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98-021 Kamehameha Highway, Suite 337 • Aiea, Hawaii 96701-4914
Telephone: (808) 484-5366 • Facsimile: (808) 484-0007

March 21, 2016

Todd Georgopapadakos
todd@dephawaii.com

Attn: Mr. Jim Schmit
ja@jasarchitect.com

Geotechnical Conformance Letter
Grading Plan
Keikilani Homes New House
Tmk: 3-6-023:006
5203 Keikilani Circle
Honolulu, Oahu, Hawaii

Masa Fujioka & Associates (MFA) is pleased to present this geotechnical conformance letter for the subject grading plan.

We have reviewed the subject grading plan, prepared by J.A. Schmit, Architect dated 2/28/16 and find that the plan is in conformance with the recommendations presented in our geotechnical report dated November 30, 2015.

- o 0 o -

It has been a pleasure to prepare this geotechnical conformance letter for you. Please do not hesitate to contact us if there are any questions regarding this letter.

Respectfully submitted,

MASA FUJIOKA & ASSOCIATES
A Professional Partnership

Masanobu R. Fujioka, P. E.
Principal-In-Charge

MASANOBU R. FUJIOKA
LICENSED PROFESSIONAL ENGINEER
No. 4357-C
HAWAII, U.S.A.

MRF

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION

LICENSE EXPIRES : 4-30-18

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November 30, 2015

MFA Project No. 15661-001

Todd Georgopapadakos
todd@dephawaii.com

Attn: Mr. Jim Schmit
js@jasarchitect.com

Subject: **Geotechnical Report**
Keikilani Homes New House
5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

Masa Fujioka & Associates (MFA) is pleased to submit this geotechnical engineering report for the subject project. The report details our investigation for the subject project, and provides analysis and recommendations. It has been our pleasure to prepare this report for you. Please contact the undersigned if there are any questions regarding this report.

Respectfully submitted,

MASA FUJIOKA & ASSOCIATES

Masanobu R. Fujioka, P.E.
Managing Principal

MASANOBU R. FUJIOKA
LICENSED PROFESSIONAL ENGINEER
No. 4357-C
HAWAII, U.S.A.

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LICENSE EXPIRES: 4-30-16

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Telephone: (808) 484-5366 • Facsimile: (808) 484-0007

Geotechnical Report
Keikilani Homes New House
5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

Prepared for:
Todd Georgopapadakos

Prepared by:
Masa Fujioka & Associates
98-021 Kamehameha Highway, Suite 337
Aiea, HI 96701

November 30, 2015
Version: FINAL Revision 1
MFA Project number 15661-001

TABLE OF CONTENTS

1.0 INTRODUCTION

Masa Fujioka and Associates (MFA) are pleased to submit this revised geotechnical report for the subject project, Keikilani Home New House, TMK (1) 3-6-023:006, Wailupe, Oʻahu, Hawaiʻi. The general location of the site is depicted on *Figure 1, Project Location Map.*

1.1 PROJECT CONSIDERATIONS

We understand that a construction of a residence and access driveway is proposed in the Wailupe Ridge area of ʻĀina Haina. We understand that JAS is the architect for the subject residence and access driveway and requires a geotechnical engineer to review available information and reports and assume the role of geotechnical engineer for the subject residence.

We understand that site development will consist of an access driveway and construction of a residence on a lot of approximately 52,000 sf.

At this time, we have been provided with plans for the development of the new house. The layout of the planned residence is depicted on *Attachment 1, Drawing C011*. We understand that the lot will require rock excavation to provide a level area for construction of the residence founded on basaltic rock. The rock cuts at the upslope end of the lot are depicted as retained by retaining walls.

We have been provided with plans for the residence. We have noted that although most of the residence will be on rock cuts, some areas at the downslope end of the residence will be in fill areas.

Previous studies have established a boulder hazard, and we understand that a boulder barrier fence is planned for construction based on a previous boulder hazard evaluation study, and will be depicted on the project plans.

2.0 SCOPE OF WORK

Based upon our understanding of the foregoing, and geological and geotechnical considerations, the following Scope of Work was performed:

1. **Data Review**

   MFA reviewed readily available soils and geologic information for the site, based on GIS-based mapping data available on State GIS files. We also reviewed the following provided documents:

   a. Geology Brief, dated July 2005, by Malama Civil Engineering

   b. Geotechnical Report dated May 2001, by E.K. Hirata and Associates

   c. Geotechnical Report dated March 2006, by Malama Civil Engineering

   d. Revised Slope Stability and Rockfall Hazard Assessment Report, dated October 2005, by Malama Civil Engineering

   e. Wailupe Mauka Soil Boundaries Map, dated August 2006, by Malama Civil Engineering

   f. Rockfall Hazard Assessment and Mitigation, 5023 Keikilani Circle, by Atlas Geotechnical, April 2015.

2. **Geologic and Geotechnical Reconnaissance**

   A site geological reconnaissance was conducted by an MFA Engineering Geologist on July 31, 2015 and a geotechnical reconnaissance was conducted by our Principal Engineer on August 3, 2015.

3. **Geotechnical Review Report**

   Based on the data review and geologic / geotechnical reconnaissance, we prepared this report.

4. **Geotechnical Consultation during Design**

   We would provide geotechnical engineering consultation during design to the project designers, i.e. civil, structural and architectural.

5. **Construction Monitoring and Consultation during Construction**

   We would provide geotechnical engineering services during construction, including laboratory testing, monitoring of earthwork, and geotechnical inspection during foundation construction, on a time and expense basis.

3.0 SITE CONDITIONS

3.1 PROJECT LOCATION

The project is located on Wiliwilinui Ridge, on TMK (1) 3-6-023:006, east of Kiai Place and north of Keikilani Circle, Wailupe, O'ahu, Hawai'i (*Figure 1*).

3.2 GEOLOGIC SETTING

3.2.1 Regional geology

The Hawaiian Archipelago is a 1600 miles long group of islands, reefs, and shoals running northwest–southeast in the Pacific Ocean. The major islands, in the southeast part of the archipelago, "are basaltic volcanic domes in various stages of dissection."[1] The islands have complex geologic histories that generally include four stages of volcanism, water and wind erosion, sea level change, catastrophic landslides and accompanying tsunami, and subsidence of the crust due to the loads of the volcanoes. The older volcanoes are experiencing rebound of the crust as they erode and the load gets lighter.

The four stages of eruption of an idealized Hawaiian volcano are: preshield, shield, postshield, and rejuvenated. They are distinguished by lava composition, eruptive rate and style, and stage of development. The rejuvenated stage occurs after up to a few million years of volcanic quiescence.

3.2.2 General geology, O'ahu, Hawai'i

The Island of O'ahu was formed by two shield volcanoes, the older Wai'anae and younger Ko'olau. The lavas of the Ko'olau Volcano banked against the Wai'anae Volcano, creating the Schofield Plateau in the center of the island. Each volcano has been truncated by

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[1] Stearns, Harold T. 1966. *Geology of the State of Hawaii.* Palo Alto: Pacific Books.

massive submarine slides – the Wai'anae Slump to the southwest, the Ka'ena Slump to the northwest, and the Nu'uanu Slide to the northeast[2].

The Wai'anae Volcanics date from about 4.0 million years ago (Ma) to about 2.9 Ma. The oldest Ko'olau basalts are dated to about 3 Ma, and the youngest of the shield-building stage to somewhere between about 1.8 to about 2.1 Ma. After a long period of quiet during which deep canyons were cut into the Ko'olau shield, volcanic activity resumed on the southeastern end of the Ko'olau Range, consisting of the sporadically scattered lava flows and vent deposits of the Honolulu Volcanics. The Honolulu Volcanics range in age from 0.8 to "somewhat younger than" 0.1 Ma. These rejuvenated-stage volcanics include the iconic Diamond Head crater, Punchbowl, Koko Head, and cones on Mokapu peninsula.[3]

The island's geologic history includes a deep (>1200 feet), gradual submergence of O'ahu in possibly Early Pleistocene time (resulting from deformation of the Earth's crust caused by the island's load on it) and oscillations of sea level (attributable to advances and recessions of the polar ice caps) in Middle and Late Pleistocene time.[4]General geology of the Ko'olaus

3.2.3 General Geology of the Ko'olaus

The Ko'olau Volcanic Series makes up the bulk of the main mass of the Ko'olau Range. Individual flows range in thickness from 10 to 80 feet, but a flow may be made up of several layers / thin beds. The flows were extruded in very fluid condition without erosional unconformities and extensive soil beds, indicating that they occurred in fairly rapid succession. "Except where they form cliffs the surface of these rocks is deeply weathered and in the lower flanks of the range is covered with a thick lateritic soil. The basalt exceeds 3,100 feet in thickness, and in general the flows have dips of 3° near the crest and 5° to 10° near the margin of the range… The basalt is almost uniformly permeable and serves both as the intake formation and the water bearer of the major part of the ground-water supply of Oahu. It supplies all the artesian wells of the island except a few near Waialua, Waianae, and Gilbert that penetrate the

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[2] Eakins, Barry W., Joel E. Robinson, Toshiya Kanamatsu, Jiro Naka, John R. Smith, Eiichi Takahashi, and David A. Clague. (2003). *Hawaii's Volcanoes Revealed* (map with accompanying text). United States Geological Survey (USGS), United States Department of the Interior. Prepared in Cooperation with the Japan Marine Science and Technology Center, University of Hawaii School of Ocean and Earth Science and Technology, and the Monterey Bay Aquarium Research Institute.

[3] Macdonald, G. A., A.T. Abbott, & F.L. Peterson (1983). *Volcanoes in the Sea: The Geology of Hawaii* (2nd Ed.). Honolulu: University of Hawaii Press.

[4] Stearns, H.T and K.N. Vaksvik. (1935). *Geology and Ground-water Resources of the Island of Oahu, Hawaii.* [Bulletin I.] Hawaii Division of Hydrography. Published in Cooperation with the Geological Survey, United States Department of the Interior. pp. 178-179.

Waianae basalts. It is the aquifer of all the high-level springs and tunnels and most of the sea-level springs in the Koolau Range."[5]

3.3 MAPPED GEOLOGY

The project site is mapped on the *Geologic Map of the State of Hawai'i*[6] as *Koolau Basalt*, geologic symbol *QTkl*. Rock type is lava flows; lithology is pāhoehoe and 'a'ā; and age range is 1.8 to 3 Ma. Proportions are "estimated to be 60 percent 'a'ā, with pāhoehoe thought to be more abundant near the crest of the Koolau Range."[7] Geologic symbols are presented on *Figure 2, Project Geologic Map*. Figure 2 also presents geologic units, which are an older nomenclature than the map symbols, and were formalized in the seminal geologic mapping of the Hawaii Division of Hydrography; however, the symbols were later adopted to meet national standards. Standard error of the mapping is 100 m (±50 m). There are nearby mapped contacts with *Lagoon and reef deposits* to the south, and with *Alluvium* to the northeast.

The Ko'olau Volcanic Series is described in the 1938 geologic map of O'ahu as "Gray, blue, red, and black jointed dense to very vesicular, holocrystalline and microcrystalline, aphanitic and porphyritic permeable effusive basalts."[8] The 1938 map also shows Wailupe Spring, somewhat south to southeast of the project site (*Figure 2A*).

The pamphlet accompanying the 2007 *Geologic Map of the State of Hawai'i* provides the following information: "Ko'olau Basalt (Pleistocene (?) and Pliocene)—Aphyric to porphyritic basalt, entirely tholeiitic in composition. Phenocrysts are olivine and plagioclase, rarely with clinopyroxene and orthopyroxene. Age certainly Pliocene and possibly Pleistocene owing to analytical error associated with youngest radiometric ages and their placement close to the 1.81-Ma Pliocene-Pleistocene boundary." [9]

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[5] Stearns and Vaksvik, Op cit., p. 93.
[6] Sherrod, D.R., Sinton, J.M., Watkins, S.E., and Brunt, K.M. 2007. *Geologic Map of the State of Hawai'i*. Open-File Report 2007-1089. United States Geological Survey.
[7] Ibid. p.72.
[8] Stearns, Harold T. 1938. *Geologic and Topographic Map of the Island of Oahu, Hawaii.* Prepared in cooperation with the United States Geological Survey.
[9] Sherrod, D.R., Sinton, J.M., Watkins, S.E., and Brunt, K.M. (2007). *Geologic Map of the State of Hawai'i*. Open-File Report 2007-1089. United States Geological Survey, p.72.

3.4 Mapped soils

Soils in the project area were mapped by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)[10]. Soils in the project area had previously been mapped in 1972 by the USDA Soil Conservation Service (SCS), predecessor to the NRCS, in cooperation with the University of Hawaii (UH) Agricultural Experiment Station[11]. In the vicinity of the project site, there is no difference between the two maps. Soils at the project site are mapped as *Rock land* (*rRk*) in the north of the site, with the southern portion mapped as *Lualualei extremely stony clay, 3 to 35 percent* slopes (*LPE*). A soils map is presented as *Figure 3, Project Soils Map*. The Soil Survey for this area was mapped at a 1:24,000 scale.

3.4.1 Rock Land (rRk)

Rock Land "is made up of areas where exposed rock covers 25 to 90 percent of the surface. It occurs on all five islands. The rock outcrops and very shallow soils are the main characteristics. The rock outcrops are mainly basalt and andesite. This land is nearly level to very steep. Elevations range from nearly sea level to more than 6,000 feet…In many areas, especially on the island of Oahu, the soil material associated with the rock outcrops is very sticky and very plastic. It also has high shrink-swell potential. Buildings on the steep slopes are susceptible to sliding when the soil is saturated. Foundations and retaining walls are susceptible to cracking."[12]

3.4.2 Lualualei extremely stony clay, 3 to 35 percent slopes (LPE)

The *Lualualei Series* "consists of well-drained soils on the coastal plains, alluvial fans, and talus slopes on the islands of Kauai, Oahu, Molokai, and Lanai. These soils developed in alluvium and colluvium. They are nearly level and gently sloping. Elevations range from 10 to 125 feet. In most places the annual rainfall amounts to 18 to 30 inches…Most of the rainfall occurs during storms in the period from November to April. There is a prolonged dry period in summer."

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[10] U.S. Department of Agriculture, Natural Resources Conservation Service. March 20, 2014 (Version 6). *Soil Survey Geographic (SSURGO) database for Island of Hawaii* [area hi801]. Retrieved June 13, 2014 from http://websoilsurvey.nrcs.usda.gov/.

[11] United States Department of Agriculture Soil Conservation Service [in cooperation with The University of Hawaii Agricultural Experiment Station]. 1972. *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. Washington, DC: U.S. Government Printing Office.

[12] Ibid. p. 119.

Lualualei extremely stony clay, 3 to 35 percent slopes (*LPE*) is described as follows: "This soil occurs on talus slopes on Oahu and Kauai. The slope range is 3 to 35 percent, but in most places the soil is moderately sloping to steep. This soil is similar to *Lualualei clay, 0 to 2 percent slopes*, except that there are many stones on the surface and in the profile. It is impractical to cultivate this soil unless the stones are removed. Runoff is medium to rapid, and the erosion hazard is moderate to severe. A representative profile of the above-mentioned *Lualualei clay, 0 to 2 percent slopes* (*LuA*), indicates the following: "[T]he surface layer, about 10 inches thick, is very dark greyish-brown, very sticky and very plastic clay that has prismatic structure. The next layer, 37 to more than 42 thick, is very dark grayish-brown, very sticky and very plastic clay that has prismatic structure. In addition, it has gypsum crystals. The soil is underlain by coral, gravel, sand, or clay at depth below 40 inches. This soil cracks widely upon drying."

Engineering interpretations for *LPE* indicate very sticky and very plastic material with high shrink-swell potential, low shear strength, stoniness, and, for foundations affecting low buildings, susceptibility to sliding on slopes more than 15 percent.

3.5 SITE GEOMORPHOLOGY

The site geomorphology conforms to the underlying geology, with the exception of a road or bench that has been graded, and some boulder removal may have been conducted on the portion of the property downgradient of the bench. Contour mapping indicates that the site elevation ranges from approximately 50 to 265 feet. A topographic site map is presented as *Figure 4*.

4.0 GEOLOGIC / GEOTECHNICAL RECONNAISSANCE

An MFA engineering geologist conducted a geologic reconnaissance on July 31, 2015, and our Principal Engineer conducted a geotechnical reconnaissance on August 3, 2015.

The site was observed to be moderately vegetated with tall grasses, agave or similar, and haole koa trees. The graded bench had been recently cleared. The bench is easily accessible from Kiai Place, across the adjacent driveway, which we understand is an easement for the subject property. A path from the bench, looping around and down to Keikilani Circle, had also recently been cleared. A high-resolution aerial image of the site, provided as *Figure 5*, shows the bench and path. *Figure 6* consists of a plan / survey map, which was provided to us, superimposed on the aerial image.

During the geological reconnaissance, the site was observed to generally match the descriptions provided in the previous reports that we reviewed. Additionally, we note that the nature of the pāhoehoe is massive – with flow thicknesses on the order of several meters. Several voids were observed in the outcrops.

5.0 PREVIOUS GEOTECHNICAL INVESTIGATIONS

The lower areas of the site were previously investigated by Hirata and Associates (2001) and by Malama Civil Engineering (2006). The locations of the borings are presented on *Attachment 1, Drawing C011*. The borings all indicate a thin surface layer of highly expansive clay up to two feet thick overlying basaltic rock. The Boring Logs are presented as *Attachment 2, Log of Borings – Hirata 2001* and as *Attachment 3, Log of Borings – Malama 2006.*

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 GENERAL

The project site primarily consists of basaltic lava flows, with a thin layer of expansive clay in the area downgradient of the graded bench. The basaltic lava flows are identified as pāhoehoe flows, which often contain voids and/or lava tubes. Precautions will be required to check for the presence of voids or lava tubes at foundation support areas.

6.2 STRUCTURE FOUNDATION SUPPORT

6.2.1 Foundations in Rock Cut Areas - We understand that the proposed residence will be primarily constructed on rock cuts. Based on the presence of pāhoehoe basaltic rock, we recommend that rock surface be checked by proofrolling with a minimum 10-ton vibratory sheepsfoot compactor under the observation of the geotechnical engineer. Any voids or lava tubes encountered should be excavated and backfilled with lean concrete, flowable fill, or with compacted granular structural fill for large voids, under the observation of the geotechnical engineer.

Following proofrolling, the residence structure may be founded on slab thickened edge foundations designed with an allowable bearing pressure of 2500 PSF. We recommend a foundation embedment depth of 16 inches and a minimum foundation width of 16 inches.

6.2.2 Foundations in Fill Areas - We have noted that a small portion of the residence will be on fill. Because of potential differential settlements between the foundations on the rock cut and the foundations overlying fills, we recommend that the foundations within fill areas be supported in one of the following ways:

1. Spread foundations that extend down to basaltic rock

2. Foundations supported by micropiles that extend into the basaltic rock.

Spread foundations should have a minimum size of 24 inches square. We recommend that each spread foundation be tied into the underlying rock with a #8 rebar placed and grouted in place within a minimum 3-inch diameter drilled hole to a depth of 10 feet below the foundation. The #8 rebar should be tied to the foundation steel for the foundations. The purpose of the #8 rebar would be to provide lateral support, extend foundation support down to basaltic rock, and to bridge cavities that may underlie the foundation. Should the drilling of the rebar encounter a void or lava tube, we recommend the following:

- Shallow voids within the first four feet below the spread foundation should be excavated and filled with lean concrete or flowable fill.
- For deeper cavities below 4 feet depth the rebar should be extended below the lava tube or void for a minimum depth of 5 feet below the void or lava tube. If the deeper lava tube or void is large, exceeding 3 feet in vertical dimension, the geotechnical engineer should be consulted for further direction.

The above procedures would also apply to spread foundations where the residence is partially on spread foundations.

Slabs over fill areas should be structurally supported.

Fills placed to grade the site to final grades should consist of compacted granular structural fills (95% compaction, ASTM D-1557) placed on the rock surface and placed in 8-inch thick compacted lifts.

6.3 EXCAVATION CONDITIONS

We anticipate that excavation of the in-situ basaltic rock will require ripping with large bulldozers or the use of hoe ram equipped hydraulic excavators.

We anticipate that vertical to basaltic rock excavations up to 4 feet in height will be stable and will not require stabilization with retaining walls or anchored shotcrete.

At this time we recommend that the design drawings depict rock excavations greater than 4 feet in height to be supported by retaining walls, using design parameters stated below in section **6.6 Retaining Walls**.

6.4 PAVEMENTS

Assuming that the traffic will consist mainly of passenger vehicles and occasional heavier vehicles such as trash pickup trucks, we recommend a pavement section for pavements over the basaltic rock consisting of 4 inches of compacted aggregate base course and 2 inches of asphaltic concrete. For pavements on steep slopes, a concrete pavement consisting of 4 inches of concrete over 4 inches of basecourse (95% compaction) is recommended. Soils overlying the basaltic rock generally consist of relatively thin layers of expansive clays. The expansive clays should be stripped off prior to grading for pavements, and replaced with compacted granular structural fill.

6.5 SITE UTILITIES

Site utilities should rest on a minimum 6-inch layer of bedding material consisting of #3B fine gravel or S4C, depending upon the type of pipe, placed with light vibratory compaction. Bedding material should be used to cover the utility line for a depth of 1 foot above the top of pipe, with light vibratory compaction, prior to placement and compaction of structural backfill.

6.6 Retaining walls

6.6.1 Retaining Walls for Upslope Cut Areas -

We recommend the following design parameters for the upslope retaining walls for basaltic rock cuts that are greater than 4 feet in height:

Active Pressure 20 PCF equivalent fluid pressure for rock cuts, with drainage

Friction Factor (basaltic rock) 0.6

Allowable Bearing Capacity 2500 PSF with 1/3 increase for dynamic loads, foundation subgrades to be checked for cavities by probing of foundations at a minimum spacing of 10 feet. Any cavities encountered to be remediated by excavation and backfilling with lean concrete, flowable fill, or with compacted granular structural fill for large voids, under the observation of the geotechnical engineer.

Passive pressures should generally be neglected due to the anticipated downslopes below retaining walls. We anticipate that retaining wall stability may require the use of anchors through the wall or vertical anchors through the foundations due to the steepness of the slopes. The geotechnical engineer should be consulted if additional wall stability is necessary.

For retaining walls along the driveway with additional traffic loads, we recommend applying an additional 100 PSF surcharge load.

6.6.2 Retaining Walls for Fill Areas - For retaining walls planned for retention of fills, we recommend that retaining wall foundations be constructed as spread foundations on basaltic rock. The retaining wall foundations can be designed using the following design parameters:

Allowable bearing capacity of 2500 PSF with a one third increase for wind and seismic loads; friction factor of 0.6. The retaining wall foundation should be checked for underlying voids or cavities by proofrolling with a minimum 10-ton vibratory sheepsfoot compactor under the observation of the geotechnical engineer. Any voids or lava tubes encountered should be excavated and backfilled with lean concrete, flowable fill, or with compacted granular structural fill for large voids, under the observation of the geotechnical engineer.

Active pressure can be based on a 30 PCF equivalent fluid pressure for granular drained horizontal backfill. We understand that fill slopes of up to 2H to 1V will be retained. For the fill slopes, we recommend an equivalent fluid pressure of 50 PCF.

Passive pressures should generally be neglected due to the anticipated downslopes below retaining walls. We anticipate that retaining wall stability may require the use of anchors through the wall or vertical anchors through the foundations due to the steepness of the slopes. The geotechnical engineer should be consulted if additional wall stability is necessary.

6.7 EARTHWORK

We anticipate that all site materials would be unsuitable for structural fill. The clay soils are expansive and should be removed from the site or possibly used for topsoil. The rock excavation materials will be oversized and unsuitable for use as fill without rock crushing. It is not likely that the site would be suitable for rock crushing operations and we anticipate that all rock excavation materials will need to be removed elsewhere for crushing or disposal. The rock excavation materials would be suitable for general fills in non-structural areas of the site, although boulders larger than 8 inches should be graded out prior to use of excavated rock for general fill.

We recommend that structural fill material consist of granular structural fill with a minimum CBR of 30 and a maximum CBR expansion of 1 percent. Structural fills should be compacted to 95% of maximum dry density (ASTM D-1557)

6.8 BOULDER MITIGATION

Based on available information, we understand that a boulder hazard has been identified for the site from steep upslope areas bordering the upslope end of the property. Design parameters for a boulder fence have been developed and are presented in Rockfall Hazard Assessment and Mitigation, 5023 Keikilani Circle, by Atlas Geotechnical, April 2015. We recommend that the boulder fence as recommended be depicted on design plans for City submittals.

7.0 SERVICES DURING DESIGN AND CONSTRUCTION

We recommend that MFA be retained to provide geotechnical services during design and construction, as detailed in this report.

8.0 LIMITATIONS

The geotechnical recommendations and conclusions presented in this report are based on the following assumptions:

1. The scope of the construction project, as described, does not change appreciably.
2. Significant variations in soil and rock properties from those encountered during the previous investigations and during our reconnaissance do not occur.
3. The geotechnical engineer-of-record will be retained to provide consultation during design and to observe actual field conditions encountered during construction to check the applicability of the recommendations presented in this report and to recommend appropriate changes in design or construction procedures, if differing conditions occur.

This report was prepared for the use of Todd Georgopapadakos, JAS Architects, and other design engineers in accordance with generally accepted geotechnical engineering principles and practices, and may not be suitable for the use of other parties.

Our services were provided consistent with normal standard of practice. No other representation is intended or implied.

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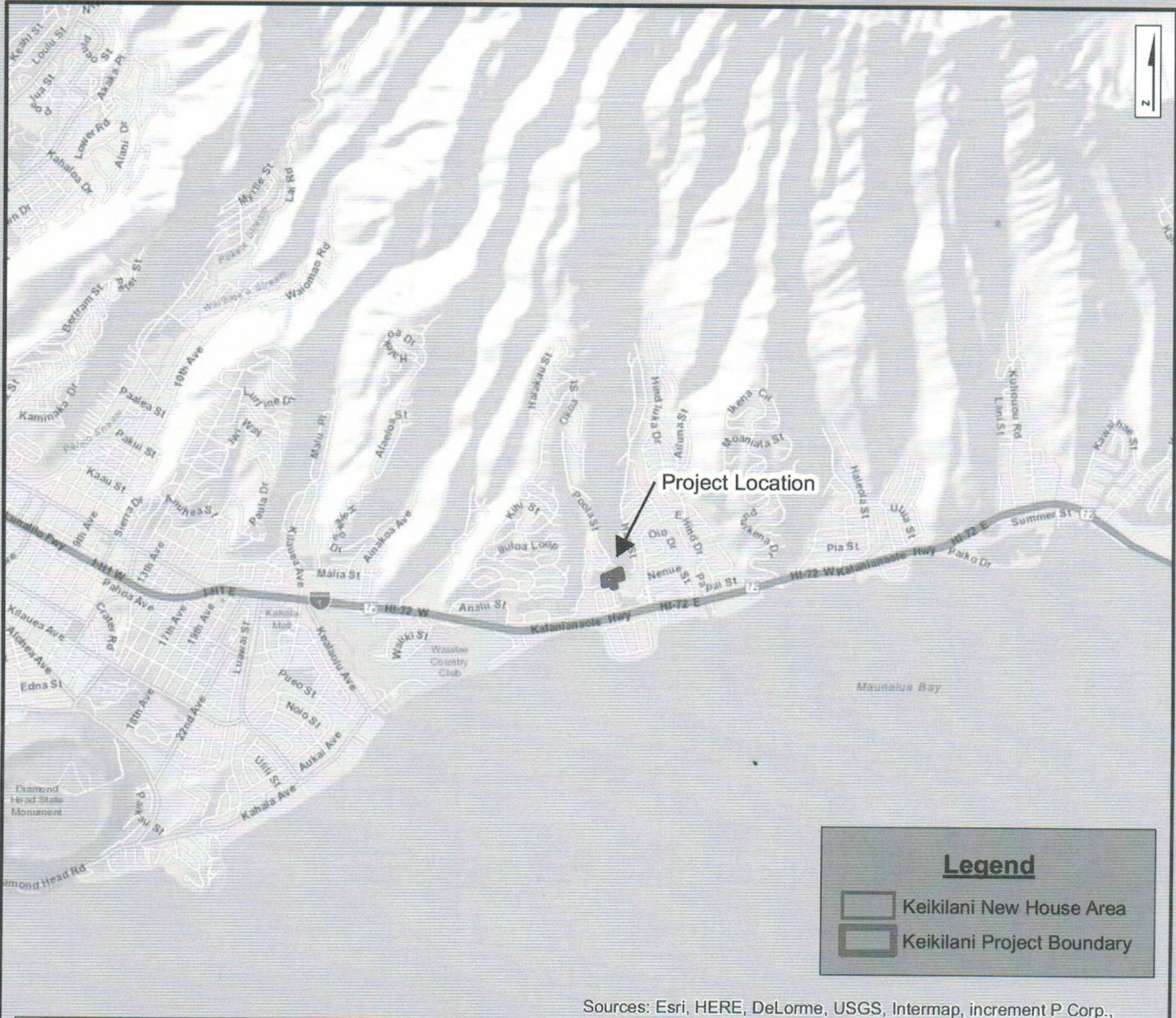
LIST OF ATTACHMENTS

FIGURES

Keikilani Homes New House



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Project Location

Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:

1. Project boundary is derived from the City and County of Honolulu GIS TMK layer (retrieved May 2013 from Honolulu Land Information System [HoLIS] ftp site ftp://gisftp.hicentral.com/) coupled with a plan provided to MFA in pdf format. MFA shifted the TMK layer approximately 36 feet based on aerial imagery, geo- referenced the plan to select corners of the shifted TMK, then modified the boundary based on the plan. This process necessarily introduces error: boundary should be considered approximate. This does not replace a survey.

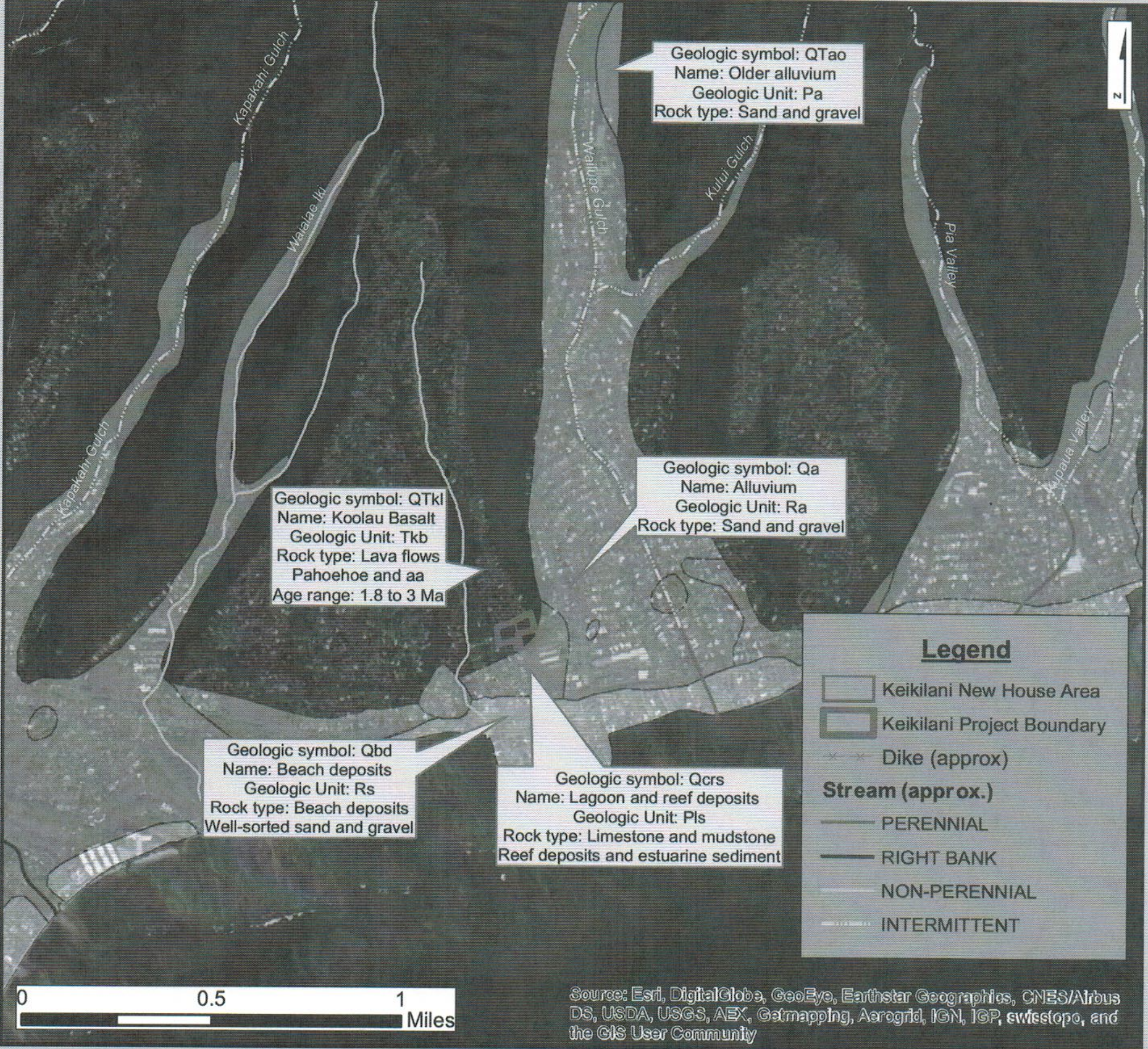
Figure 1

Project Location Map

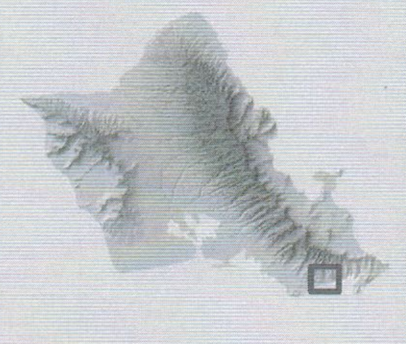
Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

MASA FUJIOKA & ASSOCIATES
ENVIRONMENTAL • GEOTECHNICAL • HYDROGEOLOGICAL CONSULTANTS

Keikilani Homes New House



Project Location



Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:
1. See Figure 1 for notes on site boundary.
2. Geology data source: Sherrod, David R., J.M. Sinton, S.E. Watkins, and K.M. Brunt. 2007. Geologic map of the State of Hawai`i: U.S. Geological Survey Open-File Report 2007-089 [http://pubs.usgs.gov/of/2007/1089/]. Map unit boundaries are only as accurate as the source data; contacts should be considered approximate. Standard error is 100 m (±50 m). Dike coverage is schematic only.
3. Streams layer source: Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR). 2004. Retrieved 2009 from Hawaii Statewide GIS Program website: http://hawaii.gov/dbedt/gis/
Based in part on USGS Digital Line Graphs, 1983 version; locations are not precise.

Figure 2

Project Geologic Map

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

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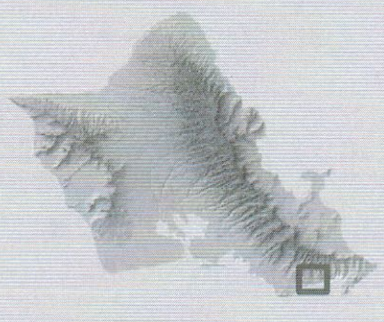
ENVIRONMENTAL • GEOTECHNICAL • HYDROGEOLOGICAL CONSULTANTS

Keikilani Homes New House

Project Location



Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:
1. See Figure 1 for notes on site boundary.
2. Geology data source: Stearns, Harold T. 1938. Geologic and Topographic Map of the Island of Oahu, Hawaii. Prepared in cooperation with the United States Geological Survey (USGS). Geo-referenced by MFA to USGS digital raster graphics. Geo-referencing is approximate.

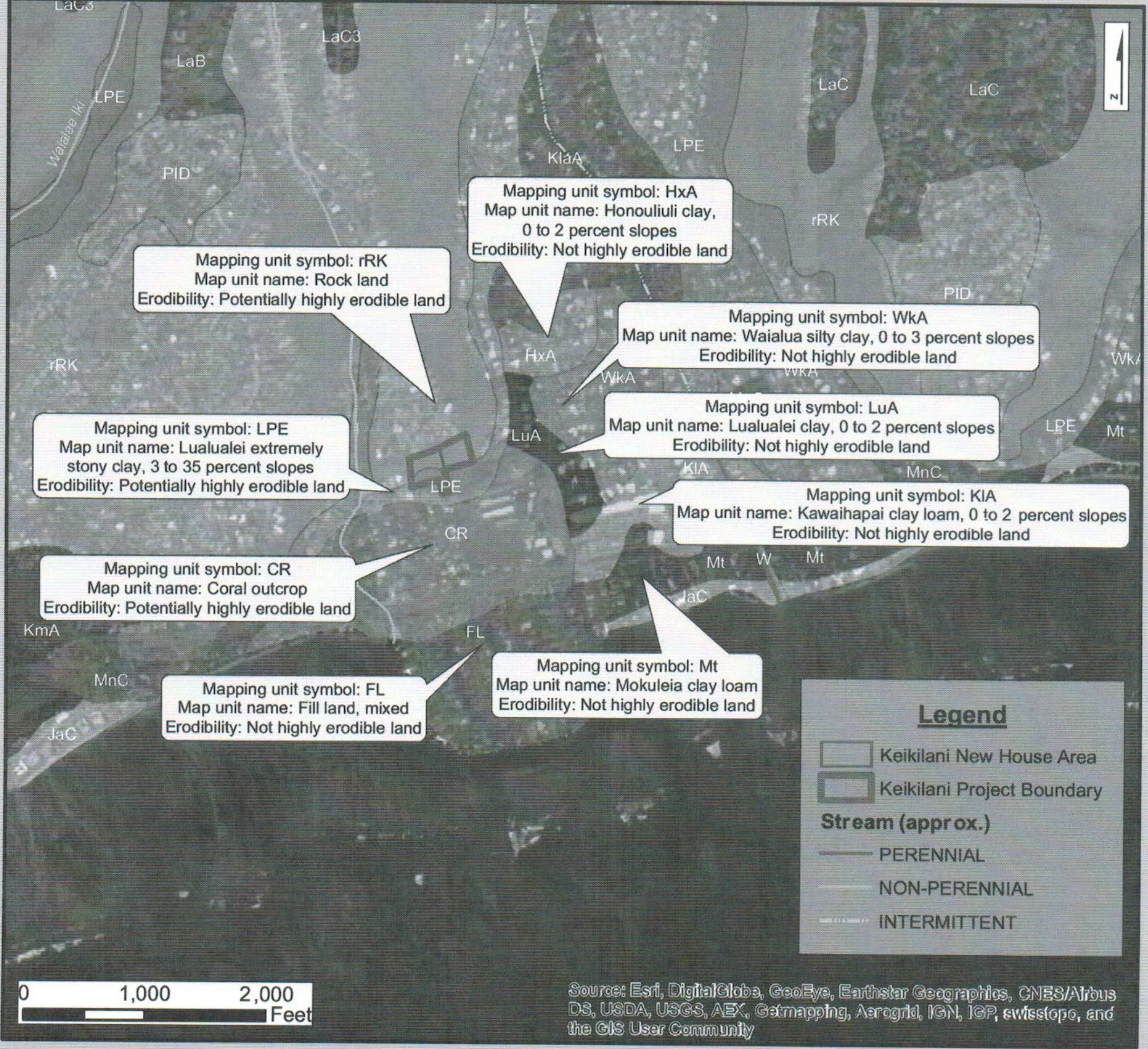
Figure 2A

1938 Geologic Map

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

MFA MASA FUJIOKA & ASSOCIATES
ENVIRONMENTAL • GEOTECHNICAL • HYDROGEOLOGICAL CONSULTANTS

Keikilani Homes New House



Project Location

Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:
1. See Figure 1 for notes on site boundary.
2. Soils data source: USDA Natural Resources Conservation Service (NRCS). 1972. Soils [Statewide GIS layer], with associated Soil Survey Geographic (SSURGO) data. Retrieved May 2009 from Hawaii Statewide GIS Program website, http://hawaii.gov/dbedt/gis/download.htm. Map unit boundaries are only as accurate as the source data; contacts should be considered approximate.
3. Streams layer source: Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR). 2004. Retrieved 2009 from Hawaii Statewide GIS Program website: http://hawaii.gov/dbedt/gis/ Based in part on USGS Digital Line Graphs, 1983 version; locations are not precise.

Figure 3

Project Soils Map

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
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Keikilani Homes New House

Project Location

Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:

1. See Figure 1 for notes on site boundary.
2. Contours from City & County of Honolulu, Department of Planning and Permitting, Honolulu Land Information System (HoLIS). 04/09/2008. Derived from the Interferometric Synthetic Aperture Radar (ifSAR) 5 meter post spacing digital terrain model from NOAA. Vertical accuracy stated to be within 1.68 meters. Retrieved May 23, 2014 from http://gis.hicentral.com/.
3. Streams layer source: Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR). 2004. Retrieved 2009 from Hawaii Statewide GIS Program website: http://hawaii.gov/dbedt/gis/ Based in part on USGS Digital Line Graphs, 1983 version; locations are not precise.

Figure 4

Project Contour Map

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

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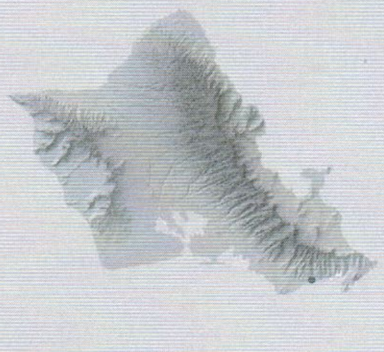
Keikilani Homes New House

Project Location



Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:

1. Project boundary is derived from the City and County of Honolulu GIS TMK layer (retrieved May 2013 from Honolulu Land Information System [HoLIS] ftp site ftp://gisftp.hicentral.com/) coupled with a plan provided to MFA in pdf format. MFA shifted the TMK layer approximately 36 feet based on aerial imagery, geo-referenced the plan to select corners of the shifted TMK, then modified the boundary based on the plan. This process necessarily introduces error: boundary should be considered approximate. This does not replace a survey.
2. Imagery from Pictometry. Image date: May 3, 2013.

Figure 5

Project Site

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

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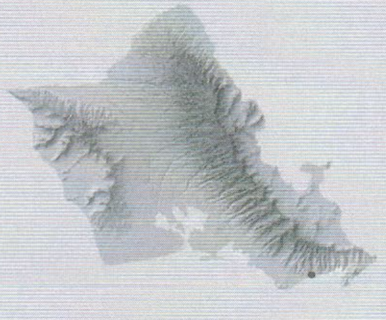
Keikilani Homes New House

Project Location



Project: 15661-001
Approved: MRF
Drawn: ECL
Date: December 2015

Notes:

1. Project boundary is derived from the City and County of Honolulu GIS TMK layer (retrieved May 2013 from Honolulu Land Information System [HoLIS] ftp site ftp://gisftp.hicentral.com/) coupled with a plan provided to MFA in pdf format. MFA shifted the TMK layer approximately 36 feet based on aerial imagery, geo-referenced the plan to select corners of the shifted TMK, then modified the boundary based on the plan. This process necessarily introduces error: boundary should be considered approximate. This does not replace a survey.
2. Imagery from Pictometry. Image date: May 3, 2013.

Figure 6

Site Plan

Geotechnical Review
Keikilani Homes New House
5084 Kiai Place & 5023 Keikilani Circle
TMK (1) 3-6-023:006
Wailupe, O'ahu, Hawai'i

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Attachment 3

Log of Borings

Malama 2006

APPENDIX A
SUBSURFACE EXPLORATION

Subsurface conditions were explored by drilling three borings at the approximate location shown in Figure 2. The boring locations were determined using a hand-help GPS device. The horizontal accuracy was 16 feet. The boring elevation was taken from the topographic survey that forms the background for Figure 2.

The boring logs summarize the subsurface conditions we encountered. The boring logs indicate the depths at which the soil units or their characteristics changed, although the change actually may have been gradual. If the change occurred between sample locations, the depth was interpreted.

Soil samples were obtained from the explorations using the following methods:

1. Standard penetration tests (SPTs) were performed in general conformance with ASTM Test Method D 1586. The sampler was driven with a cathead-operated 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 1 foot, or as otherwise indicated, into the soils is shown adjacent to the sample symbols on the boring logs. Disturbed samples were obtained from the split barrel for subsequent classification and index testing.

2. Rock core samples were recovered from the split-barrel wireline system.

Soils were classified in the field in general accordance with ASTM Standard Practice D 2488, the Standard Practice for the Classification of Soils (Visual-Manual Procedure). Rock core was logged from the box and the Rock Quality Designation (RQD) was determined in general conformance with ASTM Standard Test Method D6032. Rock core boxes were stored indoors at the site; disturbed soil samples were sent to our Makawao offices.

BORING B-4

DATE DRILLED: 18 OCTOBER 2005
DRILLING METHOD: 3" DIA. SS AUGER
CORING METHOD: NX
HAMMER WEIGHT 140 LB.
SURFACE ELEVATION: 122 FEET APPROX.

DEPTH (FT)	ROCK CORE DATA: CORE RUN	ROCK CORE DATA: RECOVERY (%)	ROCK CORE DATA: ROCK QUALITY DESIGNATION	PENETRATION RATE (IN/MIN)
1.5–5	1	19	0	4.2
5–10	2	47	60	3.0
10–15	3	10	0	5.0
15–20	4	60	28	4.3
20–25	5	60	14	1.1
25–30	6	67	21	3.8
30–35	7	40	0	6.0

Brownish gray to gray silty fat CLAY, hard, damp to moist, blocky

Dark gray and purple gray BASALT, hard, fresh to moderately weathered, vesicular

Variable progress - likely low-vesicular layers

Light to medium gray BASALT, hard, fresh to slightly weathered, highly vesicular

Drilling delayed by failed air swivel.
Resume 1335 19 OCT 05
Slow progress on rubble/cobbles

Void at 23' to 25'. No air return.

Olive-brown SILT (return dust)
Dark gray BASALT, hard, fresh, moderately fractured.

Red-brown BASALT, medium hard, moist, slightly weathered, vesicular, fractured to densely fractured

continued next page

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LOG OF BORING B-4

PROJECT NO. 00017-001-01 | FIGURE A-1

BORING B-4 (continued)

DATE DRILLED: 18 OCTOBER 2005
DRILLING METHOD: 3" DIA. SS AUGER
CORING METHOD: NX
HAMMER WEIGHT 140 LB.
SURFACE ELEVATION: 122 FEET APPROX.

DEPTH (FT)	ROCK CORE DATA: CORE RUN	ROCK CORE DATA: RECOVERY (%)	ROCK CORE DATA: ROCK QUALITY DESIGNATION	PENETRATION RATE (IN/MIN)	SAMPLE TYPE	USCS SYMBOL	DESCRIPTION
35–40	8	27	0	12.0			Dark gray and purple gray BASALT, hard, fresh to moderately weathered, vesicular
40							Boring completed at 1555 19 OCT 2005 Seepage encountered at 34 feet during coring
45							
50							
55							
60							
65							
70							

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LOG OF BORING B-4

PROJECT NO. 00017-001-01 | FIGURE A-2

BORING B-5

DATE DRILLED:	20 OCTOBER 2005
DRILLING METHOD:	3" DIA. SS AUGER
CORING METHOD:	NX
HAMMER WEIGHT	140 LB.
SURFACE ELEVATION:	95 FEET APPROX.

ROCK CORE DATA				
CORE RUN	RECOVERY (%)	ROCK QUALITY DESIGNATION	PENETRATION RATE (IN/MIN)	SAMPLE TYPE
1	73	45	1.7	
2	87	63	2.7	
3	70	40	1.4	

DEPTH (FT): 0, 5, 10, 15, 20, 25, 30, 35

USCS SYMBOL

Brownish dark gray fat CLAY, wet, medium stiff to hard, with gravels and cobbles

Dark gray BASALT, hard, fresh to slightly weathered along seams, slightly to highly vesicular, calcium carbonate deposits along fracture faces, small tubes

4' to 5' Welded ash layer, friable, weak to medium strong

5' to 6.5' Basalt rubble, closely fractured, weathered

Red-brown and light gray BASALT, moderately weathered, friable in seams, slightly vesicular to frothy

Dark gray BASALT, hard, fresh, moderately fractured, slightly to moderately vesicular, yellow chalky deposits along fracture faces, some fractures near vertical

15' Lost air circulation - likely void or tube

Boring completed at 16.3 feet on 20 October 2005

Groundwater not encountered during drilling

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LOG OF BORING B-5

PROJECT NO. 00017-001-01

FIGURE A-3

BORING B-6

DATE DRILLED: 20-21 OCTOBER 2005
DRILLING METHOD: 3" DIA. SS AUGER
CORING METHOD: NX
HAMMER WEIGHT 140 LB.
SURFACE ELEVATION: 104 FEET APPROX.

DEPTH (FT)	ROCK CORE DATA: CORE RUN	ROCK CORE DATA: RECOVERY (%)	ROCK CORE DATA: ROCK QUALITY DESIGNATION	PENETRATION RATE (IN/MIN)	SAMPLE TYPE	USCS SYMBOL	DESCRIPTION
0							Dark gray silty fat CLAY, stiff to hard, moist to wet, with gravels and cobbles
	1	57	27	1.3			Dark gray BASALT, hard, fresh to slightly weathered in fractures, slightly to moderately vesicular 3.5' to 3.7' Ash layer, friable, weak to medium strong
5							
	2	75	32	0.9			Slow coring in dense basalt
10							Red-brown BASALT, moderately weathered, moderately fractured, vesicular.
	3	63	35	0.8			Dark gray BASALT, hard, fresh, moderately fractured, slightly to moderately vesicular 13' Lost circulation - likely void or tube
15							
	4	48	15	1.0			1" Thick ash layer inclined 30-degrees. Highly vesicular above, slightly vesicular below
20							
							Boring completed at 21.0 feet on 21 October 2005 Groundwater not encountered during drilling
25							
30							
35							

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LOG OF BORING B-6

PROJECT NO. 00017-001-01

FIGURE A-4

Attachment 2

Log of Borings

Hirata 2001

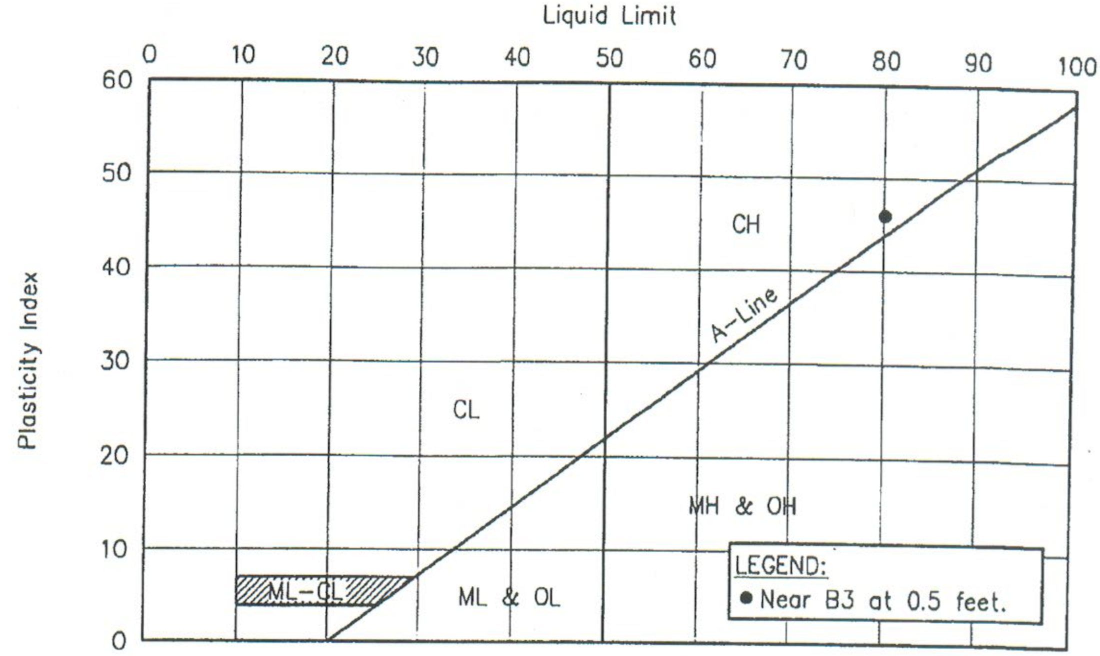
APPENDIX

MAJOR DIVISIONS			GROUP SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS (More than 50% of the material is LARGER than No. 200 sieve size.)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size.)	CLEAN GRAVELS (Little or no fines.)		GW	Well graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GRAVELS WITH FINES (Appreciable amt. of fines.)		GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 sieve size.)	CLEAN SANDS (Little or no fines.)		SW	Well graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES (Appreciable amt. of fines.)		SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS (More than 50% of the material is SMALLER than No. 200 sieve size.)	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 GREATER than 50.)			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils.
					FRESH TO MODERATELY WEATHERED BASALT
					VOLCANIC TUFF / HIGHLY TO COMPLETELY WEATHERED BASALT
					CORAL

SAMPLE DEFINITION		
2" O.D. Standard Split Spoon Sampler	Shelby Tube	RQD Rock Quality Designation
3" O.D. Split Tube Sampler	NX / 4" Coring	Water Level

W.O. 01-3428	Wailupe Cluster Development
Ernest K. Hirata & Associates, Inc.	BORING LOG LEGEND Plate A1

PLASTICITY CHART



GRADATION CHART

COMPONENT DEFINITIONS BY GRADATION	
COMPONENT	SIZE RANGE
Boulders	Above 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.76 mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76 mm)
Sand	No. 4 (4.76 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.76 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and clay	Smaller than No. 200 (0.074 mm)

W.O. 01-3428	Wailupe Cluster Development
Ernest K. Hirata & Associates, Inc.	UNIFIED SOIL CLASSIFICATION SYSTEM Plate A2

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

W.O. 01-3428

BORING NO. B1 | DRIVING WT. 140 lb. | DATE OF DRILLING 4/13/01

SURFACE ELEV. 136±* | DROP 30 in. | WATER LEVEL None

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Silty CLAY (CH) – Grayish brown, slightly moist, medium stiff to stiff, with sand, gravel, cobbles, and boulders. Covered by approximately 12 inches of grayish brown clayey silt. Begin NX coring at 2 feet. 85% Recovery from 2 to 7 feet.
5						61% Recovery from 7 to 12 feet.
10						68% Recovery from 12 to 17 feet.
15						
						End boring at 17 feet.
20						
25						* Elevations based on Topographic Survey provided by Benjamin T. Torigoe, AIA.
30						

ERNEST K. HIRATA & ASSOCIATES, INC.
Geotechnical Engineering

BORING LOG

W.O. 01-3428

BORING NO. B2 | DRIVING WT. 140 lb. | DATE OF DRILLING 4/12/01

SURFACE ELEV. 96± | DROP 30 in. | WATER LEVEL None

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Silty CLAY (CH) – Grayish brown, slightly moist, medium stiff to stiff, with sand, gravel, cobbles, and boulders. Covered by approximately 12 inches of grayish brown clayey silt.
			39/2" 10/No Penetration			
5			30/2" 10/No Penetration			
			39		18	
10						
			15/3" 10/No Penetration			
15			38/3" 10/No Penetration			
20						Begin NX coring at 20 feet. 91% Recovery from 20 to 25 feet.
25						End boring at 25 feet.
30						

Plate B2

ERNEST K. HIRATA & ASSOCIATES, INC.

Geotechnical Engineering

BORING LOG

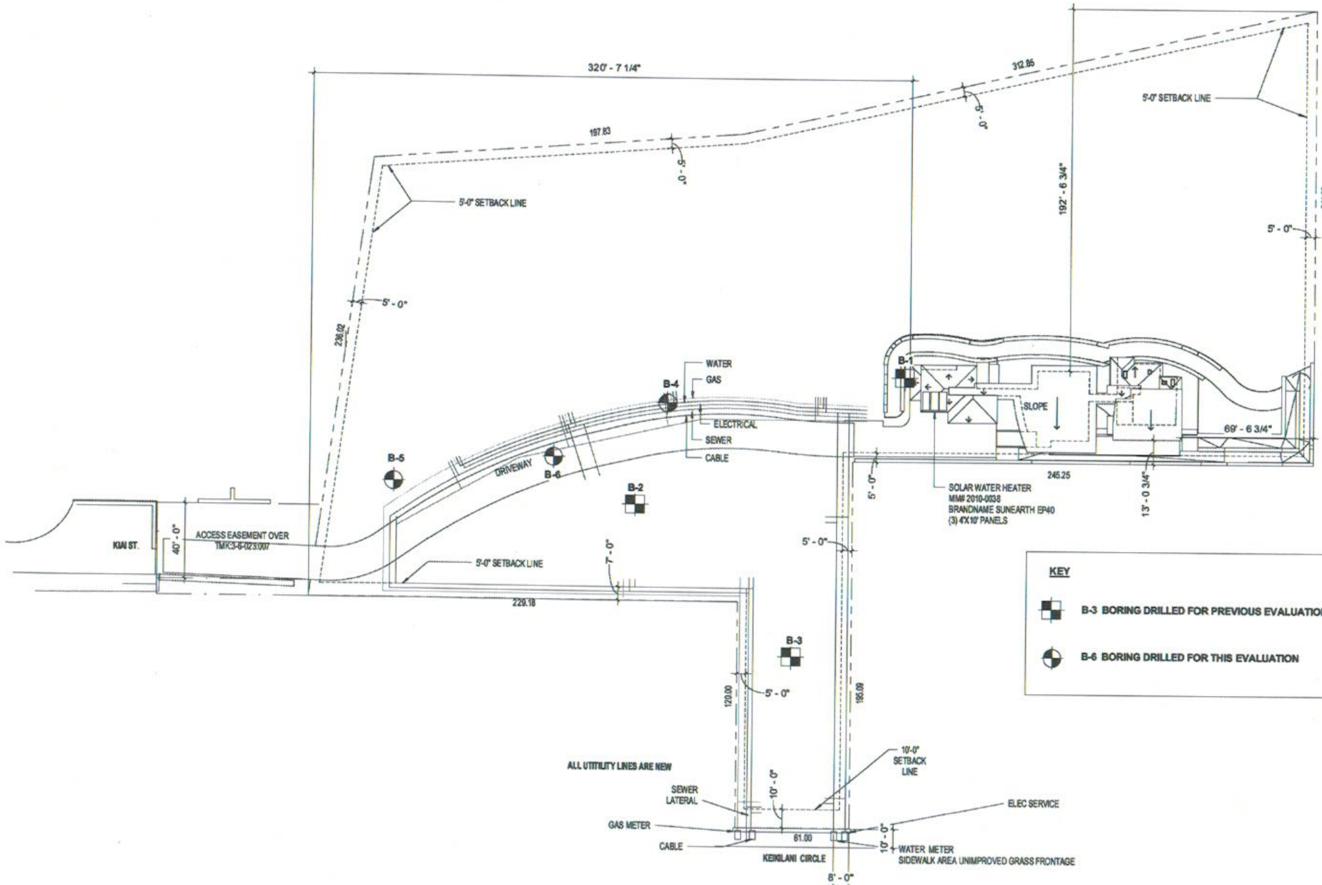
W.O. 01-3428

BORING NO. B3 DRIVING WT. 140 lb. DATE OF DRILLING 4/9/01

SURFACE ELEV. 70± DROP 30 in. WATER LEVEL None

DEPTH	GRAPH	SAMPLE	BLOWS PER FOOT	DRY DENSITY (PCF)	MOIST. CONT. (%)	DESCRIPTION
0						Silty CLAY (CH) – Grayish brown, slightly moist, medium stiff to stiff, with sand, gravel, cobbles, and boulders. Covered by approximately 12 inches of grayish brown clayey silt. Begin NX coring at 1 foot. 100% Recovery from 1 to 6 feet.
5						28% Recovery from 6 to 11 feet.
10						61% Recovery from 11 to 16 feet.
15						
						End boring at 16 feet.
20						
25						
30						

Plate B3



KEY

B-3 BORING DRILLED FOR PREVIOUS EVALUATION

B-6 BORING DRILLED FOR THIS EVALUATION

① SITE AND ROOF PLAN
1" = 30'-0"

REVISIONS/PLOTTED	
No.	Date

J.A.SCHMIT ARCHITECT
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PHONE:(808)371-9191,
FAX (808)988-2429
jim@jasarchitect.com

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.

Unnamed

KEIKILANI HOMES
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TMK: 3-6 -023:008

08/13/2015

DRW	Author
CHK	Checker

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