the Kaonohi Street Overpass located from Pearl City to Aiea on the Island of Oahu, Hawaii. A general site plan showing an overview of the project site is presented on Plate 2 for ease of reference. Based on the available information, we understand that it is proposed to widen the existing westbound lanes of the highway by another 30 feet to accommodate a sixth traffic-lane, wider existing traffic lanes, and a new shoulder lane in the westbound direction, as shown on the Site Plans, Plates 3.1 through 3.6.

The highway widening project will require construction of a new bridge viaduct structure and numerous retaining walls for grade separation. The existing bridge viaduct structure consists of 12 spans (each span measuring approximately 100 feet) from the west to the east. Each bent of the existing viaduct structure is supported by four columns with four individual footings. Each of the existing structure footings is generally supported by about 35 or 50 driven piles (depending on location). The farthest east bent footings (Bent No. 11) and the east abutment footing consist of spread footings bearing on the weathered basalt rock in the area. Widening of the existing westbound viaduct structure will consist of a 30-foot wide bridge viaduct structure with new foundations. Due to the long linear feature of the viaduct structure, the new bridge structure will be structurally connected to the existing viaduct structure. We understand that the new bridge structure (and other structures for the project) will be designed based on Load and Resistance Factor Design (LRFD) methods.

Numerous retaining walls will be required for grade separation on the north (mauka) side of the highway. Retaining walls retaining a cut condition are anticipated for approximately 800 lineal feet on the west side of the existing viaduct structure on both sides (east and west) of the existing Austin Bishop Separation structure. Considering the generally competent subsurface conditions at these locations and the generally cut condition of the retaining walls, we anticipate that these walls will likely consist of soil nail retaining walls.

The existing Austin Bishop Separation structure is a two-span bridge over-crossing the Interstate Route H-l Highway from north to south. The bridge structure is founded on a shallow foundation system. The new retaining wall abutting the northern (mauka) edge of the highway under the Austin Bishop Separation structure will truncate a portion of the existing north abutment footing of the Austin Bishop Separation structure. Based on the information provided, the bottom of the excavation for the construction of the retaining wall will be about 6 feet below the bottom of the existing north abutment footing. Therefore, we believe that shoring of the excavation and underpinning of the existing north abutment footing will be necessary.

On the west side of the existing viaduct structure, we anticipate that retaining walls and/or steepened slopes with geotextile reinforcing retaining a fill condition will be required for grade separation along approximately a 700 to 800-foot section of the highway. The subsurface conditions in this area include about 20 to 40 feet of embankment fills placed for the initial highway construction overlying deep soft soil conditions. The soft soils in this area extend to depths of about 50 to 100 feet below the ground surface (highway pavement grade). Due to the soft subsurface conditions in this area, we believe that the use of mechanically stabilized earth (MSE) retaining walls (segmental retaining walls) or steepened slopes reinforced with geotextiles would be appropriate considering the poor subsurface conditions in this area.

On the east side of the existing viaduct structure, we anticipate that retaining walls retaining a cut condition will be required for grade separation from about the east abutment of the new bridge structure to the Kaonohi Street Overpass. Considering the generally competent subsurface conditions at these locations and the generally cut condition of the retaining walls, we anticipate that these walls also will consist of soil nail retaining walls and/or conventional concrete retaining walls.

We understand that the approach fills on the west side of the existing viaduct structure has undergone substantial ground settlement, and some distress has been observed in the pavements on the highway. Based on our review of the as-built plans of this area (about Station 103+00 to about Station 111+00), we understand that sand drains were installed and pre-loading of the fill embankments was implemented during the highway construction in the late 1960s, as shown on Plate 4 (Original Ground Features). We understand that appreciable ground settlements have occurred along this portion of the highway (after the initial highway construction). In addition, it appears that continued settlement of the existing embankment at a slower settlement rate under the present conditions is likely.

Based on the history in this area, we anticipate that significant consolidation settlement of the new embankment placed over the compressible soils will occur for the new highway widening. Therefore, we anticipate that the extensive soft soils underlying the new highway embankment (widened portion) on the west side of the existing viaduct will need to be stabilized using jet-grouting methods to significantly reduce and/or arrest the settlements of the new embankment in this area.

We understand that approximately 1,400 lineal feet of noise barrier walls (NBW) distributed into two areas on the north (mauka) side of the highway will be constructed as part of the project. Based on the available information, we understand that the noise barrier walls will be constructed at the edge of the State right-of-way adjacent to private properties or on the cut slopes on the north (mauka) side of the highway. Based on current design concept, we understand that the noise barrier walls will be supported on cast-in-place concrete drilled shafts due to the relatively high loading requirements and the limited space for large continuous footings along the top of slope.

Because the new bridge structure will be structurally connected to the existing viaduct structure, one of the significant geotechnical engineering efforts on this project consists of the seismic analysis of the existing bridge viaduct structure foundations. We understand that higher order analysis will be conducted for the seismic retrofit of this bridge viaduct structure. Therefore, substantial efforts were focused on evaluating the subsurface soil conditions based on the available boring information performed during the initial bridge design in the late 1960s and providing the parameters for stiffness modeling of the existing foundations in support of the structural engineer.

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 project site. The subsurface information obtained was utilized to develop a generalized soil/rock data set for the formulation of geotechnical engineering recommendations pertaining to the design of foundations, soil stabilization, retaining structures (including specialty retaining structures), site grading, and pavements for the highway and viaduct widening project and seismic retrofit of the existing viaduct structure. In order to accomplish this, we conducted an exploration program generally consisting of the following tasks and work efforts:

1. Review of available in-house soil and geologic information around the project location. Research and review of available technical reports and available as-built plans from the Materials Research and Testing Laboratory for subsurface information. Available boring logs and laboratory test information performed during the initial bridge design were obtained and evaluated for use in our study. The characteristics of the subsurface

materials were used to evaluate and estimate the modeling parameters for this study.

2. Application of the necessary excavation permits from the City and County of Honolulu and State of Hawaii – Department of Transportation, Highways Division prior to drill crew mobilization (including preparation of a traffic control plan).

3. Coordination of the utility toning with the various utility companies and clearance of the proposed boring locations from underground utilities.

4. Provision of traffic control at the proposed boring locations during our field exploration program.

5. Mobilization and demobilization of truck-mounted drilling equipment, portable drilling equipment, water truck, and operators to the project site and back.

6. Drilling and sampling of 59 borings extending to depths ranging from about 5 to 161 feet below the existing ground level for a total of about 2,936 lineal feet of exploration. Detailed information pertaining to the boring locations are provided in Tables A-1.1 and A-1.2 of Appendix A. The drilled borings generally were distributed as follows:

   - Thirteen borings extending to depths of about 76 to 161 feet below the existing ground surface were drilled at or near the 11 bents and two abutments of the new bridge location.

   - Six borings extending to depths of about 31 to 50 feet below the ground surface were drilled for design of the new retaining walls retaining a cut condition. It should be noted that four of the borings were drilled using portable drilling equipment mounted on a fabricated platform constructed on the sloping ground.

   - Two borings extending to depths of about 45 and 65 feet below the ground level were drilled in support of the design of the underpinning of the Austin Bishop Separation structure. The two borings were used to develop foundation recommendations for the Austin Bishop Separation structure in support of the underpinning of the structure due to the highway widening at this location.

   - Six borings extending to depths of about 45 to 100 feet below the ground surface were drilled for the retaining walls retaining a fill condition. These borings were also used in support of the design of the Deep Soil Stabilization in the area. In addition, three boreholes were drilled to install two open standpipe piezometers in each boring to measure the excess pore water pressures in the soft soils induced by the load of the existing embankment fill.

- Two borings extending to depths of about 65 to 100 feet below the ground surface were drilled from the eastbound lanes of the highway located on the west side of the viaduct structure to evaluate the settlement of the approach fills.

- Four borings extending to depths of about 34 to 37 feet below the ground level were drilled in support of the design of the proposed noise barrier walls.

- Twenty six shallow core borings extending to depths of about 5 feet below the existing pavement surface were drilled on the west side of the viaduct structure for pavement design and evaluation of settlement in the area.

7. Coordination of the field exploration and logging of the borings by a field engineer or a geologist from our firm.

8. Laboratory testing of selected soil/rock samples obtained during the field exploration as an aid in classifying the materials encountered and evaluating their engineering properties.

9. Compiling and summarizing the information obtained from our research and review and from the field exploration for use in the modeling of the existing foundations for the bridges. The subsurface information was evaluated and soil parameters were estimated based on the available information and laboratory testing performed for the project.

10. Perform engineering analyses to provide stiffness modeling parameters of the existing pile foundations for the existing footings. In addition, ultimate bearing values and lateral load resistance values for shallow foundations were evaluated for the existing viaduct structure.

11. Perform additional engineering analyses to incorporate the retrofitted scheme into the substructure, as deemed appropriate by the structural engineer.

12. Analyses of the field and laboratory data to develop geotechnical recommendations pertaining to the design of the highway widening project. Geotechnical engineering analyses and recommendations include seismic considerations, bridge foundations, soil nail retaining wall, reinforced soil slope, static and seismic slope stability analyses, settlement analyses, earthwork, pavements, and construction considerations.

13. Preparation of a formal report summarizing our work on the project and presenting our findings and geotechnical engineering recommendations.

14. Coordination of our work on the project by a project engineer from our firm.

15. Quality assurance of our overall work on the project and client/design team consultation by a principal engineer from our firm.

16. Miscellaneous work efforts such as drafting, word processing, clerical support, and reproductions.

Detailed descriptions of our field exploration methodology and the logs of borings are presented in Appendix A of this report. Results of the laboratory tests performed on selected soil samples are presented in Appendix B.

END OF GENERAL

SECTION 2.0 – SITE CHARACTERIZATION

2.1 Regional Geology

The Island of Oahu was built by the extrusion of basaltic lavas from two main shield volcanoes, Waianae and Koolau. The older shield volcano (Waianae Volcano) is estimated to be middle to late Pliocene in age and forms the bulk of the western third of the island. The younger shield volcano (Koolau Volcano) is estimated to be late Pliocene to early Pleistocene (Ice Age) in age and forms the majority of the eastern two-thirds of the island. The Waianae Volcano became extinct while the Koolau Volcano remained active. Therefore, the older Waianae Volcano's eastern flank was partially buried below the younger Koolau Volcano lavas that banked against the Waianae's eastern flank. These banked and ponded lava flows formed a broad upland plateau referred to as the Schofield Plateau of Central Oahu.

During the evolutionary history of the Island of Oahu, fluctuation of the ocean sea level occurred as a result of the worldwide advance and retreat of the great continental glaciers. These sea-level changes occurred more substantially during the Pleistocene Epoch and had some effect on the geologic evolution of the Island of Oahu. The changes in worldwide sea levels affected the erosional baseline of terrestrial streams and caused local submergence and emergence of the coastal island landforms with respect to the level of the sea.

The project site is located along the distal southern flank of the Koolau Volcano as shown on the Project Location Map, Plate 1. The project site traverses a localized portion of an extensive region of multiple southwest trending streams that drain from the Koolau summit. A widened area of stream confluence is located at Waimalu Gulch, which is traversed by the existing Interstate Route H-1 Highway and Waimalu Viaduct.

The stream confluence located in the Waimalu Gulch area formed the widened gulch, which drains into the East Loch of Pearl Harbor (located about 0.75 miles toward the south of the project site). Waimalu Gulch was formed by stream incision on the southern flank of the Koolau Volcano and mass wasting erosion of the valley walls. The portion of Waimalu Gulch within the project site appears to have been affected by Pleistocene Epoch sea level changes, which alternatively submerged and emerged the gulch floor, changing the base level condition of stream erosion. Therefore, the gulch floor contains some geologic deposits that are representative of both shallow marine and terrestrial origin as evidenced by the presence of some organic-rich alluvial sediments that contain sea-shell fragments.

The project site also traverses some hilly terrain that is underlain by weathered volcanic deposits, which were erupted from the Koolau Volcano. The volcanic deposits have been mapped previously and are referred to as the Tertiary Period Koolau Volcanic Series (H.T. Stearns). The thick volcanic deposits consist of mainly thinly-bedded, sequential layers of basaltic lava flows consisting of hard basalt rock and clinker. Much of the near-surface basaltic rock is extremely weathered and has been reduced to clayey and silty saprolitic materials containing decomposed rock fragments.

In general, the near-surface saprolitic materials, which comprise the elevated terrain at the project site, typically grade with increasing depth to less-weathered basaltic rock materials. Therefore, the description and identification of the saprolitic deposits is grouped with the broader category referred to as "basalt formation" in this report. Examples of these gradational saprolitic and highly weathered rock deposits (basalt formation) are visible in the existing hillside cut slopes located in the vicinity of the project site. However, the saprolitic materials and weathered basalt rock are buried beneath the thick alluvial deposits from about Station 104+00 to about Station 109+00 and from about Station 111+00 to about Station 123+00 (Waimalu Gulch).

Based on the subsurface exploration conducted at the project site, the Waimalu Gulch floor is underlain by a substantial thickness of variable alluvial materials, which were deposited over long periods of time. The deposition of the alluvial deposits is associated with the meandering streams that once dissected the gulch floor. Based on the elevation of the gulch floor and the close proximity to the existing estuaries of Pearl Harbor, it is likely that portions of the gulch were partially submerged and soft alluvial sediments with organic materials and marine shells were deposited in a shallow marine or estuarine environment during higher stands of the sea.

2.2 Background and Land Use Considerations

In addition to the geology of the Waimalu Gulch area described in the previous section, some past agricultural land uses may have contributed to the soft soil conditions encountered at portions of Waimalu Gulch. Based on a review of available historical information for Waimalu Gulch, it appears that there were networks of agricultural ditches, which were utilized for irrigation purposes, as shown on Plate 4.

The agricultural ditch features may have contributed to some of the soft, near-surface ground conditions encountered at the site. The ditches may be responsible for the deposition of additional localized soft alluvial and fill soils on the gulch floor. Furthermore, the quality of the ditch backfill is questionable and may be undocumented. The extensive soft alluvial materials, which were deposited by the long-term migration of streams flowing across the gulch floor, have created subsurface conditions that are subject to soil consolidation and ground settlement. These thick soft ground conditions were encountered by previous test borings performed for the original design of the Interstate Route H-1 Highway.

Based on a review of the available plans for the Waimalu Viaduct and adjacent sections of the Interstate Route H-1 Highway, which were constructed in the late 1960s through early 1970s, we understand that some localized surcharge fills and sand drains were constructed during the incremental construction phasing of the Interstate Route H-1 Highway. The embankment fills and surcharge fills placed were on the order of about 40 to 50 feet in vertical height. The approximate areas of the surcharge fill are presented on the Original Ground Features, Plate 4.

The temporary surcharge load was placed in an effort to induce ground settlement and consolidation of the soft alluvial soils to an acceptable level prior to the construction of surface improvements at the site. In addition to the surcharge fill load, some vertical sand drains were constructed in an effort to increase the surcharge settlement rate (speed the surcharge process) by dissipating the pore water pressure in the subsurface soils located beneath the embankment and surcharge fills. The dissipation of the pore water pressure helps to accelerate the consolidation of the soft alluvial soils under the load of the permanent embankment fill and surcharge fill.

Following construction of the Interstate Route H-1 Highway at Waimalu, some ground settlement of the embankments occurred that caused distress to the highway pavements. It is believed that some additional settlement is occurring at the site evidenced by continued pavement distress. Several layers of asphaltic concrete overlays (as much as 5 inches or possibly thicker overlays) have been placed over the concrete pavements of the highway in this area in an effort to restore the grades of the highway pavements.

2.3 Site Description

The general location of the project site is along the Interstate Route H-1 Highway between Pearl City and Aiea in the District of Ewa on the Island of Oahu, Hawaii, as shown on the Project Location Map, Plate 1. The project limits extend from about 1,000 feet west of the existing Waiau Interchange located at about Station 73+00 (western terminus) to about 400 feet east of the existing Kaonohi Street Overpass located at about Station 139+50 (eastern limit of the project), as shown on the General Site Plan, Plate 2. The project site is bounded by the estuaries of Pearl Harbor, which are located toward the south, and by the ridges and valleys of the Koolau Mountain Range located toward the north.

In general, the Interstate Route H-1 Highway within the project limits consists of both on-grade and elevated viaduct sections surfaced with Portland Cement Concrete (PCC) pavement. The Interstate Route H-1 Highway within the project limits generally consists of five to six outbound travel lanes and five inbound travel lanes separated by a concrete median barrier. Both metal guardrails and concrete barriers, depending on the location, bound the outside shoulders of the highway.

Along the westbound segment of the Interstate Route H-1 Highway (within the project limits), there is one existing highway off-ramp for the Pearl City and Waimalu exit located near the western end of the project. This off-ramp is located easterly of the Waiau Interchange, which comprises the western limit of the project site. There are also two existing overpasses traversing the Interstate Route H-1 Highway within the project. The existing highway overpasses include the Kaahumanu Street Overpass, also known as the Austin-Bishop Separation Structure, located toward the western end of the project site and the Kaonohi Street Overpass, which is located at the eastern limit of the project.

In general, traveling eastbound from the western limit of the project site, the Interstate Route H-1 Highway passes through gently rising and falling terrain consisting of some cut slopes and fill embankments from about Station 80+00 through about Station 103+00. The Interstate Route H-1 Highway then traverses a wide lowland gulch via embankment fills and the Waimalu Viaduct from about Station 103+00 through about Station 123+00. From about Station 123+00 through Station 139+00, the Interstate Route H-1 Highway rises in elevation traversing mostly cut conditions toward the eastern limit of the project site.

From about Station 103+00 through about Station 123+00, the Interstate Route H-1 Highway is bounded by the Newtown Driving Range and residential areas to the north (mauka) and by commercial areas, Moanalua Road and Waimalu Elementary School to the south (makai). Two existing streets (Kaahele and Pono Streets) and a concrete open drainage channel traverse below the viaduct of the Interstate Route H-1 Highway.

2.4 Geologic Terms

Based on our evaluation of the geologic information obtained from the subsurface exploration and to facilitate discussion of the geologic materials encountered at the site, we have classified the materials encountered into idealized categories of earth materials and are used in the logs of borings presented in Appendix A. The idealized categories of earth materials are as follows:

- Fill Materials
- Recent Alluvium

- Conglomerate
- Old Alluvium
- Basalt Formation

2.4.1 Fill Materials

This geologic material category includes man-made earth fills that are generally encountered as surface soil deposits in developed areas. The various fill materials encountered at the project site generally range from unconsolidated deposits of stiff clays and silts to medium dense sands and gravel. The fills may have been placed as controlled fill during site grading or as undocumented deposits of stockpile or backfill. It should be noted that occasional large-sized man-made debris and/or rock fragments, such as cobbles and boulders, should be expected within the surface fill materials.

2.4.2 Recent Alluvium

This geologic material category generally consists of unconsolidated, soft to stiff gray, brown, and black-colored clays and silts with loose sands and gravel that were transported and deposited by the action of moving water (stream flow) during "Recent" geologic time. Recent alluvium may contain marsh deposits consisting of dark-colored organic clays, silts, and sands that were deposited in a shallow water or marsh environment. These deposits are typically very soft and compressible.

Recent alluvium may also contain peat and traces of relict shell or coralline material that is generally indicative of a shallow marine depositional environment. Recent alluvium may also contain some occasionally hard cobbles and boulders or decomposed rock fragments derived from erosion and transportation by stream flow. The rock fragments are typically rounded (or sub-rounded) in shape as a result of the abrasion experienced in the stream channel environment. The recent alluvium encountered at the project site typically represents buried stream channels, lagoons, and marsh depositional environments that are located mainly in valleys and other low-lying regions.

2.4.3 Conglomerate

This geologic material category generally consists of semi-consolidated to consolidated alluvial or colluvial deposits consisting of terrestrial gravel, cobbles, and boulders that may possess a matrix of finer grain sediments, such as stiff to hard clays and silts. The conglomerate materials encountered at the project site range in consistency from medium dense to very dense. Conglomerate generally contains coarse-grained clasts (cobbles, boulders, and other rock fragments) cemented within a fine-grained matrix and may resemble a soft to hard sedimentary rock upon excavation.

It is believed that the components of conglomerate have been derived from landslide activity or accumulations of rocky colluvial talus that was once positioned along the margins of the valley floor. Conglomerate is formed when poorly sorted alluvial and colluvial deposits become cemented by overburden pressure and the presence of a cementing agent, such as silica or calcium, which may be present in percolating groundwater. Conglomerate is generally encountered near the interface of the recent alluvium and the old alluvial deposits (old alluvium) at the project site.

2.4.4 Old Alluvium

This geologic material category generally consists of semi-consolidated alluvial deposits generally consisting of brown with multi-colored mottling, terrestrial, medium stiff to very stiff, clayey silts and clasts of highly weathered basalt rock fragments with some hard cobbles and boulders. The clasts of embedded highly weathered rock fragments generally are rounded in shape and resemble stream pebbles of varying geologic origin. These alluvial deposits are older in age and typically comprise the basement region of channel/valley infilling. The deposits differ from conglomerate in that the old alluvium deposits are more deeply weathered, less consolidated (softer), and contain fewer hard boulders and cobbles. Furthermore, most of the old alluvium materials encountered may be crushed and reduced to clayey silt with sand and gravel components.

2.4.5 Basalt Formation

This category of geologic material contains a broad range of volcanic basaltic rock and the in-situ weathered products including residual soils and saprolitic materials. The basalt rock and interbeds of clinker range from soft rock to very hard rock and are highly weathered to slightly weathered in character. Extremely weathered rock is referred to as saprolitic material and represents rock that has been reduced by weathering to soil-like components with decomposed rock fragments. However, the material retains the remnant rock texture such as layering, vesicularity, and some fracture patterns.

Saprolitic materials are commonly mottled in coloration and contain more sandy and gravelly components with zones of less weathered rock contained within. Completely weathered rock is referred to as a residual soil and has lost all visible rock texture characteristics. Residual soils are commonly composed of clayey and silty components of uniform coloration. Some relict boulders of hard rock may occasionally be encountered in residual soils.

2.5 Subsurface Conditions

The subsurface conditions at the new viaduct bridge structure site (from about Station 111+00 to Station 123+50) were explored by drilling and sampling 13 test borings at the abutment and pier locations, designated as Boring Nos. 1 through 13, as shown on the Site Plans (Plates 3.4 and 3.5). The 13 borings were advanced to depths of about 76 to 161 feet below the existing ground surface.

In general, the viaduct bridge site is underlain by surface fill over soft to stiff recent alluvium and stiff to hard old alluvium. The basalt formation encountered below the old alluvium ranged from extremely weathered to slightly weathered. Based on our laboratory consolidation tests, some of the soft recent alluvium deposits encountered at the site appear to be under-consolidated. A layer of dense to very dense conglomerate, consisting of cemented boulders, cobbles and gravel, was encountered near the boundary of the recent alluvium and old alluvium. The thickness of the conglomerate layer varied from approximately 7 to 15 feet. It should be noted that the conglomerate deposits were not encountered in Boring Nos. 1, 4 through 6, 12 and 13. It should also be noted that the old alluvium deposits extended to the maximum depths of Boring Nos. 4 and 5 without encountering weathered basalt formation. The anticipated subsurface conditions at the viaduct structure area are presented on the Idealized Subsurface Profile (Sta. 104+00 to Sta. 124+00), Plate 5. Groundwater was encountered in the borings drilled at the viaduct structure location at depths of about 8 to 64 feet below the existing ground surface during our field exploration. The measured groundwater levels generally correspond to about Elevations +1 to +16 feet Mean Sea Level (MSL).

The subsurface conditions in the area of the west side of the viaduct structure approach fill (from about Station 104+00 to Station 111+00) were explored by drilling and sampling six borings. The borings, designated as Boring Nos. 107 through 112, were drilled near the toe of the existing embankment on the westbound side of the Interstate Route H-1 Highway. Two borings, designated as Boring Nos. 136 and 137, were drilled in the shoulder lane on the eastbound side of the Interstate Route H-1 Highway, as shown on the Site Plan (Plate 3.3). The eight borings drilled in this area were advanced to depths of about 45 to 100 feet below the existing ground surface.

The subsurface conditions underlying the approach fills leading to the Waimalu Viaduct structure are highly variable and very complex. In general, the area of the approach fill is underlain by embankment fills placed over soft recent alluvium and/or weathered basalt formation. It should be noted that the soft recent alluvium was not encountered in Boring Nos. 111, 112 and 137. However, a substantial thickness of soft soils was encountered in Boring Nos. 107, 108, 109 and 136. The maximum thickness of soft soils encountered in the borings is 44 feet (Boring No. 136). In addition, borings drilled for the initial design of the highway also encountered the soft soils in some of the borings drilled in this area. The anticipated subsurface conditions at the approach fill area (westbound side of the highway) are presented on the Idealized Subsurface Profile Westbound (Sta. 104+00 to Sta. 112+00), Plate 6.

In addition, the anticipated subsurface conditions along the eastbound side of the highway in the approach fill area (based on compilation of borings drilled in 1960s for the initial highway design) are presented on the Idealized Subsurface Profile Eastbound (Sta. 104+00 to Sta. 112+00), Plate 7. In addition, cross sections showing the anticipated subsurface conditions across the highway at two locations (Sta. 105+50 and Sta. 111+00) are presented on the Idealized Subsurface Cross Sections, Plate 8. Groundwater was encountered at depths of about 15 to 44 feet below the existing ground surface in our borings drilled at the approach fill area during our field exploration. These groundwater levels generally correspond to about Elevations +10 to +20 feet MSL.

The subsurface conditions in the areas of the retaining walls (retaining a cut condition) were explored by drilling and sampling six borings on the existing cut slopes along the westbound side of the highway. In general, the borings at the retaining wall locations encountered surface fill over residual soils and weathered basalt formation. Groundwater was not encountered at the maximum depth of the borings drilled in this area during our field exploration. The following table summarizes the elevations at which the various soil layers were encountered in the borings.

Boring No.	Approximate Location (Station)	Elevation (feet MSL)		
		Ground Surface	Top of Residual Soil Layer	Top of Weathered Basalt Formation
B-101	89+75	+101	+88	+75
B-102	92+75	+115	+113	+99
B-103	Austin Bishop	+118	+108	+98
B-104	Austin Bishop	+120	+103	+102
B-105	98+00	+107	+107	+101
B-106	100+00	+82	+82	+82
B-141	126+55	+110	+110	+108
B-142	128+60	+117	+114	+103

The subsurface conditions at the location where the Austin Bishop Separation Structure will be underpinned were explored by drilling and sampling two borings. The borings, designated as Boring Nos. 103 and 104, were drilled at some distance behind the north abutment of the Austin Bishop Separation Structure, as shown on the Site Plan (Plate 3.1). Boring No. 103 was drilled on the western edge of the structure and was advanced to about 45 feet below the existing ground surface. Boring No. 104 was drilled on the eastern edge of the structure and extended to about 65 feet below the ground surface. In general, our borings encountered about 10 to 17 feet of fill (abutment wall backfill) over residual soils and weathered basalt formation. The elevations at which the various soil layers were encountered in the borings are also summarized in the previous table.

Several borings, designated as Boring Nos. S-1 through S-9 and A-9, were drilled in the 1960s for the initial highway construction along the west and east sides of the structure alignment, as shown on the Austin Bishop Separation Structure Layout Plan, Plate 25. The anticipated subsurface conditions along the west and east sides of the structure alignment (based on Boring Nos. 103 and 104 and compilation of the borings drilled in the 1960s for the initial highway design) are presented on the Idealized Subsurface Profile A-A' and B-B' (Plates 26 and 27).

The subsurface conditions in the areas of the new noise barrier walls (also known as sound walls) were explored by drilling and sampling four borings on top of the cut slope of the highway (north or mauka side). The locations of the four borings, designated as Boring Nos. 201 through 204, are shown on the Site Plans, Plates 3.2 through 3.6. Boring Nos. 201 and 202 were drilled for the sound walls in the area from about Station 96+00 to Station 103+50. Boring Nos. 203 and 204 were drilled for the sound walls in the area from Station 124+00 to the eastern end of project limit.

In general, Boring Nos. 201 and 202 indicated that the site is underlain by about 13 to 16 feet of residual soils over extremely to moderately weathered basalt formation extending to the maximum depths drilled of about 34 to 35 feet below the ground surface. Extremely weathered basalt formation was encountered in the two borings at about Elevation +102 feet MSL. In general, Boring Nos. 203 and 204 indicated that the extremely weathered basalt formation was present at relatively shallow depths of about 3 to 4 feet below the surface fill materials. Groundwater was not encountered in these borings at the time of our field exploration.

In addition, twenty-six shallow core borings, designated as Boring Nos. 113 through 135 (Westbound) and 138 through 140 (Eastbound) were drilled in the areas of the approach fill on the west side of the viaduct structure to examine the existing pavement section for pavement design and settlement evaluation. In general, Boring Nos. 113 through 121 and Nos. 138 through 140 were drilled in the shoulder lanes of the highway. The remaining shallow core borings (Boring Nos. 122 through 135) were drilled on the traffic lane adjacent to the outside shoulder lane. These shallow core borings generally extended to depths of about 1 to 6 feet below the existing ground surface. The approximate locations of the borings drilled are shown on the Site Plans, Plates 3.3 and 3.4.

Based on the shallow core borings, the existing pavement sections encountered in the borings are summarized in the following table. It should be noted that we encountered approximately 1.5 and 2.0 inches of void space (caused by consolidation settlement of the soft soils due to the embankment fill) below the concrete approach slab in Boring Nos. 130 and 140, respectively. Groundwater was not encountered in the shallow core borings during our field exploration.

Boring No.	Station	Depth (feet)	AC (inches)	PCC (inches)	Boring No.	Station	Depth (feet)	AC (inches)	PCC (inches)
B-113	103+89	5.0	14.5	N/A	B-126	108+17	1.5	3.0	9.5
B-114	104+85	5.0	10	N/A	B-127	108+88	5.0	5.0	9.5
B-115	105+89	1.0	7.5	N/A	B-128	109+85	4.3	4.0	9.5
B-116	106+88	1.0	6.5	N/A	B-129	110+87	5.0	4.0	9.0
B-117	108+17	5.0	7	N/A	B-130	111+00	5.5	1.0	8.5
B-118	108+88	3.5	6	N/A	B-131	105+50	5.5	7.5	9.0
B-119	109+85	5.0	7.5	N/A	B-132	107+82	5.0	10.3	9.8
B-120	110+87	5.0	7	N/A	B-133	109+85	5.0	4.8	9.0
B-121	111+00	5.0	5	N/A	B-134	110+87	5.0	5.0	9.5
B-122	103+89	5.0	16.5	N/A	B-135	110+97	5.0	3.0	9.0
B-123	104+85	4.0	8.5	N/A	B-138	109+85	6.0	7.5	N/A
B-124	105+89	1.2	4.5	9.5	B-139	110+87	5.0	8.3	N/A
B-125	106+88	5.0	4.5	9.5	B-140	110+97	5.0	9.5	N/A
Note: N/A denotes not available because the pavement section in the area did not consist of PCC									

It should be noted that groundwater levels measured in our borings during our field exploration may fluctuate depending on rainfall, time of year, stream water levels, seepage conditions, and other factors. Due to the complex subsurface conditions at the project site, perched groundwater conditions may be anticipated especially in the cut slopes exposing the weathered basalt formation. We understand that an artesian groundwater condition was observed near the centerline of Bent 1 of the viaduct structure during the field exploration for the design of the initial viaduct structure. It appears that the artesian groundwater condition was at about Elevation +20 (about 7 feet above the ground surface at that time) in the late 1960s.

Detailed descriptions of the field exploration methodology are presented in Appendix A of this report. Descriptions and graphic representations of the materials encountered in the borings are presented on the Logs of Borings, Plates A-1 through A-59 of Appendix A. The results of the laboratory tests performed on selected soil samples are presented in Appendix B.

2.6 Seismic Design Considerations

Based on the design criteria provided by the State of Hawaii - Department of Transportation, Highways Division, the project site will need to be designed based on a seismic acceleration coefficient of 0.18g. The following sections provide discussions on the seismicity of the Island of Oahu and the soil profile for seismic design at the site.

2.6.1 Earthquakes and Seismicity

In general, earthquakes that occur throughout the world are caused solely by shifts in the tectonic plates. In contrast, earthquake activity in Hawaii is linked primarily to volcanic activity. Therefore, earthquake activity in Hawaii generally occurs before or during volcanic eruptions. In addition, earthquakes may result from the underground movement of magma that comes close to the surface but does not erupt. The Island of Hawaii experiences thousands of earthquakes each year, but most of the earthquakes are so small that they can only be detected by instruments. However, some of the earthquakes are strong enough to be felt, and a few cause minor to moderate damage.

In general, earthquakes (associated with volcanic activity) are most common on the Island of Hawaii. Earthquakes that are directly associated with the movement of magma are concentrated beneath the active Kilauea and Mauna Loa Volcanoes on the Island of Hawaii. Because the majority of the earthquakes in Hawaii (over 90 percent of earthquakes) are related to volcanic activity, the risk of seismic activity and degree of ground shaking diminishes with increased distance from the Island of Hawaii. The Island of Hawaii has experienced numerous earthquakes greater than Magnitude 5 (M5+); however, earthquakes are not confined only to the Island of Hawaii.

To a lesser degree, the Island of Maui has experienced numerous earthquakes greater than Magnitude 5. Therefore, moderate to strong earthquakes have occurred in the County of Maui. The effects of earthquakes occurring on the Islands of Hawaii and Maui may be felt on the Island of Oahu. For example, several small landslides occurred on the Island of Oahu as a result of the Maui Earthquake of 1938 (M6.8). In addition, some houses on the Island of Oahu were reportedly damaged as a result of the Lanai Earthquake of 1871 (M7+).

Over the last 150 years of recorded history, we are not aware of reported earthquakes greater than Magnitude 6 occurring on the Island of Oahu. We understand that an earthquake of magnitude 4.8 to 5.0 occurred along the Diamond Head Fault in 1948 on the Island of Oahu. The moderate tremor resulted in broken store windows, ruptured building walls, and broken underground water mains.

2.6.2 Soil Profile

Our field exploration at the project site generally encountered surface fill materials over soft to stiff recent alluvium and stiff to hard old alluvium deposits. The old alluvium was underlain by basalt formation ranging from extremely weathered to slightly weathered. Based on the subsurface materials encountered in the borings drilled and the geologic setting of the area, the soil profile (from a seismic analysis standpoint) at the site may be classified as ranging from a Type I Soil Profile (at the eastern end of the viaduct structure) to a Type III and Type IV Soil Profile (toward the western portions of the structure) in general accordance with the AASHTO LRFD Bridge Design Specification, Second Edition (1998). Details of the Soil Profile Type at each bent location are presented on the Summary of Foundation Conditions and Capacity for Waimalu Viaduct Structure, Plate 9.

END OF SITE CHARACTERIZATION

SECTION 3.0 - DISCUSSION AND RECOMMENDATIONS

Based on our field exploration and review of the site history, the Interstate Route H-1 Widening, Waimalu Viaduct Westbound project site is generally underlain by highly variable and complex subsurface conditions. Our field exploration at the viaduct bridge site generally encountered a surface fill layer placed over soft to medium stiff recent alluvium and stiff to hard old alluvium. It should be noted that dense to very dense conglomerate (mixture of cobbles and boulders in a soil matrix) of about 7 to 15 feet thick was encountered in our borings drilled near the boundary of the recent alluvium and old alluvium. Below the alluvial soil layers, our borings encountered weathered basalt formation.

It should be noted that the soft recent alluvium encountered at the project site appears to be under-consolidated based on our laboratory consolidation tests. Groundwater was encountered in the borings (drilled for the new bridge structure) at depths of about 8 to 64 feet below the existing ground surface during our field exploration. In general, the measured groundwater levels correspond to about Elevations +1 to +16 feet MSL.

Based on the subsurface conditions encountered in the borings and the structural load demands of the bridge structure, we recommend that the new bridge structure be supported by a deep foundation system. Because of the complex subsurface conditions encountered at the site and other construction considerations, we recommend that the new bridge structure be supported on a combination of 4-foot and 5-foot diameter cast-in-place concrete drilled shaft foundations. Drilled shafts for the new bridge structure should extend to depths of about 46 to 119 feet below the bottom of footing elevations in order to achieve the design load capacities. The ultimate compressive load capacities of the drilled shaft foundations are on the order of about 1,530 to 3,100 kips per drilled shaft. Details pertaining to the design of the drilled shaft foundations are further discussed in the "Drilled Shaft Foundations" section of this report. Because of the competent subsurface conditions encountered at the eastern portion of the new bridge structure, Bent 11 may be supported on a shallow foundation system consisting of spread footings.

Considering the relatively high structural load capacities of the drilled shafts, we recommend that a trial shaft and load test program be implemented for this project. The trial shaft program should consist of drilling and installing one 5-foot diameter trial shaft at or near Bent 9 of the new bridge structure. The trial shaft should extend to a minimum depth of about 130 feet below the ground level. In addition, we recommend that two bi-directional static load tests utilizing the Osterberg load-cell installed in 5-foot diameter drilled shafts be conducted for the project (near Bent 2 and Bent 6 of the new bridge structure).

As mentioned previously, the subsurface conditions underlying the approach fills leading to the Waimalu Viaduct structure is highly variable and very complex. In general, the approach fill site consists of embankment fills placed over soft recent alluvium (up to about 44 feet thick in the recent borings) and/or weathered basalt formation. Our laboratory consolidation tests indicated that the soft recent alluvium encountered at the site appears to be under-consolidated. It appears that the soft recent alluvium layer may have achieved about 60 to 80 percent degree of consolidation based on analyses of the laboratory consolidation tests. Therefore, continuing settlements on the order of about 12 inches of the highway embankment may be expected to occur over time and in the future.

To stabilize the on-going settlements of the under-consolidated recent alluvium and to reduce the potential for significant ground settlement in the future, we recommend that the under-consolidated recent alluvium below the new highway embankment be stabilized by jet-grouting methods. In general, the tips of the jet-grouted columns should be extended until stiff and/or dense materials are encountered at each jet-grouted column location. Based on the subsurface conditions encountered, the lengths of the jet-grouted columns would be on the order of about 3 to 56 feet. In general, the soil stabilization should consist of 3-foot diameter jet-grouted columns spaced at about 6 feet on-center in a triangular grid pattern. Each of the jet-grouted columns would need to be able to support approximately 100 kips of load (weight of the embankment fill above the jet-grouted column).

Numerous retaining walls will be required for grade separation on the north (mauka) side of the highway. In general, we recommend that the retaining walls retaining a cut condition consist of soil nail retaining wall. For the retaining walls retaining a fill condition, we recommend that a flexible segmental retaining wall system be used at those locations. In addition, we anticipate that a reinforced soil slope with slope inclinations up to one horizontal to one vertical (1H:1V) would be used to for the fill condition on the west side of the existing viaduct structure. Due to the limited space for placement of long reinforcing elements, we recommend that imported select granular fill soils be used for the reinforced earth fill embankment. In addition, we recommend that erosion control matting be used for erosion control of the steepened slope faces.

Due to the highway widening at the Austin Bishop Separation structure, we recommend that a permanent tieback anchor system be used to provide the lateral restraint for the proposed widening project and to underpin the existing north abutment footing of the Austin Bishop Separation structure. The permanent tieback anchor system will consist of the installation of two rows of tiebacks (top and bottom) and should be post tensioned to counteract the active lateral forces acting on the existing abutment structure.

Detailed discussions and recommendations for design of foundations, soil stabilization, retaining structures (including specialty retaining structures), site grading, and pavements, and other geotechnical aspects of the project are presented in the following sections of this report.

3.1 Drilled Shaft Foundations

Based on the subsurface conditions encountered in our borings and the structural load demands of the bridge structure provided by the project structural engineer, we recommend that the new bridge structure be supported by a deep foundation system. Because of the complex subsurface conditions encountered at the site and other construction considerations, we recommend that cast-in-place concrete drilled shafts be used to support the abutment and pier structures of the new bridge. Based on the subsurface conditions encountered, we recommend that Abutments 1 and 2 and Bents 1 through 10 be supported by drilled shaft foundations. Because of the competent subsurface conditions encountered at the eastern portion of the new bridge structure, Bent 11 may be supported on a shallow foundation system consisting of spread footings.

Based on the structural load demands provided, we recommend that the drilled shaft foundations for the bridge structure consist of a combination of 4-foot and 5-foot diameter drilled shafts. In general, the cast-in-place concrete drilled shafts would derive vertical support primarily from skin friction. The end-bearing component of the drilled shafts has been discounted in our analysis due to difficulties associated with obtaining a clean bottom during construction in these relatively deep drilled shaft foundations. Therefore, the drilled shafts would need to extend to depths of about 46 to 119 feet below the bottom of footing elevations in order to achieve the design load capacities provided. Details of the drilled shaft configuration at each of the bridge abutment and pier locations are presented on the Summary of Drilled Shaft Foundation Recommendations, Plate 11.

It should be noted that basalt formation (slightly weathered and hard) was encountered at relatively shallow depths at the location of Abutment 2. Based on our field observations and the topographic survey map, a near-vertical slope is present near the new widened portion of Abutment 2. The closest distance between the new Abutment 2 structure centerline and the near-vertical slope is less than 7 feet. Considering the heavy structural loads of the Abutment 2 foundation and the stability of the near-vertical slope, we recommend that drilled shaft foundations be used to transfer the structural loads of the abutments to the portion of the ground below the bottom of the near-vertical slope face.

Based on information provided, it should be noted that the following assumptions were made and/or provided for our use in our foundation analyses:

1. Scour of the foundation materials at the abutment and pier locations will not occur at the project site.
2. Structural load demands provided by the project structural engineer are as shown on Plates 12 and 13.
3. Subsurface conditions are as encountered in the borings at each structure location.

Based on our field exploration, engineering analyses, and the above assumptions, we recommend that the drilled shafts with the compressive load capacities and estimated tip elevations presented on the Summary of Drilled Shaft Foundation Recommendations (Plate 11) be used for the extreme event and strength limit states. The compressive load capacities of the drilled shafts were computed generally based on the requirements contained in the AASHTO LRFD Bridge Design Specifications, Second Edition (1998). In order to arrive at the drilled shaft capacities for the strength limit state, a resistance factor of 0.65 has been applied to the extreme event limit state capacities for design of the drilled shaft foundations.

In general, the drilled shafts should be spaced a minimum of 2.5 times the diameter of the drilled shaft (measured from center-to-center) to avoid further reduction in vertical load capacity due to group action and to facilitate drilling of the shaft holes. Due to the spacing of the drilled shafts (2.5 diameters center-to-center), an efficiency factor of 0.65 has been applied to the extreme event and strength limit state capacities for the drilled shaft group presented on Plate 11. Due to the proximity of the drilled shafts, we recommend that drilling for the shafts within a lateral distance of 3.0 times the shaft diameter to the center of the hole being drilled should not commence until a minimum of 24 hours after the drilled shaft has been completed by the placement of concrete to the top of shaft elevation.

Based on the structural loads (foundation load demands) at the bridge abutments, we understand that the abutment footing will consist of an "L-shaped" structure supported by seven drilled shafts. In general, the abutment structure will be supported by two rows of three drilled shafts each with one additional drilled shaft located at the rear of the abutment to support the wing wall. Based on the foundation load demands on the abutment structure, we recommend that the drilled shafts supporting the abutment structure consist of 4-foot diameter drilled shafts.

In general, we recommend that the intermediate piers of the bridge structure be supported by four drilled shafts (two rows of two drilled shafts) at each of the footings with the exception of Bent 2 and Bent 11. Due to the presence of the concrete open drainage channel (Waimalu Stream) adjacent to Bent 2, we understand that Bent 2 will be supported by six drilled shafts in three rows (a 3-2-1 configuration). The 3-2-1 configuration denotes that three shafts will be used immediately adjacent to the existing concrete open drainage channel wall with two shafts and one shaft located away (further west) of the channel wall. Details pertaining to our drilled shaft foundation recommendations are presented on the Summary of Drilled Shaft Foundation Recommendations, Plate 11. In general, the compressive load capacities of the drilled shafts for the abutment and intermediate pier locations were governed by the foundation load demands from either the extreme event or strength limit states (refer to Plates 12 and 13).

Based on our evaluation of the subsurface conditions and the foundation design parameters, we anticipate that the drilled shaft installation for the project will require a highly experienced drilled shaft subcontractor. Therefore, consideration should be given to requiring pre-qualification of the drilled shaft subcontractor for this project. The subsequent subsections address the design and construction of the drilled shaft foundations, which include the following:

- Uplift Load Resistance
- Lateral Load Resistance
- Foundation Settlements
- Drilled Shaft Construction Considerations
- Workmanship
- Trial Shaft Program
- Bi-Directional Load Tests
- Non-Destructive Integrity Testing

3.1.1 Uplift Load Resistance

In general, uplift loads may be resisted by a combination of the dead weight of the drilled shaft and by shear along the shaft surface and the adjacent soils. Considering that the drilled shafts are designed based on adhesion between the shaft and the surrounding soils, recommendations pertaining to the uplift load capacity for the extreme event and strength limit states are presented on the Summary of Drilled Shaft Foundation Recommendations, Plate 11.

The uplift load capacities for the drilled shafts are based on the lengths of the drilled shafts recommended and designed for the compressive load capacities. The uplift load capacities are for groups of drilled shafts; therefore, a group uplift resistance factor of 0.55 has been applied to the values provided on Plate 11. The uplift load capacities provided include the weight of the drilled shaft. The project structural engineer should check the structural capacity of the shaft member in tension when the drilled shaft foundation is used to resist uplift loads.

3.1.2 Lateral Load Resistance

In general, lateral load resistance for the drilled shafts is a function of the stiffness of the surrounding soil, the stiffness of the shaft, allowable deflection at the top of shaft, and induced moment in the shaft. The lateral loads imposed on the foundations, lateral deflections, and maximum induced moments in the drilled shafts, based on a fixed against rotation boundary condition at the top of the drilled shaft, are presented on Plates 12 and 13.

As mentioned previously, we recommend that the drilled shafts be spaced a minimum of 2.5 times the diameter of the shaft from center-to-center. Therefore, the effect of group action was considered in our drilled shaft group lateral load analyses by including an efficiency factor in the direction of loading. These values assume that the drilled shafts in the direction of loading are spaced at 12.5 feet on center for the 4-foot or 5-foot diameter drilled shafts. The results of our lateral load analyses conducted using the "GROUP" computer program for the various loading conditions provided by the structural engineer are summarized on Plates 12 and 13. Because the drilled shafts are modeled based on a fixed-head connection at the top, the maximum moment induced in the drilled shaft should occur near the top of the drilled shaft with the exception of when the induced moment at the top of the footing is extremely high. The depths to the maximum induced moment in the drilled shafts are also provided on Plates 12 and 13.

Based on the results of our lateral analyses presented on Plates 12 and 13, the lateral stiffness of each pier (bent) location of the new bridge structure can be computed. Due to the non-linear stress-strain relationship of soils, the lateral stiffness of the drilled shaft group will be variable depending on the axial load, lateral load, and moment imposed on the foundation. Therefore, the lateral stiffness of the drilled shaft group should be considered preliminary in nature and would change based on the loading conditions. The lateral stiffness of the drilled shaft group should be used only for initial estimation of the lateral stiffness of the drilled shaft footing. Geolabs should perform additional analyses and provide refinement of the lateral stiffness of the drilled shaft footing if structural loads (axial load, lateral load, and moments) acting on the structure foundations are changed.

3.1.3 Foundation Settlements

Settlement of the drilled shaft foundation will result from elastic compression of the shaft and subgrade response of the foundation embedded in the conglomerate, old alluvium and/or weathered basalt formations. Total settlements of the drilled shafts under the strength limit state loading conditions are estimated to be on the order of less than 0.5 inches. Differential settlements between the abutments and the intermediate piers are estimated to be less than 0.25 inches. We believe that a significant portion of the settlement is elastic and should occur as the loads are applied. Post-construction foundation settlements should be less than 0.25 inches.

3.1.4 Drilled Shaft Construction Considerations

In general, the performance of drilled shafts depends significantly upon the contractor's method of installation and construction procedures. The load bearing capacities of drilled shafts depend on the frictional resistance between the shaft and the surrounding soil. Therefore, the contractor should exercise care in drilling the shaft holes and in placing concrete into the holes.

Based on our field exploration, soft to very soft and/or loose recent alluvium were encountered below the surface fills. Due to the soft/loose consistency of these materials, caving-in and/or sloughing of these materials will likely occur during the drilling operations. To reduce the potential for caving-in of the drilled holes, casing of the drilled holes will be required during the drilled shaft installation. However, it should be noted that the contractor may experience some difficulty in the removal of the casing after completion of the concrete placement due to the subsurface conditions at the project site. In addition, the anticipated shallow groundwater level at the project site may also pose some construction difficulties because direct observation of the sides and bottoms of the drilled shaft may not be possible.

Because of the potential difficulties anticipated in the extraction of the temporary casing, we recommend that the steel casing be abandoned in place. Therefore, the tip of the permanent casing should be installed to a depth below the soft/loose recent alluvium and should be extended a minimum of 3 feet into the stiff/dense underlying material below the soft/loose recent alluvium. The estimated tip elevations of the permanent casings are presented on Plate 11.

Boulders and cobbles were encountered within the alluvium in the borings drilled for this project. Therefore, difficult drilling conditions will likely be encountered at the project site and should be expected. The drilled shaft contractor will need to have the appropriate equipment and tools to drill through these types of natural obstructions, where encountered, in the subsurface. Appropriate measures will also be needed to avoid dislodging boulders into the drilled shaft hole during the drilling and shaft installation process.

In addition, the drilled shafts are designed to be embedded into the basalt formation and/or old alluvium deposits encountered at greater depths. Therefore, coring into the dense basalt formations encountered in the borings will be required. The drilled shaft contractor will need to demonstrate that the proposed drilling equipment (and coring tools) will be able to install the drilled shafts to the recommended depths and dimensions by performance of a trial shaft program.

Due to the high structural capacities recommended for the drilled shafts, the sidewalls of the drilled shaft holes will need to be "rifled" with grooves to provide the necessary contact and side shaft resistance assumed in our analyses. The grooves should be at least 2 inches deep by 3 inches wide and should run spirally along the shaft circumference at a pitch of about 12 inches. The "rifling" procedure may be omitted in the conglomerate and hard basalt rock formation. The "rifling" procedure will be required in the old alluvium and weathered basalt rock formation.

Groundwater levels may also pose further construction difficulties because direct observation of the sides and bottom of the drilled shafts would be difficult. Therefore, a representative from Geolabs should be present at the site to observe the drilling and installation of drilled shafts during construction.

3.1.5 Workmanship

The load carrying capacities of the drilled shafts depend, to a large extent, on the contact between the drilled shafts and the surrounding materials. Therefore, proper construction techniques are important. The contractor should exercise care in drilling the shaft holes, in rifling the sides of the drilled shaft holes, and in placing concrete into the holes.

Due to the presence of groundwater at relatively shallow depths, concrete placement by tremie methods will be required during construction of the drilled shafts. The concrete should be placed promptly after the completion of drilling (within 24 hours) to reduce the potential for caving in and/or softening of the sidewalls. The concrete should be placed in a suitable manner by displacing the water in an upward fashion from the bottom of the drilled hole. A low-shrink concrete mix with high slump (7 to 9-inch slump range) should be used to provide close contact between the drilled shafts and the surrounding soils. The concrete should be placed in a suitable manner to reduce the potential for segregation of the aggregates from the concrete mix.

In consideration of the difficulties of the subsurface conditions at the site and the complexity of the drilled shaft foundation for this project, we recommend that the drilled shaft contractor for this project be pre-qualified during the bidding process.

3.1.6 Trial Shaft Program

A trial shaft program is normally required and highly recommended for bridge projects. Considering the diameters and structural load capacities of the drilled shafts for this project, we recommend that a trial shaft program be undertaken to fulfill the following objectives:

- To examine the adequacy of the methods and equipment proposed by the contractor to install the drilled shafts into the conglomerate and basalt formation.
- To assess the contractor's method of rifling the sidewalls of the drilled shaft holes prior to placing tremie concrete.
- To assess the contractor's method of placing the permanent casing for the drilled shaft.
- To assess the contractor's method of tremie concrete placement.

To achieve these objectives, we recommend that the trial shaft program consist of drilling one 5-foot diameter trial shaft near the location of Bent 9. The location of the trial shaft should be near, but outside of, the intermediate pier foundation locations. We anticipate that the trial shaft will be drilled from the existing ground surface, prior to excavation of the pier footings. Therefore, in order for the trial shafts to extend to near the production shaft tip elevations, the trial shaft should have a minimum length of about 130 feet. After drilling the trial shafts, the trial shafts should be backfilled with unreinforced concrete in the same manner that the production shafts are to be constructed.

We anticipate that temporary casing will likely be required during the trial shaft installation to reduce the potential for caving-in of the drilled holes. Therefore, we recommend that a representative from Geolabs be present during the trial shaft program to evaluate the contractor's method of drilled shaft installation and to evaluate the subsurface materials encountered.

3.1.7 Bi-Directional Load Tests

As part of the pre-construction activities, we recommend that two static load tests be conducted on 5-foot diameter concrete drilled shafts constructed near the location of Bent 2 and Bent 6. The results of the load tests will be used to confirm or modify the estimated tip elevations of the production shafts. Due to the complex subsurface conditions at the site, we believe that the trial shaft should not be used as the load test shafts.

In general, we recommend that the load test shafts be structurally reinforced and instrumented with vibrating wire embedment strain gauges for load testing purposes. As a minimum, two embedment strain gauges should be placed at each level, starting from the bottom at an elevation of about 5 feet above and below the load cells and subsequently at about 8-foot intervals. A schematic sketch showing the recommended instrumentation of the load test shaft is provided on the Access Tube Detail for Cross Hole Sonic Logging Test, Plate 14.

Due to the relatively high capacities recommended for the drilled shafts, a conventional load test would not be practical and would be costly to conduct. Therefore, we recommend that bi-directional axial load tests be conducted using an expandable load cell (Osterberg Load Cell). The bi-directional load test separately tests the shear resistance and end-bearing components of the drilled shaft by loading the shaft in two directions (upward for shear resistance, and downward for end-bearing and shear resistance).

The Osterberg Load Cells should have a minimum diameter of 34 inches and should be capable of applying a load of 2,500 tons in each direction. The expandable base load cell will need to be attached to the reinforcing cage of the load test shaft prior to lowering the cage in place, as shown on Plate 14.

The drilled shaft load test should be performed in general accordance with the Quick Load Test Method of ASTM Test Designation D 1143. The load test shaft should be loaded to failure to evaluate the ultimate side shear resistance of the shaft. Installation of the expandable load cells, installation of the embedment strain gauges, performance of the bi-directional axial load tests, and presentation of the load test data should be performed by a professional experienced in these types of load testing procedures. The load test shafts should be loaded at increments of about 50 to 100 kips and should be held for a minimum of 12 hours at or near failure to evaluate the potential for creep effects.

Permanent steel casings should be installed in the load test shafts to reduce the potential for caving-in of the drilled holes. The permanent casing is desired in the drilled shaft load test to simulate the production shaft condition and to evaluate the load transfer in the permanent steel casing. The tip elevations of the permanent steel casing in the load test shafts are presented on Plate 14.

We recommend that a representative from Geolabs observe the installation and performance of the instrumented load test on the drilled shaft. It should be noted that the drilled shaft design was developed from our analysis using the field exploration data. Therefore, observation of the drilled shaft installation operations by Geolabs is a vital part of the foundation design to confirm the design assumptions.

3.1.8 Non-Destructive Integrity Testing

Based on the critical nature of the drilled shaft foundations for the new bridge structure, we recommend that non-destructive integrity testing be conducted on the production drilled shafts for the project. One of the non-destructive integrity testing methods, such as Crosshole Sonic Logging (CSL), has been gaining widespread use and acceptance for integrity testing of drilled shafts.

Crosshole Sonic Logging techniques are based on the propagation of sound waves through concrete. In general, the actual velocity of sound wave propagation in concrete is dependent on the concrete material properties, geometry of the element and wave length of the sound waves. When ultrasonic frequencies are generated, Pressure (P) waves and Shear (S) waves travel though the concrete. If anomalies are contained in the concrete, the anomalies will reduce the P-wave travel velocity in the concrete. Anomalies in the drilled shaft concrete may include soil particles, gravel, water, voids, contaminated concrete, and highly segregated constituent particles.

The transit time of an ultrasonic P-wave signal may be measured between an ultrasonic transmitter and receiver in two parallel water-filled access tubes placed into the concrete during construction. The P-wave velocity can be obtained by dividing the measured transit time from the distance between the transmitter and receiver. Therefore, anomalies may be detected (if they exist).

To reduce the potential de-bonding between the access tube and the surrounding concrete, we recommend that the access tubes consist of standard steel pipe with a minimum inside diameter of 2 inches. In addition, the access tube should be equipped with watertight coupling. In general, the access tubes should be securely attached to the interior of the reinforcing cage as near to parallel as possible in the drilled shaft. We recommend that a minimum of five access tubes be cast into the concrete of the 5-foot diameter drilled shafts and a minimum four access tubes be cast into the concrete of the 4-foot diameter drilled shaft. Details pertaining to the configuration of the access tubes for crosshole sonic logging tests are presented on Plate 14.

In addition, the access tubes should be extended from the bottom of the drilled shaft reinforcing cage to at least 3.5 feet above the top of the shaft. The bottom of the access tube should be permanently capped. It is imperative that joints required to achieve the full length of the access tubes be watertight. It is the responsibility of the contractor to take extra care to prevent damaging the access tubes during the placement of the reinforcing cage into the drilled hole. The tubes should be filled with potable water as soon as possible, but not later than 4 hours after the concrete placement. Subsequently, the top of the access tubes should be capped with watertight caps.

The Crosshole Sonic Logging (CSL) test of drilled shafts should be conducted after at least one day of curing time, but no later than 7 days after concrete placement. In addition, the CSL test of drilled shafts should be performed in general accordance with ASTM Test Designation D 6760. In the event that a drilled shaft is found to have significant anomalies and/or is suspected to be defective based on the CSL testing and/or field observations, the drilled shaft should be cored to evaluate the integrity of the concrete in the drilled shaft. The coring location within the drilled shaft should be determined by a representative from Geolabs, who should be present to observe the installation of the drilled shafts. After completion of the crosshole sonic logging of the drilled shafts, all the access tubes should be filled with grout of the same strength as the drilled shaft concrete.

As mentioned previously, the actual velocity of sound wave propagation in concrete is dependent on the concrete material properties, geometry of the element and wavelength of the sound waves. Therefore, the ultrasonic pulse velocity through the actual concrete mix should be tested in general accordance with ASTM Test Designation C 597. In general, we recommend that a series of the Ultrasonic Pulse Velocity measurements be performed at 1 day, 3 days, 5 days, 7 days, and 9 days to establish a relationship of pulse velocity of concrete and age of concrete for the actual concrete mix.

3.2 Shallow Spread Footings

As mentioned previously, the new bridge foundations will be designed based on Load and Resistance Factor Design (LRFD) methods. Based on the generally competent subsurface conditions encountered at the eastern portion of the new bridge structure, we recommend that a shallow foundation system consisting of spread footings bearing on the highly weathered, medium hard basalt rock formation be used for support of the new bridge structure at Bent 11. Based on LRFD methods, an ultimate bearing capacity of up to 30,000 pounds per square foot (psf) may be used to evaluate the extreme event limit state of the footings bearing on the highly weathered, medium hard basalt formation. To evaluate the strength limit state of the bridge structure foundations, a bearing pressure of up to 18,000 psf may be used. Footings for the structure should be embedded deep enough (about 8 to 10 feet below the ground surface) for the bottom of footing to bear directly on the surface of (or embedded into) the medium hard basalt formation.

Soft and/or loose materials (or less competent basalt formation, such as clinker seams) encountered at the bottom of the footing excavations should be over-excavated to expose the underlying medium hard basalt formation. The less competent basalt formation includes the closely to severely fractured basalt and clinker seams that may be encountered at the site. The over-excavation should be backfilled with concrete (or lean concrete), or the bottom of footing may be extended deeper to bear on the more competent basalt rock surface. In addition, concrete for the footings should be placed neat against the sides of the foundation excavations.

Foundations located next to utility trenches or easements should be embedded below a 45-degree imaginary plane extending upward from the bottom edge of the utility trench, or the footings should be extended to a depth as deep as the inverts of the utility lines. This requirement is necessary to avoid surcharging adjacent below-grade structures with additional structural loads and to reduce the potential for appreciable foundation settlement.

Based on a service limit state bearing pressure of 10,000 psf, we estimate that foundation settlements under the anticipated design loads for footings bearing directly on the highly weathered, medium hard basalt rock formation as recommended herein to be less than 0.5 inches. Differential settlements between adjacent pier and abutment footings supported on the basalt formation should be on the order of about 0.25 inches.

Lateral loads acting on the bridge structure (at Bent 11) may be resisted by frictional resistance developed between the bottom of the foundation and the bearing material and by passive pressure acting against the near-vertical faces of the foundation system. For lateral load resistance of the shallow footings, four components (friction and adhesion for sliding resistance and friction and cohesion for passive resistance) of lateral load resistance may be used in combination. It should be noted that the lateral load resistance of footings is primarily from friction and adhesion (where provided) between the base of the footings and the supporting subgrade materials. The two passive pressure resistance components (friction and cohesion) should be secondary lateral load resistance mechanisms. It is important to recognize that the components of passive pressure resistance should be reduced to account for strain compatibility due to the depth of the footings.

We recommend that coefficients of friction of 0.62 and 0.50 may be used to evaluate the sliding resistance of foundations bearing on the medium hard basalt rock formation for the extreme event limit state and strength limit state, respectively. The adhesion component of sliding resistance should be neglected in the design. Lateral load resistance due to passive pressure for footings may be estimated using a triangular pressure distribution of 500 pounds per square foot per foot of depth (pcf) and cohesion of 2,000 psf for the extreme event limit state. Passive pressure with a triangular distribution of 250 pcf and cohesion of 1,000 psf may be used to resist lateral loads for the strength limit state. It should be noted that the amount of deflection needed to mobilize the full passive pressure is at least 2.0 inches. For deflections less than that needed to mobilize full passive pressure, a linearly interpolated reduced passive pressure may be used in evaluating the lateral load resistance of the footing.

For lateral loads imposed on the spread footing during a seismic event, we recommend the following maximum soil spring stiffness be used to resist lateral loads generated from transient seismic loading conditions. These values are estimated assuming intimate contact exists between the concrete footing and the weathered basalt rock formation.

Spring Stiffness Parameter	Value
Vertical Stiffness	9,500 kips per inch
Lateral Stiffness	8,000 kips per inch
Longitudinal Rotational Stiffness	6.9×10^{6} kip-feet/radian
Transverse Rotational Spring Stiffness	1.8×10^{7} kip-feet/radian

It should be noted that the spring stiffness parameters provided assumes that the footings bear directly on or are embedded into the weathered basalt rock formation. Therefore, concrete for the footings should be placed neat against the bottom and sides of the foundation excavations. We recommend that footing excavations be observed by a representative from Geolabs prior to the placement of reinforcing steel and concrete to confirm the foundation bearing conditions.

3.3 Existing Foundation Stiffness Modeling Analysis

In order to evaluate the lateral load resistance of the existing bridge structure, foundation capacities and stiffness modeling parameters were estimated based on the soil descriptions provided in the previous boring logs for the project. Using the available subsurface information and structural loads provided, the following analyses were performed in support of the seismic evaluation of the existing Waimalu Viaduct structure.

- Bearing Capacities of Spread Footings
- Lateral Load Resistance of Spread Footings
- Lateral Load Resistance of Abutment Fills
- Axial Compression Capacities of Pile Foundations
- Lateral Load Resistance of Pile Foundations (Lateral Stiffness Springs)

It should be noted that the subsurface conditions underlying the existing Waimalu Viaduct structure are highly complex and variable. The soil profile (from a seismic analysis standpoint) at the site may be classified as ranging from a Type I Soil Profile (at the eastern end of the structure) to a Type III and Type IV Soil Profile (toward the western portion of the structure). Details pertaining to the soil profile parameters for seismic analysis of the existing structure are presented on the "Summary of Foundation Conditions and Capacity for the Waimalu Viaduct Structure" (Plate 9). The following subsections provide descriptions of the foundation parameters and our recommendations for use in evaluating the existing viaduct structure.

3.3.1 Bearing Capacities of Spread Footings

The ultimate bearing capacities of the foundation bearing materials for the columns supported on spread footings are provided on Plate 9. In general, spread footings (or continuous strip footings) were used to support the columns located at Pier 11 and the east abutment of the viaduct structure. Based on the available information and description of the foundation bearing materials, the foundation bearing materials are assumed to consist of moderately weathered basalt rock formation. We envision that the moderately weathered basalt rock formation (foundation material) grades to highly weathered in localized areas.

3.3.2 Lateral Load Resistance of Spread Footings

For lateral load resistance of the shallow footings, four components of lateral load resistance (as shown on Plate 9) may be used in combination. It should be noted that the lateral load resistance of footings is primarily from friction and adhesion (where provided) between the base of the footings and the supporting subgrade materials. The two passive pressure resistance components (friction and cohesion) should be secondary lateral load resistance mechanisms.

The two components of passive pressure resistance should be reduced to account for strain compatibility due to the depth of the footings. It should be noted that the amount of deflection needed to mobilize the full passive pressure is at least 2.5 inches. For a deflection less than that needed to mobilize full passive pressure, a linearly interpolated reduced passive pressure may be used in evaluating the lateral load resistance of the footing.

3.3.3 Lateral Load Resistance of Abutment Fills

The abutment structure may be considered as a large footing bearing on the abutment fill soils for resistance of lateral loads during a seismic event in the longitudinal direction. For lateral loads imposed on the abutments, the stiffness of the abutment fill soils will generally be mobilized prior to the lateral resistance of its foundations (either spread footings or pile foundations). Provided that intimate contact exists between the backfill soil and the abutments, an abutment fill stiffness equal to approximately 4 kips per square foot per inch of deflection may be used in resisting lateral loads. To reduce the potential for shear failure in the abutment fill soils, the lateral deflection should be limited to 1.25 inches or less. Therefore, the maximum lateral load resistance of the abutment structure should be limited to 5 kips per square foot of abutment wall face. The structural engineer should check the structure displacement required in order to engage the abutment fill soils for lateral load resistance.

It should be noted that the stiffness of the abutment fill soils only applies to forces that cause the abutment wall to move into the backfill soil (longitudinal direction). Therefore, only the lateral load resistance of the abutment foundation and wing walls may be utilized to resist the lateral loads in the transverse direction.

3.3.4 Axial Compression Capacities of Pile Foundations

As indicated on Plate 9, the tip elevations of the existing pile foundation are highly variable and range from about 30 to 140 feet below the existing ground level. Therefore, the axial capacities of the piles in compression for the portion of the structure supported on pile foundations have been estimated and are provided on Plate 9.

In general, we understand that most (if not all) of the pile locations were predrilled during the initial pile installation. Therefore, the uplift capacities of the piles would be significantly reduced based on the less than favorable soil conditions surrounding the perimeter of the existing piles (within the depths of the predrilling). In addition, it appears that non-mechanical splices were used to splice the piles based on the construction drawings. Therefore, the uplift capacity of the existing pile foundations should be neglected in the analyses due to the uncertainty in the ability of the connections to transmit tension forces.

3.3.5 Lateral Load Resistance of Pile Foundations

The calculated lateral load resistance parameters of the existing piles and pile caps are also provided on Plate 9. Lateral deflection and reactions of the pile foundations were analyzed using the computer program GROUP. The group geometry, pile properties, soil properties, and loading conditions were input into the GROUP program based on available information, structural loads provided by the project structural engineer, and our experience.

The individual concrete piles were assumed to have cracked, and a reduced modulus of elasticity (50 percent) was used in our analyses. The foundation analyses included lateral deflection and lateral stiffness in the longitudinal and transverse directions. The lateral stiffness of the pile-supported footings is provided on Plate 9.

Due to the non-linear stress-strain relationship of soils, the lateral stiffness springs at the foundation level will be variable depending on the axial load, lateral load, and moment imposed on the foundation. Therefore, the lateral stiffness springs provided on Plate 9 would change based on the loading conditions. Our lateral analyses were based on the loading information acting on the existing foundation provided by the project structural engineer (KSF, Inc.) dated October 31, 2002. The lateral stiffness springs provided for each footing on Plate 9 should be used for initial estimation of the lateral stiffness of the pile-supported footing only. If the structural loads acting on the structure change, Geolabs should perform additional analyses and provide updated lateral stiffness springs based on the updated structural loads.

3.4 Abutment Walls and Wing Walls

Based on the information provided, we understand that abutment walls and wing walls on the order of about 15 to 20 feet in height will be required at the two bridge abutment locations. Because the abutment walls and wing walls are part of the bridge structure, these walls should be supported on the same foundation system of the abutment structure. The following guidelines and parameters may be used in designing the "conventional" concrete retaining walls for the project. Discussions on specialty retaining walls, such as soil nail retaining walls, segmental retaining walls and noise barrier walls, are presented separately in subsequent sections of this report.

3.4.1 Static Lateral Earth Pressures

Retaining structures should be designed to resist lateral earth pressures due to the adjacent soils and surcharge effects. The recommended lateral earth pressures for design of retaining structures, expressed in equivalent fluid pressures of pounds per square foot per foot of depth (pcf), are presented below.

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Backfill Condition	Earth Pressure Component	Active (pcf)	At-Rest (pcf)
Level Backfill	Horizontal	32	50
	Vertical	None	None

The values provided above assume that Type A Structure Backfill Material conforming to Section 703.20 of the Hawaii Standard Specifications for Road, Bridge, and Public Works Construction (1994) will be used to backfill behind the retaining walls. It is assumed that the backfill behind the retaining walls will be compacted to at least 95 percent relative compaction. In general, an active condition may be used for gravity retaining walls or walls that are free to deflect by as much as 0.5 percent of the wall height. If the tops of walls are not free to deflect beyond this degree, or are restrained, the walls should be designed for the at-rest condition. These lateral earth pressures do not include hydrostatic pressures that might be caused by groundwater trapped behind the walls.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the depth of the wall should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the wall, a rectangular distribution with uniform pressure equal to 22 percent of the vertical surcharge pressure acting over the entire height of the wall, which is free to deflect (cantilever), may be used in design. For walls that are restrained, a rectangular distribution equal to 36 percent of the vertical surcharge pressure acting over the entire height of the wall may be used for design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

3.4.2 Dynamic Lateral Earth Forces

Dynamic lateral earth forces due to seismic loading (a_{max}= 0.17g) may be estimated by using $6.5H^2$ pounds per lineal foot of wall length for level backfill conditions, where H is the height of the wall in feet. It should be noted that the dynamic lateral earth forces provided assume that the wall will be allowed to move laterally by up to about 1.5 to 2 inches in the event of an earthquake. The resultant force should be assumed to act through the mid-height of the wall. An appropriately reduced factor of safety may be used when dynamic lateral earth forces are accounted for in the design of the retaining structures.

If the estimated amount of lateral movement is not acceptable, the retaining structure should be designed with higher dynamic lateral forces for a restrained condition. For a restrained condition (less than 0.5 inches of lateral movement), dynamic lateral forces due to seismic loading may be estimated using $11H^2$ pounds per lineal foot of wall for level backfill conditions.

3.4.3 Drainage

Abutment walls and other retaining structures should be well drained to reduce the build-up of hydrostatic pressures. A typical drainage system for abutment walls should consist of permeable material, such as AASHTO M 43, No. 67 gradation material, placed near the bottom and along the length of the wall discharging to an appropriate outlet or weepholes. As an alternative, the drainage system may consist of about 1 cubic foot of permeable material, such as AASHTO M 43, No. 67 gradation material, wrapped with non-woven, filter fabric at each of the weephole locations. The weepholes should be spaced not more than 8 feet apart.

Backfill behind the permeable drainage zone should consist of Type A Structure Backfill Material conforming to Section 703.20 of the HSS. Unless covered by concrete slabs or pavements, the upper 12 inches of backfill should consist of relatively impervious material to reduce the potential for significant water infiltration behind the walls. In addition, the backfill from the bottom of the wall to about the elevation of the weepholes should consist of relatively impervious soil backfill, such as the on-site soils or well-compacted materials, to reduce the potential for excessive water infiltration into the foundation materials.

3.5 Approach Fill Settlements

We understand that the approach fills on the west side of the existing viaduct structure has undergone substantial ground settlement, and distress has been observed in the pavements. Based on our review of the as-built plans of this area, we understand that sand drains were installed and pre-loading of the fill embankments was implemented during the initial construction, as shown on Plate 4. As mentioned previously, some past agricultural land uses including drainage ditches were excavated and subsequently backfilled at the site. The drainage ditch features are also shown on Plate 4.

Based on our field exploration, a relatively thick layer of soft to medium stiff recent alluvium is present at the approach fill area of the project site. In general, the thickness of the soft soil layer may be as much as 15 to 44 feet across the limits of the Interstate Route H-1 Highway. Idealized subsurface profiles along the westbound and eastbound lanes of the highway are presented on Plates 6 and 7. It should be noted some of the subsurface information along the eastbound lanes of the highway was based on borings drilled in 1960s for the initial design of the highway.

Based on our laboratory test results, the soft recent alluvium appears to be under-consolidated indicating that the soft soils are still undergoing consolidation settlements at this time. Based on our analyses of the laboratory consolidation tests, it appears that only 60 to 80 percent (average 70 percent) of the consolidation settlement has occurred at the present time. Therefore, on-going consolidation settlements of another 30 percent (estimated about another 12 inches) could occur on the existing Interstate Route H-1 Highway in the future. In the area where the highway widening will occur, we anticipate that additional consolidation settlements caused by the new embankment fill loads may be on the order of about 45 inches. The following table presents some of the consolidation parameters based on the laboratory consolidation tests performed on samples of the recent alluvium.

Station	Boring No. and Sample Depth	Ground Elevation (feet MSL)	Estimated Pre-Consolidation Pressure (ksf)	Approximate Overburden Pressure (ksf)	Consolidation Ratio
104+67	B-107 @ 16.5 feet	+39	2.40	1.84	1.3
104+67	B-107 @ 32.0 feet	+39	2.50	2.78	0.9
104+67	B-107 @ 36.0 feet	+39	5.10	2.85	1.8
105+52	B-108 @ 26.5 feet	+35	1.70	2.25	0.8
105+52	B-108 @ 41.5 feet	+35	2.20	2.76	0.8
105+52	B-108 @ 51.5 feet	+35	2.10	3.09	0.7
106+65	B-109 @ 41.5 feet	+35	1.50	2.61	0.6
105+50	B-136 @ 36.5 feet	+54	4.40	4.17	1.1
105+50	B-136 @ 76.5 feet	+54	4.70	6.08	0.7
107+82	B-137 @ 36.5 feet	+48	1.05	3.76	0.3

In addition, open standpipe and electronic piezometers were installed in the soft recent alluvium (adjacent to the location of Boring No. 108) to further evaluate the magnitude of the excess pore water pressure in the under-consolidated recent alluvium. Based on our initial field measurements of the pore water pressures, it appears that approximately 11 feet of excess pore water head is present in this area. Based the initial field measurements, approximately 72 percent of the consolidation settlement may have occurred at the areas where the field measurements were taken (at Boring No. 108). However, some leakage of the PVC casing housing the piezometers occurred after the initial installation. Therefore, the additional information obtained from the open standpipe and electronic piezometers on the degree of consolidation of the soft recent alluvium initiated from the existing highway embankment loading were not conclusive.

3.6 Deep Soil Stabilization

In order to stabilize the on-going settlements resulting from the potentially under-consolidated recent alluvium and to reduce the potential for significant ground settlement in the future, we recommend that the under-consolidated recent alluvium below the highway embankment on the west side of the viaduct structure be stabilized. Based on the current design concept, we understand that only the under-consolidated recent alluvium below the new embankment of the highway widening will be stabilized. Three deep soil stabilization methods were considered for this project including the following:

- Jet Grouting
- Stone Column
- Compaction Grouting

Due to relatively thick soft recent alluvium layer present at the site, stone column and compaction grouting methods should not be used. In addition, both stone column and compaction grouting methods are not able to stabilize the on-going settlements because these two methods are not able to "underpin" the existing embankment fill. Therefore, we recommend that soil stabilization by the jet-grouting method be used to stabilize the under-consolidated recent alluvium at the site.

In general, jet grouting is a technique utilizing a special drill bit and injection monitor with radial horizontal nozzles to produce stabilized soil-cement columns. The jet-grouting technique is a process that produces soil-cement columns by pumping neat cement grout slurry through horizontal jets injected at high pressures. The horizontal jets of cement grout slurry cuts and mixes the surrounding in-situ materials with the neat cement slurry grout as the drill bit is slowly rotated and withdrawn to form a soil-cement column.

In order to provide support for the new embankment of the Interstate Route H-1 Highway, we recommend that jet-grouted columns be installed under the embankment fill in the area shown on the Deep Soil Stabilization Plan, Plate 15. The jet-grouted columns would derive vertical support primarily from bearing on the stiff soils and/or weathered basalt rock formation and from skin friction along the sides of the jet-grouted columns. Based on our evaluation of the subsurface conditions and the load supporting capacity of the jet-grouted columns, we recommend that the soil stabilization consist of 3-foot diameter jet-grouted columns. The jet-grouted columns should be spaced at about 6 feet on-center in a triangular grid pattern. Based on this configuration, each of the jet-grouted columns would need to be able to support approximately 100 kips of load (weight of the embankment fill above the jet-grouted column).

In general, we estimate that foundation settlements under the anticipated 100-kip load for the jet-grouted columns bearing directly on the stiff soils and/or weathered basalt rock formation as recommended herein to be approximately 3 to 3.5 inches. Items of the jet-grouted column foundations that are addressed in the succeeding subsections include the following:

- Jet-Grouted Columns
- Jet Grouting Equipment
- Jet Grouting Test Program
- Quality Control
- Construction Considerations

3.6.1 Jet-Grouted Columns

Based on experience, the jet-grouted columns should have a minimum average diameter of 3 feet. Due to the nature of jet grouting, deviations from the specified minimum average diameter of the jet grout column is anticipated depending on the subsurface conditions. However, the jet grout column should not have a diameter less than 2.5 feet. In addition, the grout mix should have a specific gravity of at least 1.6 and should be able to produce jet-grouted columns with a 7-day unconfined compressive strength of at least 200 pounds per square inch (psi) and a 28-day unconfined compressive strength of at least 400 psi.

As noted previously, the 3-foot diameter jet-grouted columns should be installed in a triangular grid configuration at about a 6-foot center-to-center spacing. Due to the specialized nature of the jet grouting work, a representative from Geolabs should be present at the site to observe the jet-grouted column installation operations.

As mentioned previously, the subsurface conditions at the approach fill area are highly irregular and complex. An idealized geological profile along the proposed highway widening alignment in this area is presented on Plate 6. Based on the subsurface conditions, the deep soil stabilization areas are generally divided into three areas, as shown on Plates 15 and 16. Details pertaining to the three areas are summarized in the following table. The typical layout and section of the jet-grouted columns for each area are presented on Plates 17 through 20.

Deep Soil Stabilization Area	Location	Estimated Station	Estimated Top of Jet Grout Column	Estimated Tip of Jet Grout Column	Estimated Length of Jet-Grouted Column
A	Westbound Lanes	103+50 to 106+00	+16 feet MSL	-30 to –40 feet MSL	46 to 56 feet
B		107+00 to 108+50	+20 feet MSL	+11 to +17 feet MSL	3 to 9 feet
C		109+50 to 111+00	+25 feet MSL	+9 to +22 feet MSL	3 to 16 feet

In general, the jet-grouted columns should be extended until stiff/dense materials are encountered at each jet-grouted column location. Based on our field exploration, we estimated the length of the jet grout column in each area. It should be noted that the subsurface conditions at the site are highly variable and some locations may not require the soil stabilization based on the borings conducted at this time. Therefore, we recommend that a probing program be conducted prior to the installation of production jet columns to determine the approximate depths of the proposed jet-grouted columns and to evaluate the need for soil stabilization in some areas. The areas requiring deep soil stabilization may be refined based on the results from the test probe program. The recommended locations of the test probes are presented on Plate 16. Because the depths of each column will vary depending on the subsurface conditions, a representative from Geolabs should be present to observe the jet grouting operations during construction.

3.6.2 Jet Grouting Equipment

Based on the subsurface conditions at the site, we believe that either the double or triple-fluid method of jet grouting will be necessary to install the jet-grouted columns for support of the embankment fill for this project. The drilling equipment should be capable of advancing the jetting rods to the depth required for this project. The drilling equipment should also be equipped with automated controls necessary to slowly rotate and withdraw the jetting rods at those rates determined necessary for the formation of the jet-grouted columns. Rates of rotation and withdrawal of the jetting rods for each column should be recorded by the contractor and confirmed by a representative from Geolabs.

Grout mixers, holding tanks, and associated equipment should be capable of continuously producing a uniform grout mixture required for the formation of the jet-grouted columns. Uniformity of the grout mixture should be measured and recorded by the contractor by taking unit weight (density) measurements of the mixed grout by mud balance at least once every 2,000 gallons of grout mixed and pumped.

High-pressure pumps for the jet grouting operations should be capable of delivering grout at a minimum pressure of 4,000 psi. The high-pressure pumps should be equipped with the necessary gauges to measure and record grout pumping pressures, flow rate, and total grout used for each column.

3.6.3 Jet Grouting Test Program

We recommend that a jet grouting test program be undertaken to evaluate the proposed grouting methods and the ability of the proposed grout mix to produce jet grout columns meeting the depth, diameter, and material property requirements for the project. Test program should be conducted and evaluated, including the results of 28-day unconfined compressive strength tests, prior to starting production jet grouting work.

To achieve these objectives, we recommend that at least one test section consisting of a minimum of three jet grouted columns be constructed using the same procedures proposed for the production jet grouting work. The recommended test section is shown on Plates 15 and 16. Details of the test section are presented on Plate 21. In general, the jet grout columns for the test section should extend down to the stiff/dense materials encountered in our borings at the approximate elevations indicated in above table. The test columns should be installed up to near the existing ground surface to allow for later excavation for physical inspection. Excavation to expose the grout columns of the test section should not be sooner than 7 days after the jet grout columns have been constructed.

In order to determine the relationship between the jet grouting withdrawal rate and the size of the column produced, we recommend that a minimum of six "feeler" pipes consisting of a minimum 1-inch diameter steel pipe be installed within the jet grout columns of the test section, as shown on Plate 21. The steel "feeler" pipes should be installed to the maximum depth of the jet grout columns of the test section.

After the jet grout test columns have set up sufficiently, at least four continuous core samples should be obtained from the full depth of the test columns, as shown on Plate 21. In general, we recommend that triple tube core barrels with thin walls be employed to obtain a continuous core sample of the jet grout columns. The core barrel should have a nominal inside diameter of at least 2.5 inches or greater. In-lieu of coring, the contractor may obtain samples by inserting a 3-inch diameter Schedule 80 PVC pipe of sufficient length (full depth of the jet grouted columns) into a "wet" column. The pipe should be extracted the next day after the column has reached its initial set. The pipe should be placed plumb within the outer one-third of the jet grout column radius.

The core samples should be inspected and checked for segregation. Compression tests should be performed on a minimum of four cores retrieved from each of the continuous core samples to determine the 28-day compressive strengths. The compressive strength of the core samples should be determined in accordance with ASTM D 1633 or ASTM D 2850, as appropriate. If the results of the test program are not satisfactory, modifications to the jet grout column construction procedures and additional test sections may be required.

We recommend that a representative from Geolabs be present during the jet grouting test program to observe and evaluate the field performance of the proposed jet grouting equipment and methods. Therefore, observation of the jet grouting operations by Geolabs is necessary and should be designated a "Special Inspection" item.

3.6.4 Quality Control

The type of jet grouting system and grouting parameters for grout mix, grout pressures, rotational speed, lifting rate, grout flow rate, number and size of jet nozzles, and drilling methods greatly affect the performance of the jet grouted columns. Therefore, an adequate quality control program should be implemented during the production jet grouting operations.

In general, grout mix uniformity should be verified by unit weight (density) measurements of the mixed grout by mud balance, Marsh Viscosity, and/or bleed from samples taken from the grout return line, in accordance with API Standard 13B test method. At least one group of tests should be conducted for every 2 hours that the grout is mixed and pumped.

We recommend that "feeler" pipes consisting of a minimum 1-inch diameter steel pipe be installed in one out of ten (10) production jet grout columns (full depth of column). The steel "feeler" pipes should be installed at the maximum radius of the jet grout column to evaluate the radial extent of the jet grout column installed during construction.

A minimum of six cement grout samples should be fabricated in accordance with ASTM C 109. Two grout samples should be subjected to compressive strength tests at 7 days in accordance with ASTM C 39 or C 109 and ASTM D 1633, respectively. The remaining samples should be subjected to compressive strength tests at 28 days following the ASTM testing procedures.

In addition, core samples should be taken after the production jet grouted columns have reached sufficient strength. We recommend that the vertical core samples be taken from the full depth of the treated columns of about 3 percent of the total number of jet-grouted columns. The core samples at each location should be tested for unconfined compressive strength as described in the "Jet Grouting Test Program" subsection. If the samples tested do not meet the specified strength requirements, then additional replacement jet grout columns may be required, or other provisions should be implemented to compensate for the lower strength columns.

3.6.5 <u>Construction Considerations</u>

It should be noted that some of the soil stabilization areas are located in the shoulder lane of the Interstate Route H-1 Highway. Therefore, the contractor should be responsible for the appropriate traffic control requirements. In addition, grout, soil, and water spoil returns produced during the jet grouting operations should be contained and disposed of properly by the contractor. Furthermore, the holes for jet grout rods will need to be patched at the conclusion of each daily shift to allow traffic to traverse the highway pavements at high speeds.

The subsurface conditions generally consist of fills and soft to stiff alluvium. It should be noted that cobbles and boulders may be present in the surface fill materials at the site. In addition, boulders, cobbles and gravel materials are commonly encountered in the alluvial deposits at the project site. Therefore, potentially difficult drilling conditions may be encountered and should be expected by the contractor. The jet grouting contractor will need to have the appropriate equipment and tools to drill through these obstructions, where encountered.

3.7 Soil Nail Retaining Walls

As indicated previously, retaining walls retaining a cut condition are anticipated for grade separation on the west side of the viaduct structure on both sides (east and west) of the existing Austin Bishop Separation Structure. On the east side of the viaduct structure, retaining walls retaining a cut condition are also anticipated from about the east abutment to the Kaonohi Street Overpass. Based on the generally competent subsurface conditions at these locations, we believe that these walls should consist of soil nail retaining walls.

Based on the information provided, we understand that retaining walls up to about 16 feet in height will be required. The soil nail retaining wall system would serve both as temporary shoring of the excavation and the permanent retaining wall. A soil nail retaining wall system consists of a series of individual reinforcing bars grouted into drilled holes to stabilize an excavation or slope. A shotcrete facing is generally applied to the face of the reinforced excavation to provide the appearance of a conventional concrete retaining wall. The reinforcing bars provide both additional tensile and shear strengths to the soil and reinforce the sidewall of the excavation. The reinforced soil mass behaves in a manner similar to a gravity retaining wall but lacks a footing. In general, the face of the soil nail retaining wall system is slightly battered at a slope inclination of about one horizontal to twelve vertical (1H:12V). A typical cross section of the soil nail retaining wall system is presented on Plate 22.

Soil nail retaining walls are normally installed in a cut condition only. If a fill condition exists at the proposed soil nail retaining wall, we recommend that the fills be placed first to allow construction of the soil nail retaining wall entirely in a cut condition. The fill materials to be used in the area of the soil nail retaining wall should consist of the excavated on-site silty and clayey materials (general fill materials). The fill materials should be moisture-conditioned to at least 2 percent above the optimum moisture content, placed in level loose lifts of 8 inches or less, and compacted to at least 90 percent relative compaction (based on AASHTO T-180 test methods). Granular fill materials are generally not recommended for use in the area behind the soil nail retaining wall.

Design of the soil nail retaining wall system will need to consider both the internal and external stability of the reinforced soil mass. The design of the internal stability includes establishing the size, spacing, orientation, and length of the grouted reinforcing bars. The external stability includes overall slope stability of the reinforced excavation. The geotechnical design parameters needed for evaluating the internal and external stability of the soil nail retaining wall system are provided in the following table.

GEOTECHNICAL DESIGN PARAMETERS FOR THE SOIL NAIL RETAINING WALL SYSTEM	
Geotechnical Design Parameters	**Recommended Value**
Soil Unit Weight	115 pcf
Friction Angle	30 degrees
Soil Cohesion	100 psf
Ultimate Bond Stress	1,000 psf for on-site clayey silt soils

The bond stress, which is the pullout resistance per unit area of the grout/soil interface contact, is variable depending on the type of soil and grout, the overburden stress, and the construction procedures used in installing these grouted reinforcing bars. For a rough estimate, an average bond stress of 1,000 psf may be used for the on-site clayey silt soils. The bond stress used in the design will need to be confirmed in the field during construction.

Based on our slope stability analyses, we recommend that the length of the soil nails range from about 120 to 190 percent of the height of the wall depending on the geometry of the slope. The upper two rows of the soil nail may need to be embedded deeper to provide the necessary pullout resistance based on detailed analyses. It should be noted that the lower portions of the soil nail retaining wall may encounter some dense basalt formation in localized areas. The nails embedded in dense basalt rock may be reduced to at least 50 percent of the height of the wall. Based on the above minimum soil nail lengths, the soil nail retaining wall system of up to about 16 feet high should have a factor of safety of 1.5 or greater for the combined internal and external stability for the service loading condition. For the seismic loading condition, a factor of safety of 1.0 or greater for the combined internal and external stability should be achieved. As a minimum, we recommend that the nail lengths be a minimum of 8 feet in soil or in basalt formation.

The corrosion parameters of the soil are measured by minimum resistivity, pH, sulfate content and chloride content. Based on the laboratory corrosion tests performed on the soil samples from our borings at the soil nail retaining wall locations, the following corrosion parameters may be anticipated at the project site.

Parameter	Tested Values
Minimum Resistivity	2,500 to 14,300 ohm-cm
pH	5.0 to 6.0
Chloride Content	170 to 360 mg/kg (ppm)
Sulfate Content	30 to 125 mg/kg (ppm)

Based on the critical values recommended by FHWA-RD-89-198 for corrosion protection, we believe that the soil nails will require some form of corrosion protection, such as a fully encapsulated double corrosion protection system, due to the slightly elevated chloride contents of the soils.

The design of the soil nail retaining wall system does not include hydrostatic pressures that might be caused by groundwater or water trapped behind the walls. Therefore, the soil nail retaining walls should be well drained to reduce the build-up of hydrostatic pressures. A typical drainage system would consist of 2-foot wide strips of a prefabricated drainage product, such as MiraDrain or EnkaDrain, placed on the face of the excavation between the soil nails. The prefabricated drainage product should extend from the top to the base of the wall and should be hydraulically connected to a weephole at the base of the wall, as shown on Plate 22. The weepholes should discharge to appropriate outlets.

Pullout tests (proof tests) should be performed on the soil nails during construction to confirm the bond stresses used in the design. Based on the soil conditions anticipated behind the soil nail retaining wall, we recommend that a minimum of 10 percent of the total number of soil nails be tested for pullout. The pullout tests should consist of subjecting the soil nail to at least 150 percent of the design loads and the load should be held for at least 10 minutes. Of the 10 percent of the soil nails subjected to pullout tests, we recommend that a minimum of six soil nails be subjected to a creep test. The creep tests should consist of subjecting the soil nail to at least 150 percent of the design loads, and the load should be held for at least 8 hours. The test nails may be incorporated into the permanent soil nail retaining wall provided that they satisfy the test criteria. Pullout tests and creep tests on the soil nails are integral parts of the design of the soil wall retaining wall system. Therefore, we recommend that the pullout tests and creep tests be conducted under the observation of a representative from Geolabs.

Construction of the permanent soil nail retaining wall should be performed by a specialty contractor experienced in the construction of soil nail retaining walls. Due to the specialized nature of the soil nail retaining wall construction, we recommend that a representative from Geolabs be present to observe the geotechnical aspects of the soil nail retaining wall construction and testing of soil nails.

3.8 Segmental Retaining Walls

Based on current design concept, we anticipate that segmental retaining wall systems will be installed on the west side of the existing viaduct structure near the Pearl City Off-Ramp and the three existing 162-inch diameter drainage pipe culverts for grade separation.

In general, the segmental retaining wall system is a composite wall system, which utilizes high-density polyethylene, or other reinforcing elements, to reinforce the backfill zone and improve the shear strength of the reinforced soil zone. This composite system essentially forms a gravity wall structure with an ability to tolerate significant total and differential settlements. In addition, segmental retaining walls are also desirable due to the flexibility of the wall, ease of construction, high load carrying capacity, and economy.

Design of the segmental retaining wall system will need to take into consideration both the external and internal stability of the structure. In evaluating external stability, the retaining wall must satisfy four stability conditions: (1) bearing failure, (2) translational sliding, (3) overturning stability, and (4) overall slope stability. Geotechnical design parameters to evaluate these stability conditions are presented in the following subsections. Some of the geotechnical parameters necessary in evaluating the internal stability of the retaining wall are presented in the "Reinforced Fill and Backfill Materials" subsection.

3.8.1 Segmental Retaining Wall Foundations

Based on the subsurface conditions encountered at the project site, we recommend that an ultimate bearing capacity of 10,000 psf be used to evaluate the foundations bearing on the on-site clayey silts and/or compacted aggregate subbase based on an extreme event limit state. The extreme event limit state of the foundations is generally due to unique occurrences, such as seismic loading conditions.

To evaluate the strength limit state of the foundations, a bearing pressure of up to 6,000 psf may be used based on a resistance factor of 0.6. For the service limit state, a bearing pressure of 3,000 psf may be used. In general, the retaining wall should be embedded a minimum of 24 inches below the lowest adjacent finished grade. In addition, the footing should be extended deeper to obtain a minimum 5-foot setback distance measured horizontally from the outside edge of the footing to the face of the slope for sloping ground conditions.

The wall subgrades should be compacted to a minimum of 90 percent relative compaction to provide a firm an unyielding base. Soft and/or loose soils encountered at the wall subgrades should be over-excavated to a minimum depth of 24 inches below the bottom of wall elevation. The over-excavation should also extend a minimum of 24 inches laterally beyond the front face of the walls. The resulting over-excavation should be backfilled with aggregate subbase materials.

Lateral loads acting on the structures may be resisted by frictional resistance developed between the bottom of the foundation and the bearing soil and by passive earth pressure acting against the near-vertical faces of the foundation system. The following coefficient of friction values for the extreme event and strength limit states may be used for preliminary design purposes.

COEFFICIENT OF SLIDING FRICTION		
Boring Materials	**Extreme Event Limit State**	**Strength Limit State**
On-Site/General Fills	0.42	0.36
Aggregate Subbase	0.54	0.46

Resistance due to passive earth pressure may be estimated using an equivalent fluid pressure of 350 pcf and 175 pcf for level ground conditions for extreme event and strength limit states, respectively. These values assume that the soils around the foundations are well compacted. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

3.8.2 Lateral Earth Pressures

The retained soil behind the segmental retaining wall structure will exert lateral earth pressures on the structure. The recommended lateral earth pressures (expressed in equivalent fluid pressures) for design of the retaining wall structure retaining general fill materials or the on-site soils are presented in the following table.

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Backfill Condition	Earth Pressure Component	Active (pcf)	At-Rest (pcf)
Level Backfill	Horizontal	40	58
	Vertical	None	None

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Backfill Condition	Earth Pressure Component	Active (pcf)	At-Rest (pcf)
Maximum 2H:1V Sloping Backfill	Horizontal	64	80
	Vertical	32	40

The values provided above assume that the excavated on-site materials consisting of particles less than 6 inches in largest dimension and/or general fill materials will be used to backfill behind the reinforced zone of the segmental retaining wall. It is assumed that the backfill behind the retaining wall will be compacted to between 90 and 95 percent relative compaction. The lateral earth pressure values provided above do not include hydrostatic pressure that may be caused by groundwater trapped behind the retaining wall structure.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the height of the segmental retaining structure should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the structure, a rectangular distribution with uniform pressure equal to 36 percent of the vertical surcharge pressure acting on the entire height of the structure may be used in design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

Dynamic lateral earth forces due to seismic loading (a_{max}= 0.17g) may be estimated by using $6.5H^2$ pounds per lineal foot of wall length for level backfill conditions, where H is the height of the wall in feet. The resultant force should be assumed to act through the mid-height of the wall. An appropriately reduced factor of safety may be used when dynamic lateral earth forces are accounted for in the design of the retaining structures.

In general, a subdrain is recommended behind the segmental retaining wall structure to collect and discharge excess water that may infiltrate behind the wall structure. A typical subdrain would consist of a perforated pipe (with perforations down) enclosed by at least 12 inches of permeable drainage material, such as AASHTO M 43, No. 67 gradation). The perforated pipe should be directed to discharge into a proper drainage facility. The permeable drainage material should be wrapped in a non-woven filter fabric, such as Mirafi 180N or equivalent. Unless covered by concrete slabs, the upper 12 inches of backfill should consist of relatively impervious material (compacted on-site soils) to reduce the potential for significant water infiltration behind the retaining wall.

3.8.3 Overall Slope Stability

We have evaluated the overall slope stability of the wall structures planned for the project. Based on our analyses, the factor of safety for short-term and long-term stability of the segmental retaining wall is at least 1.5, which is the minimum factor of safety normally recommended. Based on our slope stability analyses, a minimum base width to wall height ratio of at least 0.80 is recommended for the segmental retaining wall structures planned at the project site.

3.8.4 Reinforced Fill and Backfill Materials

We believe that the reinforced fill material for the segmental retaining wall should consist of imported select granular fill materials. In general, the imported select granular fill materials should be well graded from coarse to fine with no particles larger than 3 inches in largest dimension. The material should also contain less than 15 percent particles passing the No. 200 sieve. The material should have a California Bearing Ratio (CBR) value of 25 or higher and a swell potential of one percent or less when tested in accordance with ASTM Test Designation D 1883.

In addition, the reinforced fill material (imported select granular fill materials) should have an angle of internal friction of at least 34 degrees when tested by the standard direct shear test (ASTM D 3080). The sample to be tested should be compacted to 95 percent relative compaction at moisture contents above the optimum.

Reinforced fill materials should be placed in level loose lifts not exceeding 8 inches in loose thickness and be compacted to at least 95 percent of the maximum dry density established in accordance with AASHTO T-180 Test Methods at moisture contents above the optimum.

3.9 Reinforced Soil Slopes

As discussed previously, we anticipate that steepened slopes with geotextile reinforcing retaining a fill condition would be required for grade separation on the west side of the existing viaduct structure. In general, we believe that fill slopes may be designed with slope inclinations up to one horizontal to one vertical (1H:1V), provided that the earth materials are reinforced with adequate layers of geogrids (or geotextiles) to strengthen the fill soils.

Geogrids are generally polymer grid structures with a tensile strength comparable to steel. It generally provides a cost-effective solution to slope stability problems, which may include the following: insufficient right-of-way, high surcharge loads, poor-quality fills, high seismic forces, steep slopes, or difficult landslide repairs. When geogrids are placed in soil, the grid geometry interlocks with the adjacent soil, creating a soil-geogrid composite with greatly enhanced engineering properties. Different grid configurations are available to provide optimum soil-grid interaction for a range of soil types and slope reinforcement applications. Reinforced slope geotextiles work in a similar manner to reinforced slope geogrids. The construction methodology is briefly described as follows.

As the slope is constructed, near-horizontal layers of geogrids are placed in the compacted fill at predetermined levels. The lengths of the geogrid layers are designed to anchor potential failure zones into stable interior sections of the embankment or hillside. As forces develop within a soil mass, the high-modulus geogrids are immediately pulled into tension. The geogrids transfer this tensile force from the unstable soil back into less-stressed portions of the slope, and stability is thus maintained.

We envision that imported select granular fill soils will be used for the reinforced earth fill embankment. Therefore, we believe that a friction angle of at least 34 degrees and a wet density of about 130 pounds per cubic foot (pcf) may be used for the design analyses of the reinforced earth slopes. A friction angle of 30 degrees and a wet density of 110 pcf may also be used for the foundation soils consisting of the stiff to very stiff clayey silt with gravel. In addition, we anticipate that general fills (such as the on-site materials) will be used for the fill materials in the areas between the reinforced fill and the existing slope. The reinforced soil slope layout and cross sections are presented on Plates 23 and 24.

In general, we recommend that the reinforced fill of the reinforced soil slope consist of imported select granular fill material, such as crushed coral, basalt, or cinder sand. The material should be well graded from coarse to fine with no particles larger than 3 inches in largest dimension. The material should have a California Bearing Ratio (CBR) value of 25 or higher and a swell potential of 1 percent or less when tested in accordance with ASTM Test Designation D 1883. In addition, the material should contain less than 15 percent particles passing the No. 200 sieve. The backfill materials should also have a Plasticity Index of less than 6 when tested in accordance with ASTM D 4318.

Based on the current design concept, we understand that the reinforced soil slope design should consider the loading from an additional 2 feet of fill on top of the finished grade for future highway improvements. Details pertaining to the recommended reinforcement lengths to provide for adequate short-term and long-term stability (minimum factor or safety of 1.3) are presented on Plate 23. In any case, the length of the geogrids should not be less than 6 feet for the heights of the reinforced soil slopes planned for the project. In addition, the keyway at the toe of the reinforced soil slope should be a minimum of 10 feet wide and 2 feet deep. A detail showing the reinforced soil slope cross section is provided on Plate 24 for reference.

The reinforced fill material (select granular fill) should have an angle of internal friction of at least 34 degrees when tested in accordance with the standard direct shear test (ASTM D 3080). The sample to be tested should be compacted to 95 percent relative compaction at a moisture content above the optimum moisture content. Fill materials for the reinforced earth slopes should be placed in loose lifts not exceeding 8 inches thick, moisture-conditioned to above the optimum moisture content, and compacted to at least 95 percent of the maximum dry density established in accordance with AASHTO T-180 test methods (ASTM D 1557).

In addition, we recommend that erosion control matting be used for erosion control of the steepened slope face. The erosion control matting may consist of multi-layered geosynthetic netting. The matting should allow grass or other natural ground cover to grow and take root through the matting. In general, the slope face should be properly graded and compacted. Materials such as rocks and vegetation that would interfere with the soil and the erosion control matting should be removed. The erosion control matting should be placed in accordance with the manufacturer's recommendations and supervision. Supervision by the manufacturer should be provided at the start up and initial installation. In general, the matting roll ends should be overlapped a minimum of 18 inches. The adjacent edges of the matting should be overlapped a minimum of 3 inches.

We also recommend that anchor trenches be installed prior to placing the erosion control matting. The anchor trenches should be a minimum of 8 inches deep and 8 inches wide. The anchor trenches should be properly backfilled and compacted to 95 percent relative compaction at a moisture content above the optimum moisture. The erosion control matting may be anchored at the overlaps by metal staples. The distribution of the staples should be a minimum of two per square yard (follow manufacturer's requirements). Wood anchors, such as pegs or stakes of any kind, which extend above the ground surface, should not be allowed.

3.10 Permanent Tieback Anchors

Based on a review of the as-built plans, the Austin Bishop Separation structure is supported entirely on a shallow foundation system bearing on the near-surface materials at the site. As indicated previously, the slopes on the north side of the Interstate Route H-1 Highway will be cut back to accommodate widening of the westbound lane of the highway. Due to the cut back of the existing slopes, the north abutment of the bridge structure will need to be underpinned or tied-back to support and restrain the structure and to allow the cut back of the northern slopes for the highway widening.

Based on our field exploration and review of the as-built plans, the subsurface conditions below the north abutment wall footing consist of stiff to very stiff residual soils extending to about 13 to 20 feet below the bottom of the footing. The residual soils are underlain by weathered basalt rock extending to the maximum depth explored. The anticipated subsurface conditions along the west and east sides of the structure alignment are presented on the Idealized Subsurface Profile A-A' and B-B' (Plates 26 and 27).

Based on the generally competent subsurface conditions anticipated and the current design concept, we recommend that a permanent tieback anchor system be used to provide the lateral support for the proposed widening project and to underpin the existing north abutment footing of the Austin Bishop Separation structure. In general, the permanent tieback anchor system will be designed to provide resistance to the lateral earth pressures below the existing footing and lateral pressures imposed from the heavily loaded existing north abutment footing. Based on the plans provided, the bottom of the existing north abutment footing is located at about +93 feet MSL. The finished grade of the westbound lane of the highway is about +91 feet MSL.

Lateral loads acting on the underpinned bridge structure may be resisted by frictional resistance developed between the bottom of the new foundation (underpinning block) and the bearing material. A coefficient of friction of 0.44 and 0.35 may be used to evaluate the sliding resistance of foundations bearing on the weathered basalt formation for the extreme event limit state and strength limit state, respectively. Resistance due to passive pressure for the existing footings and new underpinned foundations should be neglected because the abutment footing will be exposed. The following guidelines may be used in designing the permanent tieback system for this project.

3.10.1 Static Lateral Earth Pressures

The permanent tieback structure should be designed to resist lateral earth pressures due to the adjacent soils and surcharge effects. The recommended lateral earth pressures for design of retaining structures, expressed in equivalent fluid pressures of pounds per square foot per foot of depth (pcf), are presented below.

LATERAL EARTH PRESSURES FOR DESIGN OF RETAINING STRUCTURES			
Backfill Condition	Earth Pressure Component	Active (pcf)	At-Rest (pcf)
Level Backfill	Horizontal	40	58
	Vertical	None	None

The values provided above assume that the soil material around the tieback anchors is similar to the material encountered in the borings drilled in the area. Because the tops of walls are restrained, the walls should be designed for the at-rest condition. The active condition should only be used for gravity retaining walls or walls that are free to deflect by as much as 0.5 percent of the wall height. These lateral earth pressures do not include hydrostatic pressures that might be caused by groundwater trapped behind the walls.

Surcharge stresses due to areal surcharges, line loads, and point loads within a horizontal distance equal to the depth of the wall should be considered in the design. For uniform surcharge stresses imposed on the loaded side of the wall, a rectangular distribution with uniform pressure equal to 53 percent of the vertical surcharge pressure acting over the entire height of the wall, which is restrained, may be used in design. For walls that are free to deflect (cantilever), a rectangular distribution equal to 36 percent of the vertical surcharge pressure acting over the entire height of the wall may be used for design. Additional analyses during design may be needed to evaluate the surcharge effects of point loads and line loads.

3.10.2 Dynamic Lateral Earth Forces

Dynamic lateral earth forces due to seismic loading (a_{max}= 0.17g) may be estimated by using 6.5H^2 pounds per lineal foot of wall length for level backfill conditions, where H is the height of the wall in feet. It should be noted that the dynamic lateral earth forces provided assume that the wall will be allowed to move laterally by up to about 1.5 to 2 inches in the event of an earthquake. The resultant force should be assumed to act through the mid-height of the wall. An appropriately reduced factor of safety may be used when dynamic lateral earth forces are accounted for in the design of the retaining structures.

If the estimated amount of lateral movement is not acceptable, the retaining structure should be designed with higher dynamic lateral forces for a restrained condition. For a restrained condition (less than 0.5 inches of lateral movement), dynamic lateral forces due to seismic loading may be estimated using 11H^2 pounds per lineal foot of wall for level backfill conditions.

3.10.3 Construction Considerations

In order to provide temporary shoring during construction and for permanent lateral support, we envision that the permanent tieback anchor system will consist of the installation of two rows of tiebacks (top and bottom). The top tieback will connect to a concrete waler beam placed against the existing north abutment wall. The bottom tieback will connect to a concrete stressing block.

The top of the concrete stressing block is located directly below the existing abutment footing, and bottom of the stressing block is located at about Elevation +87 feet MSL (western half of the abutment) and at about Elevation +85.5 feet MSL (eastern half of the abutment). The concrete stressing block will provide the additional vertical support to the existing north abutment footing. Lateral resistance will be provided primarily through the tiebacks. Resistance due to passive earth pressure acting against the "L-shaped" stressing block should be neglected during construction.

The permanent tieback anchor system should be installed by a specialty contractor who has a minimum of five years of experience in tieback installation. Due to the specialized nature of the tieback anchor construction, observation and testing of the tieback anchor should be designated a "Special Inspection" item. Therefore, we recommend that a representative from Geolabs be present to observe the geotechnical aspects of the tieback anchor construction including observation and testing tiebacks.

3.11 Noise Barrier Walls

As previously indicated, approximately 1,400 lineal feet of noise barrier walls will be constructed on the north (mauka) side of the highway for the proposed widening project. In general, the noise barrier walls are distributed on the north (mauka) side of the highway as follows:

- Area 1 - West side of the Waimalu Viaduct (Sta. 95+76 to Sta. 102+21)
- Area 2 - East side of the Waimalu Viaduct (Sta. 125+04 to Sta. 132+50)

Based on the information provided, the noise barrier walls will be constructed near the edge of the State right-of-way adjacent to private properties or on the cut slopes on the north (mauka) side of the highway. We understand that the noise barrier walls will be supported on 24-inch cast-in-place concrete drilled shafts due to the relatively high loading requirements and the limited space for construction of a wide footing at the top of the slope. The drilled shaft foundation would provide the necessary support for vertical and lateral loads imposed on the planned noise barrier wall structures. The subsequent subsections address the design and construction of the drilled shaft foundations pertaining to the proposed noise barrier walls.

3.11.1 Foundations

Based on our field exploration, Area 1 is generally underlain by about 13 to 16 feet of residual soils over extremely to moderately weathered basalt formation extending to the maximum depths drilled of about 34 to 35 feet below the existing ground surface. Extremely weathered basalt formation was encountered in our borings at about Elevation +102 feet MSL. Our field exploration in Area 2 indicated that the extremely weathered basalt formation is present at relatively shallow depths of about 3 to 4 feet below the surface fill materials and extended to the maximum depths drilled of about 35 to 37 feet below the ground surface. Groundwater was not encountered in these borings during our field exploration.

Based on the generally competent subsurface conditions, we believe that the drilled shaft foundation for the proposed noise barrier walls would derive vertical support primarily from skin friction between the shaft and the surrounding soil. The compressive load capacities for the extreme event and strength limit states for the 24-inch diameter drilled shafts versus the length of the drilled shafts are presented in the following table.

Area	Length of Drilled Shaft (feet)	**Compressive Load Capacity Per Drilled Shaft**	
		Extreme Event Limit State (kips)	Strength Limit State (kips)
Area 1	10	12	8
	15	75	49
	20	138	89
Area 2	10	18	12
	15	113	73
	20	207	134

The compressive load capacities of the drilled shafts were computed generally based on the requirements contained in the AASHTO LRFD Bridge Design Specifications, Second Edition (1998). In order to arrive at the drilled shaft capacities for the strength limit state, a resistance factor of 0.65 has been applied to the extreme event limit state capacities for design of the drilled shaft foundations.

In general, the drilled shafts should be spaced a minimum of three times the diameter of the drilled shaft (measured from center-to-center) to avoid further reduction in vertical load capacity due to group action, interaction effects between adjacent shafts, and to facilitate drilling of the shaft holes.

Uplift loads may be resisted by a combination of the dead weight of the drilled shaft and by shear along the shaft surface and the adjacent soils. Considering that the drilled shafts are designed based on adhesion between the shaft and the surrounding soils, the recommended uplift capacity for the extreme event and strength limit states for the various lengths are presented in the following table.

Area	Length of Drilled Shaft (feet)	**Uplift Load Capacity Per Drilled Shaft**	
		Extreme Event Limit State (kips)	Strength Limit State (kips)
Area 1	10	11	8
	15	48	29
	20	85	51
Area 2	10	15	10
	15	69	41
	20	123	72

The uplift load capacities for the drilled shafts are based on the lengths of the drilled shafts designed for the compressive load capacities. In order to arrive at the drilled shaft uplift capacities for the strength limit state, a resistance factor of 0.55 has been applied to the extreme event limit state capacities for design of the drilled shaft foundations. In addition, a group uplift resistance factor of 0.55 has been applied to the values provided above. The uplift load capacities provided include the weight of the drilled shaft. The project structural engineer should check the structural capacity of the shaft member in tension when the drilled shaft foundation is used to resist uplift loads.

3.11.2 Lateral Load Resistance

Lateral loads imposed on the noise barrier wall foundations may be resisted by resistance of the shaft-soil system to deflect. Lateral load resistance of the drilled shaft is a function of the stiffness of the surrounding soil, the stiffness of the shaft, allowable deflection at the top of shaft, and induced moment in the shaft.

The computer program, Lpile plus, was used to calculate the lateral load resistance of the shafts. We envision that the relatively small shaft cap and/or concrete beam on top of the drilled shafts would not provide sufficient restraint from rotation at the top of shaft to achieve a fixed-head boundary condition. Therefore, we have estimated the lateral load resistance of the 24-inch drilled shaft under ¼-inch and ½-inch lateral deflection for the free head boundary condition only. The results of our analysis are summarized in the following table.

It should be noted that Geolabs should perform additional analyses and provide refinement of the lateral load analysis based on the actual loads, including axial load, lateral load, and moments, acting on the drilled shaft foundations.

Area	Length of Drilled Shaft (feet)	Allowable Lateral Deflection (inches)	Lateral Load Applied at Top (kips)	Maximum Moment Induced in Shaft (kip-ft)
Area 1	10	0.25	16.0	37.0 @ 4.5 ft depth
		0.50	19.3	45.0 @ 4.5 ft depth
	15	0.25	23.1	75.8 @ 6.5 ft depth
		0.50	29.5	101.7 @ 7.0 ft depth
	20	0.25	23.7	79.6 @ 6.5 ft depth
		0.50	32.8	125.8 @ 7.5 ft depth
Area 2	10	0.25	17.7	44.6 @ 4.7 ft depth
		0.50	21.4	54.6 @ 4.7 ft depth
	15	0.25	25.3	87.1 @ 6.5 ft depth
		0.50	33.4	123.3 @ 7.0 ft depth
	20	0.25	25.4	87.5 @ 6.0 ft depth
		0.50	35.5	138.3 @ 7.0 ft depth

3.11.3 Foundation Settlements

Settlement of the drilled shaft foundation will result from elastic compression of the shaft and subgrade response of the foundation embedded in the very stiff residual soils or the medium hard, extremely weathered basalt formations. Total settlements of the drilled shafts under the strength limit state loading conditions are estimated to be on the order of less than 0.5 inches. Differential settlements are estimated to be less than 0.25 inches. We believe that a significant portion of the settlement is elastic and should occur as the loads are applied. Post-construction foundation settlements should be less than 0.25 inches.

3.11.4 Construction Considerations

General guidelines for drilled shaft construction considerations and workmanship have been discussed in Subsections 3.1.4 and 3.1.5 of this report. As mentioned previously, the proposed noise barrier walls are located near the edge of the State right-of-way adjacent to private properties or on the cut slopes on the north (mauka) side of the highway. Therefore, it should be noted that there is limited space for construction activities at the location of the proposed noise barrier wall structures.

In addition, boulders and hard basalt formation may be encountered in the extremely weathered basalt formations at the site and should be expected during the drilled shaft excavation. Proper drilling methods should be used to advance the excavation of the drilled shafts to the design depths.

3.12 Site Grading

We anticipate that site grading consisting of cuts of up to about 20 feet and fills of up to about 18 feet will be required to achieve the design finished grades. In addition, deep foundation excavations and subsequent backfills of up to about 15 feet deep will be required for construction of the abutment and pier foundations. In general, grading work should conform to the Hawaii Standard Specifications for Road, Bridge, and Public Works Construction (1994) and the site-specific recommendations contained in this report. Items of site grading that are addressed in the subsequent subsections include the following:

- Cut and Fill Slope Design
- Site Preparation
- Fills and Backfills
- Fill Placement and Compaction Requirements
- Excavations

Site grading operations should be observed by qualified technical personnel. It is important that a qualified representative be present to observe the site preparation to evaluate whether undesirable materials are encountered during the excavation and scarification process, and whether the exposed soil/rock conditions are similar to those encountered in our exploration.

3.12.1 Cut and Fill Slope Design

Based on the subsurface conditions anticipated along the highway widening, we believe that the planned cut slopes will likely expose stiff to very stiff clayey silts with some gravel (weathered basalt formation). In general, we believe that a cut slope inclination of 2H:1V or flatter may be used for the design of the planned cut slopes for the highway widening project.

In general, permanent embankments constructed of the compacted on-site soils should also be designed with a slope inclination of 2H:1V or flatter. Fills to be placed on existing slopes with inclinations steeper than 5H:1V should be keyed and benched into the existing slope to provide stability of the new fill against sliding. The keyway at the bottom of fill slopes should be embedded at least 2 feet below the lowest adjacent grade and should have a minimum base width of 10 feet.

Excessive surface water runoff over the slope face may cause erosion of the exposed soils, thus jeopardizing the long-term stability and performance of the cut and fill slopes. Therefore, it is our opinion that slopes should be protected by appropriate slope planting or by other means, such as placement of geotextile fabrics on the slope face, as soon as practical after the slope is constructed.

3.12.2 Site Preparation

At the on-set of earthwork, areas within the contract grading limits should be thoroughly cleared and grubbed. It should be noted that portions of the existing terrain are heavily vegetated. Vegetation, debris, deleterious materials, and other unsuitable materials, should be removed and disposed of properly off-site to reduce the potential for contamination of the excavated materials.

Soft and yielding areas encountered during clearing and grubbing below areas designated to receive fill should be over-excavated to expose firm natural material, and the resulting excavation should be backfilled with well-compacted general fill. The excavated soft soils should be properly disposed of off-site.

In general, the over-excavated subgrades and areas designated to receive fills (exposing soils) should be scarified to a depth of about 8 inches, moisture-conditioned to above the optimum moisture content, and recompacted to a minimum of 90 percent relative compaction.

3.12.3 Fills and Backfills

The abutment and pier footings will be located at depths of about 10 to 15 feet below the existing ground surface. In general, backfills from the tops of footings to the finished grades may consist of compacted general fills. In general, the near-surface silty and clayey soils encountered during our field exploration should be suitable for use as general fill materials, provided that the maximum particle size is less than 6 inches in largest dimension. The on-site cut materials generated from excavations into the underlying weathered basalt formation may be used as general fill or backfill materials, provided that they are screened of the over-sized materials and/or processed to meet the above gradation requirements (less than 6 inches in largest dimension).

Imported material to be used as select granular fill should be non-expansive granular material, such as crushed coral, mudrock, basalt, or cinder sand. The select granular fill should be well graded from coarse to fine with no particles larger than 3 inches in largest dimension. The material should also contain less than 15 percent particles passing the No. 200 sieve. The material should have a laboratory CBR value of 25 or more and should have a maximum swell value of one percent or less. Imported fill materials should be tested for conformance with these recommendations prior to delivery to the project site for the intended use.

3.12.4 Fill Placement and Compaction Requirements

In general, fills and backfills should be moisture-conditioned to above the optimum moisture content, placed in level lifts not exceeding 8 inches in loose thickness, and compacted to at least 90 percent relative compaction. Fills and backfills within 3 feet of the pavement grade elevation should be compacted to a minimum of 95 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same soil determined in accordance with AASHTO T-180. Optimum moisture is the water content (percentage by dry weight) corresponding to the maximum dry density. Compaction should be accomplished by sheepsfoot rollers, vibratory rollers, or other types of acceptable compaction equipment. Water tamping, jetting, or ponding should not be allowed to compact the fills.

It should be noted that some of the on-site soils generally exist in a relatively moist to wet condition. Therefore, some moisture reduction may be required to achieve the minimum 90 percent compaction criteria, especially for materials primarily consisting of silts and clays. Aeration to lower the soil moisture and more compaction effort to achieve the specified compaction would generally reduce the rate of fill placement for this project. In addition, adequate stockpile areas may not be readily available on-site. Contractors proposing to work on this project should be encouraged to examine the site conditions and its limitations.

3.12.5 Excavations

Our site reconnaissance and field exploration program disclosed that the near-surface soils generally consist of stiff to very stiff clayey silts with some gravel. Weathered basalt rock formation and boulders may be encountered in deeper excavations and in localized areas along the project alignment. In general, it is our opinion that conventional heavy excavation equipment, such as a large bulldozer, excavator, or similar heavy construction equipment, may achieve the excavations into these materials. However, excavations into the harder areas will likely require the use of hoerams or chipping.

The method and equipment to be used for excavation should be determined by the contractor, subject to practical limits and safety considerations. The excavations should comply with all applicable local safety requirements. The above discussions regarding the rippability of the surface materials are based on field data obtained from our field reconnaissance and the borings performed at the subject site. Contractors proposing to work on this project should be encouraged to examine the site conditions to make their own interpretation.

3.13 Shoring

We anticipate that temporary excavations will be required for construction of the bridge foundations. Open-cut excavation may be desirable in shallow excavations, such as the abutment and some of the pier footing excavations, provided that the excavation may be setback away from existing on-grade and below-grade structures and utility lines. Based on the boring information, we believe that temporary cut slopes on the order of about 1H:1V or flatter may be used for open-cut excavations in the medium stiff to stiff silty soils anticipated at the project site. Excavated soils should not be stockpiled closer than a horizontal distance equal to the depth of the excavation from the edge of the excavation to reduce the potential for excessive ground movement.

We understand that some of the pier footings may be located close to structures and/or improvements such that open-cut excavations will not be practical. Therefore, these excavations will need to be adequately shored. Some of the possible shoring methods include a soldier pile and lagging shoring system and/or sheet piles. The excavation support and shoring system used must comply with applicable safety requirements, and the adequacy and safety of the shoring installation should be made the sole responsibility of the contractor. His/her representative, who should be required to be continuously present on site during excavation and construction work, will have the best opportunity to promptly observe changing conditions during construction, such as unforeseen subsurface conditions, unexpectedly high groundwater table, inappropriate construction sequence or techniques, etc., which may affect the shoring stability.

In general, some minor movements of the shoring system and the adjacent ground may still occur due to changes in earth stresses during excavation. Due to the complexity of the stress changes, it is difficult to accurately estimate the magnitude of movement. The magnitude also depends greatly upon workmanship, such as how quickly and tightly the shoring and bracing supports are installed, on the subsurface conditions, the size of the excavation, and the rate of excavation. Therefore, it is important to realize that the excavation shoring should be installed properly and as early as practical, if necessary, and that the adjacent ground should be continuously monitored for cracks, dips, and/or other indications of movements with instruments. It is recommended that a qualified geotechnical engineer and a structural engineer be retained by the contractor to design and evaluate the shoring system used.

3.14 Pavement Design

It should be noted that a Pavement Justification Report was prepared by our office for this project and has been transmitted separately. Therefore, detailed discussions pertaining to the design of the pavement structural sections for this project should be referred to the Pavement Justification Report prepared in support of the project.

3.15 Design Review

Final drawings and specifications for the proposed construction should be forwarded to Geolabs for review and written comments prior to advertisement for bids. This review is necessary to evaluate adherence of the plans and specifications with the intent of the foundation and earthwork recommendations provided herein. If this review is not made, Geolabs cannot assume responsibility for misinterpretation of the recommendations presented in this report.

3.16 Post-Design Services/Services During Construction

It is highly recommended that Geolabs be retained to provide geotechnical engineering support and continued services during construction of the proposed project. The items of construction monitoring that are critical requiring "Special Inspection" for this project include the following:

- Observation of the trial shaft installation
- Observation of the load test shaft installation and load testing
- Observation of the production drilled shaft installation
- Observation of the shallow foundation excavations
- Observation of the jet grouting test section
- Observation of the production jet grout columns
- Observation of the soil nail retaining wall installation and testing
- Observation of the segmental retaining wall construction
- Observation of the reinforced soil slope construction
- Observation of the permanent tieback anchors installation and testing
- Observation of the subgrade soil preparation

Other aspects of the earthwork construction should also be observed by a representative from Geolabs. This is to observe compliance with the intent of 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. The recommendations provided in this report are contingent upon such observations. If the actual subsurface conditions encountered during construction are different from those assumed or considered in this report, then appropriate modifications to the design should be made.

END OF DISCUSSION AND RECOMMENDATIONS

SECTION 4.0 - LIMITATIONS

The analyses and recommendations submitted in this report are based in part upon information obtained from field borings and a review of previous borings performed for the initial design of this portion of the highway. Variations of conditions between and beyond the field 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 in this report.

The locations of the field borings indicated in this report are approximate, having been estimated by taping from visible features shown on the topographic survey map provided by R.M. Towill Corporation on January 25, 2002 and January 9, 2003. Elevations of the borings were interpolated based on the contours and spot elevations shown on the same topographic maps. The locations and elevations of the field borings should be considered accurate only to the degree implied by the methods used.

The stratification breaks shown on the graphic representations of the borings depict the approximate boundaries between soil/rock types and, as such, may denote a gradual transition. Water level data from the borings 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 groundwater was not encountered in some of the borings at the time of our field exploration. However, it must be noted that fluctuation may occur due to variation in rainfall, perched groundwater conditions, stream water level, and other factors.

This report has been prepared for the exclusive use of R.M. Towill Corporation and their client, State of Hawaii - Department of Transportation, Highways Division, for specific application to the Interstate Route H-1 Widening, Waimalu Viaduct (Westbound) 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 engineers in the preparation of the design for the widening of the highway and viaduct structure project.

Therefore, this report may not contain sufficient data, or the proper information, for use to form the basis for preparation of construction cost estimates or contract bidding. A contractor wishing to bid on this project should retain a competent geotechnical engineer to assist in the interpretation of this report and/or performance of site-specific exploration for bid estimating purposes.

The owner/client should be aware that unanticipated soil conditions are commonly encountered. Unforeseen soil 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.

END OF LIMITATIONS

CLOSURE

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

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Plate 2	-	General Site Plan
Plates 3.1 thru 3.6	-	Site Plans
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Plate 5	-	Idealized Subsurface Profile (Sta. 104+00 to Sta. 124+00)
Plate 6	-	Idealized Subsurface Profile (Westbound) (Sta. 104+00 to Sta. 112+00)
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Respectfully submitted,

GEOLABS, INC.

By ______________________
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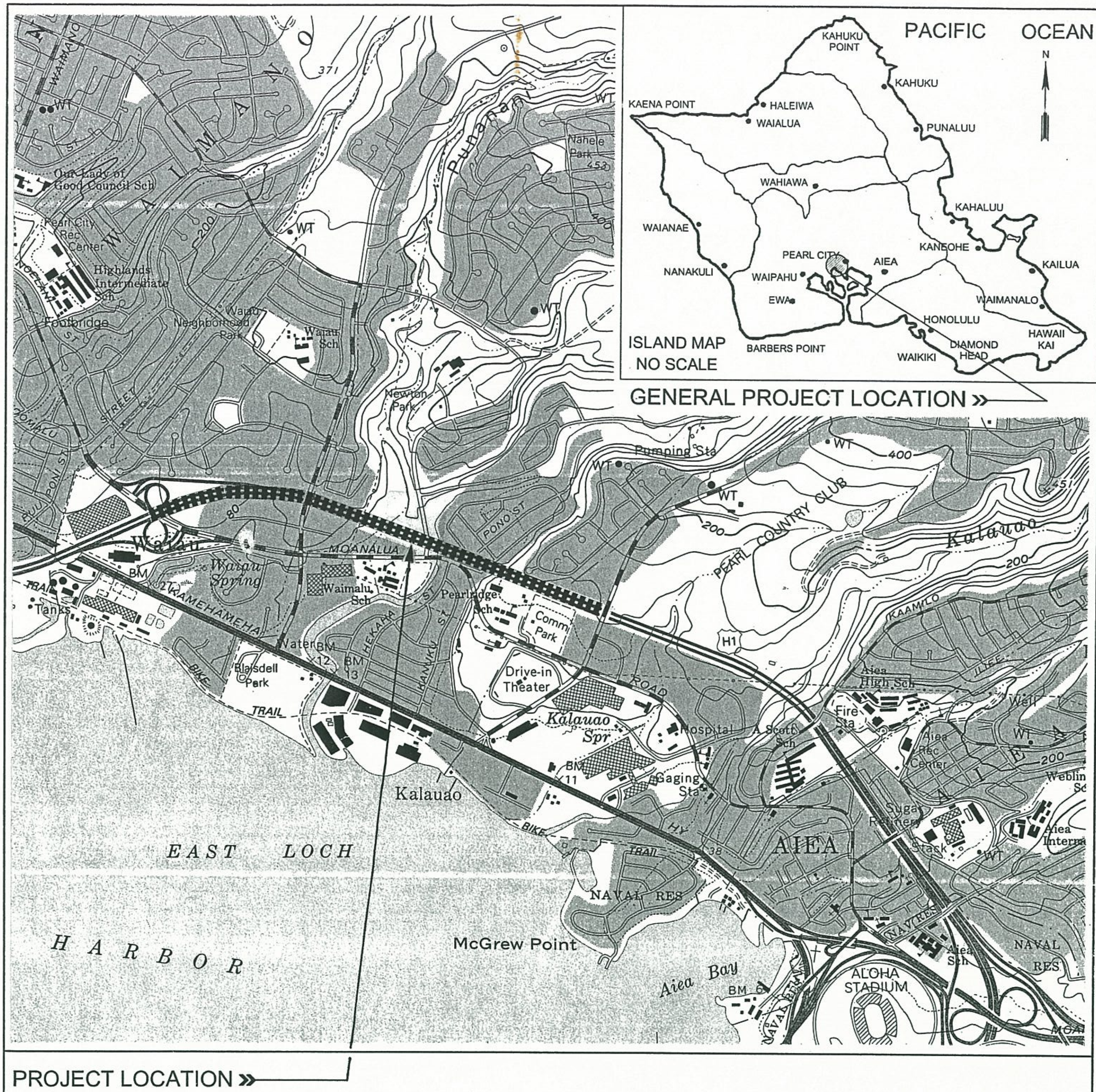
Vice President

RML:JC:as

(h:\4800 Series\4850-00B.jc2.pg.91)

PLATES



2000 1000 0 2000 FT.

GRAPHIC SCALE

N

REFERENCE: U.S.G.S. QUADRANGLE MAP; WAIPAHU, OAHU, HAWAII (1983).

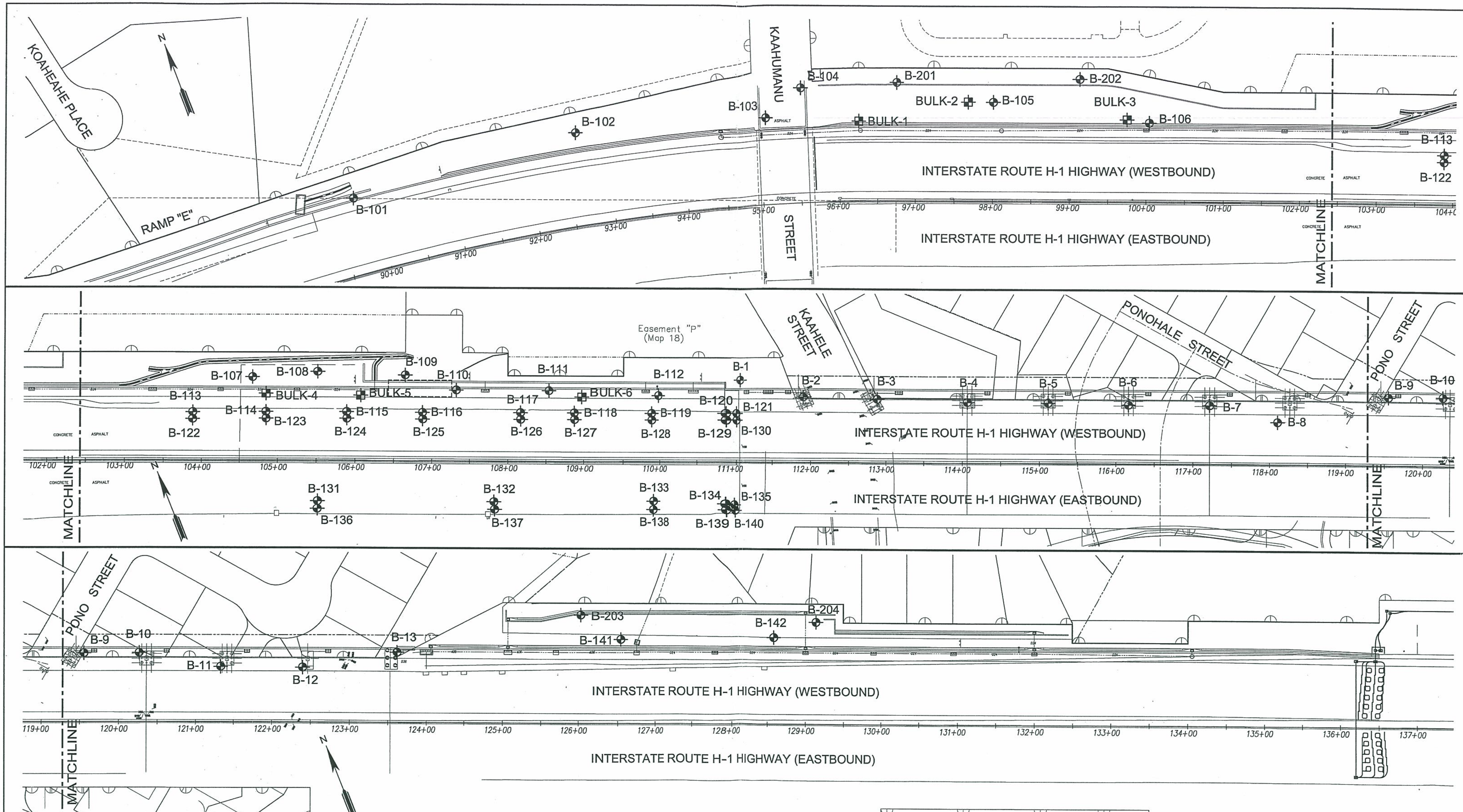
PROJECT LOCATION MAP

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.

Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	
SCALE	W.O.	
1" = 2,000'	4850-00(B)	1



LEGEND:

APPROXIMATE BORING LOCATION

APPROXIMATE BULK SAMPLE LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 60 120 240 360 FT.

GRAPHIC SCALE

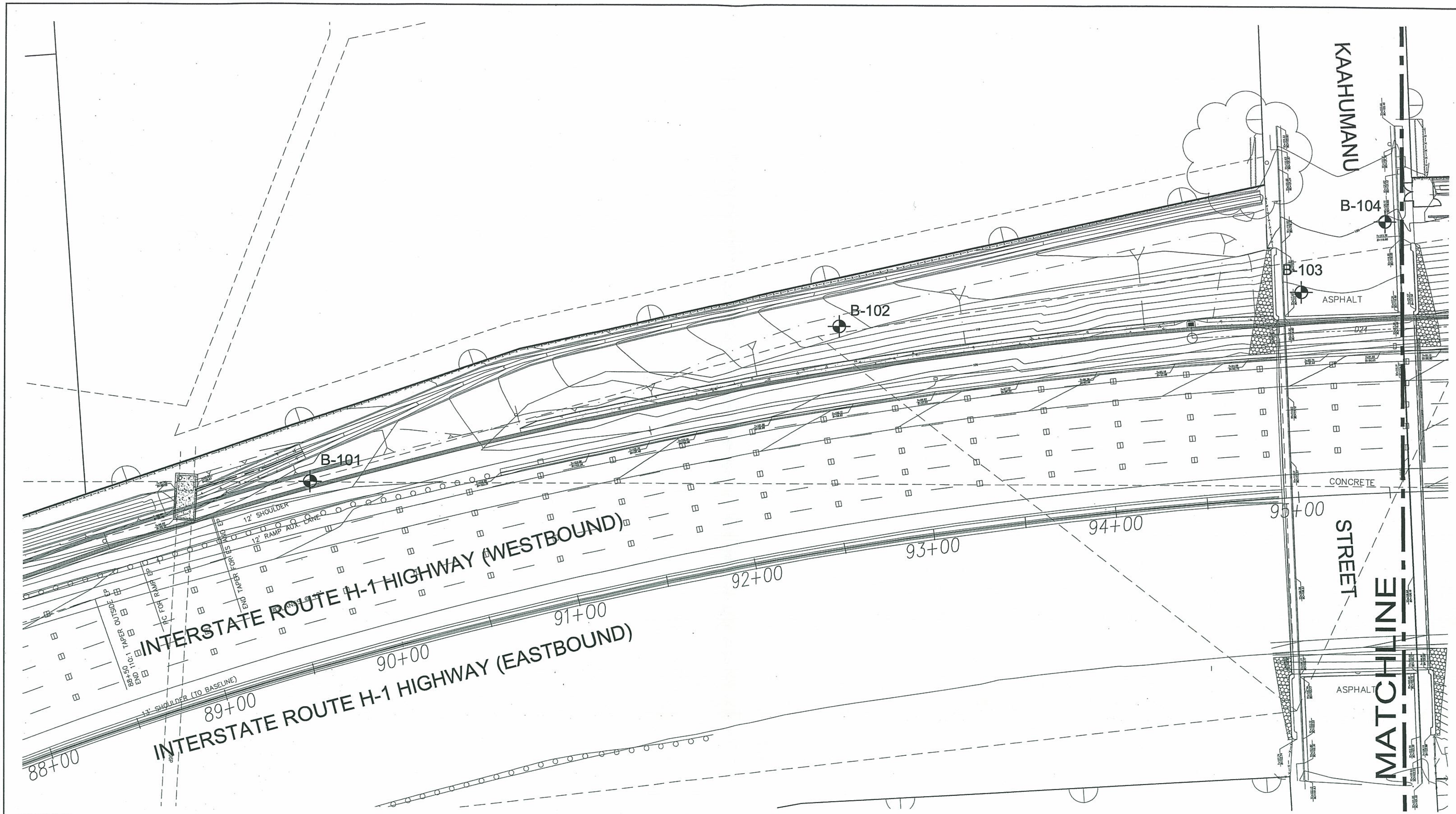
GENERAL SITE PLAN

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	2
SCALE	W.O.	
1" = 120'	4850-00(B)	

File: 4850-00(B)SitePlans.dwg Jan 27, 2003 - 10:33am



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 25 50 100 150 FT.
GRAPHIC SCALE

N

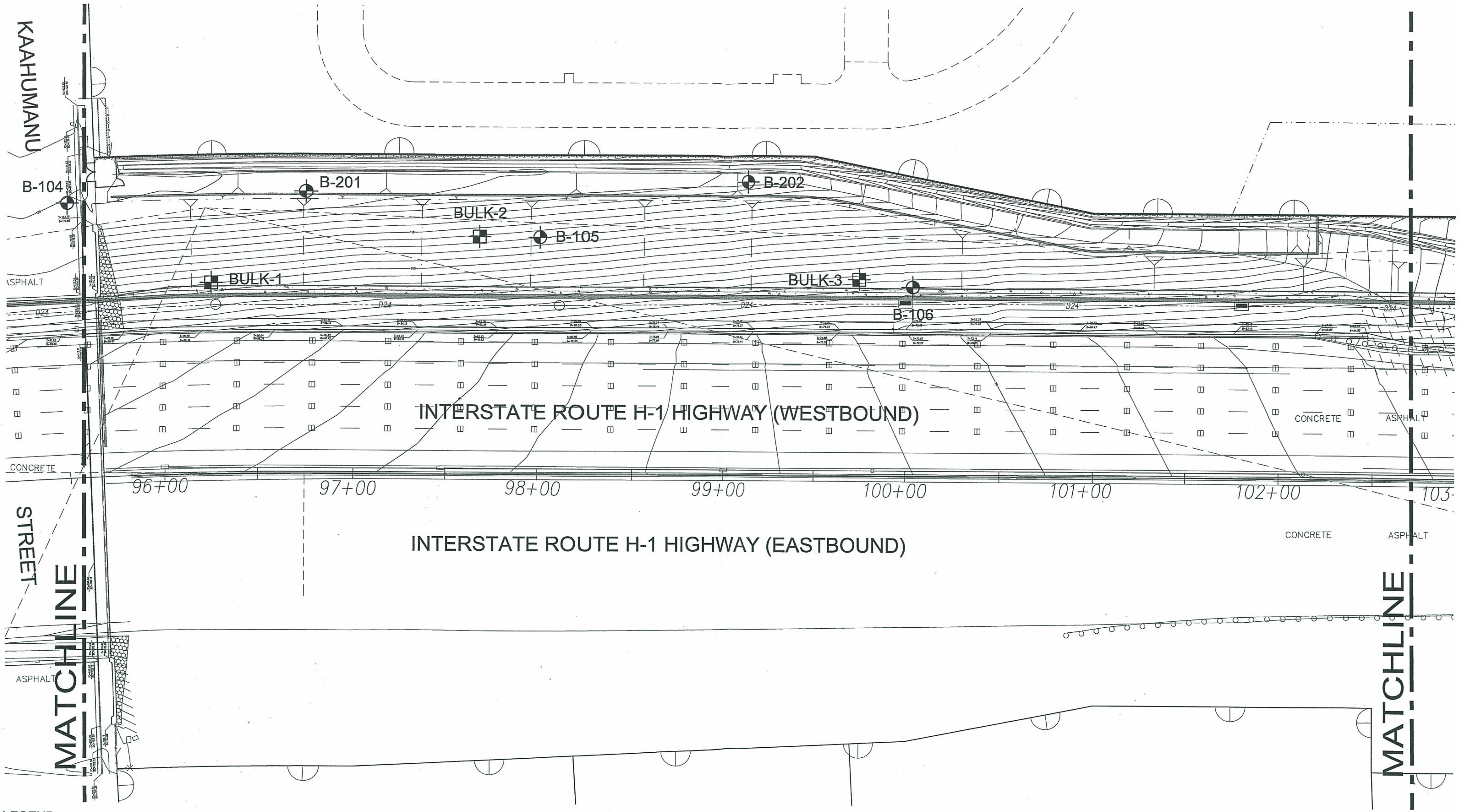
SITE PLAN

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	3.1
SCALE	W.O.	
1" = 50'	4850-00(B)	

File: 4850-00(B)SitePlans.dwg Jan 27, 2003 - 10:34am



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 25 50 100 150 FT.
GRAPHIC SCALE

N

SITE PLAN

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	
SCALE	W.O.	3.2
1" = 50'	4850-00(B)	

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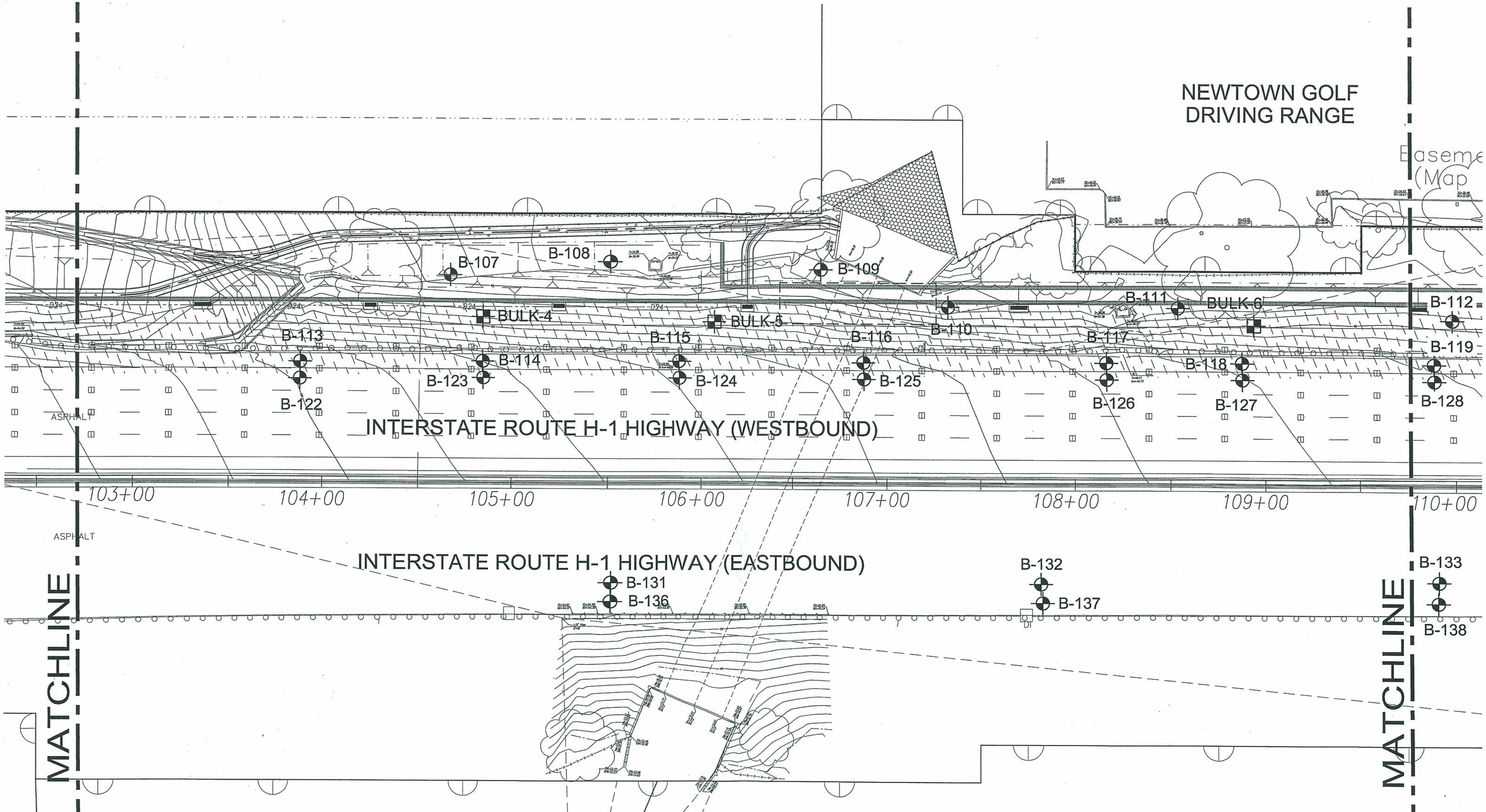


LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BULK SAMPLE LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 25 50 100 150 FT.
GRAPHIC SCALE

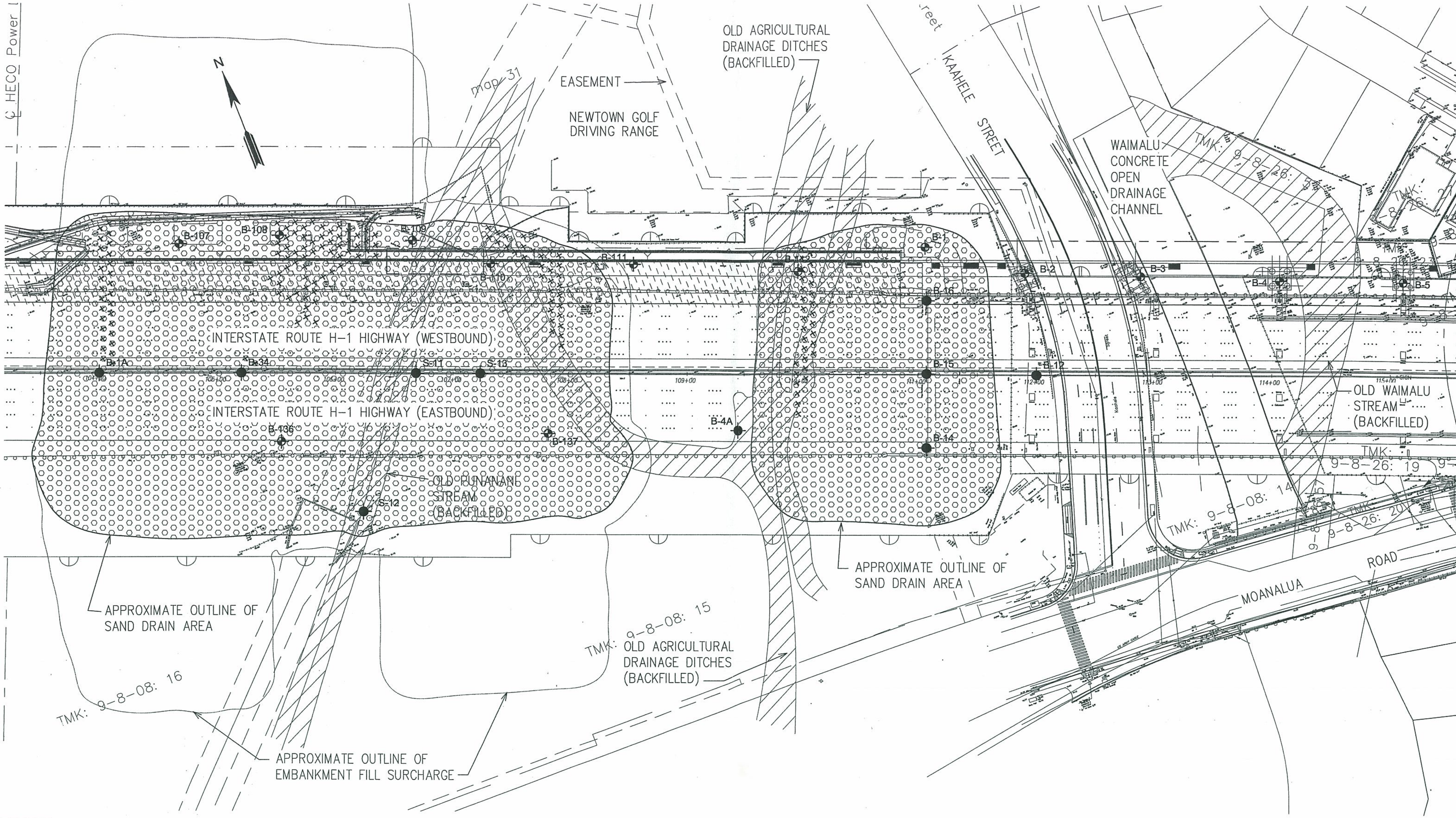
SITE PLAN

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	
SCALE	W.O.	
1" = 50'	4850-00(B)	3.3

File: 4850-00(B)SitePlans.dwg Jan 27, 2003 - 10:36am



LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BORING LOCATION (DRILLED IN 1967)

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL COPORATION CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 40 80 160 240 FT.
GRAPHIC SCALE

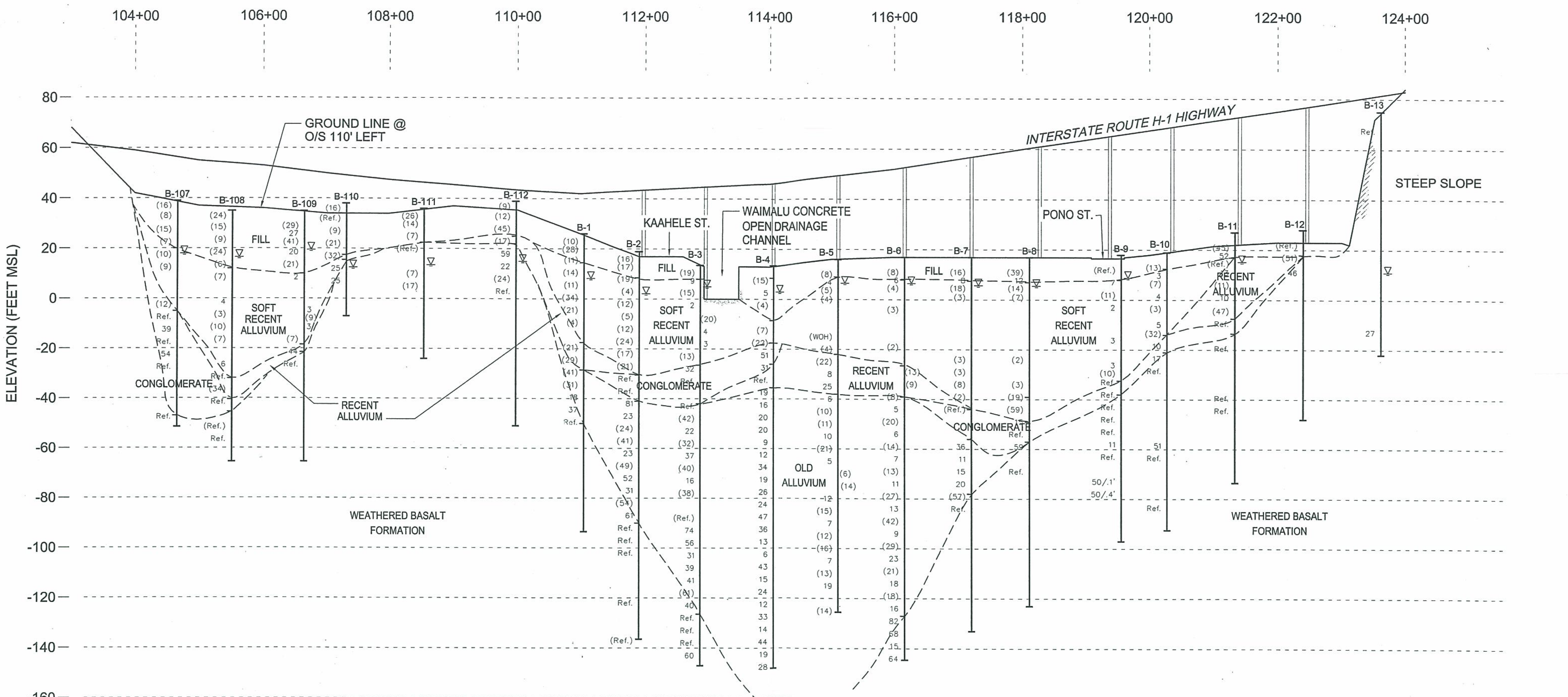
ORIGINAL GROUND FEATURES (STA. 103+50 TO STA. 115+50)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	4
SCALE	W.O.	
1" = 80'	4850-00	

File: 4850-00(B)OriginalGroundFeatures.dwg Jan 27, 2003 - 10:47am



IDEALIZED SUBSURFACE PROFILE
(STA. 104+00 TO STA. 124+00)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

LEGEND:

20 BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 2-INCH O.D. STANDARD PENETRATION SAMPLER

(20) BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 3-INCH O.D. MODIFIED CALIFORNIA SAMPLER

NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

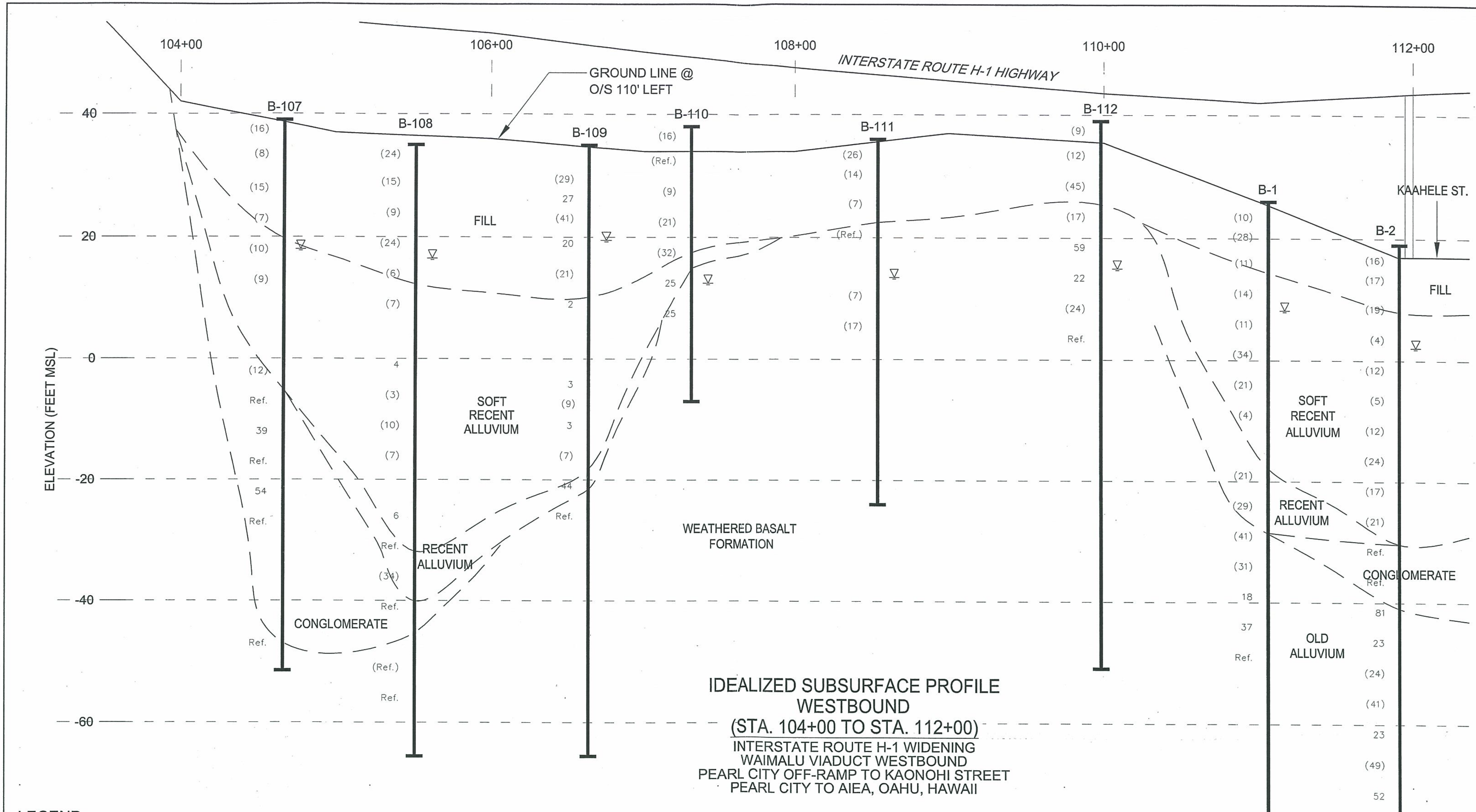
0 80 160 320 480 FT.
GRAPHIC SCALE (HORIZONTAL)

0 20 40 60 80 FT.
GRAPHIC SCALE (VERTICAL)

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	5
SCALE	W.O.	
AS SHOWN	4850-00(B)	

File: 4850-00(B)ProfilesWestbound.dwg Jan 16, 2003 - 4:54pm



IDEALIZED SUBSURFACE PROFILE
WESTBOUND
(STA. 104+00 TO STA. 112+00)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

LEGEND:

20 BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 2-INCH O.D. STANDARD PENETRATION SAMPLER

(20) BLOW COUNT REQUIRED FOR 12 INCHES OF PENETRATION OF A 3-INCH O.D. MODIFIED CALIFORNIA SAMPLER

NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

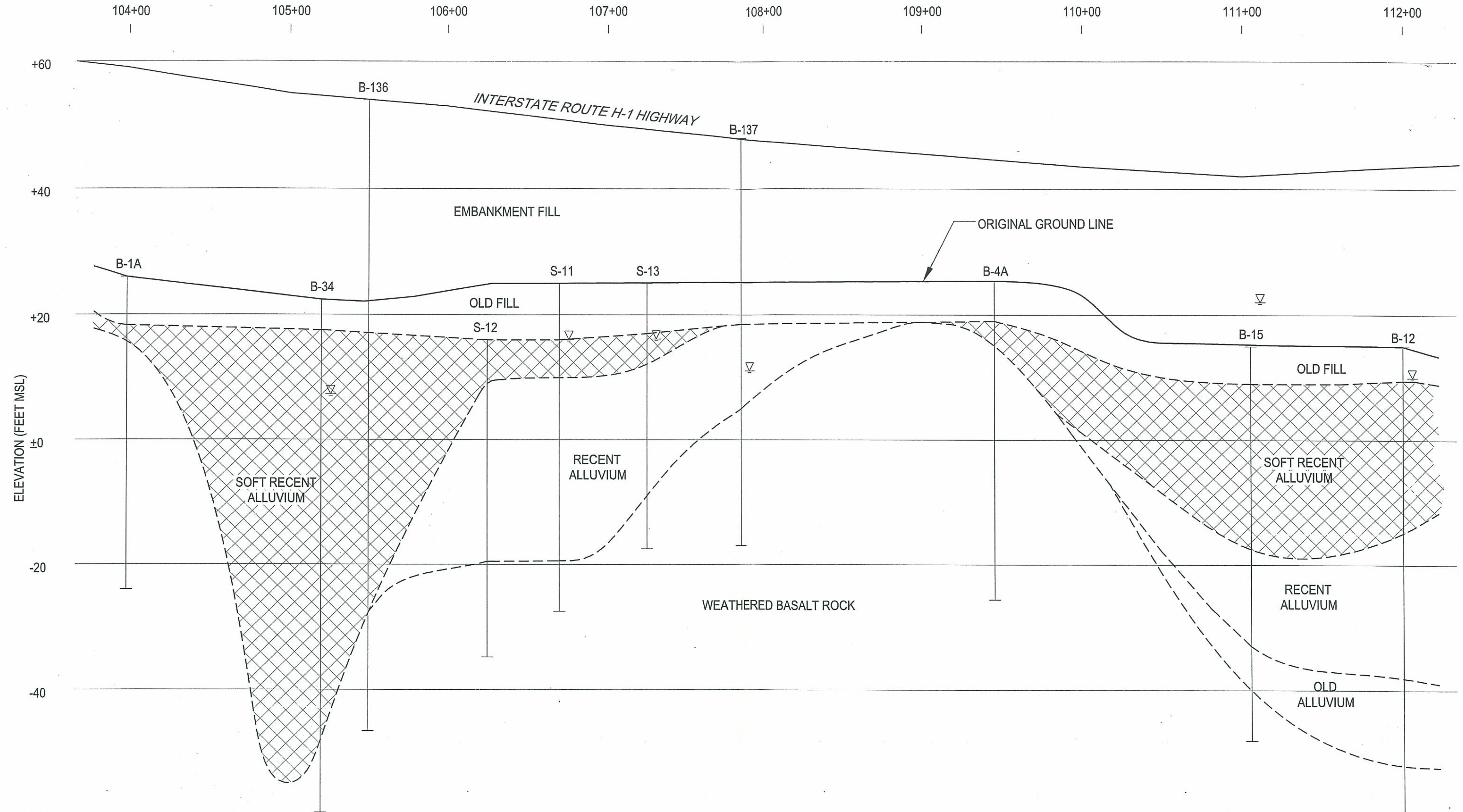
0 30 60 120 180 FT.
GRAPHIC SCALE (HORIZONTAL)

0 5 10 20 30 FT.
GRAPHIC SCALE (VERTICAL)

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	
SCALE	W.O.	6
AS SHOWN	4850-00(B)	

File: 4850-00(B)ProfilesWestbound.dwg Jan 16, 2003 - 4:57pm



0 30 60 120 180 FT.

GRAPHIC SCALE (HORIZONTAL)

0 15 30 45 FT.

GRAPHIC SCALE (VERTICAL)

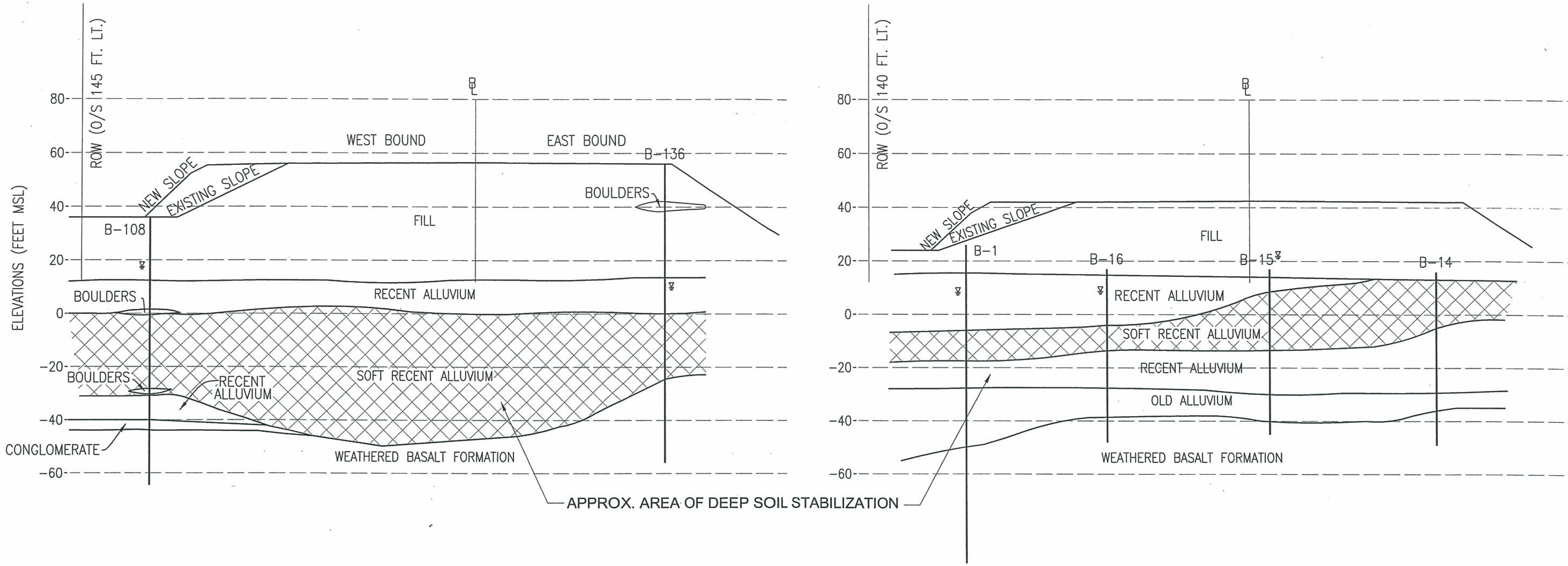
NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

IDEALIZED SUBSURFACE PROFILE
EASTBOUND
(STA. 104+00 TO STA. 112+00)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC. Geotechnical Engineering		
DATE: JANUARY 2003	DRAWN BY: KJD	PLATE
SCALE: HORIZ: 1" = 60' VERT: 1" = 15'	W.O.: 4850-00(B)	7

File: 4850-00(B)ProfileEastbound.dwg Jan 17, 2003 - 10:29am



IDEALIZED SUBSURFACE CROSS SECTION
(STA. 105+50)

IDEALIZED SUBSURFACE CROSS SECTION
(STA. 111+00)

IDEALIZED SUBSURFACE CROSS SECTIONS (STA. 105+50 AND STA. 111+00)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	8
SCALE	W.O.	
1" = 40'	4850-00(B)	

0 20 40 80 120 FT.
GRAPHIC SCALE

NOTE: THE CONDITIONS ILLUSTRATED ARE BASED ON OUR BORINGS AND GEOLOGICAL INTERPRETATIONS. WHILE THESE ARE BELIEVED TO BE GENERALLY CORRECT, THE CONDITIONS MAY VARY LOCALLY FROM THOSE INDICATED.

File: 4850-00(B)Plate8.dwg Jan 17, 2003 - 10:35am

SUMMARY OF FOUNDATION CONDITIONS AND CAPACITY FOR WAIMALU VIADUCT STRUCTURE

	Location	Abutment A	Pier 1	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	Abutment B
	Station	111+00	112+00	113+00	114+00	115+20	116+17	117+22	118+27	119+32	120+37	121+42	122+47	123+52
	Type of Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Pile Foundation	Spread Footing	Strip Footing
	No. of Piles in Footing	107	50	50	50	50	50	35	35	35	35	35	N/A	N/A
Elevation (feet, MSL)	Original Ground Elevation	+14.5	+15.0	+14.0	+12.0	+15.0	+16.0	+18.0	+18.5	+19.0	+20.5	+23.5	+27.0	+72.0
	Existing Ground Elevation	+35.0	+15.0	+14.0	+12.0	+15.0	+16.0	+18.0	+18.5	+19.0	+20.5	+23.5	+27.0	+84.0
	Bottom of Footing/ Pile Cut-off	+29.0	+3.0	-8.0	-8.0	+3.0	+6.0	+8.0	+8.0	+9.5	+12.0	+13.0	+17.0	+64.0 to +69.0
	As-Built Pile Tip	-27 to -35	-35 to -80	-34 to -128	-34 to -55	-40 to -70	-39 to -80	-46 to -70	-41 to -55	-50 to -100	-17 to -30	-4 to -20	N/A	N/A
	Thickness of Soft Soils (feet)	24	43	48	19	42	59.5	48	46	55	20	0	0	0
	Soil Profile Type (Seismic Analysis)	III	III	IV	III	III	IV	IV	IV	IV	III	I	I	I
Axial Compression Load Capacity	Original Design Pile Capacity	32 tons Per Pile	32 tons Per Pile	32 tons Per Pile	32 tons Per Pile	32 tons Per Pile	32 tons Per Pile	45 tons Per Pile	45 tons Per Pile	45 tons Per Pile	45 tons Per Pile	45 tons Per Pile	7 ksf Allowable Bearing Capacity	10 ksf Allowable Bearing Capacity
	Estimated Ultimate Pile Capacity	187 tons Per Pile	118 tons Per Pile	109 tons Per Pile	110 tons Per Pile	121 tons Per Pile	124 tons Per Pile	139 tons Per Pile	227 tons Per Pile	282 tons Per Pile	130 tons Per Pile	158 tons Per Pile	70 ksf Ultimate Bearing Capacity	75 ksf Ultimate Bearing Capacity
	Factored Capacity (Strength Limit State)	78 tons Per Pile	49 tons Per Pile	45 tons Per Pile	46 tons Per Pile	51 tons Per Pile	52 tons Per Pile	58 tons Per Pile	95 tons Per Pile	117 tons Per Pile	54 tons Per Pile	66 tons Per Pile	42 ksf Bearing Pressure	45 ksf Bearing Pressure
Longitudinal	Lateral Spring Stiffness (kips/in) (Pile Foundation)	N/A	1542	335	952	586	554	1100	489	492	743	1,331	N/A	
Transverse		N/A	1490	313	745	785	645	1005	491	460	408	1,662	N/A	

			Pier 11	Abutment B
Lateral Load Resistance (Shallow Foundation)	Sliding Resistance	Friction, $\tan\delta$	0.49	0.62
		Adhesion, c (psf)	Neglect	
	Ultimate Passive Resistance	Friction, $K_p \gamma$ (pcf)	440	500
		Cohesion, $2C\sqrt{(K_p)}$ (psf)	2000	Neglect

SUMMARY OF EXISTING PILE GROUP LATERAL LOAD ANALYSIS (EXTREME EVENT LIMIT STATE)

Location	No. of Pile in Footing	Column I.D.	Direction	Loading Information				ϕ16" Octagonal Concrete Pile Reaction Components			
				Axial	Lateral	Moment	Lateral Deflection	Compression	Tension	Maximum Moment	Depth
				(kips)		(kip-ft)	(inches)	(kips)		(kip-ft)	(feet)
Abutment A	107	N/A	Longitudinal	Loading does not govern							
Bent 1	50	A-D	Longitudinal	1990	-586	-5183	-0.38	91	-26	-24	4
		B	Transverse	2160	-432	-6686	-0.29	74	0	-24	5
Bent 2	50	A-D	Longitudinal	2540	-439	-6062	-1.31	102	-16	-38	9
		B	Transverse	2363	-432	-6686	-1.38	79	0	-43	9
Bent 3	50	A-D	Longitudinal	1661	-238	-8777	-0.25	85	-46	-9	5
		B	Transverse	2094	-432	-6686	-0.58	75	0	-30	7
Bent 4	50	A-D	Longitudinal	2051	-604	-4950	-1.03	91	-24	-41	7
		B	Transverse	2020	-432	-6686	-0.55	71	0	-29	7
Bent 5	50	A-D	Longitudinal	1815	-543	-5052	-0.98	85	-28	-39	7
		B	Transverse	2019	-432	-6686	-0.67	70	0	-33	7
Bent 6	35	A-D	Longitudinal	1372	-187	-6383	-0.17	96	-45	-8	3
		B	Transverse	1895	-432	-6686	-0.43	97	-33	-32	5
Bent 7	35	A-D	Longitudinal	1710	-465	-4714	-0.95	104	-34	-38	7
		B	Transverse	1909	-432	-6686	-0.88	104	-26	-38	7
Bent 8	35	A-D	Longitudinal	1936	-438	-4874	-0.89	114	-22	-37	7
		B	Transverse	1910	-432	-6686	-0.94	109	-20	-40	7
Bent 9	35	A-D	Longitudinal	1376	-156	-6591	-0.21	90	-48	-7	4
		B	Transverse	1852	-432	-6686	-1.06	92	-41	-42	7
Bent 10	35	A-D	Longitudinal	1850	-426	-4951	-0.32	94	-49	-20	4
		B	Transverse	1929	-432	-6686	-0.26	92	-37	-23	4

Remarks: Loading information was provided by KSF, Inc. dated October 28, 2002 and revised on October 31, 2002;

SUMMARY OF DRILLED SHAFT FOUNDATION RESISTANCE RECOMMENDATIONS

Location	Approx. Ground Elevation	Approx. Bottom of Footing Elevation	Drilled Shaft Diameter	No. of Drilled Shaft in Footing	Estimated Tip of Permanent Casing	Drilled Shaft Embedment	Estimated Tip of Drilled Shaft	Estimated Steel Casing Length	Estimated Drilled Shaft Length	Compressive Load Capacity Per Drilled Shaft			Uplift Load Capacity Per Drilled Shaft	
										Unfactored	Extreme Event Limit State	Strength Limit State	Extreme Event Limit State	Strength Limit State
	(feet MSL)		(feet)		(feet MSL)	(feet)	(feet MSL)	(feet)		(kips)				
Abutment A	+35.5	+28.5	4.0	7	-21	45	-65	49	94	1900	1230	**800**	1040	570
Pier 1	+19.0	+7.6	5.0	4	-28	54	-82	36	90	2150	**1400**	910	1160	630
Pier 2	+14.0	+4.8	5.0	6	-30	55	-84	34	89	2000	1300	**850**	**1100**	600
Pier 3	+13.0	+4.2	5.0	4	-21	63	-84	25	88	2120	**1380**	900	1160	630
Pier 4	+16.0	+7.2	5.0	4	-36	76	-112	43	119	2600	**1690**	1100	1430	780
Pier 5	+17.0	+8.6	5.0	4	-32	64	-96	41	105	2120	**1380**	900	1160	630
Pier 6	+17.0	+9.0	5.0	4	-47	45	-92	56	101	1900	**1230**	800	1040	570
Pier 7	+17.0	+7.0	5.0	4	-52	29	-81	59	88	1900	**1230**	800	1040	570
Pier 8	+18.0	+7.5	5.0	4	-36	41	-76	43	84	2120	**1380**	900	1160	630
Pier 9	+19.0	+11.1	4.0	4	-17	35	-52	28	63	1530	1000	**650**	840	460
Pier 10	+27.0	+19.0	5.0	4	N/A	46	-27	N/A	46	1900	1230	**800**	1040	570
Pier 11	+28.0	+18.0	Spread Footing											
Abutment B	+75.0	+64.0	4.0	6	N/A	46	**18**	N/A	46	3100	2000	1300	1700	930

Remarks:
1 Assuming top of the permanent steel casing is located at bottom of footing;
2 Assuming the permanent steel casing is installed below the soft soil or loose sandy soil and extend about 3 feet into the firm/dense material below the soft soil layer.

SUMMARY OF DRILLED SHAFT GROUP LATERAL LOAD ANALYSIS (STRENGTH LIMIT STATE)

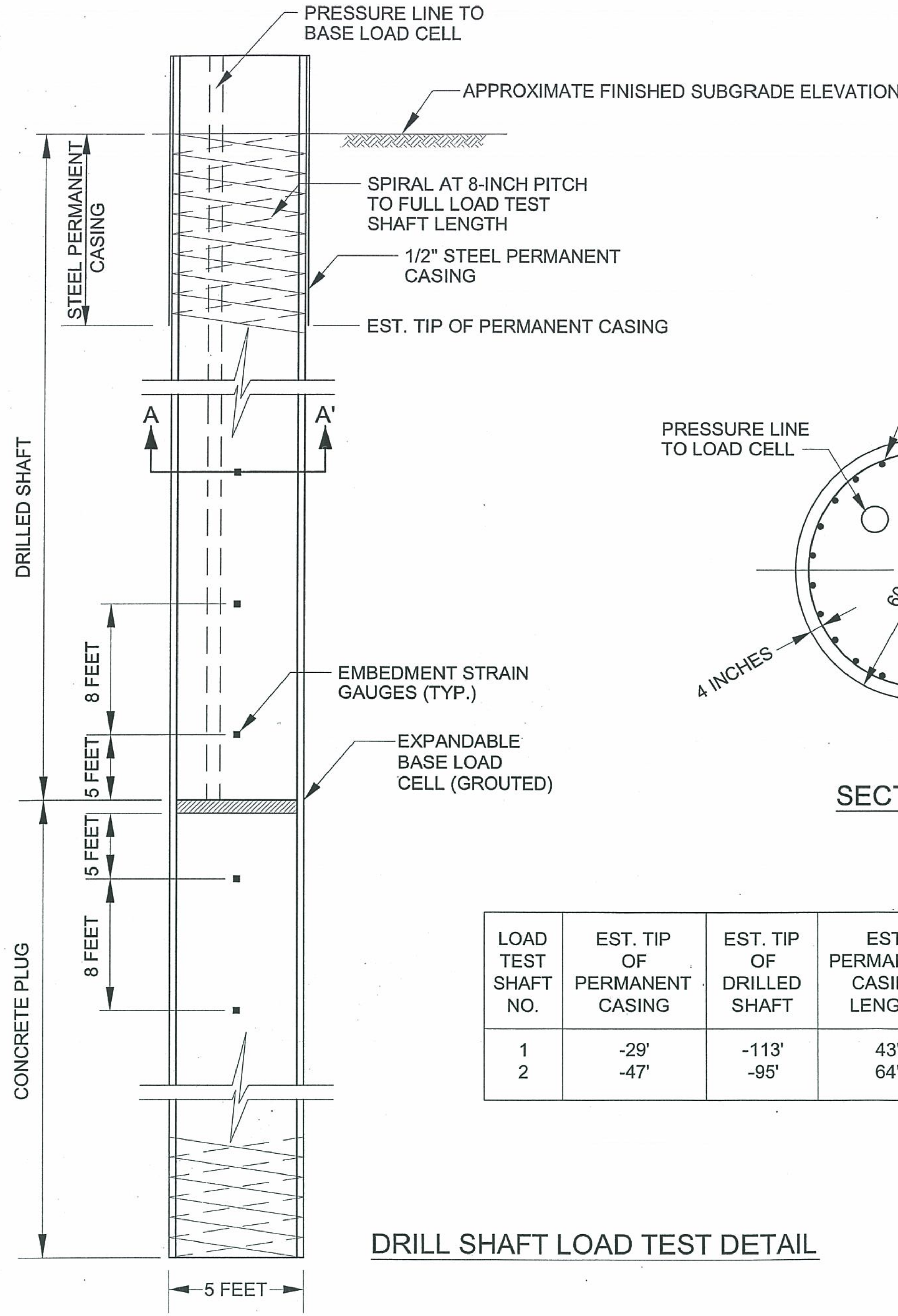
Location	No. of Drilled Shaft in Footing	Condition	Direction	Loading Information			Deflection		Drilled Shaft Reaction Components			
				Axial	Lateral	Moment	Vertical	Horizontal	Maximum Compression	Maximum Uplift	Maximum Moment	Depth
				(kips)		(k-ft)	(inches)		(kips)		(k-ft)	(feet)
Abutment A	7	Strength I	Longitudinal	2000	310	3980	0.00	0.206	745	-80	321	18
Bent 1	4	Maximum	Longitudinal	2674	49	2200	0.08	0.02	597	0	176	2
		Minimum		1586	-169	-531	0.06	-0.05	478	0	146	0
		Maximum	Transverse	2674	0	30	Loading case does not govern design					
		Minimum		1586	0	30						
Bent 2	6	Maximum	Longitudinal	3152	149	1017	0.15	-0.09	815	0	-780	0
		Minimum		1962	-7	-2045	0.08	-0.06	560	0	-515	0
		Maximum	Transverse	3152	0	-161	Loading case does not govern design					
		Minimum		1962	0	-161						
Bent 3	4	Maximum	Longitudinal	2010	5	2094	0.06	0.02	425	0	133	0
		Minimum		1210	-26	-344	0.03	-0.01	285	0	-27	20
		Maximum	Transverse	2010	0	-228	0.07	0.00	491	0	-14	0
		Minimum		1210	0	-1736	0.04	-0.01	312	0	-83	0
Bent 4	4	Maximum	Longitudinal	2594	-35	3137	0.07	0.01	574	0	276	0
		Minimum		1487	-202	359	0.05	-0.04	441	0	238	0
		Maximum	Transverse	2594	0	1720	0.07	0.01	604	0	152	0
		Minimum		1487	0	-425	0.04	0.00	381	0	-48	0
Bent 5	4	Maximum	Longitudinal	2597	182	741	0.08	0.07	559	0	177	19.26
		Minimum		1490	12	-2287	0.05	-0.01	431	0	-189	0
		Maximum	Transverse	2597	0	1731	0.08	-0.01	609	0	181	0
		Minimum		1490	0	-413	0.04	0.00	382	0	-47	0
Bent 6	4	Maximum	Longitudinal	1941	6	2165	0.07	0.02	433	0	222	0
		Minimum		1160	-31	-585	0.03	-0.01	283	0	-32	14
		Maximum	Transverse	1941	0	182	0.07	0.00	482	0	29	0
		Minimum		1160	0	-1328	0.04	-0.01	324	0	-121	0
Bent 7	4	Maximum	Longitudinal	2634	-26	3104	0.10	0.02	590	0	314	0
		Minimum		1517	-157	361	0.06	-0.04	422	0	142	0
		Maximum	Transverse	2634	0	1530	0.10	0.01	624	0	166	0
		Minimum		1517	0	-612	0.05	0.00	391	0	-78	0
Bent 8	4	Maximum	Longitudinal	2924	140	959	0.10	0.03	665	0	132	10
		Minimum		1732	4	-2180	0.06	-0.01	483	0	-224	0
		Maximum	Transverse	2924	0	-8	Loading case does not govern design					
		Minimum		1732	0	-8						
Bent 9	4	Maximum	Longitudinal	1956	0	2004	0.09	0.02	433	0	154	0
		Minimum		1161	-22	-368	0.05	0.00	304	0	-38	1
		Maximum	Transverse	1956	0	-326	0.09	0.00	496	0	-35	0
		Minimum		1161	0	-1838	0.06	-0.01	341	0	-144	0
Bent 10	4	Maximum	Longitudinal	2634	-13	3112	0.07	0.00	732	0	304	0
		Minimum		1510	-137	221	0.04	-0.01	408	0	-65	12
		Maximum	Transverse	2634	0	1515	0.07	0.00	693	0	-166	0
		Minimum		1510	0	-629	0.04	0.00	390	0	-80	0
Abutment B	6	Strength I	Longitudinal	2000	310	3980	0.078	0.00	348	0	-137	9

Remarks: Loading information was provided by KSF, Inc. dated November 21, 2002;

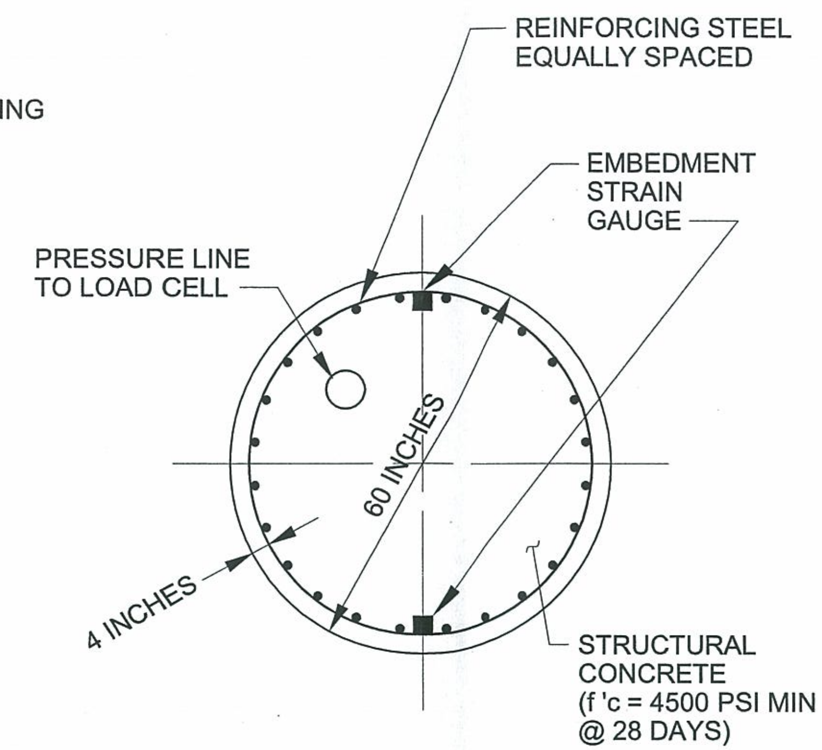
SUMMARY OF DRILLED SHAFT GROUP LATERAL LOAD ANALYSIS (EXTREME EVENT LIMIT STATE)

Location	No. of Drilled Shaft in Footing	Condition	Direction	Loading Information				Drilled Shaft Reaction Components			
				Axial	Lateral	Moment	Lateral Deflection	Maximum Compression	Maximum Uplift	Maximum Moment	Depth
				(kips)		(k-ft)	(inches)	(kips)		(k-ft)	(feet)
Abutment A	7	EE I	Longitudinal	1560	620	4840	0.49	825	-305	1042	0
Bent 1	4	1.3D + Sx	Longitudinal	2248	-806	-6314	-1.44	1360	-239	2342	0
		1.3D - Sx		2040	858	7052	1.61	1390	-370	-2592	0
		1.3D + Sz	Transverse	2118	-293	-3599	-0.23	793	0	349	0
		1.3D - Sz		2170	267	5777	0.23	861	0	298	23
Bent 2	6	1.3D + Sx	Longitudinal	2674	-856	-8529	-3.67	1150	-1070	-3600	39
		1.3D - Sx		2745	727	10539	0.42	634	0	-1683	0
		1.3D + Sz	Transverse	2952	-723	-14270	-0.97	1130	-573	1708	0
		1.3D - Sz		2466	739	16502	1.02	1130	-714	-1750	0
Bent 3	4	1.3D + Sx	Longitudinal	2009	-369	-7227	-0.26	881	0	-485	22
		1.3D - Sx		991	364	7139	0.24	632	-144	459	23
		1.3D + Sz	Transverse	2529	-1000	-10000	-1.99	1310	-46	-3050	27
		1.3D - Sz		471	1000	10000	1.00	1070	-831	-2067	0
Bent 4	4	1.3D + Sx	Longitudinal	2352	-814	-8331	-1.03	1400	-225	1900	0
		1.3D - Sx		1681	967	8850	1.34	1390	-553	-2583	0
		1.3D + Sz	Transverse	2570	-965	-9030	-1.37	1620	-330	2525	0
		1.3D - Sz		1464	987	8819	1.38	1360	-626	-2675	0
Bent 5	4	1.3D + Sx	Longitudinal	1936	-870	-8780	-1.21	1340	-375	2017	0
		1.3D - Sx		2107	709	7925	0.69	1170	-120	-1125	0
		1.3D + Sz	Transverse	2266	-282	-3129	-0.15	785	0	-304	19
		1.3D - Sz		1777	315	3078	0.16	684	0	308	21
Bent 6	4	1.3D + Sx	Longitudinal	1987	-420	-10895	-0.35	1020	-26	-650	16
		1.3D - Sx		1054	415	10726	0.32	789	-262	595	18
		1.3D + Sz	Transverse	2483	-700	-10000	-1.41	1190	0	-1575	24
		1.3D - Sz		559	700	10000	0.65	830	-551	-875	0
Bent 7	4	1.3D + Sx	Longitudinal	2618	-813	-14604	-3.07	1100	0	-3367	19
		1.3D - Sx		1701	909	15498	2.88	1090	-242	2883	23
		1.3D + Sz	Transverse	3059	-731	-12782	-2.71	1100	0	-3217	17
		1.3D - Sz		1259	791	13083	1.63	1010	-379	1767	24
Bent 8	4	1.3D + Sx	Longitudinal	2053	-1000	-13000	-3.09	1340	-310	-2833	32
		1.3D - Sx		2297	1000	13000	3.31	1350	-206	3058	31
		1.3D + Sz	Transverse	2220	-378	-13819	-0.39	1190	-76	-732	20
		1.3D - Sz		2129	348	13405	0.38	1130	-66	689	18
Bent 9	4	1.3D + Sx	Longitudinal	1830	-15	-803	-0.01	482	0	-68	0
		1.3D - Sx		997	15	819	0.01	275	0	70	0
		1.3D + Sz	Transverse	2499	-600	-2212	-2.42	707	0	-1892	17
		1.3D - Sz		328	610	2217	0.58	485	-321	-1100	0
Bent 10	4	1.3D + Sx	Longitudinal	2113	-507	-9541	-0.55	954	0	-1288	16
		1.3D - Sx		1302	611	10873	0.39	934	-283	1008	20
		1.3D + Sz	Transverse	2512	-666	-14968	-1.61	1040	0	-3000	14
		1.3D - Sz		902	779	15058	0.79	975	-524	1825	20
Abutment B	6	EE I	Longitudinal	1560	620	4840	0.07	271	0	658	5

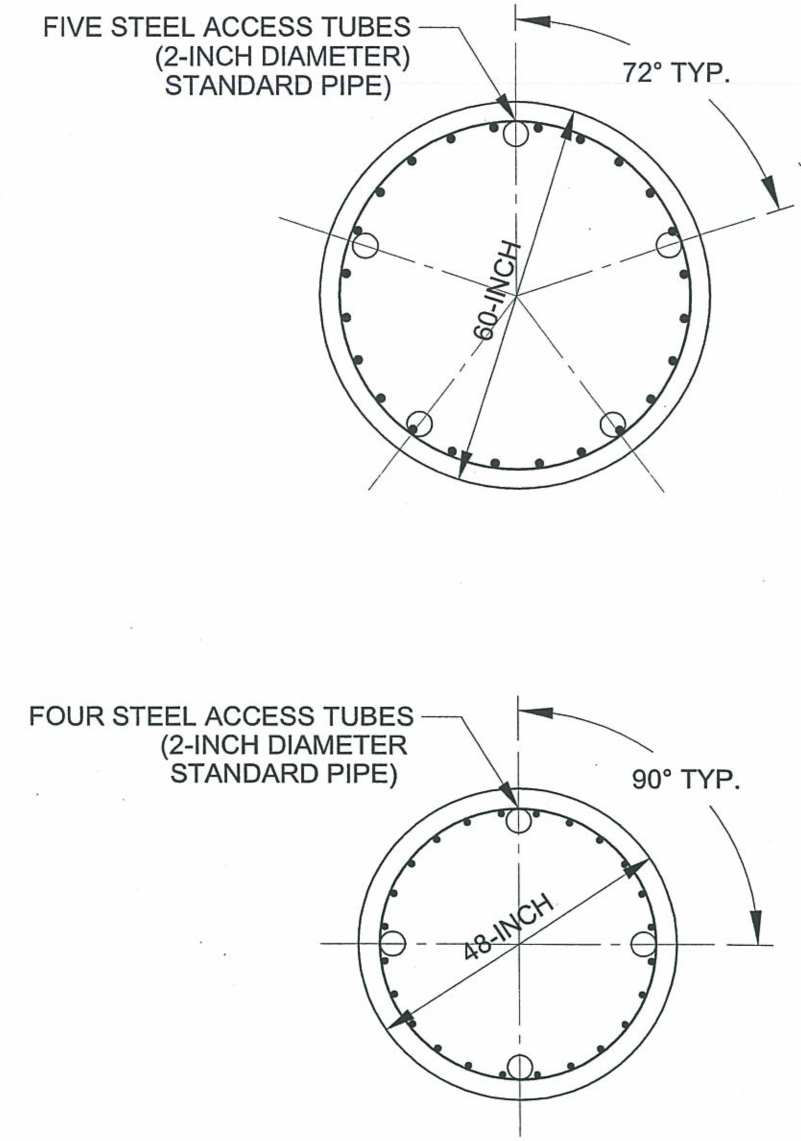
Remarks: Loading information was provided by KSF, Inc. dated October 11, 2002 and revised October 23, 2002;



DRILL SHAFT LOAD TEST DETAIL



SECTION A-A'



ACCESS TUBE DETAIL FOR CROSS HOLE SONIC LOGGING TEST

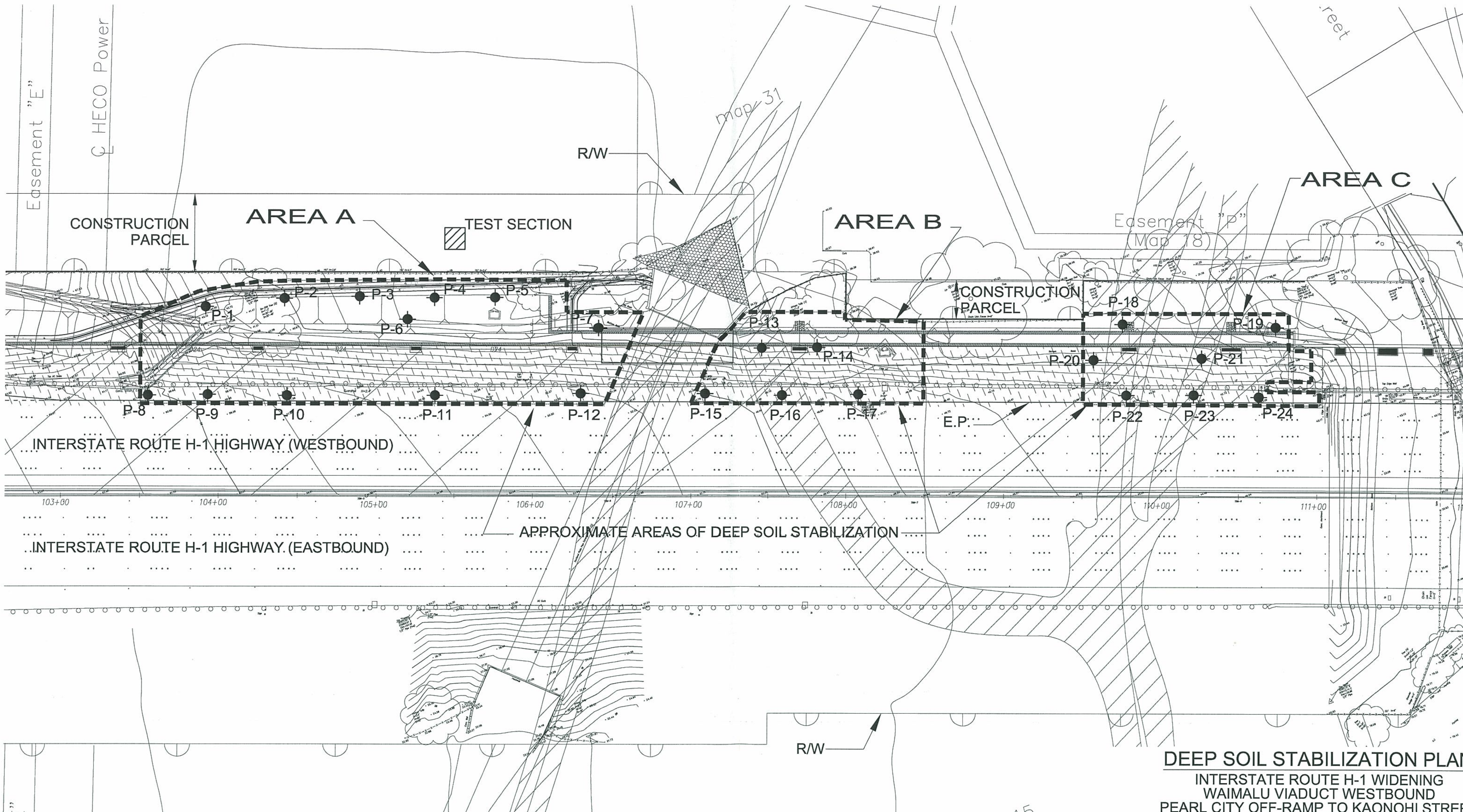
LOAD TEST SHAFT NO.	EST. TIP OF PERMANENT CASING	EST. TIP OF DRILLED SHAFT	EST. PERMANENT CASING LENGTH	EST. DRILLED SHAFT LENGTH	EST. CONCRETE PLUG LENGTH	TOTAL NO. OF EMBEDMENT STRAIN GAUGE
1	-29'	-113'	43'	127'	40'	36
2	-47'	-95'	64'	112'	30'	26

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KJD	
SCALE	W.O.	
NOT TO SCALE	4850-00(B)	14

File: 4850-00(B)NewDrillShaft-FINALplate13.dwg Jan 17, 2003 - 10:39am



LEGEND:

- APPROXIMATE TEST PROBE LOCATION
- APPROXIMATE TEST SECTION LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 30 60 120 180 FT.
GRAPHIC SCALE

N

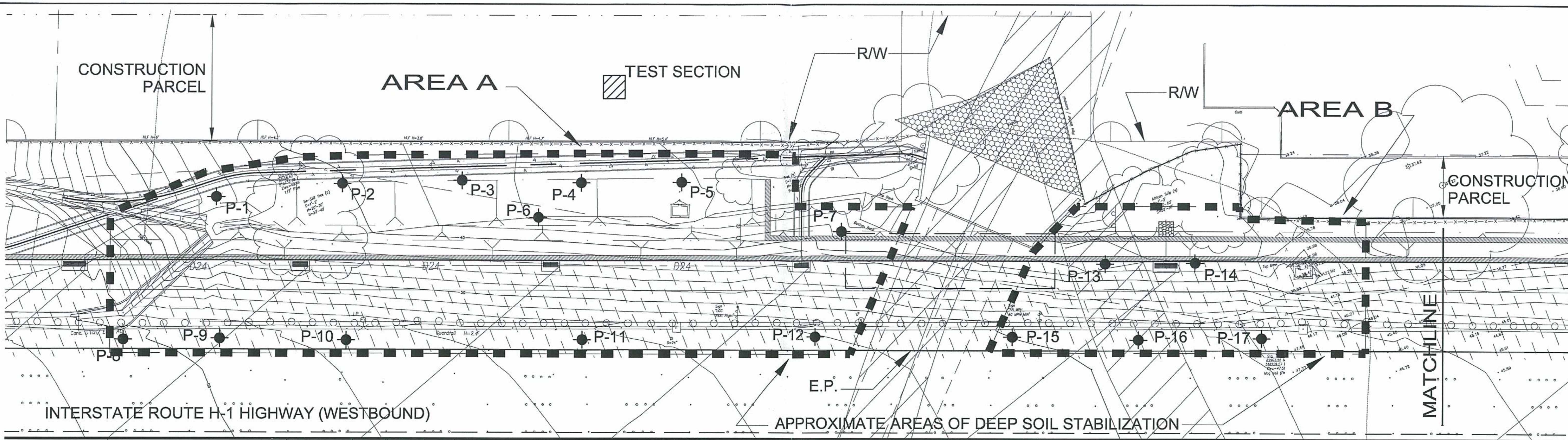
DEEP SOIL STABILIZATION PLAN

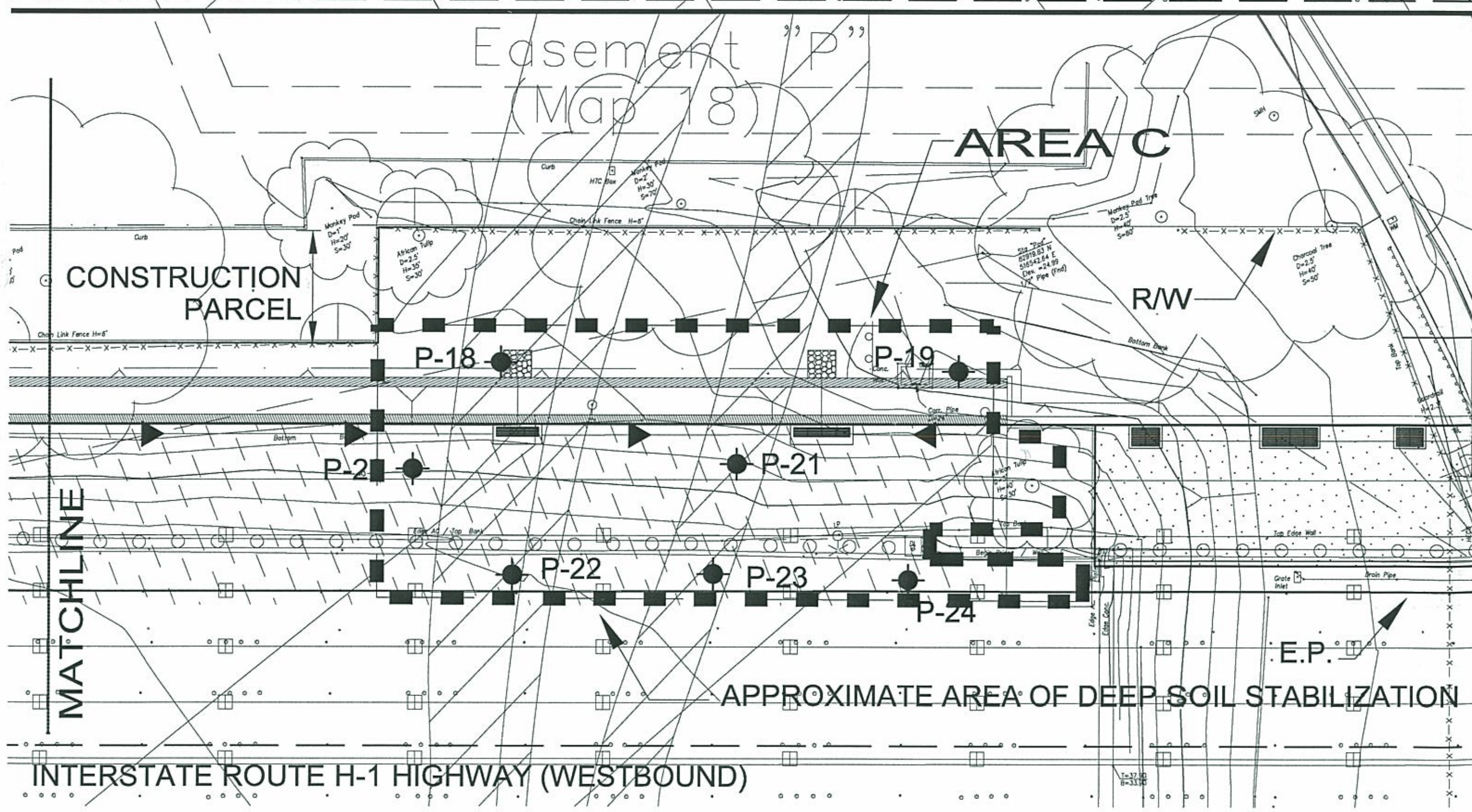
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KHN	
SCALE	W.O.	
1" = 60'	4850-00(B)	15

File: 4850-00(B)DeepSoilStabPlan.DWG Jan 27, 2003 - 11:30am





AREA A	
TEST PROBE NO.	APPROX. DEPTH (FT.)
P-1	40
P-2	45
P-3	60
P-4	70
P-5	70
P-6	60
P-7	60
P-8	50
P-9	60
P-10	65
P-11	90
P-12	90

AREA B	
TEST PROBE NO.	APPROX. DEPTH (FT.)
P-13	30
P-14	30
P-15	50
P-16	50
P-17	50

AREA C	
TEST PROBE NO.	APPROX. DEPTH (FT.)
P-18	40
P-19	40
P-20	40
P-21	40
P-22	60
P-23	60
P-24	60

LEGEND:

- APPROXIMATE TEST PROBE LOCATION
- APPROXIMATE TEST SECTION LOCATION

REFERENCE: SITE PLAN TRANSMITTED BY R. M. TOWILL CORPORATION ON AUGUST 9, 2002 AND JANUARY 23, 2003.

0 20 40 80 120 FT.
GRAPHIC SCALE

N

DEEP SOIL STABILIZATION AREAS DETAIL

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

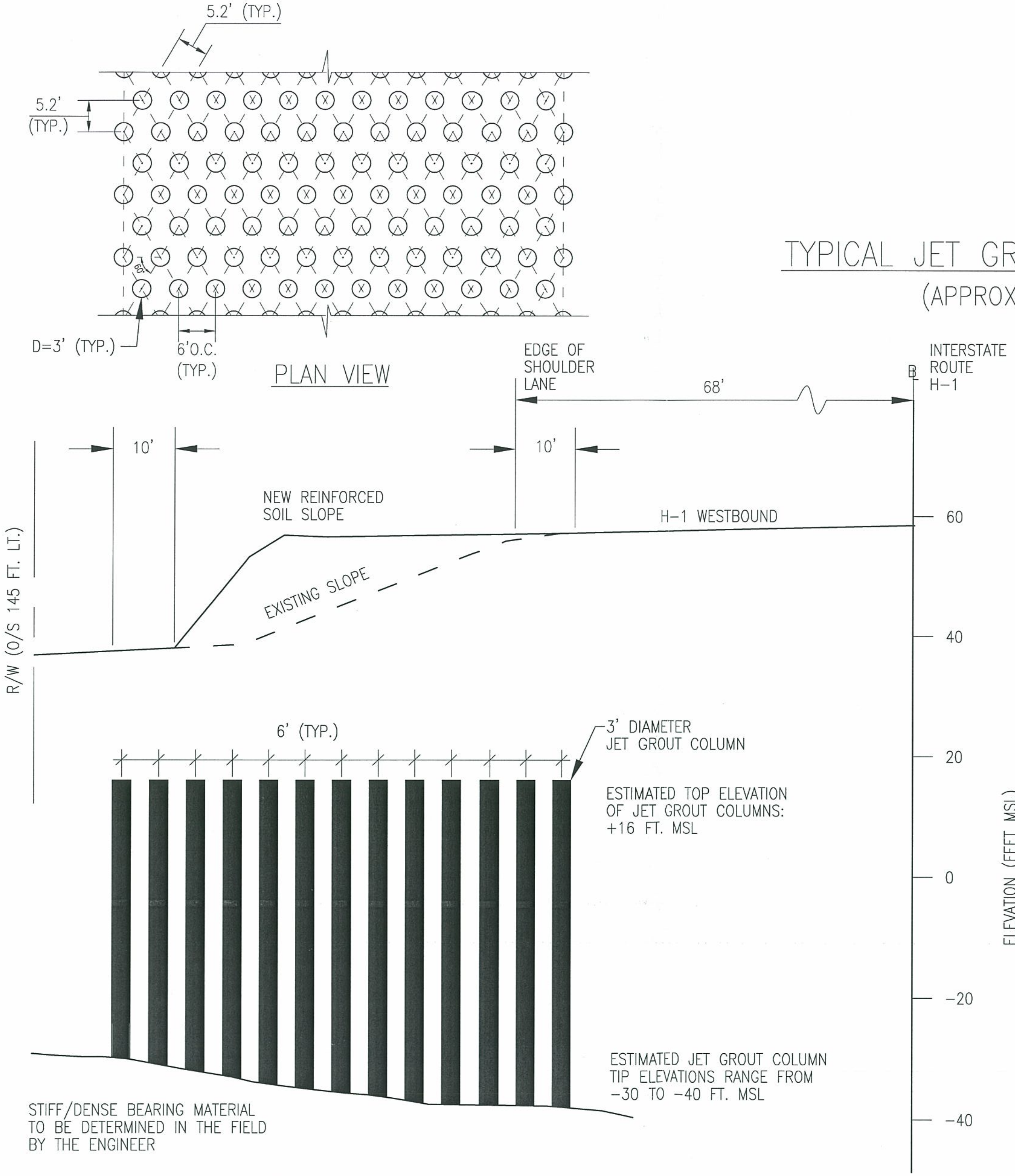
GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	16
1" = 40'	4850-00(B)	

File: 4850-00(B)DeepSoilStabAreasDetail.DWG Jan 27, 2003 - 11:46am

TYPICAL JET GROUT COLUMN LAYOUT

(APPROX. STA. 105+00)



JET GROUTING TYPICAL LAYOUT AND SECTION (AREA A)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

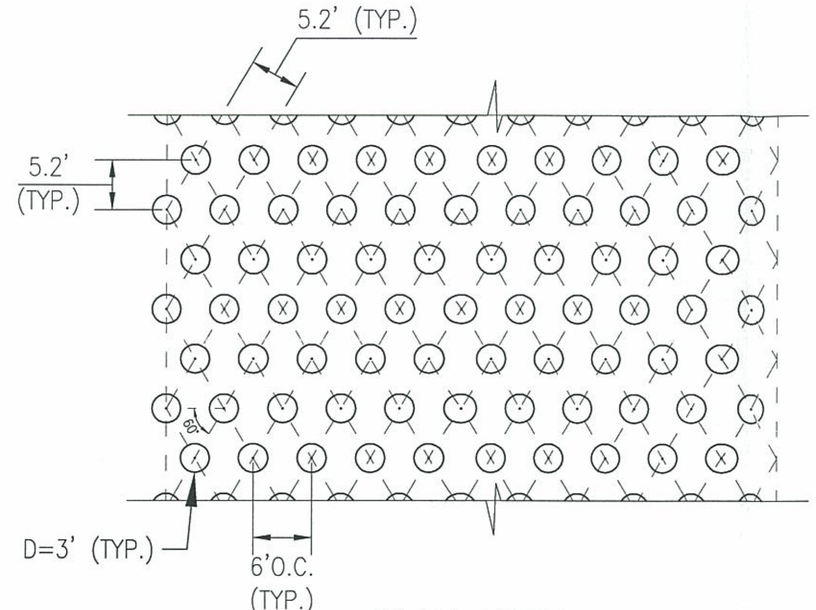
GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	17
1" = 20'	4850-00(B)	

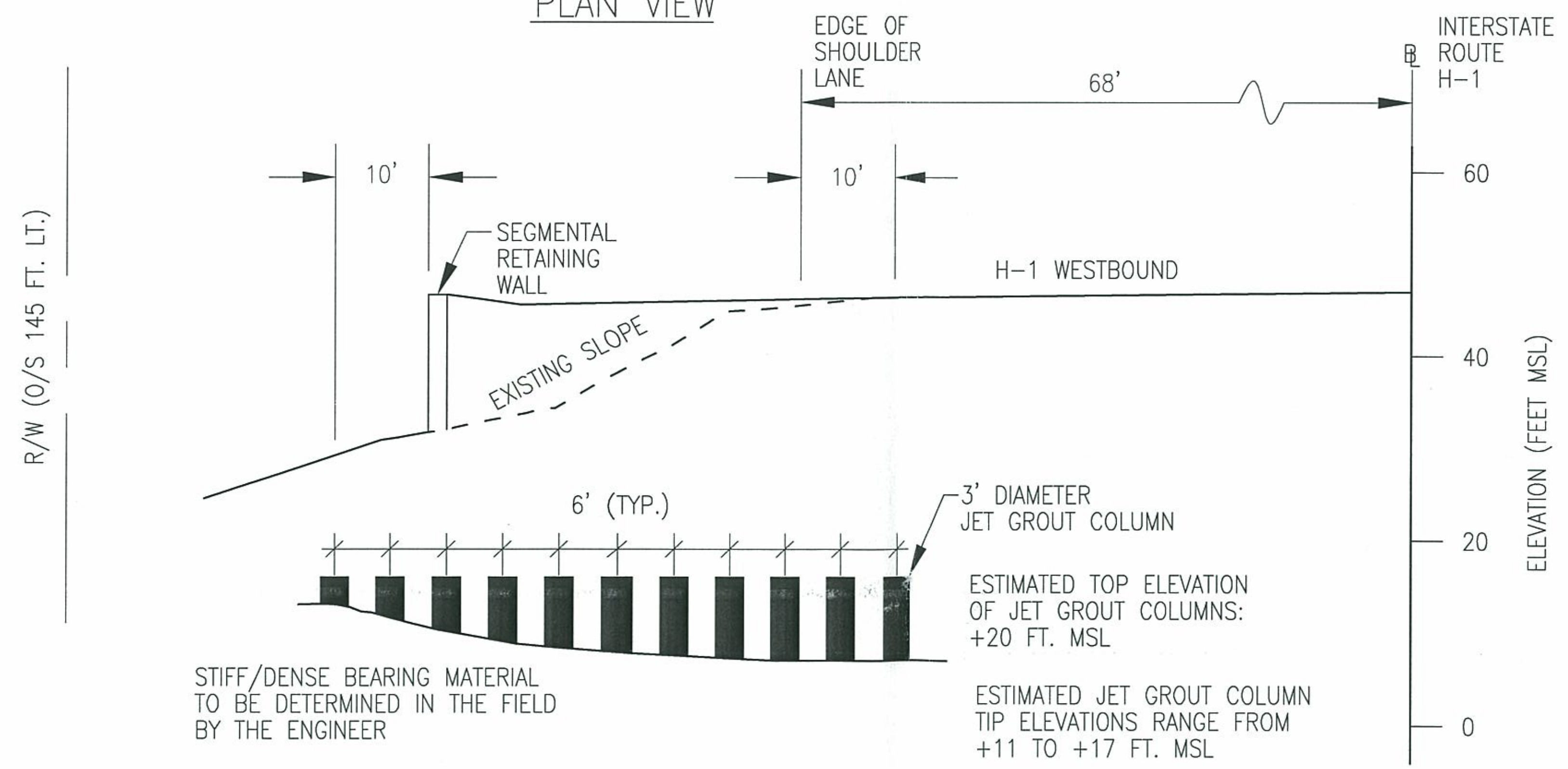
File: 4850-00(B)JetGroutLayout.dwg Jan 27, 2003 - 12:07pm

TYPICAL JET GROUT COLUMN LAYOUT

(APPROX. STA. 107+50)



PLAN VIEW



SECTION VIEW

0 10 20 40 60 FT.

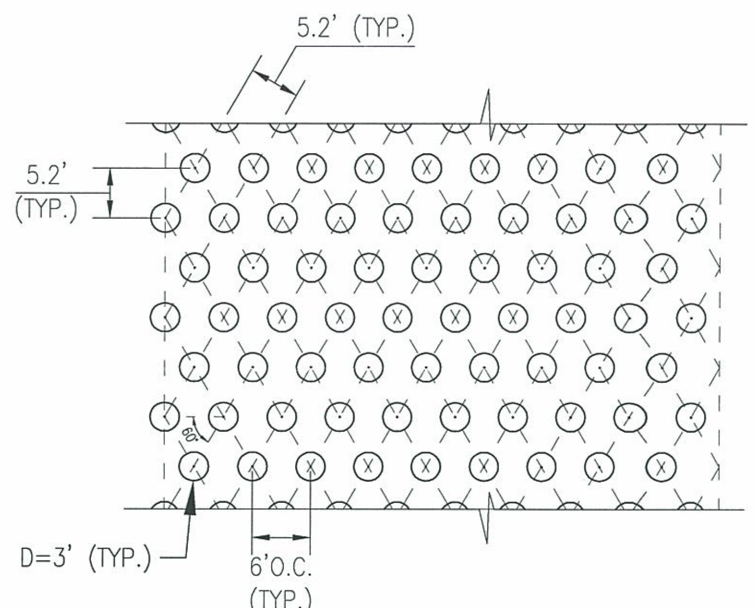
GRAPHIC SCALE

JET GROUTING TYPICAL LAYOUT AND SECTION (AREA B STA. 107+50)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

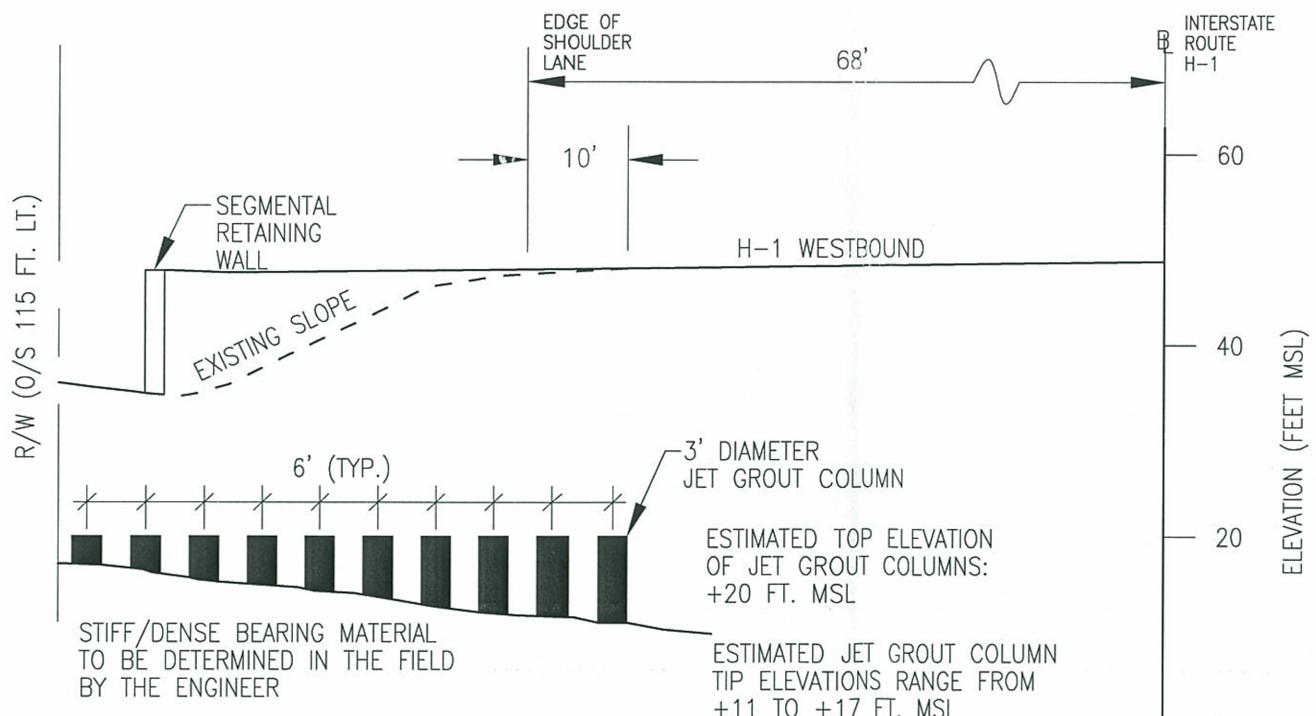
DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	18
1" = 20'	4850-00(B)	



PLAN VIEW

TYPICAL JET GROUT COLUMN LAYOUT

(APPROX. STA. 108+00)



SECTION VIEW

0 10 20 40 60 FT.

GRAPHIC SCALE

JET GROUTING TYPICAL LAYOUT AND SECTION (AREA B STA. 108+00)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

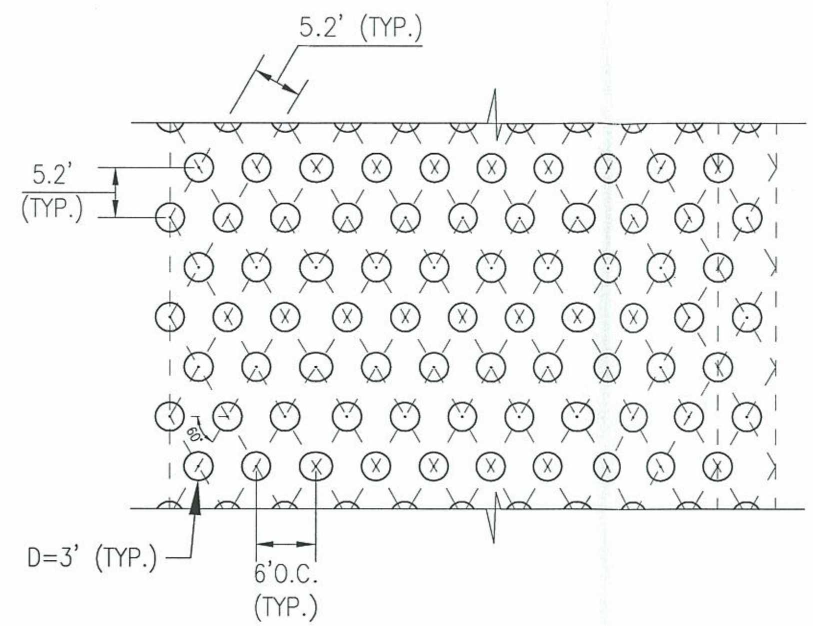
GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	
1" = 20'	4850-00(B)	19

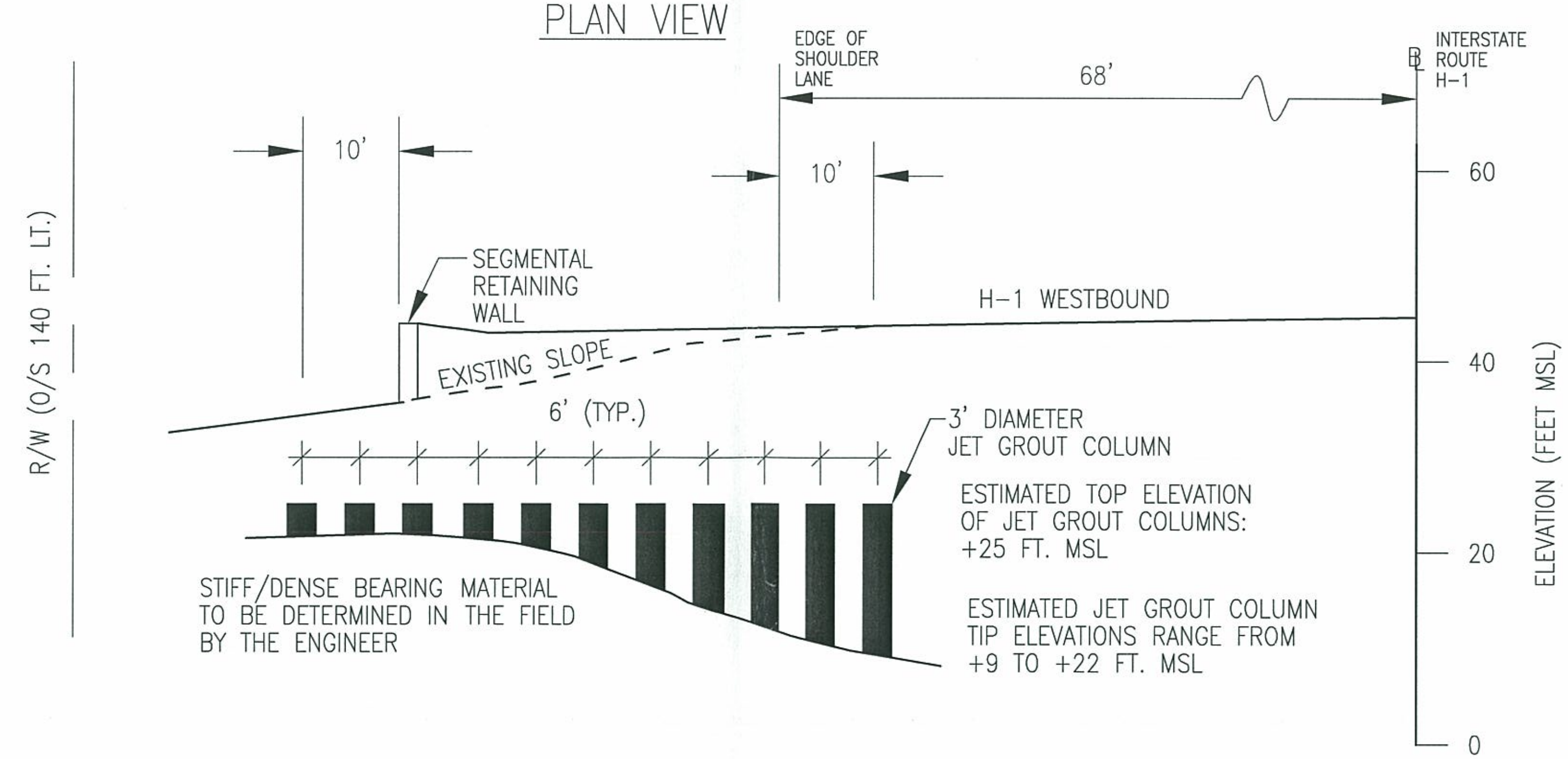
File: 4850-00(B)JetGroutLayout.dwg Jan 27, 2003 - 12:08pm

TYPICAL JET GROUT COLUMN LAYOUT

(APPROX. STA. 110+50)



PLAN VIEW



SECTION VIEW

0 10 20 40 60 FT.

GRAPHIC SCALE

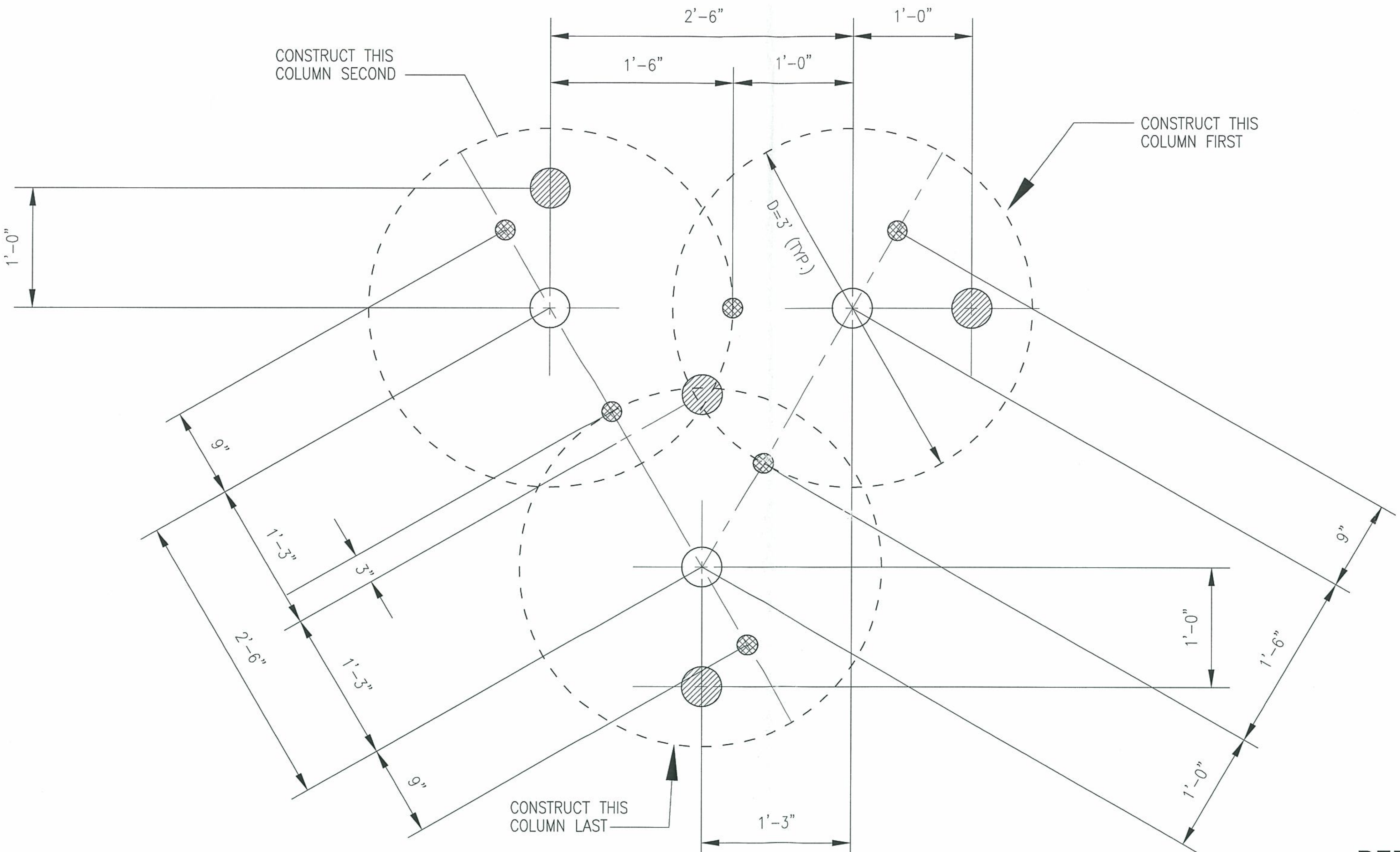
JET GROUTING TYPICAL LAYOUT AND SECTION (AREA C)

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	
1" = 20'	4850-00(B)	20

File: 4850-00(B)JetGroutLayout.dwg Jan 27, 2003 - 12:09pm



PLAN VIEW OF TEST SECTION

STEEL "FEELER" PIPE

CORE SAMPLE LOCATION

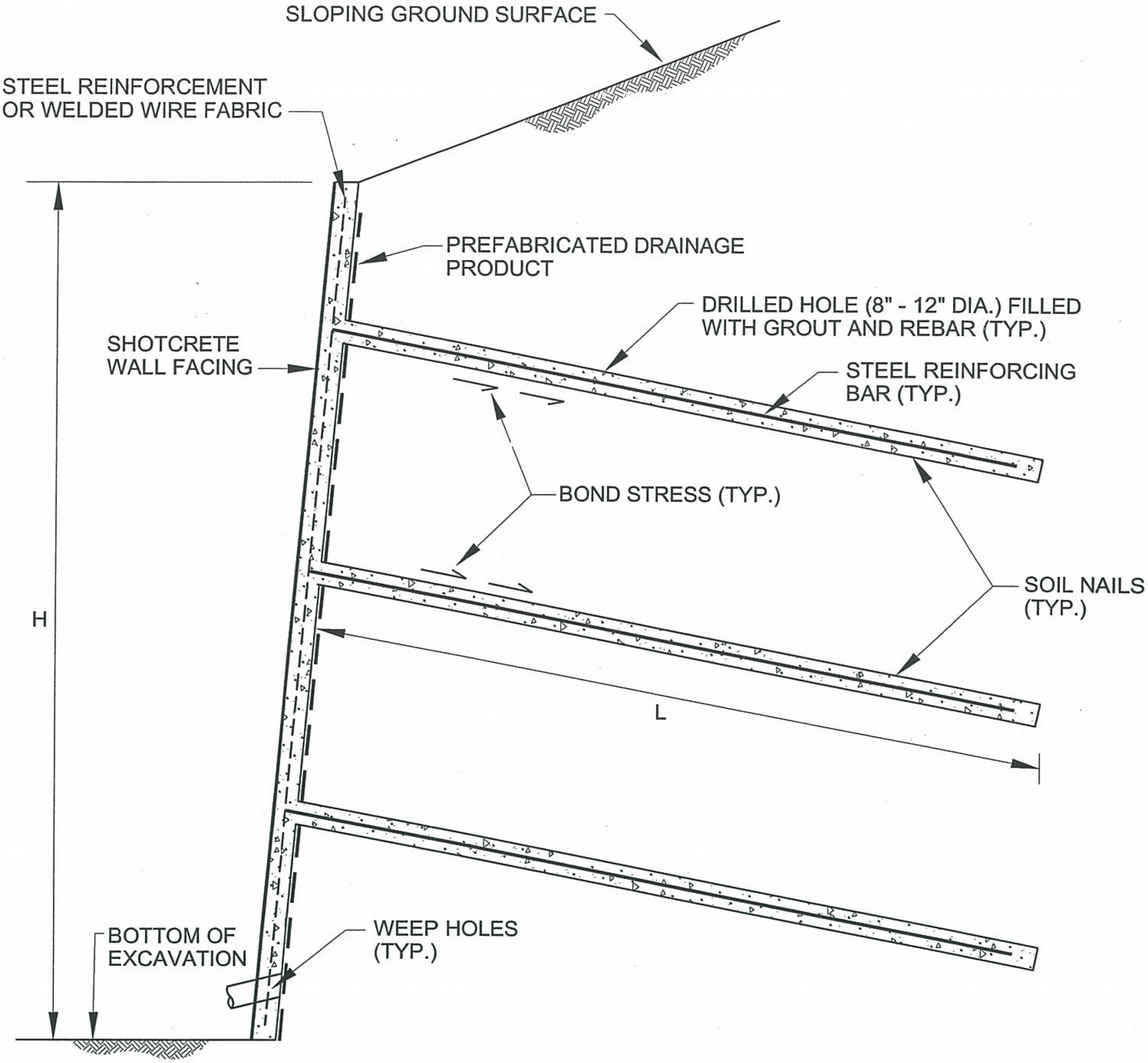
DEEP SOIL STABILIZATION TEST SECTION DETAIL

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	21
1" = 1'-0"	4850-00(B)	

File: 4850-00(B)JetGroutLayout.dwg Jan 27, 2003 - 12:12pm



NOTES:

1. FOR A ROUGH ESTIMATE OF SOIL NAIL LENGTHS, AN AVERAGE BOND STRESS OF 1000 PSF IN SOIL AND 2,000 PSF IN BASALT MAY BE USED. THE ACTUAL LENGTHS OF SOIL NAIL SHOULD BE DETERMINED IN THE FIELD BASED ON THE PULLOUTS TESTS.

2. THE RATIO OF L/H SHOULD BE AT LEAST 1.0 FOR NAILS EMBEDDED IN SOIL AND A MAXIMUM OF 0.5 FOR NAILS EMBEDDED IN ROCK. THE MINIMUM LENGTH OF NAILS SHOULD NOT BE LESS THAN 8 FEET.

3. PULLOUT TESTS SHOULD BE PERFORMED IN THE FIELD TO CONFIRM THE AVERAGE BOND STRESSES USED IN DESIGN.

4. SEE TEXT OF REPORT FOR SOIL PARAMETERS TO BE USED IN THE DESIGN.

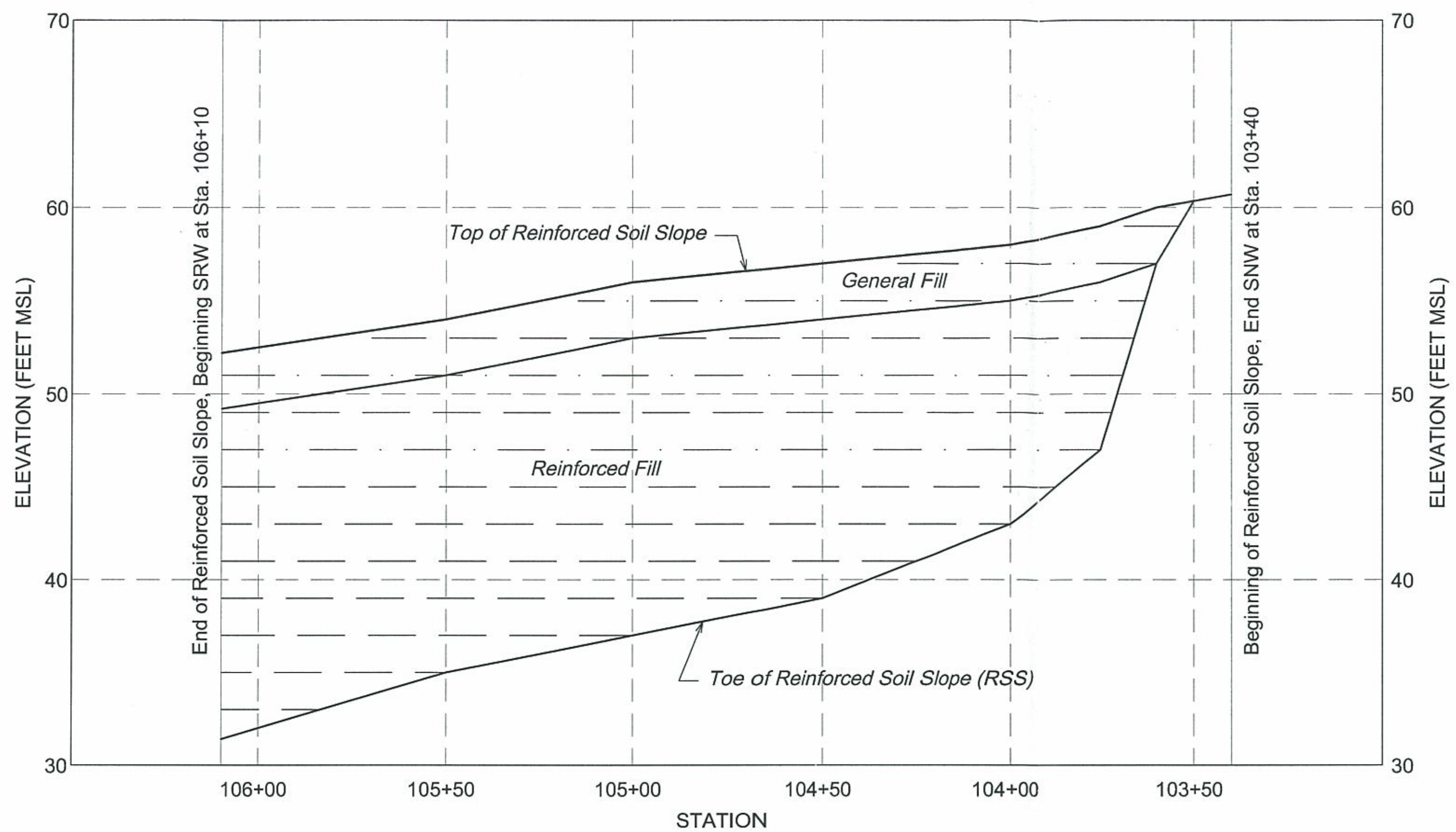
TYPICAL SOIL NAIL RETAINING WALL DETAIL

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	22
NOT TO SCALE	4850-00(B)	

File: 4850-00(B)TypSoilNailWall.dwg Jan 17, 2003 - 1:19pm



REINFORCED SOIL SLOPE LAYOUT

SCALE: HORIZ. 1"= 50'
VERT. 1"= 10'

LEGEND:

— — — PRIMARY REINFORCEMENT

—·— SECONDARY REINFORCEMENT

REINFORCED SOIL SLOPE - REINFORCEMENT SCHEDULE

ELEV. (FEET MSL)	PRIMARY REINFORCEMENT EMBEDMENT LENGTH (FEET)											
	FROM	STA. 103+40	STA. 103+60	STA. 103+75	STA. 104+00	STA. 104+25	STA. 104+50	STA. 104+75	STA. 105+00	STA. 105+25	STA. 105+50	STA. 105+85	TYPE OF REINFORCEMENT
	TO	STA. 103+60	STA. 103+75	STA. 104+00	STA. 104+25	STA. 104+50	STA. 104+75	STA. 105+00	STA. 105+25	STA. 105+50	STA. 105+85	STA. 106+10	
+59'		-	4	-	-	-	-	-	-	-	-	-	SECONDARY
+57'		-	4	4	4	-	-	-	-	-	-	-	SECONDARY
+55'		-	4	4	4	4	4	4	4	-	-	-	SECONDARY
+53'		-	14	14	14	14	14	14	14	20	-	-	PRIMARY
+51'		-	4	4	4	4	4	4	4	4	4	4	SECONDARY
+49'		-	14	14	14	14	14	14	14	20	20	20	PRIMARY
+47'		-	-	4	4	4	4	4	4	4	4	4	SECONDARY
+45'		-	-	14	14	14	14	14	14	20	20	20	PRIMARY
+43'		-	-	-	14	14	14	14	14	20	20	20	PRIMARY
+41'		-	-	-	-	14	14	14	14	20	20	20	PRIMARY
+39'		-	-	-	-	-	14	14	14	20	20	20	PRIMARY
+37'		-	-	-	-	-	-	-	14	20	20	20	PRIMARY
+35'		-	-	-	-	-	-	-	-	-	20	20	PRIMARY
+33'		-	-	-	-	-	-	-	-	-	-	20	PRIMARY

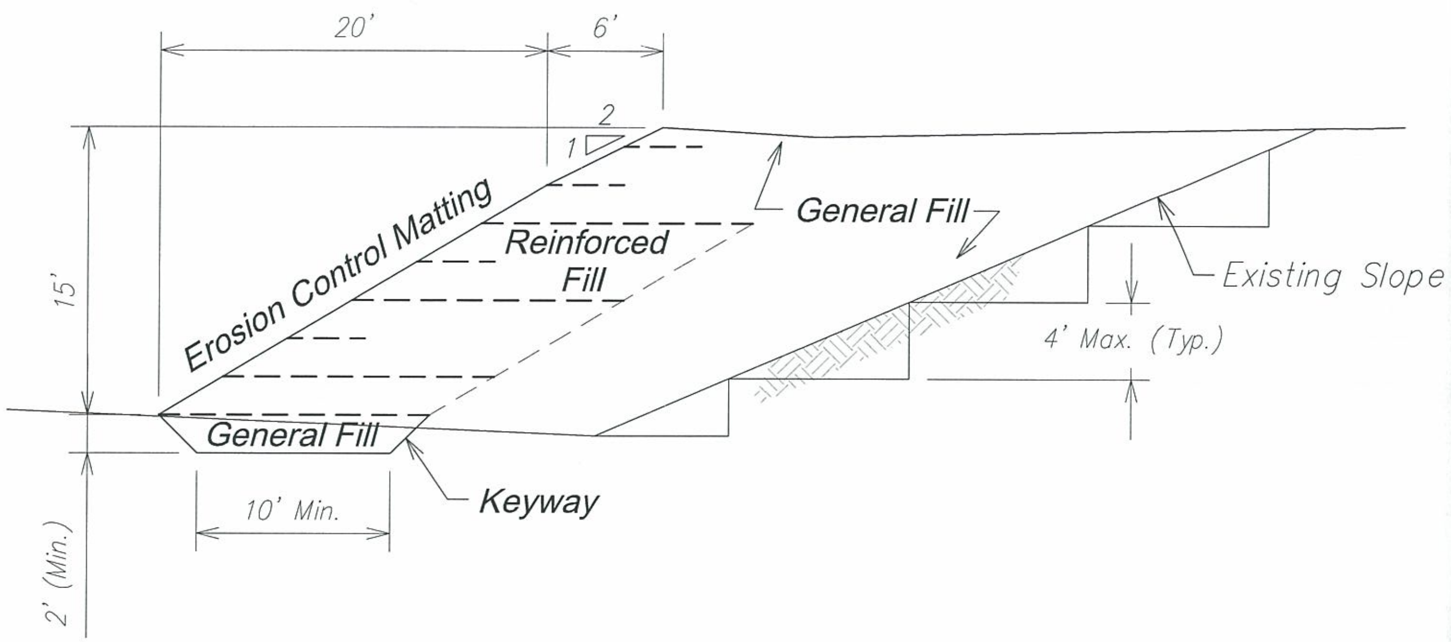
REINFORCED SOIL SLOPE LAYOUT AND SCHEDULE

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

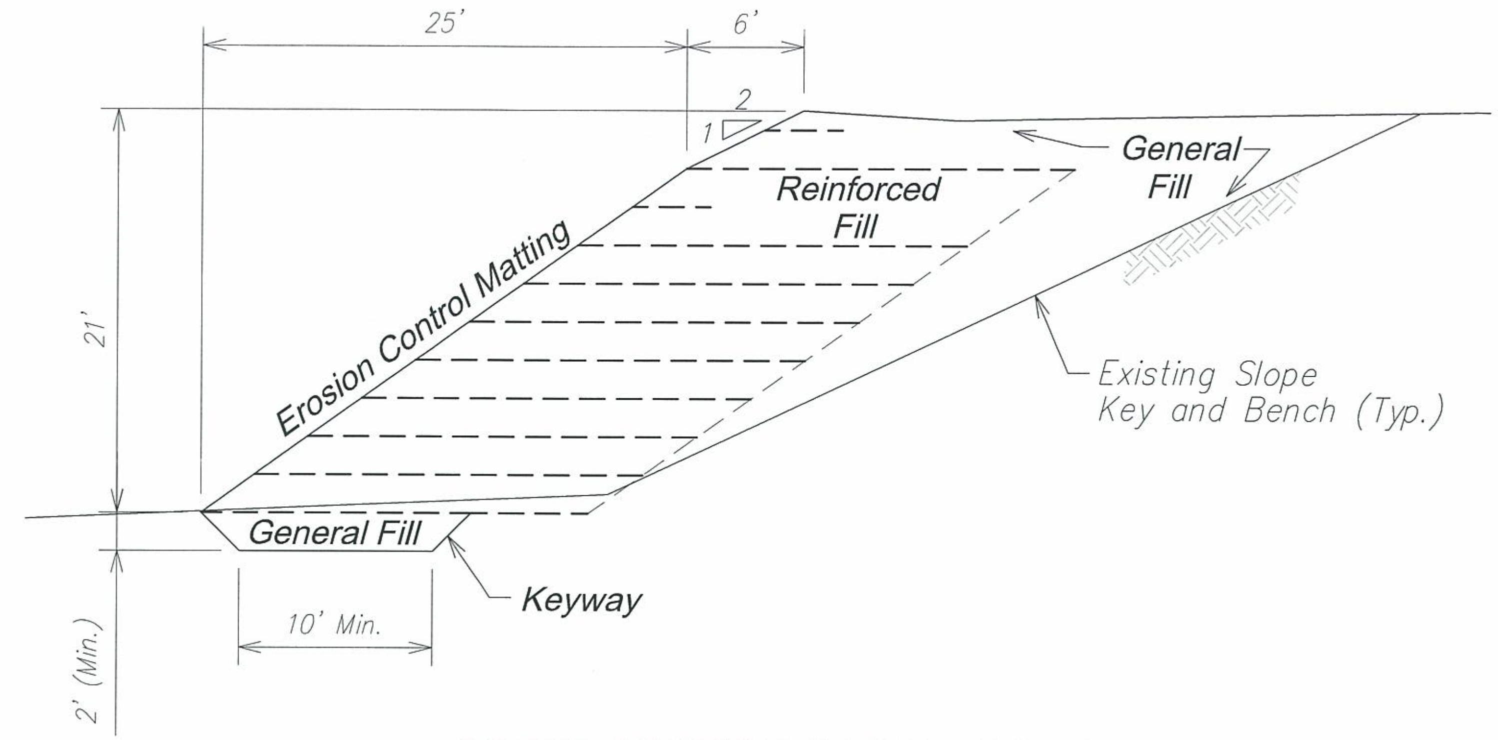
GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	23
AS SHOWN	4850-00(B)	

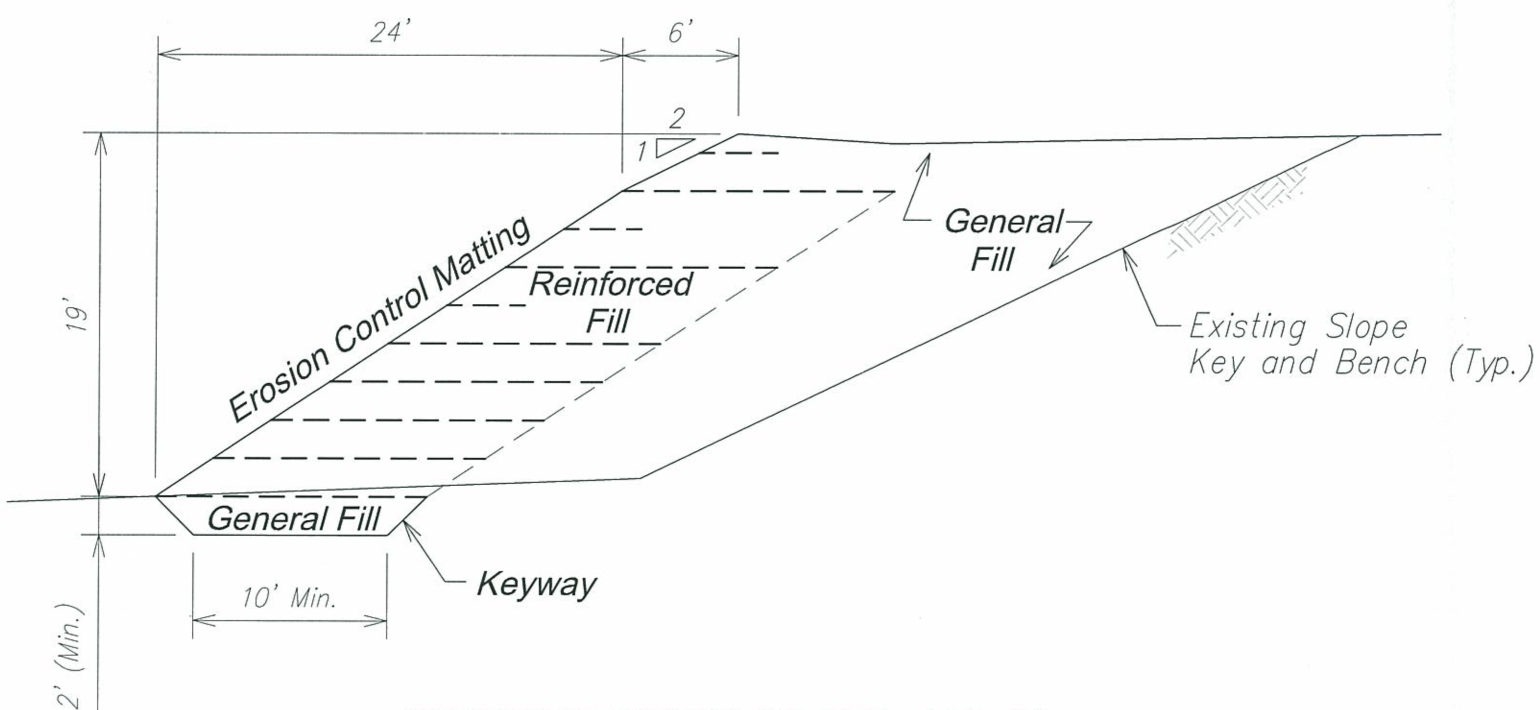
File: 4850-00(B)Plate22&23.dwg Jan 17, 2003 - 1:48pm



CROSS SECTION AT STA. 104+00



CROSS SECTION AT STA. 106+00



CROSS SECTION AT STA. 105+00

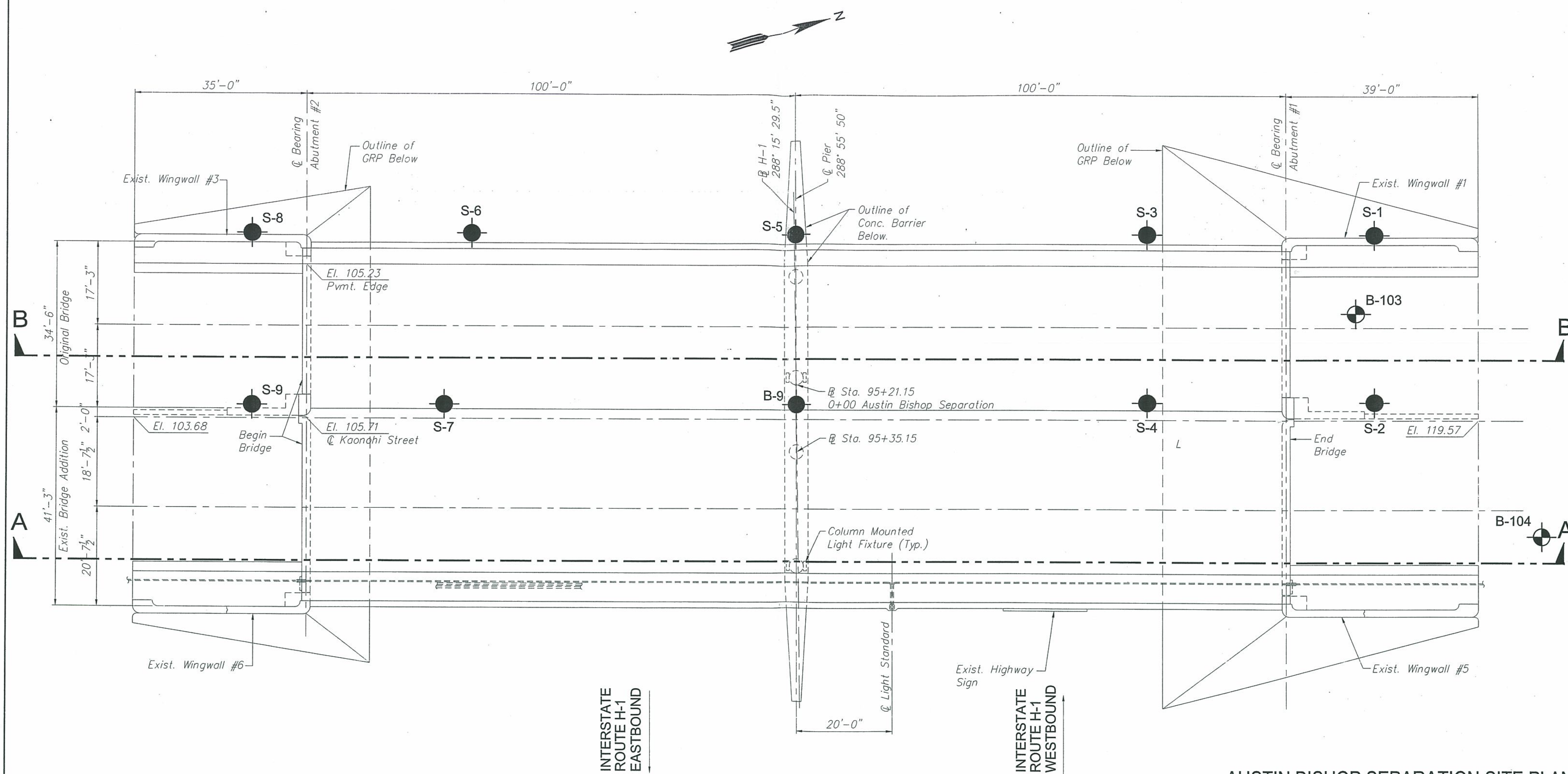
REINFORCED SOIL SLOPE CROSS SECTIONS

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	EGP	
SCALE	W.O.	24
1"= 10'	4850-00(B)	

File: 4850-00(B)Plate22823.dwg Jan 20, 2003 - 10:41am



AUSTIN BISHOP SEPARATION SITE PLAN

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

LEGEND:

- APPROXIMATE BORING LOCATION
- APPROXIMATE BORING LOCATION (DRILLED IN 1967)

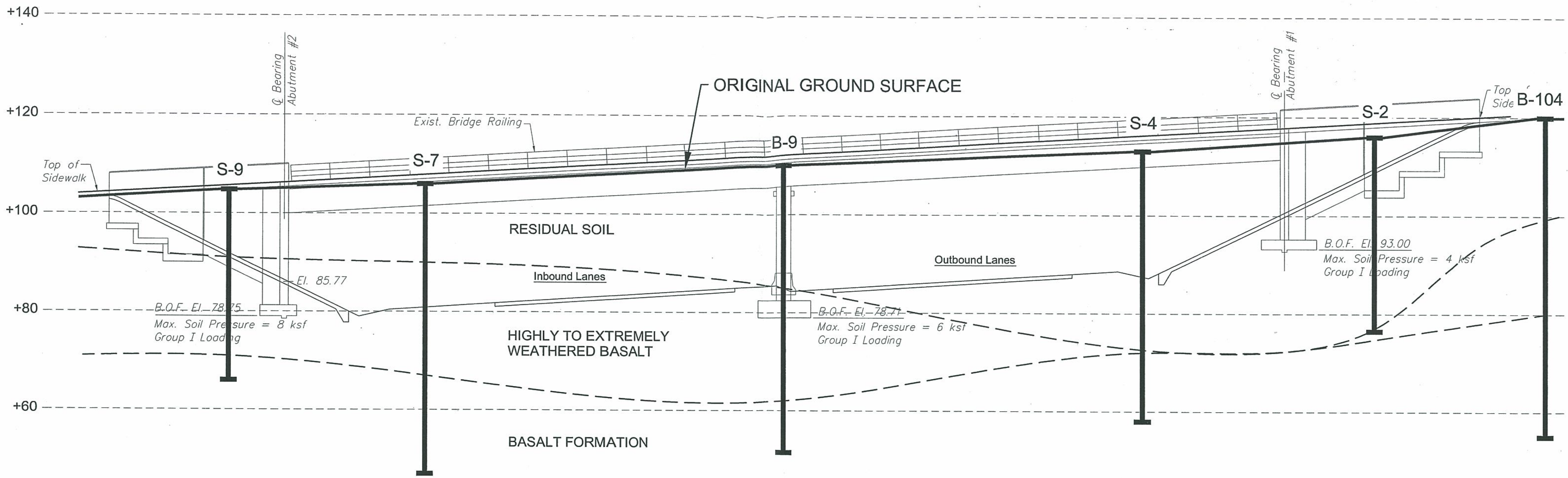
REFERENCE: BRIDGE LAYOUT PLAN TRANSMITTED BY RANDAL S. FUROMOTO AND ASSOCIATES, INC. ON FEBRUARY 14, 2002.

0 10 20 40 60 FT.
GRAPHIC SCALE

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KJD	
SCALE	W.O.	25
1" = 20'	4850-00(B)	

File: 4850-00AustinBishopSeperationPlan.dwg Jan 17, 2003 - 2:38pm



IDEALIZED SUBSURFACE PROFILE A-A'

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

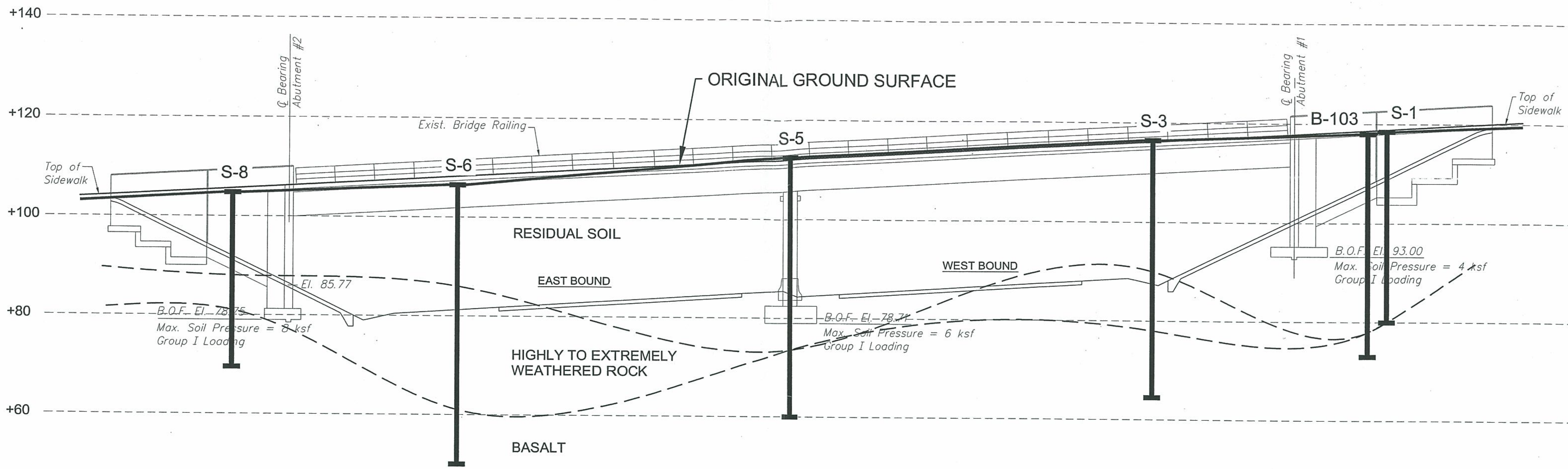
0 10 20 40 60 FT.
GRAPHIC SCALE

REFERENCE: ELEVATION & LONGITUDINAL SECTION TRANSMITTED BY RANDAL S. FUROMOTO AND ASSOCIATES, INC. ON FEBRUARY 14, 2002.

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KJD	
SCALE	W.O.	26
1" = 20'	4850-00(B)	

File: 485-00AustinBishopSeperationProfileA&B.dwg Jan 17, 2003 - 2:41pm



File: 485-00AustinBishopSeperationProfileA&B.dwg Jan 17, 2003 - 2:41pm

REFERENCE: ELEVATION & LONGITUDINAL SECTION TRANSMITTED BY RANDAL S. FUROMOTO AND ASSOCIATES, INC. ON FEBRUARY 14, 2002.

0 10 20 40 60 FT.

GRAPHIC SCALE

IDEALIZED SUBSURFACE PROFILE B-B'

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY OFF-RAMP TO KAONOHI STREET
PEARL CITY TO AIEA, OAHU, HAWAII

GEOLABS, INC.
Geotechnical Engineering

DATE	DRAWN BY	PLATE
JANUARY 2003	KJD	
SCALE	W.O.	27
1" = 20'	4850-00(B)	

APPENDIX A

Field Exploration and Logs of Borings

APPENDIX A

Field Exploration

The subsurface conditions at the project site were explored by drilling and sampling 13 borings, designated as Boring Nos. 1 through 13, near the abutment and pier locations. Forty-two (42) borings, designated as Boring Nos. 101 through 142, were drilled along the alignment of the project site for the design of retaining walls, deep soil stabilization, pavement analysis, and grading. In addition, four borings, designated as Boring Nos. 201 through 204, were drilled on the top of the highway cut slope on the westbound side of the Interstate Route H-1 Highway for the design of the sound walls. The locations of the borings drilled are shown on the Site Plans, Plates 3.1 through 3.6. The details of boring locations and the boring depths are summarized in Tables A-1.1 and A-1.2. The borings were drilled using a truck-mounted drill rig or portable drilling equipment equipped with continuous flight augers and coring tools.

The materials encountered in the borings were classified by visual and textural examination in the field by an engineer or a geologist, who monitored the drilling operations on a near-continuous basis. These classifications were further reviewed visually and by testing in the laboratory. Soils were classified in general conformance with the Unified Soil Classification System, as shown on Plate A. Graphic representations of the materials encountered are provided on the Logs of Borings, Plates A-1.1 through A-59.

Relatively "undisturbed" soil samples were obtained from the borings drilled in general accordance with ASTM Test Designation D 3550, Ring-Lined Barrel Sampling of Soils, by driving a 3-inch OD Modified California sampler with a 140-pound hammer falling 30 inches. Some samples were obtained from the drilled borings in general accordance with ASTM Test Designation D 1586, 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 Boring at the appropriate sample depths.

Pocket penetrometer and torvane shear tests were performed on selected cohesive soil samples retrieved in the field. The pocket penetrometer test provides an indication of the unconfined compressive strength of the soil sample. The torvane shear test provided a quick estimate of the undrained shear strength of the soil sample. Results of the pocket penetrometer tests and the torvane shear tests are presented on the Logs of Borings at the appropriate sample depths and are summarized in Tables B-1.1 through B-1.15.

Core samples of the rock formations encountered at the site were obtained using diamond core drilling techniques in general accordance with ASTM Standard Practice D 2113, 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 material left in the hollow core of the bit is mechanically recovered for examination and description.

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 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, 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 formation with a high RQD values would be very difficult to rip and would probably require more arduous methods of excavation.

(h:\4800 Series\4850-00B.jc2-pg.95)

Approximate Boring Locations
Interstate Route H-1 Widening
Waimalu Viaduct Westbound
Pearl City Off-Ramp to Kaonohi Street

Boring No.	Station No.	Offset from Centerline (feet)	Surface Elevation (feet MSL)	Depth of Boring (feet)	Adjacent Future Structures
B-1	111+06	109 Left	+26.0	119.5	Abutment A
B-2	111+91	87 Left	+19.0	155.5	Pier 1
B-3	112+89	85 Left	+13.5	160.5	Pier 2
B-4	114+06	81 Left	+13.0	161.5	Pier 3
B-5	115+11	80 Left	+16.0	141.5	Pier 4
B-6	116+16	78 Left	+17.0	161.5	Pier 5
B-7	117+21	78 Left	+17.0	150.0	Pier 6
B-8	118+11	56 Left	+17.0	140.0	Pier 7
B-9	119+55	90 Left	+18.0	115.0	Pier 8
B-10	120+28	91 Left	+19.0	111.5	Pier 9
B-11	121+34	73 Left	+27.0	100.5	Pier 10
B-12	122+40	72 Left	+28.0	76.0	Pier 11
B-13	123+62	92 Left	+75.0	97.0	Abutment B
B-101	89+78	100 Left	+101.0	31.5	Soil Nail Retaining Wall
B-102	92+66	122 Left	+115.0	50.0	
B-103	95+08	113 Left	+118.0	45.0	Tieback Retaining Wall
B-104	95+57	149 Left	+120.0	65.0	
B-105	98+02	128 Left	+107.0	41.5	Soil Nail Retaining Wall
B-106	100+05	103 Left	+82.0	32.0	
B-107	104+67	110 Left	+39.0	90.5	Reinforced Soil Slope
B-108	105+52	117 Left	+35.0	100.5	
B-109	106+65	112 Left	+35.0	100.5	
B-110	107+32	93 Left	+38.0	45.0	
B-111	108+54	95 Left	+36.0	60.0	
B-112	109+98	87 Left	+39.0	90.0	
B-136	105+50	65 Right	+54.0	100.5	Deep Soil Stabilization
B-137	107+82	64 Right	+48.0	65.0	
B-141	126+53	111 Left	+110.0	37.0	Soil Nail Retaining Wall
B-142	128+59	113 Left	+117.0	37.0	
Bulk-1	96+26	104 Left	+100.0	1.0	Excavation
Bulk-2	97+69	129 Left	+108.0	1.0	
Bulk-3	99+76	107 Left	+87.0	1.0	
Bulk-4	104+85	88 Left	+48.0	1.0	Embankment
Bulk-5	106+08	86 Left	+47.0	1.0	
Bulk-6	108+93	85 Left	+40.0	1.0	

Notes: MSL - Mean Sea Level
60 Right - Boring is offset 60 feet to the right of the centerline
70 Left - Boring is offset 70 feet to the left of the centerline

(h:\4800 Series\4850-00B,BoringLocations.jc1)

Approximate Boring Locations
Interstate Route H-1 Widening
Waimalu Viaduct Westbound
Pearl City Off-Ramp to Kaonohi Street

Boring No.	Station No.	Offset from Centerline (feet)	Surface Elevation (feet MSL)	Depth of Boring (feet)	Adjacent Future Structures
B-113	103+89	65 Left	+60.0	5.0	Pavements (Westbound)
B-114	104+85	65 Left	+56.0	5.0	
B-115	105+89	65 Left	+53.0	1.0	
B-116	106+88	64 Left	+51.0	1.0	
B-117	108+17	65 Left	+47.0	5.0	
B-118	108+88	65 Left	+45.0	3.5	
B-119	109+85	64 Left	+43.5	5.0	
B-120	110+87	65 Left	+42.0	5.0	
B-121	111+00	65 Left	+42.0	5.0	
B-122	103+89	56 Left	+61.0	5.0	
B-123	104+85	56 Left	+57.0	4.0	
B-124	105+89	56 Left	+54.0	1.2	
B-125	106+88	55 Left	+51.5	5.0	
B-126	108+17	56 Left	+48.0	1.5	
B-127	108+88	56 Left	+46.0	5.0	
B-128	109+85	55 Left	+44.5	4.3	
B-129	110+87	56 Left	+43.0	5.0	
B-130	111+00	56 Left	+43.0	5.5	
B-131	105+50	54 Right	+54.0	5.5	Pavements (Eastbound)
B-132	107+82	54 Right	+48.0	5.0	
B-133	109+85	53 Right	+44.0	5.0	
B-134	110+87	55 Right	+43.0	5.0	
B-135	110+97	57 Right	+43.0	5.0	
B-138	109+85	64 Right	+44.0	6.0	
B-139	110+87	63 Right	+43.0	5.0	
B-140	110+97	64 Right	+43.0	5.0	
B-201	96+78	154 Left	+118.0	34.0	Noise Barrier Walls
B-202	99+14	160 Left	+115.0	35.0	
B-203	126+04	143 Left	+120.0	37.5	
B-204	129+15	134 Left	+123.0	35.0	

Notes: MSL - Mean Sea Level
60 Right - Boring is offset 60 feet to the right of the centerline
70 Left - Boring is offset 70 feet to the left of the centerline

(h:\4800 Series\4850-00(A).BoringLocations.jc1)

GEOLABS, INC.

Geotechnical Engineering

Boring 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	LL	LIQUID LIMIT
	(3-INCH) O.D. MODIFIED CALIFORNIA SAMPLE	PI	PLASTICITY INDEX
S	SHELBY TUBE SAMPLE	TV	TORVANE SHEAR (tsf)
G	GRAB SAMPLE	PEN	POCKET PENETROMETER (tsf)
	CORE SAMPLE	UC	UNCONFINED COMPRESSION (psi)
		⊻	WATER LEVEL OBSERVED IN BORING

Plate

A

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 1

Approximate Ground Surface Elevation (feet MSL): 26 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** stiff, damp (fill)
	27	85			10	4.0			
	31	81			28	2.3	5		
	8		50					GW	Gray **SANDY GRAVEL,** medium dense, damp (fill)
								MH	Brown **CLAYEY SILT,** stiff, moist (fill)
TV=0.5	39	82			11	0.8	10		
			70					CH	Gray **CLAY,** stiff, moist (recent alluvium)
LL=64 PI=34	35	80			14	2.8	15		
			33						
							▽	OL	Dark gray **ORGANIC SILT** with some roots, soft, wet (recent alluvium)
	15	118			11		20	GP	Brownish gray rounded **SANDY GRAVEL** with silt, medium dense (recent alluvium)
TV=0.4	57	76				0.5		OL	Dark gray **ORGANIC SILT,** soft (recent alluvium)
			85					GP	Brownish gray rounded **SANDY GRAVEL** with silt, medium dense (recent alluvium)
	14	122			34	4.3	25		
			0						
	15	111			21	4.3	30		
			0						
								SM	Dark gray **SILTY FINE SAND** with traces of gravel, loose (recent alluvium)
							35		

Date Started:	March 6, 2002	Water Level: ▽	17.8 ft. 3/7/02 1150 HRS
Date Completed:	March 7, 2002		18.5 ft. 3/7/02 1540 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	119.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 1.1

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 1

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
TV=0.2	70	58	100		4	0.8		ML	Dark gray **SANDY SILT** with shell fragments, soft (recent alluvium)
TV=0.15									
	37	80				2.5	40		
			17						
LL=70 PI=40			98		21	2.8	45	CH	Gray **CLAY,** very stiff (recent alluvium)
	39	83	100		29	2.8	50	MH	Grayish brown **CLAYEY SILT** with some rounded gravel, very stiff (recent alluvium)
	46	72	100		41	2.5	55	SM	Brownish gray **SILTY SAND** with highly weathered rounded rock, dense to very dense (old alluvium)
	54	63	100		31	4.3	60		grades to dense
	57		100		18		65		grades to medium dense
							70		

Date Started:	March 6, 2002	Water Level: ▽	17.8 ft. 3/7/02 1150 HRS 18.5 ft. 3/7/02 1540 HRS
Date Completed:	March 7, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	119.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 1.2

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 1

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	34				37					SM	grades to dense
			70								
	43				16/.5' +50/.0' Ref.		75				grades to very dense
			100	100							Brownish gray vesicular **BASALT**, moderately fractured, moderately weathered, medium hard (basalt formation)
UC=738											
			100	100			80				grades to slightly fractured, slightly weathered, hard
UC=197											
			100	100			85				grades to massive, very hard
			100	85			90				grades to vugular, slightly fractured, slightly to moderately weathered, hard to very hard
			100	100			95				grades to vesicular, massive, slightly weathered, very hard
			100	90			100				grades to vugular, moderately fractured, slightly to moderately weathered, hard to very hard
							105				

Date Started:	March 6, 2002	Water Level: ⊻	17.8 ft. 3/7/02 1150 HRS	Plate
Date Completed:	March 7, 2002		18.5 ft. 3/7/02 1540 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 1.3
Total Depth:	119.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, 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
			100	100							grades to massive, slightly weathered, hard
			100	70			110				grades to vesicular, slightly fractured
			100	100			115				grades to massive
							120				Boring terminated at 119.5 feet * Elevations estimated from Site Plans dated January 25, 2002 provided by R.M. Towill Corporation.
							125				
							130				
							135				
							140				

Date Started:	March 6, 2002	Water Level: ⊻	17.8 ft. 3/7/02 1150 HRS	Plate
Date Completed:	March 7, 2002		18.5 ft. 3/7/02 1540 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 1.4
Total Depth:	119.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 2

Approximate Ground Surface Elevation (feet MSL): 19 *

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)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** stiff, damp (fill)
	25	84			16	4.3			
	30	78			17	4.0	5		grades to dark brown, stiff to very stiff
	36	68			19	3.3	10		
			33					MH	Brown **CLAYEY SILT** with sand, very stiff, moist (recent alluvium)
	94	49			4	1.0	15		grades to soft to very soft, wet
			10					OL	Dark gray **ORGANIC SILT** with roots, soft (recent alluvium)
TV=0.2	89	43			12		20		
	127	32	0			2.5		SM	Dark gray **SILTY SAND** with rounded gravel, loose to medium dense (recent alluvium)
	44	74			5	1.8	25		grades to loose
			0						
	17				12		30	GW-GM	Grayish brown **SILTY ROUNDED GRAVEL** with sand, loose to medium dense
			10						
							35		

Date Started:	March 8, 2002	Water Level: ∇	16.9 ft. 3/11/02 0815 HRS
Date Completed:	March 13, 2002		19 ft. 3/13/02 0805 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	155.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 2.1

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 2

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	17				24			GW-GM	grades to medium dense
			0						
	16				17		40		
			43						
	42	79			21	3.0	45	MH	Gray **CLAYEY SILT** with sand and cobbles, very stiff (recent alluvium)
	39	70							
			100						
			45		25/.0' Ref.		50	GP	Gray **BOULDERS, COBBLES AND GRAVEL** with cemented silty sand, very dense (conglomerate)
			17		50/.5' Ref.		55		
	28				81		60	MH	Brownish gray **CLAYEY SILT** with rounded basaltic gravel, very hard (old alluvium)
			50						
	23				23		65		grades to very stiff
			0				70		

Date Started:	March 8, 2002	Water Level: ⊻	16.9 ft. 3/11/02 0815 HRS 19 ft. 3/13/02 0805 HRS	Plate
Date Completed:	March 13, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	155.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 2.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 2

(Continued from previous plate)

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
	62	56			24	4.0				MH	
			100								
	49	71			41	4.3	75				grades to very stiff to hard
			100								
	48				23		80				grades to very stiff
			79								
	55	65			49	3.8	85				grades to hard
			67								
	42				52		90				
			50								
	50				31		95				
			100								
	40	73			54	4.3	100				
			86								
							105				

Date Started:	March 8, 2002	Water Level: ⊻	16.9 ft. 3/11/02 0815 HRS 19 ft. 3/13/02 0805 HRS	Plate
Date Completed:	March 13, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	155.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 2.3
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 2

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	39		67		61					MH	grades to very hard
			25	0	25/.0' Ref.		110				Brownish gray **BASALT**, severely fractured, highly to extremely weathered, soft (basalt formation)
	15		64	29	50/.3' Ref.		115				grades to moderately fractured, highly to moderately weathered, medium hard
UC=1618			90	90	30/.0' Ref.		120				grades to gray vesicular, slightly fractured, slightly weathered, hard
UC=714			80	67			125				grades to moderately fractured
			90	80			130				grades to brownish gray, slightly fractured
			60	10			135				grades to severely fractured, highly weathered, soft to medium hard
							140				

Date Started:	March 8, 2002	Water Level: ∇	16.9 ft. 3/11/02 0815 HRS 19 ft. 3/13/02 0805 HRS	Plate
Date Completed:	March 13, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 2.4
Total Depth:	155.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 2

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
			100	75	30/.0' Ref.						grades to gray, moderately fractured, moderately to slightly weathered, medium hard to hard
			55	45			145				grades to slightly fractured, slightly weathered, hard
											Gray **CLINKER** (basalt formation)
			0	0			150				
	24				25/.0' Ref.		155				
											Boring terminated at 155.5 feet
							160				
							165				
							170				
							175				

Date Started:	March 8, 2002	Water Level: ⊻	16.9 ft. 3/11/02 0815 HRS 19 ft. 3/13/02 0805 HRS	Plate
Date Completed:	March 13, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	155.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 2.5
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC.
Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring
3

Approximate Ground Surface Elevation (feet MSL): 13.5 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								MH	Brown **CLAYEY SILT** with gravel and cobbles, very stiff, moist (fill)
	21	75			19	4.3			
	46				9	4.3	5		
								CH	Grayish brown **SILTY CLAY** with sand, medium stiff to stiff, moist (recent alluvium)
LL=64 PI=34	53	68			15	0.75	10		
	56	63							
								OL	Gray **SANDY ORGANIC SILT** with roots, soft (recent alluvium)
	60				2		15		grades with fine sand
						0.25		OH	Gray **ORGANIC CLAYEY SILT** with shell fragments, soft (recent alluvium)
								SM	Dark gray **SILTY SAND** with gravel, medium dense (recent alluvium)
							20		
					20				
			80						
									grades to loose
							25		
	59				4				
						0.0		ML	Dark gray fine **SANDY SILT** with organic debris, very soft (recent alluvium)
			48						
								SM	Dark gray **SILTY FINE SAND,** very loose (recent alluvium)
							30		
	57				3				
			67						
							35		grades to **SILTY COARSE SAND** with rounded gravel

Date Started:	April 22, 2002	Water Level: ⊻	8.6 ft. 4/23/02 0903 HRS
Date Completed:	April 24, 2002		7.4 ft. 4/24/02 0815 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	160.5 feet	Drilling Method:	5" Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 3.1

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
TV=0.2	45	79			13	0.5		SM	
			64						
									grades with cobbles
	20				32		40	GP	Gray **BOULDERS, COBBLES AND GRAVEL** with sand and silt, medium dense to dense (conglomerate)
			81						
							45		
			70		30/.0' Ref.				
							50		
			50						
							55		
			70		50/.1' Ref.			MH	Grayish brown **CLAYEY SILT** with sand and weathered rounded rock, hard (old alluvium)
							60		
	52	62			42	4.3			
			100			2.2			
							65		
	57				22				grades to very stiff
			100						
							70		

Date Started:	April 22, 2002	Water Level: ∇	8.6 ft. 4/23/02 0903 HRS; 7.4 ft. 4/24/02 0815 HRS
Date Completed:	April 24, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	160.5 feet	Drilling Method:	5" Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 3

(Continued from previous plate)

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
LL=63 PI=26	46	70			32	1.5				MH	Grayish brown **CLAYEY SILT** with sand and rounded rock, very stiff to hard (old alluvium)
			81			2.5					
							75				
	53				37						
			100								
							80				
TV=0.5	54	62			40	0.8					
			100								
						1.5					
							85				
	56				16						grades to stiff to very stiff
			100								
							90				
TV=0.5	63	63			38	0.8					grades to hard
			100								
							95				
			95								
							100				
	49	67			75/.5' Ref.	2.5					
			100								
							105				

Date Started:	April 22, 2002	Water Level: ⊻	8.6 ft. 4/23/02 0903 HRS 7.4 ft. 4/24/02 0815 HRS	Plate A - 3.3
Date Completed:	April 24, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	160.5 feet	Drilling Method:	5" Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 3

(Continued from previous plate)

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
	51				74					MH	Grayish brown **CLAYEY SILT** with sand and rounded rock, hard (old alluvium)
			100								
						2.0					
							110				
	67				56						
			100								
						4.0					
							115				
	43				31						
			100								
							120				
	33				39						
			100								
						4.0					
							125				
	40				41	2.7					
			100								
							130				
	61	61			61	2.5					
			100								
						3.1					
							135				
	40				40						
			95								
							140				

Date Started:	April 22, 2002	Water Level: ⊻	8.6 ft. 4/23/02 0903 HRS
Date Completed:	April 24, 2002		7.4 ft. 4/24/02 0815 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	160.5 feet	Drilling Method:	5" Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 3

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	42		100		52/.5' Ref.						Grayish brown **BASALT**, severely fractured, extremely weathered, soft (basalt formation)
							145				
			82		57/.5' Ref.						grades to highly weathered, soft to medium hard
						4.0					grade to interbedded with brown silty clay seams
							150				
	41		96		50/.3' Ref.						grades to extremely weathered, soft
							155				
	46		100		60	1.5					
							160				
											Boring terminated at 160.5 feet
							165				
							170				
							175				

Date Started:	April 22, 2002	Water Level: ∇	8.6 ft. 4/23/02 0903 HRS 7.4 ft. 4/24/02 0815 HRS
Date Completed:	April 24, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	160.5 feet	Drilling Method:	5" Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 3.5

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 4

Approximate Ground Surface Elevation (feet MSL): 13 *

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)	USCS	Description
							0	MH	Brown **CLAYEY SILT** with gravel (fill)
	23	76			15		5	SM	Brown **SILTY SAND** with basaltic gravel, medium dense, damp (fill)
	17				5		10 (▽)		grades to loose
	25	83			4		15	GW-GM	Brown **SILTY GRAVEL** with sand, very loose (fill)
	63	68			Push/ 2.0'	1.3	20		
								OL	Dark gray **ORGANIC SILT** with sand, medium stiff (recent alluvium)
	96	45			7	2.5	25		
TV=0.4	76	52			22	0.5	30		
								GP	Brownish gray **SANDY ROUNDED GRAVEL** with silt, medium dense (recent alluvium)
			24						
							35		

Date Started:	January 7, 2002	Water Level: ▽	10.5 ft. 1/7/02 1400 HRS	Plate
Date Completed:	January 10, 2002		9.1 ft. 1/10/02 1615 HRS	
Logged By:	K. Gronseth	Drill Rig:	CME-75	A - 4.1
Total Depth:	161.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 4

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									(Continued from previous plate)
	31				51			GP	grades to dense to very dense
			86						
LL=57 PI=25	39				31	>4.5	40	MH	Brown **CLAYEY SILT** with some sand, very stiff to hard (recent alluvium)
			57						
	26				50/.4' Ref.		45	SC	Brown **CLAYEY SAND** with gravel and cobbles, very hard (recent alluvium)
			41						
									BOULDER
	60				19		50	MH	Orange-brown with black mottling **CLAYEY SILT** with rounded rock, very stiff (old alluvium)
			100						
	59				16		55		
			100						
	60				20		60		
			50						
									grades with small rounded pebbles and cobbles
	52				20		65		
			0						
							70		

Date Started:	January 7, 2002	Water Level: ∇	10.5 ft. 1/7/02 1400 HRS
Date Completed:	January 10, 2002		9.1 ft. 1/10/02 1615 HRS
Logged By:	K. Gronseth	Drill Rig:	CME-75
Total Depth:	161.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 4.2

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring 4

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	55				9					MH	grades to medium stiff to stiff
			71								
LL=58 PI=25	56				12		75				grades to stiff
			93								
	64				34		80				grades to brown, hard
			38								
	56				19		85				grades to very stiff
			95								
	55				26		90				
			100								
	57				24		95				
			100			0.75					
	48				47		100				grades to hard
			86								
							105				

Date Started:	January 7, 2002	Water Level: ∇	10.5 ft. 1/7/02 1400 HRS 9.1 ft. 1/10/02 1615 HRS
Date Completed:	January 10, 2002		
Logged By:	K. Gronseth	Drill Rig:	CME-75
Total Depth:	161.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 4.3

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 4

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
	50				36					MH	grades to brown with orange and black mottling clayey silt
			71								
	57				13	0.5	110				grades to stiff
			100								
TV=0.4											
TV=0.4	73				6		115				grades to soft to medium stiff
			100								
LL=49 PI=12	52				43		120			ML	Orange-brown **CLAYEY SILT** with rounded rock, very stiff (old alluvium)
			100								
	54				15	1.5	125				grades to stiff to very stiff
			100								
	54				24	1.8	130			MH	Orange-brown with black mottling **CLAYEY SILT** with basaltic gravel, very stiff (old alluvium)
			100								
LL=57 PI=21	54				12	1.0	135				grades to stiff
			74								
							140				

Date Started:	January 7, 2002	Water Level: ⊻	10.5 ft. 1/7/02 1400 HRS	Plate
Date Completed:	January 10, 2002		9.1 ft. 1/10/02 1615 HRS	
Logged By:	K. Gronseth	Drill Rig:	CME-75	A - 4.4
Total Depth:	161.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 4

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	52				33					MH	grades to orange-brown with black mottling clayey silt, hard (old alluvium)
			100								
TV=0.4	55				14	0.8	145				grades to stiff
			100								
	48				44	3.3	150				grades to hard
			100								
	54				19	1.0	155				grades to very stiff
			19								
	52				28		160				
											Boring terminated at 161.5 feet
							165				
							170				
							175				

Date Started:	January 7, 2002	Water Level: ⊻	10.5 ft. 1/7/02 1400 HRS 9.1 ft. 1/10/02 1615 HRS	Plate
Date Completed:	January 10, 2002			
Logged By:	K. Gronseth	Drill Rig:	CME-75	A - 4.5
Total Depth:	161.5 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 5

Approximate Ground Surface Elevation (feet MSL): 16 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Brown **CLAYEY SILT** with traces of roots, medium stiff, damp (fill)
TV=0.7	37	70			8	0.5	5		
LL=61 PI=27	42				4			MH	Brown **CLAYEY SILT,** soft, moist (recent alluvium)
							▽ (9.5)		
	65	60			5	2.0	10	ML	Brown **CLAYEY SILT** with sand and weathered basaltic gravel, soft (recent alluvium)
					4	2.5	15	ML	Gray **SANDY SILT,** soft (recent alluvium)
TV=0.2	69 71	59 57				0.5		OL	Dark gray **ORGANIC CLAYEY SILT,** soft (recent alluvium)
LL=72 PI=34 TV=0.2	60 64	68 60				0.3	20	OH	Dark gray **SILT,** soft (recent alluvium)
TV=0.1	63						25		grades with clay and shell fragments
			33						
TV=0.1	69	58			Wt. of Hammer		30		grades with sand, very soft
			0						
							35		

Date Started:	February 5, 2002	Water Level: ▽	9.5 ft. 2/5/02 1115 HRS	Plate
Date Completed:	February 7, 2002		9.5 ft. 2/13/02 0715 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	141.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 5.1
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 5

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
TV=0.1	74	56			4	0.3		OH	grades to soft
			64						
								MH	Gray **CLAYEY SILT** with some rounded gravel and cobbles, very stiff (recent alluvium)
TV=0.2	37	85			22	1.0	40		
			71						
						1.5			
	55				8		45		
			71					SM	Dark gray **SILTY SAND** with rounded gravel and cobbles, loose (recent alluvium)
								GM	Grayish brown **SILTY GRAVEL** with sand and clay, medium dense (recent alluvium)
	25				25		50		
			43						
								MH	Orange-brown with black mottling **CLAYEY SILT** with rounded rock, medium stiff (old alluvium)
LL=51 PI=9	52				6		55		
			100						
	61	64			10	2.3	60		grades to stiff
			100						
	51				11	3.3	65		
	59	67	100						
							70		

Date Started:	February 5, 2002	Water Level: ∇	9.5 ft. 2/5/02 1115 HRS
Date Completed:	February 7, 2002		9.5 ft. 2/13/02 0715 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	141.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 5

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)	USCS	Description
	57				10			MH	
			86						
	55	68			21	4.3	75		grades to very stiff
			100						
LL=56 PI=11	60				5	2.0	80		grades to soft to medium stiff
			100						
TV=1.2	57	66			6	2.5	85		grades to medium stiff
			100						
TV=0.8	57	69			14	2.0	90		grades to stiff
			100						
	55				12		95		
			100			1.5			
TV=1.0	59	66			15	1.8	100		
			100						
							105		

Date Started:	February 5, 2002	Water Level: ∇	9.5 ft. 2/5/02 1115 HRS 9.5 ft. 2/13/02 0715 HRS	Plate
Date Completed:	February 7, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 5.3
Total Depth:	141.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 5

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	54				7					MH	grades to medium stiff
			100								
	51	74			12	4.3	110				grades to stiff
			100								
	54				16	2.8	115				
	60		100								
LL=54 PI=18 TV=0.2	57				7	1.0	120				grades to medium stiff
			100								
	60				13	1.5	125				grades to stiff
	51	70	100								
	48				19		130				grades to very stiff
			100								
			85				135				
							140				grades to orange-brown, stiff

Date Started:	February 5, 2002	Water Level: ⊻	9.5 ft. 2/5/02 1115 HRS	Plate
Date Completed:	February 7, 2002		9.5 ft. 2/13/02 0715 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 5.4
Total Depth:	141.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	58				14	1.5				MH	
	63	63									
											Boring terminated at 141.5 feet
							145				
							150				
							155				
							160				
							165				
							170				
							175				

Date Started:	February 5, 2002	Water Level: ∇	9.5 ft. 2/5/02 1115 HRS 9.5 ft. 2/13/02 0715 HRS
Date Completed:	February 7, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	141.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 6

Approximate Ground Surface Elevation (feet MSL): 17 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
										MH	Brown **CLAYEY SILT** with traces of gravel, medium stiff, damp (fill)
	33	57			8	3.5	5				
	40				6						grades to moist
										MH	Brown **CLAYEY SILT** with traces of roots, soft, moist (recent alluvium)
	64	62			4	0.5 ∇	10				
	58	65				3.0	15			OL	Dark gray **ORGANIC CLAYEY SILT** with sand, soft (recent alluvium)
			85								
										OH	Dark gray **ORGANIC SILTY CLAY,** soft (recent alluvium)
	51	72			3	0.3	20				
											grades with sand
			0								
						0.0					
LL=72 PI=36 TV=0.3	63	65				0.5	25				grades to soft to medium stiff
			0								
							30				
			0								
											grades with shell fragments
							35				

Date Started:	February 7, 2002	Water Level: ∇	10.5 ft. 2/7/02 1500 HRS	Plate
Date Completed:	February 12, 2002		10.2 ft. 2/13/02 0716 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 6.1
Total Depth:	161.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 6

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
TV=0.1					2	0.3		OH	grades to dark brown organic clayey silt with sand, very soft
	80	55							
			0						
	31	82				3.0	40		grades to soft to medium stiff
			85						
								SM	Dark gray **SILTY SAND** with gravel, loose to medium dense (recent alluvium)
	53	71			13	3.0	45		
								MH	Gray **CLAYEY SILT** with gravel, stiff (recent alluvium)
			100						
									grades with boulders
TV=1.1	50	73			9	1.5	50		grades with sand, medium stiff to stiff
			100						
	54	69			8	1.3	55		grades to medium stiff
								MH	Orange-brown with black mottling **CLAYEY SILT** with sand, medium stiff (old alluvium)
			64						
LL=55 PI=20	65				5		60		grades with weathered rounded rock
			100						
	53	70			20	2.5	65		grades to very stiff
			88						
							70		

Date Started:	February 7, 2002	Water Level: ∇	10.5 ft. 2/7/02 1500 HRS	Plate
Date Completed:	February 12, 2002		10.2 ft. 2/13/02 0716 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 6.2
Total Depth:	161.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring

6

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	61				6			MH	grades to medium stiff
			100						
	59	67			14	2.8	75		grades to stiff
			100						
	61				7		80		grades to medium stiff
			100						
	59	66			13		85		grades to stiff
			100						
	59				11		90		
			50						
TV=1.0	53	69			27	1.8	95		grades to very stiff
			100						
LL=59 PI=22	56				13		100		grades to stiff
			91						
							105		

Date Started:	February 7, 2002	Water Level: ⊻	10.5 ft. 2/7/02 1500 HRS
Date Completed:	February 12, 2002		10.2 ft. 2/13/02 0716 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	161.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 6.3

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring
6

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	56	71			42	4.0		MH	grades with extremely weathered basaltic rock
			100						
	57				9		110		
			50						
TV=1.0	57	68			29	2.5	115		grades to very stiff
			100						
	53				23	3.0	120		
			100						
TV=1.0	54				21	3.3	125		
	57	68	100						
	23				18	1.5	130		
			100						
TV=1.1	58	67			18	1.3	135		grades to stiff to very stiff
			100			2.5			
							140		

Date Started:	February 7, 2002	Water Level: ⊻	10.5 ft. 2/7/02 1500 HRS
Date Completed:	February 12, 2002		10.2 ft. 2/13/02 0716 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	161.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate
A - 6.4

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 6

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
LL=63 PI=23	54				16	1.0				MH	grades with weathered rounded rock
			100								
											Brownish gray with orange mottling **BASALT**, severely fractured, extremely to highly weathered, soft (basalt formation)
	37				82		145				
			100	30							
	38				68		150				
			33								
	51				15		155				
			100								
	42				64		160				
											Boring terminated at 161.5 feet
							165				
							170				
							175				

Date Started:	February 7, 2002	Water Level: ⊽	10.5 ft. 2/7/02 1500 HRS	Plate
Date Completed:	February 12, 2002		10.2 ft. 2/13/02 0716 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	161.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 6.5
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 7

Approximate Ground Surface Elevation (feet MSL): 17 *

Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Brown **CLAYEY SILT,** stiff, moist (fill)
	37	75			16	4.0	5		
	39				8	1.5			grades with gravel, medium stiff
	24	95			18	4.3	10	GM	Brown **SILTY ROUNDED GRAVEL** with sand, medium dense, wet (recent alluvium)
							▽		
								SM	Brown **SILTY FINE SAND,** loose (recent alluvium)
TV=0.3	65	61			3	0.5	15		
TV=0.1	73		15			0.5		MH	Brownish gray **CLAYEY SILT,** soft (recent alluvium)
								OL	Dark gray **ORGANIC CLAYEY SILT** with sand, soft (recent alluvium)
	53	65				1.3	20		
			100						
	66	57				1.3	25		
			83						
	93	49				0.8	30		grades to very soft
	51		83			1.3			
							35		

Date Started:	February 13, 2002	Water Level: ▽	11.3 ft. 2/13/02 1010 HRS 10 ft. 2/21/02 0745 HRS	Plate
Date Completed:	February 14, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 7.1
Total Depth:	150 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 7

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	94	47				2.8		OL	grades to soft
			0						
TV=0.4	84	50			3	0.5	40		grades to very soft to soft
			0						
TV=0.4	87	46			3	0.5	45		
			0						
TV=0.3	111	41			8	0.5	50		grades to medium stiff
			71						
								SM	Dark gray **SILTY FINE SAND,** very loose (recent alluvium)
TV=0.2	133	41			2		55		
			71						
	40				10/.5' +41/.0' Ref.		60		
			100					GP	Gray **BOULDERS, COBBLES AND GRAVEL** with sand, very dense (conglomerate)
			90				65		
							70		

Date Started:	February 13, 2002	Water Level: ∇	11.3 ft. 2/13/02 1010 HRS
Date Completed:	February 14, 2002		10 ft. 2/21/02 0745 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	150 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 7.2

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 7

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			95							GP	grades to moderately well cemented
										ML	Brownish gray **SANDY SILT** with rounded rock, hard (old alluvium)
	63				36		75				
			100								
	76				11		80				grades to medium stiff to stiff
			100								
	69				15		85				grades to stiff
			100								
	63				20		90				grades to very stiff
			100								
	52	68			57	4.3	95				Brownish gray vesicular **BASALT**, severely fractured, extremely weathered, soft to friable,breaks down to sandy gravel with silt (basalt formation)
			100	0							
			100	70	25/.0' Ref.		100				grades to grayish brown, moderately fractured, highly weathered, soft
											grades to brownish gray vugular, moderately weathered, medium hard
							105				

Date Started:	February 13, 2002	Water Level: ⊻	11.3 ft. 2/13/02 1010 HRS	Plate
Date Completed:	February 14, 2002		10 ft. 2/21/02 0745 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 7.3
Total Depth:	150 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 7

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			100	100							
UC=2352											grades to massive, slightly weathered, hard
UC=843											
			100	100			110				grades to gray vesicular, unweathered, very hard
			100	100			115				
			100	100			120				
			100	95			125				grades to slightly weathered
			100	80			130				
			100	100			135				
							140				

Date Started:	February 13, 2002	Water Level: ∇	11.3 ft. 2/13/02 1010 HRS	Plate
Date Completed:	February 14, 2002		10 ft. 2/21/02 0745 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 7.4
Total Depth:	150 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description (Continued from previous plate)
UC=1876			100	95							grades to brownish gray vugular, slightly fractured, hard to very hard
			100	100			145				
							150				Boring terminated at 150 feet
							155				
							160				
							165				
							170				
							175				

Date Started:	February 13, 2002	Water Level: ∇	11.3 ft. 2/13/02 1010 HRS
Date Completed:	February 14, 2002		10 ft. 2/21/02 0745 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	150 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **8**

Approximate Ground Surface Elevation (feet MSL): 17 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Brown **CLAYEY SILT,** very stiff, moist (fill)
	31	78			39	3.5	5		
	40				12	1.0			grades to stiff
	35	83			14	4.3	10		
							▽	GW	Grayish brown **SANDY ROUNDED GRAVEL** with silt, medium dense, wet (recent alluvium)
								OL	Dark gray **ORGANIC SANDY SILT** with traces of clay, soft (recent alluvium)
TV=0.2	70	56			7	0.3	15		
			100					OH	Dark gray **ORGANIC CLAYEY SILT** with traces of sand, soft to medium stiff (recent alluvium)
								OH	Dark gray **ORGANIC CLAYEY SILT** with sand, soft (recent alluvium)
LL=73 PI=37	65	60				0.3	20		
			50						
TV=0.2	64	59				0.5	25		
			0						
							30		grades to very soft
			17						
									grades with shell fragments and some cemented siltstone
							35		

Date Started:	February 19, 2002	Water Level: ▽	11.5 ft. 2/19/02 1325 HRS	Plate
Date Completed:	February 22, 2002		8.5 ft. 2/21/02 1020 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 8.1
Total Depth:	140 feet	Drilling Method:	Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 8

(Continued from previous plate)

Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
TV=0.5	81	51				0.5		OH	
			50						
	73	58			2	1.0	40		grades to soft to very soft
			100						
TV=0.1	118	41				0.5	45		grades to medium stiff
			50						
									grades with seams of silty fine sand
	70	60			3	0.25	50		grades to soft to very soft
			0						
	74	53			19	1.0	55		
								GW	Gray rounded **SANDY GRAVEL** with silt, medium dense (recent alluvium)
			0						
TV=0.2	62	64			59	0.8	60		grades with cobbles, dense
			50						
								SM	Gray **SILTY SAND,** loose (recent alluvium)
	65				15		65		
								GP	Gray **BOULDERS, COBBLES AND GRAVEL** with sand and silt, very dense (conglomerate)
			33						
							70		

Date Started:	February 19, 2002	Water Level: ⊻	11.5 ft. 2/19/02 1325 HRS	Plate
Date Completed:	February 22, 2002		8.5 ft. 2/21/02 1020 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 8.2
Total Depth:	140 feet	Drilling Method:	Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 8

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			85		50/.1' Ref.					GP	
	45				59		75				Brownish gray vesicular **BASALT**, moderately fractured, extremely weathered, soft (basalt formation)
			84	42							
UC=438											
			100	60			80				grades to vugular, highly weathered, medium hard
											grades to vesicular, highly fractured, extremely weathered, soft
	19				50/.4' Ref.		85				
			100	100							grades to slightly fractured, moderately weathered, hard
			100	95			90				grades to moderately fractured
			100	100			95				
											grades to highly weathered, medium hard to hard
UC=265											
			100	100			100				
											grades to gray, moderately weathered, hard
							105				

Date Started:	February 19, 2002	Water Level: ∇	11.5 ft. 2/19/02 1325 HRS	Plate
Date Completed:	February 22, 2002		8.5 ft. 2/21/02 1020 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 8.3
Total Depth:	140 feet	Drilling Method:	Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 8

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
			100	100							grades to vugular, massive, slightly weathered, very hard
			100	100			110				grades to slightly fractured, moderately weathered, hard
											grades to slightly weathered
			100	100			115				
UC=565											
			100	100			120				grades to vesicular, slightly fractured to massive, hard to very hard
			100	60			125				grades to brownish gray, moderately fractured, moderately to highly weathered, medium hard
			100	100			130				grades to gray, slightly fractured to massive, slightly weathered to unweathered, hard
UC=836 UC=1089											
			100	100			135				grades to massive, unweathered, very hard
							140				Boring terminated at 140 feet

Date Started:	February 19, 2002	Water Level: ∇	11.5 ft. 2/19/02 1325 HRS 8.5 ft. 2/21/02 1020 HRS	Plate
Date Completed:	February 22, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	140 feet	Drilling Method:	Hollow-Stem Auger & PQ Coring	A - 8.4
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 9

Approximate Ground Surface Elevation (feet MSL): 18 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT** with sand and traces of gravel, very hard, damp (fill)
	24	80			50/.4' Ref.	4.3	5		
							▽ 9.2		
LL=78 PI=38	52				7		10	MH	Brown **CLAYEY SILT** with traces of gravel, medium stiff (recent alluvium)
TV=0.4	68	54			11	1.0	15	OH	Dark gray **ORGANIC SILTY CLAY** with roots, stiff (recent alluvium)
LL=66 PI=31	66				2		20		grades to very soft
					Push/ 2.0'		25		
	73				Push/ 2.0'		30		
TV=0.1	71				3	0.0			grades to dark gray to black with sand and shell fragments
							35		

Date Started:	January 14, 2002	Water Level: ▽	9.2 ft. 1/14/02 0940 HRS	Plate
Date Completed:	January 17, 2002			
Logged By:	K. Gronseth	Drill Rig:	CME-75	
Total Depth:	115 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	A - 9.1
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 9

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
TV=0.4	63	60			Push/ 2.0'	0.5				OH	grades to dark gray
					Push/ 2.0'		40				
LL=93 PI=53	75				3	0.0					
TV=0.4	70	55			10	1.0	45				grades to medium stiff to stiff
			71								grades with roots and leaves
			91		50/.1' Ref.		50			GP	Gray **BOULDERS, COBBLES AND GRAVEL** with sand and silt, very dense (conglomerate)
	50		96	24	50/.3' Ref.		55				Brownish gray vesicular **BASALT**, closely fractured, slightly weathered, very hard (basalt formation)
	22		96	52	50/.2' Ref.		60				grades to gray, moderately fractured
			100	72	30/.0' Ref.		65				grades to slightly fractured
							70				

Date Started:	January 14, 2002	Water Level: ⊻ 9.2 ft. 1/14/02 0940 HRS	Plate
Date Completed:	January 17, 2002		
Logged By:	K. Gronseth	Drill Rig: CME-75	A - 9.2
Total Depth:	115 feet	Drilling Method: 4" Solid-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy: 140 lb. wt., 30 in. drop	

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Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring **9**

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Description
			37	18	30/.1' Ref.			
								Reddish gray **CLINKER**, closely fractured, extremely weathered, soft, breaks down to sandy gravel with clay (basalt formation)
	78				11		75	
			100	36				grades to moderately fractured, highly weathered
	19		86	78	50/.3' Ref.		80	Dark gray vesicular **BASALT**, moderately to slightly fractured, slightly weathered, very hard (basalt formation)
			100	63			85	grades to gray, moderately fractured, moderately weathered, hard to very hard
UC=2179								
			83	76	50/.1'		90	grades to slightly fractured
	28		100	89	50/.4'		95	grades to slightly fractured to massive, slightly weathered to unweathered
			97	92			100	
							105	grades to brownish gray, slightly fractured, moderately weathered, hard

Date Started:	January 14, 2002	Water Level: ⊻	9.2 ft. 1/14/02 0940 HRS
Date Completed:	January 17, 2002		
Logged By:	K. Gronseth	Drill Rig:	CME-75
Total Depth:	115 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 9.3

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 9

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
			100	90							
UC=546											
											Reddish gray **CLINKER**, moderately fractured, highly weathered, medium hard to hard (basalt formation)
			80	68			110				Reddish gray vugular **BASALT**, moderately fractured, moderately weathered, hard (basalt formation)
UC=1572											
							115				Boring terminated at 115 feet
							120				
							125				
							130				
							135				
							140				

Date Started:	January 14, 2002	Water Level: ⊻	9.2 ft. 1/14/02 0940 HRS	Plate
Date Completed:	January 17, 2002			
Logged By:	K. Gronseth	Drill Rig:	CME-75	A - 9.4
Total Depth:	115 feet	Drilling Method:	4" Solid-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 10

Approximate Ground Surface Elevation (feet MSL): 19 *

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Brown **CLAYEY SILT** with traces of cobbles and gravel, medium stiff, very moist (fill)
TV=1.1	36	83			13	2.0	5		grades with multi-color mottling, stiff
LL=57 PI=26	41				3			MH	Dark reddish brown **CLAYEY SILT,** very soft, very moist (recent alluvium)
			36						
							10		
	102	42			7	0.3		CH	Grayish brown with multi-color mottling **SILTY CLAY,** medium stiff (recent alluvium)
			40						
							15		grades with some organic debris
	85				4			CL	Gray **SILTY CLAY** with traces of organic debris, soft (recent alluvium)
			38						
							20		grades to very soft
TV=0.2	58	63			3	0.5		OH	Dark gray **ORGANIC SILTY CLAY** with some fine sand and organic debris, very soft (recent alluvium)
TV=0.1	60	65				0.0			
							25		
	68				5				grades to soft
			24					ML	Dark gray **SANDY SILT** with some highly weathered basaltic gravel, soft to medium stiff (recent alluvium)
							30		
	43	76			32	3.8			
			95					GC	
							35		

Date Started:	January 21, 2002	Water Level: ∇	Not Measured**	Plate
Date Completed:	January 28, 2002			
Logged By:	E. Shinsato	Drill Rig:	CME-55	
Total Depth:	111.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 10.1
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 10

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
										GC	Grayish brown **CLAYEY GRAVEL** with seams of weathered subrounded gravel and sand, loose to medium dense (conglomerate)
	61				10						
			43								
							40				Brownish gray vesicular **BASALT**, severely fractured, extremely to highly weathered, soft (basalt formation)
	65				17						
			45	0							
							45				
	43		84	75	45/.3' Ref.						grades to gray, moderately fractured, moderately weathered, medium hard to hard
							50				
			97	97							
							55				Reddish brown **CLINKER**, slightly fractured, highly weathered, medium hard (basalt formation)
UC=293			100	97							
											Gray with multi-color seams vesicular **BASALT**, moderately fractured, slightly weathered, hard (basalt formation)
							60				
			87	82							grades to vugular
							65				
			92	87							
UC=2331							70				

Date Started:	January 21, 2002	Water Level: ⊽	Not Measured**	Plate A - 10.2
Date Completed:	January 28, 2002			
Logged By:	E. Shinsato	Drill Rig:	CME-55	
Total Depth:	111.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 10

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											(Continued from previous plate)
			33	8							
											grades to brownish gray, severely fractured, highly weathered
							75				Orange-grayish brown **CLINKER** with clay seams, severely fractured, extremely weathered, soft to medium hard (basalt formation)
	55				51						
			100								
							80				
UC=286	24		100	95	40/.2' Ref.						grades to grayish brown, moderately fractured, highly weathered, medium hard
							85				
			100	100							
											Brownish gray vesicular **BASALT**, moderately to closely fractured, moderately weathered, hard (basalt formation)
							90				
			100	100							grades to gray, moderately to slightly fractured, slightly weathered
UC=1071							95				
			37	20							grades to severely fractured
							100				
			100	100	25/.0' Ref.						
							105				grades to vugular, moderately to slightly fractured, very hard

Date Started:	January 21, 2002	Water Level: ∇	Not Measured**	Plate
Date Completed:	January 28, 2002			
Logged By:	E. Shinsato	Drill Rig:	CME-55	A - 10.3
Total Depth:	111.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 10

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			100	100							grades to vesicular
											grades to highly weathered, medium hard
							110				
UC=162											
											Boring terminated at 111.5 feet * *Due to Rotary Wash Drilling Method
							115				
							120				
							125				
							130				
							135				
							140				

Date Started:	January 21, 2002	Water Level: ⊻	Not Measured**	Plate
Date Completed:	January 28, 2002			
Logged By:	E. Shinsato	Drill Rig:	CME-55	A - 10.4
Total Depth:	111.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 11

Approximate Ground Surface Elevation (feet MSL): 27 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	CL	4-inch **CONCRETE** Brown **SILTY CLAY** with some gravel and sand, stiff, moist (fill)
	26	84			45	4.3	5	CH	Brown **SILTY CLAY** with some sand, hard, moist (fill)
	32				52				
	45	70			47/.5' +30/.2' Ref.	4.3	10	ML	Brown **SANDY SILT** with some gravel, very hard, very moist (recent alluvium)
LL=64 PI=28	59				13	0.5	15	MH	Grayish brown with orange mottling **CLAYEY SILT** with sand and gravel, stiff (recent alluvium)
	53	68			11	1.0	20		grades to medium stiff to stiff
	41				10		25		grades to dark brown, stiff
			0						
TV=0.75					47	1.5	30		
			100						
							35		

Date Started:	January 28, 2002	Water Level: ∇	11.8 ft. 1/28/02 1610 HRS 9.8 ft. 1/30/02 1342 HRS
Date Completed:	January 30, 2002		
Logged By:	E. Shinsato	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 11.1

BORING LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 11

(Continued from previous plate)

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
			83		25/.0' Ref.					GP	Brownish gray **BOULDERS, COBBLES AND GRAVEL,** very dense (conglomerate)
							40				
			88	32							Grayish brown vesicular **BASALT**, severely fractured, highly to extremely weathered, medium hard (basalt formation)
							45				
	44				33/.5' +50/.4' Ref.						
UC=460			100	53							grades to moderately fractured, highly to moderately weathered
							50				
			93	63							
							55				
			100	100							grades to slightly fractured, highly weathered
UC=567											grades to severely fractured, hard
							60				
			92	78							grades to dark gray, slightly fractured, slightly weathered
							65				
			60	43	20/.0' Ref.						Reddish grayish brown **CLINKER**, severely to moderately fractured, highly weathered, soft (basalt formation)
							70				

Date Started:	January 28, 2002	Water Level: ⊻	11.8 ft. 1/28/02 1610 HRS 9.8 ft. 1/30/02 1342 HRS	Plate
Date Completed:	January 30, 2002			
Logged By:	E. Shinsato	Drill Rig:	CME-75	
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 11.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring

11

(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)	Description
	49				28/.5' +50/.4' Ref.			
			100	79				grades to brownish gray, moderately fractured, moderately weathered, medium hard
			100	58			75	grades to severely fractured
								Gray vesicular **BASALT**, massive, slightly weathered, hard (basalt formation)
			100	100			80	
			100	100			85	
UC=6480								
			100	87			90	grades to moderately weathered
								grades to reddish grayish brown, moderately fractured, highly weathered, medium hard
			100	100			95	grades to massive, moderately weathered
UC=1757								
							100	Boring terminated at 100.5 feet
							105	

Date Started:	January 28, 2002
Date Completed:	January 30, 2002
Logged By:	E. Shinsato
Total Depth:	100.5 feet
Work Order:	4850-00(B)

Water Level: ▽	11.8 ft. 1/28/02 1610 HRS
	9.8 ft. 1/30/02 1342 HRS
Drill Rig:	CME-75
Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 11.3

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 12

Approximate Ground Surface Elevation (feet MSL): 28 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	GM	4-inch **ASPHALTIC CONCRETE**
									Grayish brown **SILTY GRAVEL,** dense, damp (base course)
								CH	Brown **SILTY CLAY,** very stiff to hard, damp (fill)
	17				10/.0' Ref.		5		
								MH	Reddish brown **CLAYEY SILT,** stiff, moist
	37	55			51		10		Grayish brown **BASALT**, severely fractured, extremely weathered, soft (basalt formation)
			65	0					
									Reddish grayish brown **CLINKER**, severely fractured, extremely to highly weathered, soft (basalt formation)
							15		
	52				46				Brown vesicular **BASALT**, severely fractured, highly weathered, soft (basalt formation)
			100	100					
							20		
UC=205			100	100					grades to vugular, moderately fractured, soft to medium hard
							25		
UC=156			100	100					
UC=148									Gray **CLINKER**, severely fractured, highly weathered, soft (basalt formation)
							30		
			100	85					Brownish gray vesicular **BASALT**, severely to moderately fractured, moderately weathered, medium hard (basalt formation)
							35		grades to moderately fractured

Date Started:	January 30, 2002	Water Level: ▽	Not Measured**	Plate
Date Completed:	February 4, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	76 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 12.1
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 12

(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
UC=474			95	70							grades to severely to moderately fractured
											Reddish brown **CLINKER**, highly weathered, soft (basalt formation)
							40				Grayish brown vugular **BASALT**, moderately fractured, highly weathered, medium hard (basalt formation)
			100	65							grades to slightly weathered, hard
							45				grades to slightly fractured, very hard
			100	70							
											Reddish brown **CLINKER**, highly weathered, soft (basalt formation)
											Brownish gray vesicular **BASALT**, slightly fractured, highly to moderately weathered, medium hard (basalt formation)
							50				
			100	100							grades to moderately to slightly weathered, hard
							55				
			100	100							grades to slightly fractured to massive, slightly weathered to unweathered, very hard
							60				
			100	100							grades to slightly fractured
							65				
			100	100							grades to massive
							70				

Date Started:	January 30, 2002	Water Level: ⊻	Not Measured**	Plate
Date Completed:	February 4, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	76 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 12.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 12

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
			100	100			75				grades to reddish gray, slightly fractured, slightly to moderately weathered, hard
							80				Boring terminated at 76 feet * *Due to Rotary Wash Drilling Method
							85				
							90				
							95				
							100				
							105				

Date Started:	January 30, 2002	Water Level: ∇	Not Measured**	Plate
Date Completed:	February 4, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 12.3
Total Depth:	76 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 13

Approximate Ground Surface Elevation (feet MSL): 75 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
										MH	Brown **CLAYEY SILT,** medium stiff, friable (residual)
			67	50							Gray dense with some vugular **BASALT**, slightly fractured, slightly weathered, very hard (basalt formation)
							5				grades to brownish gray vesicular, moderately fractured, moderately weathered, hard
	25		100	80	55/.5' Ref.						
UC=2290											
							10				grades to gray, slightly fractured
UC=2524			95	60							grades to vugular, moderately fractured, slightly weathered
							15				
UC=2015			97	80							grades to dense
							20				
UC=2144											grades to vugular, slightly fractured, very hard
			97	83							grades to dense, massive
							25				
UC=1352 UC=1602			100	75							grades to vugular
							30				
			100	100							
							35				

Date Started:	May 3, 2002	Water Level: ⊻	64 ft. 5/6/02 1640 HRS
Date Completed:	May 6, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	97 feet	Drilling Method:	4" Auger & 4" Casing
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 13.1

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 13

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
UC=1598											
UC=1074			88	52							
							40				
			100	78							grades to brownish gray vesicular, moderately fractured, moderately to highly weathered, medium hard
							45				grades to gray, slightly fractured, slightly weathered, hard
			100	100							
UC=2053											
							50				
			100	100							
							55				
			95	80							
UC=363							60				grades to brownish gray, moderately to slightly fractured, slightly to moderately weathered, medium hard to hard
			100	58							
							▽ (64)				
							65				
			82	28							grades to severely fractured
							70				

Date Started:	May 3, 2002	Water Level: ▽	64 ft. 5/6/02 1640 HRS	Plate
Date Completed:	May 6, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	97 feet	Drilling Method:	4" Auger & 4" Casing	A - 13.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 13

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			90	38							
UC=938							75				
			63	22							grades to brown and gray, extremely weathered, soft
							80				
			87	70							grades to gray, vugular, slightly fractured, slightly weathered, very hard
							85				grades to brown and gray, severely fractured, highly weathered, soft to medium hard
	73				27						
			100	88							grades to gray, vugular, slightly fractured, slightly weathered, very hard
UC=2775							90				
			100	90							
							95				**CLINKER**
											Gray vesicular **BASALT**, slightly fractured, slightly weathered, hard
											Boring terminated at 97 feet
							100				
							105				

Date Started:	May 3, 2002	Water Level: ⊻	64 ft. 5/6/02 1640 HRS
Date Completed:	May 6, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	97 feet	Drilling Method:	4" Auger & 4" Casing
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 13.3

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 101

Approximate Ground Surface Elevation (feet MSL): 101 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** very stiff to hard, damp (fill)
	21	85			40	4.3			
	23				15				
	24	98			69	4.3	5		
	26				82		10		
							13	MH	Reddish brown **CLAYEY SILT** with sand and rock, very stiff to hard, moist (residual)
	39	79			92	4.3	15		
	29				42		20		
	31	76			106	4.3	25		
							26		Brownish gray vesicular **BASALT**, moderately fractured, highly weathered, soft to medium hard (basalt formation)
	29				103		30		
							31.5		Boring terminated at 31.5 feet
							35		

Date Started:	April 18, 2002	Water Level: ∇	Not Encountered	Plate A - 14
Date Completed:	April 18, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	31.5 feet	Drilling Method:	5" Auger	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 102

Approximate Ground Surface Elevation (feet MSL): 115 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** stiff, dry (fill)
	21	82			86	4.3		MH	Reddish brown **CLAYEY SILT,** hard, damp (residual)
	21				65				
	20	95			39/.5' +50/.2'	4.3	5		
	25				34		10		
	28				72/.5'		15		
			100	50					Gray vesicular **BASALT**, moderately fractured, slightly weathered, hard (basalt formation)
									Brownish gray **BASALT**, severely fractured, highly weathered, soft (basalt formation)
			100	0			20		
			100	50			25		
									Brownish gray **CLINKER**, severely fractured, slightly to moderately weathered, medium hard to hard (basalt formation)
			100	60			30		
									Gray dense **BASALT**, closely fractured, slightly weathered, very hard (basalt formation)
							35		

Date Started:	April 18, 2002	Water Level: ∇	Not Encountered	Plate A - 15.1
Date Completed:	April 18, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	50 feet	Drilling Method:	5" Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 102

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 (Continued from previous plate)
			100	100							
			100	100			40				grades to moderately fractured
			95	80			45				grades to vugular
											Reddish brown **CLINKER**, severely fractured, slightly weathered, hard (basalt formation)
							50				Boring terminated at 50 feet
							55				
							60				
							65				
							70				

Date Started:	April 18, 2002	Water Level: ∇	Not Encountered	Plate A - 15.2
Date Completed:	April 18, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	50 feet	Drilling Method:	5" Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 103

Approximate Ground Surface Elevation (feet MSL): 118 *

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
							0			GW	3-inch **ASPHALTIC CONCRETE**
	28				12					MH	Brown **SANDY GRAVEL** with silt and clay, medium dense, damp (base course)
											Reddish brown **CLAYEY SILT** with sand and gravel, stiff, damp (fill)
	23	83			21	4.3	5				
	24				56		10			ML	Yellowish brown **SANDY SILT** with gravel, hard, damp (residual)
	36	80			52	4.3	15				grades with multi-color mottling with clay
	28				50/.5'		20				Gray with multi-color mottling **BASALT**, severely fractured, highly weathered, medium hard, breaks down to sandy gravel (basalt formation)
	36	79			60/.5'	4.3	25				
	20				93		30				grades to brown with multi-color mottling
							35				

Date Started:	March 18, 2002	Water Level: ∇	Not Encountered
Date Completed:	March 18, 2002		
Logged By:	L. Wang	Drill Rig:	CME-75
Total Depth:	45 feet	Drilling Method:	4" Auger, 6" H. S. Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 16.1

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 103

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	14				116						grades to grayish brown
			100	60			40				grades to reddish brown to gray, moderately fractured, slightly weathered, hard
							45				Boring terminated at 45 feet
							50				
							55				
							60				
							65				
							70				

Date Started:	March 18, 2002	Water Level: ▽	Not Encountered	Plate
Date Completed:	March 18, 2002			
Logged By:	L. Wang	Drill Rig:	CME-75	
Total Depth:	45 feet	Drilling Method:	4" Auger, 6" H. S. Auger & PQ Coring	A - 16.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 104	

Approximate Ground Surface Elevation (feet MSL): 120 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0		3-inch **ASPHALTIC CONCRETE**
	19	110			35	>4.5		GW	Grayish brown **SANDY GRAVEL** with silt, medium dense, damp (base course)
								MH	Reddish brown **CLAYEY SILT,** very stiff to hard, damp (fill)
	25				32		5		
			0						
	30				30		10		grades with dark gray mottling with sand, slightly moist
			0						
	30				51		15		
			100	0				SM	Gray **SILTY SAND** with gravel, dense, moist (residual)
									Brownish gray **BASALT**, severely fractured, extremely to highly weathered, medium hard to soft (saprolite)
			100	0			20		
			75	0			25		
			90	85			30		grades to moderately to slightly fractured, highly weathered, soft
							35		

Date Started:	March 19, 2020	Water Level: ▽	Not Enountered	Plate
Date Completed:	March 20, 2002			
Logged By:	L. Wang	Drill Rig:	CME-75	A - 17.1
Total Depth:	65 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 104

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description (Continued from previous plate)
			100	20							grades to severely fractured, highly to extremely weathered, soft to medium hard
			100	20			40				
											Gray and brown dense **BASALT**, moderately to closely fractured, moderately weathered, medium hard (basalt formation)
			90	45			45				
											grades to gray, moderately fractured, slightly weathered, hard
			97	80			50				grades to slightly fractured
			100	99			55				grades to massive
			100	97			60				
							65				Boring terminated at 65 feet
							70				

Date Started:	March 19, 2020	Water Level: ⊻	Not Enountered	Plate
Date Completed:	March 20, 2002			
Logged By:	L. Wang	Drill Rig:	CME-75	A - 17.2
Total Depth:	65 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 105

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)	USCS	Description
									Approximate Ground Surface Elevation (feet MSL): 107 *
	25	79			54/.5' +50/.2'			MH	Reddish brown **CLAYEY SILT,** very stiff to hard, damp (residual)
	22				33		5		grades with rock
									Tannish gray **BASALT**, highly weathered, soft to medium hard (basalt formation)
	22				95/.5'		10		
			77	36					grades to gray, vesicular, slightly fractured, slightly weathered, very hard
							15		grades to brownish gray, closely fractured, moderately weathered, medium hard to hard
			100	27					grades to gray, moderately fractured, slightly weathered, hard
							20		
			48	10					Gray and brown cemented **CLINKER,** dense (basalt formation)
							25		
			60	18					grades to red and gray, closely fractured, moderately weathered, medium hard
							30		
			95	50					grades to grayish red, moderately fractured
							35		

Date Started:	May 15, 2002	Water Level: ∇	Not Encountered	Plate
Date Completed:	May 15, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	A - 18.1
Total Depth:	41.5 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 105

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
			85	55							grades to hard
							40				Gray dense **BASALT**, slightly fractured, slightly weathered, very hard (basalt formation)
											Boring terminated at 41.5 feet
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	May 15, 2002	Water Level: ∇	Not Encountered	Plate
Date Completed:	May 15, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	A - 18.2
Total Depth:	41.5 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 106

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	Approximate Ground Surface Elevation (feet MSL): 82 * — Description
							0				Brownish gray **BASALT**, closely to moderately fractured, highly to moderately weathered, medium hard (basalt formation)
			3	0							
							5				
	42				95/.5' Ref.						
			100	56							
							10				Gray and brown well cemented **CLINKER**, moderately fractured, moderately weathered, medium hard (basalt formation)
			100	80							grades to grayish red, slightly fractured, hard
							15				grades to brownish gray, slightly weathered, very hard
			95	85							Gray dense **BASALT**, slightly fractured, slightly weathered, very hard (basalt formation)
							20				
			100	100							
							25				
			100	90							
							30				
											Boring terminated at 32 feet
							35				

Date Started:	May 14, 2002	Water Level: ∇	Not Encountered	Plate A - 19
Date Completed:	May 14, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	32 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 107

Approximate Ground Surface Elevation (feet MSL): 39 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								MH	Reddish brown **CLAYEY SILT** with gravel, stiff, damp (fill)
	28	82			16	4.3			
	32	76			8	4.3	5		grades to medium stiff, slightly moist
			0						
	31	89			15	1.5	10		grades to stiff
			0						
TV=0.8	42 46	76 75			7	1.8	15		grades to medium stiff, moist
			15						
								OH	Gray **ORGANIC CLAY,** medium stiff, moist (recent alluvium)
	39	78			10	1.5 ▽	20		
								MH	Brown **CLAYEY SILT** with some rounded gravel, medium stiff (recent alluvium)
			0						
	61	67			9	0.5	25		
			33						
								OH	Gray **ORGANIC CLAY,** soft to medium stiff (recent alluvium)
	66 65	63 59				2.0	30		
			17				35		

Date Started:	February 25, 2002	Water Level: ▽	21 ft. 2/27/02 1225 HRS
Date Completed:	February 26, 2002		21 ft. 2/28/02 0735 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	90.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 20.1

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 107

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	59	69				0.5		OH	
			0						
							40		
	92	42			12	2.0			grades with roots
						1.0			
			67						
								GP	Gray **BOULDERS, COBBLES AND GRAVEL** in a matrix of brown clayey silt, very dense (conglomerate)
							45		
			40		20/.0' Ref.				
							50		
	24				39				grades to dense
			100						
							55		
	30		100		26/.5' +25/0' Ref.				grades to very dense
							60		
	30				54				
			100						
							65		
	39		100		25/.0' Ref.				
							70		

Date Started:	February 25, 2002	Water Level: ∇	21 ft. 2/27/02 1225 HRS
Date Completed:	February 26, 2002		21 ft. 2/28/02 0735 HRS
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	90.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 107

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
			100							GP	grades to cemented
			80				75				
			0				80				
	28		50		25/.0' Ref.		85				Brown vesicular **BASALT**, severely fractured, extremely weathered, friable (basalt formation)
							90				Boring terminated at 90.5 feet
							95				
							100				
							105				

Date Started:	February 25, 2002	Water Level: ⊻	21 ft. 2/27/02 1225 HRS 21 ft. 2/28/02 0735 HRS
Date Completed:	February 26, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	90.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 108

Approximate Ground Surface Elevation (feet MSL): 35 *

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								MH	Reddish brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	24	88			24	4.5			
	35	73			15	1.9	5		grades to stiff, moist
	38	77			9	1.3	10		grades with sand and traces of gravel, medium stiff
TV=0.8	39	55			24	1.5	15		
			50						**BOULDER**
								SM	Brown and gray **SILTY SAND** with gravel, loose (fill)
TV=0.6	50	76			6	1.8	20		
			100						
								MH	Grayish brown **CLAYEY SILT** with sand, medium stiff (recent alluvium)
	52 57	69 68			7	1.5	25		
			100						
							30	OH	Gray **ORGANIC CLAYEY SILT** with sand and gravel, medium stiff (recent alluvium)
	41	67				0.8			
			50					GP	Gray **BOULDERS, COBBLES AND GRAVEL,** medium dense (recent alluvium)
							35		

Date Started:	February 27, 2002	Water Level: ∇	18.5 ft. 3/1/02 0845 HRS
Date Completed:	February 28, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **108**

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	44				4			OH	Gray **ORGANIC CLAYEY SILT** with sand and gravel, very soft (recent alluvium)
			100						
							40		
TV=0.5	58	65			3	1.5			
			100						
							45		
	89	49			10	2.3			grades with sand seams, medium stiff to stiff
			100						
									grades with shell fragments
							50		grades to medium stiff
	87 99	49 44			7	2.4			
			100						
							55		
	73	55				3.0			
			100						
							60		
	105				6				
			100						
							65		**BOULDER**
			60		25/.0' Ref.			OH	Gray **ORGANIC CLAYEY SILT,** medium stiff (recent alluvium)
								SM	Gray **SILTY SAND** with gravel and cobbles, medium dense (recent alluvium)
							70		

Date Started:	February 27, 2002	Water Level: ⊻	18.5 ft. 3/1/02 0845 HRS
Date Completed:	February 28, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 108

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
	29	95			34	4.5				SM	
			33								
							75				
			73		25/.1' Ref.					GP	Gray **BOULDERS, COBBLES AND GRAVEL** with sand, very dense (conglomerate)
							80				
			100								Grayish brown **BASALT**, severely fractured, highly to extremely weathered, friable (basalt formation)
							85				
	41	81	100	0	23/.5' +25/.0' Ref.	2.5					
							90				
			100	100	25/.0' Ref.						
							95				
			100	100							grades to moderately fractured, highly weathered, medium hard
							100				
											Boring terminated at 100.5 feet
							105				

Date Started:	February 27, 2002	Water Level: ∇	18.5 ft. 3/1/02 0845 HRS
Date Completed:	February 28, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 21.3

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 109

Approximate Ground Surface Elevation (feet MSL): 35 *

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)	USCS	Description
								MH	Reddish brown **CLAYEY SILT** with some roots and traces of cobbles and gravel, stiff to very stiff, damp (fill)
							5		
	25	71			29	3.0			
	17				27				
			17						
							10		
	24	87			41	4.3			
			0						
							▽ 15		
	38				20				
			100						
							20		**BOULDER**
	38	79			21	3.5		MH	Brown with multi-color mottling **CLAYEY SILT** with some gravel and sand and traces of organic debris, very stiff (fill)
			62						
							25	OL	Dark gray **ORGANIC CLAYEY SILT** with some subrounded gravel and traces of organic debris, very soft (recent alluvium)
	60				2				
			21						
							30		
			47						
							35		

Date Started:	February 23, 2002	Water Level: ▽	15.5 ft. 2/28/02 0730 HRS
Date Completed:	February 25, 2002		
Logged By:	Shinsato & Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 22.1

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 109

(Continued from previous plate)

Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								GC	Brown **CLAYEY GRAVEL** with sand, very loose (recent alluvium)
	75				3			OH	Dark gray **SILTY ORGANIC CLAY** with traces of roots, very soft (recent alluvium)
			100				40		
	65	65			9	1.5			grades to medium stiff to soft
	75	51							
			62						
							45		
	67				3				grades with some shell fragments, soft to very soft
TV=0.2			100			0.5			
							50		
	56	68			7	1.8			grades with some rounded gravel, medium stiff
			100						
								CH	Grayish brown **SILTY CLAY** with some cobbles and gravel, very stiff (recent alluvium)
							55		
	46				44				
									Brown vesicular **BASALT**, severely fractured, moderately weathered, medium hard (basalt formation)
			100	15					
							60		
	36				50/.4' Ref.				
			100	20					grades to vugular, medium hard to hard
							65		
			100	33					grades to grayish brown, highly weathered, soft
							70		

Date Started:	February 23, 2002	Water Level: ⊻	15.5 ft. 2/28/02 0730 HRS
Date Completed:	February 25, 2002		
Logged By:	Shinsato & Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 22.2

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 109

(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
			100	70							grades to vesicular, closely fractured, slightly to moderately weathered, hard
							75				
			100	67							grades to vugular, moderately fractured, moderately weathered, medium hard
							80				
			100	100							grades to gray, slightly weathered, hard
							85				
			100	100							grades to very hard
							90				
			100	100							
							95				
			100	100							
							100				
											Boring terminated at 100.5 feet
							105				

Date Started:	February 23, 2002	Water Level: ⊻	15.5 ft. 2/28/02 0730 HRS	Plate
Date Completed:	February 25, 2002			
Logged By:	Shinsato & Latronic	Drill Rig:	CME-75	A - 22.3
Total Depth:	100.5 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **110**

Approximate Ground Surface Elevation (feet MSL): 38 *

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	27	88			16	4.5		MH	Brown **CLAYEY SILT** with gravel, stiff, damp (fill)
TV=0.7	32	86	22		25/.0' Ref.	2.0	5		grades with concrete debris
TV=0.6	35	82	33		9	1.8	10		grades to medium stiff, moist
TV=0.3	43	47	33		21		15		grades to very stiff
	30	89	100	0	32	4.3	20	CH	Brown **SILTY CLAY,** very stiff, slightly moist (fill)
									Brown and gray vesicular **BASALT**, moderately fractured, highly to extremely weathered, medium hard to soft (basalt formation)
	49		100	50	25		25 ▽		
	33		100	23	25		30		
							35		

Date Started:	March 1, 2002	Water Level: ▽	25.5 ft. 3/1/02 1435 HRS
Date Completed:	March 1, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	45 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 23.1

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 110

(Continued from previous plate)

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
			100	80							grades to gray, dense, massive, unweathered, very hard
			100	70			40				
											grades to grayish brown, vesicular, moderately fractured, highly weathered, medium hard
							45				Boring terminated at 45 feet
							50				
							55				
							60				
							65				
							70				

Date Started:	March 1, 2002	Water Level: ⊽	25.5 ft. 3/1/02 1435 HRS	Plate
Date Completed:	March 1, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 23.2
Total Depth:	45 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 111

Approximate Ground Surface Elevation (feet MSL): 36 *

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
							0			MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	23	87			26	4.5					
	32	75			14	2.8	5				grades to stiff, slightly moist
TV=0.5	38	78			7	0.8	10				grades to medium stiff, moist
			50								
											Gray dense with some vugular **BASALT**, moderately fractured, slightly weathered, very hard (basalt formation)
	8	84	100	50	25/.0' Ref.		15				
			100	0			20				grades to brown and gray vesicular, severely fractured, extremely weathered, friable
	93				7		25				
			100	0							
	61	66			17	4.5	30				grades to brownish gray vugular, moderately fractured, moderately weathered, soft
			100	33							
							35				

Date Started:	March 4, 2002	Water Level: ▽	22.5 ft. 3/7/02 0705 HRS	Plate
Date Completed:	March 4, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 24.1
Total Depth:	60 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 111

(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
			90	75							grades to hard
			100	75			40				grades to vesicular, medium hard
			100	100			45				grades to gray, slightly fractured, slightly to moderately weathered, medium hard to hard
			100	100			50				grades to unweathered to slightly weathered, very hard
			100	100			55				grades to moderately fractured, hard
							60				Boring terminated at 60 feet
							65				
							70				

Date Started:	March 4, 2002	Water Level: ⊻	22.5 ft. 3/7/02 0705 HRS
Date Completed:	March 4, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	60 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 24.2

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 112

Approximate Ground Surface Elevation (feet MSL): 39 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** medium stiff to stiff, damp (fill)
	25	82			9	4.3			
	34	76			12	4.3	5		grades with gravel, stiff
	20	96			45	4.3	10		grades to dark gray with sand and coralline gravel, hard, dry
			33						
							14	CH	Gray **CLAY,** stiff to very stiff, damp (recent alluvium)
	29	88			17	4.3	15		
			85	17					
							17		Brownish gray **BASALT**, severely fractured, extremely weathered, soft (basalt formation)
	39				59		20		
			100	0					grades to moderately fractured, highly weathered
							24 (water level)		
	56				22		25		
			85	33					grades to severely fractured, extremely weathered
	71	53			24	4.3	30		
			100	23					
							35		

Date Started:	March 5, 2002	Water Level: ⊽	24 ft. 3/7/02 0710 HRS
Date Completed:	March 6, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	90 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 112

(Continued from previous plate)

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
			100	100	25/.0' Ref.						Gray vugular **BASALT**, slightly fractured, slightly weathered, hard to very hard (basalt formation)
			100	100			40				grades to grayish brown, vesicular, moderately fractured, moderately weathered, medium hard
			100	90			45				grades to brownish gray, slightly weathered, hard
			100	100			50				grades to gray, vugular, slightly fractured to massive, slightly weathered to unweathered, very hard
			100	100			55				
			100	100			60				grades to slightly fractured, slightly weathered, hard
			100	70			65				
											Reddish gray **CLINKER**, highly weathered
											Gray vugular **BASALT**, moderately fractured, slightly weathered, hard (basalt formation)
							70				

Date Started:	March 5, 2002	Water Level: ∇	24 ft. 3/7/02 0710 HRS	Plate
Date Completed:	March 6, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	90 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	A - 25.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 112

(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
			100	95							
			95	90			75				grades to slightly fractured, very hard
			80	50			80				Reddish gray **CLINKER**, highly weathered
											Brownish gray vugular **BASALT**, moderately fractured, slightly weathered, hard (basalt formation)
			70	30			85				
							90				Boring terminated at 90 feet
							95				
							100				
							105				

Date Started:	March 5, 2002	Water Level: ⊻	24 ft. 3/7/02 0710 HRS	Plate
Date Completed:	March 6, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 25.3
Total Depth:	90 feet	Drilling Method:	10" Hollow-Stem Auger & PQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **113**

Approximate Ground Surface Elevation (feet MSL): 60 *

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
											14.5-inch **ASPHALTIC CONCRETE**
	12				41					GW	Brown **SILTY GRAVEL** with sand, dense, slightly moist (base course)
	37	81			10	1.8				MH	Brown **CLAYEY SILT,** medium stiff to stiff, moist (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 5, 2002	Water Level: ∇	Not Encountered
Date Completed:	March 5, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 26

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **114**

Approximate Ground Surface Elevation (feet MSL): 56 *

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
											10-inch **ASPHALTIC CONCRETE**
	15				31					GW	Brown **SILTY GRAVEL** with sand, medium dense to dense, moist (base course)
	32	79			8	4.3				MH	Brown **CLAYEY SILT,** medium stiff, slightly moist to moist (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 15, 2002	Water Level: ∇	Not Encountered
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 27

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 115

Approximate Ground Surface Elevation (feet MSL): 53 *

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
											7.5-inch **ASPHALTIC CONCRETE**
										GW	**BASE COURSE**
											Boring terminated at 1 foot
							5				
							10				
							15				

Date Started:	March 15, 2002	Water Level: ⊻	Not Encountered
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	1 foot	Drilling Method:	Concrete Cutter
Work Order:	4850-00(B)	Driving Energy:	N/A

Plate A - 28

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 116

Approximate Ground Surface Elevation (feet MSL): 51 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											6.5-inch **ASPHALTIC CONCRETE**
										GW	**BASE COURSE**
											Boring terminated at 1 foot
							5				
							10				
							15				

Date Started:	March 15, 2002	Water Level: ⊻	Not Encountered
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	1 foot	Drilling Method:	Concrete Cutter
Work Order:	4850-00(B)	Driving Energy:	N/A

Plate A - 29

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring

117

Approximate Ground Surface Elevation (feet MSL): 47 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											7-inch **ASPHALTIC CONCRETE**
	11				37					GW	Brown **SILTY GRAVEL** with sand, dense, damp (base course)
	32	81			21	3.8				MH	Brown **CLAYEY SILT,** very stiff, slightly moist (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 15, 2002	Water Level: ▽	Not Encountered	Plate
Date Completed:	March 15, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger	A - 30
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 118

Approximate Ground Surface Elevation (feet MSL): 45 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											6-inch **ASPHALTIC CONCRETE**
	13				20					GW	Brown **SILTY GRAVEL** with sand, medium dense, slightly moist (base course)
	32									MH	Brown **CLAYEY SILT,** very stiff, slightly moist (fill)
					50/.0' Ref.						Boring terminated at 3.5 feet
							5				
							10				
							15				

Date Started:	March 15, 2002	Water Level: ∇	Not Encountered
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	3.5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 31

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 119

Approximate Ground Surface Elevation (feet MSL): 43.5 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											7.5-inch **ASPHALTIC CONCRETE**
	13				32					GW	Brown **SILTY GRAVEL** with sand, dense, slightly moist (base course)
LL=53 PI=23	33	81			14	4.3				MH	Brown **CLAYEY SILT,** stiff, slightly moist (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 15, 2002	Water Level: ⊽	Not Encountered	Plate A - 32
Date Completed:	March 15, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 120

Approximate Ground Surface Elevation (feet MSL): 42 *

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											7-inch **ASPHALTIC CONCRETE**
										GW	Brown **SILTY GRAVEL** with sand, medium dense, very moist (base course)
	26				22						
										MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	20	92			20	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 14, 2002	Water Level: ⊻	Not Encountered
Date Completed:	March 14, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Approximate Ground Surface Elevation (feet MSL): 42 *

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
							0				5-inch **ASPHALTIC CONCRETE**
	6				31					GW	Brown **SILTY GRAVEL** with sand, dense, dry to damp (base course)
	14	110			17	4.3				MH	Brown **CLAYEY SILT** with gravel, stiff, dry to damp (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 14, 2002
Date Completed:	March 14, 2002
Logged By:	S. Latronic
Total Depth:	5 feet
Work Order:	4850-00(B)
Water Level: ∇	Not Encountered
Drill Rig:	DIEDRICH D-25
Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 122

Approximate Ground Surface Elevation (feet MSL): 61 *

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
							0				16.5-inch **ASPHALTIC CONCRETE**
	14				29					GW	Brown **SILTY GRAVEL** with sand, medium dense, moist (base course)
										MH	Brown **CLAYEY SILT** with gravel, stiff to medium stiff, slightly moist (fill)
	30	90			9	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 15, 2002	Water Level: ∇ Not Encountered	Plate A - 35
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig: DIEDRICH D-25	
Total Depth:	5 feet	Drilling Method: Concrete Cutter & 4" Solid-Stem Auger	
Work Order:	4850-00(B)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **123**

Approximate Ground Surface Elevation (feet MSL): 57 *

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
											8.5-inch **ASPHALTIC CONCRETE**
											10-inch **CEMENT TREATED BASE COURSE**
	11				18					GW	Brown **SILTY GRAVEL** with sand, medium dense, slightly moist (base course)
	25				25/.0' Ref.					MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
											Boring terminated at 4 feet
							5				
							10				
							15				

Date Started:	March 15, 2002	Water Level: ∇	Not Encountered
Date Completed:	March 14, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	4 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 36

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 124

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): 54 * **Description**
											4.5-inch **ASPHALTIC CONCRETE**
											9.5-inch **PORTLAND CEMENT CONCRETE (PCC)**
											Boring terminated at 1.2 feet
							5				
							10				
							15				

Date Started:	March 15, 2002	Water Level: ▽	Not Encountered	Plate A - 37
Date Completed:	March 15, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	1.2 feet	Drilling Method:	Concrete Cutter	
Work Order:	4850-00(B)	Driving Energy:	N/A	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 125

Approximate Ground Surface Elevation (feet MSL): 51.5 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									4.5-inch **ASPHALTIC CONCRETE**
									9.5-inch **PORTLAND CEMENT CONCRETE (PCC)**
	31				16			GW	Brown **SILTY GRAVEL** with sand, medium dense, moist to wet (base course)
	23	87			19	3.8		MH	Brown **CLAYEY SILT,** very stiff, damp (fill)
							5		Boring terminated at 5 feet
							10		
							15		

Date Started:	March 15, 2002	Water Level: ⊽	Not Encountered
Date Completed:	March 15, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 38

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 126

Approximate Ground Surface Elevation (feet MSL): 48 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											3-inch **ASPHALTIC CONCRETE**
											9.5-inch **PORTLAND CEMENT CONCRETE (PCC)**
										GW	**BASE COURSE**
											Boring terminated at 1.5 feet
							5				
							10				
							15				

Date Started:	March 14, 2002
Date Completed:	March 14, 2002
Logged By:	S. Latronic
Total Depth:	1.5 feet
Work Order:	4850-00(B)
Water Level:	Not Encountered
Drill Rig:	DIEDRICH D-25
Drilling Method:	Concrete Cutter
Driving Energy:	N/A

GEOLABS, INC.

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INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring
127

Approximate Ground Surface Elevation (feet MSL): 46 *

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
							0				5-inch **ASPHALTIC CONCRETE**
											9.5-inch **PORTLAND CEMENT CONCRETE (PCC)**
										GW	Brown **SILTY GRAVEL** with sand, dense, damp (base course)
	27				30						
										MH	Brown **CLAYEY SILT** with traces of gravel, very stiff, damp (fill)
	27	82			30	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 14, 2002
Date Completed:	March 14, 2002
Logged By:	S. Latronic
Total Depth:	5 feet
Work Order:	4850-00(B)

Water Level: ⊻	Not Encountered
Drill Rig:	DIEDRICH D-25
Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Driving Energy:	140 lb. wt., 30 in. drop

Plate
A - 40

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **128**

Approximate Ground Surface Elevation (feet MSL): 44.5 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											4-inch **ASPHALTIC CONCRETE**
											9.5-inch **PORTLAND CEMENT CONCRETE (PCC)**
											3-inch **CEMENT TREATED BASE COURSE**
	18				29					GW	Brown **SILTY GRAVEL** with sand, dense, damp (base course)
										MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	27	76			25/.3' Ref.	4.3					
											Boring terminated at 4.3 feet
							5				
							10				
							15				

Date Started:	March 14, 2002	Water Level: ▽	Not Encountered
Date Completed:	March 14, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	4.3 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 41

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 129

Approximate Ground Surface Elevation (feet MSL): 43 *

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
							0				4-inch **ASPHALTIC CONCRETE**
											9-inch **CONCRETE** (approach slab)
										GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
	30				16					MH	Brown **CLAYEY SILT** with traces of gravel, very stiff, damp (fill)
	27	81			23	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	March 14, 2002	Water Level: ⊻	Not Encountered	Plate A - 42
Date Completed:	March 14, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	5 feet	Drilling Method:	Concrete Cutter & 4" Solid-Stem Auger	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 130

Approximate Ground Surface Elevation (feet MSL): 43 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									1-inch **ASPHALTIC CONCRETE**
									8.5-inch **CONCRETE** (approach slab)
									1.5-inch **VOID**
	28	90			19	4.3		GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
								GW	Gray **SANDY GRAVEL** with silt, medium dense, damp (fill)
	7				16				
	7				24				
							5		
									Boring terminated at 5.5 feet
							10		
							15		

Date Started:	March 14, 2002	Water Level: ∇ Not Encountered	Plate A - 43
Date Completed:	March 14, 2002		
Logged By:	S. Latronic	Drill Rig: DIEDRICH D-25	
Total Depth:	5.5 feet	Drilling Method: Concrete Cutter & 4" Solid-Stem Auger	
Work Order:	4850-00(B)	Driving Energy: 140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 131

Approximate Ground Surface Elevation (feet MSL): 54 *

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
											7.5-inch **ASPHALTIC CONCRETE**
											9-inch **PORTLAND CEMENT CONCRETE (PCC)**
	16				21					GW	Brown **SILTY GRAVEL** with sand, medium dense, moist (base course)
	32	92			61	1.3	5			MH	Brown **CLAYEY SILT** with gravel, stiff to very stiff, slightly moist (fill)
											Boring terminated at 5.5 feet
							10				
							15				

Date Started: April 29, 2002	Water Level: ∇	Not Encountered	Plate
Date Completed: April 29, 2002			
Logged By: S. Latronic	Drill Rig:	CME-75	A - 44
Total Depth: 5.5 feet	Drilling Method:	6" Casing & 5" Auger	
Work Order: 4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 132

Approximate Ground Surface Elevation (feet MSL): 48 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											10.3-inch **ASPHALTIC CONCRETE**
											9.8-inch **PORTLAND CEMENT CONCRETE (PCC)**
											5-inch **CEMENT TREATED BASE COURSE**
	11				10					GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
	33	72			11	4.3				MH	Brown **CLAYEY SILT** with gravel, stiff, slightly moist (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	May 1, 2002	Water Level: ⊻	Not Encountered	Plate
Date Completed:	May 1, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	5 feet	Drilling Method:	6" Casing & 5" Auger	A - 45
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 133

Approximate Ground Surface Elevation (feet MSL): 44 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
											4.8-inch **ASPHALTIC CONCRETE**
											9-inch **PORTLAND CEMENT CONCRETE (PCC)**
											5.5-inch **CEMENT TREATED BASE COURSE**
	15				25					GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
										MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	24	83			44	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	May 1, 2002	Water Level: ∇	Not Encountered	Plate
Date Completed:	May 1, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	5 feet	Drilling Method:	6" Casing & 5" Auger	A - 46
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 134

Approximate Ground Surface Elevation (feet MSL): 43 *

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
											5-inch **ASPHALTIC CONCRETE**
											9.5-inch **CONCRETE** (approach slab)
	12				30					GW	Brown **SILTY GRAVEL** with sand, dense, damp (base course)
	27	84			34	4.3				MH	Brown **CLAYEY SILT,** very stiff, damp (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	May 1, 2002	Water Level: ⊻	Not Encountered	Plate A - 47
Date Completed:	May 1, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	5 feet	Drilling Method:	6" Casing & 5" Auger	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 135

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): 43 * **Description**
											3-inch **ASPHALTIC CONCRETE**
											9-inch **CONCRETE** (approach slab)
											2-inch **VOID**
	13				22					GW	Brown **SILTY GRAVEL** with sand, medium dense, slightly moist (base course)
										MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	24	79			46	4.3					
							5				Boring terminated at 5 feet
							10				
							15				

Date Started:	May 1, 2002	Water Level: ▽	Not Encountered	Plate
Date Completed:	May 1, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	A - 48
Total Depth:	5 feet	Drilling Method:	6" Casing & 5" Auger	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **136**

Approximate Ground Surface Elevation (feet MSL): 54 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0		20-inch **ASPHALTIC CONCRETE**
								GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
								MH	Brown **CLAYEY SILT** with gravel, medium stiff to stiff, moist (fill)
	35	81			8	1.0	5		
	32				15	1.3	10		
							15		**BOULDER**
			100						
	28	89			22/.5' +25/.3' Ref.	4.0			
			44					MH	Brown **CLAYEY SILT,** very stiff, moist (fill)
	32				18		20		grades with gravel
			63						
	34	89			26	2.0	25		
			100						
	33				37		30		
			29						
							35		

Date Started:	April 26, 2002	Water Level: ⊻	43.8 ft. 4/29/02 0900 HRS
Date Completed:	April 29, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	6" Casing & 5" Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 49.1

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 136

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	40	78			13	0.8		MH	grades to stiff
	38	79							
			0						
							40		
LL=55 PI=29	32				15	1.0		CH	Dark brown **SILTY CLAY** with some organics, stiff, moist (recent alluvium)
			33						
							45		
	44	72			19	1.0			grades with rounded gravel
			90						
						0.5			grades with cobbles
							50		
			50						
						1.0			
							55	OH	Dark gray **ORGANIC CLAY** with roots, medium stiff to soft (recent alluvium)
	75	50			38				
			100						
							60		
	56				6	0.5			grades with silt
			100						grades with some cobbles
							65		
	62	62			17				grades to soft to very soft
			79			0.0			
							70		

Water level: ▽ at 43.8 ft.

Date Started:	April 26, 2002	Water Level: ▽	43.8 ft. 4/29/02 0900 HRS
Date Completed:	April 29, 2002		
Logged By:	S. Latronic	Drill Rig:	CME-75
Total Depth:	100.5 feet	Drilling Method:	6" Casing & 5" Auger
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 49.2

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 136

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	83	50						OH	grades with shell fragments
						1.3			
			100						
							75		
LL=73 PI=39	64	61				2.0			
			100						
							80		Gray **BASALT**, severely fractured, highly weathered, soft to medium hard (basalt formation)
	49				38	2.0			
			100	0					
							85		
	50				18/.5' +30/.3' Ref.				
			95	55					grades to moderately fractured, slightly weathered, hard
							90		
			100	15					grades to severely fractured, moderately weathered, soft to medium hard
							95		
			100	15					grades to grayish brown, extremely weathered
						3.0			
							100		
									Boring terminated at 100.5 feet
							105		

Date Started:	April 26, 2002	Water Level: ⊻	43.8 ft. 4/29/02 0900 HRS	Plate
Date Completed:	April 29, 2002			
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	100.5 feet	Drilling Method:	6" Casing & 5" Auger	A - 49.3
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring

137

Approximate Ground Surface Elevation (feet MSL): 48 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0		20-inch **ASPHALTIC CONCRETE**
								GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
								MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	30	83			28	>4.5	5		
	26				20		10		
									grades with cobbles
	30	80			21	4.0	15		
			29						
									5-inch **OLD ASPHALTIC CONCRETE** (old roadway)
								GW	**OLD BASE COURSE**
								MH	Brown **CLAYEY SILT** with gravel, stiff, moist (old fill)
	30				11	1.5	20		
			83						
						2.0			
	41	76			28		25		grades to very stiff
			86						
								CH	Gray **SILTY CLAY** with some organics, stiff to very stiff, moist (recent alluvium)
	37				16		30		
			100						
						1.3			
							35		

Date Started:	April 30, 2002
Date Completed:	May 1, 2002
Logged By:	S. Latronic
Total Depth:	65 feet
Work Order:	4850-00(B)

Water Level: ∇	36.5 ft. 5/1/02 0915 HRS
	38.4 ft. 5/1/02 1000 HRS
Drill Rig:	CME-75
Drilling Method:	6" Casing & 5" Auger
Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 50.1

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 137

(Continued from previous plate)

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	46	66			25	1.5		CH	grades to brown, very stiff
			100						
	10		78	22	50/.2' Ref.		40		**COBBLES AND BOULDERS**
									Gray vesicular **BASALT**, moderately fractured, moderately to highly weathered, medium hard (basalt formation)
			90	75			45		grades to slightly fractured, slightly weathered, hard
									Reddish brown **CLINKER,** dense, severely fractured, slightly weathered, hard
			100	35			50		Reddish brown vesicular **BASALT** with clay seams, moderately fractured, moderately to slightly weathered, medium hard (basalt formation)
			100	70			55		grades to hard
			100	85			60		grades to light brownish gray, slightly to moderately fractured, slightly weathered
							65		Boring terminated at 65 feet
							70		

Water level: ∇ at approximately 36.5 ft.

Date Started:	April 30, 2002	Water Level: ∇	36.5 ft. 5/1/02 0915 HRS	Plate
Date Completed:	May 1, 2002		38.4 ft. 5/1/02 1000 HRS	
Logged By:	S. Latronic	Drill Rig:	CME-75	
Total Depth:	65 feet	Drilling Method:	6" Casing & 5" Auger	A - 50.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **138**

Approximate Ground Surface Elevation (feet MSL): 44 *

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
											7.5-inch **ASPHALTIC CONCRETE**
										GW	Brown **SILTY GRAVEL** with sand, medium dense, damp (base course)
	27	78			30/.5' Ref.	4.3				MH	Brown **CLAYEY SILT** with gravel, very stiff, damp (fill)
	24				24		5				
											Boring terminated at 6 feet
							10				
							15				

Date Started: May 1, 2002	Water Level: ∇ Not Encountered		Plate A - 51
Date Completed: May 1, 2002			
Logged By: S. Latronic	Drill Rig:	CME-75	
Total Depth: 6 feet	Drilling Method:	6" Casing & 5" Auger	
Work Order: 4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 139

Approximate Ground Surface Elevation (feet MSL): 43 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
									8.3-inch **ASPHALTIC CONCRETE**
	12				41			GW	Brown **SILTY GRAVEL** with sand, dense, slightly moist (base course)
								MH	Brown **CLAYEY SILT,** very stiff, damp (fill)
	29	90			48	4.3			
							5		Boring terminated at 5 feet
							10		
							15		

Date Started: May 1, 2002	Water Level: ∇ Not Encountered		Plate A - 52
Date Completed: May 1, 2002			
Logged By: S. Latronic	Drill Rig:	CME-75	
Total Depth: 5 feet	Drilling Method:	6" Casing & 5" Auger	
Work Order: 4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring **140**

Approximate Ground Surface Elevation (feet MSL): 43 *

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
							0				9.5-inch **ASPHALTIC CONCRETE**
	14				53					GW	Brown **SILTY GRAVEL** with sand, dense, slightly moist (base course)
	18	86			37	4.0				MH	Brown **CLAYEY SILT** with gravel, stiff to very stiff, damp (fill)
							5				Boring terminated at 5 feet
							10				
							15				

Date Started: May 1, 2002	Water Level: ∇ Not Encountered		Plate A - 53
Date Completed: May 1, 2002			
Logged By: S. Latronic	Drill Rig: CME-75		
Total Depth: 5 feet	Drilling Method: 6" Casing & 5" Auger		
Work Order: 4850-00(B)	Driving Energy: 140 lb. wt., 30 in. drop		

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 141

Approximate Ground Surface Elevation (feet MSL): 110 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** very stiff, damp (residual)
	34	82			30	>4.5		MH	Grayish brown **BASALT,** extremely weathered, soft (breaks down to clayey silt with rock) (basalt formation)
	22				23				
	29	80			29	>4.5	5		
									Reddish brown with gray mottling **BASALT**, severely fractured, highly weathered, soft to medium hard (basalt formation)
	32				73		10		
			23	0					
							15		
	45				87				
			100	45					grades to gray, vugular, moderately fractured, slightly weathered, hard to very hard
							20		
			100	65					
							25		
			100	53					
							30		
			100	78					
							35		

Date Started:	May 9, 2002	Water Level: ⊽	Not Encountered	Plate
Date Completed:	May 9, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	A - 54.1
Total Depth:	37 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 141

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
											grades to massive
											Boring terminated at 37 feet
							40				
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	May 9, 2002	Water Level: ⊻	Not Encountered	Plate
Date Completed:	May 9, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	A - 54.2
Total Depth:	37 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 142

Approximate Ground Surface Elevation (feet MSL): 117 *

Laboratory: Other Tests	Laboratory: Moisture Content (%)	Laboratory: Dry Density (pcf)	Field: Core Recovery (%)	Field: RQD (%)	Field: Penetration Resistance (blows/foot)	Field: Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	31	90			107	>4.5		MH	Reddish brown **CLAYEY SILT,** very stiff, damp (fill)
	27				27			MH	Brown **CLAYEY SILT,** very stiff, damp (residual)
	36	81			52	>4.5	5		grades with orange and gray mottling
	28				63		10		
	26	82	39	22	100/.4' Ref.		15		Reddish brown with gray mottling **BASALT**, severely fractured, highly weathered, soft to medium hard (basalt formation)
			80	27					
							20		grades to gray, vugular, moderately to closely fractured, slightly weathered, hard to very hard
			100	60					
							25		
			95	60					
							30		grades to moderately to slightly fractured
			100	67					
							35		

Date Started:	May 10, 2002	Water Level: ▽	Not Encountered
Date Completed:	May 10, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	37 feet	Drilling Method:	4" Auger & 4" Casing & HQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 55.1

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
											grades to moderately fractured
											Boring terminated at 37 feet
							40				
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	May 10, 2002	Water Level: ⊻	Not Encountered
Date Completed:	May 10, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	37 feet	Drilling Method:	4" Auger & 4" Casing & HQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 201

Approximate Ground Surface Elevation (feet MSL): 118 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	22	103			63			MH	Reddish brown **CLAYEY SILT,** very stiff, damp (residual)
	20				78	>4.5			grades to hard
	23	100			86	>4.5	5		
	25				82		10		grades to light orange-brown
	26	93			75	>4.5	15		
								MH	Reddish brown **BASALT,** extremely weathered, soft (breaks down to clayey silt with weathered rock) (basalt formation)
	38				25	4.5	20		
	38	57	81	21	70/.5' Ref.		25		Grayish brown vesicular **BASALT**, closely to severely fractured, moderately to highly weathered, medium hard (basalt formation)
			85	15					
							30		grades to gray, severely fractured
									Boring terminated at 34 feet
							35		

Date Started:	May 17, 2002	Water Level: ∇	Not Encountered
Date Completed:	May 20, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25 & MOBILE B-80
Total Depth:	34 feet	Drilling Method:	4" Auger & HQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 202

Approximate Ground Surface Elevation (feet MSL): 115 *

Other Tests (Laboratory)	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%) (Field)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
	23	85			50	3.0		MH	Reddish brown **CLAYEY SILT,** very stiff, damp (residual)
	20				39	>4.5			grades to hard
	22	81			60/.4' Ref.		5		grades to orange-brown
	24				37	>4.5	10		
								MH	Brown **BASALT,** extremely weathered, soft (breaks down to clayey silt with rock) (basalt formation)
	40	79			57	2.0	15		
	35				64		20		
	32	78			50/.3' Ref.		25		
			95	60					Gray **BASALT**, moderately to slightly fractured, slightly to moderately weathered, hard to very hard (basalt formation)
			64	21			30		grades to dense, closely to severely fractured, moderately weathered
							35		Boring terminated at 35 feet

Date Started:	May 17, 2002	Water Level: ∇	Not Encountered
Date Completed:	May 17, 2002		
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25
Total Depth:	35 feet	Drilling Method:	4" Auger & HQ Coring
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 57

BORING_LOG 4850-00.GPJ GEOLABS.GDT 1/16/03

GEOLABS, INC.

Geotechnical Engineering

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Log of Boring **203**

Approximate Ground Surface Elevation (feet MSL): 120 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** very stiff, damp (fill)
	20	101			53				
	25				65	>4.5			grades to hard
								MH	Brown **BASALT,** extremely weathered, soft (breaks down to clayey silt with some rock) (basalt formation)
	25	88			54/.5' +50/.3' Ref.	>4.5	5		
	19				31		10		
	27	86			79		15		grades to gray
	29				53		20		grades to brownish gray
	26	88			50/.3' Ref.		25		
									Gray **BASALT**, severely fractured, moderately to highly weathered, medium hard (basalt formation)
	10		14	0	50/.1' Ref.		30		
	35		85	13	100/.5' Ref.		35		

Date Started:	May 20, 2002
Date Completed:	May 21, 2002
Logged By:	S. Latronic
Total Depth:	37.5 feet
Work Order:	4850-00(B)

Water Level: ▽	Not Encountered
Drill Rig:	DIEDRICH D-25
Drilling Method:	4" Auger & HQ Coring
Driving Energy:	140 lb. wt., 30 in. drop

Plate A - 58.1

Laboratory			Field								
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	(Continued from previous plate) Description
											Boring terminated at 37.5 feet
							40				
							45				
							50				
							55				
							60				
							65				
							70				

Date Started:	May 20, 2002	Water Level: ∇	Not Encountered	Plate
Date Completed:	May 21, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	37.5 feet	Drilling Method:	4" Auger & HQ Coring	A - 58.2
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

GEOLABS, INC. Geotechnical Engineering	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Log of Boring 204

Approximate Ground Surface Elevation (feet MSL): 123 *

Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							0	MH	Reddish brown **CLAYEY SILT,** very stiff to hard, damp (fill)
	21	97			55	>4.5			
								MH	Reddish brown **BASALT,** extremely weathered, soft (breaks down to clayey silt) (basalt formation)
	23				60				
							5		
	27	89			50/.3' Ref.				
							10		
	29				58				grades with orange mottling
							15		
	25	86			55/.5' +50/.3' Ref.				grades with rock
							20		
	25				50/.3' Ref.				
			100	22					Brownish gray **BASALT**, severely fractured, moderately to highly weathered, medium hard
							25		
			83	50					
									grades to moderately fractured, slightly weathered, hard to very hard
							30		
			100	88					
									grades to vugular
							35		Boring terminated at 35 feet

Date Started:	May 21, 2002	Water Level: ⊻	Not Encountered	Plate A - 59
Date Completed:	May 21, 2002			
Logged By:	S. Latronic	Drill Rig:	DIEDRICH D-25	
Total Depth:	35 feet	Drilling Method:	4" Auger & HQ Coring	
Work Order:	4850-00(B)	Driving Energy:	140 lb. wt., 30 in. drop	

APPENDIX B

Laboratory Testing and Laboratory Test Data

APPENDIX B

Laboratory Testing

Moisture content (ASTM D 2216) and unit weight (ASTM D 2937) determinations were performed on selected soil samples as an aid in the classification and evaluation of soil properties. The results of these tests are presented on the Logs of Borings at the appropriate sample depths and are summarized on Tables B-1.1 through B-1.15.

Twenty-six Atterberg Limits tests (ASTM D 4318) were performed on selected samples of the soils to evaluate the liquid and plastic limits and to aid in soil classification. Results of the tests are summarized on the Logs of Borings at the appropriate sample depths. Graphic presentations of the test results are provided on Plates B-1.1 through B-1.3 and are summarized on Tables B-1.1 through B-1.15.

Eleven sieve analysis tests (ASTM C 117 and C 136) were performed on selected materials encountered in the borings to evaluate the gradation characteristics of the soils and to aid in soil classification. Graphic presentations of the grain size distribution are provided on Plates B-2.1 through B-2.3 and are also summarized on Tables B-1.1 through B-1.15.

Twelve unconsolidated undrained triaxial compression (TXUU) tests (ASTM Test Designation D 2850) were performed on selected soil samples to evaluate the undrained shear strength of the silty and clayey soils encountered. The approximate in-situ effective overburden pressure was used as the applied confining pressure for the relatively "undisturbed" soil sample. The test results and the stress-strain curves are presented on Plates B-3.1 through B-3.12. The test results are summarized on Tables B-2.1 through 2.4.

Fifty-six unconfined compression tests (ASTM Test Designation D 2938) were performed on the selected core samples to evaluate the unconfined compressive strength of the weathered basalt rock. The test results are summarized on Tables B-2.1 through B-2.5.

Nine strained-controlled, consolidated-drained direct shear tests (ASTM Test Designation D 3080) were performed on selected in-situ and remolded soil samples to evaluate the shear strength characteristics of the in-situ soils and remolded soils as fill materials. The test results are presented on Plates B-4.1 through B-4.9 and are summarized on Tables B-2.1 through B-2.5.

Thirteen consolidation tests (ASTM Test Designation D 2435) were performed on selected soft to stiff silty and clayey soil samples to evaluate the compressibility characteristics of the on-site compressible soils. The test results are presented on Plates B-5.1 through B-5.13 and are summarized on Table B-3.

One Modified Proctor compaction test (ASTM D 1557) was performed on a bulk sample obtained to evaluate the relationship between the moisture content and the dry density of the near-surface soils as fill materials. The test results are presented on Plate B-6.

Five laboratory Resistance Value tests (AASHTO T 190) were performed on selected bulk samples of the near-surface soils to evaluate the pavement support characteristic of the soils. The test results are presented on Table B-4.

Four sets of corrosivity tests, consisting of pH (SW 9045B), minimum resistivity (EPA 120.1), chloride content (EPA 325.2), and sulfate content (EPA 375.2) tests, were performed on selected soil samples obtained from our field exploration. The test results are presented on Table B-5.

(h:\4800 Series\4850-00B.jc2-pg.98)

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
B-1	3.0		X	27	85	108							4		
	6.0		X	31	81	106							2.3		
	10.5		X	39	82	114							0.8	0.5	
	15.5		X	35	80	108	64	30	34				2.8		
	20.5		X	57	76	120							0.5	0.4	
	25.5		X	14	122	139							4.3		
	30.5		X	15	111	128							4.3		
	35.5		X	70	58	98				1	56	43	0.8	0.2	
	41.0		X	37	80	110							2.5		
	45.5		X	39	75	104	70	30	40				2.8		
	50.5		X	39	83	116							2.8		
	55.5		X	46	72	105							2.5		
	60.5		X	54	63	97							4.3		
	65.5	X		57											
	70.5	X		34											
	75.5	X		43											
B-2	3.0		X	25	84	105							4.3		
	6.0		X	30	78	101							4		
	11.0		X	36	68	93							3.3		
	16.0		X	94	49	95							1		TXUU
	20.0		X	127	32	73								0.2	
	21.0		X	89	43	81							2.5		
	26.0		X	44	74	107				7	81	12	1.8		
	31.0		X	17						87	8	5			
	36.0		X	17						85	12	3			
	41.0		X	16						65	28	7			
	46.0		X	42	79	112							3		
	61.0	X		28											
	66	X		23											
	71.0		X	62	56	91							4		TXUU
	76.0		X	49	71	106							4.3		
	81.0	X		48											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
	86.0		X	55	65	101							3.8		
	91.0	X		42											
	96.0	X		50											
	101.0		X	40	73	102							4.3		
	106.0	X		39											
	115.0	X		15											
	155.0		X	24											
B-3	3.0		X	21	75	91							4.3		
	6.0	X		46									4.3		
	10.0		X	53	68	104	64	30	34				0.75		
	11.0		X	56	63	98									
	16.0	X		60									0.25		
	20.5		X												
	26.5	X		59									0		
	31.5	X		57						0	75	25			
	36.5		X	45	79	115.0				1	83	17	0.5	0.2	
	40.5	X		20											
	61.5		X	52	62	94							4.3		
	66.5	X		57											
	71.5		X	46	70	102	63	37	26				1.5		
	76.5	X		53											
	81.5		X	54	62	96							0.8	0.5	
	86.5	X		56											
	91.5		X	63	63	103							0.8	0.5	
	101.0		X	49	67	100							2.5		
	106.5	X		51											
	111.5	X		67											
	116.5	X		43											
	121.5	X		33											
	126.5	X		40									2.8		
	131.5		X	61	61	98							2.5		
	136.5	X		40											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	141.0	X		42											
	151.0	X		41											
	156.5	X		46									1.5		
B-4	6.0		X	23	76	94									
	11.0	X		17						40	47	14			
	16.0		X	25	83	104				48	42	9			
	21.0		X	63	68	111							1.3		
	26.0		X	96	45	88							2.5		Consol.
	31.0		X	76	52	92							0.5	0.4	
	36.0	X		31											
	41.0	X		39			57	32	25				>4.5		
	46.0	X		26											
	51.0	X		60											
	56.0	X		59											
	61.0	X		60											
	66.0	X		52											
	71.0	X		55											
	76.0	X		56			58	33	25						
	81.0	X		64											
	86.0	X		56											
	91.0	X		55											
	96.0	X		57											
	101.0	X		48											
	106.0	X		50											
	111.0	X		57									0.5		
	116.0	X		73										0.4	
	121.0	X		52			49	37	12						
	126.0	X		54									1.5		
	131.0	X		54									1.8		
	136.0	X		54			57	36	21				1		
	141.0	X		52											
	146.0	X		55									0.8	0.4	

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
	151.0	X		48									3.3		
	156.0	X		54									1		
	161.0	X		52											
B-5	6.0		X	37	70	96							0.5	0.7	
	7.5	X		42			61	34	27						
	11.0		X	65	60	99							2		
	16.0		X	69	59	100							2.5		Consol.
	17.5		X	71	57	98							0.5	0.2	
	21.0		X	60	68	109	72	38	34						Consol.
	22.0		X	64	60	98							0.3	0.2	
	26.0		X	63										0.1	
	31.0		X	69	58	98								0.1	
	36.0		X	74	56	97							0.3	0.1	
	41.0		X	37	85	117							1	0.2	
	46.0	X		55											
	51.0	X		25						52	34	15			
	56.0	X		52			51	42	9						
	61.0		X	61	64	103							2.3		
	65.0		X	51									3.3		
	66.0		X	59	67	107									
	71.0	X		57											
	76.0		X	55	68	105							4.3		
	81.0	X		60			56	45	11				2		
	86.0		X	57	66	104							2.5	1.2	
	91.0		X	57	69	108							2	0.8	
	96.0	X		55											
	101.0		X	59	66	105							1.8	1	
	106.0	X		54											
	111.0		X	51	74	112							4.3		
	115.0		X	54									2.8		
	116.0		X	60	65	104									TXUU
	121.0	X		57			54	36	18				1	0.2	

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
	125.0		X	60											
	126.0		X	51	70	106							1.5		
	131.0	X		48											
	140.0		X	58									1.5		
	141.0		X	63	63	103									TXUU
B-6	6.0		X	33	57	76							3.5		
	7.5	X		40											
	11.0		X	64	62	102							0.5		
	16.0		X	58	65	103							3		
	21.0		X	51	72	109							0.3		
	26.0		X	63	65	106	72	36	36				0.5	0.3	
	31.0		X												
	36.0		X	80	55	99							0.3	0.1	
	41.0		X	31	82	107							3		
	46.0		X	53	71	109							3		
	51.0		X	50	73	110							1.5	1.1	
	56.0		X	54	69	106							1.3		
	61.0	X		65			55	35	20						
	66.0		X	53	70	107							2.5		
	71.0	X		61											
	76.0		X	59	67	107							2.8		TXUU
	81.0	X		61											
	86.0		X	59	66	105									
	91.0	X		59											
	96.0		X	53	69	106							1.8	1	
	101.0	X		56			59	37	22						
	106.0		X	56	71	111							4		
	111.0	X		57											
	116.0		X	57	68	107							2.5	1	
	121.0	X		53									3		
	125.0		X	54									3.3		
	126.0		X	57	68	107								1	TXUU

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
	131.0	X		23									1.5		
	136.0		X	58	67	106							1.3	1.1	
	141.0	X		54			63	40	23				1		
	146.0	X		37											
	151.0	X		38											
	156.0	X		51											
	161.0	X		42											
B-7	6.0		X	37	75	103							1.5		
	7.5	X		39											
	11.0		X	24	95	118							4.3		
	15.0		X	65	61	101							0.5	0.3	
	16.0		X	73									0.5	0.1	
	21.0		X	53	65	100							1.3		
	26.0		X	66	57	95							1.3		
	30.5		X	93	49	95							0.8		TXUU
	31.5		X	51									1.3		
	36.0		X	94	47	91							2.8		TXUU
	41.0		X	84	50	92							0.5	0.4	
	46.0		X	87	46	86							0.5	0.4	
	51.0		X	111	41	87							0.5	0.3	
	56.0		X	133	41	96								0.2	
	61.0		X	40											
	76.0	X		63											
	81.0	X		76											
	86.0	X		69											
	91.0	X		63											
	96.0		X	52	68	103							4.3		
B-8	6.0		X	31	78	102							3.5		
	7.5	X		40									1		
	11.0		X	35	83	112							4.3		
	16.0		X	70	56	95							0.3	0.2	
	21.0		X	65	60	99	73	36	37				0.3		

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	26.0		X	64	59	97							0.5	0.2	
	31.0		X												
	36.0		X	81	51	92							0.5	0.5	Consol.
	41.0		X	73	58	100							1		
	46.0		X	118	41	89							0.5	0.1	
	51.0		X	70	60	102							0.25		
	56.0		X	74	53	92							1		
	61.0		X	62	64	104							0.8	0.2	
	66.0	X		65											
	76.0	X		45											
	86.0	X		19											
B-9	6.0		X	24	80	99							4.3		
	11.0	X		52			78	40	38						
	16.0		X	68	54	91							1	0.4	
	21.0	X		66			66	35	31						
	26.0		X												
	31.0		X	73											
	33.0	X		71									0	0.1	
	36.0		X	63	60	98							0.5	0.4	
	41.0		X												
	43.0	X		75			93	40	53				0		
	46.0		X	70	55	94							1	0.4	
	50.0	X													
	55.0	X		50											
	60.0	X		22											
	76.0	X		78											
	80.0	X		19											
	95.0	X		28											
B-10	6.0		X	36	83	113							2	1.1	
	7.5	X		41			57	31	26						
	12.5		X	102	42	85							0.3		
	17.5	X		85											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits (%) LL	PL	PI	Particle-Size Analysis (%) Gravel	Sand	Silt/Clay	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	22.5		X	58	63	100							0.5	0.2	
	24.5		X	60	65	104							0	0.1	
	27.5	X		68						2	38	59			
	32.5		X	43	76	109							3.8		
	37.5	X		61											
	42.5	X		65											
	47.0	X		43											
	77.5	X		55											
	81.5	X		24											
B-11	6.0		X	26	84	106							4.3		
	7.5	X		32											
	11.0		X	45	70	102							4.3		
	16.0	X		59			64	36	28				0.5		
	21.0		X	53	68	104							1		
	26.0	X		41											
	31.5		X										1.5	0.75	
	46.5	X		44											
	71.5	X		49											
B-12	5.0		X	17											
	11.0		X	37	55	75									
	17.0	X		52											
B-13	7.0	X		25											
B-101	2.0		X	21	85	103							4.3		
	4.0	X		23											
	6.0		X	24	98	122							4.3		
	11.0	X		26											
	16.0		X	39	79	110							4.3		
	21.0	X		29											
	26.0		X	31	76	100							4.3		
	31.0	X		29											
B-102	2.0		X	21	82	99							4.3		Direct Shear
	4.0	X		21											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	6.0		X	20	95	114							4.3		
	11.0	X		25											
	16.0	X		28											
B-103	2.0	X		28											
	6.0		X	23	83	102							4.3		
	11.0	X		24											
	16.0		X	36	80	109							4.3		
	21.0	X		28											
	26.0		X	36	79	107							4.3		
	31.0	X		20											
	36.0	X		14											
B-104	2.0		X	19	110	131							>4.5		
	6.0	X		25											
	11.0	X		30											
	16.0	X		30											
B-105	2.0		X	25	78	99									Direct Shear
	6.0	X		22											Corrosion
	11.0	X		22											
B-106	8.0	X		42											Corrosion
B-107	2.0		X	28	82	106							4.3		
	6.0		X	32	76	100							4.3		
	11.5		X	31	89	117							1.5		Direct Shear
	16.0		X	42	76	108							1.8	0.8	
	16.5		X	46	75	110									Consol.
	21.5		X	39	78	108							1.5		
	26.5		X	60	62	100							0.5		Direct Shear
	31.0		X	66	63	105							2		Direct Shear
	32.0		X	65	59	97									TXUU & Consol.
	37.0		X	59	69	109							0.5		Consol.
	41.5		X	92	42	81							1		
	51.5	X		24											
	56.0	X		30											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	61.5	X		30											
	66.0	X		39											
B-108	2.0		X	24	88	109							4.5		
	6.5		X	35	73	99							1.9		
	11.5		X	38	77	106							1.3		TXUU
	16.5		X	39	55	77							1.5	0.8	
	21.5		X	50	76	114							1.8	0.6	
	26.0		X	52	69	105							1.5		
	26.5		X	57	68	107									Consol.
	31.5		X	41	67	95							0.8		TXUU
	36.5	X		44											
	41.5		X	58	65	103							1.5	0.5	Consol.
	46.5		X	89	49	93							2.3		
	51.0		X	87	49	92							2.4		
	51.5		X	99	44	88									Consol.
	57.0		X	73	55	95							3		
	61.5	X		105											
	71.5		X	29	95	123							4.5		
	86.0		X	41	81	114							2.5		
B-109	6.0		X	25	71	89							3		
	7.5	X		17											
	12.0		X	24	87	108							4.3		
	16.5	X		38											
	21.5		X	38	79	109							3.5		
	26.5	X		60											
	32.0		X												
	37.5		X												
	39.0	X		75											
	41.0		X	65	65	107							1.5		
	41.5		X	75	51	89									Consol.
	46.5	X		67											
	51.5		X	56	68	106							1.8		

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
	56.5	X		46											
	61.0	X		36											
B-110	2.0		X	27	88	112							4.5		
	5.0		X	32	86	114							2	0.7	
	11.0		X	35	82	111							1.8	0.6	
	16.0		X	43	47	67								0.3	
	21.0		X	30	89	116							4.3		
	26.0	X		49											
	31.0	X		33											
B-111	3.0		X	23	87	107							4.5		
	6.0		X	32	75	99							2.8		
	11.0		X	38	78	108							0.8	0.5	
	15.0		X	8	84	91									
	26.0		X	93											
	31.0		X	61	66	106									
B-112	2.0		X	25	82	103							4.3		
	6.0		X	34	76	102							4.3		
	11.0		X	20	96	115							4.3		
	16.0		X	29	88	114							4.3		
	21.0	X		39											
	26.0	X		56											
	31.0		X	71	53	91							4.3		
B-113	2.5	X		12											
	4.5		X	37	81	111							1.8		
B-114	2.0	X		15											
	4.5		X	32	79	104							4.3		
B-117	2.0	X		11											
	4.5		X	32	81	107							3.8		
B-118	2.0	X		13											
	3.5		X	32											
B-119	2.0	X		13											
	4.5		X	33	81	108	53	30	23				4.3		

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Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Sample		Moisture Content	Dry Density	Unit Weight	Atterberg Limits			Particle-Size Analysis			Pocket Pen.	Torvane	Remarks/Other Tests
		SPT	UD				LL	PL	PI	Gravel	Sand	Silt/Clay			
	(ft)			(%)	(pcf)		(%)			(%)			(tsf)		
B-120	2.5		X	26											
	4.5		X	20	92	110							4.3		
B-121	2.0	X		6											
	4.5		X	14	110	125							4.3		
B-122	2.5	X		14											
	4.5		X	30	90	117							4.3		
B-123	3.0	X		11											
	4.0		X	25											
B-125	2.5	X		31											
	4.5		X	23	87	107							3.8		
B-127	3.0	X		27											
	4.0		X	27	82	104							4.3		
B-128	2.5	X		18											
	4.0		X	27	76	97							4.3		
B-129	3.0	X		30											
	4.5		X	27	81	103							4.3		
B-130	2.0		X	28	90	115							4.3		
	3.5	X		7											
	5.0	X		7											
B-131	3.0	X		16											
	5.0		X	32	92	121							1.3		
B-132	3.0	X		11											
	4.5		X	33	72	96							4.3		
B-133	2.5	X		15											
	4.5		X	24	83	103							4.3		
B-134	2.5	X		12											
	4.5		X	27	84	107							4.3		
B-135	2.5	X		13											
	4.5		X	24	79	98							4.3		
B-136	6.0		X	35	81	109							1		
	11.0	X		32									1.3		
	17.5		X	28	89	114							4		

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	21.0	X		32											
	26.5		X	34	89	119							2		
	31.5	X		33											
	36.0		X	40	78	109							0.8		
	36.5		X	38	79	109									Consol.
	41.5	X		32			55	26	29				1		
	46.5		X	44	72	104							1		
	51.0		X												
	56.5		X	75	50	88									
	61.5	X		56									0.5		
	66.5		X	62	62	100									
	71.5		X	83	50	92							1.3		
	77.0		X	64	61	100	73	34	39				2		TXUU & Consol.
	81.5	X		49									2		
	86.5	X		50											
B-137	6.0		X	30	83	108							>4.5		
	11.0	X		26											
	16.0		X	30	80	104							4		
	21.0	X		30									1.5		
	26.0		X	41	76	107							2		
	31.0	X		37											
	36.0		X	46	66	96							1.5		Consol.
	40.0	X		10											
B-138	3.0		X	27	78	99							4.3		
	5.5	X		24											
B-139	2.0	X		12											
	4.5		X	29	90	116							4.3		
B-140	2.0	X		14											
	4.5		X	18	86	102							4		
B-141	2.0		X	34	82	109							>4.5		Direct Shear
	4.0	X		22											
	6.0		X	29	80	103							>4.5		

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Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	11.0	X		32											Corrosion
	18.0	X		45											
B-142	2.0		X	31	90	118							>4.5		
	4.0	X		27											
	6.0		X	36	81	110							>4.5		
	11.0	X		28											Corrosion
	15.0		X	26	82	103									
B-201	1.5		X	22	103	126									Direct Shear
	4.0	X		20									>4.5		
	6.5		X	23	100	123							>4.5		
	11.5	X		25											
	16.0		X	26	93	117							>4.5		
	21.0	X		38									>4.5		
	25.0		X	38	57	79									
B-202	1.5		X	23	85	105							3		Direct Shear
	4.0	X		20									>4.5		
	6.0		X	22	81	99									
	11.5	X		24									>4.5		
	16.5		X	40	79	111							2		
	21.5	X		35											
	26.0		X	32	78	103									
B-203	2.0		X	20	101	121									
	4.5	X		25									>4.5		
	6.5		X	25	88	110							>4.5		
	11.0	X		19											
	16.0		X	27	86	109									
	21.0	X		29											
	25.0		X	26	88	111									
	30.0	X		10											
	33.0	X		35											
B-204	2.0		X	21	97	117							>4.5		
	4.5	X		23											

Summary of Index Property Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (ft)	Sample SPT	Sample UD	Moisture Content (%)	Dry Density (pcf)	Unit Weight (pcf)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI (%)	Particle-Size Analysis Gravel (%)	Particle-Size Analysis Sand (%)	Particle-Size Analysis Silt/Clay (%)	Pocket Pen. (tsf)	Torvane (tsf)	Remarks/Other Tests
	6.0		X	27	89	113									
	11.5	X		29											
	16.0		X	25	86	108									
	21.0	X		25											

Notes:
1 SPT: Disturbed sample obtained from Standard Penetration Test.
2 UD: Relatively "Undisturbed" sample obtained from modified California Sampler or Shelby Tube Sampler.
3 TXUU: Unconsolidated Undrained Triaxial Compression test performed on sample. See Tables B-2.1 through 2.5 for summary results.
4 Direct Shear: Direct Shear test performed on sample. See Tables B-2.1 through 2.5 AND Table B-4 for summary results.
5 Consol: Consolidation test performed on sample. See Table B-3 for summary results.
6 Corrosion: Corrosion tests performed on sample. See Table B-5 for summary results.

(h:\4800 Series\4850-00B.jc1)

Summary of Strength Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Moisture Content	Dry Density	Unit Weight	Unconfined Compressive Strength	TXUU			Direct Shear	
						Undrained Shear Strength s_u	Shear Strain	Confining Pressure	Cohesion c	Friction Angle ϕ
	(feet)	(%)	(pcf)		(ksf)	(ksf)	(%)	(ksf)	(psf)	(°)
B-1	76.5		132		106					
B-1	80.5		123		28					
B-2	16.0	94	49	95		0.6	14.8	1.7		
B-2	71.0	62	56	91		4.2	7.0	3.8		
B-2	120.5		136		233					
B-2	124.5		118		103					
B-5	116.0	60	65	104		3.7	14.8	5.0		
B-5	141.0	63	63	103		2.1	14.5	6.1		
B-6	76.0	59	67	107		2.4	14.8	3.3		
B-6	126.0	57	68	107		1.9	14.3	5.4		
B-7	30.5	93	49	95		0.8	12.7	1.8		
B-7	36.0	94	47	91		1.5	6.0	1.9		
B-7	108.0		133		339					
B-7	109.0		148		121					
B-7	141.5		136		270					
B-8	79.0		92		63					
B-8	99.0		96		38					

Summary of Strength Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Moisture Content	Dry Density	Unit Weight	Unconfined Compressive Strength	TXUU			Direct Shear	
						Undrained Shear Strength s_u	Shear Strain	Confining Pressure	Cohesion c	Friction Angle ϕ
	(feet)	(%)	(pcf)		(ksf)	(ksf)	(%)	(ksf)	(psf)	(°)
B-8	117.0		124		81					
B-8	131.0		135		120					
B-8	132.0		120		157					
B-9	87.0		121		314					
B-9	106.0		113		79					
B-9	112.0		121		226					
B-10	57.0		124		42					
B-10	70.0		149		336					
B-10	83.0		116		41					
B-10	95.0		117		154					
B-10	111.0		114		23					
B-11	47.0		103		66					
B-11	57.0		117		82					
B-11	87.0		173		933					
B-11	98.0		118		253					
B-12	21.5		82		30					
B-12	27.0		74		28					

Summary of Strength Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Moisture Content	Dry Density	Unit Weight	Unconfined Compressive Strength	TXUU			Direct Shear	
						Undrained Shear Strength s_u	Shear Strain	Confining Pressure	Cohesion c	Friction Angle ϕ
	(feet)	(%)	(pcf)		(ksf)	(ksf)	(%)	(ksf)	(psf)	(°)
B-12	27.5		85		22					
B-12	29.0		88		21					
B-12	35.5		130		68					
B-13	8.5		122		330					
B-13	12.5		138		363					
B-13	18.5		121		290					
B-13	21.5		148		309					
B-13	28.5		146		195					
B-13	29.0		145		231					
B-13	35.5		143		230					
B-13	36.0		139		155					
B-13	48.5		145		296					
B-13	60.5		114		52					
B-13	74.5		124		135					
B-13	89.5		160		400					
B-102	2.0	38	79	109					381	26
B-102	17.5		119		725					
B-102	31.0		115		122					

Summary of Strength Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Moisture Content	Dry Density	Unit Weight	Unconfined Compressive Strength	TXUU			Direct Shear	
						Undrained Shear Strength s_u	Shear Strain	Confining Pressure	Cohesion c	Friction Angle ϕ
	(feet)	(%)	(pcf)		(ksf)	(ksf)	(%)	(ksf)	(psf)	(°)
B-102	39.5		159		2189					
B-104	31.0		91		18					
B-104	33.5		95		15					
B-104	51.0		175		5135					
B-105	1.0	19	83	99					137	32
B-105	35.0		99		52					
B-105	40.5		151		459					
B-106	11.0		99		73					
B-106	13.0		117		94					
B-106	18.5		176		1240					
B-107	11.5	32	88	116					500	33
B-107	26.0	60	62	100					186	27
B-107	31.0	64	59	97					500	22
B-107	32.0	49	70	104		2.5	7.0	2.5		
B-108	11.5	38	77	106		2.3	7.3	1.3		
B-108	31.5	41	67	94		1.3	14.8	2.7		
B-136	76.0	61	64	102		1.5	8.6	5.6		
B-201	1.5	36	84	114					648	24

Summary of Strength Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Moisture Content	Dry Density	Unit Weight	Unconfined Compressive Strength	TXUU			Direct Shear	
						Undrained Shear Strength s_u	Shear Strain	Confining Pressure	Cohesion c	Friction Angle ϕ
	(feet)	(%)	(pcf)		(ksf)	(ksf)	(%)	(ksf)	(psf)	(°)
B-202	1.5	40	80	112					270	29
B-141	2.0	24	79	98					235	31
B-141	22.5		156		574					
B-141	35.0		170		838					
B-142	18.5		163		141					
B-142	25.5		166		775					

(h:\4800 Series\4850-00B.jc1)

Summary of Consolidation Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth	Ground Water Level	Atterberg Limits			Moisture		Dry Density		Estimated Pre-Consolidation Pressure	Approx. Overburden Pressure	Over Consolidation Ratio
			LL	PL	PI	Initial	Final	Initial	Final	P_p'	σ_o'	
	(feet)	(feet	(%)			(%)		(pcf)		(ksf)		(OCR)
B-4	26.0	+3	64	30	34	99	75	46	58	1.25	1.52	0.8
B-5	16.5	+6				65	53	62	71	1.32	1.23	1.1
	22.0		72	38	34	64	54	60	72	1.04	1.41	0.7
B-8	36.0	+17				100	90	43	50	1.80	1.99	0.9
B-107	16.5	+18				46	43	75	82	2.40	1.84	1.3
	32.0					65	64	59	68	2.50	2.78	0.9
	36.0					59	49	69	78	5.10	2.85	1.8
B-108	26.5	+16				57	48	68	79	1.70	2.25	0.8
	41.5					62	53	63	74	2.20	2.76	0.8
	51.5					99	92	44	50	2.10	3.09	0.7
B-109	41.5	+19				75	58	51	65	1.50	2.61	0.6
B-136	36.5	+10	73	34	39	38	35	81	89	4.40	4.17	1.1
	76.5					57	48	68	79	4.70	6.08	0.8
B-137	36.0	+11				47	44	68	81	1.05	3.76	0.3

Notes:

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

(h:\4800 Series\4850-00B.jc1)

Summary of Bulk Sample Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Bulk Sample No.	Atterberg Limits			Proctor		Resistance Value Test			Direct Shear	
	LL	PL	PI	MDD	OMC	Molding Moisture	Molding Dry Density	R-Value	c	ϕ
	(%)			(pcf)	(%)	(%)	(pcf)		(psf)	(°)
Bulk-1						40	82	16		
Bulk-2				98	25				616	23
Bulk-3						32	90	49		
Bulk-4						32	90	12		
Bulk-5						34	88	17		
Bulk-6						34	87	13		

Notes: LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
MDD = Maximum Dry Density
OMC = Optimum Moisture Content
c = cohesion
ϕ = friction angle

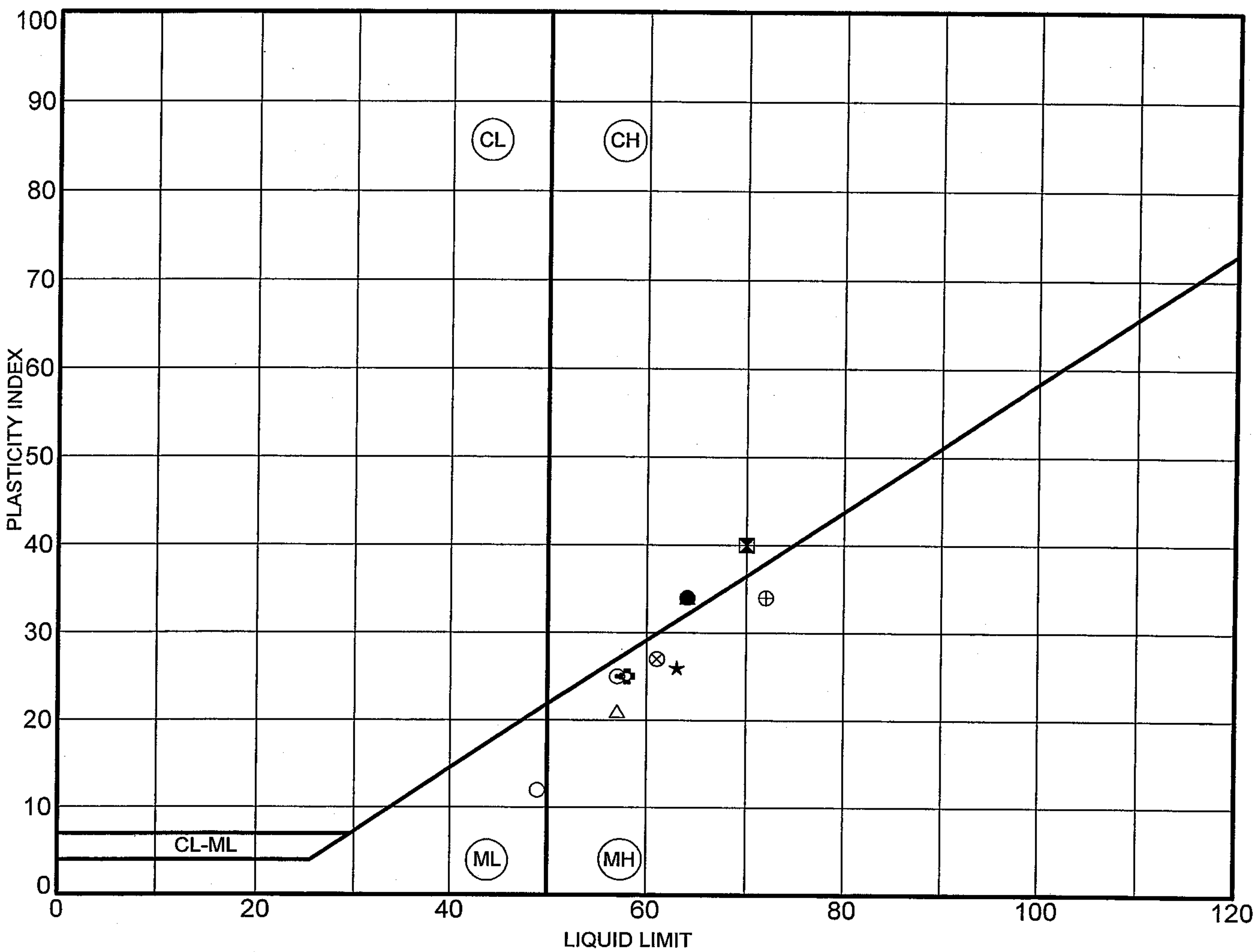
(h:\4800 Series\4850-00B.jc1)

Summary of Corrosion Test Results
Interstate Route H-1 Widening Waimalu Viaduct Westbound
Pearl City Off-Ramp To Kaonohi Street

Boring No.	Depth (feet)	Minimum Resistivity (ohm-cm)	pH	Chloride (mg/kg)	Sulfate (mg/kg)
B-105	5.0	2480	5.1	176	127
B-106	7.0	10500	6.1	364	32
B-141	10.0	8260	5.2	223	48
B-142	10.0	14300	6.3	289	119

Test Methods:		
	Minimum Resistivity	EPA 120.1
	Corrosivity pH	SW 9045B
	Chloride	EPA 325.2
	Sulfate	EPA 375.2

(h:\4800 Series\4850-00B.jc1)



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-1	14.5 - 16.0	64	30	34	Gray CLAY (CH)
⧗	B-1	44.5 - 46.0	70	30	40	Gray CLAY (CH)
▲	B-3	10.0 - 11.0	64	30	34	Grayish brown SILTY CLAY (CH) with sand
★	B-3	70.5 - 72.0	63	37	26	Grayish brown CLAYEY SILT (MH) with sand and gravel
⊙	B-4	40.0 - 41.5	57	32	25	Brown CLAYEY SILT (MH) with some sand
✿	B-4	75.0 - 76.5	58	33	25	Orange-brown with black mottling CLAYEY SILT (MH) with gravel
○	B-4	120.0 - 121.5	49	37	12	Orange-brown CLAYEY SILT (ML) with gravel
△	B-4	135.0 - 136.5	57	36	21	Orange-brown with black mottling CLAYEY SILT (MH)
⊗	B-5	6.5 - 8.0	61	34	27	Brown CLAYEY SILT (MH)
⊕	B-5	20.0 - 22.0	72	38	34	Dark gray ORGANIC SILT (OH)

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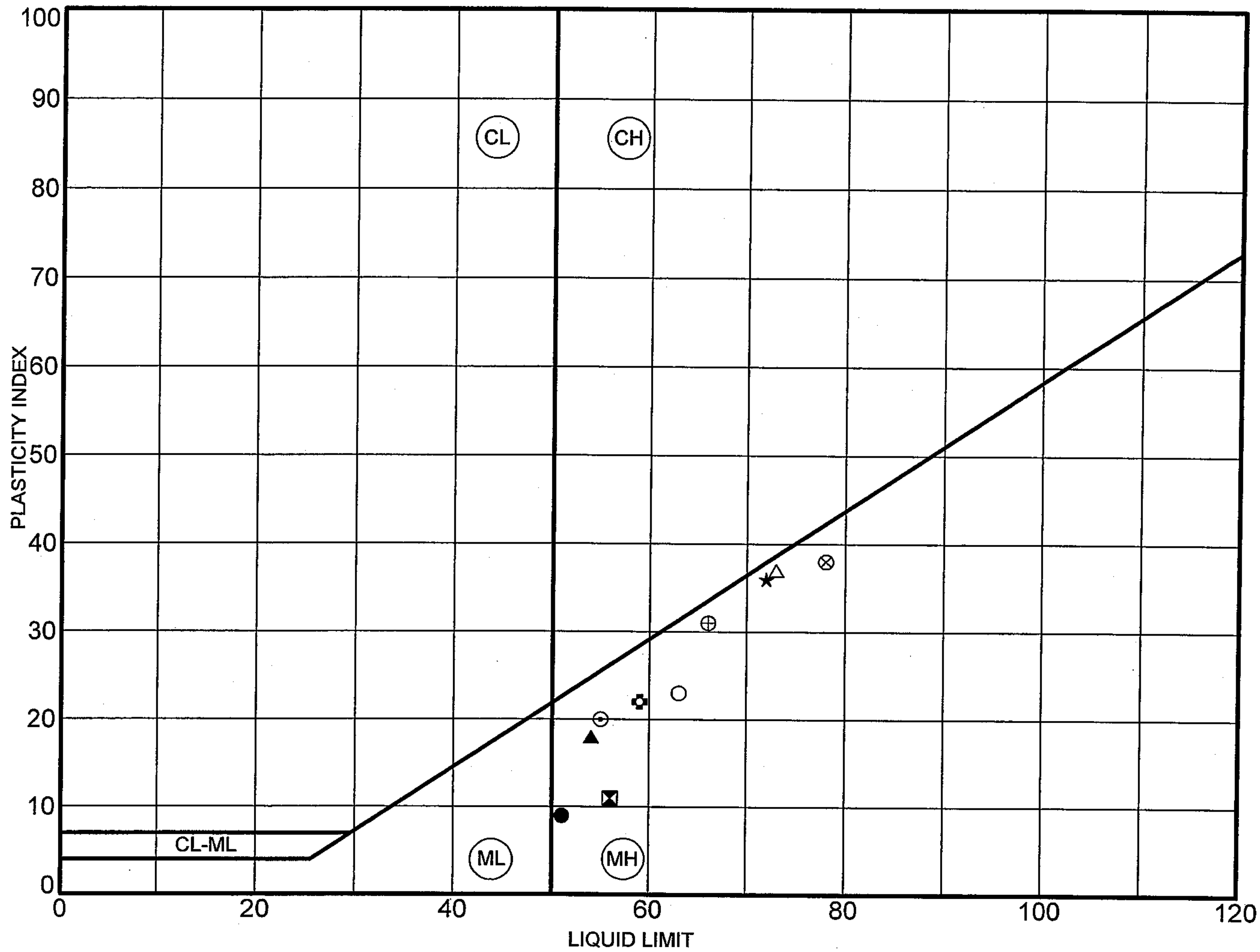
ATTERBERG LIMITS TEST RESULTS - ASTM D 4318

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 1.1



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-5	55.0 - 56.5	51	42	9	Orange-brown with black mottling CLAYEY SILT (MH) with gravel
⊠	B-5	80.0 - 81.5	56	45	11	Orange-brown with black mottling CLAYEY SILT (MH) with gravel
▲	B-5	120.0 - 121.5	54	36	18	Orange-brown with black mottling CLAYEY SILT (MH) with gravel
★	B-6	25.0 - 27.0	72	36	36	Dark gray ORGANIC SILTY CLAY (OH) with sand
⊙	B-6	60.0 - 61.5	55	35	20	Orange-brown with black mottling CLAYEY SILT (MH) with sand
✿	B-6	100.0 - 101.5	59	37	22	Orange-brown w/ black mott. CLAYEY SILT (MH) w/ sand & gravel
○	B-6	140.0 - 141.5	63	40	23	Orange-brown with black mottling CLAYEY SILT (MH) with gravel
△	B-8	20.0 - 22.0	73	36	37	Dark gray ORGANIC CLAYEY SILT (OH) with sand
⊗	B-9	10.0 - 11.5	78	40	38	Brown CLAYEY SILT (MH) with traces of gravel
⊕	B-9	20.0 - 21.5	66	35	31	Dark gray ORGANIC SILTY CLAY (OH)

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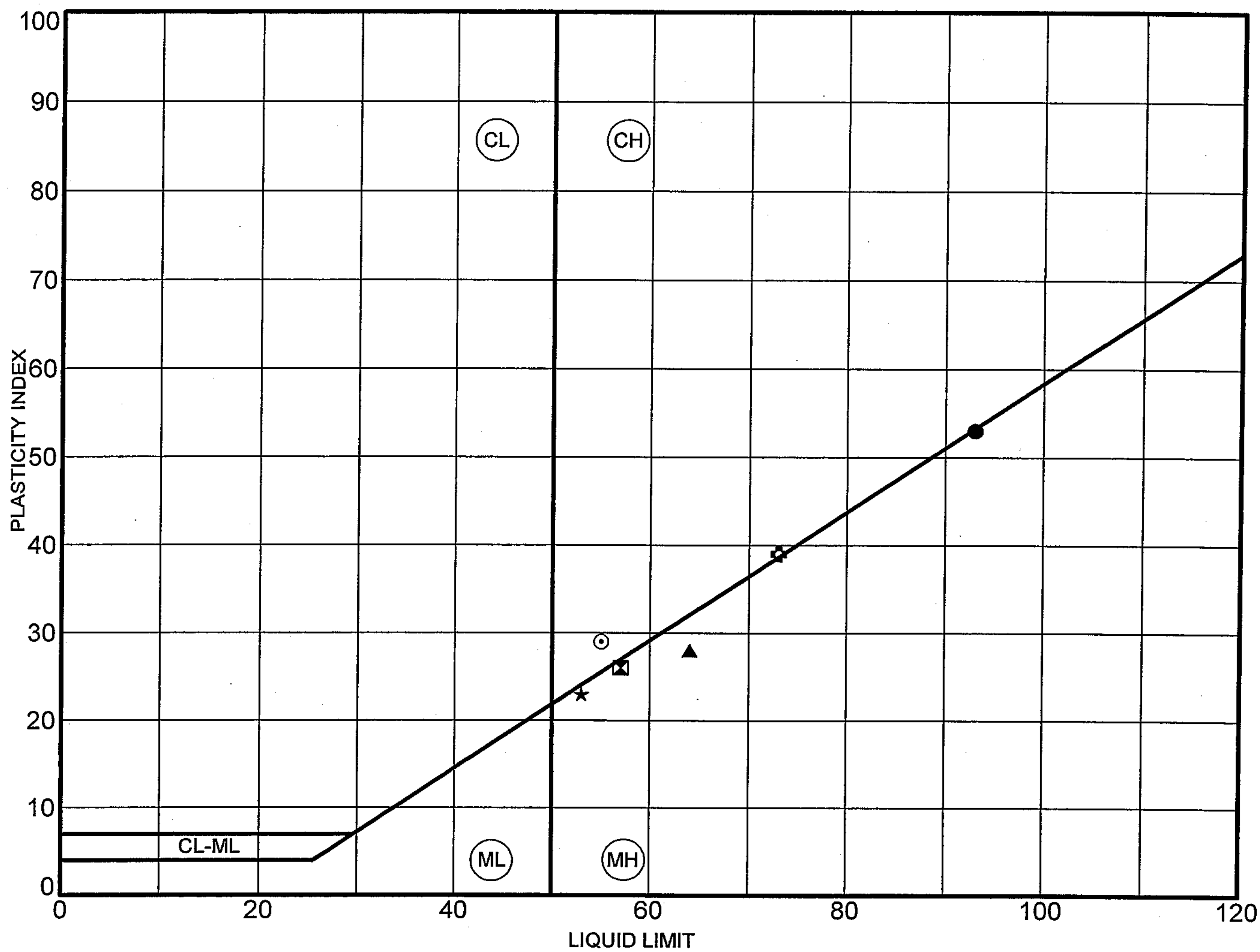
ATTERBERG LIMITS TEST RESULTS - ASTM D 4318
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 1.2

G_ATTERBERG 4850-00.GPJ GEOLABS.GDT 9/5/02



	Sample	Depth (ft)	LL	PL	PI	Description
●	B-9	42.0 - 43.5	93	40	53	Dark gray ORGANIC SILTY CLAY (OH)
⊠	B-10	6.5 - 8.0	57	31	26	Dark reddish brown CLAYEY SILT (MH)
▲	B-11	15.0 - 16.5	64	36	28	Grayish brown w/ orange mottling CLAYEY SILT (MH)
★	B-119	3.5 - 5.0	53	30	23	Brown CLAYEY SILT (MH)
⊙	B-136	40.5 - 42.0	55	26	29	Dark brown SILTY CLAY (CH) with some organics
✿	B-136	75.5 - 77.5	73	34	39	Dark gray ORGANIC CLAY (OH)

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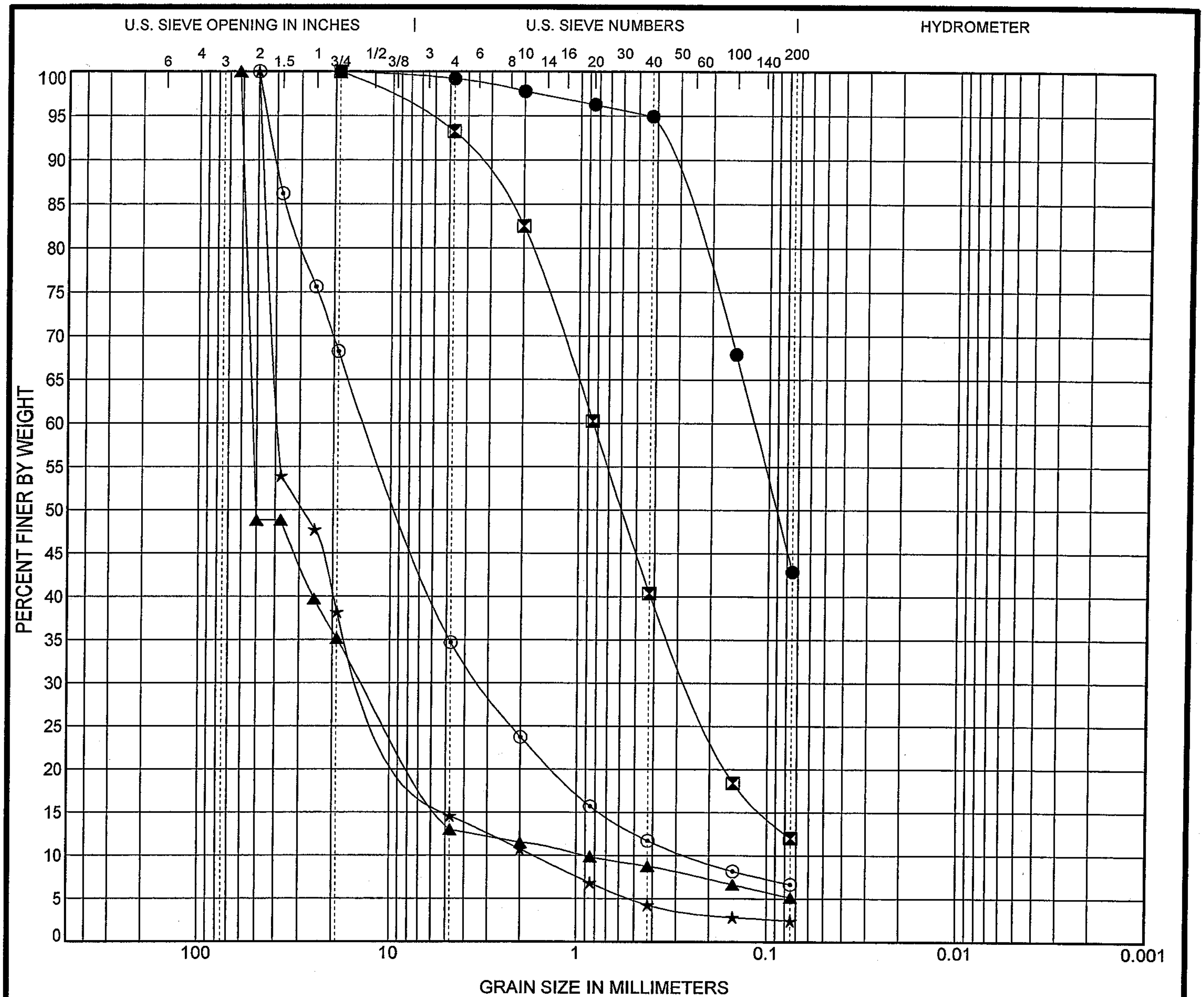
W.O. 4850-00(B)

ATTERBERG LIMITS TEST RESULTS - ASTM D 4318

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 1.3

G_ATTERBERG 4850-00.GPJ GEOLABS.GDT 9/5/02



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-1	34.5 - 36.0	Dark gray SILTY SAND (SM) w/ traces of gravel					
⊠	B-2	25.0 - 26.5	Dark gray SILTY SAND (SM) with gravel				1.3	14.0
▲	B-2	30.0 - 31.5	Grayish brown SILTY GRAVEL (GW-GM) with sand				4.0	58.0
★	B-2	35.0 - 36.5	Grayish brown SILTY GRAVEL (GW-GM) with sand				2.1	23.0
⊙	B-2	40.0 - 41.5	Grayish brown SILTY GRAVEL (GW-GM) with sand				3.1	53.1

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-1	34.5 - 36.0	19	0.12			0.8	56.3	42.9
⊠	B-2	25.0 - 26.5	19	0.842	0.259		6.8	81.2	12.0
▲	B-2	30.0 - 31.5	62.5	52.495	13.755	0.905	87.0	7.9	5.2
★	B-2	35.0 - 36.5	50	38.949	11.729	1.694	85.4	12.1	2.5
⊙	B-2	40.0 - 41.5	50	13.519	3.275	0.255	65.3	28.0	6.7

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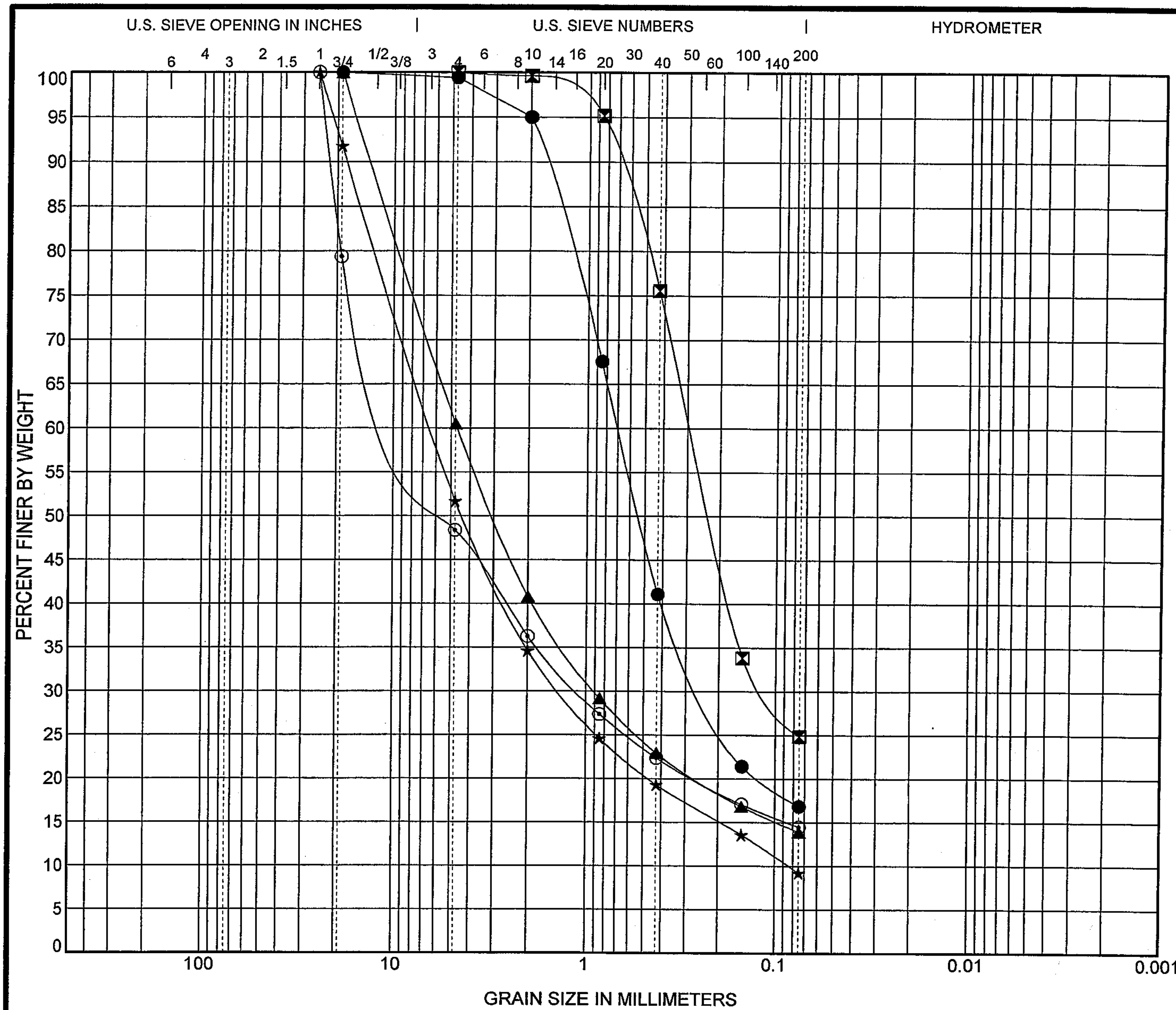
W.O. 4850-00(B)

GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 2.1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-3	35.5 - 36.5	Dark gray SILTY SAND (SM) with gravel					
⊠	B-3	36.5 - 37.0	Dark gray SILTY SAND (SM) with gravel					
▲	B-4	10.0 - 11.5	Brown SILTY SAND (SM) with gravel					
★	B-4	15.0 - 16.5	Brown SILTY GRAVEL (GW-GM) with sand				3.4	75.0
⊙	B-5	50.0 - 51.5	Grayish brown SILTY GRAVEL (GM) with sand and clay					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-3	35.5 - 36.5	19	0.697	0.236		0.6	82.5	16.9
⊠	B-3	36.5 - 37.0	4.75	0.288	0.111		0.0	75.1	24.9
▲	B-4	10.0 - 11.5	19	4.649	0.902		39.5	46.6	13.9
★	B-4	15.0 - 16.5	25	6.33	1.344	0.084	48.3	42.4	9.3
⊙	B-5	50.0 - 51.5	25	7.98	1.091		51.6	33.9	14.5

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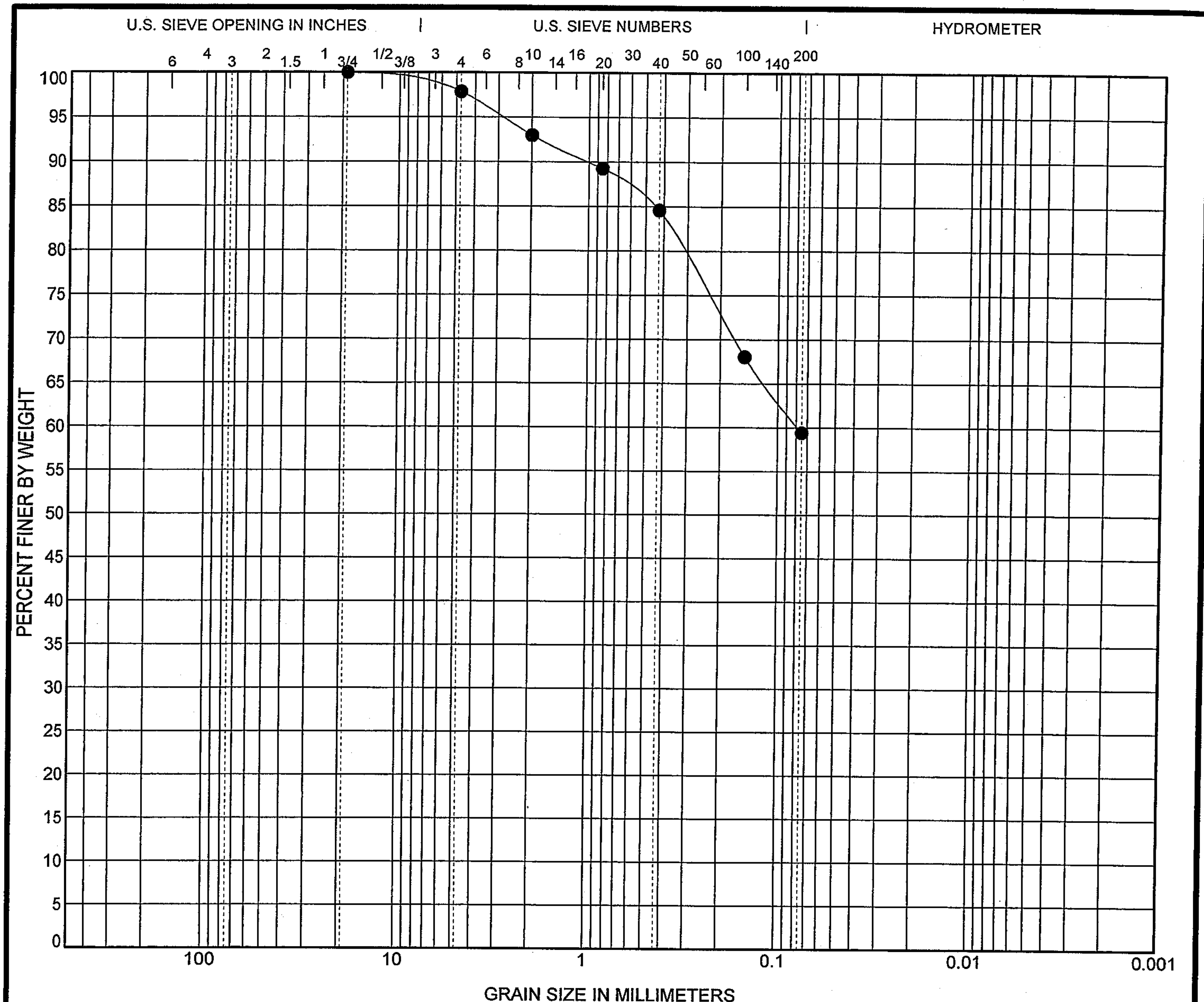
W.O. 4850-00(B)

GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 2.2



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	B-10	26.5 - 28.0	Dark gray SANDY SILT (ML) with some gravel					

	Sample	Depth (ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Fine
●	B-10	26.5 - 28.0	19	0.079			2.1	38.4	59.4

G GRAIN SIZE 4850-00.GPJ GEOLABS.GDT 9/5/02

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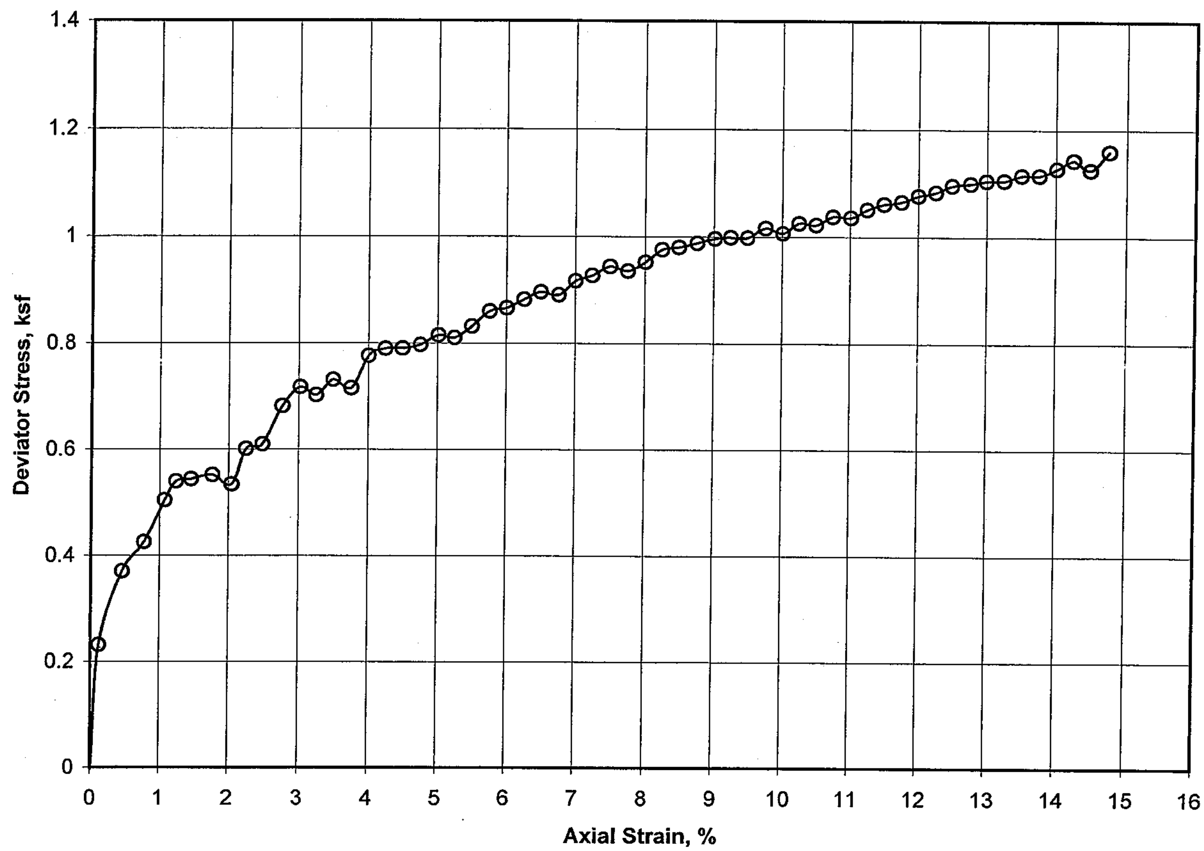
GRAIN SIZE DISTRIBUTION - ASTM C 117 & C 136

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 2.3

UNCONSOLIDATED UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION - ASTM D 2850



LOCATION: B - 2
DEPTH : 15 - 16.5 feet

DESCRIPTION: Brown **CLAYEY SILT (MH)** with sand

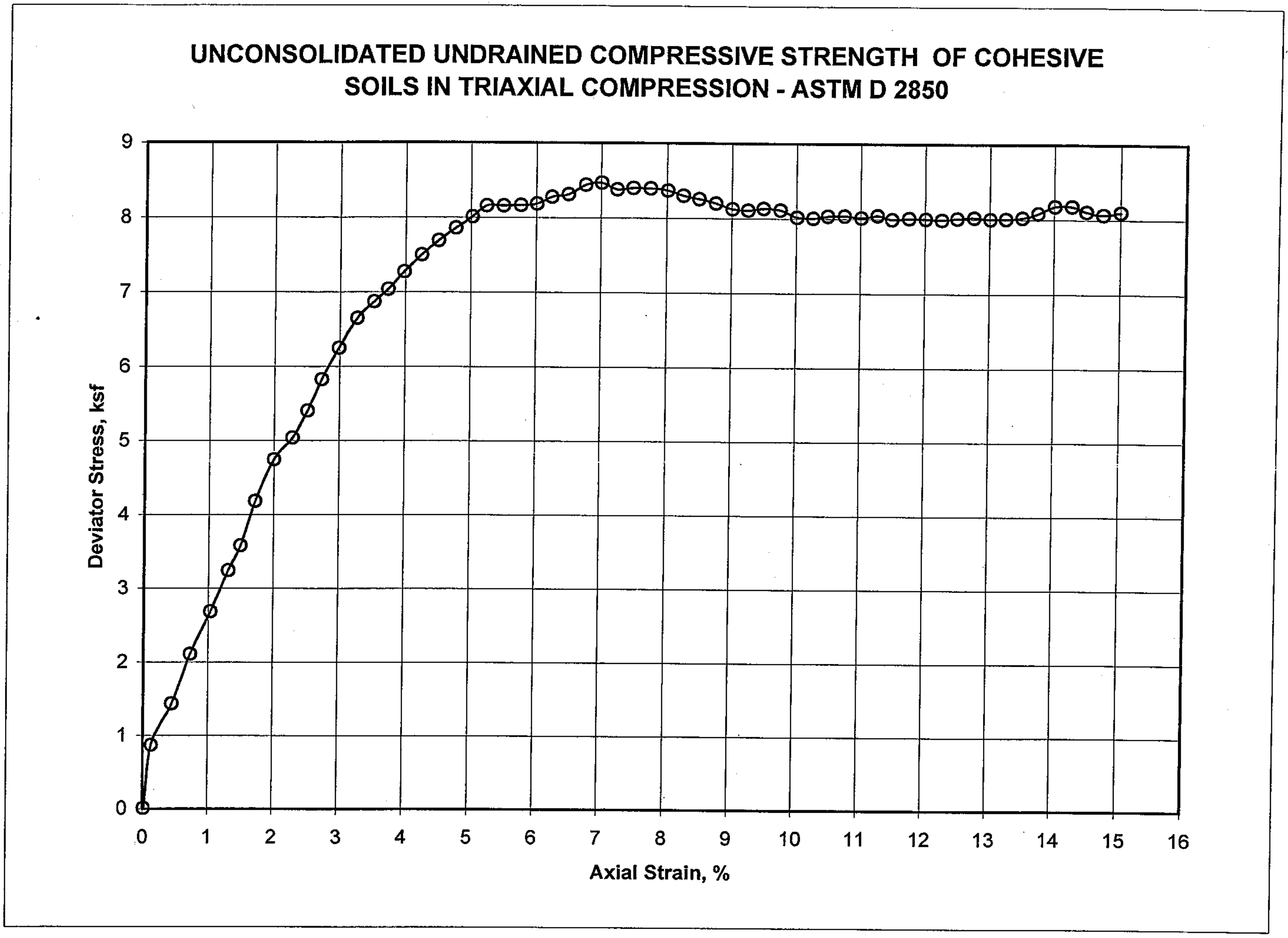
DRY DENSITY: 49.0 pcf
MOISTURE CONTENT: 94.0 %

AT FAILURE

CONFINING PRESSURE =	1.70 ksf		
MAX. DEVIATOR STRESS =	1.16 ksf @	14.8	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 2
DEPTH : 70 - 71.5 feet

DESCRIPTION: Brown gray **CLAYEY SILT (MH)**

DRY DENSITY: 56.0 pcf
MOISTURE CONTENT: 62.0 %

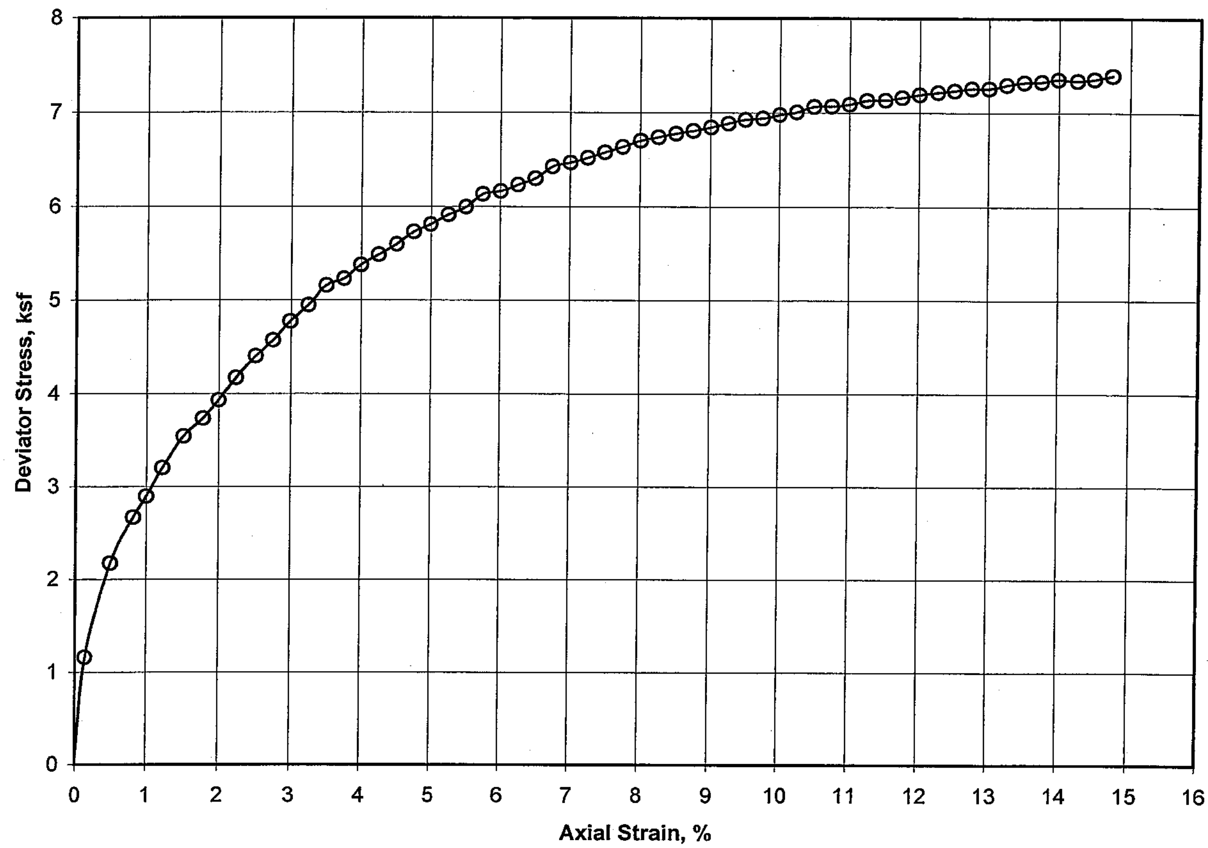
AT FAILURE

CONFINING PRESSURE =	3.80 ksf		
MAX. DEVIATOR STRESS =	8.47 ksf @	7.0	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)

UNCONSOLIDATED UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION - ASTM D 2850



LOCATION: B - 5
DEPTH : 115 - 116.5 feet

DESCRIPTION: Orange-brown with black mottling **CLAYEY SILT (MH)**

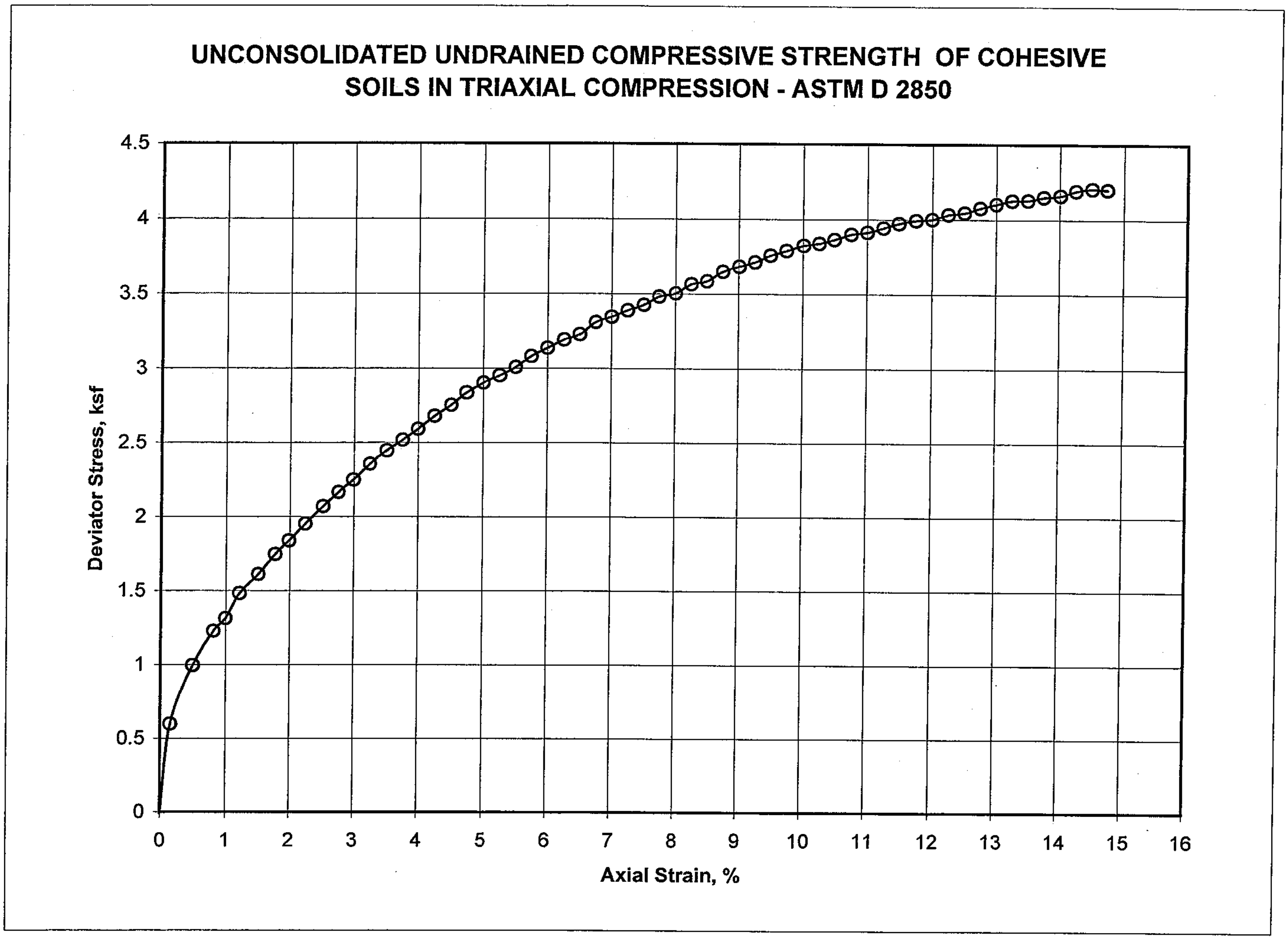
DRY DENSITY: 65.0 pcf
MOISTURE CONTENT: 60.0 %

AT FAILURE

CONFINING PRESSURE =	5.00 ksf		
MAX. DEVIATOR STRESS =	7.40 ksf @	14.8	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 5
DEPTH : 140 - 141.5 feet

DESCRIPTION: Orange-brown **CLAYEY SILT (MH)**

DRY DENSITY: 63.0 pcf
MOISTURE CONTENT: 63.0 %

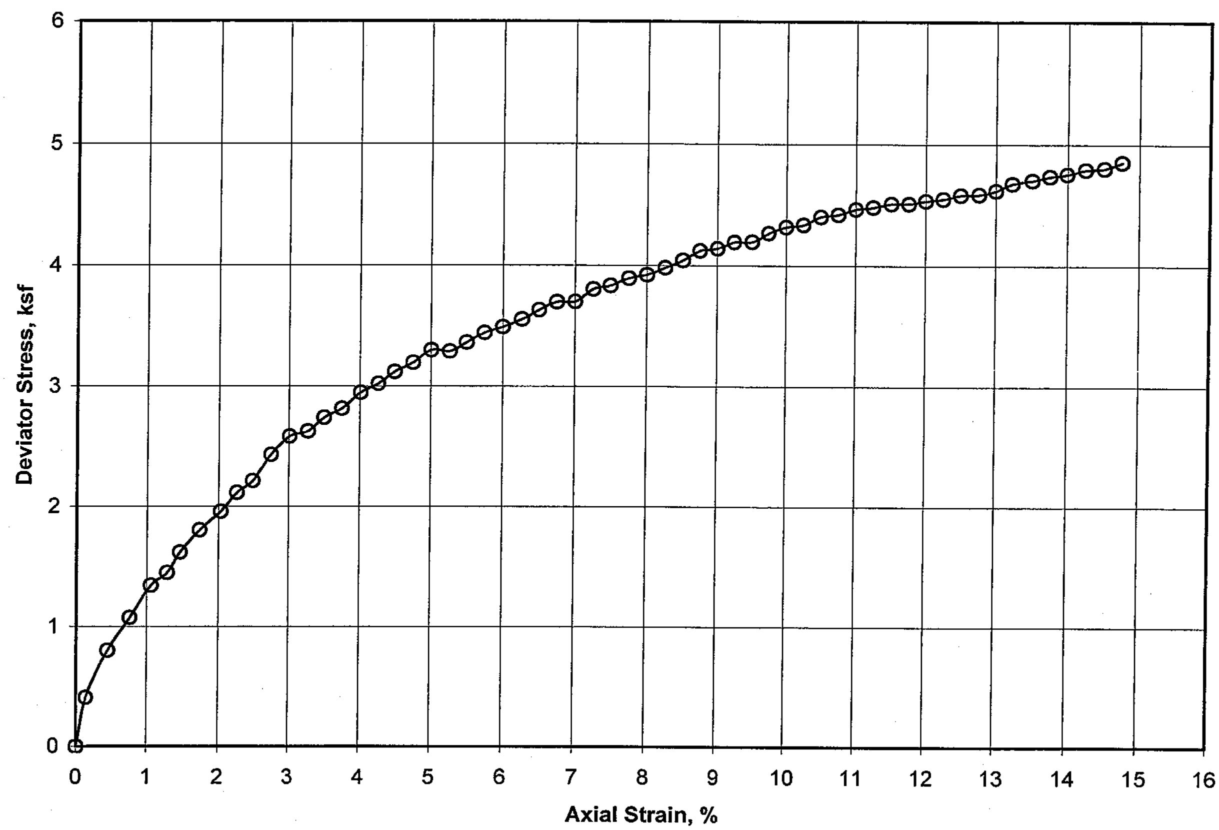
AT FAILURE

CONFINING PRESSURE = 6.10 ksf
MAX. DEVIATOR STRESS = 4.21 ksf @ 14.5 % STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)

UNCONSOLIDATED UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION - ASTM D 2850



LOCATION: B - 6
DEPTH : 75 - 76.5 feet

DESCRIPTION: Orange-brown with black mottling **CLAYEY SILT (MH)** with sand

DRY DENSITY: 67.0 pcf
MOISTURE CONTENT: 59.0 %

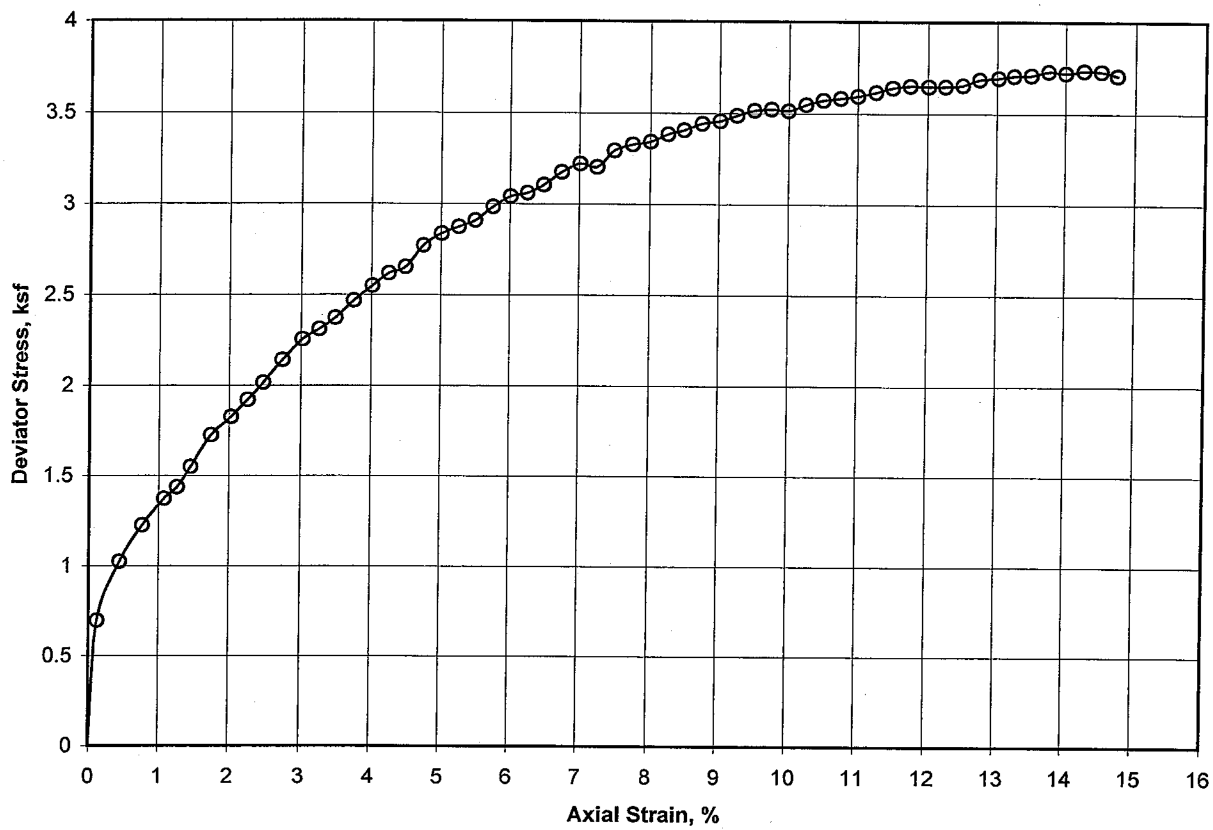
AT FAILURE

CONFINING PRESSURE =	3.30 ksf		
MAX. DEVIATOR STRESS =	4.85 ksf @	14.8	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)

UNCONSOLIDATED UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION - ASTM D 2850



LOCATION: B - 6
DEPTH : 125 - 126.5 feet

DESCRIPTION: Orange-brown with black mottling **CLAYEY SILT (MH)** with sand

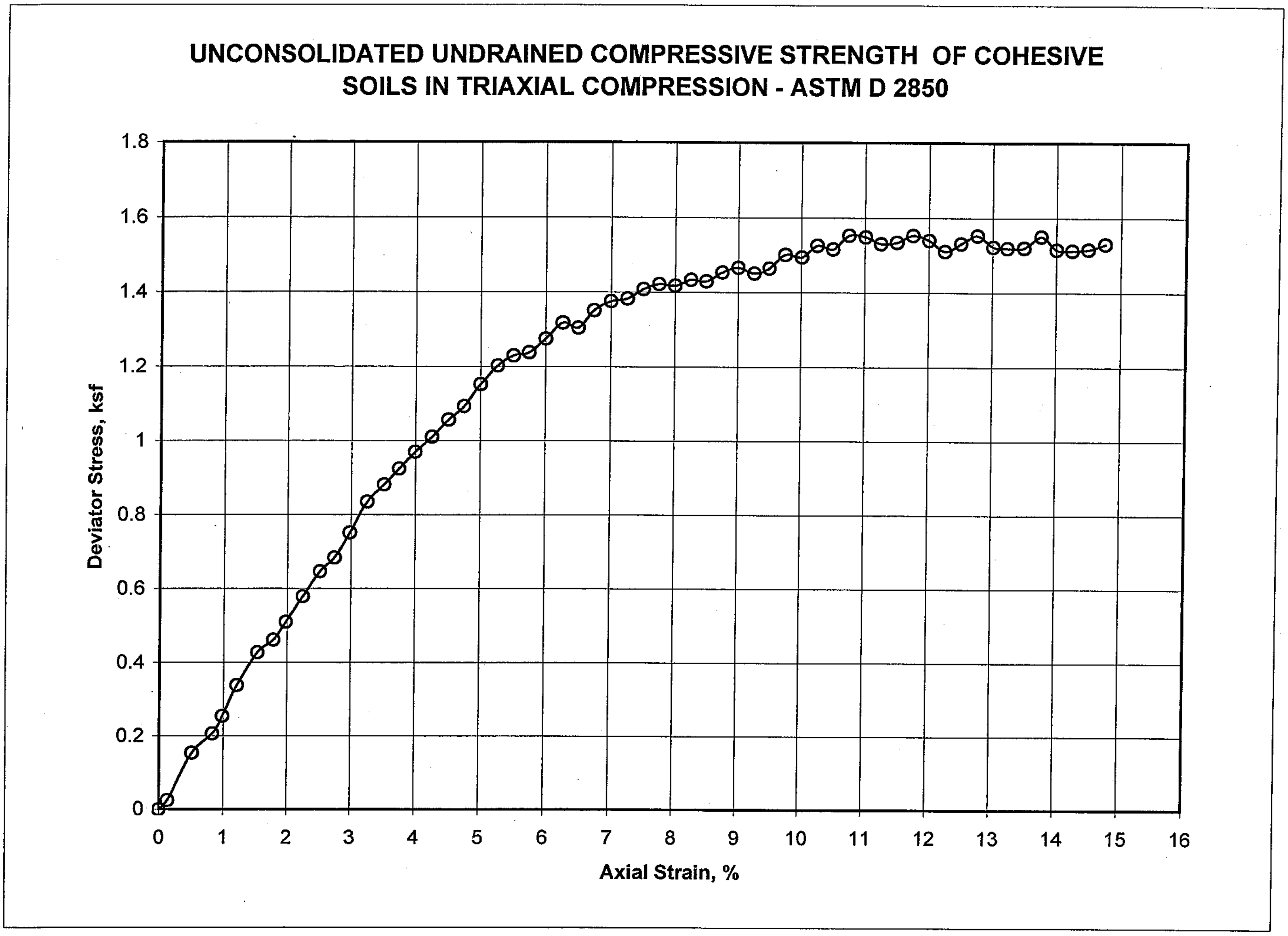
DRY DENSITY: 68.0 pcf
MOISTURE CONTENT: 57.0 %

AT FAILURE

CONFINING PRESSURE =	5.40 ksf		
MAX. DEVIATOR STRESS =	3.74 ksf @	14.3	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 7
DEPTH : 30 - 32 feet

DESCRIPTION: Dark gray **ORGANIC CLAYEY SILT (MH)** with sand

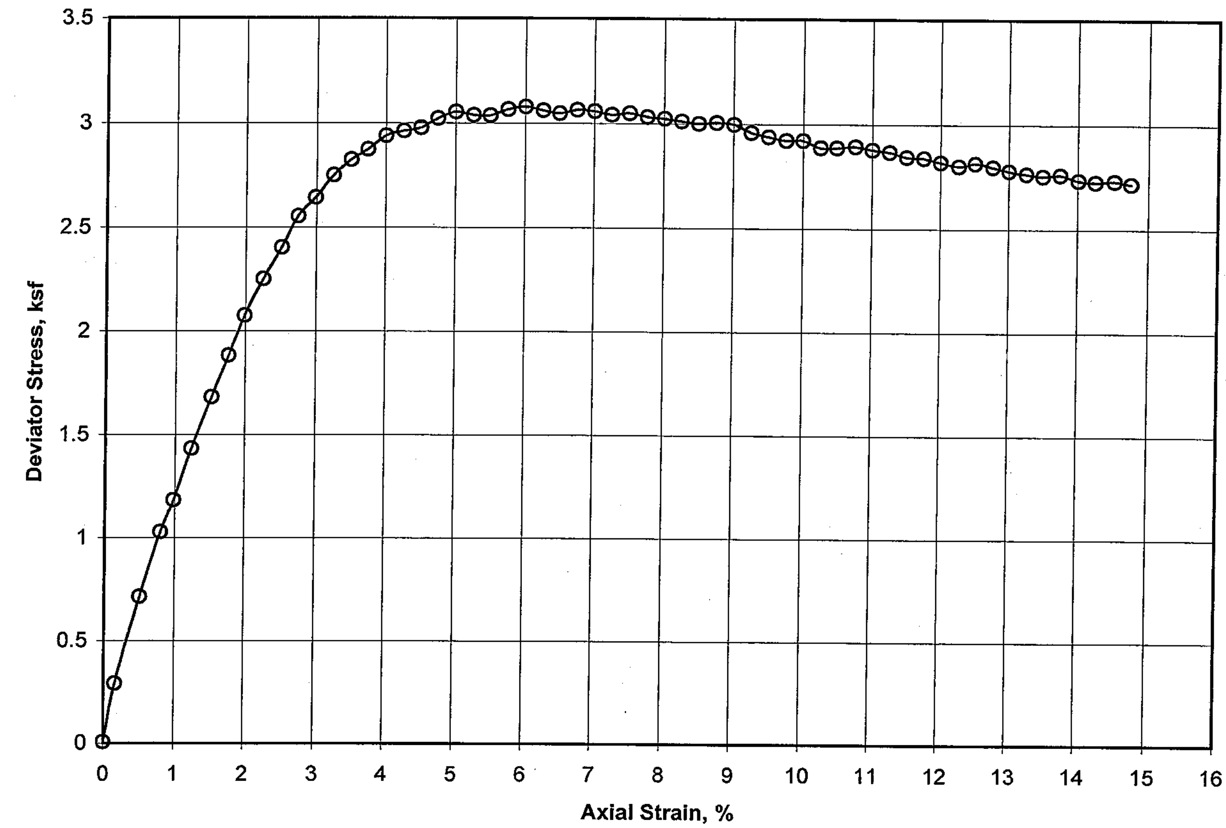
DRY DENSITY: 49.0 pcf
MOISTURE CONTENT: 93.0 %

AT FAILURE

CONFINING PRESSURE = 1.80 ksf
MAX. DEVIATOR STRESS = 1.55 ksf @ 12.7 % STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 7
DEPTH : 35 - 37 feet

DESCRIPTION: Dark gray **ORGANIC CLAYEY SILT (MH)** with sand

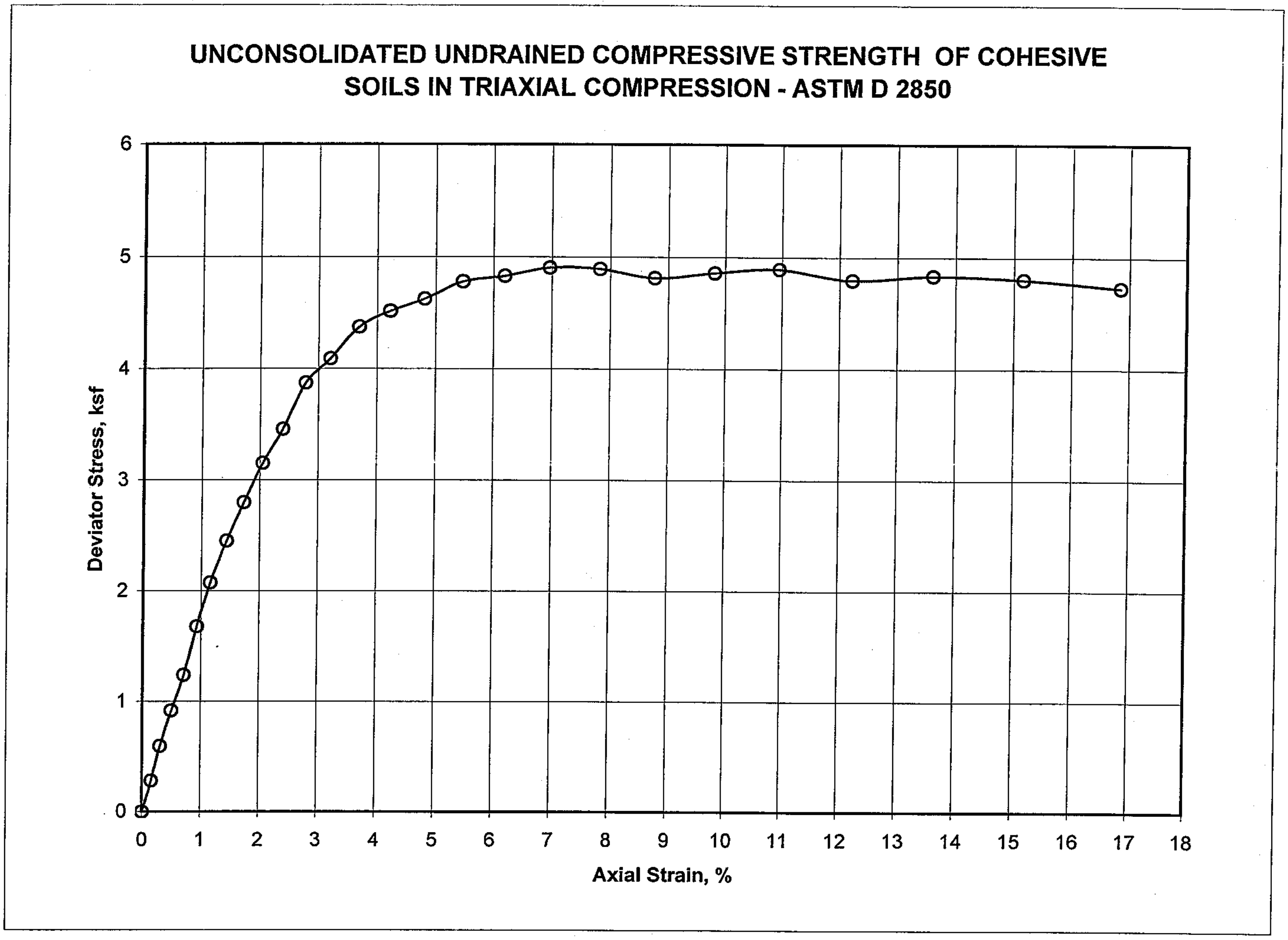
DRY DENSITY: 47.0 pcf
MOISTURE CONTENT: 94.0 %

AT FAILURE

CONFINING PRESSURE =	1.90 ksf		
MAX. DEVIATOR STRESS =	3.08 ksf @	6.0	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 107
DEPTH : 30.5 - 32.5 feet

DESCRIPTION: Gray **ORGANIC CLAY (OH)**

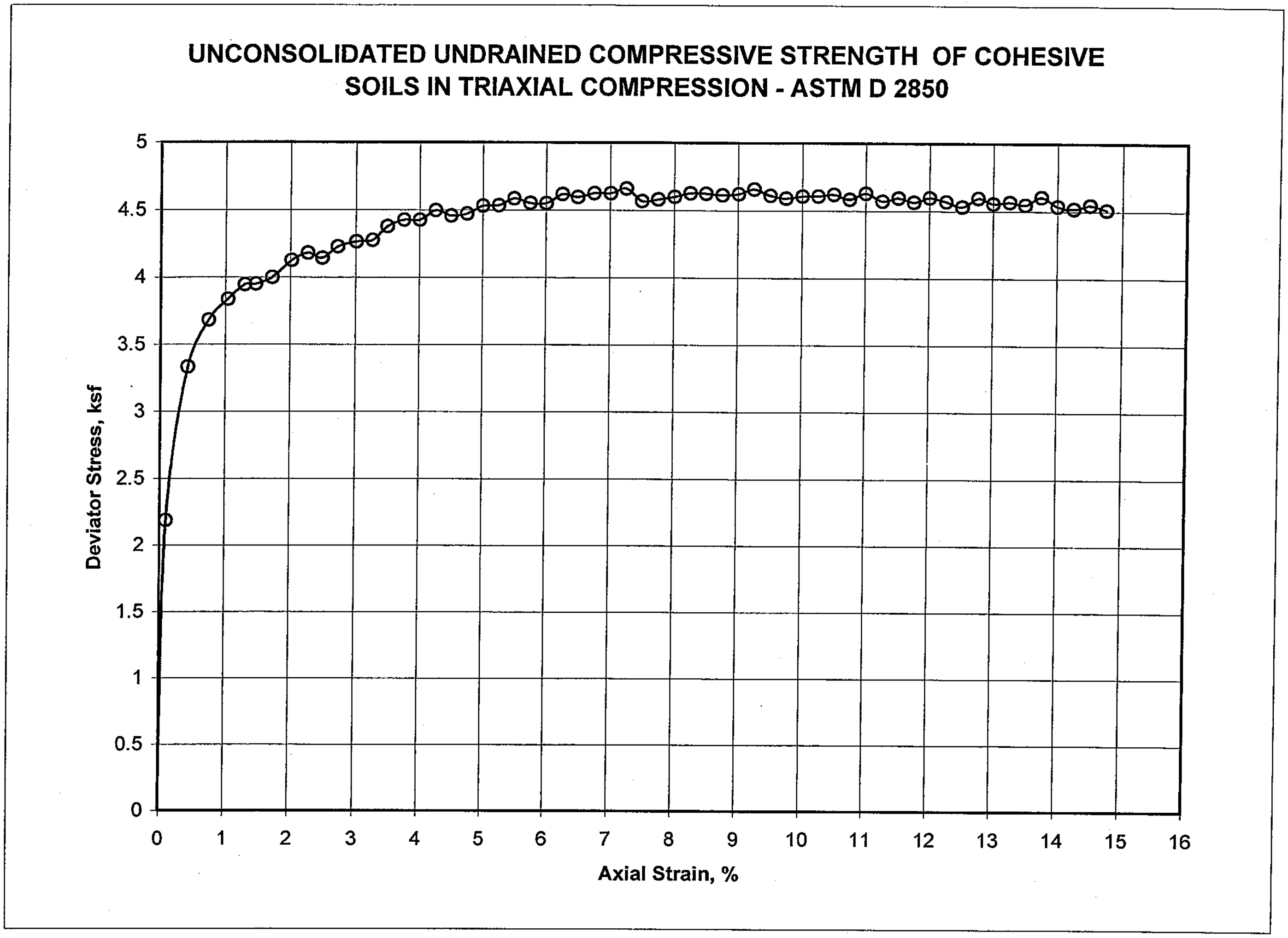
DRY DENSITY:	70.3 pcf	SAMPLE DIAMETER:	2.749 inches
MOISTURE CONTENT:	48.6 %	SAMPLE HEIGHT:	5.851 inches

AT FAILURE

STRAIN RATE =	0.58 %/min.		
CONFINING PRESSURE =	2.45 ksf		
MAX. DEVIATOR STRESS =	4.90 ksf @	7.0	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Sep 02	W.O. 4850-00(B)



LOCATION: B - 108
DEPTH : 10.5 - 12 feet

DESCRIPTION: Reddish brown **CLAYEY SILT (MH)** with sand and trace of gravel

DRY DENSITY: 77.0 pcf
MOISTURE CONTENT: 38.0 %

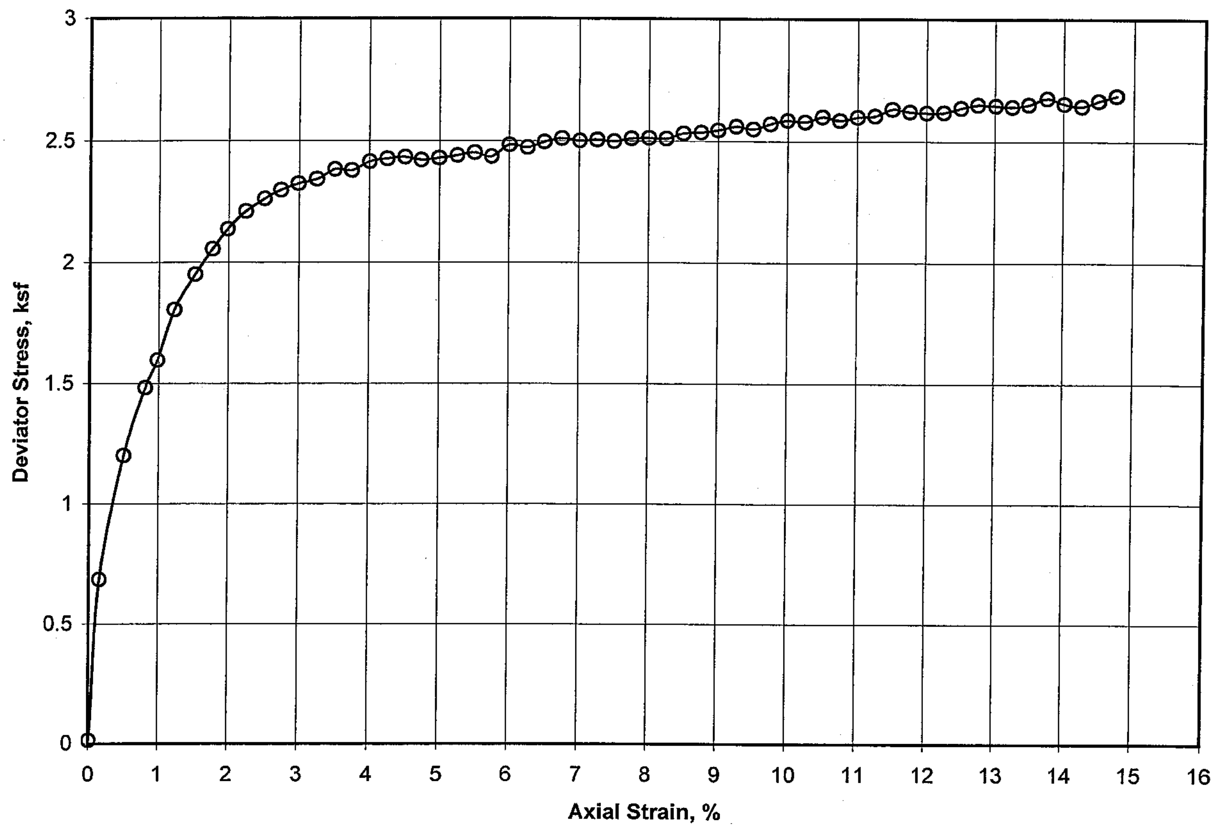
AT FAILURE

CONFINING PRESSURE = 1.30 ksf
MAX. DEVIATOR STRESS = 4.66 ksf @ 7.3 % STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)

UNCONSOLIDATED UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION - ASTM D 2850



LOCATION: B - 108
DEPTH : 30.5 - 32 feet

DESCRIPTION: Gray **ORGANIC CLAYEY SILT (MH)** with sand and gravel

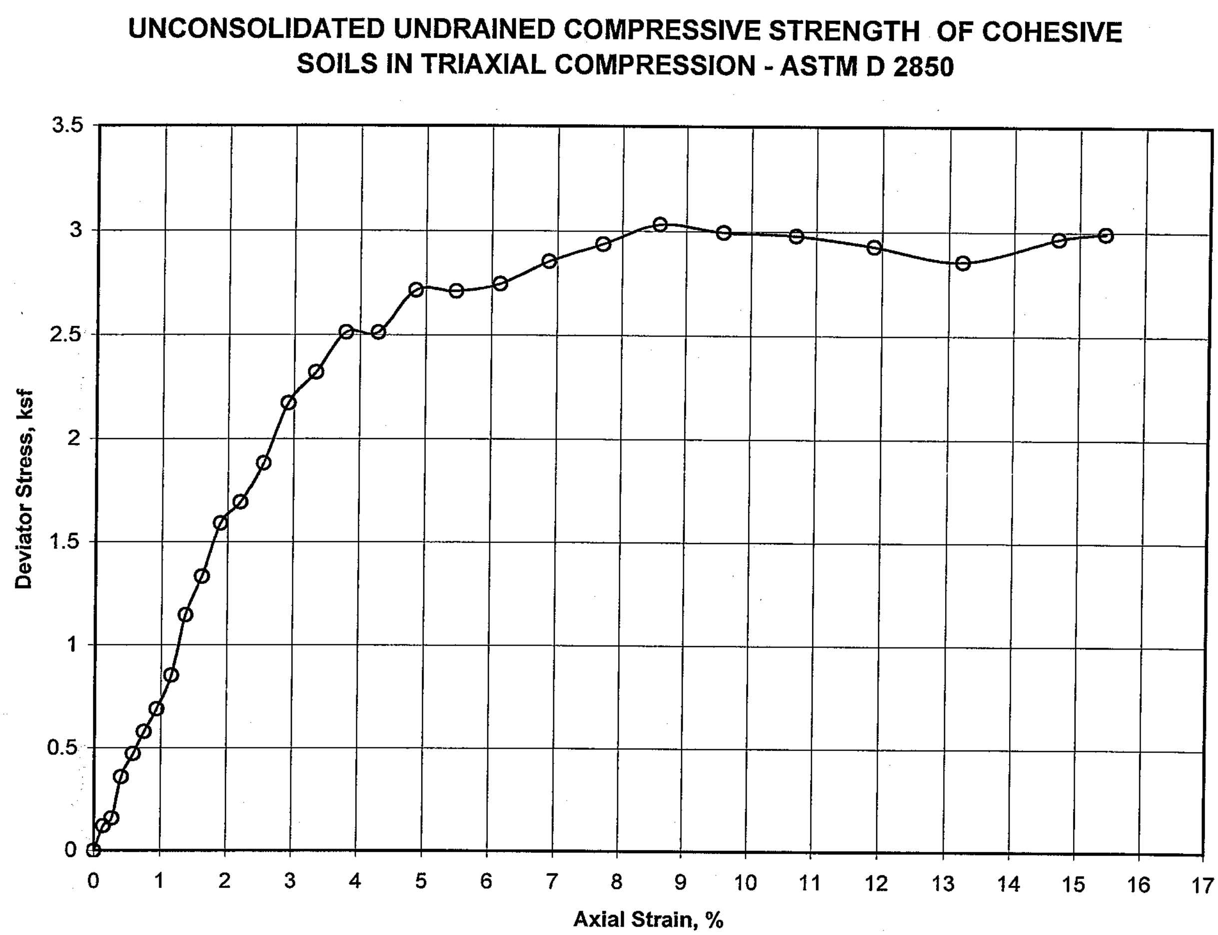
DRY DENSITY: 67.0 pcf
MOISTURE CONTENT: 41.0 %

AT FAILURE

CONFINING PRESSURE =	2.70 ksf		
MAX. DEVIATOR STRESS =	2.69 ksf @	14.8	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Apr 02	W.O. 4850-00(B)



LOCATION: B - 136
DEPTH : 75.5 - 77.5 feet

DESCRIPTION: Dark gray **ORGANIC CLAY (OH)**

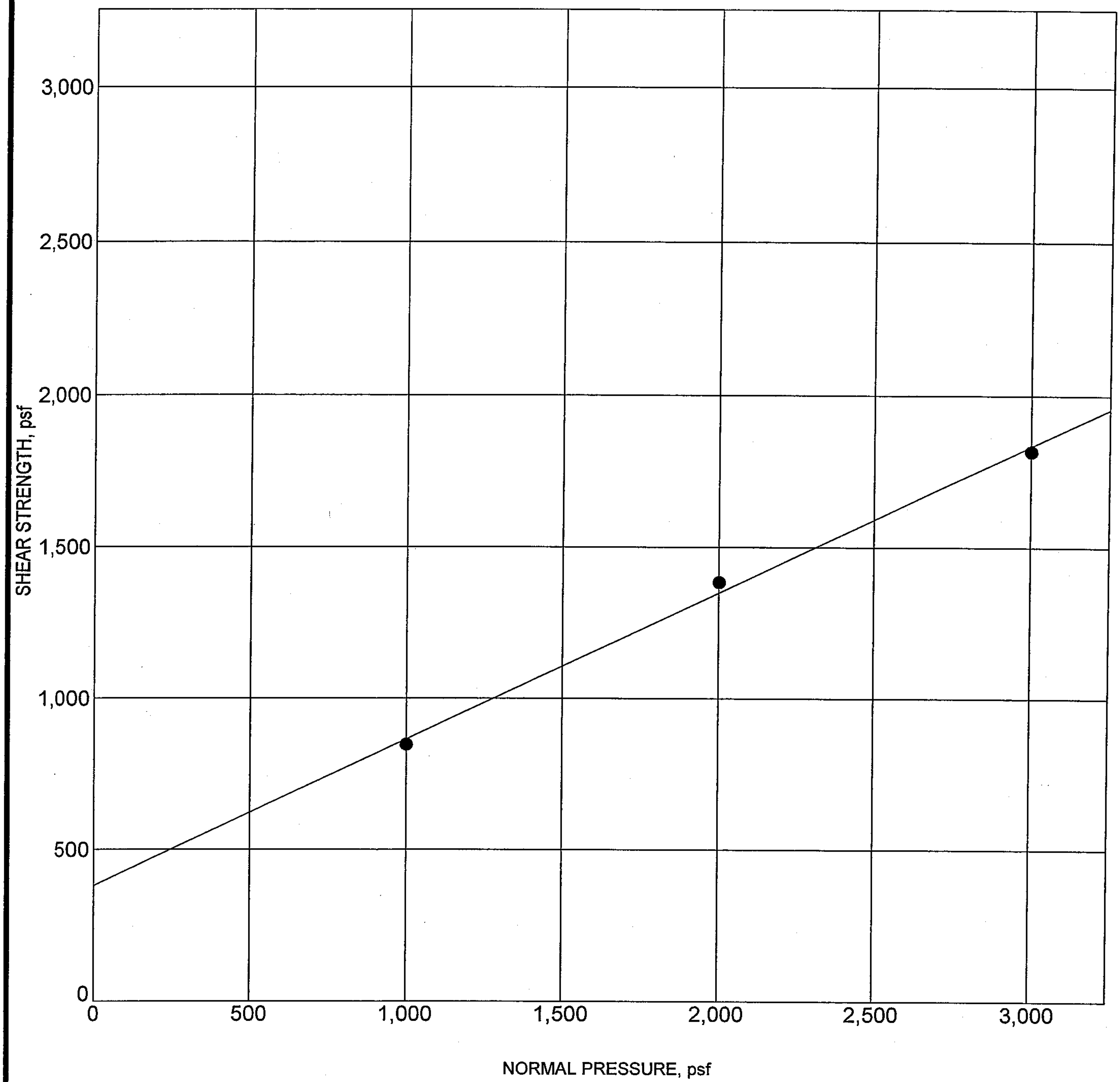
DRY DENSITY:	63.5 pcf	SAMPLE DIAMETER:	2.809 inches
MOISTURE CONTENT:	61.2 %	SAMPLE HEIGHT:	5.671 inches

AT FAILURE

STRAIN RATE =	0.66 %/min.		
CONFINING PRESSURE =	5.62 ksf		
MAX. DEVIATOR STRESS =	3.03 ksf @	8.6	% STRAIN

PROJECT:
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
F.A.I. PROJ. NO. IM-HP-H1-1(237)
PEARL CITY TO AIEA, OAHU, HAWAII

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
GEOLABS, INC. *Geotechnical Engineering*	
DATE Aug 02	W.O. 4850-00(B)



Friction angle (degrees):	**26**
cohesion (psf):	**381**

Sample: B-102
Depth: SURFACE
Description: Reddish brown CLAYEY SILT

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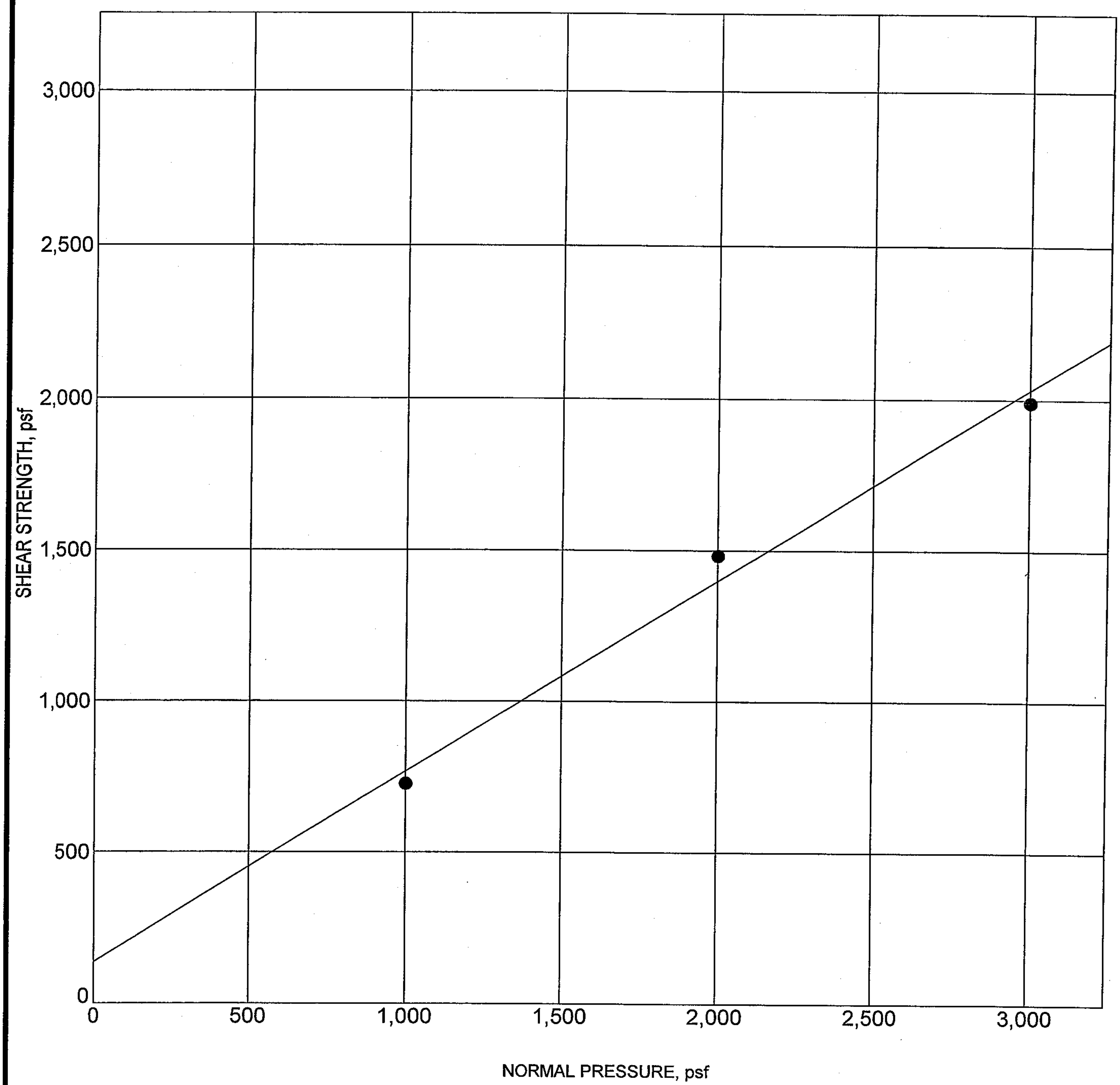
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

DIRECT SHEAR TEST - ASTM D 3080
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 4.1

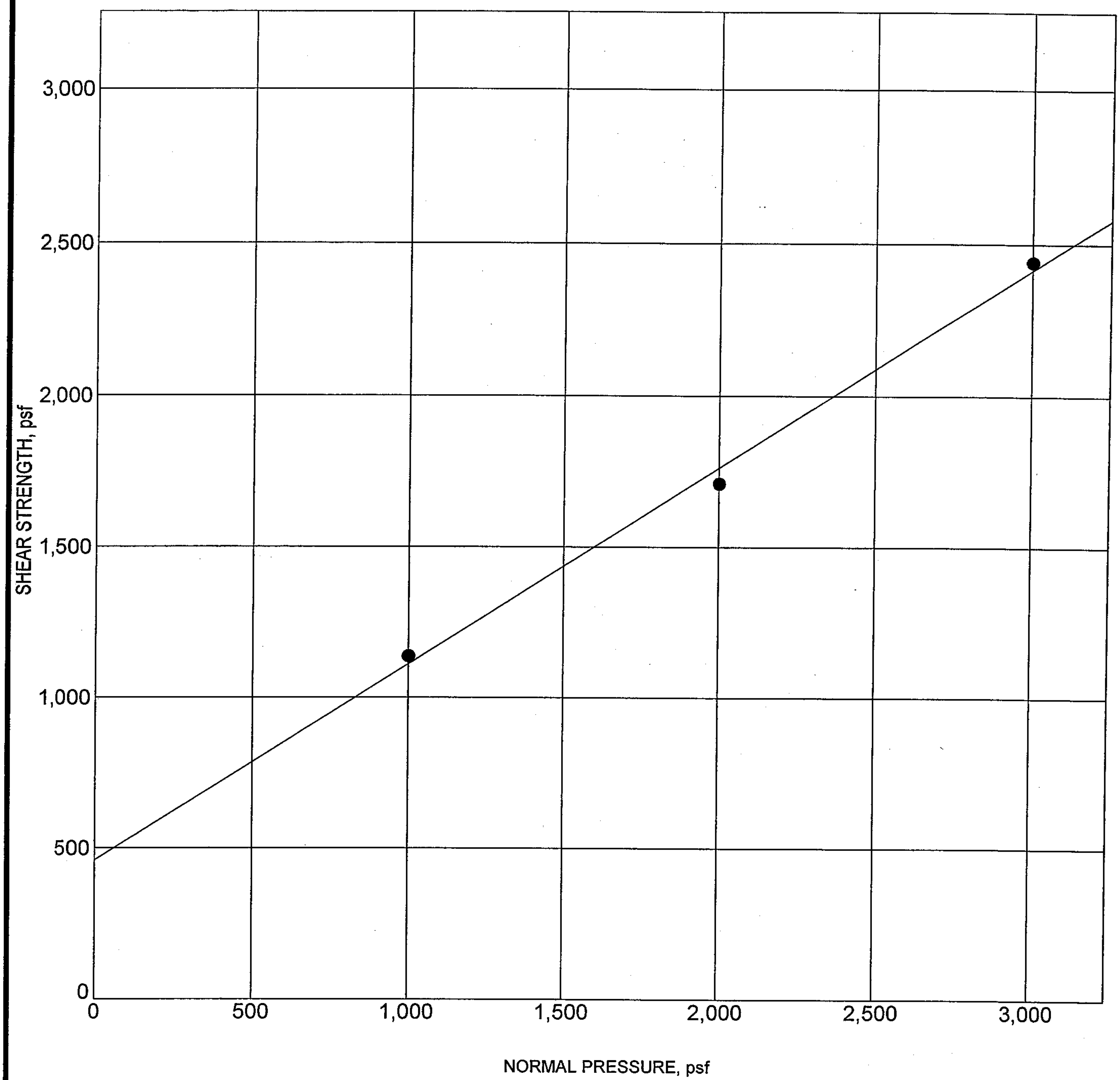


Friction angle (degrees):	**32**
cohesion (psf):	**137**

Sample: B-105
Depth: 0.0 - 0.5 feet
Description: Reddish brown SILTY CLAY

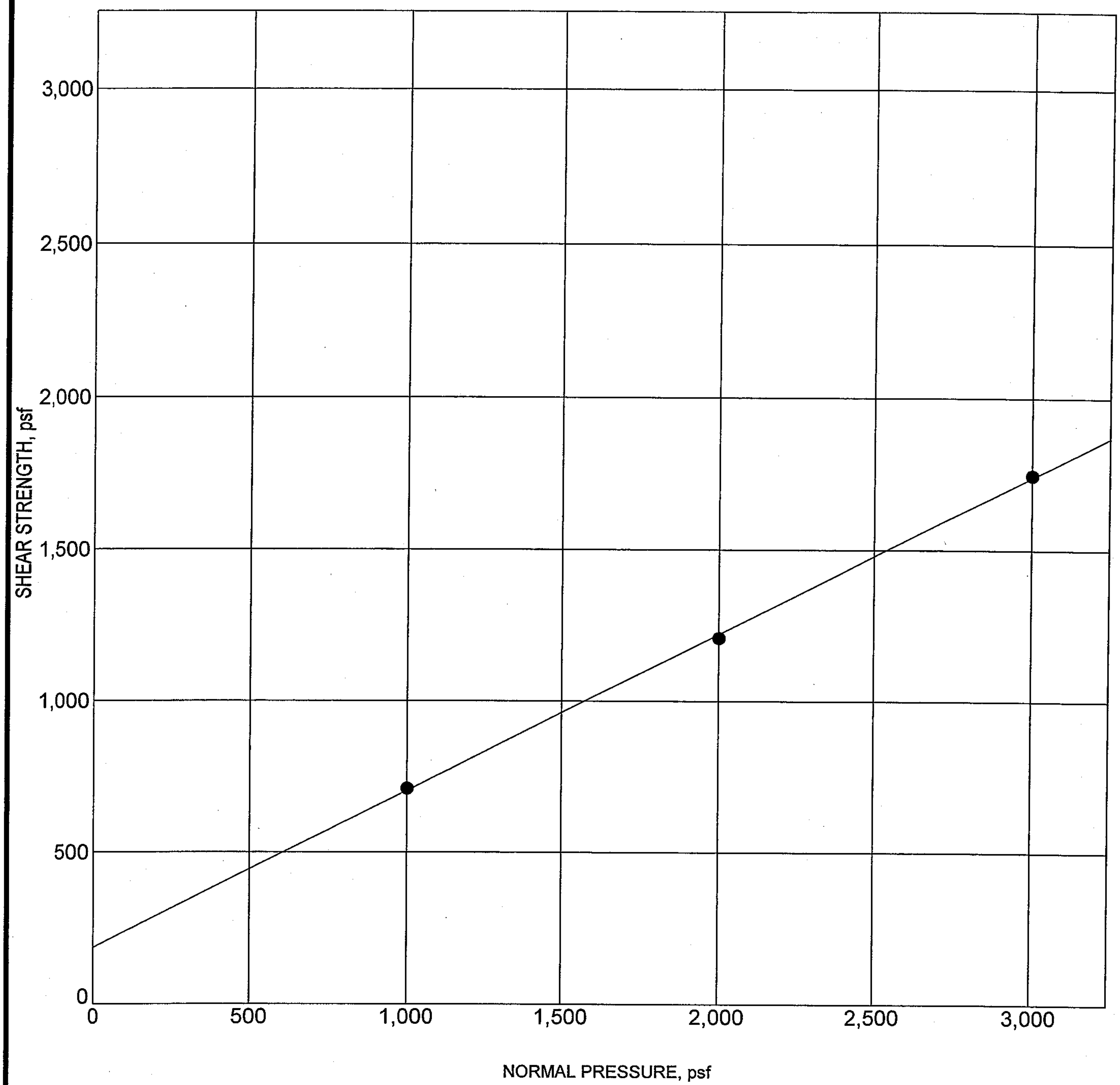
GEOLABS, INC. GEOTECHNICAL ENGINEERING	**DIRECT SHEAR TEST - ASTM D 3080**	
W.O. 4850-00(B)	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Plate B - 4.2

G DIRECT SHEAR 4850-00.GPJ GEOLABS.GDT 9/5/02



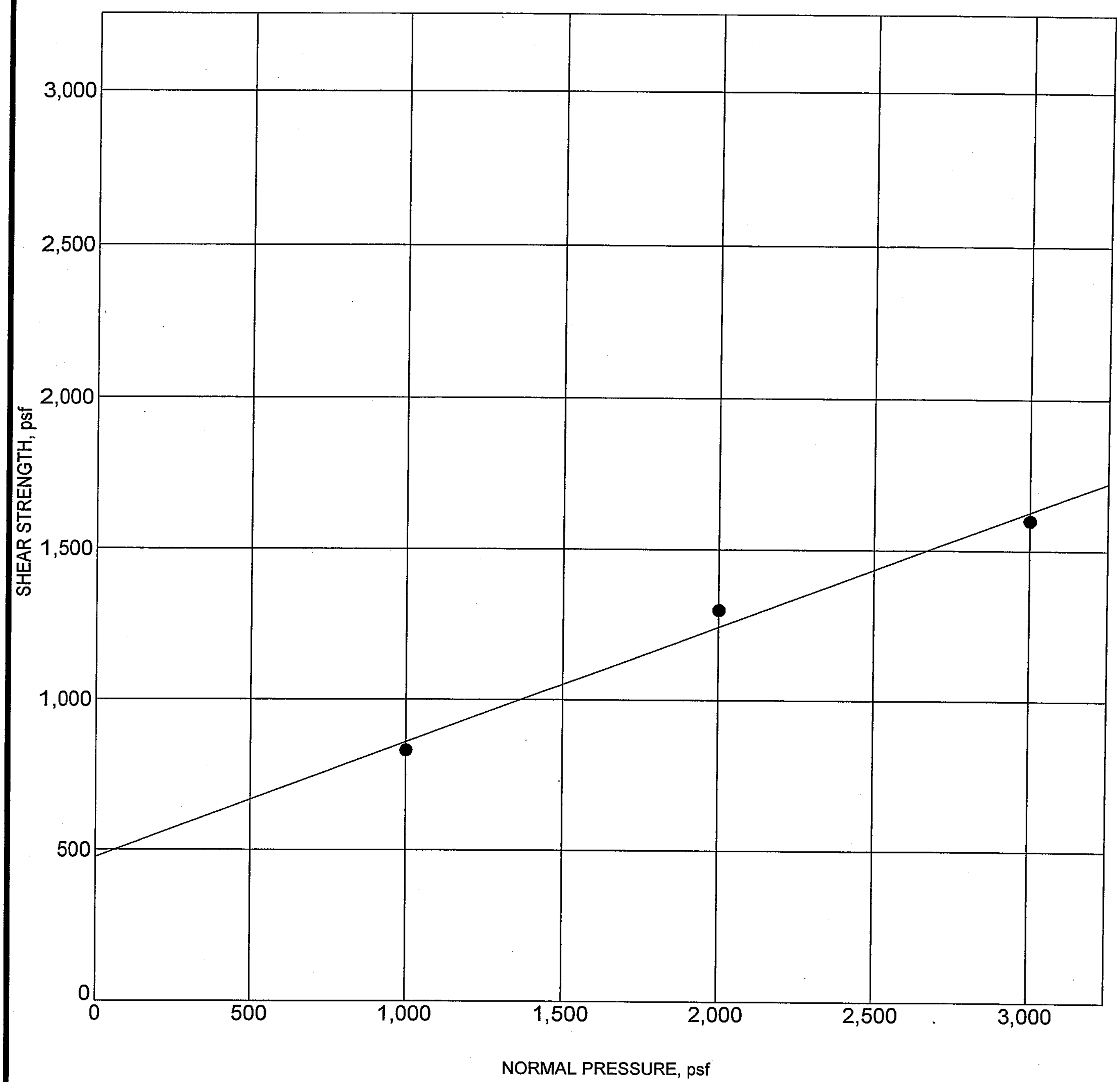
Friction angle (degrees):	**33**
cohesion (psf):	**500**

Sample: B-107
Depth: 10.5 - 12.0 feet
Description: Reddish brown SILTY CLAY



Friction angle (degrees):	**27**
cohesion (psf):	**186**

Sample: B-107
Depth: 25.5 - 27.0 feet
Description: Brown CLAYEY SILT with some gravel



Friction angle (degrees):	**22**
cohesion (psf):	**500**

Sample: B-107
Depth: 30.5 - 32.5 feet
Description: Dark gray Silty CLAY

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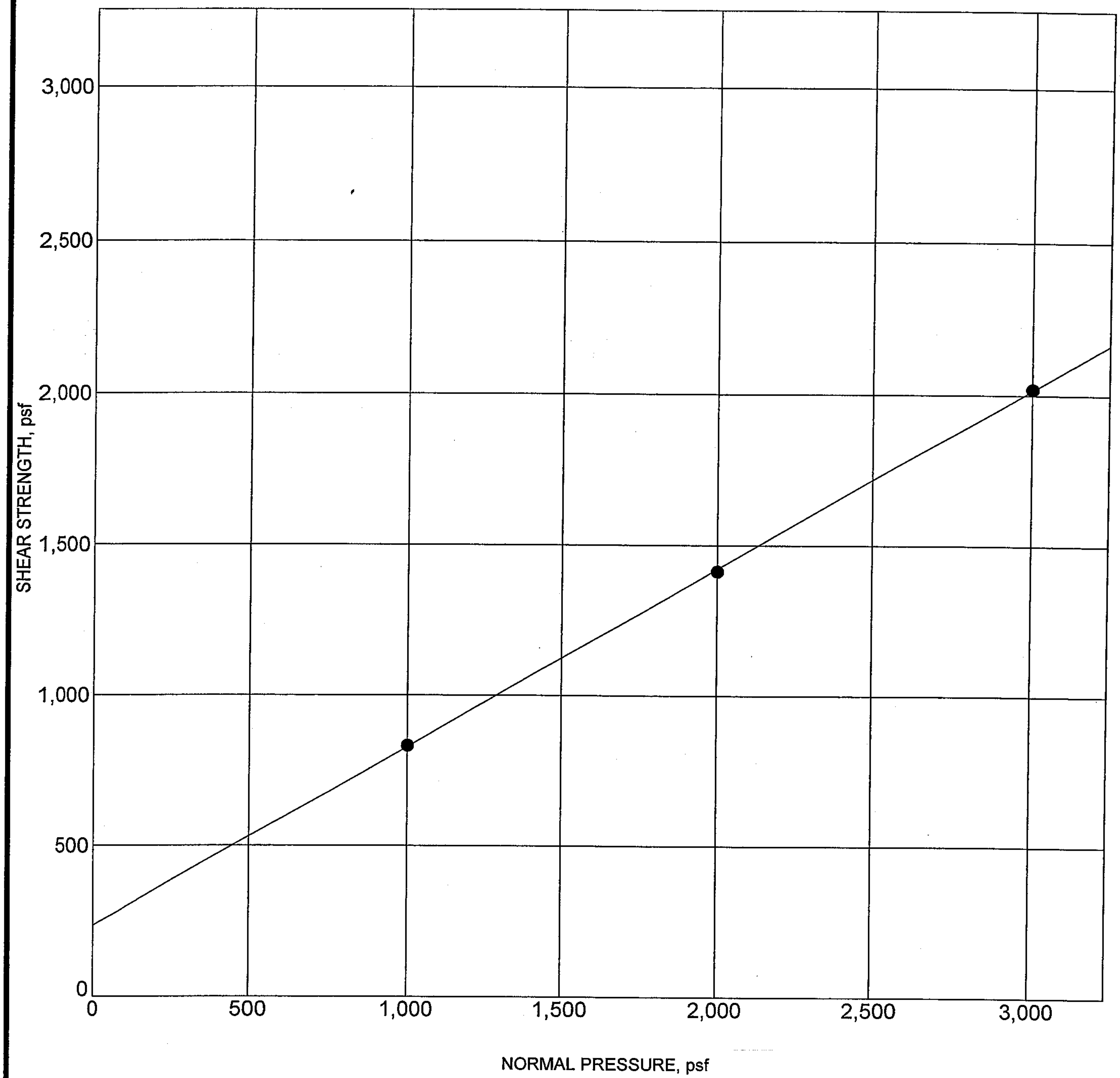
GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

DIRECT SHEAR TEST - ASTM D 3080
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 4.5



Friction angle (degrees):	**31**
cohesion (psf):	**235**

Sample: B-141
Depth: 0.0 - 0.5 feet
Description: Reddish brown SILTY CLAY

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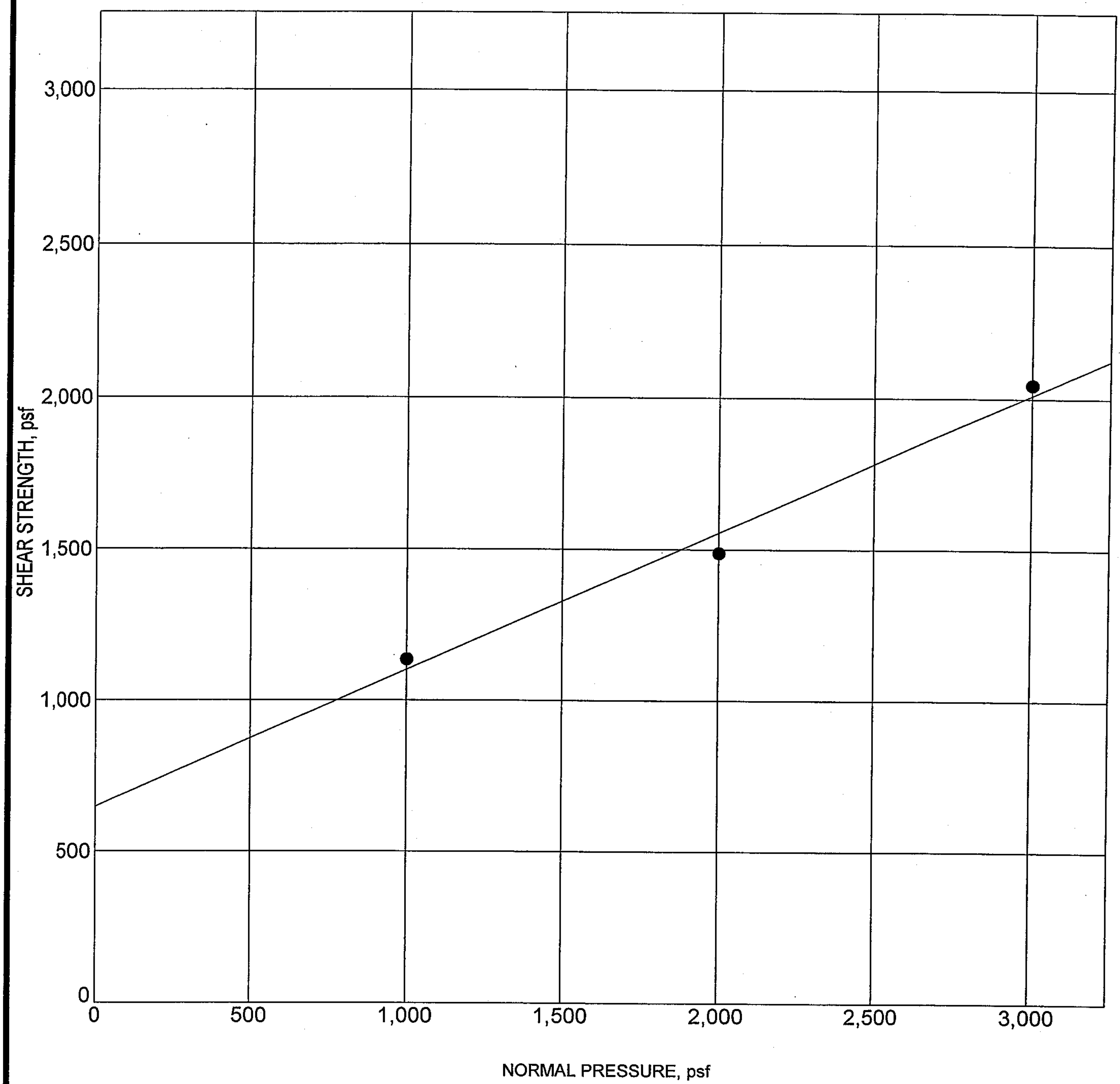
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

DIRECT SHEAR TEST - ASTM D 3080
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

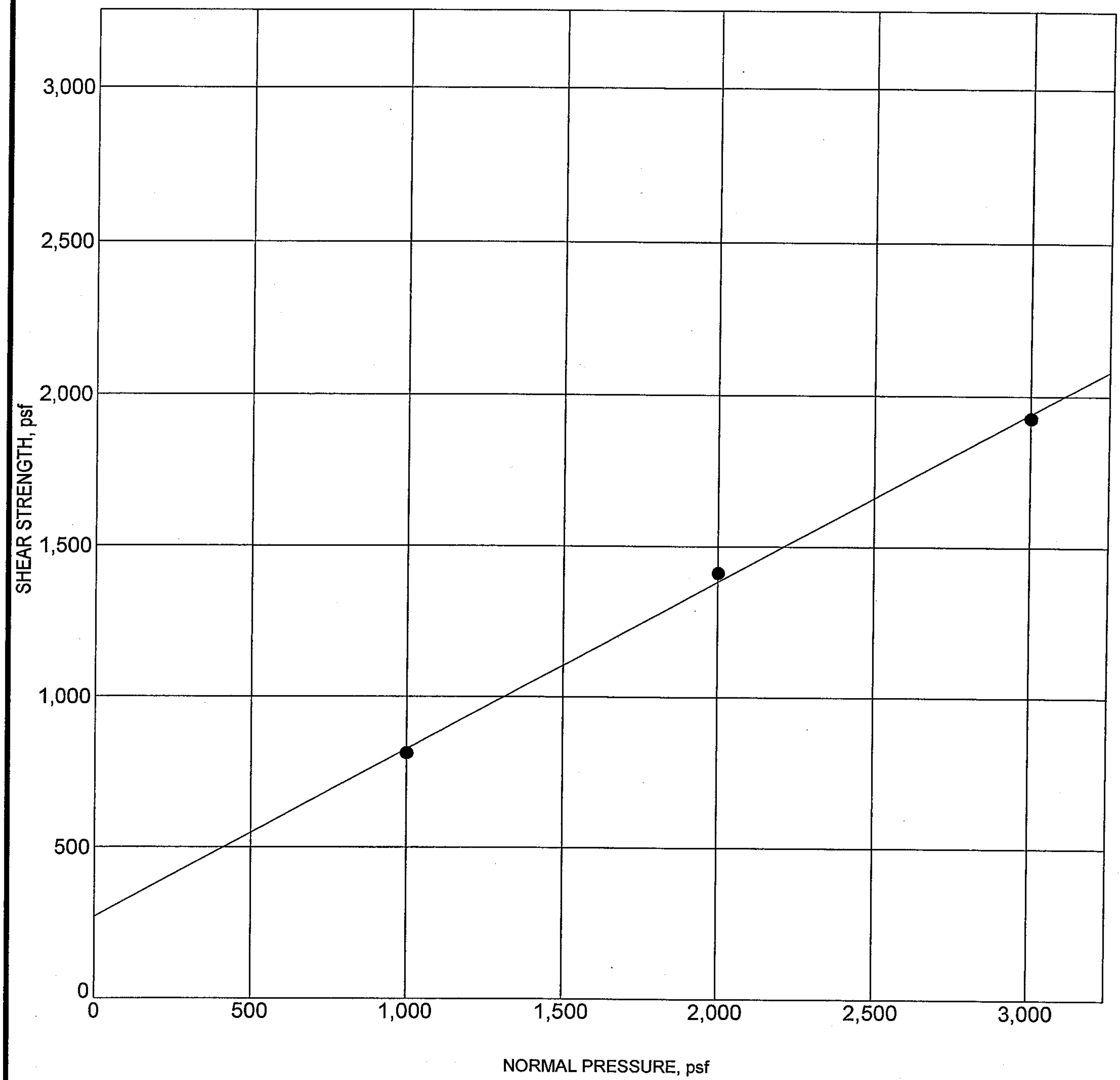
Plate
B - 4.6



Friction angle (degrees):	**24**
cohesion (psf):	**648**

Sample: B-201
Depth: 0.0 - 0.5 feet
Description: Reddish brown SILTY CLAY

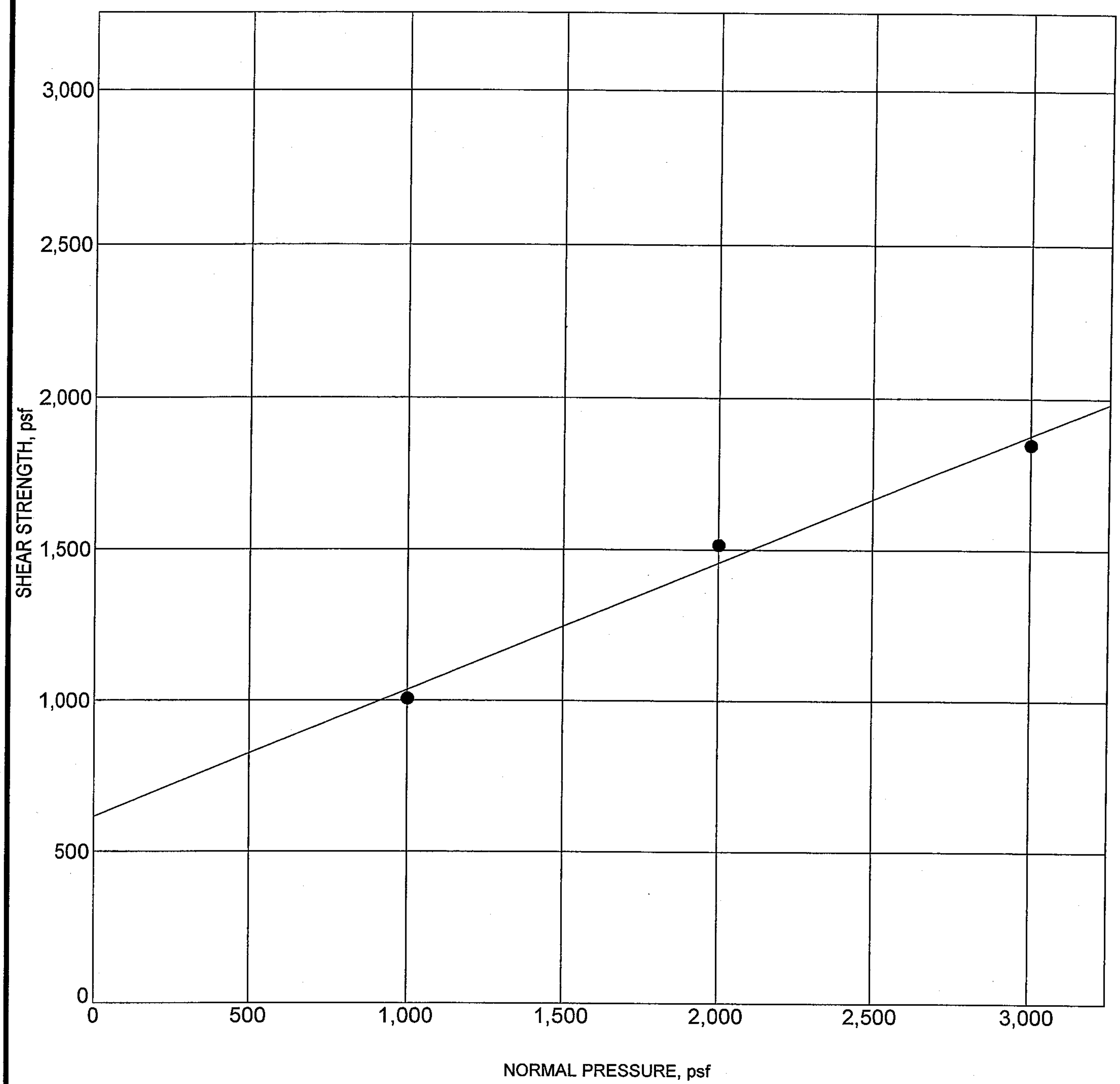
GEOLABS, INC. GEOTECHNICAL ENGINEERING	DIRECT SHEAR TEST - ASTM D 3080	
W.O. 4850-00(B)	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Plate B - 4.7



Friction angle (degrees): **29**
cohesion (psf): **270**

Sample: B-202
Depth: 0.0 - 0.5 feet
Description: Reddish brown SILTY CLAY

GEOLABS, INC. GEOTECHNICAL ENGINEERING	DIRECT SHEAR TEST - ASTM D 3080	
W.O. 4850-00(B)	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Plate B - 4.8



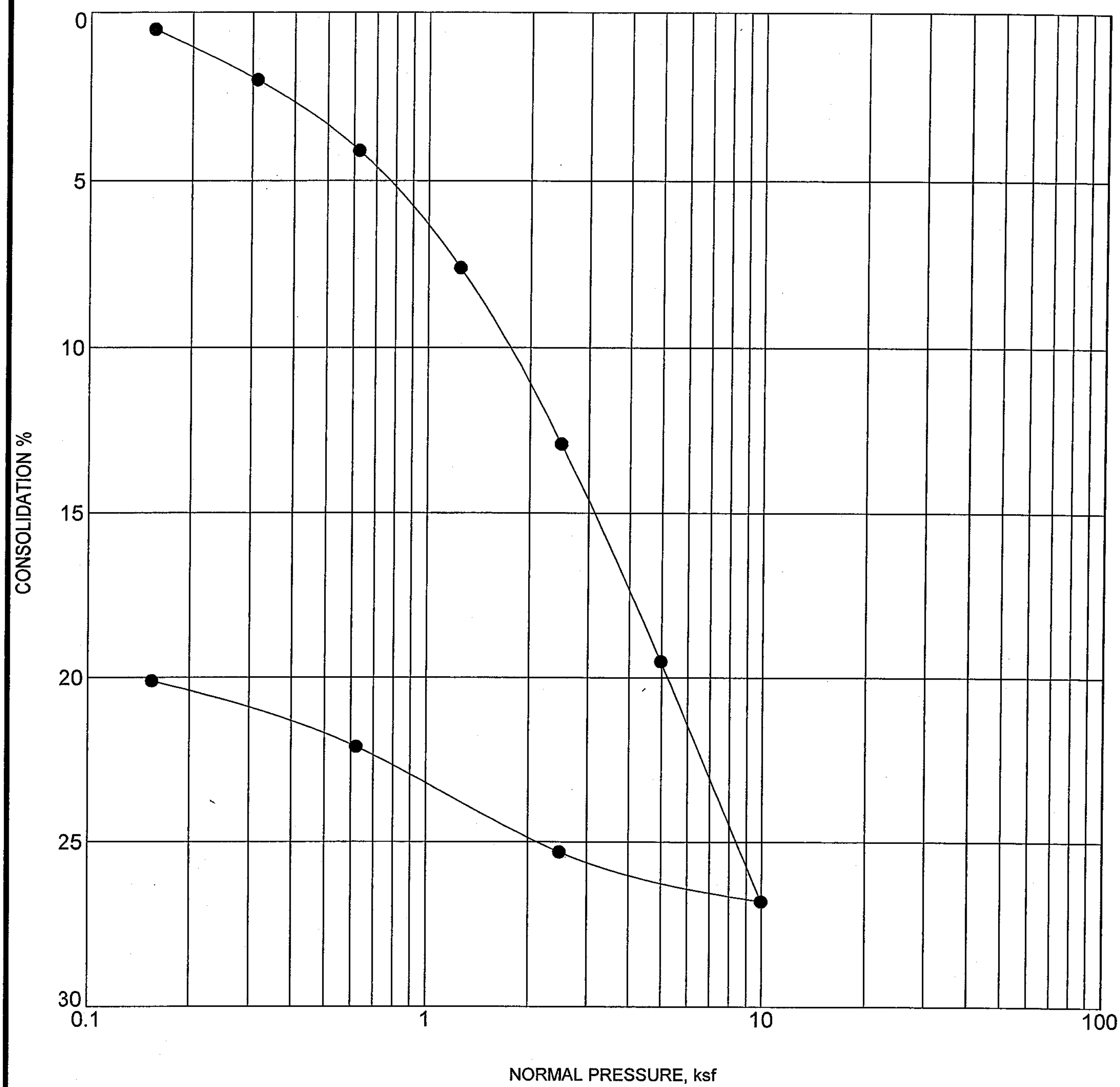
Friction angle (degrees):	**23**
cohesion (psf):	**616**

Sample: Bulk-102
Depth: SURFACE
Description: Reddish brown CLAYEY SILT with some decomposed rock

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

DIRECT SHEAR TEST - ASTM D 3080
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 4.9



	Initial	Final
water content, %:	98.6	75.1
dry density, pcf:	46.2	57.8

Sample: B-4
Depth: 25.0 - 26.5 feet
Description: Gray brown CLAYEY SILT with fine sand

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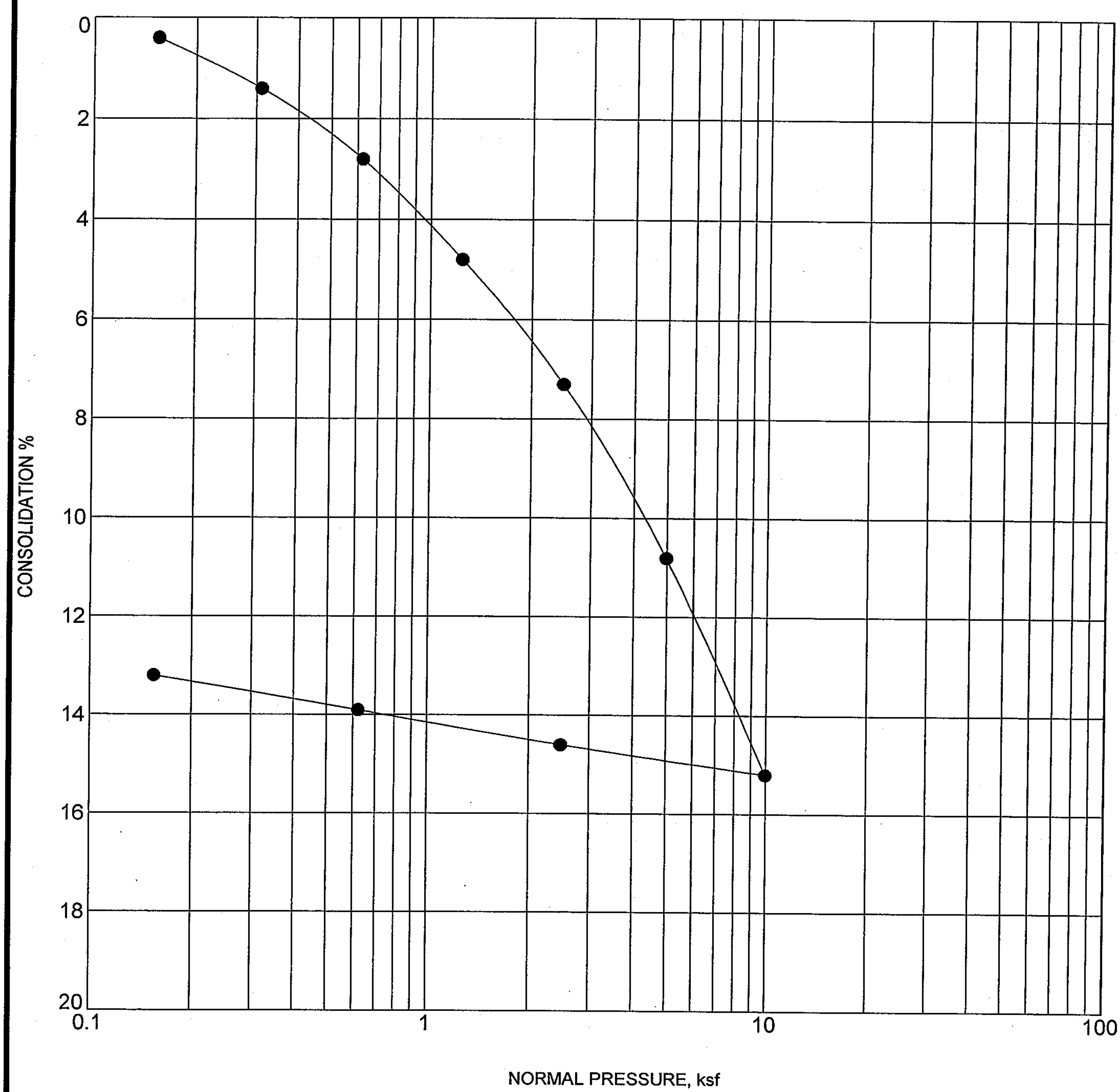
GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.1



	Initial	Final
water content, %:	64.5	52.6
dry density, pcf:	61.5	70.9

Sample: B-5
Depth: 15.0 - 16.5 feet
Description: Gray SANDY SILT (ML)

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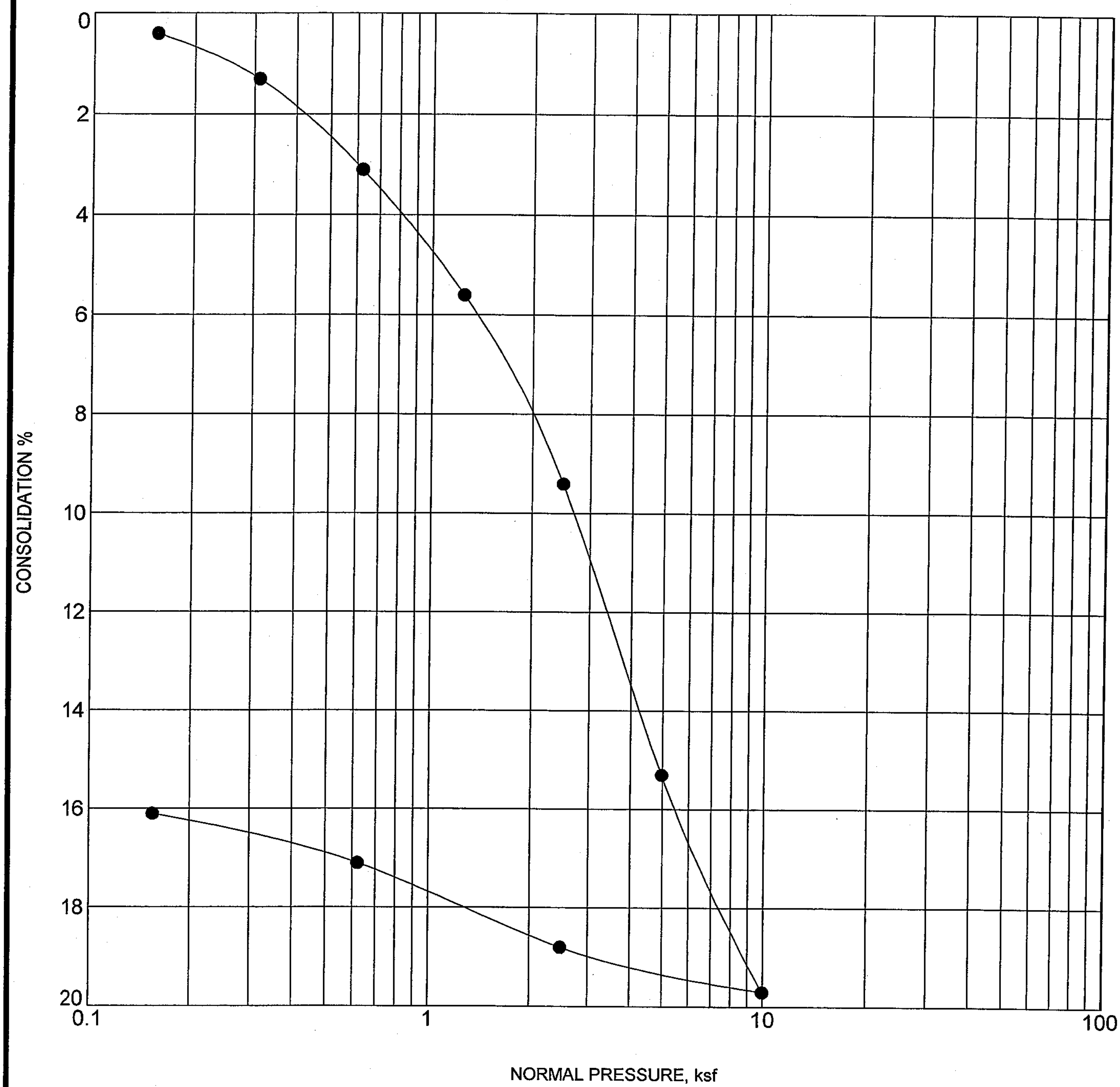
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.2



	Initial	Final
water content, %:	63.8	54.0
dry density, pcf:	60.4	72.0

Sample: B-5
Depth: 20.0 - 22.0 feet
Description: Dark gray ORGANIC SILT (OH)

GEOLABS, INC.
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W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.3

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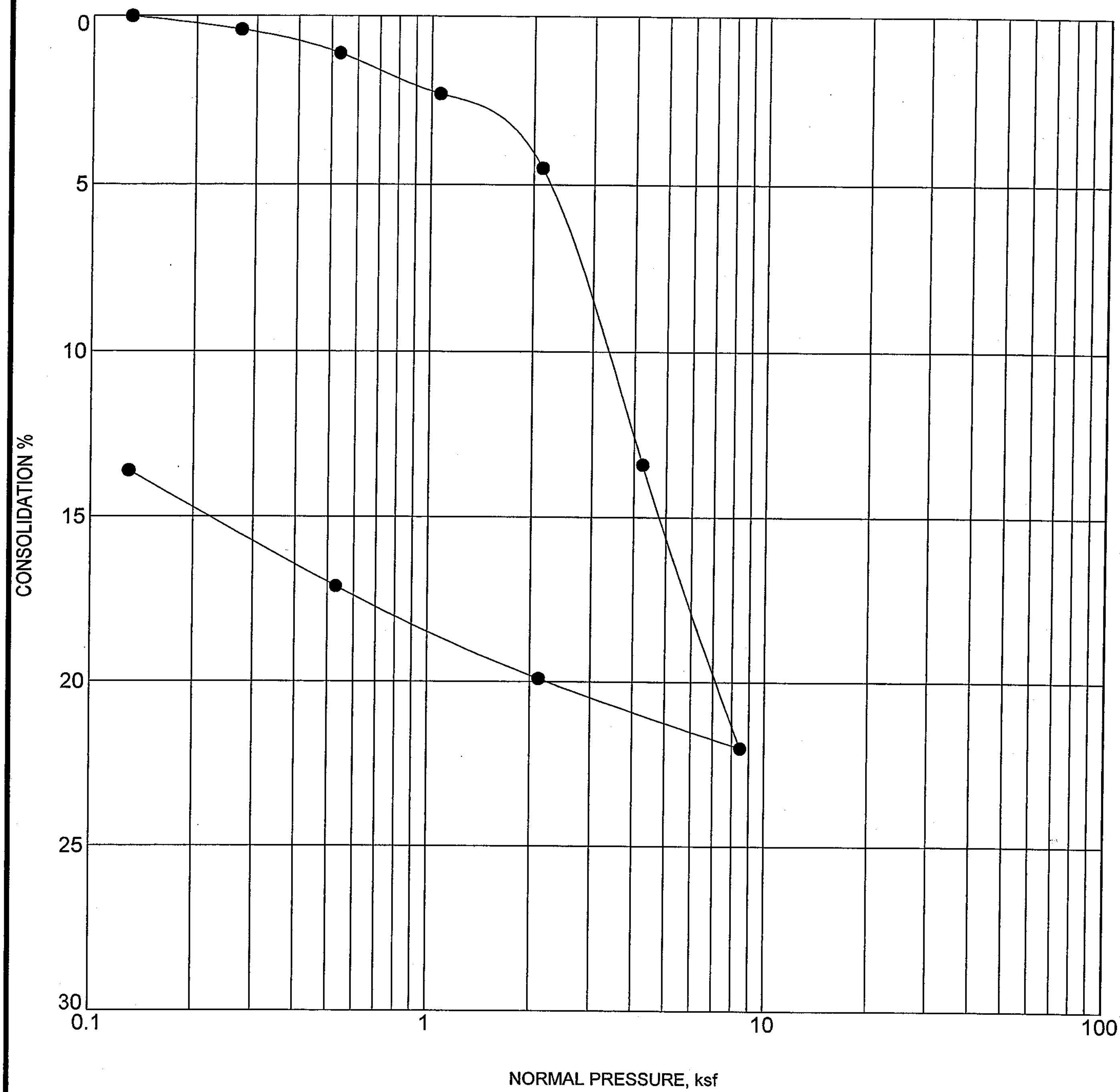

	Initial	Final
water content, %:	99.8	89.9
dry density, pcf:	43.3	50.1

Sample: B-8
Depth: 35.0 - 37.0 feet
Description: Dark gray ORGANIC CLAYEY SILT with sand

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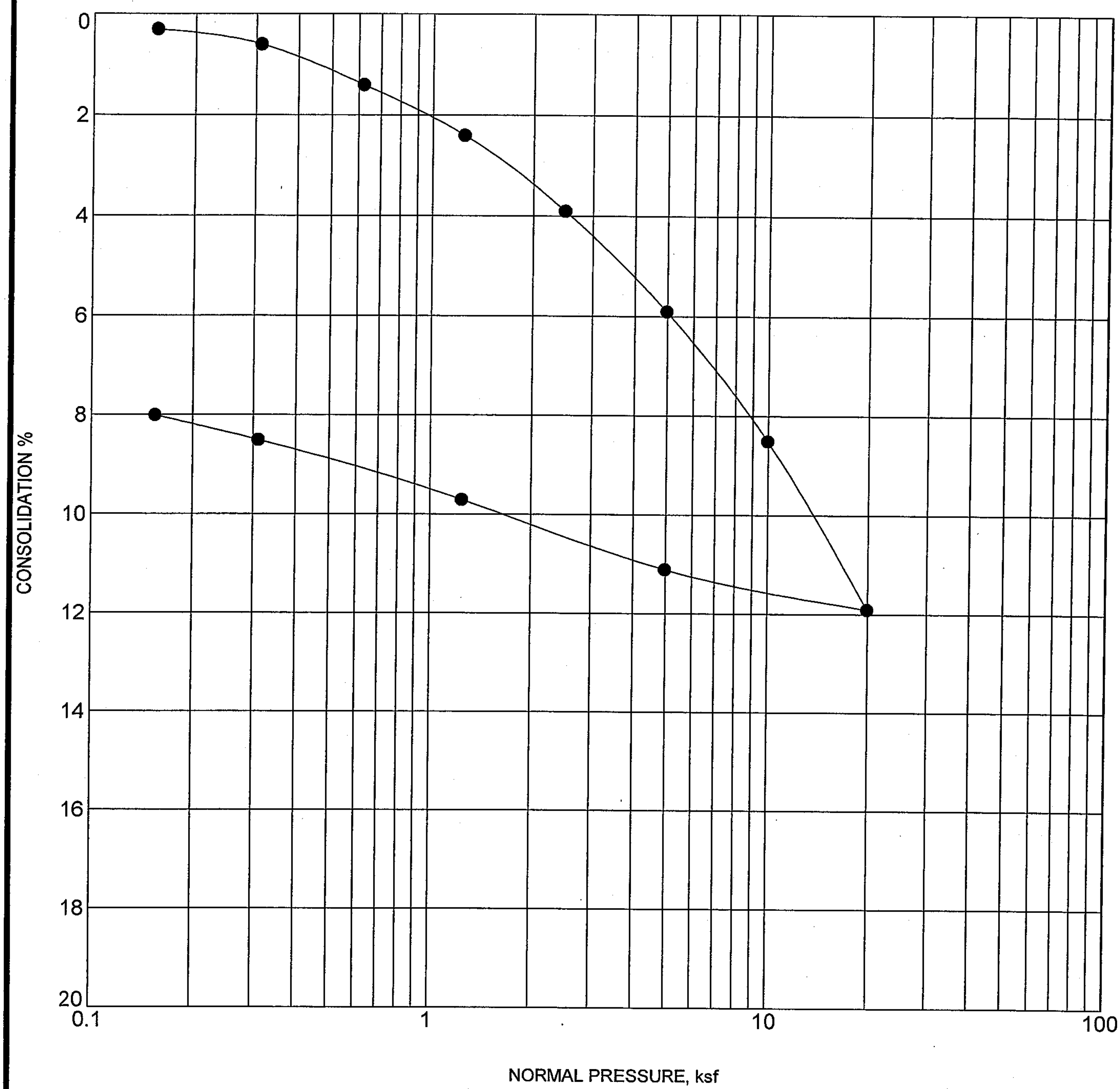
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.4



	Initial	Final
water content, %:	46.4	42.8
dry density, pcf:	75.0	81.5

Sample: B-107
Depth: 15.5 - 17.0 feet
Description: Reddish brown CLAYEY SILT with gravel

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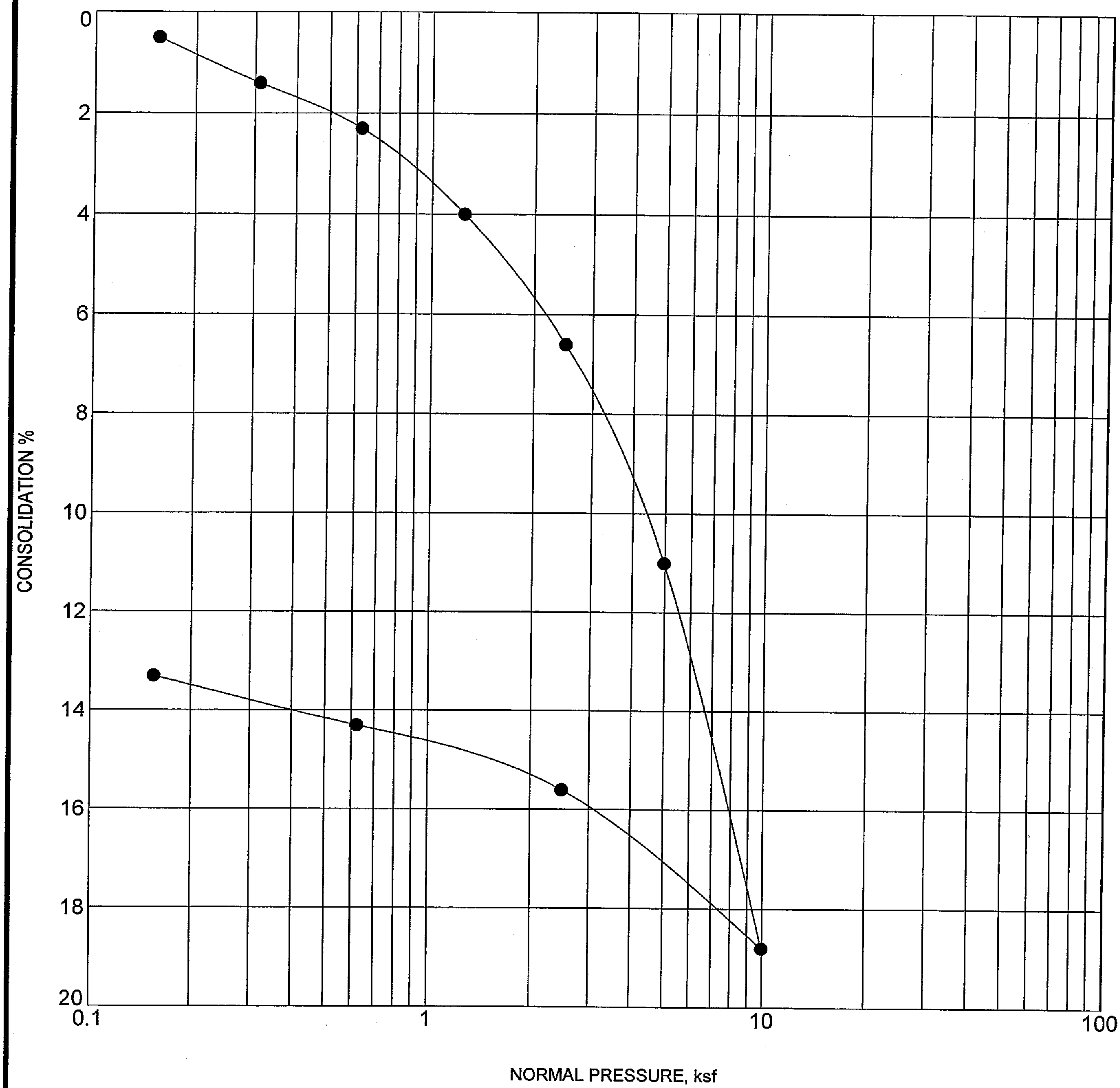
GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.5



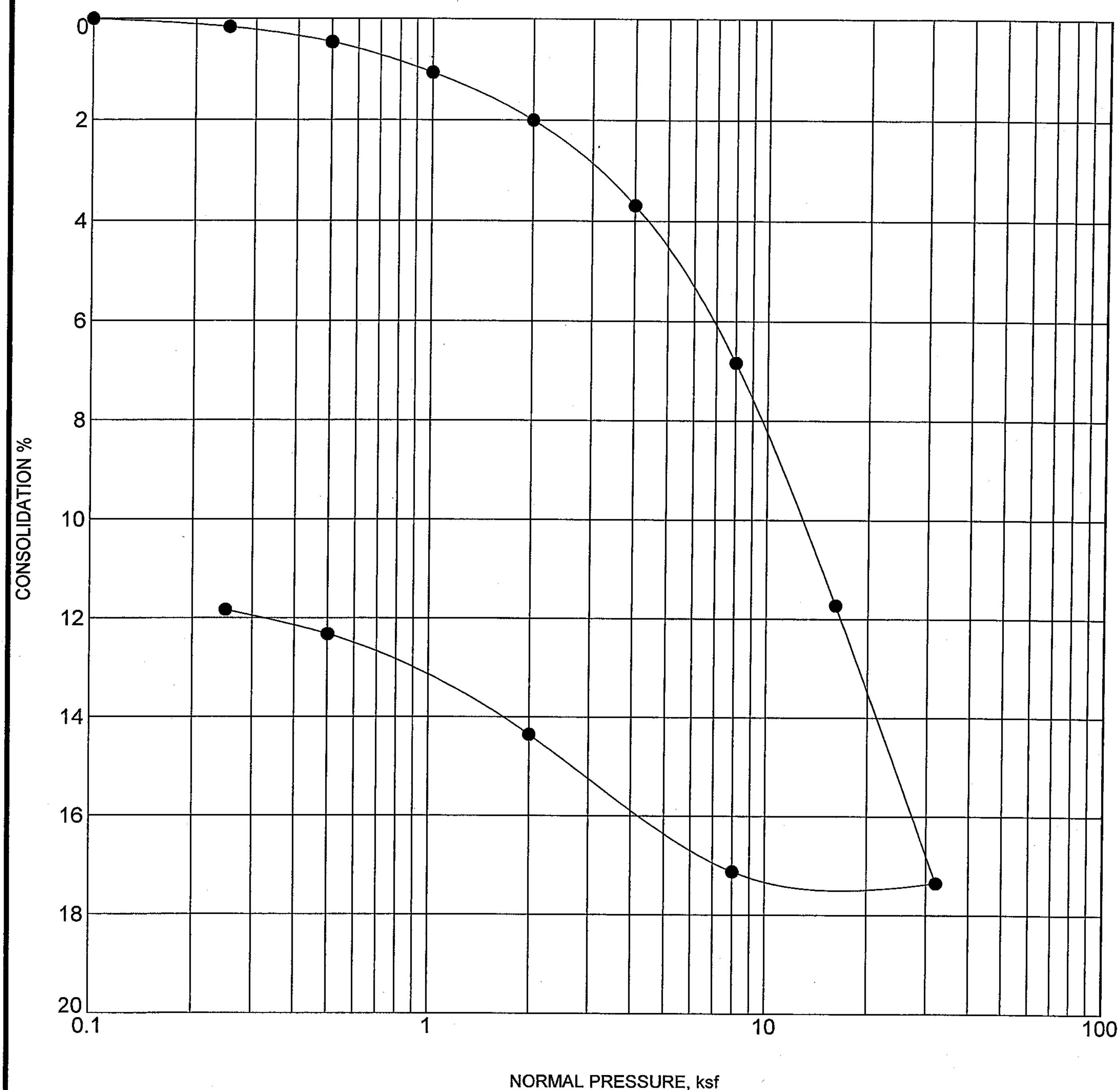
	Initial	Final
water content, %:	65.4	63.6
dry density, pcf:	59.3	68.4

Sample: B-107
Depth: 30.5 - 32.5 feet
Description: Dark gray Silty CLAY

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.6



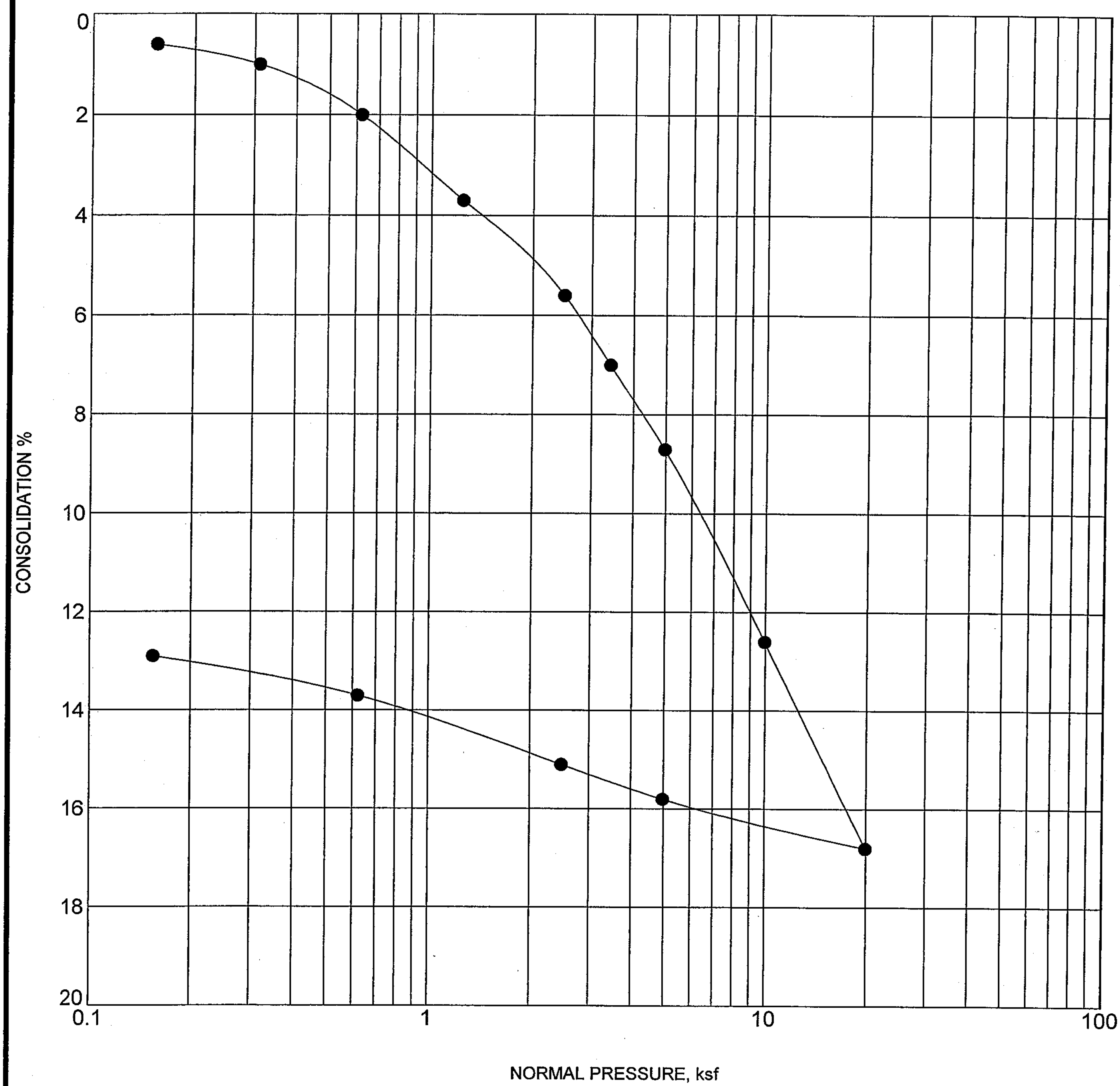
	Initial	Final
water content, %:	58.9	49.2
dry density, pcf:	68.5	77.7

Sample: B-107
Depth: 35.5 - 37.5 feet
Description: Gray ORGANIC CLAY

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.7



	Initial	Final
water content, %:	56.9	48.2
dry density, pcf:	68.3	78.5

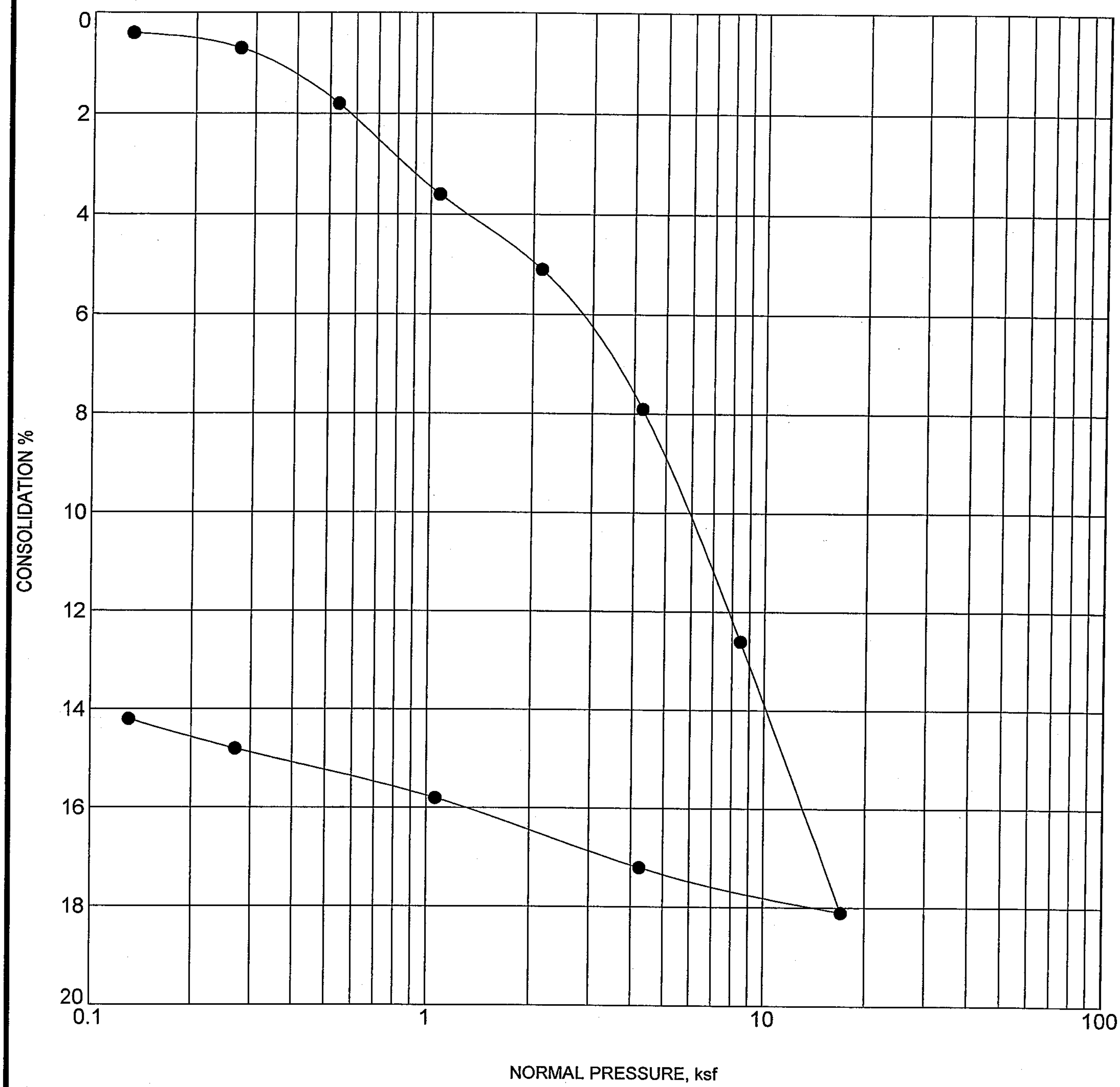
Sample: B-108
Depth: 25.5 - 27.0 feet
Description: Grayish brown CLAYEY SILT with sand

GEOLABS, INC.
GEOTECHNICAL ENGINEERING
W.O. 4850-00(B)

CONSOLIDATION TEST - ASTM D 2435

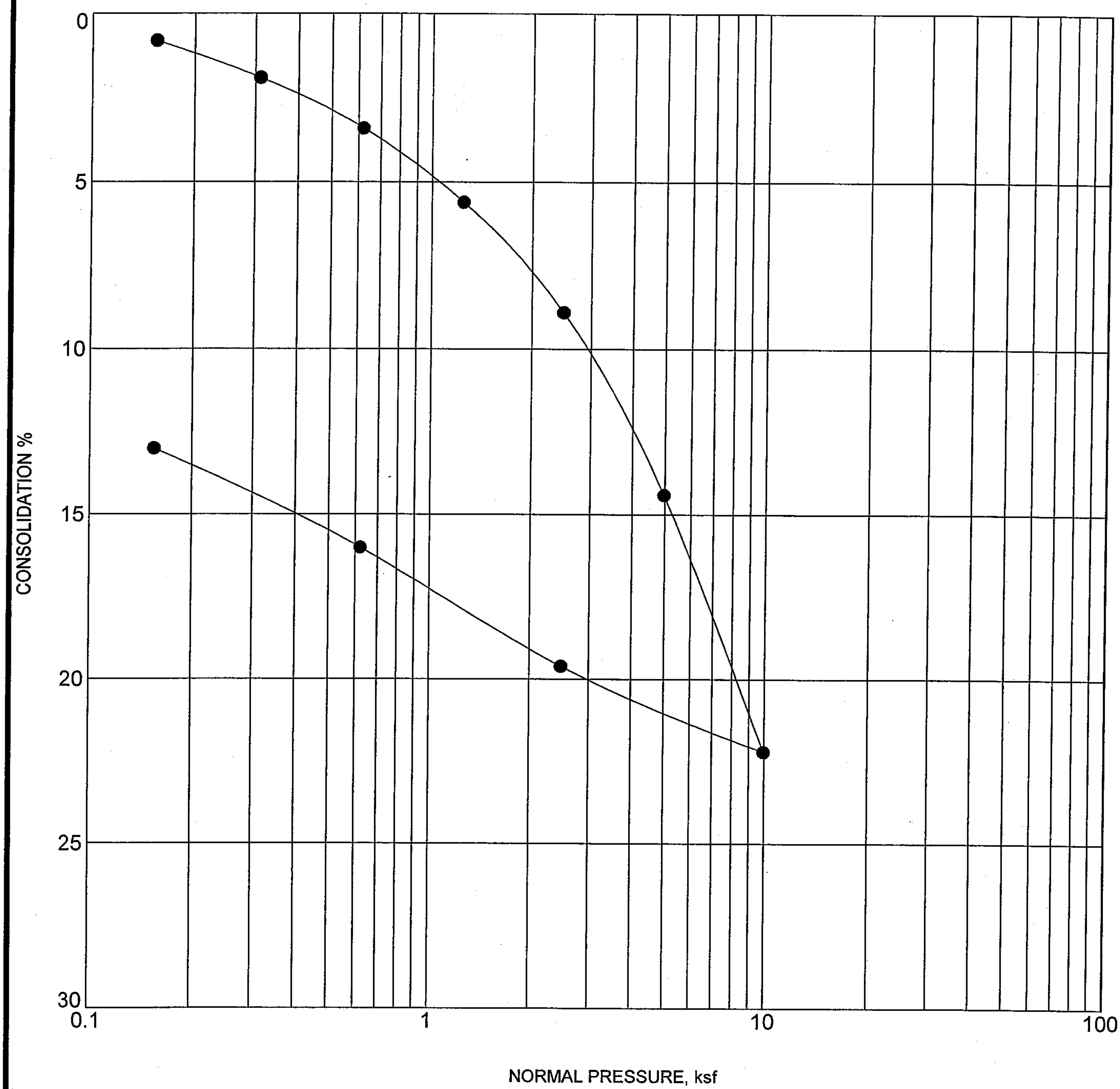
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.8



	Initial	Final
water content, %:	61.9	52.5
dry density, pcf:	63.2	73.7

Sample: B-108
Depth: 40.5 - 42.0 feet
Description: Gray ORGANIC CLAYEY SILT with sand and gravel



	Initial	Final
water content, %:	98.5	91.8
dry density, pcf:	43.9	50.4

Sample: B-108
Depth: 50.5 - 52.0 feet
Description: Gray ORGANIC CLAYEY SILT with sand and gravel

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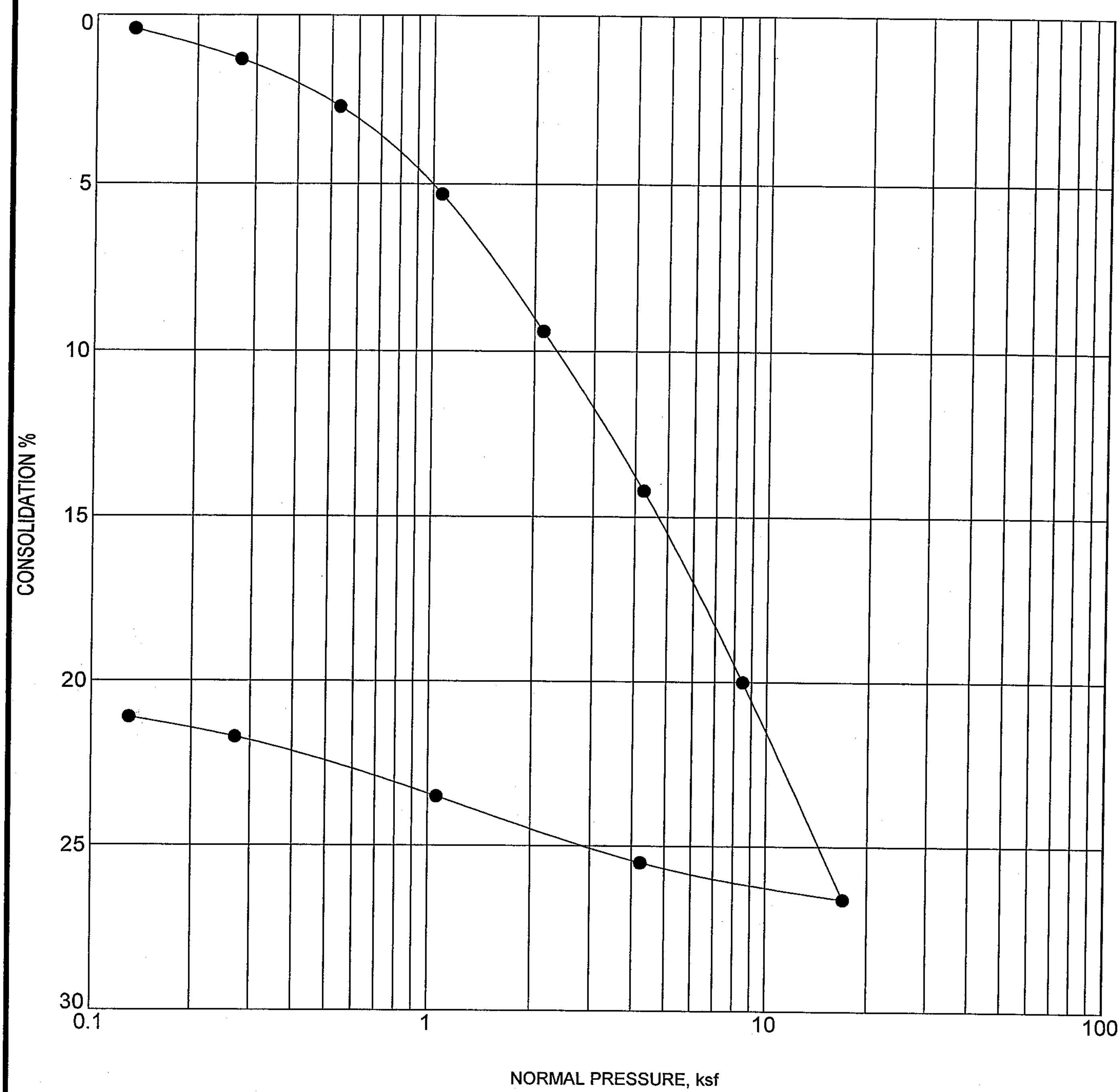
CONSOLIDATION TEST - ASTM D 2435

INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.10



	Initial	Final
water content, %:	75.2	57.9
dry density, pcf:	51.3	65.1

Sample: B-109

Depth: 40.5 - 42.0 feet

Description: Dark gray SILTY ORGANIC CLAY with traces of roots

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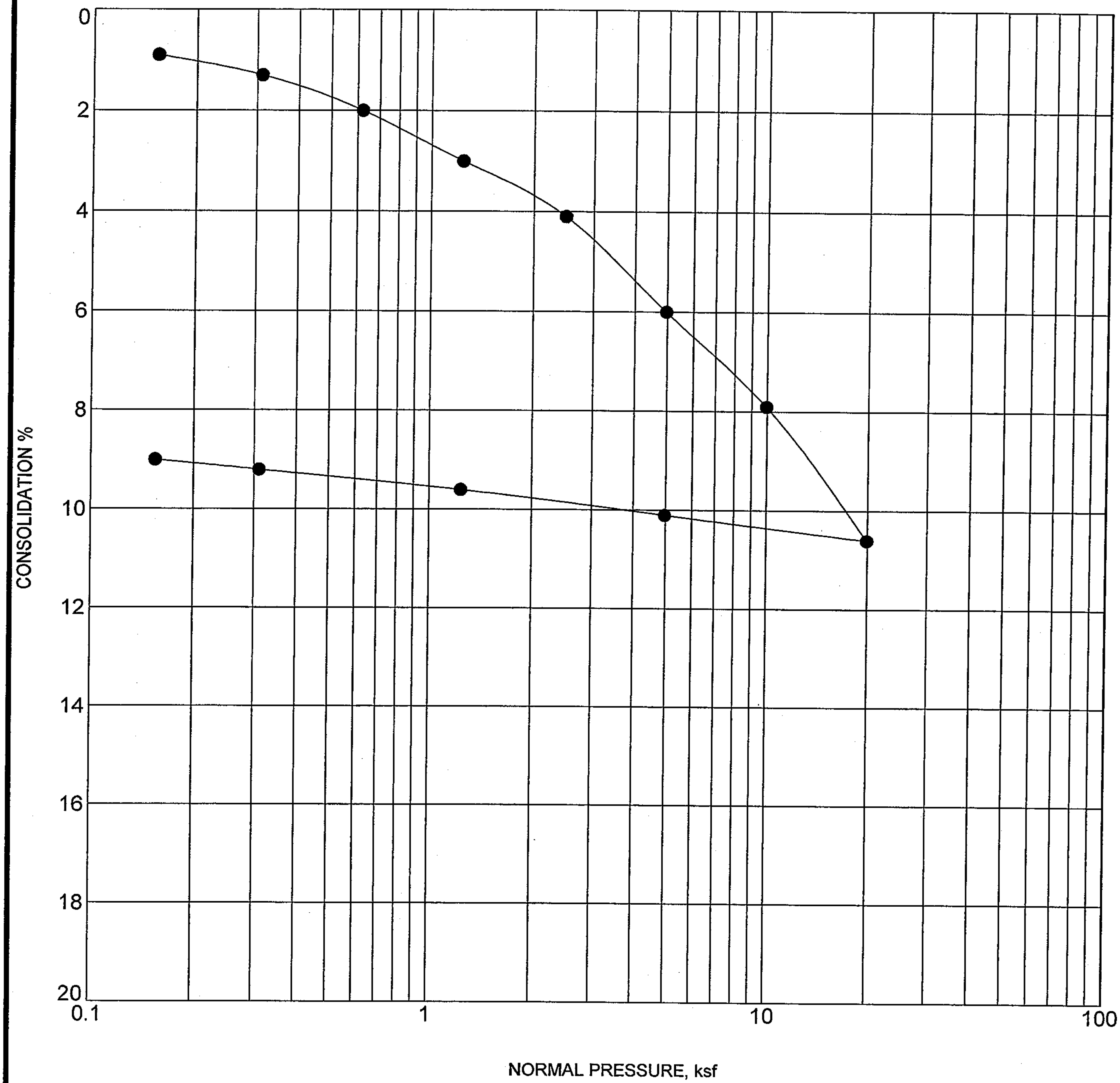
INTERSTATE ROUTE H-1 WIDENING

WAIMALU VIADUCT WESTBOUND

PEARL CITY TO AIEA, OAHU, HAWAII

Plate

B - 5.11



	Initial	Final
water content, %:	37.6	34.7
dry density, pcf:	80.7	88.7

Sample: B-136
Depth: 35.5 - 37.0 feet
Description: Brown CLAYEY SILT

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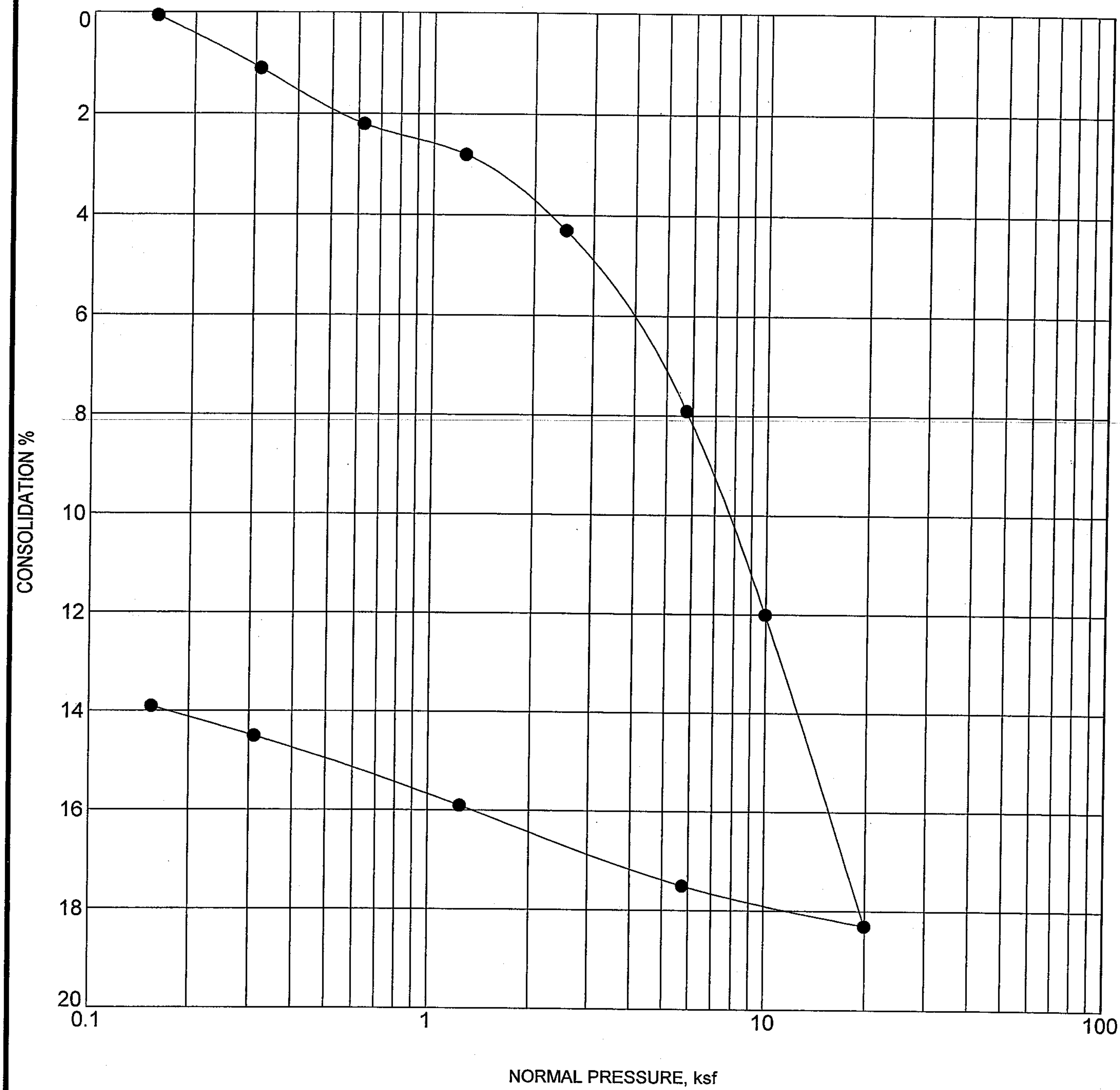
CONSOLIDATION TEST - ASTM D 2435
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.12



	Initial	Final
water content, %:	58.1	51.4
dry density, pcf:	62.7	72.8

Sample: B-136
Depth: 75.5 - 77.5 feet
Description: Dark gray ORGANIC CLAY (OH)

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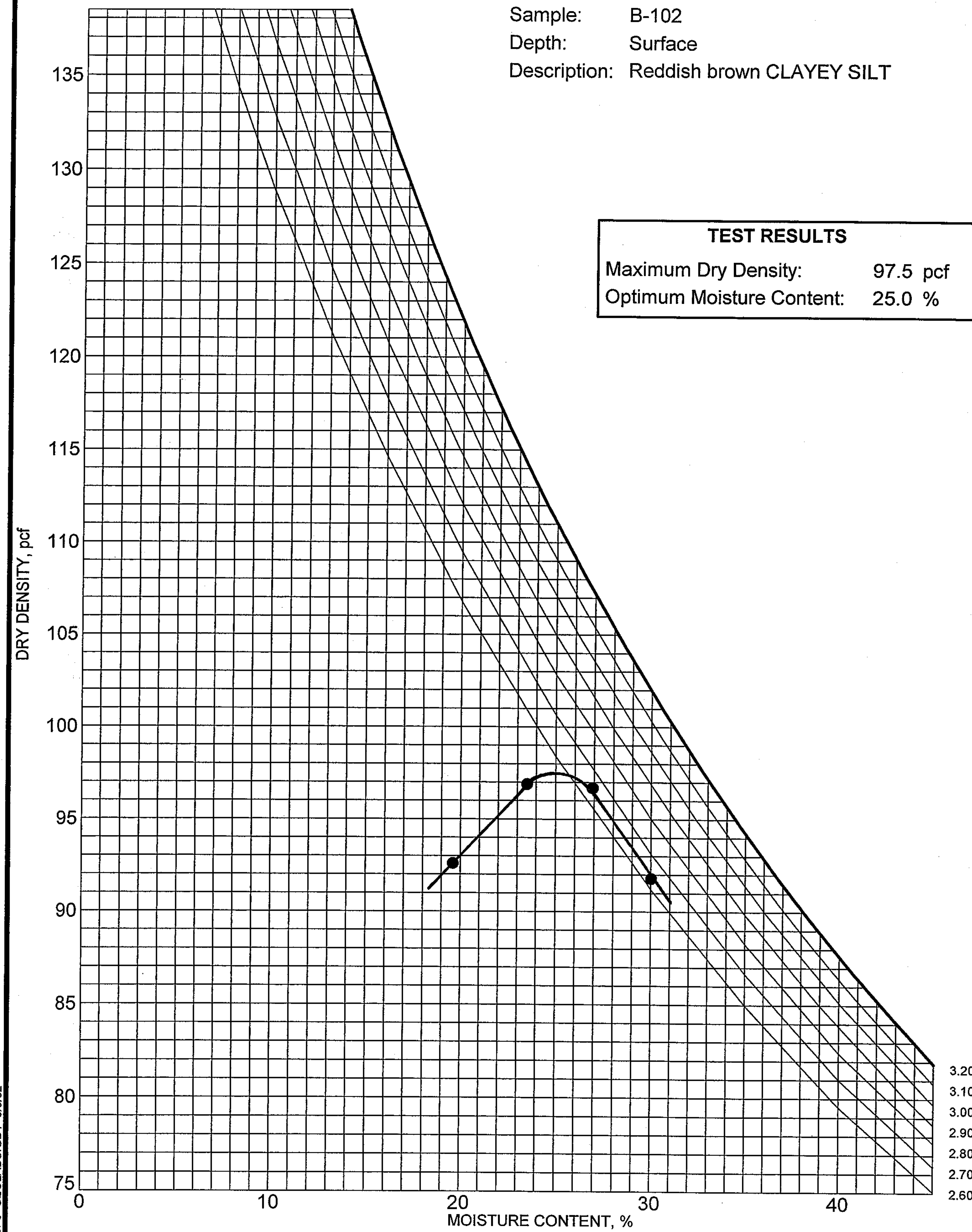
INTERSTATE ROUTE H-1 WIDENING
WAIMALU VIADUCT WESTBOUND
PEARL CITY TO AIEA, OAHU, HAWAII

Plate
B - 5.13

Sample: B-102
Depth: Surface
Description: Reddish brown CLAYEY SILT

TEST RESULTS	
Maximum Dry Density:	97.5 pcf
Optimum Moisture Content:	25.0 %



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W.O. 4850-00(B)	INTERSTATE ROUTE H-1 WIDENING WAIMALU VIADUCT WESTBOUND PEARL CITY TO AIEA, OAHU, HAWAII	Plate B - 6