APPENDIX D

Final Preliminary Engineering Report
Hawaiian Memorial Park Cemetery
Expansion Project – August 2018

Prepared by: Sam O. Hirota, Inc.

FINAL
Preliminary Engineering Report Hawaiian Memorial Park Cemetery Expansion Project

Kaneohe, Island of O'ahu
August 10, 2018

Prepared For: HHF Planners

Prepared By:

No. 9776-C

THIS WORK WAS PREPARED BY
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1. INTRODUCTION

1.1 Project Location

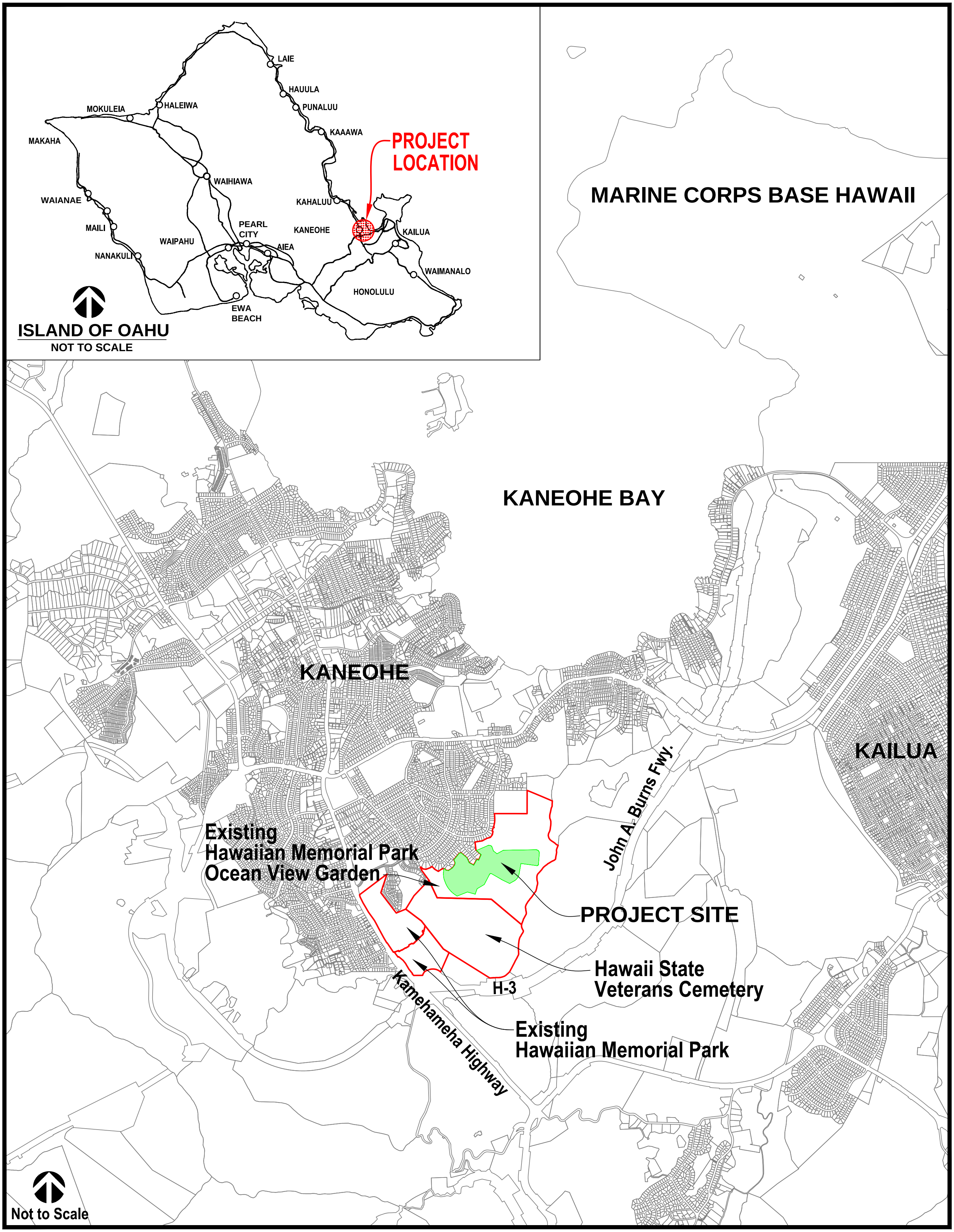
The proposed project is located in Kaneohe, Hawaii, along Kamehameha Highway near the H3 Freeway (See Figure 1.1**,** Project Location). The Hawaiian Memorial Park (HMP) property is served by two access driveways along Kamehameha Highway, which also serve as access to the Hawaii State Veterans Cemetery. The Project Site is located southeast (mauka) of the Pikoiloa Subdivision, near Lipalu and Ohaha Streets, east of Ocean View Garden, west of Kapa'a Quarry, and approximately 2000' south of Pohai Nani Retirement Home.

1.2 Project Description

The project consists of a 53.449 acre expansion of the existing Hawaiian Memorial Park, including the development of new burial areas, roadways, and the establishment of a cultural preserve. Work shall include grading, construction of new retaining walls, roadways, rockfall mitigation, fencing, drainage, and potable water system.

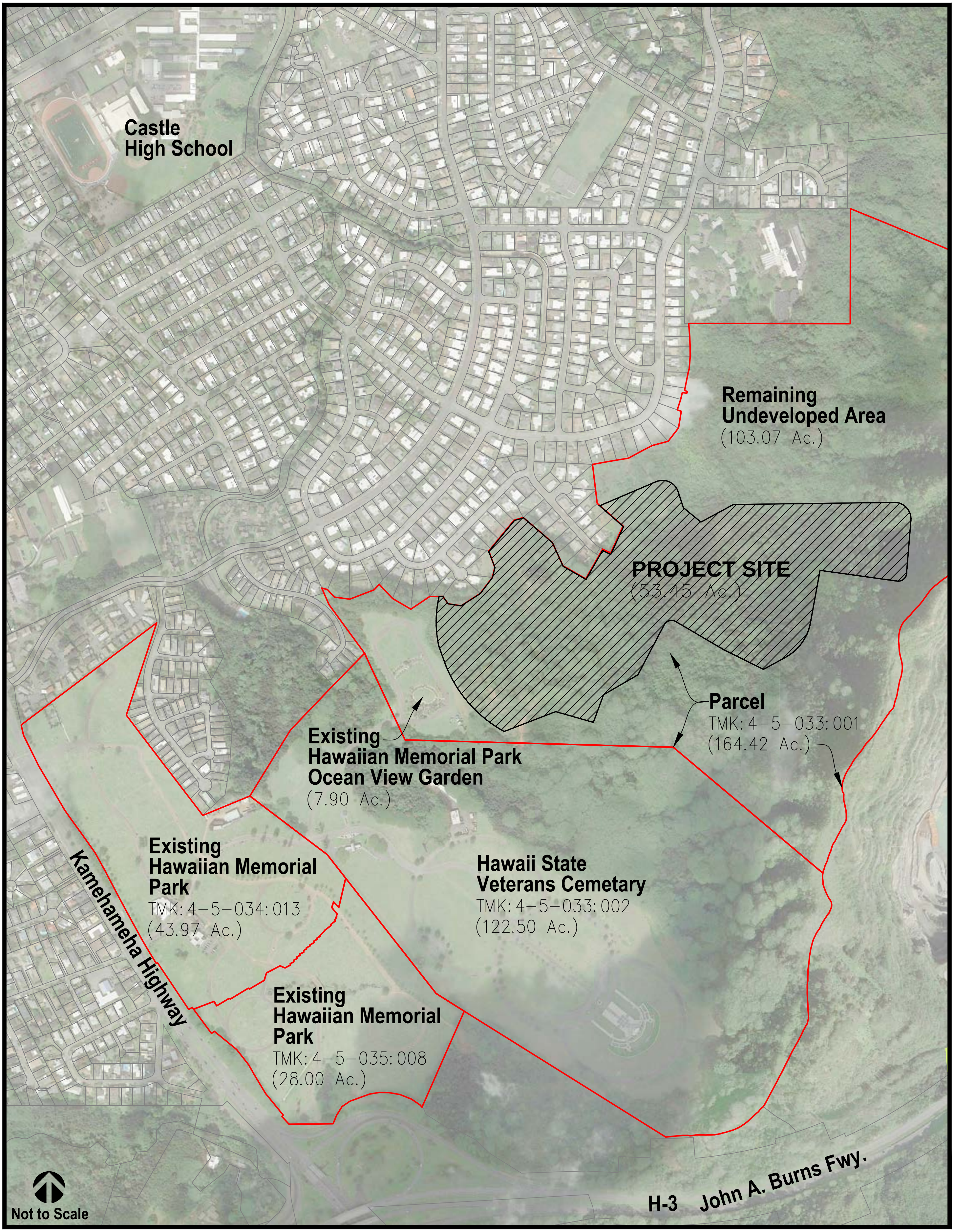
Originally developed in 1958, the cemetery consisted of two parcels, approximately 72 acres in size, located directly adjacent to Kamehameha Highway (TMKs 4-5-034:013 and 4-5-035:008). Later expansion projects have included the donation of 122.50 acres to create the Hawaii State Veterans Cemetery (TMK 4-5-033:002) and 7.90 acres of cemetery at HMP Ocean View Garden (TMK 4-5-033: portion 001).

The project parcel is identified on O'ahu Tax Map Key (TMK) (1) 4-5-33: portion 001, as shown on Figure 1.2, Tax Map Key.



Project Location Map **Figure 1.1**

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii



Tax Map Key **Figure 1.2**

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

2. EXISTING CONDITIONS

The expansion of HMP is comprised of 53.45 acres of forested land, which is currently undeveloped. In the 1900's the land was used for agricultural and ranching operations purposes, including a dairy, but has sat fallow for several decades. Large canopy trees occupy the majority of the site, most of them being invasive species. Underlying areas have different conditions across the site, including exposed boulders, vegetative ground cover, and remnants of an old jeep trail.

2.1 Climate

The project site is located along the windward side of O‘ahu. Temperatures along the windward side and statewide are moderate and equable throughout most of the year. This reflects the small seasonal variation in the energy received from the sun and the tempering effect of the surrounding Pacific Ocean. The mean annual temperature recorded in Kaneohe, O‘ahu, ranges from between the 77°F and 85°F, with occasional reaches into the 90 °F range. Rainfall for the area ranges in excess of 50 inches per year. The wettest month of the year is November with an average rainfall exceeding 6 inches.

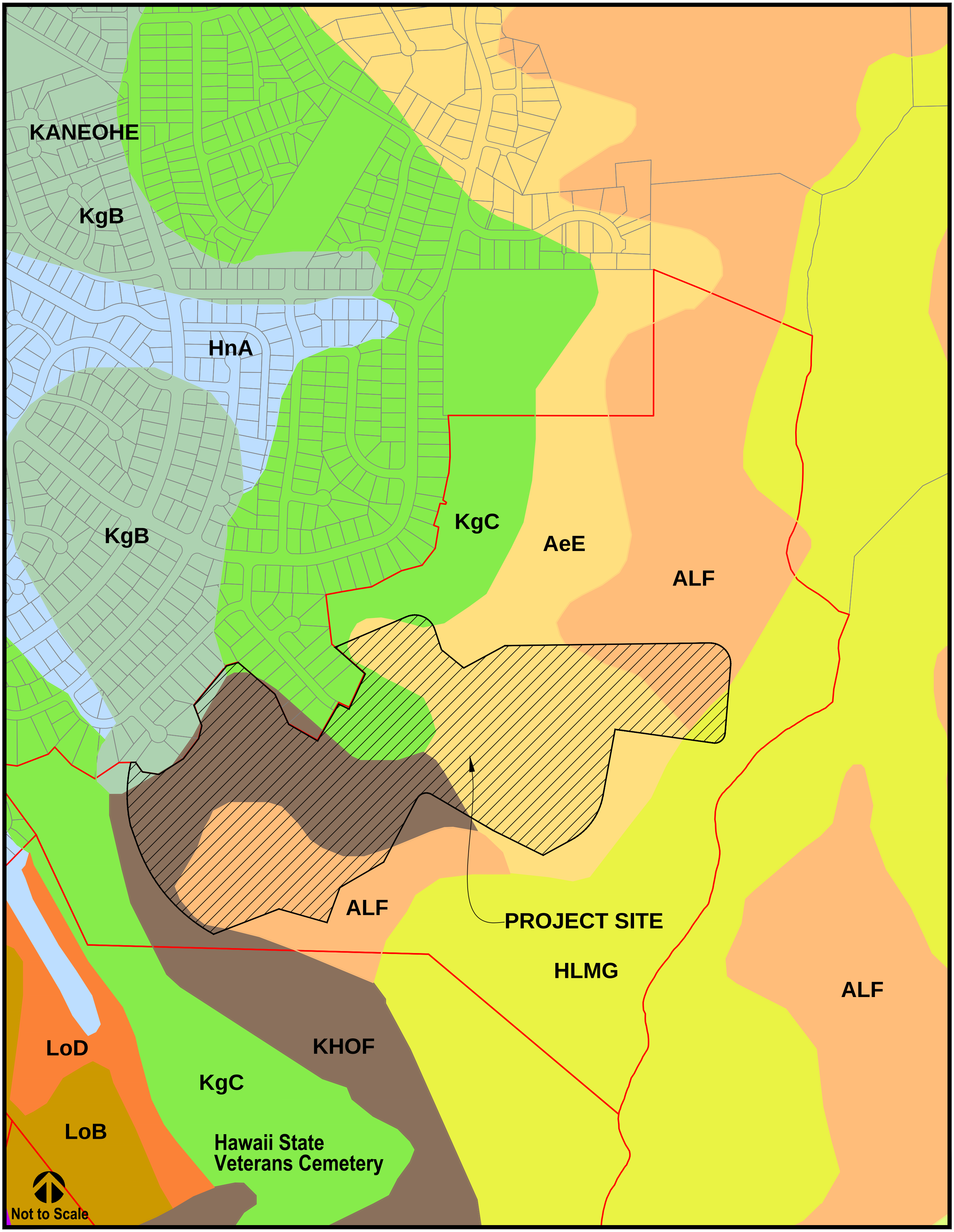
2.2 Soil Conditions

On site soils are largely comprised of silty clays as designated by the U.S. Department of Agriculture, Soil Conservation Service (see Figure 2.1):

The mauka reaches of the site are bounded by the Helemano Silty Clay (HLMG) series. Commonly found on the side of gulches, the Helemano series has typical slopes of 30-90%. It is defined has having moderately rapid permeability, medium to very rapid runoff, and severe to very severe erosion. You typically would find areas of rock outcropping, steep stony land and eroded areas within this type of soil.

The lower portion of the project site consists of Kaneohe Silty Clays (KHOF and KgC), Soils of the Kaneohe Series consist of well-drained soils on terraces and alluvial fans. The erosion potential ranges from moderate to severe with a medium to rapid runoff.

Throughout the middle portions of the site, Alaeloa Silty Clays (AeE and ALF) soils are found. Defined as being well-drained on the uplands. AeE has typical slopes of 15-35% with rapid permeability, moderate erosion with medium runoff. While ALF, is found in areas with slopes ranging from 40-70% with rapid to very rapid runoff. This class of soil is known to be severely erosive.



Soil Conditions Map **Figure 2.1**

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

As noted in the Phase 1 Potential Rockfall and Slope Hazard Assessment, prepared by Geolabs, their reconnaissance indicated areas with slopes flatter than 2H:1V were comprised of mixed silty and clayey alluvial and colluvial soils. Large boulders were found throughout the basin area of the site, and were likely a result of erosion.

2.3 Flood Hazard

According to the Flood Insurance Rate Map (FIRM), Community-Panel Number 15003C0270JG, dated November 4, 2014, the majority of project area is designated by FEMA as Zone D. Zone D is defined as having an undetermined flood hazard, but flooding is possible. The site is comprised of many ravines and gullies where possible localized flooding may occur, however, large scale flooding is not anticipated.

A small portion of the site, between the adjacent homes and the proposed cemetery land, along the northern (makai) edge is contained within Zone X. FEMA defines Zone X as areas outside of the base flood (100-year flood), but within the 500 year flood. See Figure 2.2 for Flood Insurance Rate Map.

Remaining areas of HMP, including the State Veterans Cemetery, fall within Zone D.

2.4 Topography

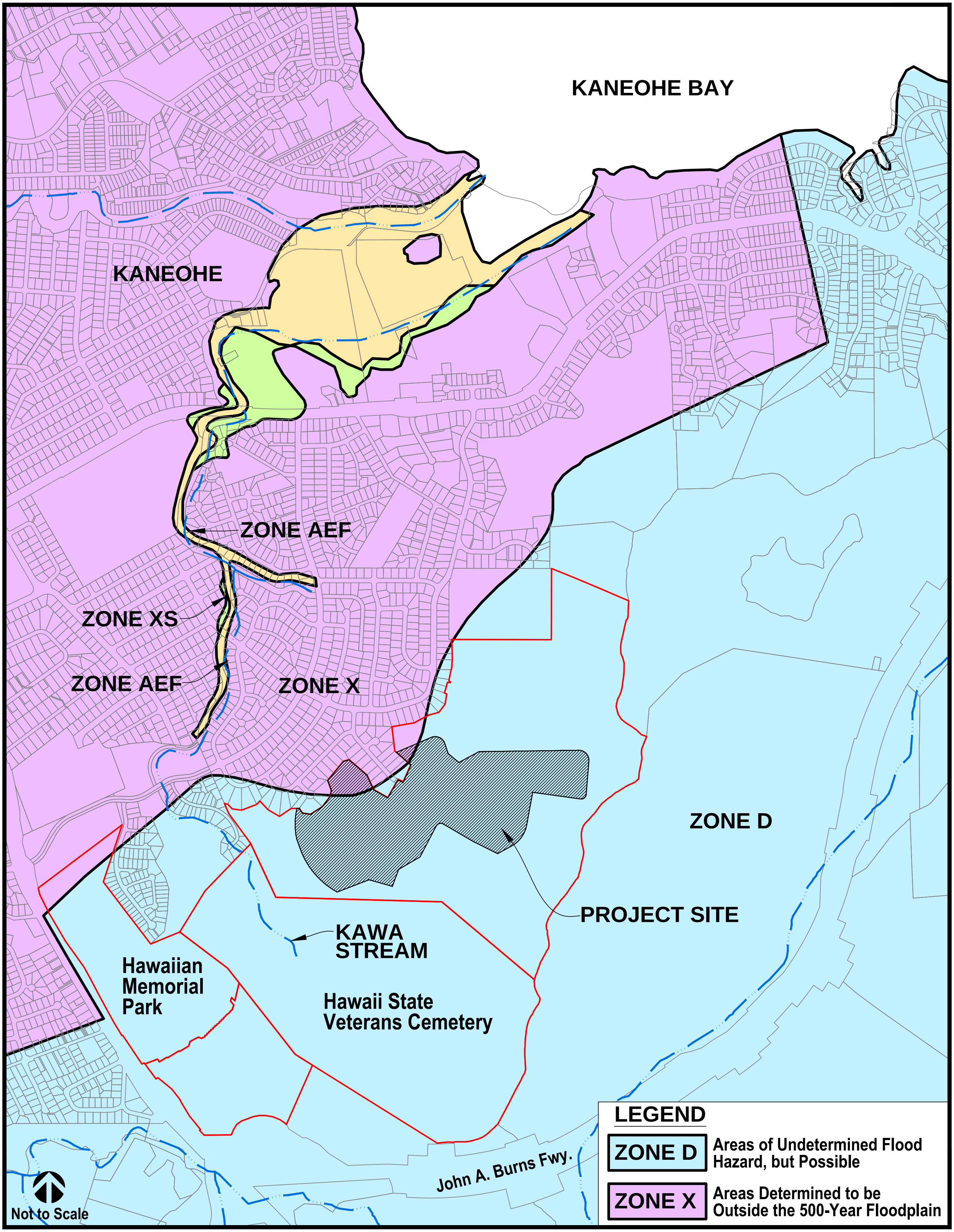
Sitting on the opposite side of the slope of which Kapaa Quarry is, the HMP Expansion site ranges in elevation from 172’ to 412’ MSL. The existing slopes are vastly varying from 0% to 100%, as shown in Figure 2.3.

The western portion of the site, adjacent to Ocean View Garden, contains a large hillside, which serves as a ridgeline, directing stormwater both towards and away from the project site. The slopes of the hillside are as high as 90% in some areas.

As you move east across the site, the slopes decrease significantly, having an average of 25-30%. Various smaller ridgelines and valleys exist throughout the site. The topography creates channels directing runoff generally in a mauka to makai alignment.

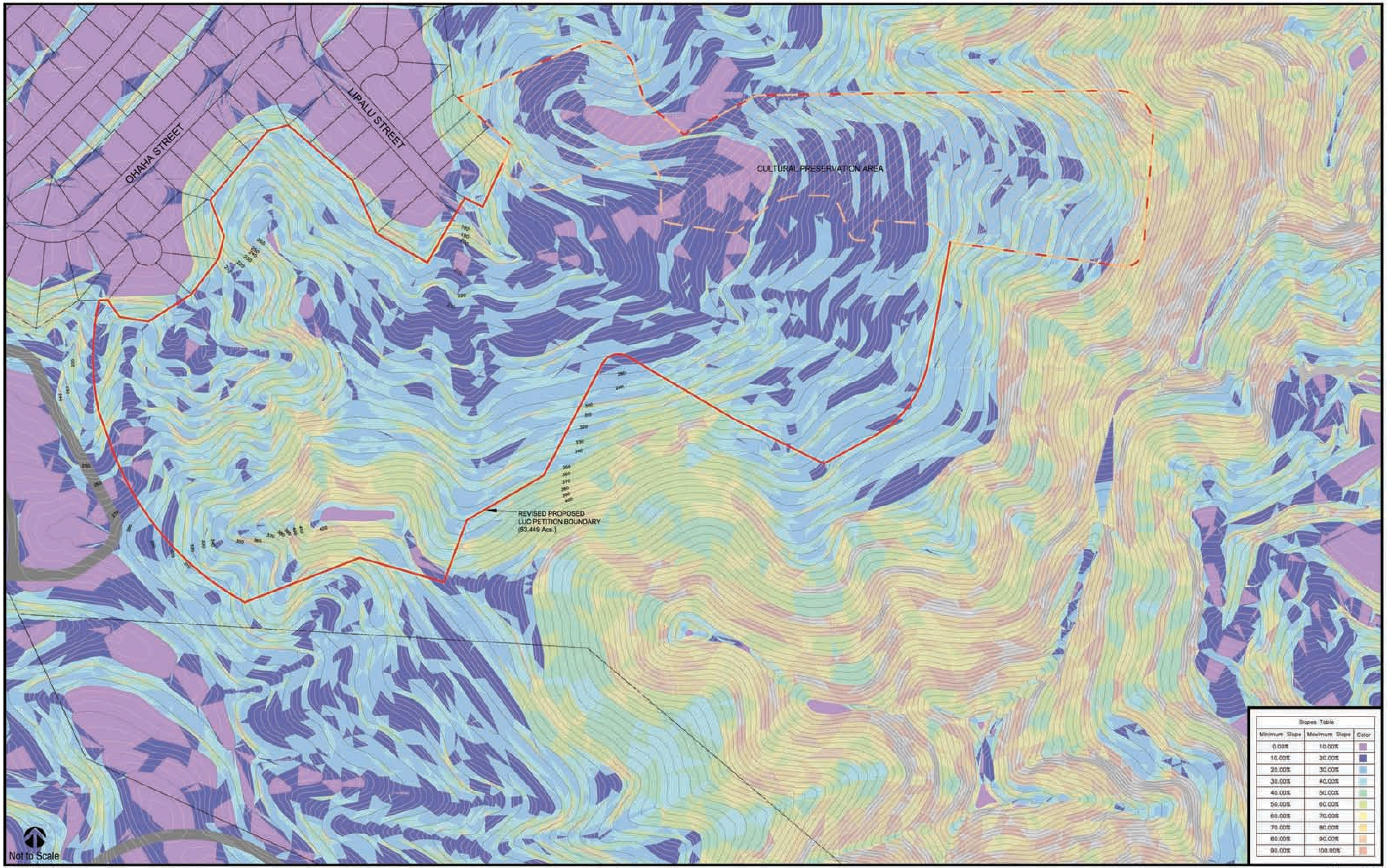
2.5 Hydrology

For the purpose of the drainage assessment, the drainage area encompasses the 54.45 acres of project site and a contributing watershed area for a total of 93.2 acres, as shown in Figure 2.4. In addition to the on-site drainage areas, the “project area” also consists of offsite drainage areas. The land mauka, up to an elevation of 670’ MSL, of



Flood Insurance Rate Map **Figure 2.2**

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

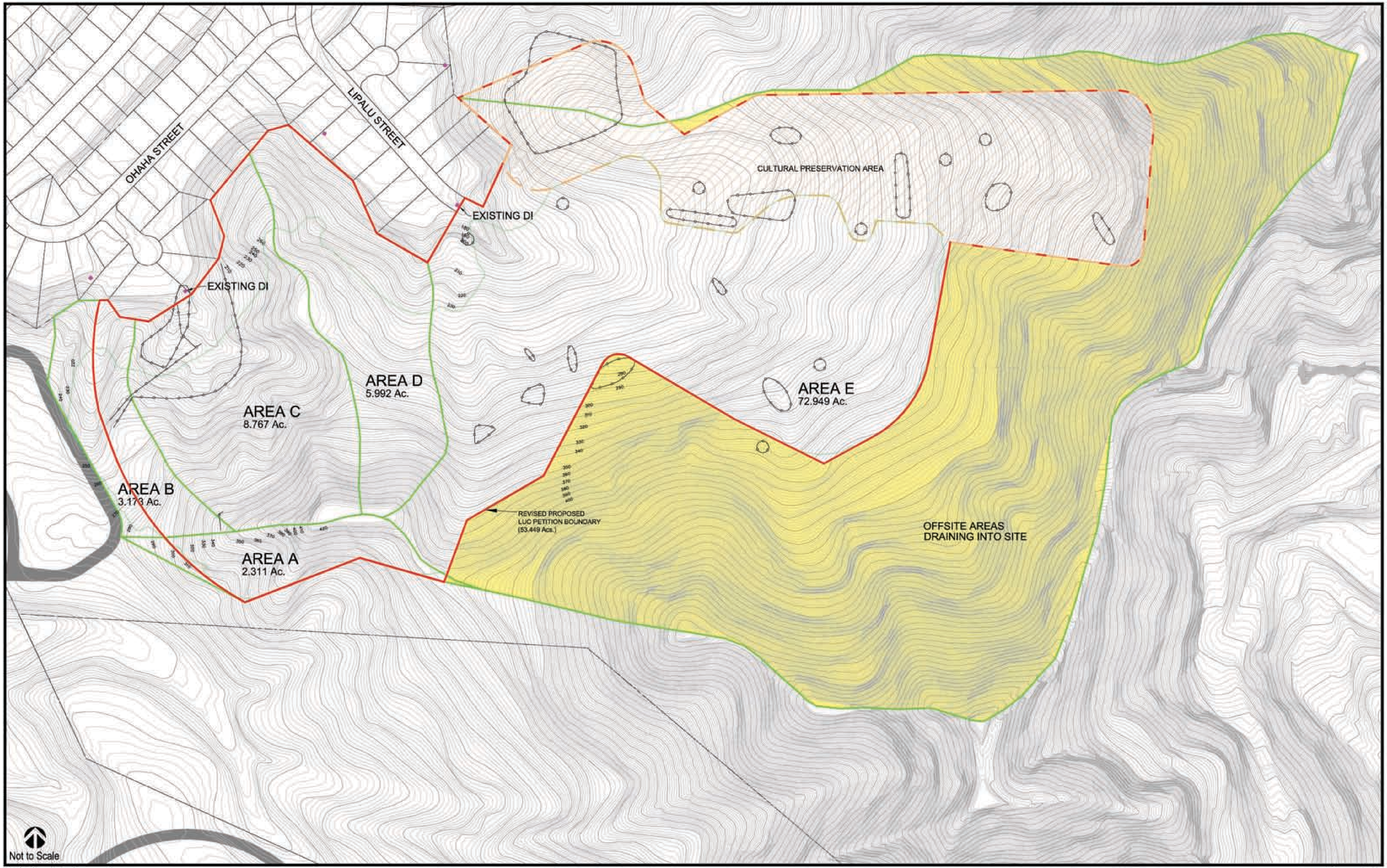


Slopes Table		
Minimum Slope	Maximum Slope	Color
0.00%	10.00%	🟪
10.00%	20.00%	🟦
20.00%	30.00%	🟦
30.00%	40.00%	🟦
40.00%	50.00%	🟩
50.00%	60.00%	🟩
60.00%	70.00%	🟨
70.00%	80.00%	🟨
80.00%	90.00%	🟧
90.00%	100.00%	🟥

Existing Topography

Figure 2.3

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii



Existing Drainage Areas

Figure 2.4

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

the project area is taken into consideration as off-site drainage. Generally, the drainage will flow in a north-northwesterly direction toward the existing catchment structures located on Lipalu and Ohaha Streets.

At the time the Pikoiloa subdivision was developed, concrete swales, indicated as diversion ditches on the as-built drawings, were constructed within the backyards of the home lots bordering HMP. These swales were designed to carry runoff from HMP into the two catchments listed above. The swales are within private property and the responsibility of the individual property owners to maintain. Site inspections throughout the years have shown these swales have been poorly maintained and neighbors have complained about flooding when these swales become overwhelmed.

As mentioned previously, the site contains many large canopy trees. During field investigations, we noted the canopy, primarily from invasive albizia trees, prevented sunlight from filtering through. This is prevalent on the western portion of the site, where minimal ground cover is evident and some erosion is occurring. While the eastern half of the site has more sun exposure, due to the smaller canopy trees such as native Koa, the ground cover consists of heavy vines over the existing boulders.

The drainage calculations were prepared in accordance with the updated Storm Drainage Standards, Department of Planning and Permitting, City and County of Honolulu, dated August 2017. Calculations were prepared for the 10 year – 1 hour and the 100 year – 1 hour storm events. For both storm events, we assumed a standard runoff coefficient of 0.35 from Band 3 in Table 1 of the standards. This coefficient falls within the center of the band and is a conservative value for timber lands of moderate to steep slopes and may differ from actual field values. The flows for the 10 year and 100 year storms are approximately 110 cfs and 174 cfs.

3. PROPOSED DEVELOPMENT

3.1 Grading

3.1.1 Finish Grades

An initial grading concept has been developed as part of this report. The grading is based on contours generated by US Geological Survey data. Future iterations of the grading may change as more accurate data becomes available.

The proposed project would involve the construction of a new 24' wide roadway system providing access to the future gravesites. Roadway slopes vary throughout the site and will not exceed 18% grade. Adjacent to the roadways are the proposed gravesites, which have slopes no greater than 20% to allow for pedestrian access. Along the fringes of the project site, retaining walls and cut/ fill slopes will be used to tie into existing grades. Per the geotechnical engineers recommendation, both the cut and fill slopes shall not exceed 2H:1V. Fill slopes shall have benches at maximum 30' height intervals and shall be keyed to provide additional stability. Subdrains shall be installed at the base of fill slopes to assure seepage water doesn't accumulate at the toe of the slope causing instability. The grading concept is shown in Figure 3.1.

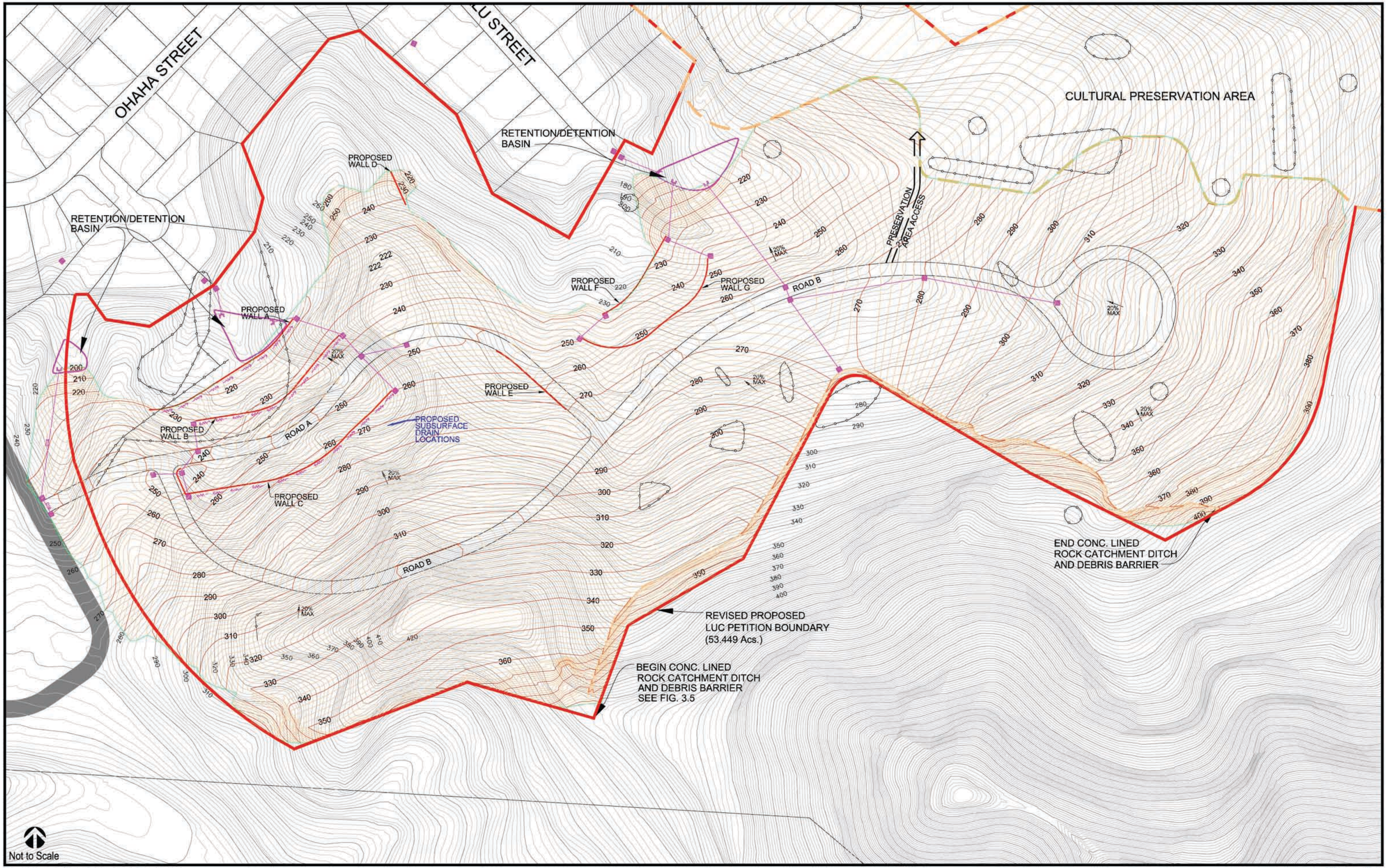
In order to achieve the desired finish grades, it is necessary to remove the existing hillside on the western portion of the site. A smaller ridge line near Ohaha Street will also be excavated. The excess soil will be used to fill the lower portions of the basin areas within the project site. A site section portraying the large cut section at the hillside and the lower fill areas is shown in Figure 3.2.

The estimated area of disturbance for earth moving activities is 33.6 acres. Proposed grading cut and fill is shown on Figure 3.3. The quantities of excavation and embankment are as follows:

Estimated Excavation	470,960 cy
Estimated Embankment	413, 673 cy
Net	57,287 cy (cut)

The excess material will need to be removed from the site during the grading phase of work. It is assumed this material will be trucked off the site to other project sites on island requiring fill material.

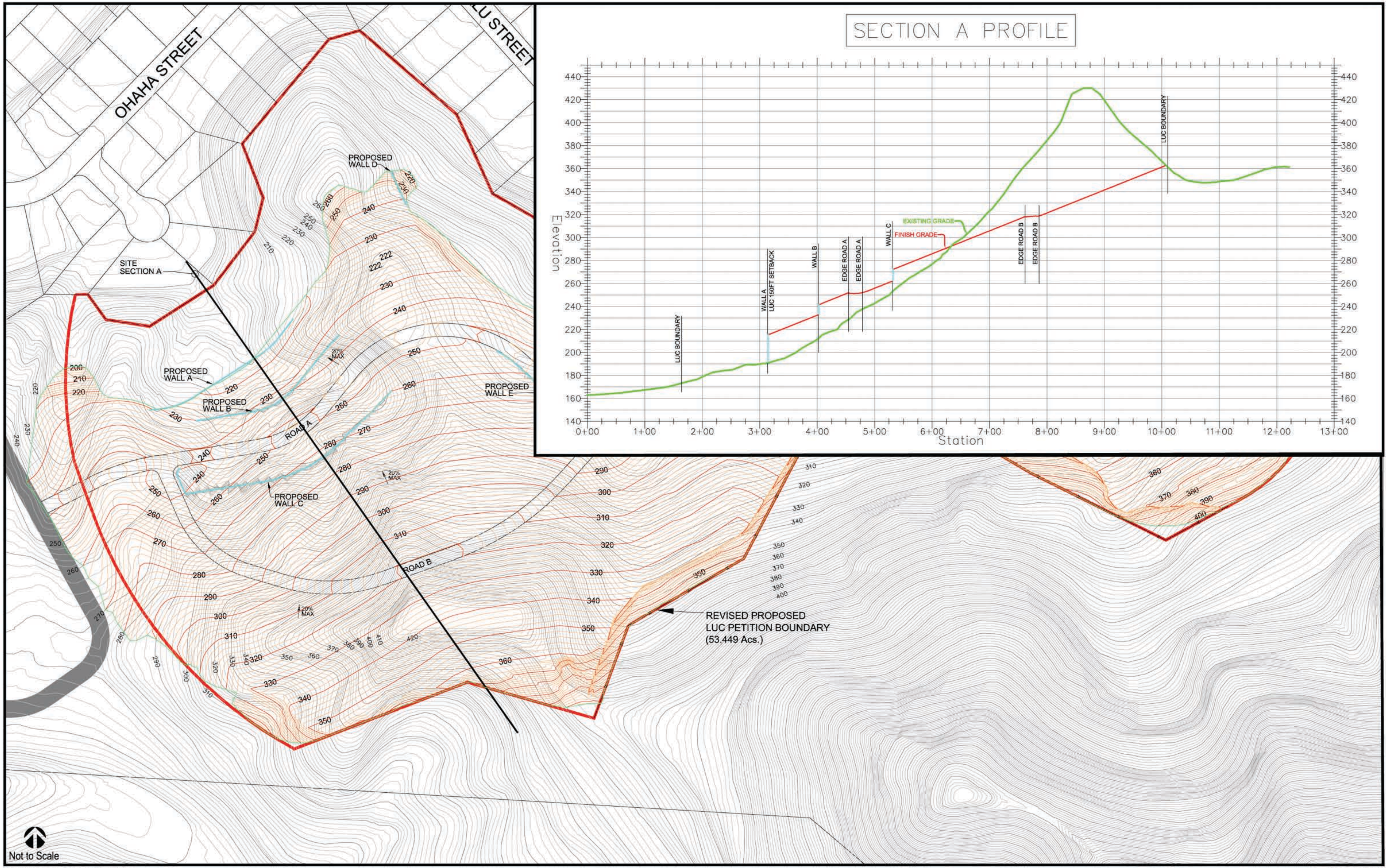
A small perennial groundwater seep has been located near Ohaha Place, as noted in Tom Nance Water Resource Engineering Report contained in Appendix B. The report recommends the installation of two or three subsurface drains in this area, in order, to protect the quantity and direction of groundwater flow. The potential locations of these drains are provided in Figure 3.2.



Proposed Grading and Drainage

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

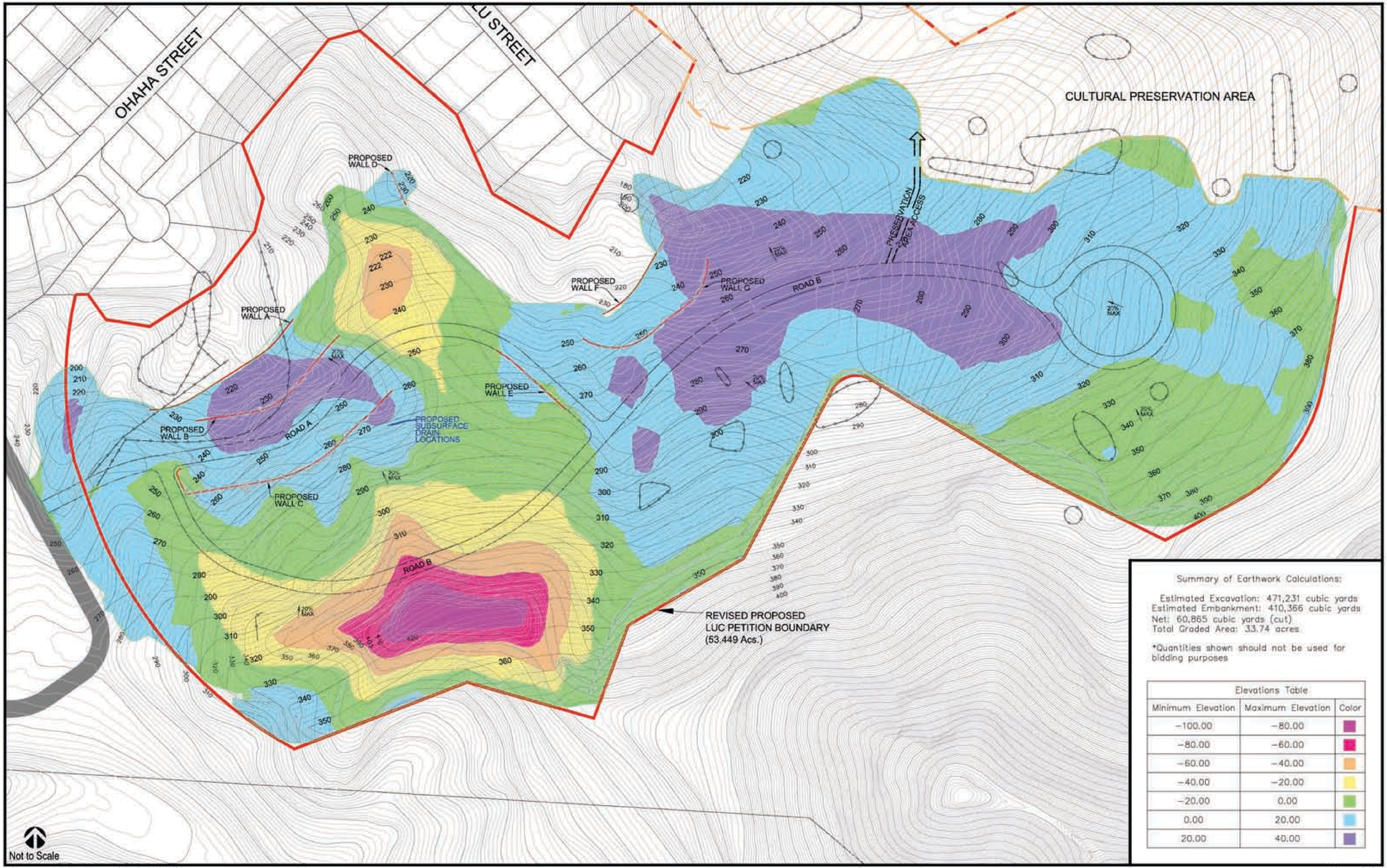
Figure 3.1



Proposed Site Sections

Figure 3.2

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii



Summary of Earthwork Calculations:

Estimated Excavation: 471,231 cubic yards
Estimated Embankment: 410,366 cubic yards
Net: 60,865 cubic yards (cut)
Total Graded Area: 33.74 acres

*Quantities shown should not be used for bidding purposes

Elevations Table		
Minimum Elevation	Maximum Elevation	Color
−100.00	−80.00	🟪
−80.00	−60.00	🟥
−60.00	−40.00	🟧
−40.00	−20.00	🟨
−20.00	0.00	🟩
0.00	20.00	🟦
20.00	40.00	🟪

Proposed Grading Cut & Fill Plan
Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

Figure 3.3

It is anticipated the quantities will be revised or updated as part of the design phase of work as more accurate topographic survey data is available.

The roadway alignment and earthwork balance requirements necessitate the need for retaining walls to be constructed at various locations within the site. Keystone walls, such as shown below, will be constructed. The walls average 10’ in height, with a maximum height of 25’. Where the taller wall sections are required, the keystone will be terraced to provide for a more aesthetic view complete with landscaping. The use of walls taller than 10’ has been kept to a minimum.

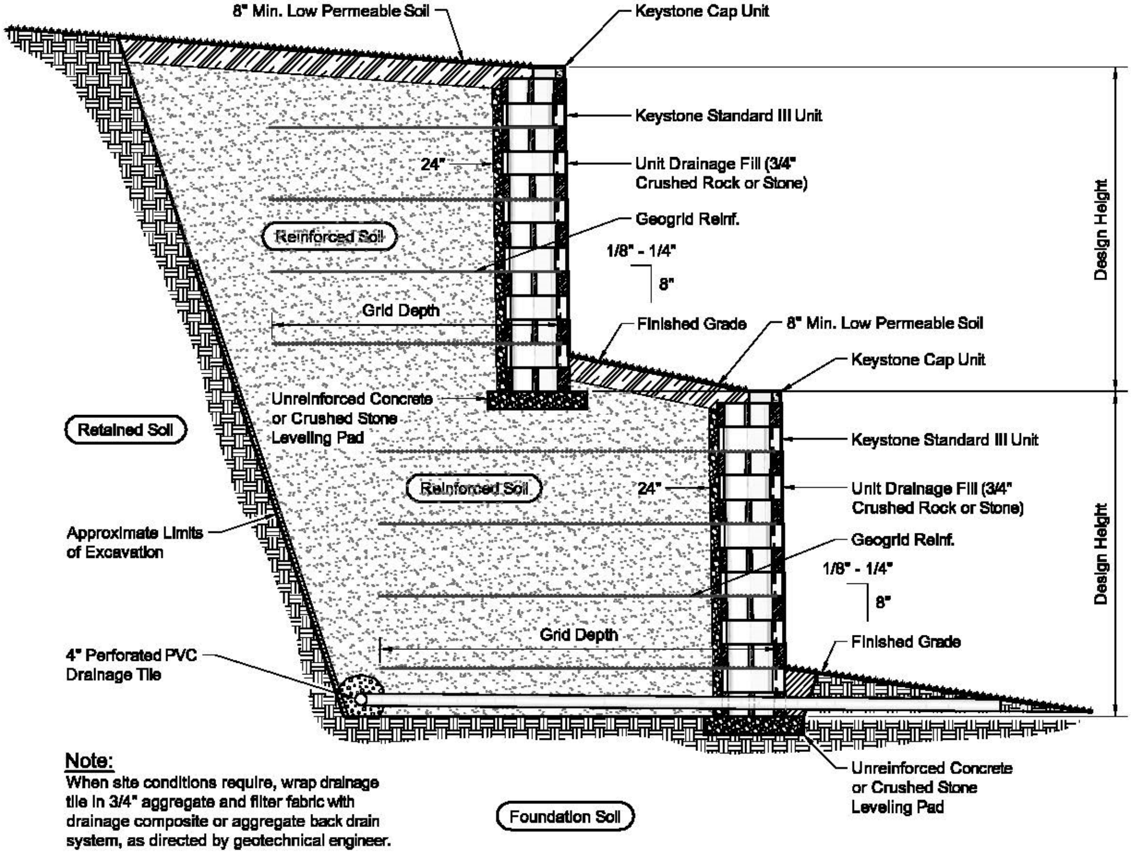


Figure 3.4 Typical Keystone Wall

The Geotechnical Engineer’s Phase 1 Rockfall and Slope Hazard Assessment determined rockfall hazard conditions within the project site. The recommended mitigation alternative is a concrete lined rockfall catchment ditch with a chain link fence on the upslope side. This ditch would serve a dual purpose preventing rocks from falling into the site, while also acting as a drainage ditch for upslope runoff. A section of the ditch and fence is provided in Figure 3.5.

Proposed drainage areas for this site are shown in Figure 3.6.

3.1.2 Grading During Construction

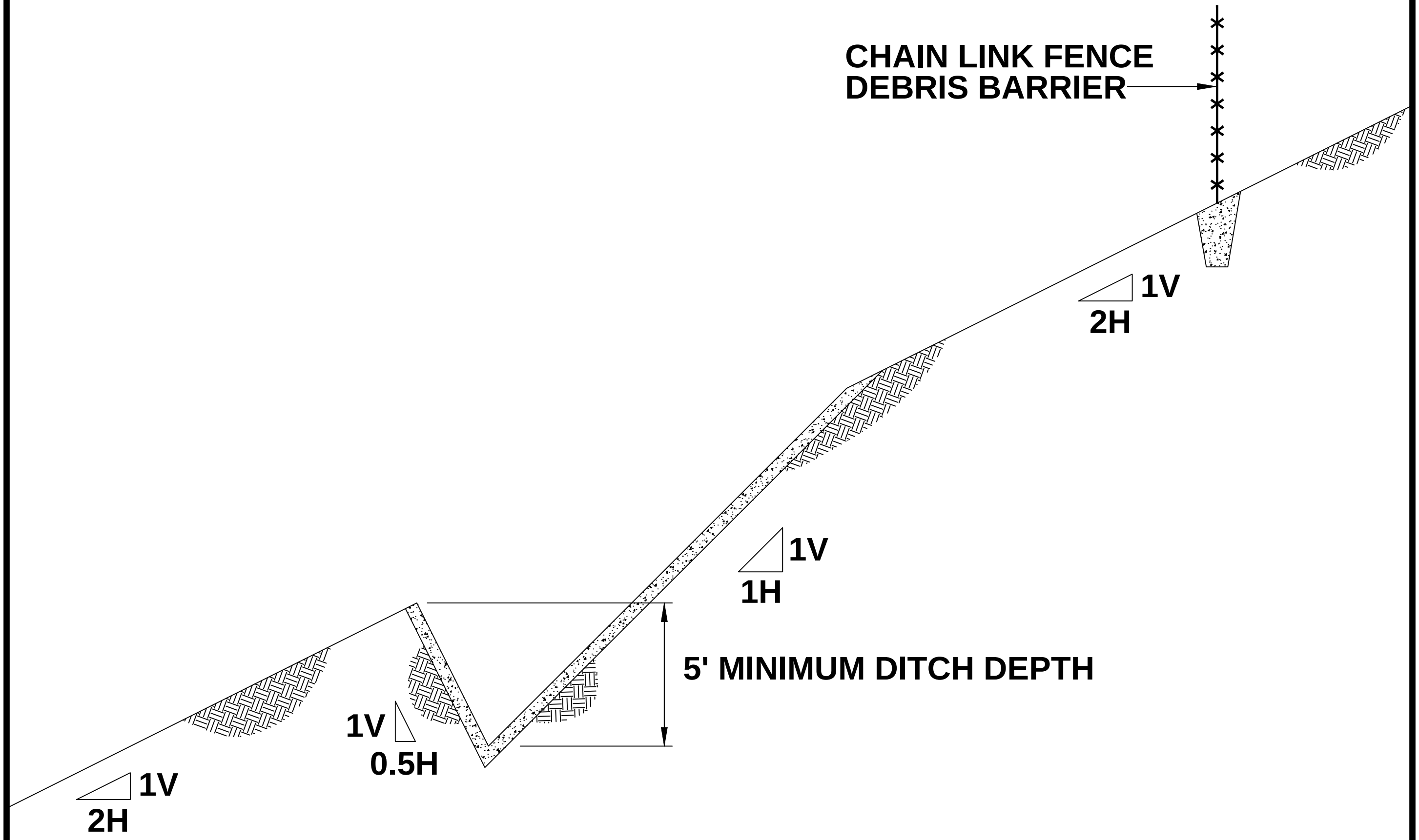
The proposed cemetery expansion project is defined as a Category 5 project in the new DPP Rules Related to Water Quality. Category 5 projects involve more than 1 acre of disturbance triggering the requirement for grading, grubbing, stockpiling, and National Pollutant Discharge Elimination System (NPDES) permits. Projects also require the preparation of an Erosion and Sediment Control Plan (ESCP), which contains the following information: (1) project site information detailing existing and finish grading and drainage conditions; (2) Best Management Practices (BMPs) addressing erosion and sediment control during construction; (3) BMP monitoring; and (4) inspection reporting until the project site is stabilized.

General BMPs will include the following:

1. In general construction will be limited near drainage ways to avoid the potential for release of sediments into stormwater.

2. *Before Construction*
    a. Existing ground cover will not be destroyed, removed or disturbed more than 20 calendar days prior to start of construction.
    b. Erosion and sediment control measures will be in place and functional before earthwork may begin, and will be maintained throughout the construction period. Temporary measures may be removed at the beginning of the work day, but shall be replaced at the end of the work day.

3. *During Construction*
    a. Clearing shall be held to the minimum necessary for grading, equipment operation, and site work.
    b. Construction shall be sequenced to minimize the exposure time of cleared surface areas. Areas of one phase, maximum of 5 acres in size, shall be stabilized before another phase can be initiated. Slope management and protection is required for slopes exceeding 15%. Stabilization shall be accomplished by protecting areas of disturbed soils from rainfall and runoff by use of structural controls such as PVC sheets or geotextile filter fabric.

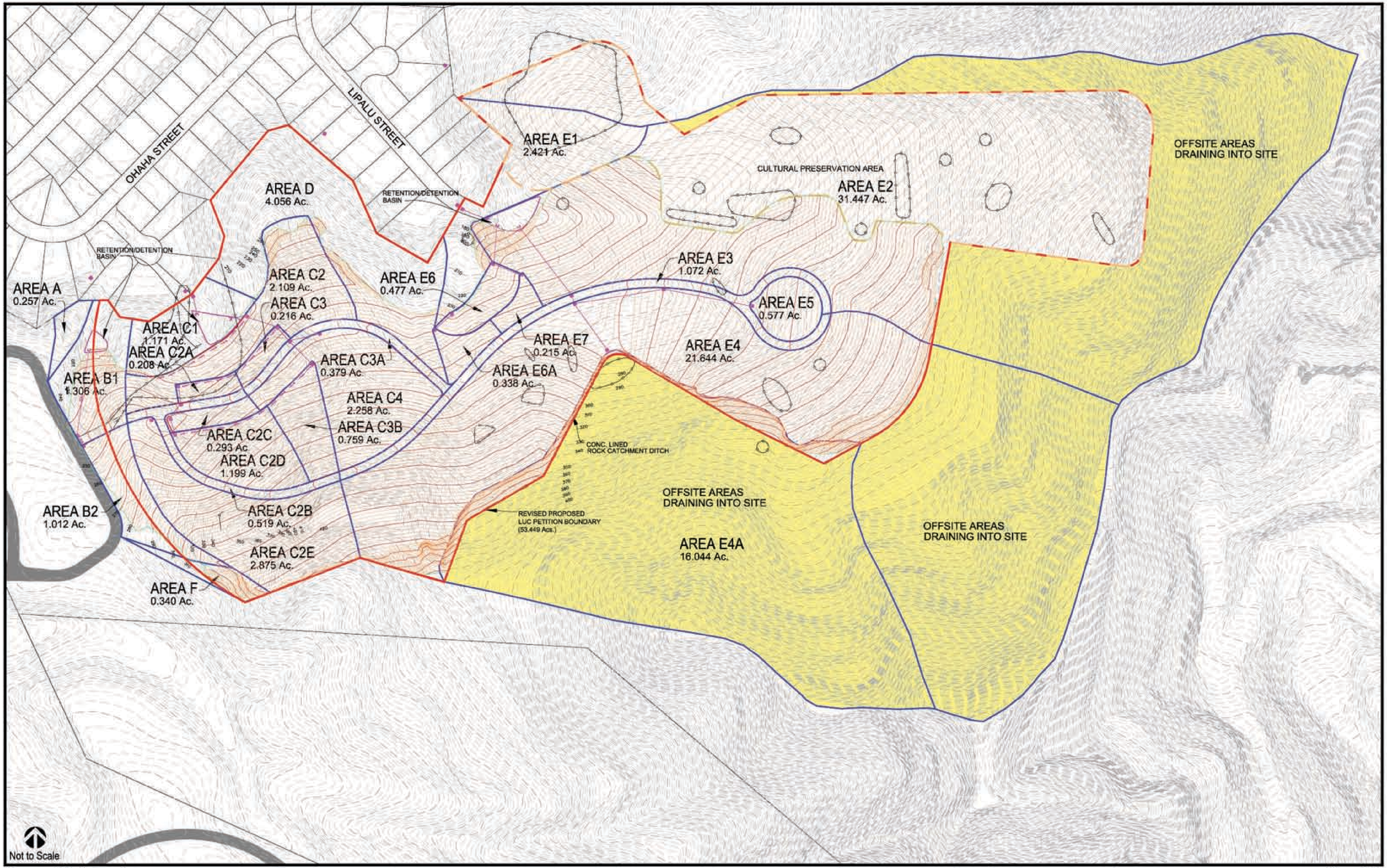


SOURCE: GEOTECHNICAL FINDINGS AND PRELIMINARY RECOMMENDATIONS,
HAWAII MEMORIAL PARK CEMETERY EXPANSION
GEOLABS INC., DECEMBER 12, 2017

Not to Scale

Rockfall Mitigation **Figure 3.5**

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii



Proposed Drainage Areas

Hawaiian Memorial Park Cemetery Expansion Project
Kaneohe, Oahu, Hawaii

Figure 3.6

    c. berms or sediment basins, or vegetative controls such as grass seedling or hydromulch. In addition, buffer strips 10’ wide, at the toe of all slopes, and upstream diversion of storm water are required.
    d. All control measures shall be checked and repaired as necessary, e.g., weekly in dry periods and within 24 hours after any heavy rainfall event. During periods of prolonged rainfall, daily checking shall be conducted.

4. *During Adverse Weather Conditions*
    a. The contractor shall listen to weather reports daily while conducting work. If an emergency weather warning is issued, work shall cease. All equipment and materials shall be secured against wind, rainfall and flooding, and the work area cleared of construction debris to the extent practicable. Work shall not resume until conditions improve and weather warnings are rescinded.
    b. Prior to recommencement of work activities following an event, the Contractor shall inspect all BMPs, including silt fence, sandbag barriers, and stabilized construction entrance, to ensure that they are not damaged, and that all BMP’s are properly installed and functioning
    c. Construction materials and debris that is dispersed due to wind or rainfall shall be collected by the Contractor and reused or disposed of in compliance with State and County regulations.

It is anticipated the grading for this project will be done in one phase, in maximum 5 acre increments, and take 12-16 months.

Sediment basins are required during construction for Category 5 projects. Sediment basins are depressions or excavated basins designed to collect and detain runoff, allowing suspended soil particles to settle. They are generally 3-8’ deep and have controlled outlets and overflow spillways, so water is not permanently contained. These must be sized to handle the volume of runoff from a 2 yr-24 hr storm event or 3,600 cubic feet per acre area to be drained. A portion of the basins will be converted to retention/detention basins as a permanent BMP after construction is complete. Further discussion of the conversion of these basins to a post-development low impact development (LID) strategy is discussed later in this report.

Per the Geotechnical Engineers recommendations, fill slopes will be constructed by overfilling and cutting back to the design slope to achieve a well-compacted slope. All surface runoff shall be diverted away from slopes during construction to minimize erosion of the slope faces. Soil conditions on site indicate large settlements, up to 8”-12” for 30’ of thickness could occur in the fill slopes. It is recommended by the Geotechnical Engineer to overfill the slopes based on the anticipated settlement amount. A settlement waiting period, approximately 2-6 months, may be necessary for areas which will receive improvements such as the roadways, drain and water lines. Further discussion of the fill slopes and settlement can be found in their Technical Memorandum. Anticipating a moderate settlement waiting period will need to be implemented, it is anticipated grading of the entire site will take 12-16 months.

3.2 Drainage

The City & County of Honolulu adopted the new "Rules Relating to Water Quality" of the Administrative Rules, Title 20, Department of Planning and Permitting, Chapter 3, as amended August 16, 2017. These new rules address Water Quality both during the construction period and afterward.

3.2.1 Proposed Hydrology

As the HMP Expansion is constructed, the nature of the land will be altered. The rate at which surface runoff flows (usually measured in cubic feet per second, cfs) will change and the quantity of runoff will also change resulting from the altered nature of the land. The offsite runoff entering the Project Site is assumed to remain unchanged. The change in runoff from the Project Site was determined as described below.

In general, storm runoff will continue to travel from the upper *mauka* lands through the project to the catchment structures on the makai side. Runoff from the off site *mauka* areas is not expected to increase as it enters the property.

The site hydrology will be altered with the grading proposed for this project, however, the runoff will continue to outlet into the same existing inlet structures above Lipalu and Ohaha Streets. The runoff patterns within the site will be modified and water will be collected within various storm drain lines installed throughout the site, which is discussed further in the next section.

The proposed impervious area resulting from development of the new roadway and future grave stone markers is approximately 3 acres. The remainder of the site will be comprised of cemetery land, undisturbed cultural reserve, and undeveloped mountainous terrain located *mauka* of the project area. This equates to a total increase in impervious area from new development within the 92.3 acre drainage basin of approximately 3 percent.

As discussed above, this analysis addresses both the 10 year -1hr and the 100 year -1hr storm event. Flow calculations based on the rational method prescribed from the City and County of Honolulu Rules *Relating to Storm Drainage Standards* are contained in Table 1-1. Calculations are provided in Appendix A.

	Rainfall Intensity 10yr-1hr (inches)	Rainfall Intensity 100yr-1hr (inches)	Runoff Coefficient	Flow Q_{10} (cfs)	Flow Q_{100} (cfs)
Existing Conditions	2.96	4.63	0.35	110.3	173.9
Proposed Conditions	2.96	4.63	0.25-0.35	106.1	166.0
Differential				-4.2 (-4%)	-7.9 (-4%)

Table 1-1
Proposed Runoff Rates

The development of the cemetery addition will result in a reduction of the flow rate due to several factors. Development of the cemetery will reduce the slopes on the large open portion of the site and improve the permeability with the turf grass that will be utilized, reducing the runoff coefficient to 0.25-0.30 on average. The slopes across the site will be reduced, lowering the velocity of the runoff and increasing the time of concentration within the project site. These factors result in a reduction of the Q_{10} and Q_{100} by 4.2 and 7.9 cfs, respectively.

3.2.2 Future Runoff Volume Calculations

As discussed in the previous section, runoff rates from the site will be decreased. The decrease in runoff rate will also produce a decrease in runoff volume, which is a direct result of the increase in the runoff coefficient. Providing a well landscaped, stable surface for the stormwater to infiltrate will decrease to overall volume of water leaving the site. The runoff volumes are contained in the table below.

	Rainfall Intensity 10yr-1hr (inches)	Rainfall Intensity 100yr-1hr (inches)	Runoff Coefficient	Volume V_{10} (cf)	Volume V_{100} (cf)
Existing Conditions	2.96	4.63	0.35	350,465	548,194
Proposed Conditions	2.96	4.63	0.25-0.35	331,810	519,014
Differential				-18,665 (-5.5%)	-29,180 (-5.5%)

Table 1-2
Proposed Runoff Volume

3.2.3 Drainage Pipe System

The roadways will be graded to direct runoff into drain inlets adjacent to the road. The runoff from the drain inlets and be piped through a drain lines to convey stormwater to the lower portions of the site, where retention/detention basins will be constructed. Further discussion of the basins is contained in the next section of the report. The basins will act as a detention system as well as retention for water quality purposes. Water shall drain from the basins through outlet structures, which will direct flow into pipes outletting adjacent to the exiting catchment structures at Lipalu and Ohaha Streets.

In the final design, further analysis on inlet and outlet structures, junction-structures, slope of pipes, and open channel sections will be performed to enhance engineering efficiency.

Drainage systems design will meet the requirements of the Rules Relating to Storm Drainage Standards, City and County of Honolulu, August 2017.

3.2.4 Water Quality

Chapter 6 of the newly adopted "Rules Relating to Water Quality" defines the post-construction requirements for water quality. Within this chapter, the cemetery expansion is defined as a Priority A project, which involves land disturbance of one or more acres. Post-construction storm water requirements include: incorporation of appropriate low impact development (LID) strategies and source control BMPs, including on-site retention of the water quality volume (WQV) or biofiltration BMPs for the remaining portion of the WQV not retained on-site.

The WQV is defined as the design storm runoff depth times the volumetric runoff coefficient times the drainage management area times the percentage of impervious area on site. For this calculation, the design storm runoff depth is 1” for basins and the water quality volume is approximately 12,700 cf for the 33.6-acre of disturbed area within the project site.

It is proposed to use two LID strategies and source control BMPs in order to meet the requirements of Chapter 6: (1) retention/detention basins, and (2) vegetative buffers.

As discussed previously, sediment basins will be constructed prior to grading operations in order to handle sediment laden runoff as a result of the land disturbance. A portion of these basins, along the lower portion of the site, will remain as a post-construction LID. It is anticipated an additional 12,700 cf of storage and infiltration from the permanent retention detention basins, reducing the volume of discharge by an additional 3% for the 100yr-1hr storm event will be achieved. A retention detention basin is a shallow man-made impoundment intended to provide for the temporary storage of storm water runoff to allow particles to settle and detain the peak runoff. It has a shallow permanent pool and is designed to drain between storm events. The basins shall have an invert sloped between 1-2 percent, interior side slopes (length per unit height) no steeper than 3:1 unless approved by a licensed professional engineer with geotechnical expertise, a minimum length to width ratio of 2 to 1, and a maximum depth of 6 feet. With outlets no smaller than 4 inches in diameter, the basin shall drain completely in 48 hours when full and 24-36 hours when half full. An emergency spillway will be designed to allow the basin to safely overtop when experiencing a larger storm event.

The development of the gravesites will create a natural vegetated buffer strip. A vegetated buffer strip is a grassy slope vegetated with turf grass that is designed to accommodate sheet flow. They remove pollutants by vegetative filtration. Vegetated Buffer Strips shall have a length (in the direction of flow) no less than 15 feet, the depth of flow shall not exceed 1 inch, and the velocity shall not exceed 1 foot per second. The flow length of the tributary area discharging onto the strip shall not exceed 75 feet.

3.3 Roadways

Vehicular access to the project site will be provided by a new project roadways that connects to the existing roadway servicing HMP Ocean View Garden. The roadway, as shown in the Figures provided with this report, will meander through the site with a cul-de-sac at the end. Similar to the existing roadways throughout HMP, the road will be 24' in width, asphaltic concrete pavement with rolled curbs. A similar roadway is shown in the photo below.

3.4 Potable Water

The existing Veteran's Cemetery is serviced by the City and County of Honolulu Board of Water Supply water system, via a 6" meter on Kamehameha Highway. Ocean View Garden is serviced separately, via a 1" lateral with a 5/8" meter on Kumakua Pl. Currently, HMP water usage is approximately 50,000 gallons per day for all of the cemetery operations.

Water usage for the proposed development will be for irrigation usage only. No potable water uses will occur within the Cemetery Expansion.

The adjacent Veteran’s Cemetery obtains non-potable water from the Halekou irrigation wells located adjacent to the H-3 Freeway and Kamehameha Highway interchange. There are currently six existing wells, which were drilled in 1983 and are owned and operated by the State of Hawaii. The elevation of the well heads is approximately 240’ MSL (USGS Kaneohe Quadrangle 1998). The elevation of the Veteran’s Cemetery ranges from 300-340’MSL. The existing irrigation system at the Veteran’s Cemetery is known to function properly.

Option 1 is to upsize the lateral leading from Kumakua Pl to Ocean View Garden and constructing a new pipe to the proposed development. The current 5/8” water meter for Ocean View Garden would need to be upsized to a 2” water meter to account for the additional irrigation flow. The Board of Water Supply has indicated the existing system is adequate to accommodate the additional demands from the new irrigation system at the time of request and is subject to change.

Option 2 is an extension of the current irrigation system servicing the Veteran’s Cemetery. We’re unable to obtain as-built drawings of the existing pump stations at the wells or the irrigation system servicing the Veteran’s Cemetery. The current volume of water being pumped from the Halekou Wells is also unknown. This option may require an upgrade of the pumps at the Halekou wells to service the additional demand from the project. The system would have additional friction losses in the new pipelines and have a higher static head due to the higher elevations within the cemetery expansion site, which approach 400’MSL.

3.5 Wastewater

The project will not generate wastewater flows, so no further analysis is required.

4. REFERENCES

Rules relating to Water Quality of the Administrative Rules, Title 20, Department of Planning and Permitting, Chapter 3, amended August 16, 2017.

Storm Drainage Standards, Department of Planning and Permitting, City and County of Honolulu, August 2017.

City and County of Honolulu, Water System Standards, Board of Water Supply, City and County of Honolulu, State of Hawaii, 2002

Phase 1 Potential Rockfall and Slope Hazard Assessment, Hawaiian Memorial Park Cemetery Expansion, Geolabs, Inc., January 18, 2018.

Websites used in this report:

City and County of Honolulu: Board of Water Supply
http://www.hbws.org/cssweb/

City and County of Honolulu: Department of Planning and Permitting
Interactive GIS Maps and Data - http://gis.hicentral.com

State of Hawaii: Department of Land and Natural Resources
Commission on Water Resource Management - http://dlnr.hawaii.gov/cwrm/
Engineering Division, National Flood Insurance Program - http://dlnreng.hawaii.gov/nfip/
Flood Hazard Assessment Tool - http://gis.hawaiinfip.org/fhat/

State of Hawaii: Department of Health
Clean Water Branch - http://health.hawaii.gov/cwb/
e-Permitting Portal - https://eha-cloud.doh.hawaii.gov/epermit/

State of Hawaii: Hawaii Administrative Rules
http://hawaii.gov/lrb/desk/hi3.html

United States: National Oceanic and Atmospheric Administration
National Climate Date Center - http://www.ncdc.noaa.gov/
National Weather Service Hawaiian Forecast Office - http://www.prh.noaa.gov/hnl/
Western Regional Climate Center - http://www.wrcc.dri.edu/

United States: National Resource Conservation Service
Web Soil Survey - http://websoilsurvey.nrcs.usda.gov/app/

APPENDIX A

Table 1

RUNOFF CALCULATIONS

Date: January 2018
SOH#170600

PRE DEVELOPMENT HYDROLOGY

1 HOUR DESIGN STORMS

Area #	Area (sf)	Area (Ac)	C	Length (ft)	Avg Slope (%)	Tc (min)	I_{10} (in)	I_{100} (in)	Correction Factor	Q_{10} (cfs)	V_{10} (cf)	Q_{100} (cfs)	V_{100} (cf)
A	100,679	2.3	0.35	450	28%	19	2.96	4.63	1.75	4.2	8692	6.6	13596
B	138,224	3.2	0.35	800	22%	25	2.96	4.63	1.55	5.1	11933	8.0	18666
C	381,870	8.8	0.35	700	36%	22	2.96	4.63	1.70	15.4	32968	24.4	51568
D	261,000	6.0	0.35	750	31%	24	2.96	4.63	1.60	9.9	22533	15.7	35246
E	3,177,672	72.9	0.35	2,300	29%	56	2.96	4.63	1.00	75.6	274339	119.2	429118
	Total	**93.2**								**110.3**	**350465**	**173.9**	**548194**

NOTES:
1) All calculations are based on the C&C of Honolulu Storm Drainage Standards dated August 2017.
2) "C" was assumed to be c=0.35, Table 1 upper portion of Band 3 - timber lands of moderate to steep slopes, mountainous, farming.
3) Intensity and Precipitation Depth for 10 and 100 year 1-hour rainfall values extracted from “NOAA Atlas 14”, Weather Bureau, US Department of Commerce.
4)Tc was calculated using the NRCD TR-55 method using n value of 0.4 for tree with light underbrush

Precip $Depth_{10}$ (in)	Precip $Depth_{100}$ (in)
2.96	**4.63**

Table 2

RUNOFF CALCULATIONS

Date: January 2018
SOH#170600

POST DEVELOPMENT HYDROLOGY

1 HOUR DESIGN STORMS

Area #	Area (sf)	Area (Ac)	C	Length (ft)	Avg Slope (%)	Tc (min)	I_{10} (in)	I_{100} (in)	Correction Factor	Q_{10} (cfs)	V_{10} (cf)	Q_{100} (cfs)	V_{100} (cf)
A	11,181	0.26	0.30	230	22%	15	2.96	4.63	1.97	0.5	827	0.7	1,294
B1	56,910	1.31	0.27	190	28%	14	2.96	4.63	2.00	2.1	3,790	3.3	5,929
B2	44,073	1.01	0.30	500	18%	21	2.96	4.63	1.75	1.6	3,261	2.5	5,101
C1	50,994	1.17	0.30	280	18%	18	2.96	4.63	1.85	1.9	3,774	3.0	5,903
C2	91,866	2.11	0.25	460	8%	23	2.96	4.63	1.62	2.5	5,665	4.0	8,861
C2A	9,065	0.21	0.25	190	11%	16	2.96	4.63	1.95	0.3	559	0.5	874
C2B	22,593	0.52	0.90	700	11%	26	2.96	4.63	1.53	2.1	5,016	3.3	7,845
C2C	12,765	0.29	0.25	250	9%	20	2.96	4.63	1.80	0.4	787	0.6	1,231
C2D	52,212	1.20	0.25	475	14%	21	2.96	4.63	1.75	1.6	3,220	2.4	5,036
C2E	125,245	2.88	0.25	820	15%	26	2.96	4.63	1.53	3.3	7,723	5.1	12,081
C3	9,404	0.22	0.25	380	16%	18	2.96	4.63	1.85	0.3	580	0.5	907
C3A	16,508	0.38	0.90	500	6%	25	2.96	4.63	1.58	1.6	3,665	2.5	5,732
C3B	33,060	0.76	0.25	380	16%	18	2.96	4.63	1.85	1.0	2,039	1.6	3,189
C4	98,348	2.26	0.25	380	18%	18	2.96	4.63	1.85	3.1	6,065	4.9	9,486
D	176,664	4.06	0.27	400	10%	21	2.96	4.63	1.78	5.8	11,766	9.1	18,404
E1	105,461	2.42	0.35	620	18%	24	2.96	4.63	1.60	4.0	9,105	6.3	14,242
E2	1,369,832	31.45	0.35	2,400	27%	70	2.96	4.63	0.90	29.6	118,262	46.2	184,984
E3	46,706	1.07	0.90	790	9%	28	2.96	4.63	1.50	4.3	10,369	6.8	16,219
E4	942,833	21.64	0.30	2,000	30%	65	2.96	4.63	0.95	18.4	69,770	28.8	109,133
E4A	698,891	16.04	0.35	1,500	37%	53	2.96	4.63	1.10	18.4	60,338	28.8	94,379
E5	25,140	0.58	0.25	180	11%	16	2.96	4.63	1.95	0.8	1,550	1.3	2,425
E6	20,790	0.48	0.25	110	16%	12	2.96	4.63	2.20	0.8	1,282	1.2	2,005
E6A	14,742	0.34	0.25	200	10%	16	2.96	4.63	1.95	0.5	909	0.8	1,422
E7	9,355	0.21	0.25	100	20%	10	2.96	4.63	2.35	0.4	577	0.6	902
F	14,796	0.34	0.25	70	40%	7	2.96	4.63	2.65	0.7	912	1.1	1,427
	Total	**93.2**								**106.1**	**331,810**	**166.0**	**519,014**
										V increase	**-18,655**	**V increase**	**-29,180**

NOTES
1) All calculations are based on the C&C of Honolulu Storm Drainage Standards dated August 2017.
2) "C" was assumed as 0.25 for developed cemetery land, Table 1 lower limit of Band 3 - timber lands of moderate to steep slopes, mountainous, farming.
3) Intensity and Precipitation Depth for 10 and 100 year 1-hour rainfall values extracted from “NOAA Atlas 14”, Weather Bureau, US Department of Commerce
4) Rational Formula was used to estimate volumetric runoff.
5)Tc was calculated using the NRCD TR-55 method using n value of 0.24 dense grasses

Precip Depth$_1$ (in)	Precip Depth$_2$ (in)
2.96	**4.63**

BMP Sizing Worksheet: Infiltration Basin

Project: Hawaiian Memorial Park

Date: Jan-18

1. Water Quality Volume

a. BMP Tributary Drainage Area, **A**	33.6	ac
b. % Impervious Area, **I**	6	%
c. Water Quality Design Storm Depth, **P**	1.0	in
d. Volumetric Runoff Coefficient, **C**	0.104	
e. Water Quality Volume, **WQV**	12,685	cu-ft

2. Maximum Storage Depth

a. Soil Infiltration Rate, **k** (0.5 min)		in/hr
b. Infiltration Rate Safety Factor (2 - 5), $\mathbf{F_s}$		
c. Drawdown Time, **t**	48	hrs
d. Max. Storage Depth, $\mathbf{d_{max}}$	#DIV/0!	ft

3. Design Storage Depth

a. Ponding Depth, $\mathbf{d_p}$		ft

4. Basin Invert Footprint

b. Reservoir Fill Time, **T**	2	hrs
c. Min. Bottom Surface Area, $\mathbf{A_b}$	#DIV/0!	sq-ft

5. Basin Area Requirements

a. Side Slopes (length per unit height), **z** (3.0 min)		
b. Freeboard, **f** (1.0 min)		ft
c. Invert Width, $\mathbf{w_b}$		ft
d. Invert Length, $\mathbf{l_b}$	#DIV/0!	ft
e. Top Width, $\mathbf{w_t}$	0.0	ft
f. Top Length, $\mathbf{l_t}$	#DIV/0!	ft
g. Min. Top Surface Area excluding pretreatment, $\mathbf{A_{BMP}}$	#DIV/0!	sq-ft

APPENDIX B

Assessment of the Potential Impact on Groundwater of the Proposed Expansion of the Hawaiian Memorial Park

Prepared for:

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Honolulu, Hawaii 96817

April 2018

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Introduction

An expansion of the Hawaiian Memorial Park (HMP) Cemetery is proposed which will require a land use boundary amendment from Conservation to Urban for 53.45 acres of TMK 4-5-033:001. The Petition Area in question is shown on Figure 1. Of the 53.45-acre area, 28.2 acres would be for cemetery use. The remaining area would consist of internal roadways, open space, and a cultural reserve.

This report addresses the potential impact on groundwater resources should the land use boundary amendment be granted and the proposed project is implemented. The assessment addresses groundwater on a regional scale and also deals with a site specific issue regarding a dug well and perennial seep, the discharge from which has created a habitat for the damsel fly which must be preserved.

Geologic Setting of the Petition Area

All of HMP, including the Petition Area, is located within the caldera of the Koolau Mountain (labeled the Kailua Caldera on Figure 2). The caldera filling lavas which lie beneath HMP are a part of the Kailua Member of the Koolau volcanics. Its basalt flows are dense, massive, and relatively impermeable due to almost complete filling of interstices with secondary minerals resulting from hydrothermal alteration. Clinker beds, where they occur, have been cemented into hard and essentially impermeable breccia. Joints of intruded dikes are also filled with secondary minerals. In short, development of even a moderate capacity well anywhere in the Kailua volcanics beneath the HMP property would not be possible. This is in sharp contrast to the permeability most other basalts of the Koolau mountain.

Also of significance is the deep weathering of the Kailua volcanics across the HMP site. This has resulted in stiff silt and clay residual soils underlain by saprolite to depths exceeding 50 feet.

Regional Groundwater Perspective

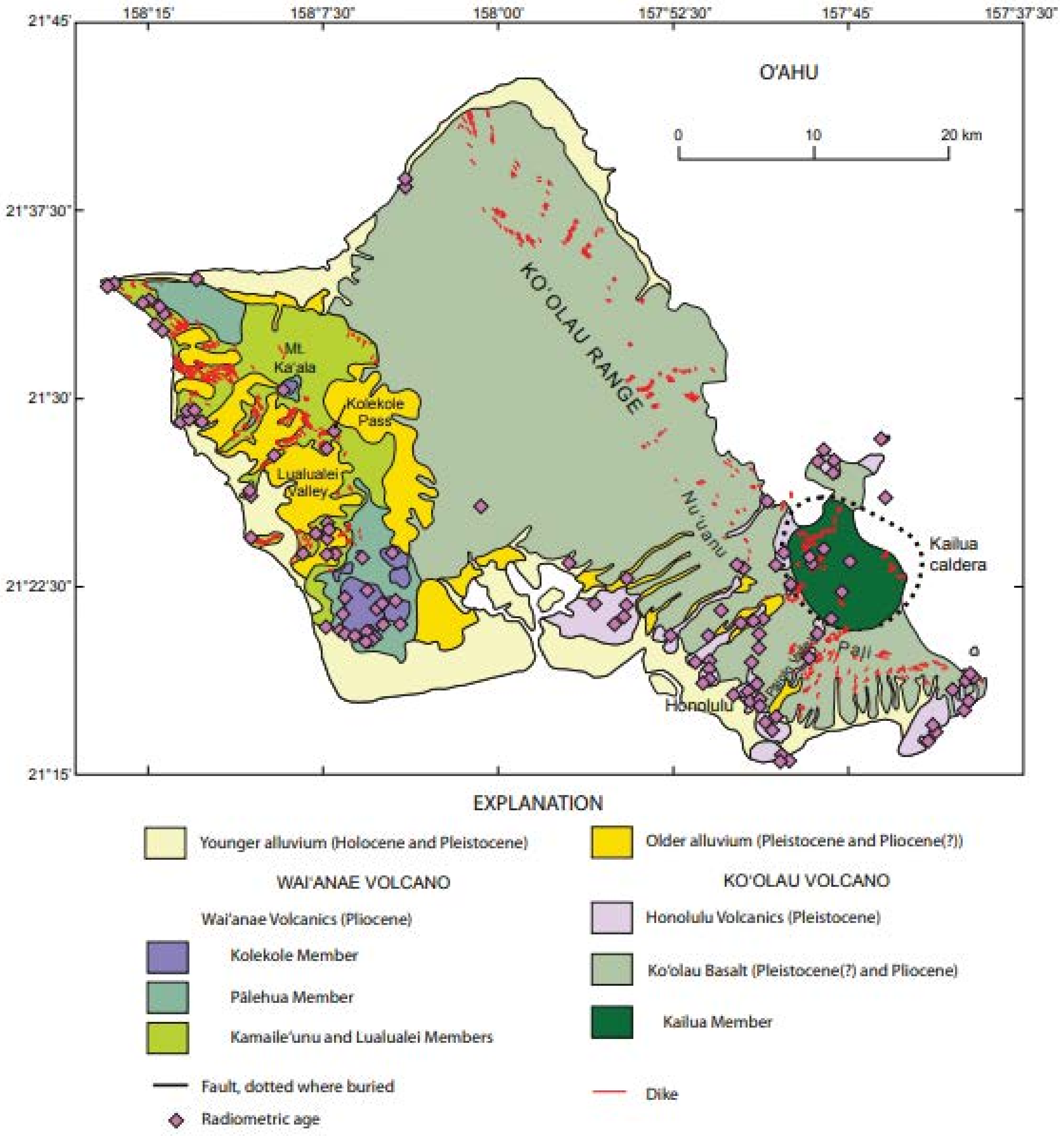
The HMP site is at the south end of the area designated by the State Commission on Water Resource Management (CWRM) as the Koolaupoko Aquifer System. It is a 27-square mile area bounded by the Koolau Crest and the shoreline and extending from Oneawa Hills at the south end to the north ridge line of Waikane Valley. The CWRM has set the aquifer’s sustainable yield at 30 million gallons per day (MGD) and has issued water use permits to 19 wells with a total permitted use of 10.312 MGD. As shown on Figure 3, total use by these wells has closely matched the combined permitted use amount.

Project Vicinity Map (by HHF Planners)

Figure 1

Hawaiian Memorial Park Cemetery Expansion Project Kāneʻohe,
Oʻahu, Hawaiʻi

o:_18-23

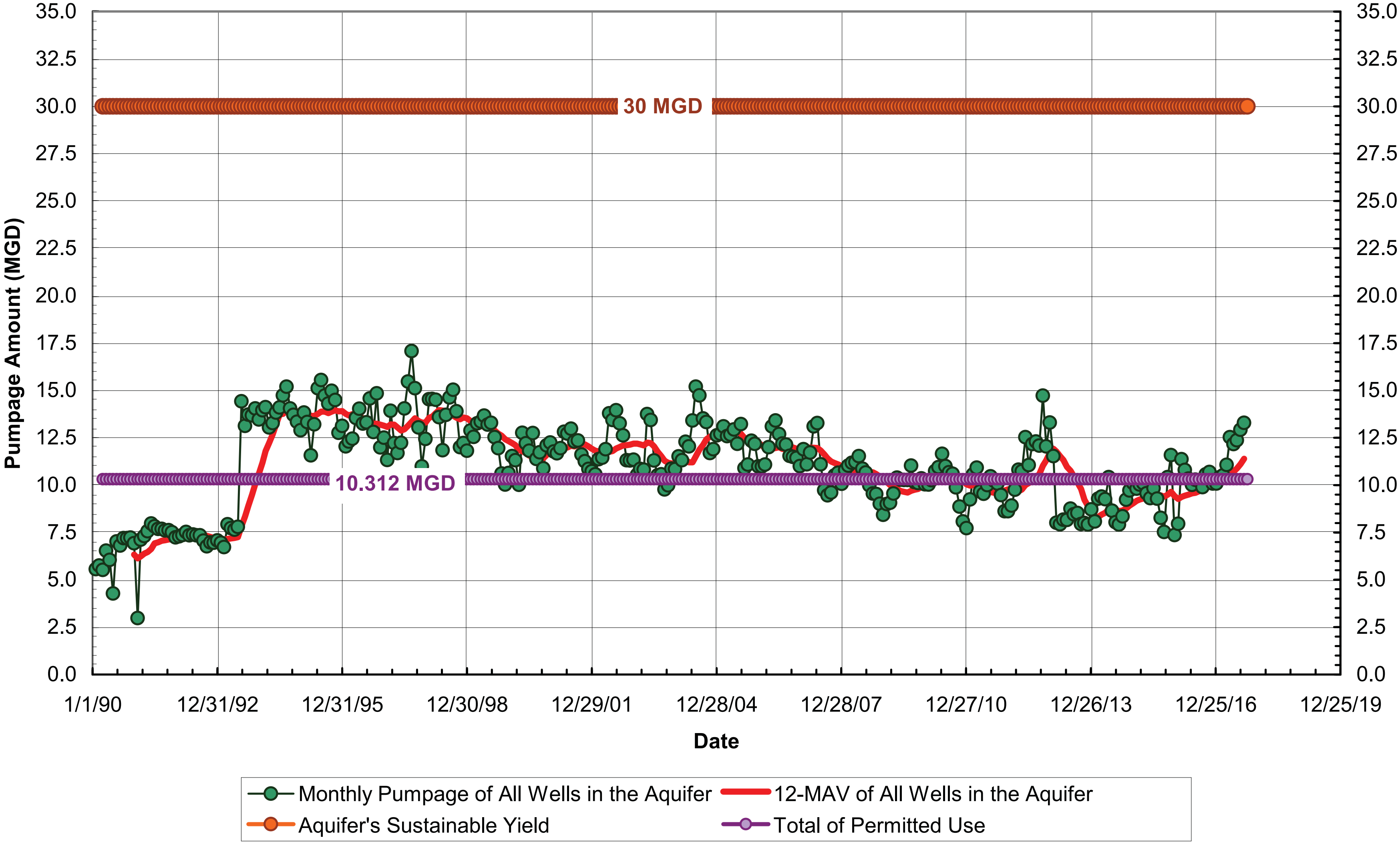


Source: Sherrod et al (2007 : p. 19)

Figure 2

Location of the Koolau Caldera

Figure 3. Pumpage of Wells in the Koolaupoko Aquifer System in Comparison to the CWRM's Sustainable Yield of the Aquifer System and the Total of Permitted Use



Of the 19 wells in the aquifer with permitted use permits, nine are nominally upgradient of the HMP site. Their locations are shown on Figure 4 and information on them is presented in Table 1. Most notable is that all of these wells tap into high level groundwater standing between 200 and 570 feet above sea level, apparently all drawing from dike confined compartments in the Koolau's dike complex. Since the mid-1990s, total pumpage of all nine wells has been less than their combined permitted use (Figure 5). Based on the locations of these wells and the groundwater occurrence they draw from, nothing at the existing HMP or what is planned for its expansion in the Petition Area has or will have an impact on their ongoing uses.

There are also five wells which are nominally downgradient from HMP. Their locations are also shown on Figure 4 and information on their construction and hydraulic performance are presented in Table 2. All five are shallow irrigation wells of modest capacity within the Bay View Golf Course. They draw water exclusively from the overlying alluvium of clayey silt and gravel rather than from the volcanics at depth. Use of the wells does require a Water Use Permit from the CWRM, but apparently such a permit was never obtained. Their modest use was reported to the CWRM for the 29-month period from the July 1997 to November 1999 (Figure 6), but not since then. It is not known if these wells are still in use. However, the planned expansion of HMP in the Petition Area would have no impact on their viability if they are still in use.

Information and Analysis of the Dug Well and Seep in the Petition Area

There is a dug well and perennial seep in the Petition Area that is of concern. Figure 7 shows their locations about 300 feet northwest of the loop road in the Ocean View Garden. The well is 11.5 feet deep below the top of its square-shaped concrete rim. The opening of the concrete is 2.65 by 2.9 feet. The dug borehole below the concrete is substantially larger than this opening. Figure 8 is a schematic cross section of the well and Appendix A contains photos of it. As measured a number of times during the field investigation, the water level in the well was consistently above the ground level on the downstream side of the well. The well is not registered with the CWRM and no information about its installation or past use could be found. Based on old pipe laying nearby, it may at one time have been a modest source of supply.

A small but perennial seep emerges about four feet downslope from the well. Further down the waterway, the flowrate in the waterway continuously increases enroute to its ultimate discharge into the drain inlet at the upper end of Ohaha Place. Given the additions to the flowrate enroute downslope, it is more accurate to describe the seep as an area of discharge rather than a discharge from a single point.

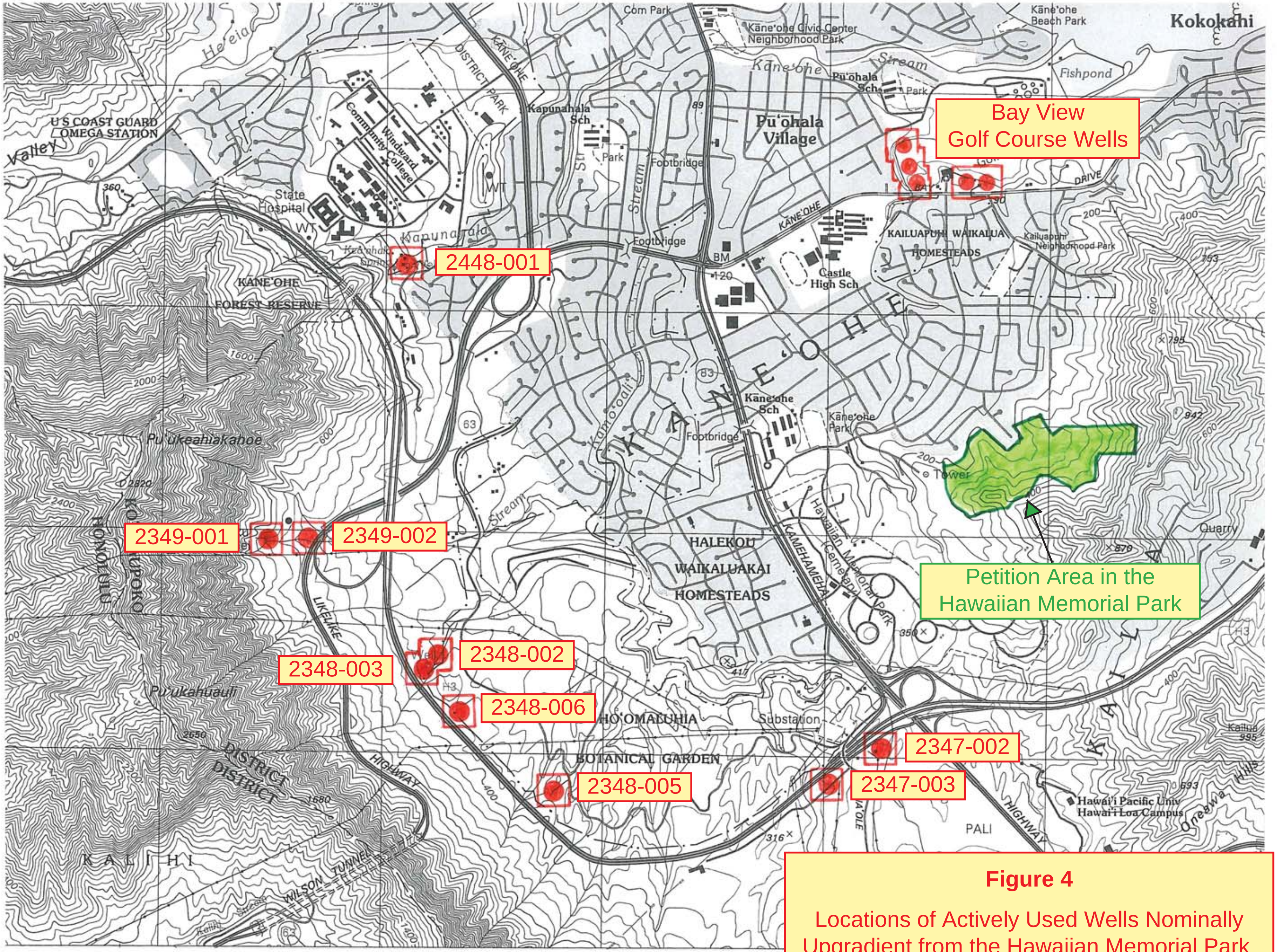


Figure 4

Locations of Actively Used Wells Nominally Upgradient from the Hawaiian Memorial Park

Scale: 1" = 2000'

o:_18-23

Table 1. Summary Information of Active Wells Nominally Upgradient of the Hawaiian Memorial Park

Well No.	Well Name	WUP (MGD)	Year Drilled	Ground Elevation (Ft. MSL)	Well Depth (Feet)	Elevation at Bottom (Ft. MSL)	SWL (Ft. MSL)	Hydraulic Performance (Feet @ GPM)	Installed Pump (GPM)
Wells of the Honolulu Board of Water Supply									
2348-002	Kuou I-1	2.375	1955	274	418	-144	310	262 @ 820	- -
2348-003	Kuou I-2	0.100	1955	293	280	13	290	5.2 @ 1500	2100
2348-005	Kuou II		1986	342	550	-208	258	126 @ 994	700
2348-006	Kuou III	0.700	1984	324	566	-242	255	135 @ 609	500
2349-001	Luluku Tunnel	0.713	1948	570	- -	- -	570	- -	- -
2349-002	Luluku	1.050	1984	412	460	-48	362	120 @ 739	700
Other Nominally Upgradient Wells									
2347-002	Koolau GC-1	0.150	1988	234	130	104	201	4.4 @ 300	350
2347-003	Koolau GC-2		1988	246	130	116	219	6 @ 400	350
2448-001	Hawaii State Hospital	0.088	1946	252	249	3	249	- -	450

Figure 5. Pumpage of the Nine Wells Nominally Upgradient of the Hawaiian Memorial Park

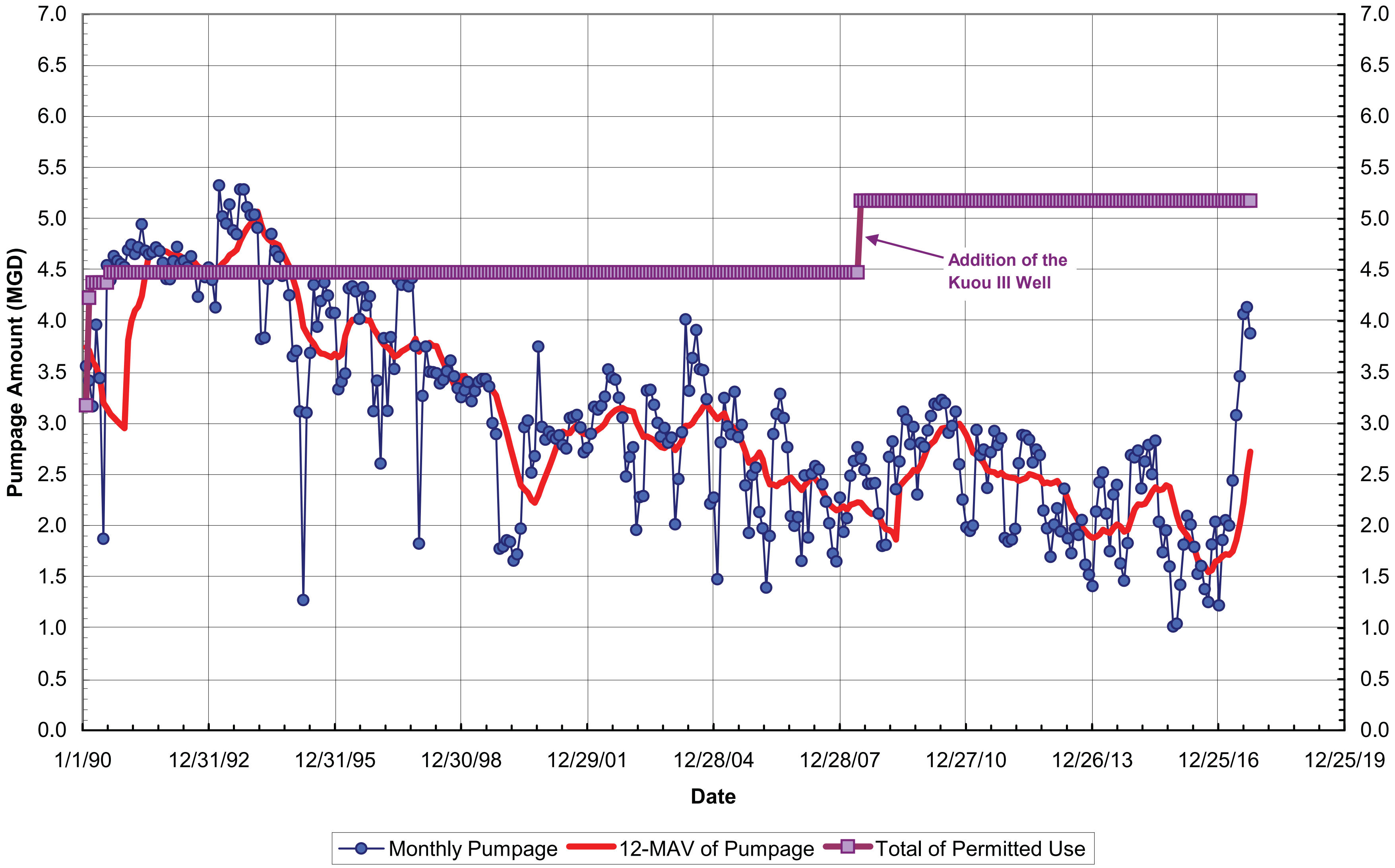
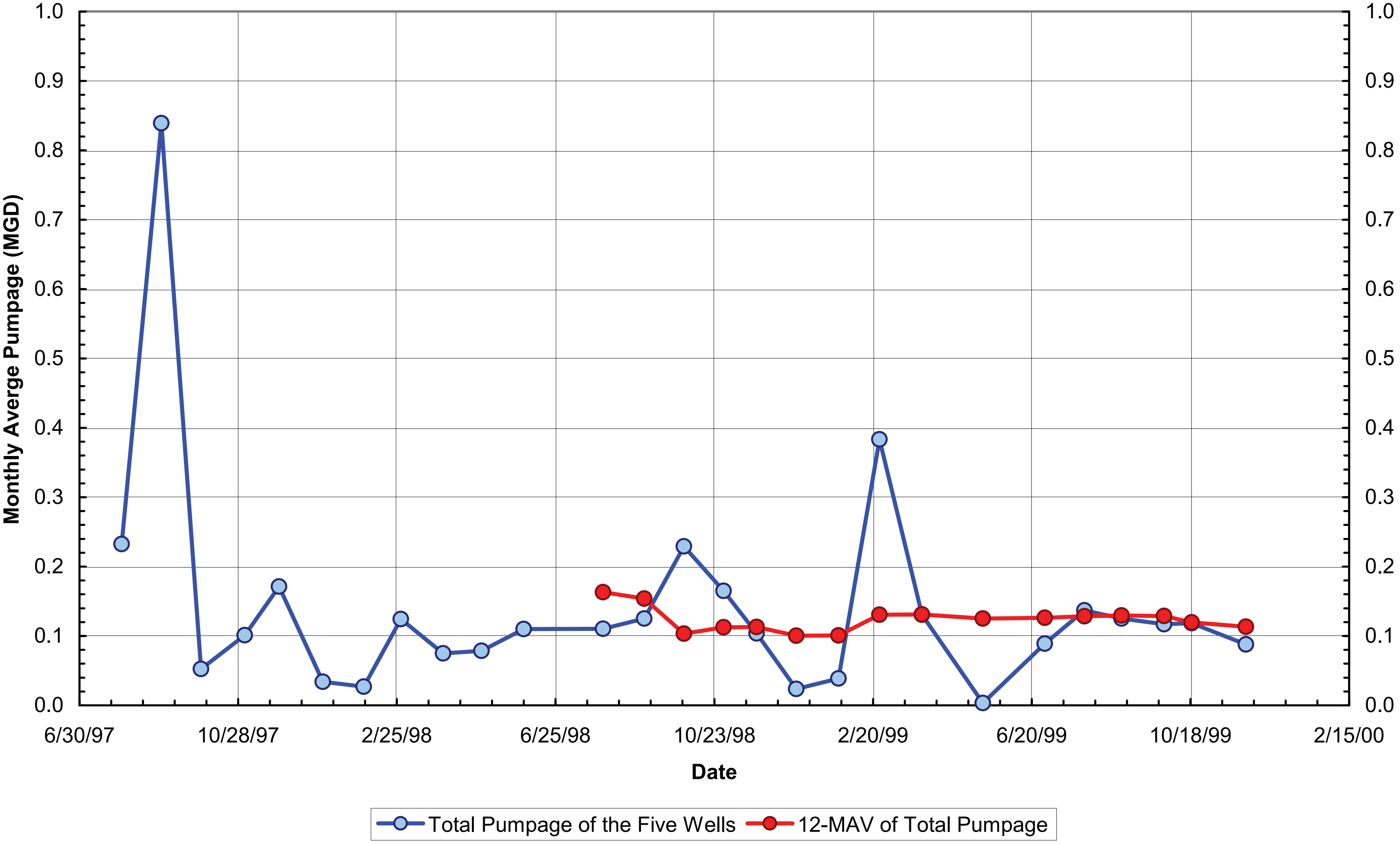


Table 2. Summary Information on the Five Bay View Golf Course Irrigation Wells

Well No.	Well Name	Year Drilled	Ground Elevation (Ft. MSL)	Well Depth (Feet)	Elevation at Bottom (Ft. MSL)	SWL (Ft. MSL)	Hydraulic Performance (Feet @ GPM)	Current Use
2447-002	Bay View 1	1995	13	50	-37	4.4	7.5 @ 50	Irrigation
2447-003	Bay View 2	1995	14	50	-36	5.1	5.8 @ 100	Irrigation
2447-004	Bay View 3	1995	15	50	-35	8.5	12 @ 60	Irrigation
2447-005	Bay View 4	1996	11	50	-39	8.4	7.4 @ 100	Irrigation
2447-006	Bay View 5	1996	22	60	-38	5.3	8.6 @ 100	Irrigation

Figure 6. Pumpage of the Bay View Golf Course Wells as Reported to the State Commission on Water Resource Management



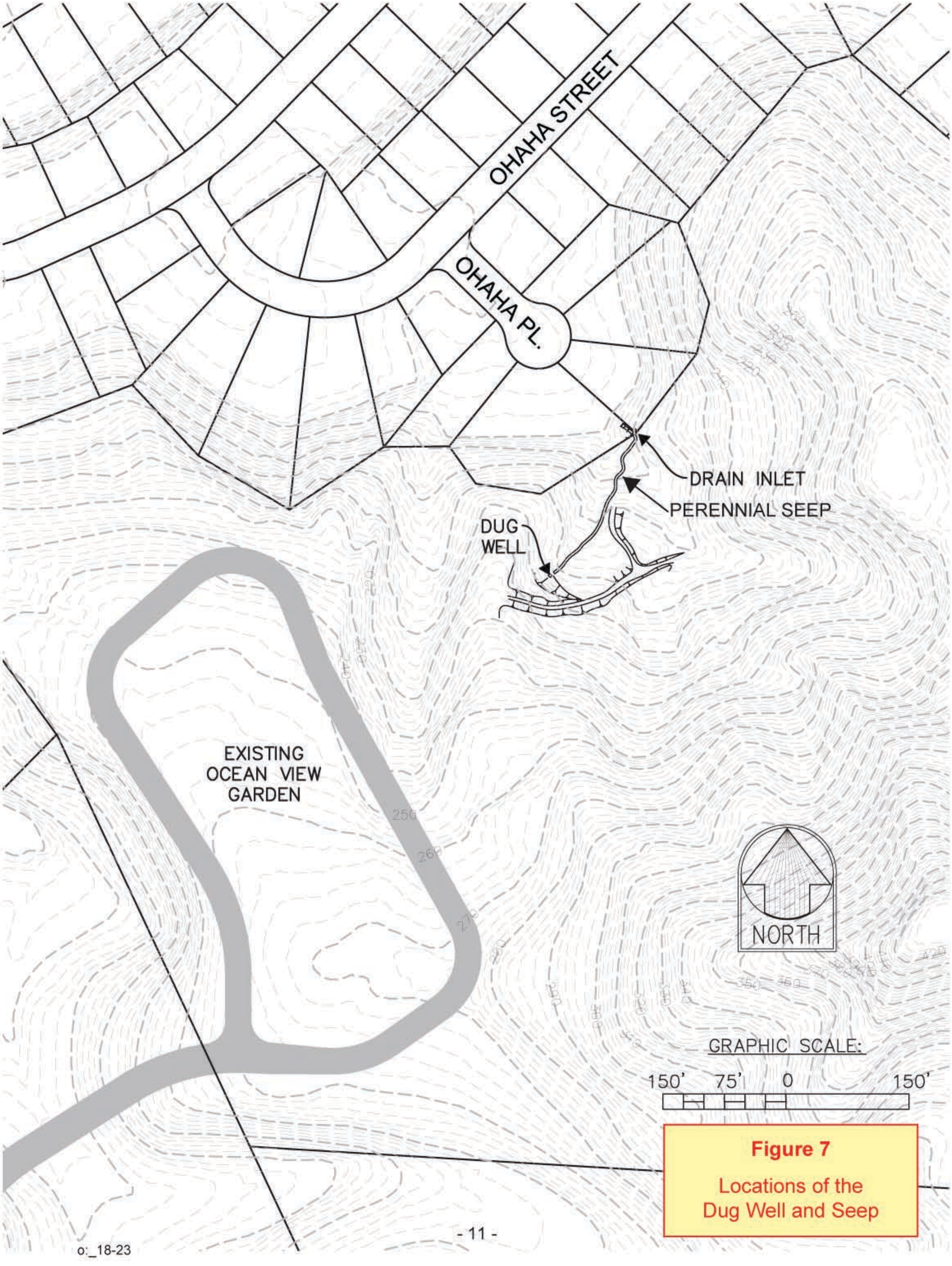


Figure 7

Locations of the Dug Well and Seep

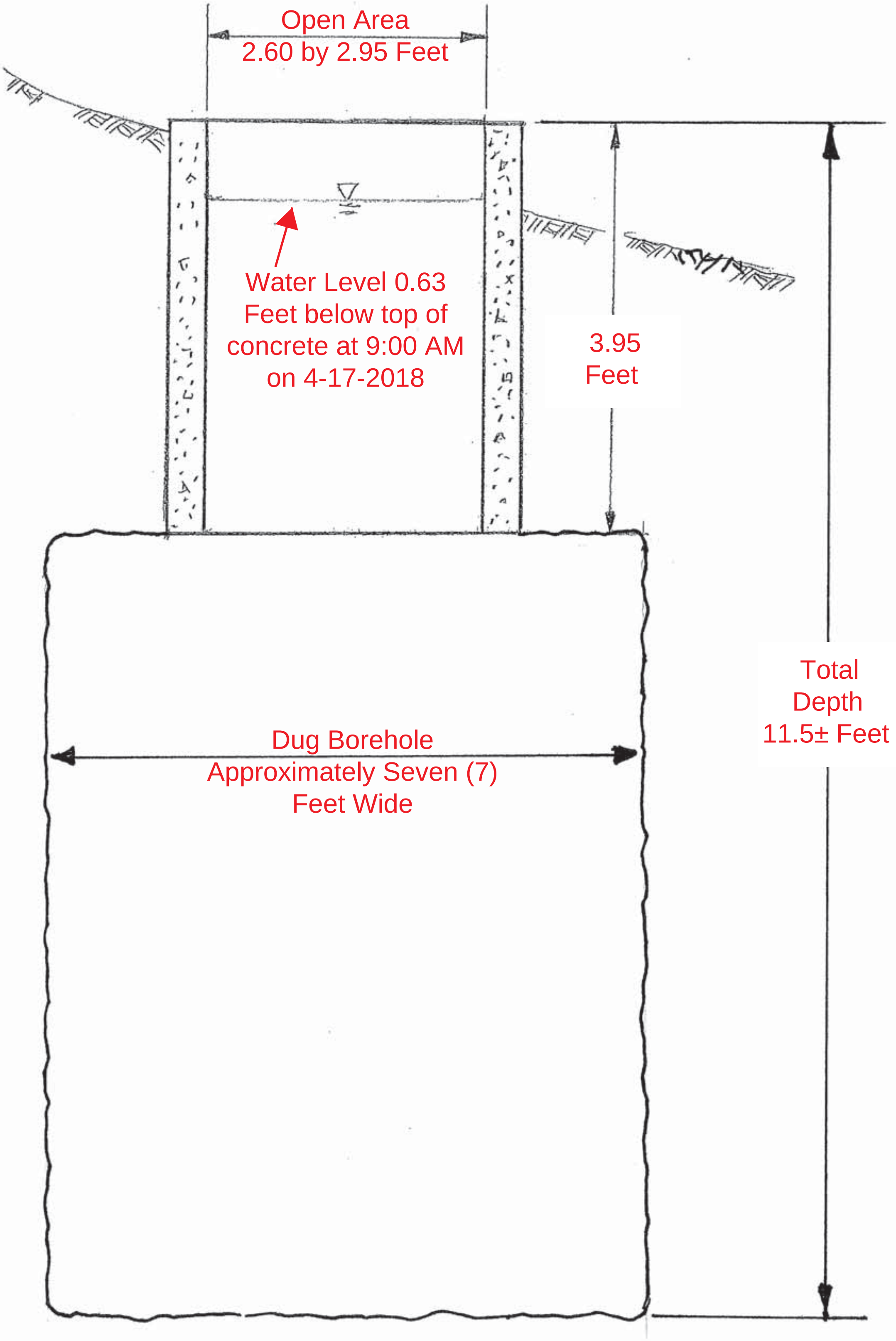


Figure 8

Schematic Cross Section of Dug Well

Implementation of the HMP expansion into the Petition Area would involve installation of retaining walls and fill of tens of feet in depth in the area upslope from the well and seep. Figures 9 and 10 illustrate these possibilities. On the assumption that supply to the dug well and seep is from a shallow perched water source that might be adversely impacted by footings for the retaining walls and/or compression by the weight of tens of feet of fill, two types of field investigation were undertaken: (1) drilling of four boreholes directly upslope of the well and seep; and (2) a siphon and pump test of the well to determine if subsurface leakage from the well is creating the seep that emerges just four feet downslope. Results of each of these investigations are described in the paragraphs following.

Results of the Four Boreholes Drilled Above the Well and Seep

Figure 11 shows the approximate locations of the four boreholes drilled above the well and seep and Appendix B contains the logs of these boreholes prepared by Geolabs, Inc. Although an obvious perching member was not encountered in the borings, the water level response in all four boreholes was instructive. Water was not encountered in each borehole until each borehole had been drilled down to between 15 to 20 feet below ground. After reaching that depth, the water level in each borehole very slowly rose up (Steven Carr of Geolabs, personal communication). Table 3 prepared by Geolabs documents this slow filing in each of the boreholes. As the tabulation of approximate water levels in the boreholes and the well in Table 4 shows, the semi-confined groundwater residing in the poorly permeable residual soil has a relatively steep downslope gradient

Results of Siphon and Pump Testing the Dug Well

On April 17, 2018, testing of the dug well was undertaken with two basic objectives: (1) to confirm that the semi-confined groundwater occurrence found at the four Geolabs boreholes directly upslope also exists at the dug well; and (2) to confirm that the seep that emerges four feet downslope of the well is a result of subsurface leakage from the well. Both aspects of the groundwater occurrence were confirmed by the test.

The intention was to run the test by siphoning from the well (and discharging downslope to maintain the siphon) rather than by pumping. Siphoning was begun at about 9:30AM at about 30 GPM, but the siphon was lost in less than 10 minutes. An attempt to restart the siphon also failed, this time in less than five (5) minutes. Thereafter, the well was pumped with a small, 1/4 horsepower sump pump, first at 17 GPM and then at about 15 GPM. The several aspects to note from the test data depicted on Figures 12 and 13 are as follows:

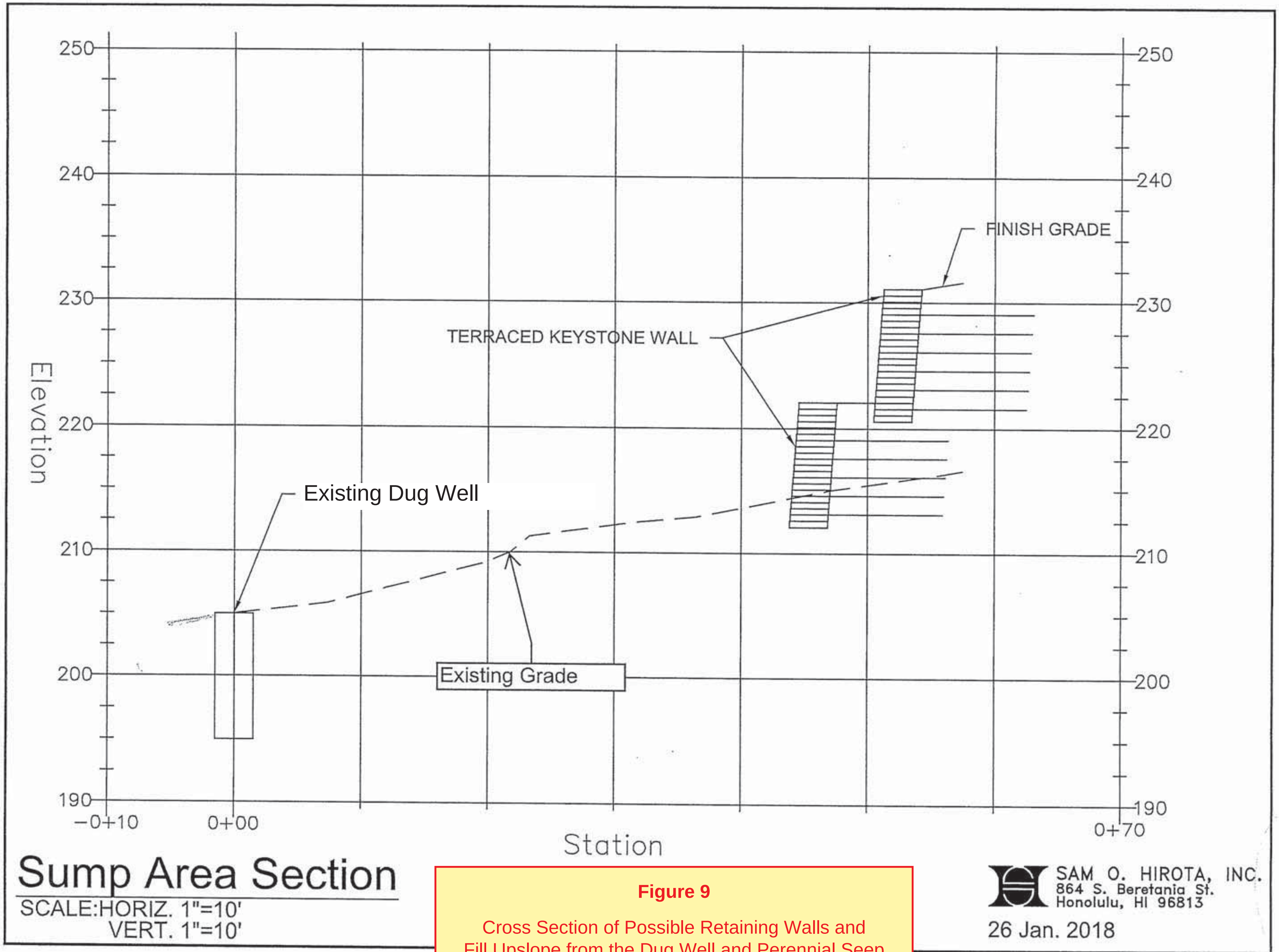
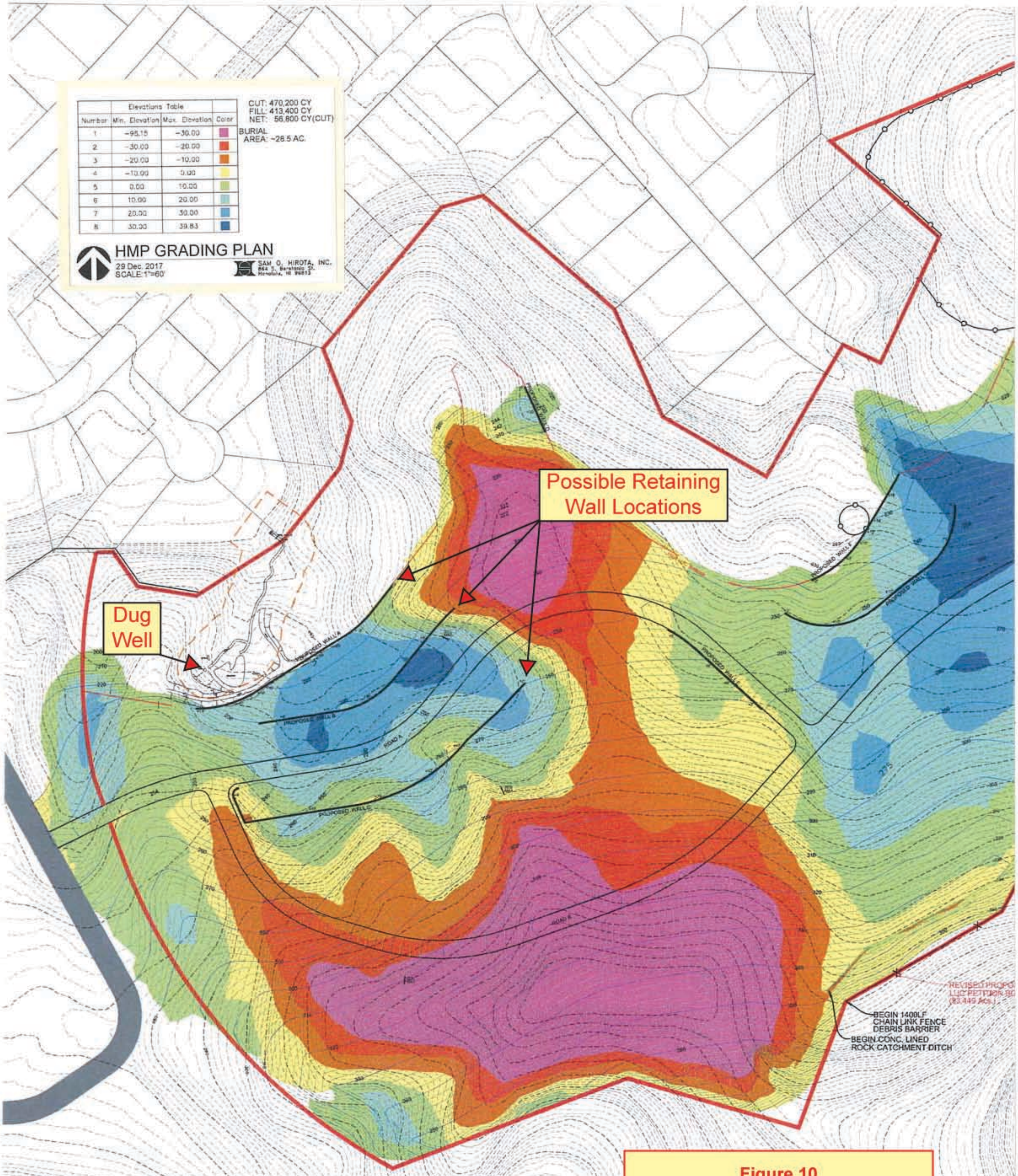


Figure 9

Cross Section of Possible Retaining Walls and Fill Upslope from the Dug Well and Perennial Seep



	Elevations Table		
Number	Min. Elevation	Max. Elevation	Color
1	-95.15	-30.00	🟪
2	-30.00	-20.00	🟥
3	-20.00	-10.00	🟧
4	-10.00	0.00	🟨
5	0.00	10.00	🟩
6	10.00	20.00	🟦
7	20.00	30.00	🟦
8	30.00	39.83	🟦

Figure 10

Possible Retaining Wall Locations

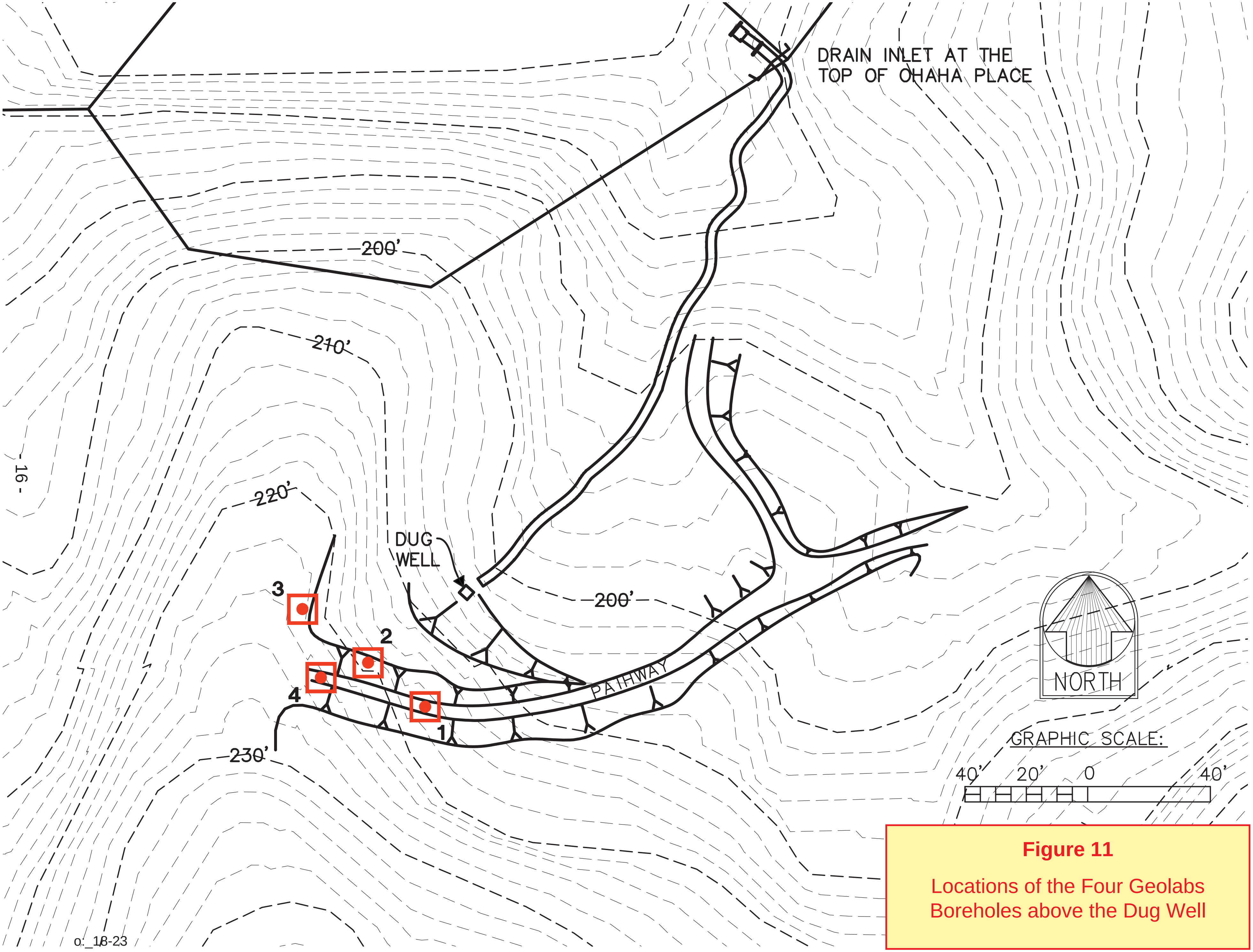


Figure 11

Locations of the Four Geolabs Boreholes above the Dug Well

Table 3. Water Level Measurements in the Four Boreholes
by Geolabs, Inc.

BORING NO. 1 WATER LEVEL MEASUREMENTS		
DATE/TIME	DEPTH TO WATER (FT.)	BOREHOLE DEPTH (FT.)
3/20/18 0945 hrs.	11.2	22
3/20/18 1030 hrs.	10.5	22
3/20/18 1120 hrs.	9.9	22
3/21/18 0800 hrs.	9.8	19
3/21/18 1130 hrs.	9.9	19
3/21/18 1435 hrs.	9.8	19
3/22/18 0755 hrs.	9.8	19
3/22/18 1330 hrs.	9.7	19
3/23/18 0745 hrs.	9.7	19

BORING NO. 2 WATER LEVEL MEASUREMENTS		
DATE/TIME	DEPTH TO WATER (FT.)	BOREHOLE DEPTH (FT.)
3/20/18 1450 hrs.	11.8	23
3/21/18 0805 hrs.	10.5	18.5
3/21/18 1135 hrs.	10.3	18.5
3/21/18 1440 hrs.	10.4	18.5
3/22/18 0750 hrs.	10.5	18.5
3/22/18 1115 hrs.	10.3	18.5
3/22/18 1325 hrs.	9.5	18.5
3/23/18 0750 hrs.	10.3	18.5

BORING NO. 3 WATER LEVEL MEASUREMENTS		
DATE/TIME	DEPTH TO WATER (FT.)	BOREHOLE DEPTH (FT.)
3/21/18 1245 hrs.	Not Encountered	18.5
3/21/18 1430 hrs.	Not Encountered	18.5
3/22/18 0745 hrs.	15.2	18.5
3/22/18 1110 hrs.	15.3	18.5
3/22/18 1320 hrs.	14.6	18.5
3/23/18 0755 hrs.	15.5	18.5

BORING NO. 4 WATER LEVEL MEASUREMENTS		
DATE/TIME	DEPTH TO WATER (FT.)	BOREHOLE DEPTH (FT.)
3/22/18 1201 hrs.	15.1	22
3/22/18 1315 hrs.	13.3	22
3/23/18 0800 hrs.	13.5	20

Table 4. Elevations, Depths, and Water Levels in the Four Boreholes in Comparison to the Dug Well

Borehole Number	Approximate Ground Elevation (Ft. MSL)	Borehole Depth (Feet)	Approximate Elevation at Bottom (Ft. MSL)	Depth to Water (Feet)	Approximate Water Level (Ft. MSL)
1	217	22	195	10	207
2	218	23	195	10	208
3	222	19	203	15	207
4	224	19	205	13	211
Well	205	12	193	2	203

Figure 12. Water Level Response to the Siphon and Pump Test of the HMP Dug Well

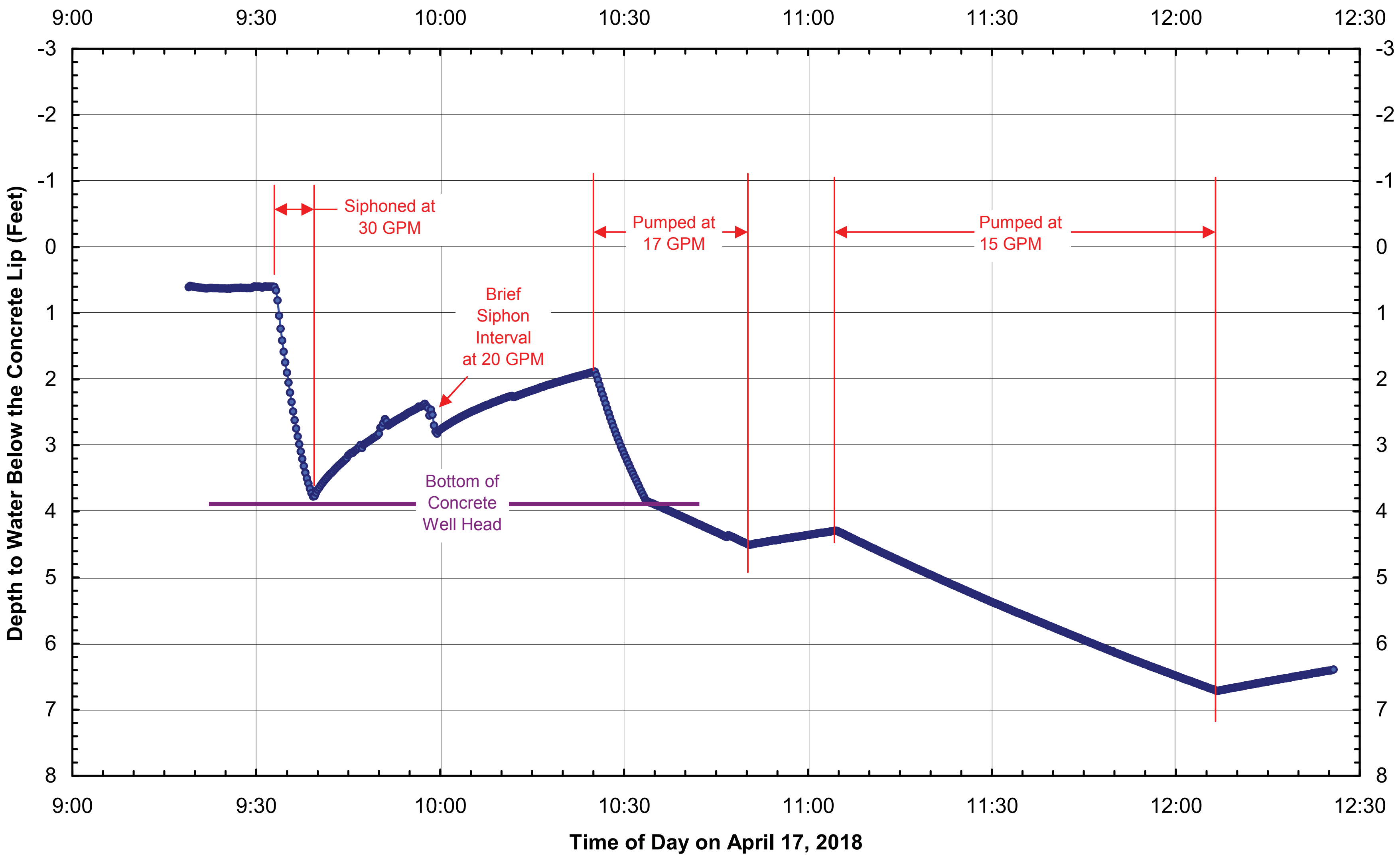
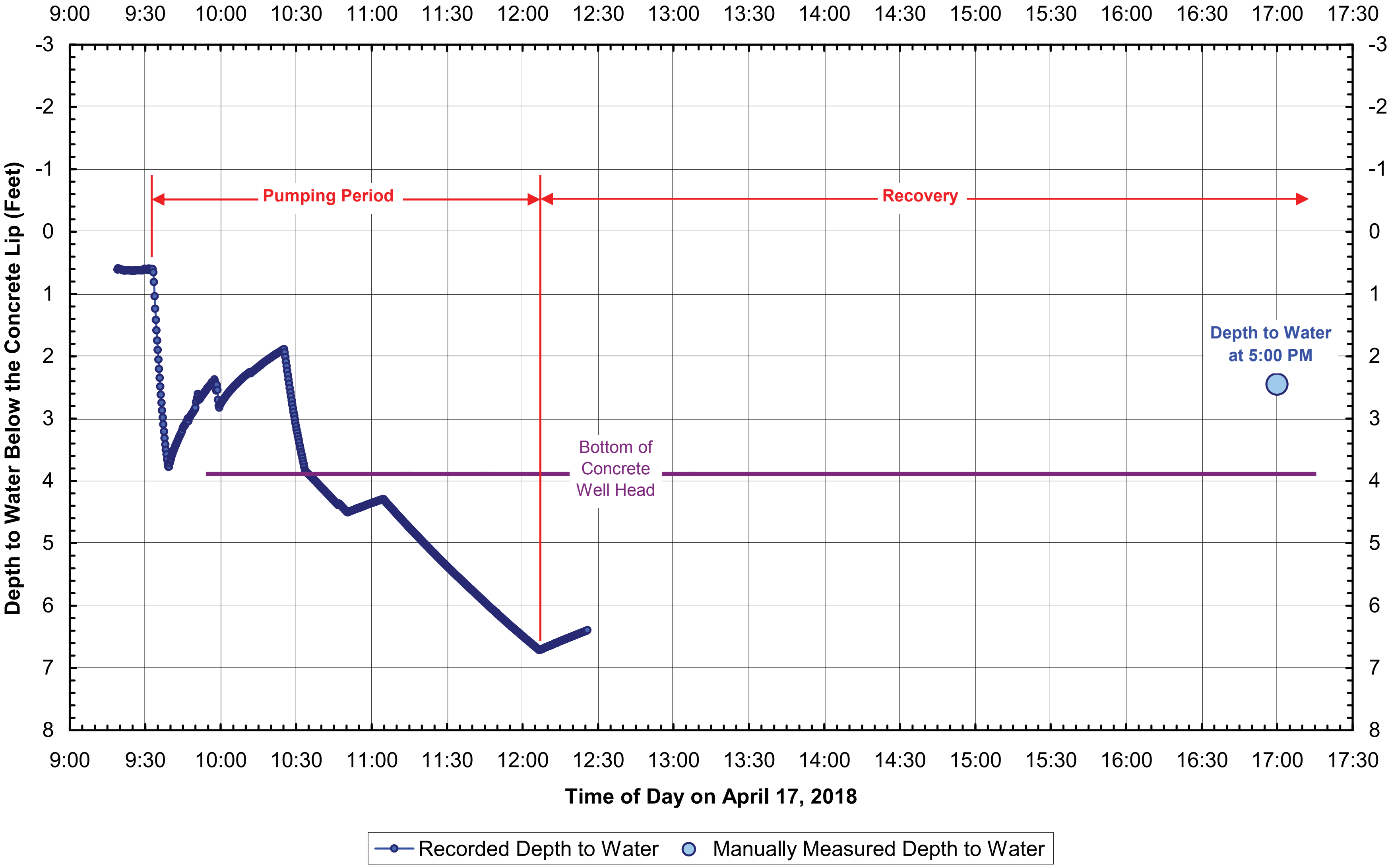


Figure 13. Manually Measured Recovered Water Level in the HMP Dug Well



- When the water level in the well was drawn down about halfway down the concrete well head, the seep that emerges about four feet downslope had stopped flowing. Clearly, the seep is maintained by subsurface leakage from the well.
- Over the period of intermittent siphoning and then pumping, a total of 1615 gallons was removed from the well. Assuming the 7-foot wide borehole below the concrete is approximately round, 950 gallons was removed from storage in the well itself and the remaining 665 gallons flowed from the formation into the well. That inflow was at an average of about 4.3 GPM.
- The recovered water level was manually measured at 5:00PM (Figure 13). The water level had risen up inside the concrete well head, but not high enough to have started flow in the downstream seep. Average inflow to the well from the time pumping was stopped at 12:07PM until the 5:00PM measurement was approximately 3.1 GPM.
- The well's water level was checked at 9:30AM on the day following (April 18th). The water level had fully recovered (actually to a level 0.1-foot higher than at the start of the test the day before). The seep below the well was fully restored at that time.

Summary of Findings, Conclusions, and Recommendations

1. The entire Petition Area overlies on a geologic formation known as the Kailua series volcanics. These caldera-filling volcanics are virtually impermeable. As such, none of the proposed actions within the Petition Area have the potential to impact ongoing or possible future uses of groundwater drawn from the permeable Koolau volcanics of the Koolaupoko Aquifer System.

2. With regard to the perennial groundwater seep which has created the habitat for the damsel fly, field observations, the four boreholes drilled by Geolabs, Inc., and the test of the dug well have established the following regarding this groundwater occurrence:

   (a) The groundwater seep is maintained by the natural discharge of groundwater moving downslope through the poorly permeable residual soils overlying the unweathered Kailua volcanics at depth.

   (b) In the vicinity of the dug well and the four Geolabs boreholes upslope from the wells, the groundwater is actually semi-confined. The groundwater movement is through soils at depths of 10 feet or more rather than through the surface soils.

   (c) The upper end of the seep begins about four (4) feet downslope of the dug well. Based on results of the well test, flow in the upper one third to one half of the linear seep is maintained by subsurface leakage from the well.

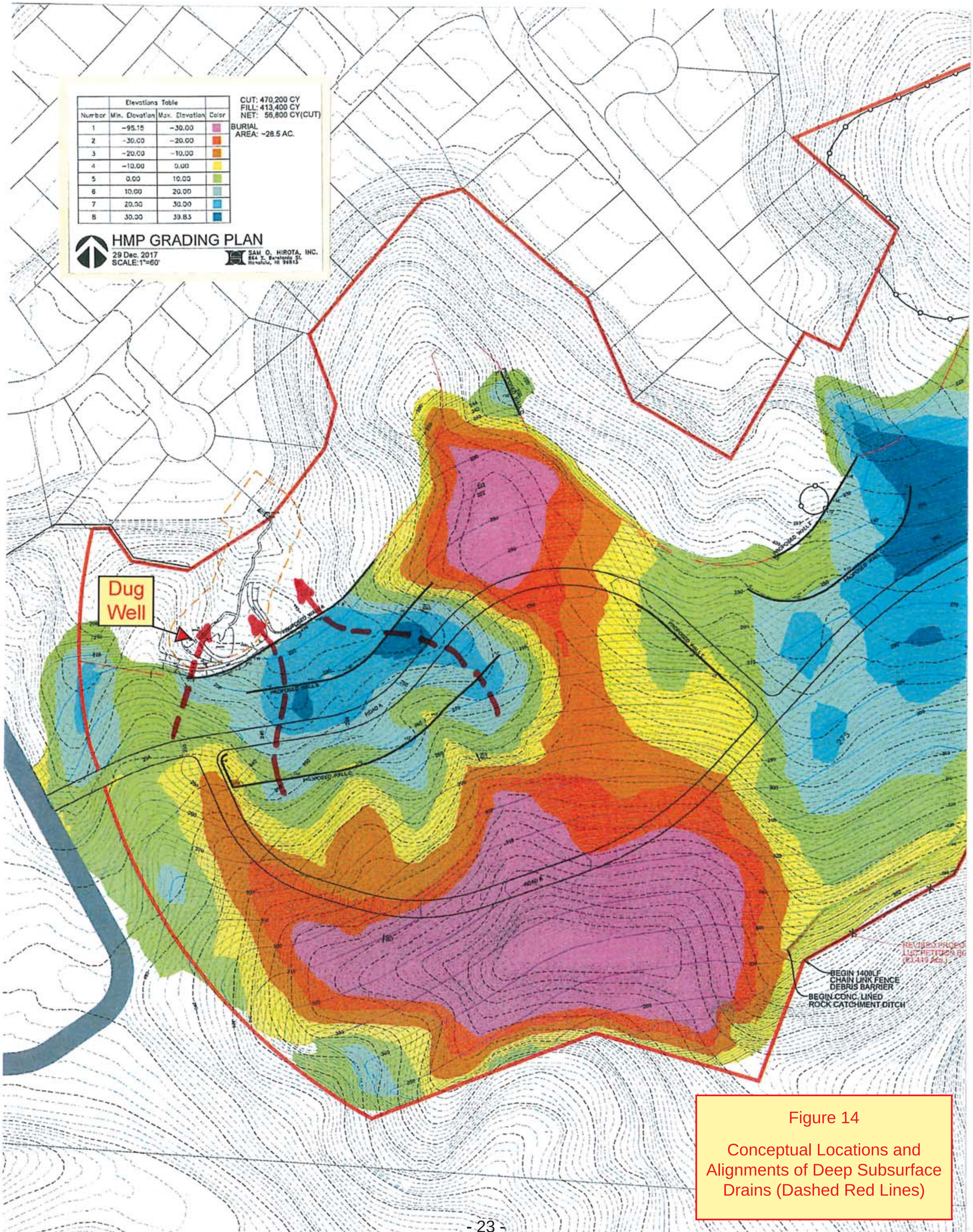
(d) Further downslope, flow in the seep increases continuously to its ultimate discharge into the Ohaha Place drainage system.

3. The proposed expansion into the Petition Area would include construction of a sequence of three (essentially parallel) retaining walls upslope of the dug well and perennial seep (Walls A, B, and C on Figure 10) and fill heights of 10 to 30 feet behind these walls (depths of fill are color coded on Figure 10). The concern is that the retaining walls and/or the fill behind them may intercept, impede, or reroute the groundwater flow that maintains the perennial seep and thereby diminish or destroy the damsel fly habitat. This potential impact is addressed in the following:

(a) Based on the groundwater occurrence established by the four Geolabs borings and the dug well, the footings of the proposed retaining walls would be too shallow to intercept the groundwater moving downslope. The walls and the fill behind them will have subsurface drains (Geolabs Inc., 2018: page 30 and Plate 6), but these will be too shallow to intercept the groundwater which maintains the downslope seep.

(b) Loading by the fill behind the retaining walls does have the potential to compress the soils below through which the groundwater is moving downslope. As such, this loading could reduce the permeability of these already poorly permeable soils, impeding or re-routing the downslope direction of the groundwater flow.

(c) To ensure that the quantity and direction of groundwater flow is maintained, at least two and possibly three deeper subsurface drains should be constructed. These would be aligned approximately perpendicular to the retaining walls and installed at depths to intercept and convey the flow of groundwater to the dug well seep. Their possible alignments are shown conceptually on Figure 14. Their exact locations, alignments, and depths would be determined with the drilling of additional boreholes in the project's design phase.



	Elevations Table		
Number	Min. Elevation	Max. Elevation	Color
1	-95.15	-30.00	🟪
2	-30.00	-20.00	🟥
3	-20.00	-10.00	🟧
4	-10.00	0.00	🟨
5	0.00	10.00	🟩
6	10.00	20.00	🟦
7	20.00	30.00	🟦
8	30.00	39.83	🟦

Figure 14

Conceptual Locations and Alignments of Deep Subsurface Drains (Dashed Red Lines)

References

Geolabs, Inc. 2018. Phase 1 Potential Rockfall and Slope Hazard Assessment, Hawaiian Memorial Park Cemetery Expansion. Consultant Report prepared for HHF Planners.

Sherrod, D. R., J. M. Sinton, S. E. Watkins, and K. M. Brunt. 2007. Geologic Map of the State of Hawaii. U.S. Geological Survey Open-File Report 2007-1089, U.S. Department of the Interior, U.S. Geological Survey.

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Sterns, H. T. 1939. Geologic Map and Guide of the Island of Oahu, Hawaii. Bulletin 2, Division of Hydrography, Territory of Hawaii.

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Appendix

A. Photos of the Dug Well and Seep Taken on March 30, 2018

B. Logs of the Boreholes Drilled Above the Dug Well and Seep by Geolabs, Inc.

C. Logs of the B-1 and B-2 Boreholes Drilled in Ocean View Garden by Geolabs, Inc.

Appendix A

Photos of the Dug Well and Seep
Taken on March 30, 2018

View of the Concrete Top of the Well
Note the Water Level in Relation to the Adjacent Ground Level

View of the Top of the Well from the Other Side
Note Tree Growth into the Well

Relationship of the Well to the Emergent Seep Four Feet Downslope

Flow from the Seep to the Adjacent Subdivision’s Drain Inlet

Appendix B

Logs of the Boreholes Drilled Above the Dug Well and Seep by Geolabs, Inc.

PLog

GEOLABS, INC.

Geotechnical Engineering

GROUNDWATER SPRING DISCHARGE
Hawaiian Memorial Park

Log of Boring

1

Approximate Ground Surface
Elevation (feet): 218 *
Latitude:21.39464
Longitude: -157.7887

Field										
Drilling Notes	Sample Quality	Rec. Length/ Sample Length (inches)	RQD Length/ Sample Length (inches)	Blows/ 6"	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
									MH	Orangish brown **CLAYEY SILT**, stiff to very stiff, moist (residual soil)
	Good	10/18"		3/8/11						
	Fair	23/24"		5/7/10/13						
									CH	Mottled orangish brown and gray **SILTY CLAY**, very stiff, moist (residual soil)
						5				
									MH	Mottled orangish brown with some gray **CLAYEY SILT**, stiff to very stiff, moist (residual soil)
	Good	16/18"		6/10/13						
	Fair	23/24"		3/5/6/9						
					▼					
						10				grades with gray silty clay seams locally
	Good	15/18"		8/10/12						
										grades with decomposed gravel
									SM	Brown with trace gray **SILTY SAND (BASALTIC)**, loose to medium dense, very moist to wet (saprolite)
						15				
	Fair	22/24"		1/2/1/2						
										grades with sandy silt
									ML	Gray with some brown **CLAYEY SILT** with some fine sand, stiff, moist (residual soil)
	Fair	23/24"		2/5/6/4		20				
										Boring terminated at 22 feet
						25				
						30				
						35				

Date/Time Started:	March 19, 2018 10:45	Water Level: ▼	9.1 ft. 03/22/2018 1330 HRS	Plate
Date/Time Completed:	March 20, 2018 11:20			
Logged By:	S. Latronic	Driller Name:	K. Vongamath	
Project Engineer:	Steven Carr	Drill Rig:	MINUTEMAN	
Total Depth:	22 feet	Drilling Method:	3" Solid Stem Auger	
Work Order:	7604-10	Driving Energy:	140 lb. wt., 30 in. drop	

BORING LOG DRAFT 7604-10.GPJ GEOLABS.GDT 3/23/18

PLog

GEOLABS, INC.

Geotechnical Engineering

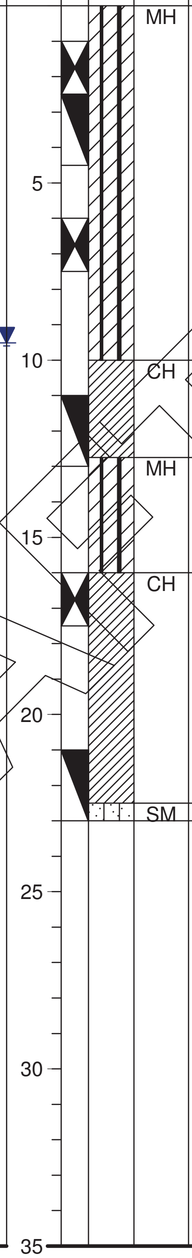
GROUNDWATER SPRING DISCHARGE
Hawaiian Memorial Park

Log of Boring

2

Approximate Ground Surface
Elevation (feet): 220 *
Latitude:21.39451
Longitude: -157.78868

Field											
Drilling Notes	Sample Quality	Rec. Length/ Sample Length (inches)	RQD Length/ Sample Length (inches)	Blows/ 6"	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
									MH	Orangish brown with trace gray **CLAYEY SILT**, stiff to very stiff, moist (residual soil)
	Good	10/18"		5/9/15						
	Fair	16/24"		5/6/5/7						
						5				grades with gray silty clay seams locally
	Good	10/18"		5/8/13						
					▼					
						10			CH	Gray with trace brown **FAT CLAY**, stiff, moist (residual soil)
	Fair	24/24"		2/4/4/3						
									MH	Brown with some gray **CLAYEY SILT**, stiff, moist to very moist (residual soil)
						15				
										grades with gravel (basaltic)
	Good	16/18"		4/8/11					CH	Mottled brown and gray **SILTY CLAY**, stiff to very stiff, moist (residual soil)
						20				
	Fair	24/24"		3/5/6/6						
									SM	Brown **SILTY SAND (BASALTIC)** with some decomposed gravel, medium dense, very moist to wet (saprolite)
						25				Boring terminated at 23 feet
						30				
						35				



Date/Time Started:	March 20, 2018 11:30	Water Level: ▼	9.5 ft. 03/22/2018 1325 HRS
Date/Time Completed:	March 20, 2018 15:30		
Logged By:	S. Latronic	Driller Name:	K. Vongamath
Project Engineer:	Steven Carr	Drill Rig:	MINUTEMAN
Total Depth:	23 feet	Drilling Method:	3" Solid Stem Auger
Work Order:	7604-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate

PLog

GEOLABS, INC.

Geotechnical Engineering

GROUNDWATER SPRING DISCHARGE
Hawaiian Memorial Park

Log of Boring

3

Approximate Ground Surface
Elevation (feet): 221 *
Latitude:21.39473
Longitude: -157.78871

Drilling Notes	Sample Quality	Rec. Length/ Sample Length (inches)	RQD Length/ Sample Length (inches)	Blows/ 6"	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
							MH	Orangish brown **CLAYEY SILT**, stiff to very stiff, moist (residual soil)
	Good	10/18"		9/17/29				
	Fair	15/24"		6/6/6/9				
						5		
	Good	9/18"		5/10/10				
						10		
	Fair	14/24"		4/6/8/7			ML/MH	Mottled orangish brown to yellowish brown **CLAYEY SILT**, stiff, moist to very moist (residual soil)
						▼ 15		
	Good	16/18"		5/11/12				
								grades with decomposed gravel
							CH	Brownish gray to gray **FAT CLAY**, stiff, very moist (residual soil)
	Fair	17/24"		6/9/10/13		20		
								Boring terminated at 22 feet
						25		
						30		
						35		

Date/Time Started:	March 21, 2018 09:00	Water Level: ▼	14.6 ft. 03/22/2018 1320 HRS
Date/Time Completed:	March 21, 2018 14:50		
Logged By:	S. Latronic	Driller Name:	K. Vongamath
Project Engineer:	Steven Carr	Drill Rig:	MINUTEMAN
Total Depth:	22 feet	Drilling Method:	3" Solid Stem Auger
Work Order:	7604-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate

PLog

GEOLABS, INC.

Geotechnical Engineering

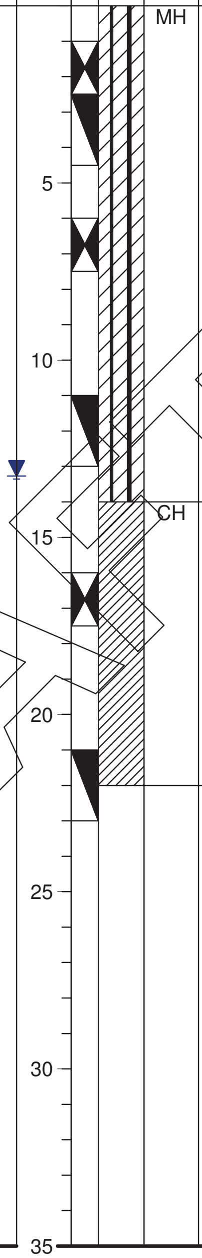
GROUNDWATER SPRING DISCHARGE
Hawaiian Memorial Park

Log of Boring

4

Approximate Ground Surface
Elevation (feet): 225 *
Latitude:21.3946
Longitude: -157.78868

Drilling Notes	Sample Quality	Rec. Length/ Sample Length (inches)	RQD Length/ Sample Length (inches)	Blows/ 6"	Pocket Pen. (tsf)	USCS	Description
	Good	16/18"		11/13/26		MH	Orangish brown with trace yellowish brown **CLAYEY SILT**, stiff to very stiff, moist (residual soil)
	Fair	19/24"		8/8/10/9			
	Good	8/18"		8/9/12			grades with trace gray silty clay seams locally
	Fair	13/24"		3/4/5/7			grades with decomposed gravel
	Good	17/18"		4/7/8		CH	Brownish gray to gray **FAT CLAY**, stiff, moist to very moist (residual soil)
	Fair	24/24"		3/4/4/7			grades with brown clayey silt seams locally
							Boring terminated at 23 feet



Date/Time Started:	March 22, 2018 08:30	Water Level: ▼	13.3 ft. 03/22/2018 1315 HRS
Date/Time Completed:	March 22, 2018 14:00		
Logged By:	S. Latronic	Driller Name:	K. Vongamath
Project Engineer:	Steven Carr	Drill Rig:	MINUTEMAN
Total Depth:	23 feet	Drilling Method:	3" Solid Stem Auger
Work Order:	7604-10	Driving Energy:	140 lb. wt., 30 in. drop

Plate

Appendix C

Logs of the B-1 and B-2 Boreholes Drilled in Ocean View Garden

by Geolabs, Inc.

GEOLABS, INC.

Geotechnical Engineering

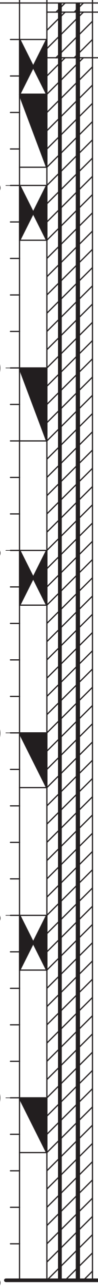
PHASE I POTENTIAL ROCKFALL AND
SLOPE HAZARD ASSESSMENT
HAWAIIAN MEMORIAL PARK CEMETERY EXPANSION
TMK: 4-5-033: 001
KANEOHE, OAHU, HAWAII

Log of Boring

1

Approximate Ground Surface Elevation (feet): 269 *

Laboratory		Field							
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	USCS	Description
								MH	Orangish brown **CLAYEY SILT** with a little gravel (basaltic), very stiff, moist (fill)
	50	62			12	4.0		MH	
								MH	Mottled orangish brown **CLAYEY SILT** with some sand, very stiff, moist (residual soil)
	54				5				
									Mottled orangish brown with some dark gray **CLAYEY SILT** with some sand and traces of decomposed gravel, stiff to very stiff, moist (saprolite)
Direct Shear	56	62			9	4.0	5		
LL=72 PI=22	62				6		10		
TXCU					7	4.0	15		grades with yellowish brown mottling locally
	49				17		20		grades more clayey locally
	53	70			24	4.0	25		
LL=79 PI=30	59				11		30		
							35		



Date Started:	October 12, 2017	Water Level: ▼	Not Encountered
Date Completed:	October 12, 2017		
Logged By:	S. Latronic	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*
Total Depth:	46.5 feet	Drilling Method:	4" Solid Stem Auger
Work Order:	7604-00	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 1.1

GEOLABS, INC.

Geotechnical Engineering

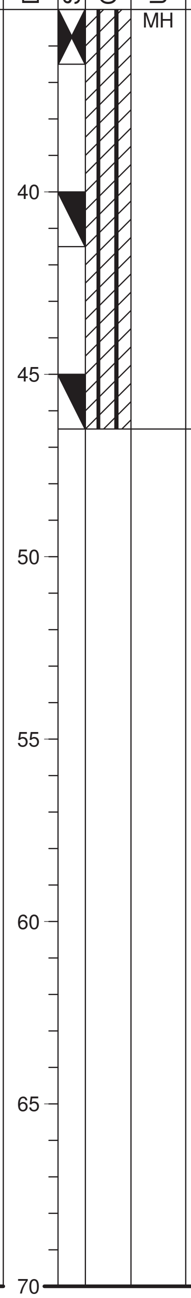
PHASE I POTENTIAL ROCKFALL AND
SLOPE HAZARD ASSESSMENT
HAWAIIAN MEMORIAL PARK CEMETERY EXPANSION
TMK: 4-5-033: 001
KANEOHE, OAHU, HAWAII

Log of Boring

1

(Continued from previous plate)

Laboratory			Field						
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	USCS	Description
Direct Shear	55	69			18	2.3	MH	
	51				10			
								grades with highly weathered basalt corestones locally
LL=66 PI=33	48				15			
								grades to very moist



Boring terminated at 46.5 feet

* Elevations based on available Grading Plan for Ocean View Gardens.

Date Started:	October 12, 2017	Water Level: ▼	Not Encountered
Date Completed:	October 12, 2017		
Logged By:	S. Latronic	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*
Total Depth:	46.5 feet	Drilling Method:	4" Solid Stem Auger
Work Order:	7604-00	Driving Energy:	140 lb. wt., 30 in. drop

Plate

A - 1.2

BORING_LOG 7604-00.GPJ GEOLABS.GDT 11/30/17

GEOLABS, INC.

Geotechnical Engineering

PHASE I POTENTIAL ROCKFALL AND
SLOPE HAZARD ASSESSMENT
HAWAIIAN MEMORIAL PARK CEMETERY EXPANSION
TMK: 4-5-033: 001
KANEOHE, OAHU, HAWAII

Log of Boring

2

Approximate Ground Surface Elevation (feet): 263 *

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
										MH	Brown **CLAYEY SILT** with some sand and traces of gravel (basaltic), very stiff to hard, moist (fill)
	34	82			40	4.5		⧗			
LL=66 PI=29	34				30			▼			
	32	86			34	4.5	5	⧗			
	37				40			▼			
										MH	Mottled orangish brown **CLAYEY SILT**, very stiff to hard, moist (residual soil)
										MH	Mottled grayish brown with some orange **CLAYEY SILT** with some sand and a little decomposed gravel, hard, moist (saprolite)
LL=65 PI=8	35	77			68	4.5	10	⧗			
										MH	Mottled orangish brown **CLAYEY SILT** with some sand, stiff to very stiff, moist (saprolite)
	55				6		15	▼			
Direct Shear	54	50			16	3.5	20	⧗			
											grades more sandy locally
LL=81 PI=21	65				5		25	▼			
Direct Shear	71	57			13	2.3	30	⧗			
											grades more clayey
							35				

Date Started:	October 12, 2017
Date Completed:	October 12, 2017
Logged By:	S. Latronic
Total Depth:	46.5 feet
Work Order:	7604-00

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

Plate

A - 2.1

GEOLABS, INC.

Geotechnical Engineering

PHASE I POTENTIAL ROCKFALL AND
SLOPE HAZARD ASSESSMENT
HAWAIIAN MEMORIAL PARK CEMETERY EXPANSION
TMK: 4-5-033: 001
KANEOHE, OAHU, HAWAII

Log of Boring
2

Laboratory			Field								(Continued from previous plate)
Other Tests	Moisture Content (%)	Dry Density (pcf)	Core Recovery (%)	RQD (%)	Penetration Resistance (blows/foot)	Pocket Pen. (tsf)	Depth (feet)	Sample	Graphic	USCS	Description
	50				17					MH	Mottled yellowish brown and gray **CLAYEY SILT** with a little gravel (basaltic) and remnant rock structure, very stiff, moist (saprolite)
	44	77			26	3.5	40				
											grades with highly weathered basalt corestones locally
	23				19		45				
											grades more silty
											Boring terminated at 46.5 feet
							50				
							55				
							60				
							65				
							70				

Date Started:	October 12, 2017	Water Level: ▼	Not Encountered
Date Completed:	October 12, 2017		
Logged By:	S. Latronic	Drill Rig:	CME-45C TRUCK *(Energy Transfer Ratio = 78%)*
Total Depth:	46.5 feet	Drilling Method:	4" Solid Stem Auger
Work Order:	7604-00	Driving Energy:	140 lb. wt., 30 in. drop

Plate
A - 2.2