Final Environmental Impact Statement

Prepared in Accordance with Hawaii Revised Statutes Chapter 343 and Hawaii Administrative Rules Chapter 11-200.

PVT Integrated Solid Waste Management Facility Relocation

Waianae District, Oahu, Hawaii

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January 2020

Volume II

Prepared for:

PVT LAND COMPANY LIMITED

Prepared by:

HARTCROWSER

PRYZM CONSULTING

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APPENDIX A
Geology, Hydrology, and Water Quality Report

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Geology, Hydrology and Water Quality Report

PVT Integrated Solid Waste Management Facility Relocation
Nānākuli, O‘ahu, Hawai‘i

March 2019

Prepared for:

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List of Acronyms

°C	Degrees Celsius
BMP	Best Management Practice
BS	Beaches
C&D	Construction and Demolition
$CaCO_3$	Calcium Carbonate
cis-1,2-DCE	Cis-1,2-Dichloroethene
cm/s	Centimeters per Second
CR	Coral Outcrop
CUSUM	Cumulative Sum
DCA	1,2-Dichloroethane
DLNR	State of Hawai'i Department of Land and Natural Resources
DMR	Discharge Monitoring Report
DOH	State of Hawai'i Department of Health
DRO	Diesel Range Organics
EAL	Environmental Action Level
HAR	Hawai'i Administrative Rules
LPE	Lualualei Extremely Stony Clay, 3 to 35 percent slopes
LuB	Lualualei Clay, 2 to 6 percent slopes
mg/l	Milligrams per Liter
µg/l	Micrograms per Liter
µmhos/cm	Micromhos per Centimeter
MnC	Mamala Stony Silty Clay Loam, 0 to 12 percent slopes
mS/cm	Millisiemens per Centimeter
MRD	Materials Recovery and Diversion
MSL	Mean Sea Level
MTBE	Methyl Tert-Butyl Ether
NA	Not Analyzed
ND	Not Detected, Non-Detect
NGPC	Notice of General Permit Coverage
NL	Not Listed
NM	Not Measured
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
PCE	Tetrachloroethene
ppm	Parts per Million
PvC	Pulehu Very Stony Clay Loam, 0 to 12 percent slopes;
PVT ISWMF	PVT Integrated Solid Waste Management Facility
rRK	Rock Land
SCS	Soil Conservation Service
SOEST	University of Hawai'i School of Ocean and Earth Science and Technology

TCE	Trichloroethene
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UIC	Underground Injection Control
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound

Section 1 Introduction

This report summarizes the results of a geology, hydrology and water quality study of the PVT Integrated Solid Waste Management Facility (PVT ISWMF) located in Nānākuli, on the leeward coast of the Island of Oʻahu, Hawaiʻi. The study involved a review of available geologic and hydrologic data from the literature and a review of site-specific data from soil borings, test pits, existing groundwater wells, and surface water sampling points located on the PVT ISWMF property. The data was compiled into this report to present an overview of surface water and groundwater conditions at PVT ISWMF and the proposed relocation site, and a discussion of the anticipated impact that proposed improvements and relocation of operations from one area of the site to another will have on surface water and groundwater.

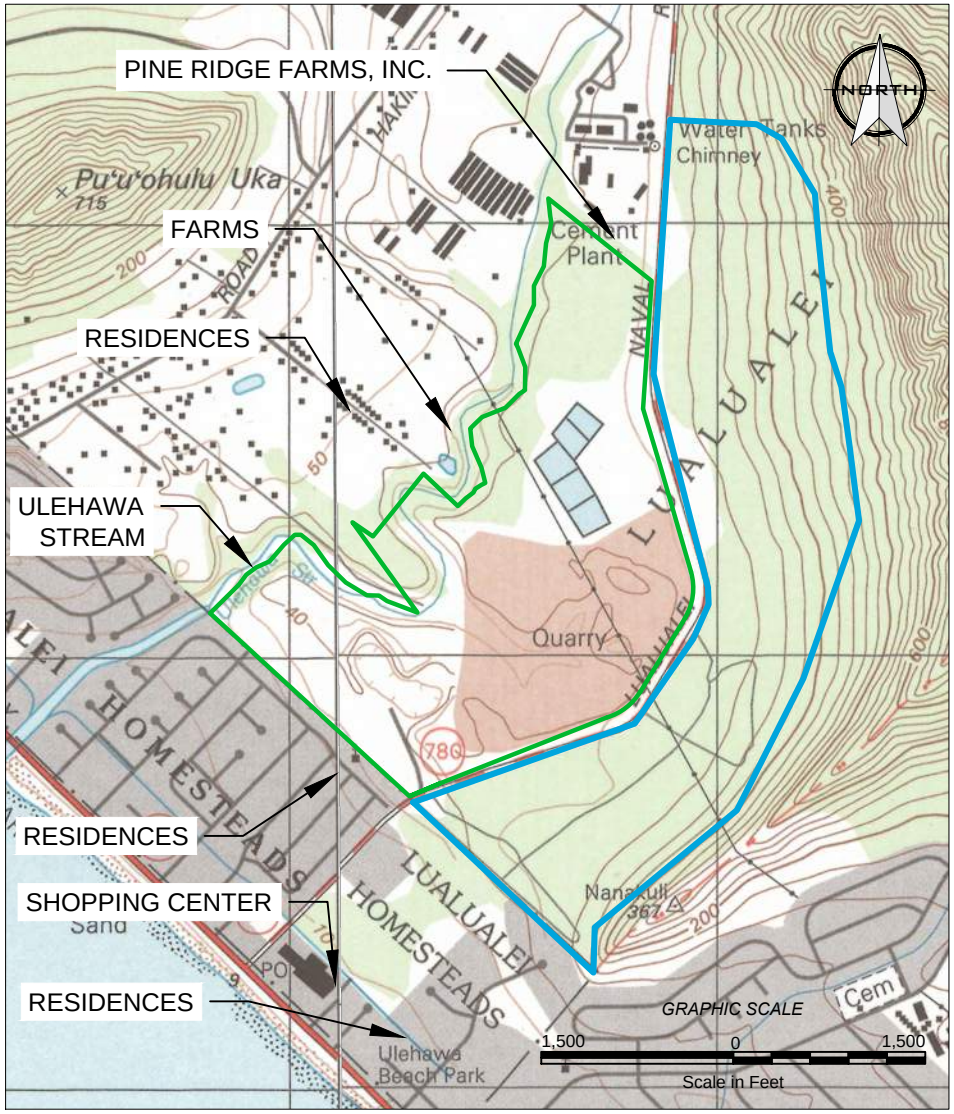
Section 2 Site Description

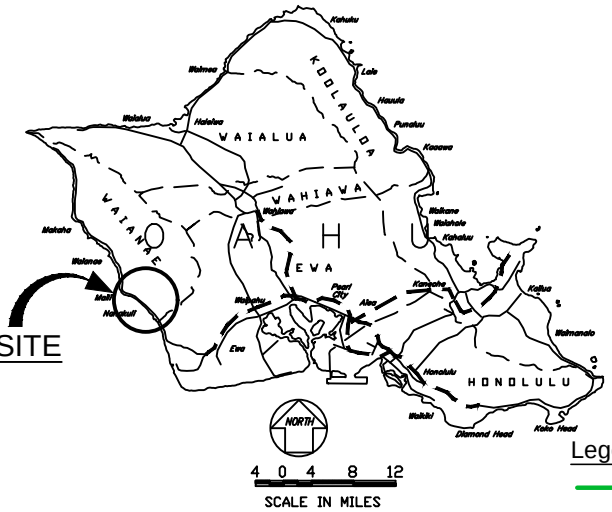
The PVT ISWMF is located in the community of Nānākuli near the western coast of the Island of Oʻahu, Hawaiʻi. The property begins approximately 1,600 feet northeast of the intersection of Farrington Highway and Lualualei Naval Road, and extends northerly approximately one mile along Lualualei Naval Road, as shown on Figure 1, Site Vicinity Map, and Figure 2, Current Site Plan.

The developed portion of the facility covers approximately 200 acres and is bordered to the east by Lualualei Naval Road, to the west by Ulehawa Stream, to the south by a residential neighborhood, and to the north by Pine Ridge Farms, Inc., a trucking, concrete and asphalt recycling, and concrete production facility. PVT ISWMF operations include a construction and demolition (C&D) material landfill with asbestos disposal and liquids solidification areas, and a recycling and materials recovery operation.

An undeveloped parcel of 179 acres to the east of Lualualei Naval Road, owned by Leeward Land, an affiliate of PVT, is currently used for soil borrow, water supply, and drainage control. The undeveloped parcel is bordered to the north and east by the naturally vegetated and steeply sloped Puʻu Heleakalā, to the south by a residential neighborhood, and to the west by Lualualei Naval Road. Further west is the developed portion of PVT ISWMF and Pine Ridge Farms, Inc. The general land use of the surrounding area includes low-density residential, commercial, and agricultural properties, in addition to industrial and undeveloped properties.

The facility, under previous ownership, began landfill operations in 1985 to fill depressions from past quarry activities (Clayton Environmental Consultants, 1992). The facility has historically accepted demolition and landscaping waste, roofing and other non-degradable materials, incinerator ash, shredded automobiles, encapsulated or bagged asbestos, and oily waste (Clayton Environmental Consultants, 1992). Currently, the only wastes accepted for disposal at the landfill are C&D material, asbestos-containing material, and contaminated soil. In accordance with the facility's operations plan, facility personnel follow detailed operational procedures for the acceptance of solid waste.





Legend

- Existing ISWMF Property Boundary
- Project Site Property Boundary

Reference: USGS, 1998; Google Earth, 2018.

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Drawn by: LBM
Date: February 2019

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Figure 1
Site Vicinity Map

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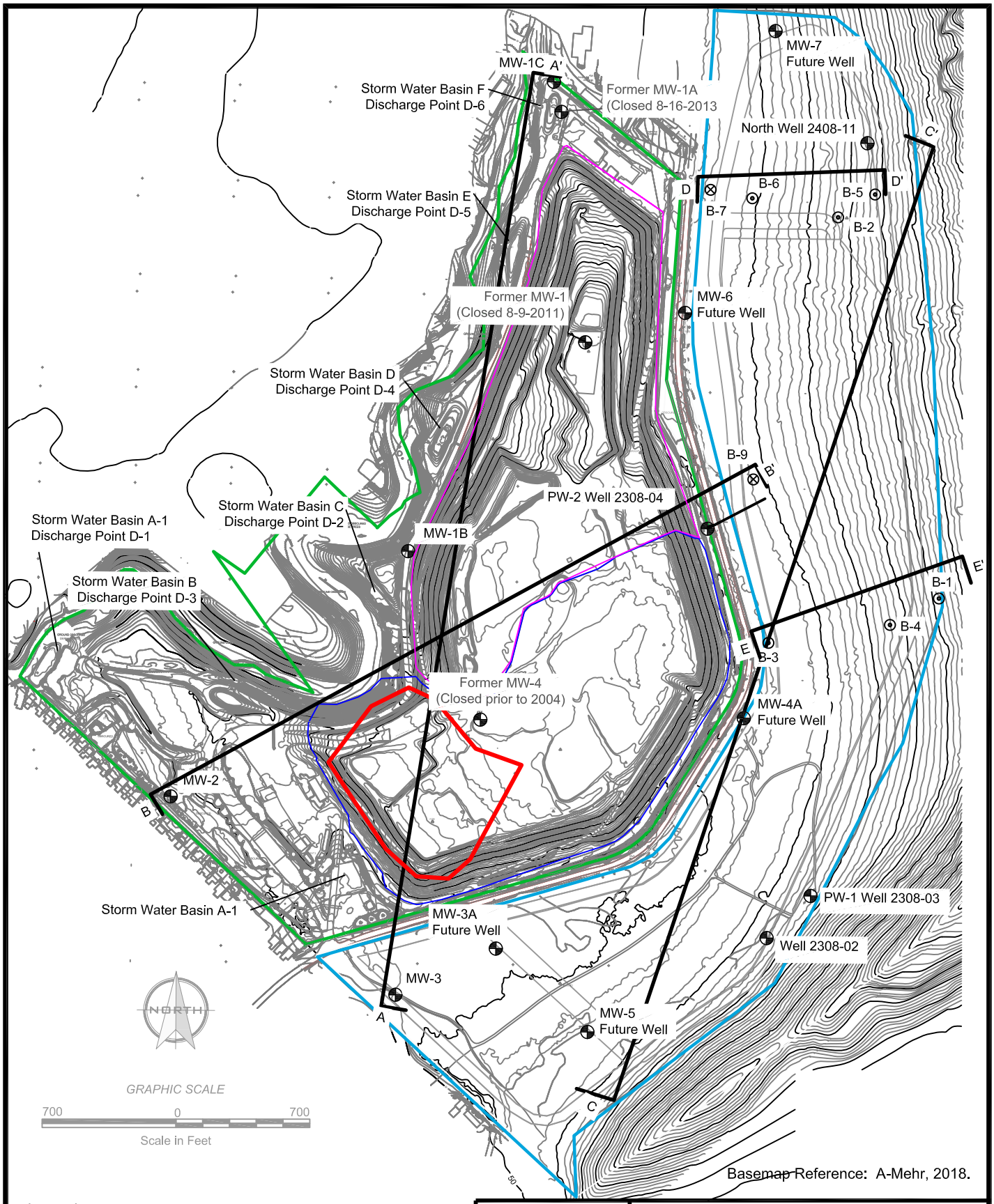
Facility Relocation
Nanakuli, Oahu, Hawaii



Legend

- Well Location
- Project Site Property Boundary
- Existing PVT ISWMF Property Boundary
- Phase II
- Phase I
- MFA Boring
- Geolabs Boring
- Asbestos Disposal Area
- Geological Cross Sections

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Figure 2
Current Site Plan

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The C&D landfill is currently comprised of two areas, Phase I and Phase II. The 49-acre Phase I area of the landfill includes the original portion of the C&D landfill, which received debris prior to October 9, 1993, and the asbestos disposal area. Phase I of the landfill is earth-lined with no leachate collection system. C&D debris disposal operations in Phase I had low compaction densities, producing a fill that contains a substantial amount of void spaces. As a result, this historic area of landfill has been prone to subsurface fires due to the intrusion of oxygen into the void space. In response, PVT is authorized by its Solid Waste Management Permit to: (1) remove previously buried debris; (2) process the debris to recover recyclable materials; and (3) replace any unrecyclable materials in the landfill.

The 104-acre Phase II area of the landfill consists of a series of cells numbered Cell 1 through Cell 9. To date, Cells 1 through 9A are constructed and Cell 9B, the last remaining permitted disposal area, is partly occupied by the recycling and materials recovery operation and the liquid waste solidification area. The Phase II landfill cells are constructed with an impermeable composite liner and leachate collection and removal system. In 2011, PVT ISWMF began operating the six-acre recycling and materials recovery and diversion (MRD) facility to recover, reuse and recycle both previously landfilled debris and incoming debris.

The 179-acre undeveloped parcel to the east of Lualualei Naval Road is referred to in this report as the Project Site, and is the location of the proposed operational improvements. Currently, the Project Site consists of open land mostly covered by low-growing grasses, shrubs, and trees. The Project Site is largely undeveloped apart from some unpaved roads/paths, two non-potable brackish water industrial supply wells (one of which is not yet in service), one PVT groundwater monitoring well, and two 25,000-gallon water storage tanks, which are used to supply operational water to the existing ISWMF operation.

Section 3 Proposed Improvements

The proposed improvements at PVT ISWMF include:

- Relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations;
- Relocation, modernization and enhancement of recycling operations (e.g. installation of two MRD process lines); and
- Installation of renewable energy facilities to power PVT operations (e.g. one 1,000-kilowatt hour enclosed gasification unit or anaerobic digestion system and approximately seven acres of photovoltaic panels).

These activities would occur on the 179-acre undeveloped parcel east of Lualualei Naval Road, referred to as the Project Site. Approximately 75 acres of the 179-acre parcel are proposed to be lined for development and operation of a C&D debris landfill (Phase III). An area of approximately 10 acres at the north end of the Project Site would accommodate process lines

MRD-2 and MRD-3, which are to be developed and operated to increase the processing capacity and minimize landfilling of recyclable materials. The gasification unit or anaerobic digestion system would also be located in the MRD area of the Project Site. Figure 3 shows the proposed development plan for the Project Site.

The proposed project extends the service life of the PVT ISWMF operations. PVT does not propose to increase the maximum permitted daily tonnage of C&D waste limit of 3,000 tons per day, and therefore, no increase from the current maximum daily truck trips of 300 is proposed. PVT will continue to employ 60 full-time and 20 temporary personnel. The hours of operations would not change.

The development of the proposed project is scheduled to begin once all permits are obtained. The relocation of operations to the project site is dictated by the capacity remaining at the existing PVT ISWMF. The airspace will be maximized at the existing PVT ISWMF facility before utilizing the landfill at the new site.

Section 4 Geologic Setting

4.1 Climate

The climate of Oʻahu is subtropical characterized by mild temperatures throughout the year, moderate humidity, persistence of northeasterly trade winds, significant differences in rainfall within short distances, and infrequent severe storms (National Weather Service, 2015). Another primary characteristic of Oʻahu's climate is the presence of only two seasons: a dry season generally occurring between May and October, and a wet season generally occurring between October and April (National Weather Service, 2015).

The Nānākuli area averages approximately 11 inches of rainfall per year, based on the last 15 years of data from the on-site weather station at PVT ISWMF. Most of the annual precipitation falls between November and March. During these months, rainfall averages one to two inches per month, with generally less than one inch per month falling during the rest of the year. The average adjusted pan evaporation in the Nānākuli area is approximately 80 inches per year (Ekern and Chang, 1985).

Temperatures during the day range from the low 60s to the upper 70s during the winter months, and from the lower 70s to the upper 80s during the summer months (A-Mehr, 2011).

4.2 Topography

PVT ISWMF is located in Lualualei Valley, a broad amphitheater-headed valley located on the west side of the Waiʻanae mountain range. The valley floor comprises approximately 14 square miles and is relatively flat, with the exception of several volcanic peaks located in the lower parts of the valley. These peaks include Puʻu o Hulu Kai, Puʻu o Hulu Uka, and Puʻu Heleakalā. PVT ISWMF is located between Puʻu Heleakalā (elevation 1,890 feet above mean sea level

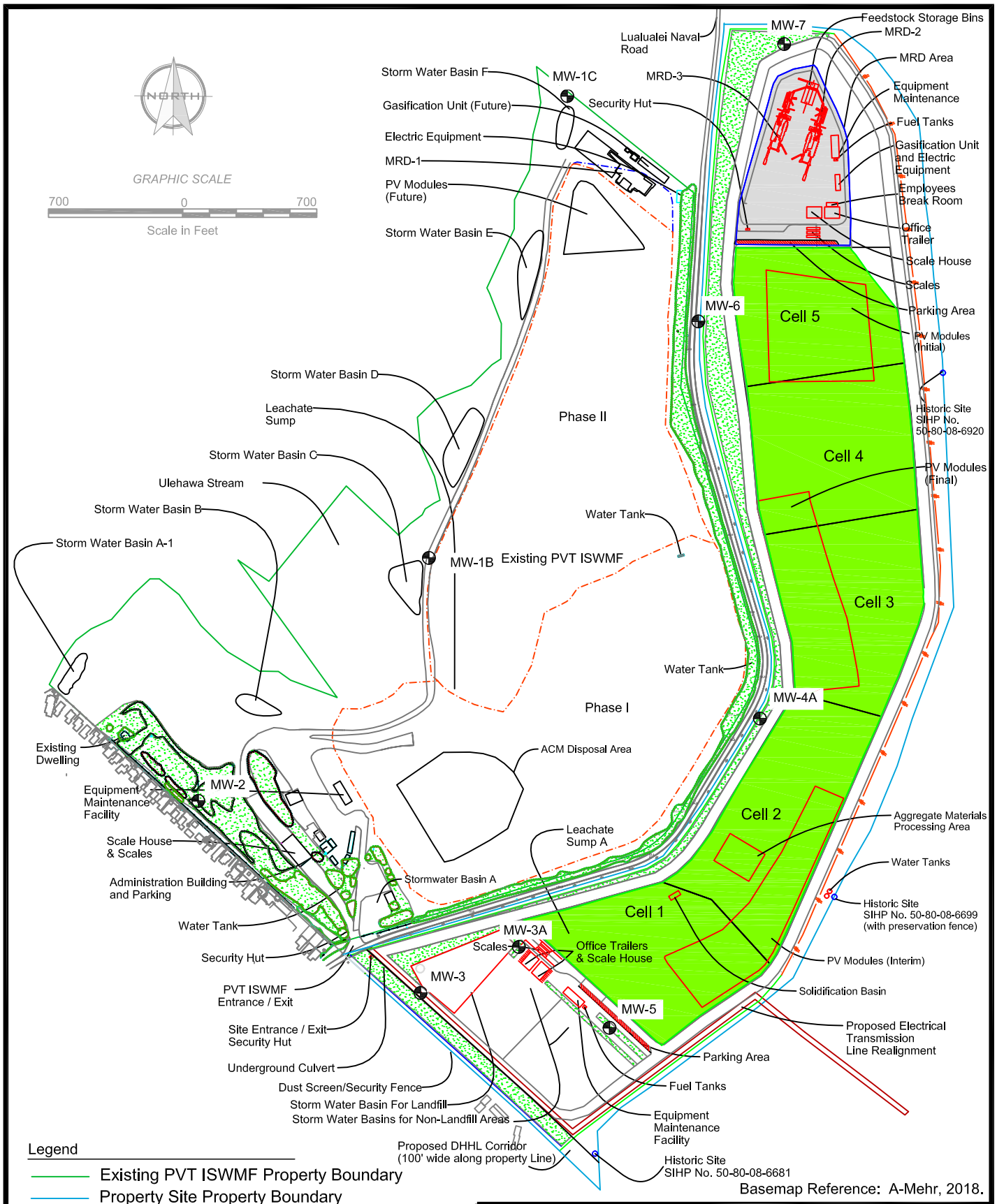

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Figure 3
Project Site Development Plan

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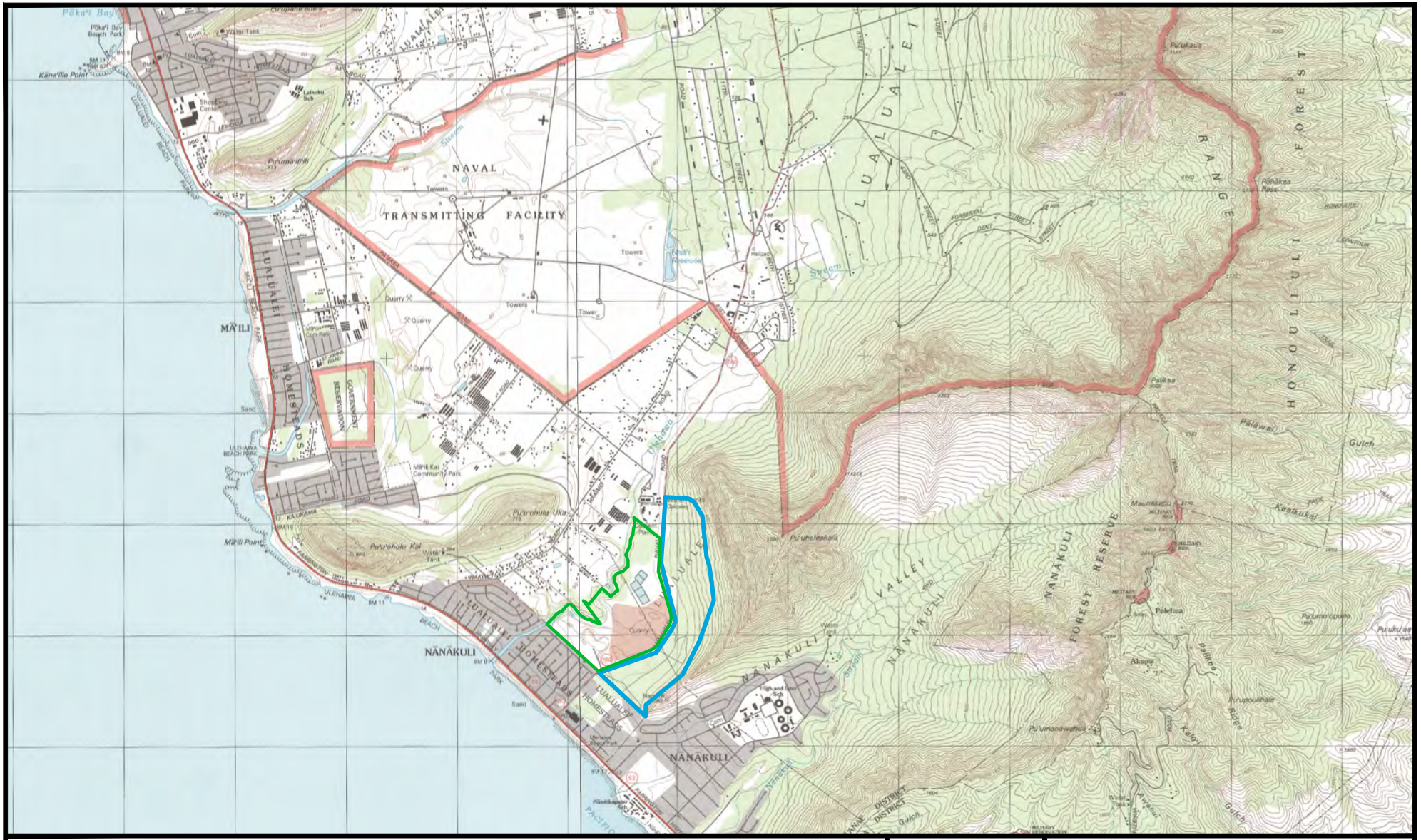
Nanakuli, Oahu, Hawaii

[MSL]) and Puʻu o Hulu Uka (elevation 715 feet MSL). In the valley the regional topography slopes gently down toward the ocean, as shown in Figure 4, Regional Topography. Elevations in the developed portion of the site prior to landfilling ranged from approximately 20 to 60 feet MSL (United States Geological Survey [USGS], 1983), while current site elevations in these areas range from approximately 20 to 175 feet MSL. In the undeveloped Project Site parcel east of Lualualei Naval Road, the elevations range from approximately 40 to 300 feet MSL as shown on Figures 1 and 2. The southwestern side of the property is located approximately 2,000 feet from the shoreline, and the most inland portions of the property are within 7,500 feet of the shoreline.

4.3 Regional Geology

The island of Oʻahu was built by three shield volcanoes, the Kaʻena, Waiʻanae, and Koʻolau volcanoes (Macdonald et al., 1983 and Sinton et al., 2014). The now submerged Kaʻena volcano is the oldest of the three volcanoes; however, the Waiʻanae volcano rose above sea level first on the eastern flanks of Kaʻena approximately 3.9 million years ago (Sinton et al., 2014). Kaʻena emerged above sea level approximately 400,000 years later, followed by the Koʻolau volcano in another 500,000 years (Sinton et al., 2014). The present-day island of Oʻahu consists of the Waiʻanae Range (the eroded remnant of the Waiʻanae volcano) forming the western portion of the island, and the Koʻolau Range (the eroded remnant of the Koʻolau volcano) forming the eastern portion of the island. The term "range" expresses the fact that the shield form of the volcano has been eroded to form long narrow ridges. The eroded remnant of the Kaʻena volcano forms a submarine ridge located northwest of the island of Oʻahu (Sinton et al., 2014).

The rocks of the Waiʻanae volcano are known as the Waiʻanae Volcanics, and are subdivided into four members: the Lualualei (oldest), Kamaileʻunu, Pālehua, and Kolekole (youngest) Members. The Lualualei Member consists of tholeiitic basaltic lava flows that built the main mass of the Waiʻanae shield volcano, 3.9 to 3.55 million years ago (University of Hawaiʻi School of Ocean and Earth Science and Technology [SOEST], 2015). During this shield-building stage, lava erupted along two, or possibly three, rift zones, and a well-developed caldera was present in Lualualei Valley (SOEST, 2015). In a later shield-building stage (approximately 3.55 to 3.06 million years ago) lavas from the Kamaileʻunu Member erupted within the caldera and along rift zones outside of the caldera (SOEST, 2015). The Kamaileʻunu lavas, which include plagioclase-bearing tholeiitic and alkalic basalts and basaltic hawaiites, eventually filled the caldera (SOEST, 2015). The Pālehua Member represents the post-caldera stage-eruptions, which occurred 3.06 to 2.98 million years ago, forming a relatively thin "alkalic cap" covering the top of the shield volcano (SOEST, 2015). The Pālehua Member lavas primarily contain hawaiite, with local occurrences of alkalic basalts and mugearite (Sinton, 1986). At the end of Pālehua volcanism a major erosional event occurred, possibly the great offshore, submarine Waiʻanae slump (SOEST, 2015). Following this event the plumbing system of the Waiʻanae Volcano was changed so that more mafic magmas from deep in the crust, the Kolekole Member, were erupted, carrying with them wall-rock fragments (xenoliths) of the deep crustal magma chamber (SOEST, 2015). The Kolekole Member includes the young cones and flows of Puʻu



Legend

Existing PVT ISWMF Property

Project Site Property Boundary

NORTH

GRAPHIC SCALE

5,000 0 5,000

Scale in Feet

Reference: USGS, 1998.

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Figure 4
Regional Topography

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Kapuaʻi, Puʻu Kuʻua, Puʻu Makakilo, Puʻu Pālailai, and Puʻu Kapolei on the southern end of the Waiʻanae Range, a post-erosional flow at Kolekole Pass, the summit region of Mt. Kaʻala (the highest point on Oahu), and Pahole and Kuaokalā regions in the northern part of the Waiʻanae Range (Sinton, 1986 and SOEST, 2015). Figure 5 shows the regional geology.

The repeated eruptions that built the Waiʻanae shield volcano occurred along two or possibly three rift zones, now marked by innumerable exposed dikes. Dikes form from lava congealing in the fissures that bring it to the surface. In the site vicinity dikes intrude most members of the Waiʻanae Volcanics. They are sparse in the poorly permeable, massive, thick-bedded flows of the Pālehua member and are numerous in the highly permeable, thin-bedded flows of the Lualualei and Kamaileʻunu members (Takasaki, 1971).

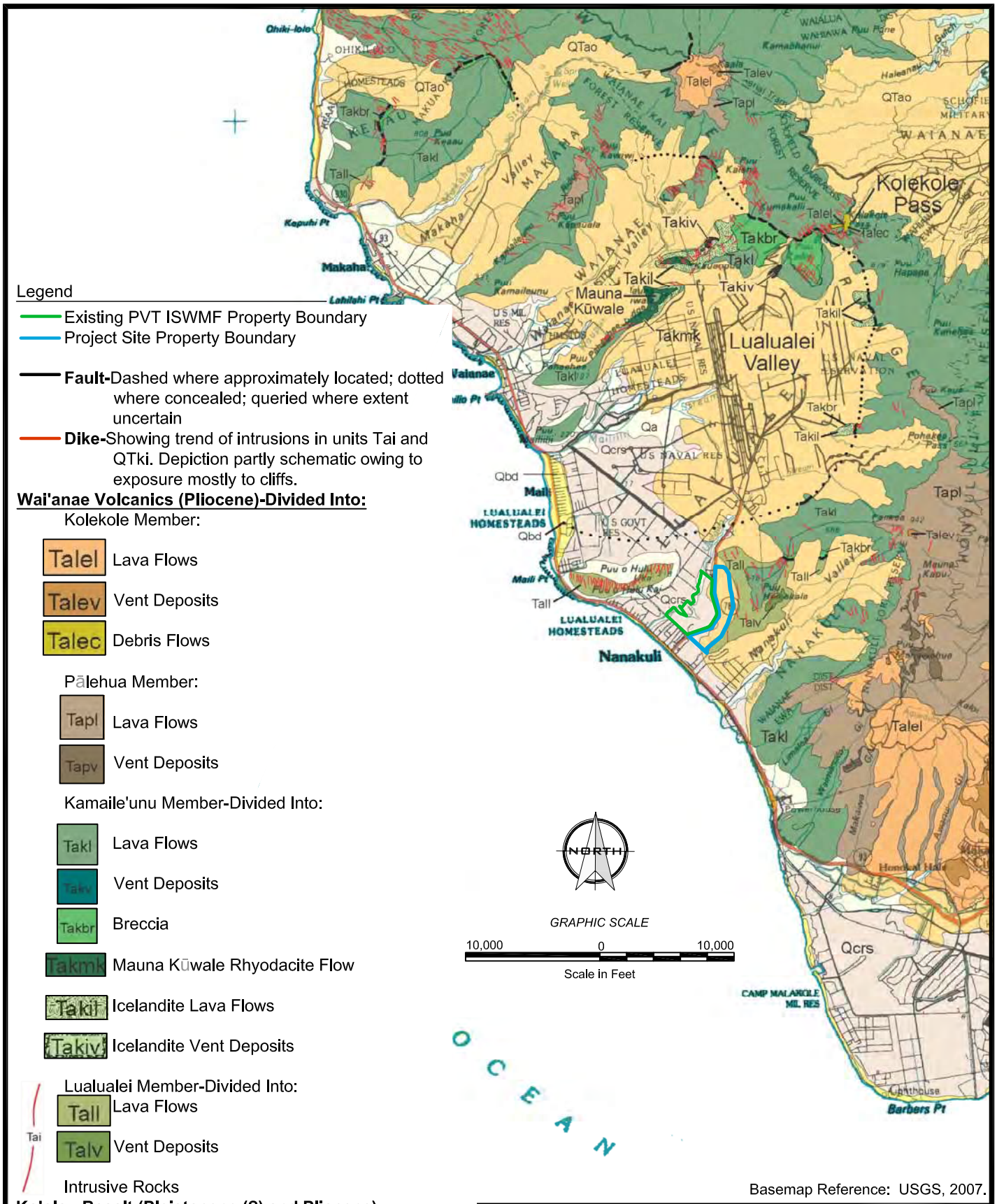
The erosion of the Waiʻanae shield volcano formed large valleys on the western side of the Waiʻanae Range. These valleys (such as Lualualei) are some of the largest in Hawaiʻi, and they are believed to represent the sources for large landslides now seen on the sea floor to the west of the island (Presley et al., 1997). These valleys have extensive accumulations of alluvium and colluvium.

Also occurring along the Waiʻanae coast, and along most of Oʻahu's shorelines, are emerged coral reefs. These reefs formed during the interglacial stages when sea level was higher than it is now. Near Waiʻanae, the reef limestone extends to about 87 feet above sea level and is overlain by almost 10 feet of fossiliferous lithified beach sand (Macdonald, et al., 1983). This calcareous sedimentary material consists of coral, coral rubble, and beach sand.

PVT ISWMF is located in Lualualei Valley, which was formed by the Lualualei and Kamaileʻunu Members of the Waiʻanae Volcanics. The caldera for the Waiʻanae Volcano occupies most of Lualualei Valley; the caldera boundary is just north of the PVT ISWMF, as shown by the dotted fault line on Figure 5, Regional Geology. Lualualei Valley was formed by streams that eroded the Waiʻanae Volcano, filling the valley with alluvial and colluvial deposits. In addition, a catastrophic erosional event (mass-wasting), evident from the submarine landslide deposits located offshore, may have contributed to the formation of the valley (Presley et al., 1997). Reef deposits were laid down in Lualualei Valley approximately 500,000 years ago when sea level was 100 feet above the current sea level. The reef filled the valley to an approximate depth of 300 feet (Macdonald, et al., 1983).

4.4 Site Geology

Geologic materials at the PVT ISWMF site, as shown on Figure 5, include calcareous reef rock and marine sediment, chiefly emerged coral reefs and lagoonal deposits, on the western portion of the site (developed area), and primarily older alluvium on the eastern portion of the site (Project Site area) (Stearns, 1938 and USGS, 2007). The older alluvium generally consists of mottled brown to red brown, deeply weathered, poorly sorted, and nearly impermeable, friable conglomerates (Stearns, 1938). Younger alluvium is present on the far western portion of the developed portion of the site along Ulehawa Stream. Underlying the calcareous reef



Basemap Reference: USGS, 2007.

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Figure 5
Regional Geology

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rock, marine sediments, and alluvium are lava flows of the Lualualei Member of the Waiʻanae Volcanics, which comprise the entire mountain of Puʻu Heleakalā, peaking just east of the Project Site.

Based on soil borings and excavation at the site, the natural surface material is a brown to dark brown clayey silt (alluvium) derived from the surrounding volcanic peaks (Mountain Edge Environmental, Inc., 2004). The underlying soil in the western portion of the site is tan silty clay with coral sand and coral fragments. This tan coralline material is approximately 6 to 18 feet thick and consists of large to small coral fragments, in which all the interstitial void space has been filled with calcic silt and clay, embedded in a calcic sand, silt and clay matrix. This material was originally deposited in a relatively quiet back-bay type of environment similar to the back bay areas of Pearl Harbor. Undisturbed samples of matrix have yielded permeabilities of 10^{-5} centimeters per second (cm/s), and this same material when used for backfill and compacted to 90% of maximum has yielded permeabilities of 10^{-7} cm/s (Joseph, 2004). In some areas of the PVT ISWMF site this soil includes more cemented coral and coralline gravel with sand and silts, which likely formed in a more active reef front or beach environment. These deposits range from 5 to 40 feet deep and are intermingled with alluvial deposits in some locations (Mountain Edge Environmental, Inc., 2004). Figures 6 and 7 show geological cross sections detailing subsurface conditions encountered during installation of groundwater wells in the western portion of the site.

The Project Site lies on the lower slopes of Puʻu Heleakalā. Soil borings, test pits, and wells drilled at the Project Site encountered primarily alluvium and colluvium overlying basalt rock at depth (C.W. Associates, Inc., 1991, and Masa Fujioka & Associates, 1995a and 1995b). In the northern portion of the Project Site colluvial materials consisting of basaltic cobbles and boulders intermingled with brown adobe clay were encountered to depths of 65 feet below the ground surface overlying consolidated colluvium basaltic rock to depths of 280 feet (Juturna, LLC, 2017a). In the southern portion of the Project Site and in the western portion of Project Site along Lualualei Naval Road, coralline material was encountered beneath the clayey surface soils; and in the southernmost part of the Project Site coral outcrops were encountered (C.W. Associates, Inc., 1991, and Masa Fujioka & Associates, 1995a and 1995b). Figures 8, 9, and 10 show geologic cross sections through the Project Site.

4.5 Soils

According to the United States Department of Agriculture (USDA), Soil Conservation Service (SCS) (Foote et al., 1972), soils occurring on the PVT ISWMF site include Pulehu Very Stony Clay Loam, 0 to 12 percent slopes (PvC); Mamala Stony Silty Clay Loam, 0 to 12 percent slopes (MnC); Lualualei Extremely Stony Clay, 3 to 35 percent slopes (LPE); Lualualei Clay, 2 to 6 percent slopes (LuB); and Rock Land (rRK). Figure 11 shows the locations of these soils at the site as mapped by the USDA SCS (Foote et al., 1972).

As shown on Figure 11, the Pulehu Very Stony Clay Loam is located in the developed portion of the site along Ulehawa Stream. This soil developed in alluvium washed from basic igneous

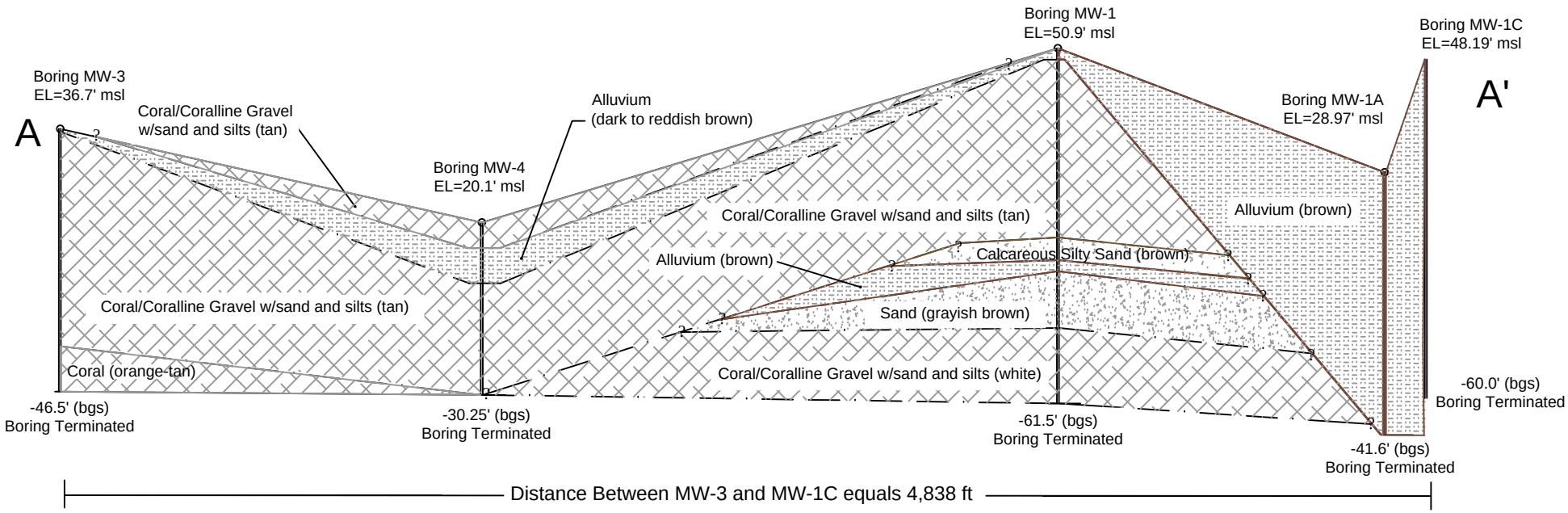

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Figure 6
Geologic Cross Section
A-A'

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Nanakuli, Oahu, Hawaii

Reference: Mountain Edge, 2004 based on boring logs by Clayton Environmental Consultants,1992, and Juturna LLC, 2014b.

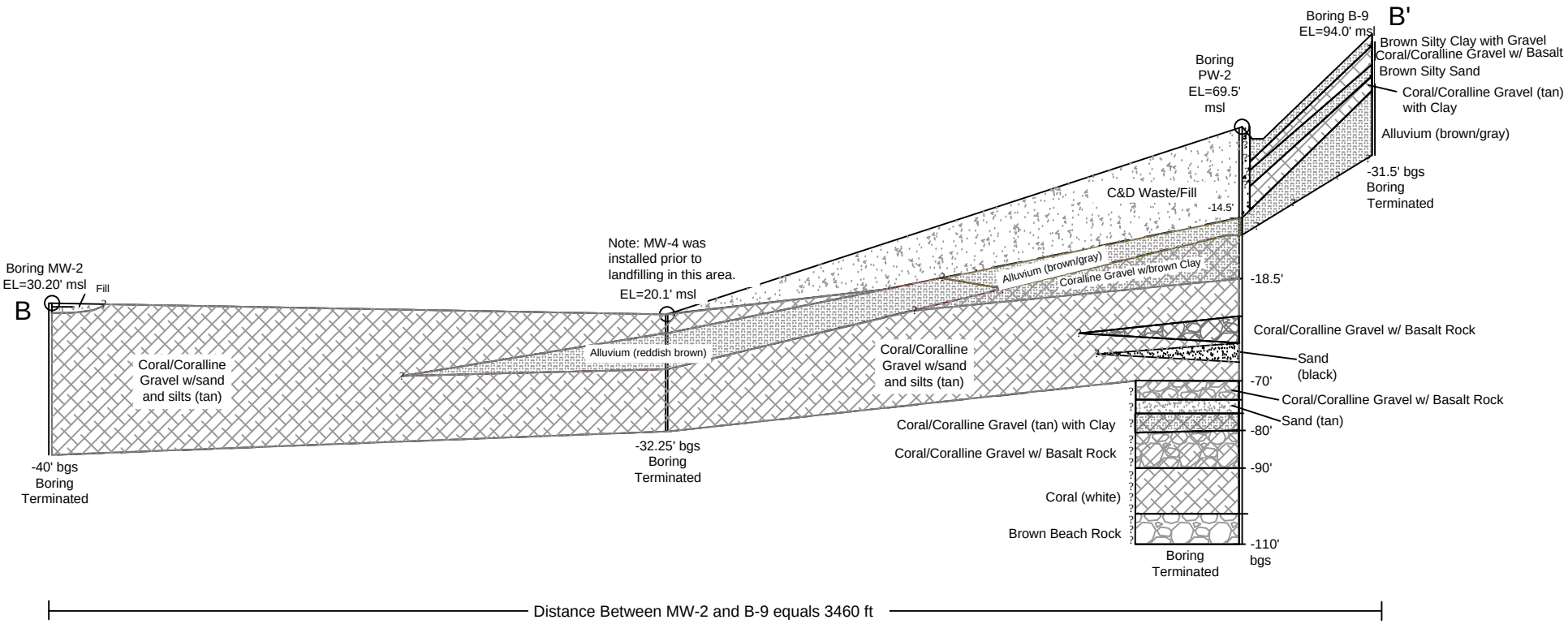

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Figure 7
Geologic Cross Section
B-B'

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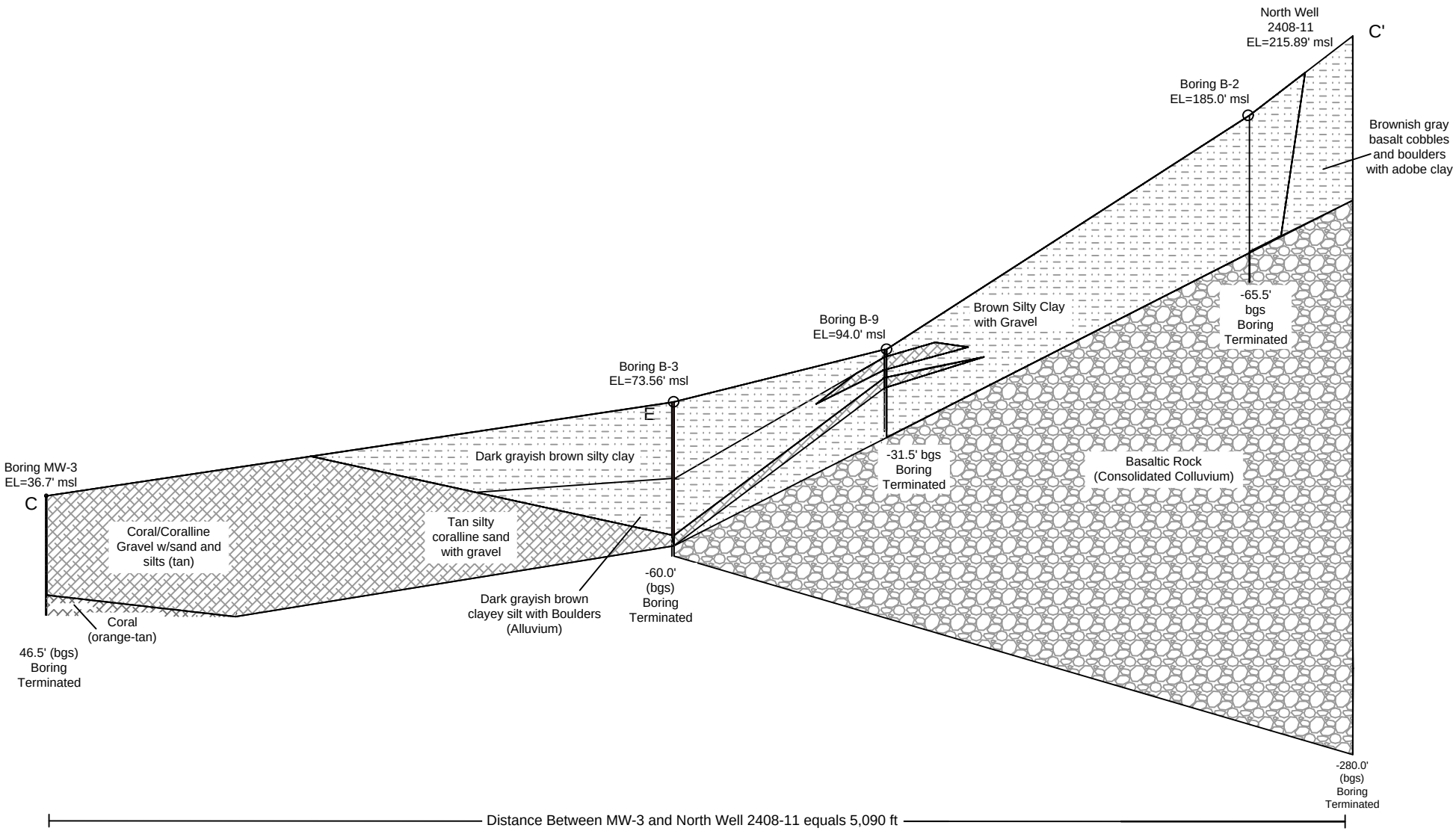
Nanakuli, Oahu, Hawaii

Reference: Mountain Edge, 2004 based on boring logs by Clayton Environmental Consultants,1992 and Mountain Edge Environmental, Inc., 2003, C.W. Associates, Inc. 1991.



Approved by: JKH
Drawn by: LBM
Date: February 2019

Figure 8
Geologic Cross Section
C-C'

Geology, Hydrology and Water Quality Report
PVT Integrated Solid Waste Management
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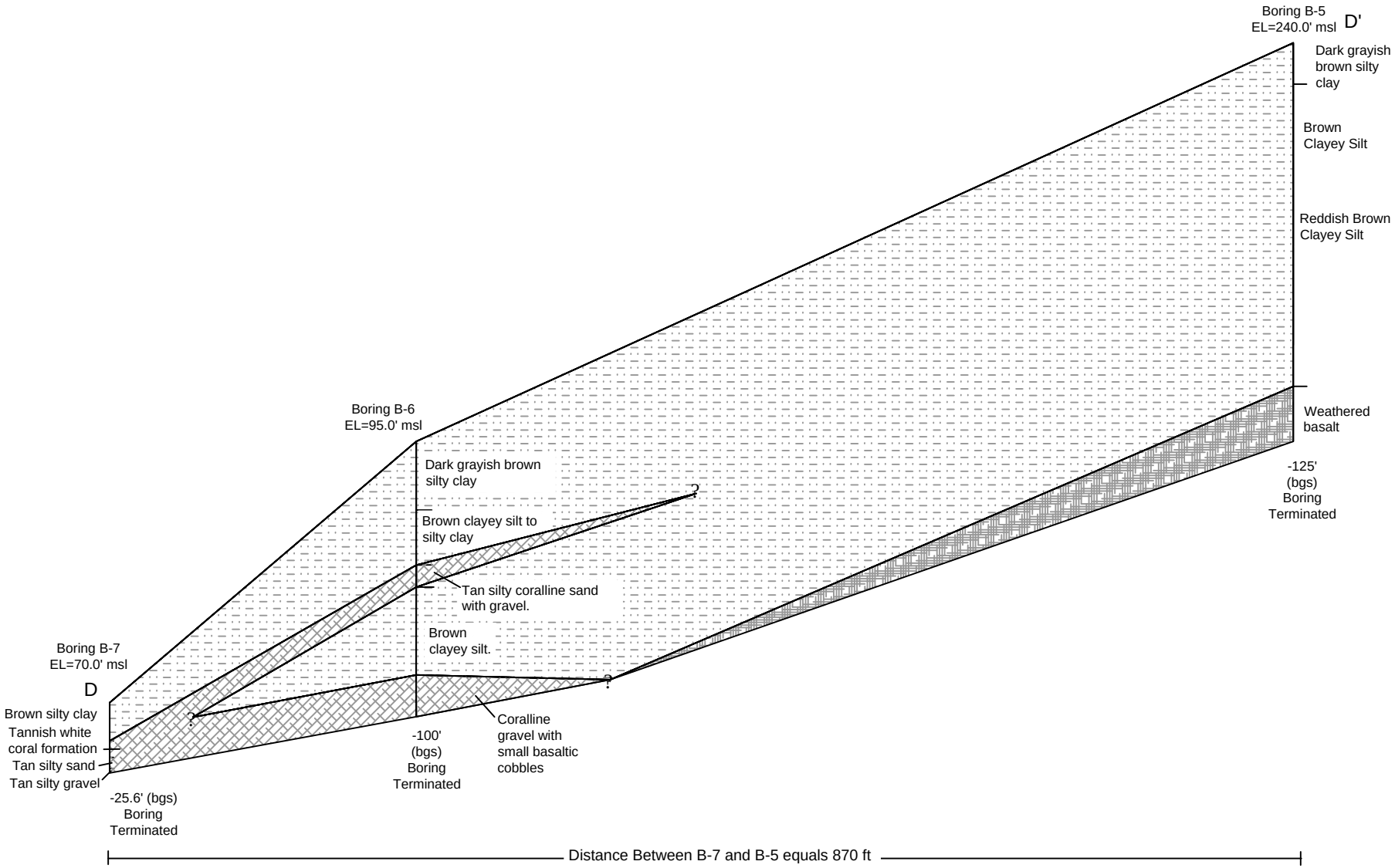
Reference: Mountain Edge, 2004 based on boring logs by Clayton Environmental Consultants,1992,
Masa Fujioka and Associates 1995a and b, C.W. Associates, Inc. 1991, and Juturna LLC 2017a.



Approved by: JKH
Drawn by: LBM
Date: February 2019

Figure 9
Geologic Cross Section
D-D'

Geology, Hydrology and Water Quality Report
PVT Integrated Solid Waste Management
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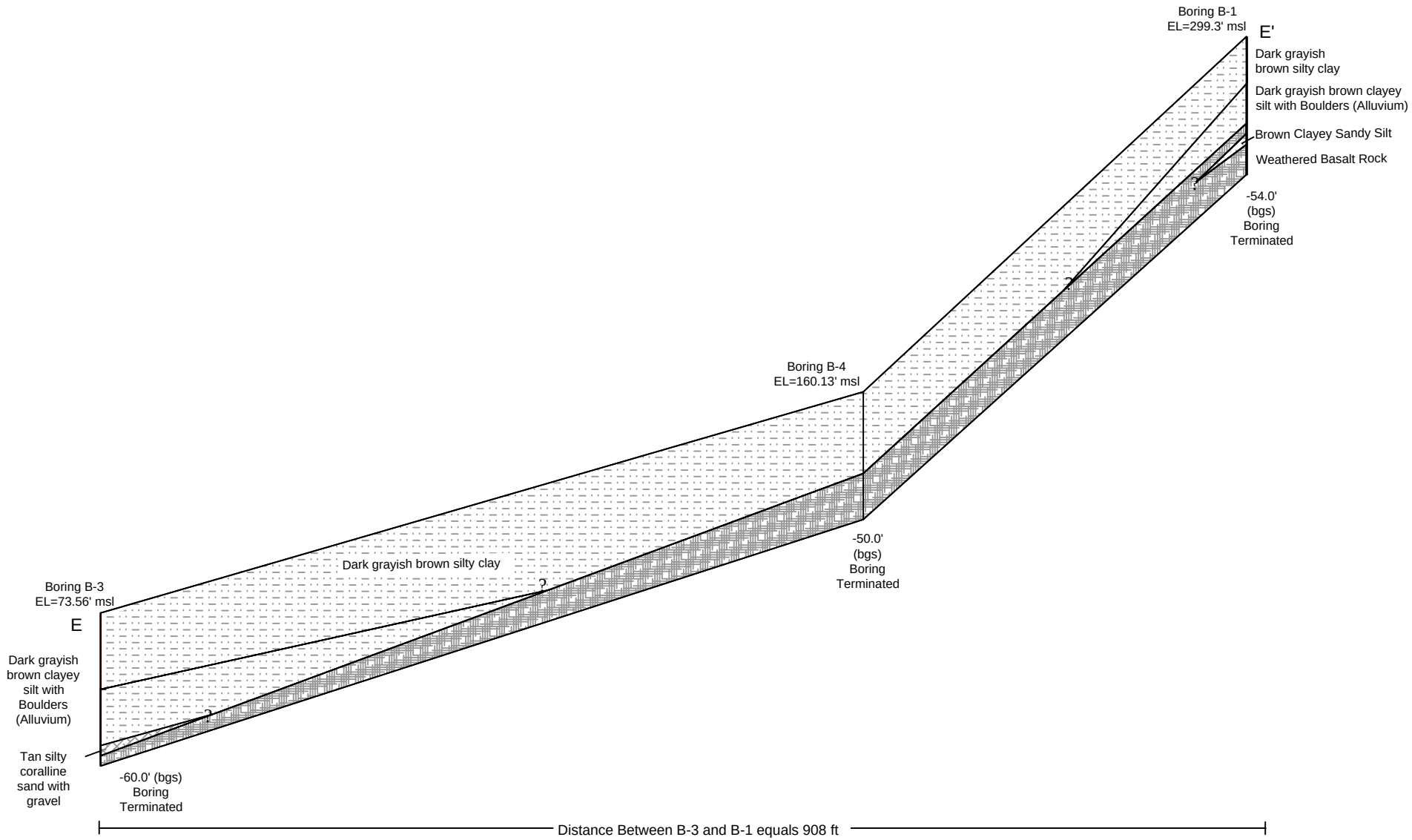
Reference: Masa Fujioka and Associates 1995a and b, C.W. Associates, Inc. 1991.



Approved by: JKH
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Date: February 2019

Figure 10
Geologic Cross Section
E-E'

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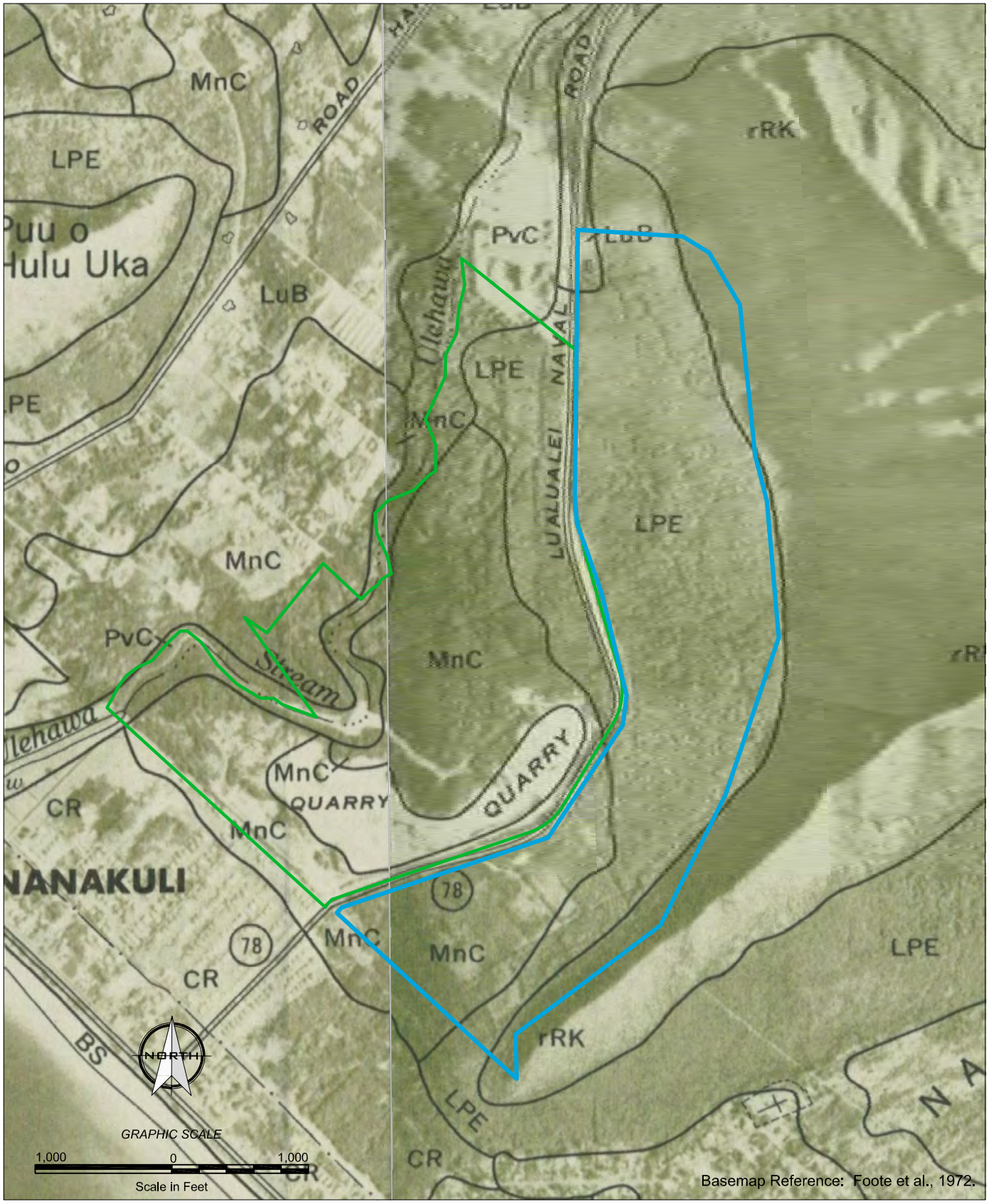
Reference: Masa Fujioka and Associates 1995a and b.



Legend

Existing PVT ISWMF Property Boundary

Project Site Property Boundary

LPE- Lualualei extremely stony clay, 3 to 35 percent slopes
MnC- Mamala stony silty clay loam, 0 to 12 percent slopes
PvC- Pulehu very stony clay loam, 0 to 12 percent slopes
LuB- Lualualei clay, 2 to 6 percent slopes
rRK- Rock land
CR- Coral outcrop
BS- Beaches

Approved by: JKH
Drawn by: LBM
Date: February 2019

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Figure 11
USDA SCS Soil Map

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rocks. Pulehu Very Stony Clay Loam is a dark brown clay loam underlain by dark-brown, dark grayish-brown, and brown stratified loam, loamy sand, fine sandy loam, and silt loam. As much as three percent of the surface of Pulehu Very Stony Clay Loam is covered with stones (Foote, et al., 1972).

The Mamala Stony Silty Clay Loam originally covered most of the central and southern portions of the PVT ISWMF site, but much of this soil has been removed during previous quarry activities, covered due to landfilling, or used as cover material for landfilling operations. Mamala Stony Silty Clay Loam soils formed in alluvium deposited over coral limestone and consolidated calcareous sand (Foote et al., 1972). These soils generally consist of dark reddish-brown stony silty clay loam with coral rock fragments common in the surface layer and throughout the profile (Foote et al., 1972).

The Lualualei Extremely Stony Clay, which occurs along the lower slopes of Puʻu Heleakalā, developed in alluvium and colluvium. Some of these soils, primarily west of Lualualei Naval Road, have also been removed due to landfilling or used as cover material for landfilling operations. Lualualei Extremely Stony Clay generally consists of very dark grayish-brown, very sticky and very plastic clay that has prismatic structure and many stones on the surface and throughout the profile. According to Foote et al. (1972), this soil cracks widely upon drying, has a high shrink-swell potential, and often contains gypsum crystals.

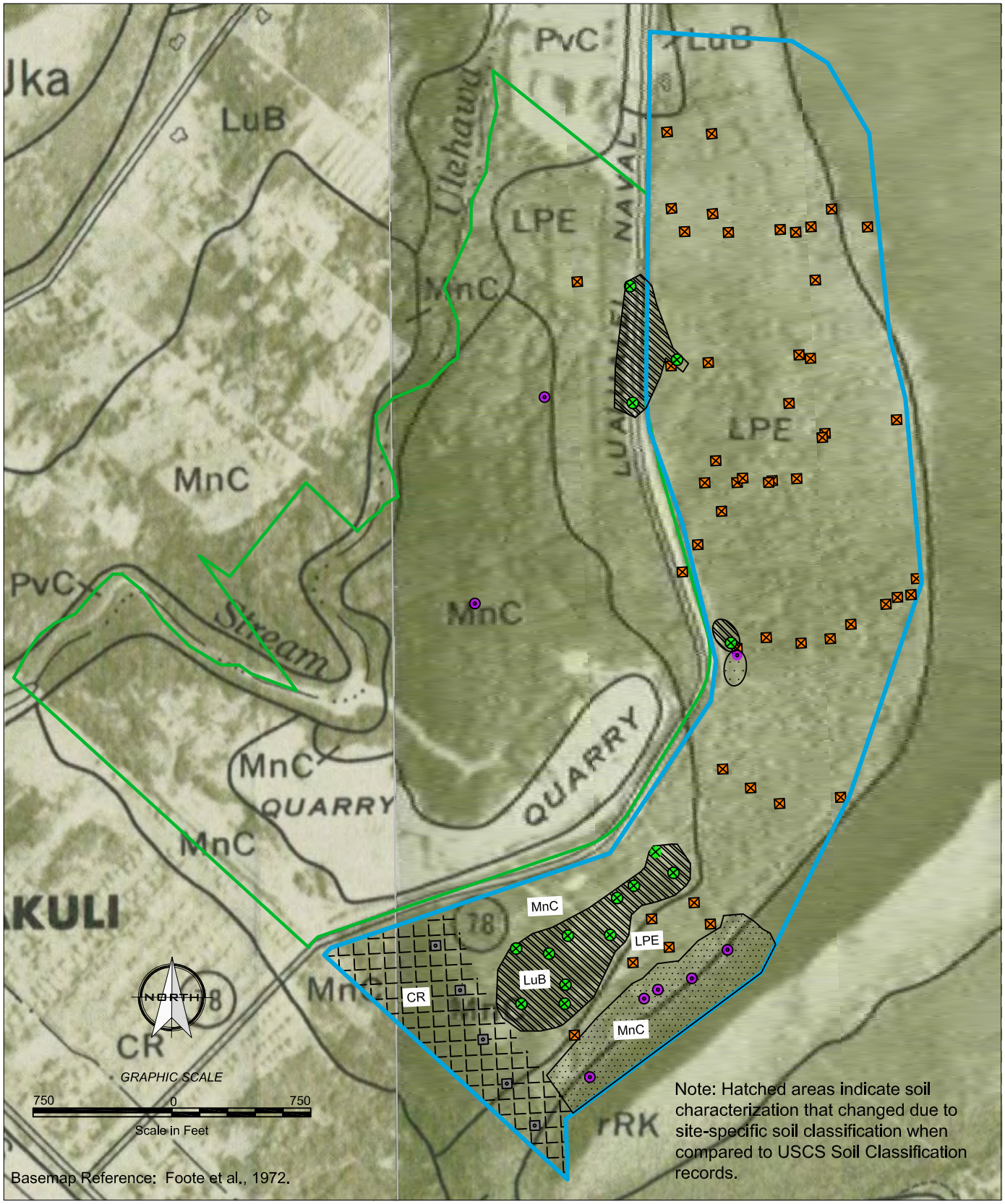
Lualualei Clay, as mapped by Foote et al. (1972) on Figure 11, occurs in a very small area on the Project Site, along Lualualei Naval Road. Lualualei Clay is similar to Lualualei Extremely Stony Clay except that it does not have stones in the surface and in the profile (Foote et al., 1972). Using the data from boring logs and test pits installed throughout the Project Site (C.W. Associates, Inc., 1991, and Masa Fujioka & Associates, 1995a and 1995b), an updated soil map was developed as shown on Figure 12. On the updated soil map (Figure 12) a larger area of Lualualei Clay, an additional area of Mamala Stony Silty Clay Loam, and an area of Coral Outcrop (CR), was identified in the southern portion of the Project Site. According to Foote et al. (1972), Coral Outcrop consists of coral or cemented calcareous sand. In some locations there is a thin layer of friable, red soil material, similar to Mamala Stony Silty Clay Loam, in cracks, crevices, and depressions within the Coral Outcrop (Foote et al., 1972).

A small portion of the Project Site on the upper slopes of Puʻu Heleakalā is considered Rock Land (rRK), which is made up of areas where exposed rock covers 25 to 90 percent of the surface. Rock outcrops and very shallow soils are the main characteristics of Rock Land (Foote et al., 1972).

Section 5 Hydrogeology

5.1 Regional Hydrogeology

Most of the fresh groundwater supply in the Waiʻanae District occurs in flows of the Lualualei and Kamaileʻunu Members of the Waiʻanae Volcanics. Flows of the Pālehua and Kolekole



Legend

- Existing PVT ISWMF Property Boundary
- Project Site Property Boundary

LPE- Lualualei extremely stony clay, 3 to 35 percent slopes
MnC- Mamala stony silty clay loam, 0 to 12 percent slopes
PvC- Pulehu very stony clay loam, 0 to 12 percent slopes
LuB- Lualualei clay, 2 to 6 percent slopes
rRK- Rock land
CR- Coral outcrop
BS- Beaches

- LPE Field Soil Characterization
- LuB Field Soil Characterization
- CR Field Soil Characterization
- MnC Field Soil Characterization

Approved by: JKH
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Date: February 2019

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Figure 12
Updated Soil Map

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Members are mostly above the water table, and contain only a small perennial supply. Some fresh groundwater occurs in the sedimentary material; however, development of this supply is generally limited by the low permeability of alluvium and seawater intrusion in the calcareous reef rock and marine sediments (Takasaki, 1971).

The groundwater reservoir in the volcanic rocks is very large, the top of which extends from an altitude of a few feet near the coast to over 1,800 feet near the crest of the Waiʻanae Range. The bottom of the volcanic aquifer is undetermined but is probably limited by the inability of the rocks to transmit water at some great depth below sea level. The quality of water from wells tapping the volcanic aquifer is generally good, except in near-shore areas and areas abutting landward edges of the coralline aquifer where intrusion by seawater occurs. The quantity and orientation of dikes occurring within the volcanic aquifer greatly controls the permeability of the aquifer because the dikes are less permeable than the rocks they intrude. Where dikes are few and mostly parallel, they channel groundwater along their trend. Where dikes are numerous and intersect, they form compartments reducing the lateral movement of groundwater and impounding it at altitudes higher than in areas where dikes are less abundant (Takasaki, 1971).

The erosion of the Waiʻanae shield volcano formed large valleys on the western side of the Waiʻanae Range. These valleys have extensive accumulations of alluvium and colluvium. The older alluvium is moderately to well consolidated and weathered in its entirety. This material is generally poorly permeable and acts as a confining member where it overlies more permeable saturated rocks. The younger alluvium consists of reworked older alluvium occurring in and near stream channels and overlying the older alluvium. The younger alluvium is poorly to moderately permeable; its yield from wells is small, but the groundwater quality is generally fair to good, even near the coast. Talus, consisting mainly of poorly consolidated gravel and boulders, also occurs in the valleys of the Waiʻanae Range. The talus is highly permeable; however, the storage is generally small (Takasaki, 1971).

Groundwater also occurs within the highly permeable calcareous reef rock and marine sediments near sea level. The coralline rocks extend inland approximately two miles in Lualualei Valley (Stearns, 1938). Many wells have been drilled into this aquifer, primarily for irrigation use; however, the wells are brackish and many have been abandoned due to an increase in chloride content of the water with continued pumping. Fresh water within the coralline aquifer occurs as a thin and unstable lens floating on seawater. This lens is subject to rapid contamination by seawater if wells tapping the aquifer are pumped heavily. The lack of fresh water needed to develop a thicker freshwater lens is partly due to the abundant growth of kiawe in the Waiʻanae area. Transpiration by kiawe, from shallow groundwater in volcanic rock and alluvium, reduces the underflow that would flow from these aquifers to the coralline aquifer. Transpiration by kiawe that grows over the coralline aquifer also constitutes the main discharge of groundwater from this aquifer (Takasaki, 1971).

Groundwater occurring within the younger alluvium is generally fresh and water levels are higher than in the coralline aquifer; however, seawater intrusion occurs where the alluvium aquifer abuts the coralline aquifer and in near-shore areas (Takasaki, 1971).

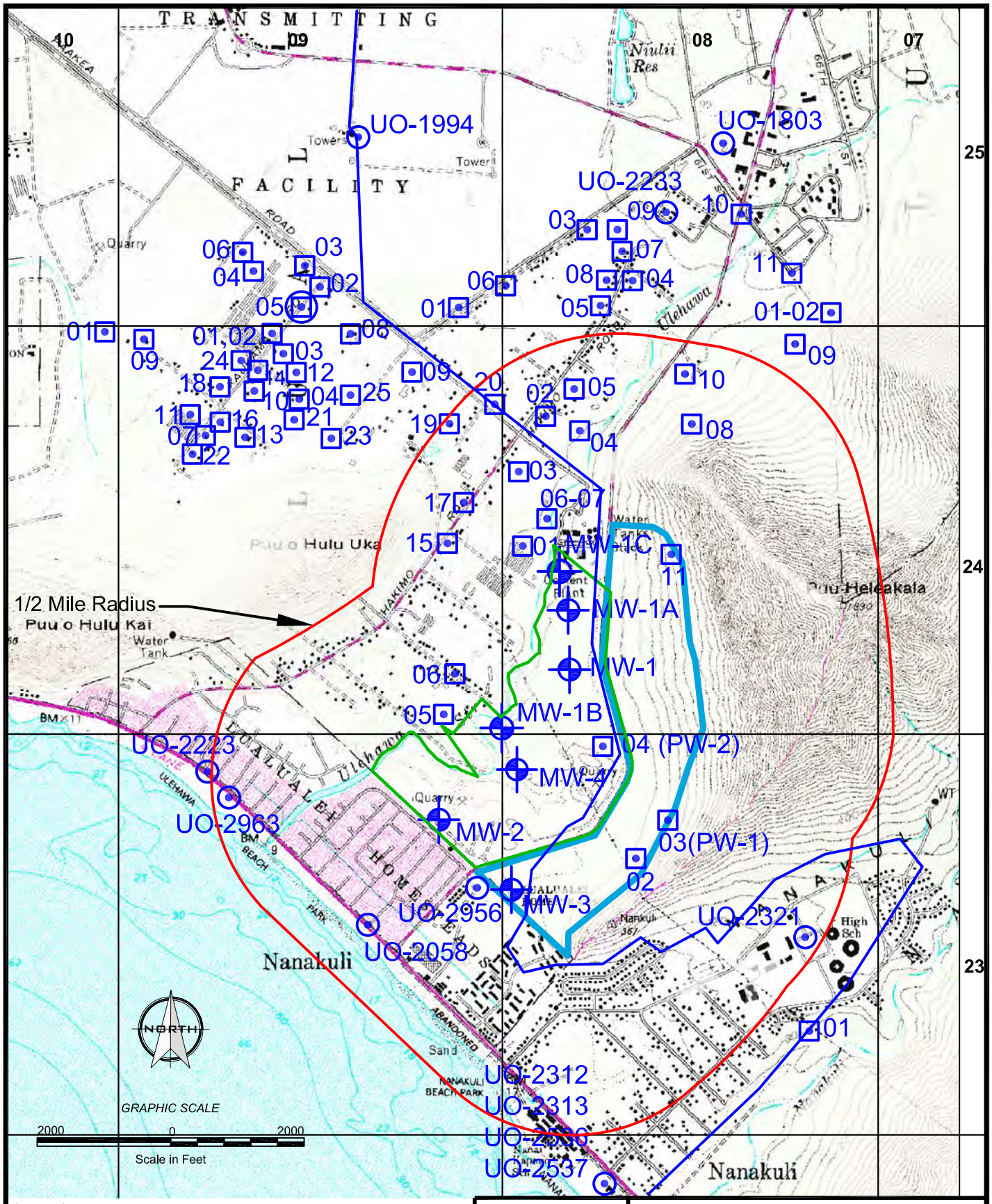
5.2 Wells in the Site Vicinity

Figure 13, Well Location Map, shows the locations of groundwater withdrawal wells in the vicinity of the PVT ISWMF property that are registered with the State of Hawai'i, Department of Land and Natural Resources (DLNR), Commission on Water Resources Management (DLNR, 2018), and the locations of injection wells that are permitted with the Underground Injection Control (UIC) Section of the State of Hawai'i, Department of Health (DOH) Safe Drinking Water Branch (DOH, 2018). DLNR and DOH do not regulate or record the locations of groundwater monitoring wells; however, Figure 13 does show the locations of PVT ISWMF's active monitoring wells. Based on information provided by DLNR (2018), no drinking water wells are located on, downgradient of, or within one mile of the subject property. The closest drinking water well is located over one mile northwest and upgradient of the site. Wells in the site vicinity are used for irrigation, industrial purposes, injection of wastewater or storm water, or are currently sealed or unused (DLNR, 2018 and DOH, 2018). Tables 1 and 2 provide information on registered wells within one-half mile of the site.

Four wells are located on the PVT ISWMF property west of Lualualei Naval Road, and four wells are located on the Project Site. These eight wells are owned by PVT ISWMF. The wells on the Project Site include well PW-1 (State No. 2308-03) which provides water for dust control at PVT ISWMF; well 2308-02 which is unused; monitoring well MW-3 which is one of the four active groundwater monitoring wells for PVT ISWMF; and the north well (State No. 2408-11) installed in 2017 to provide additional water for dust control. The four wells located on the PVT ISWMF property west of Lualualei Naval Road include well PW-2 (State No. 2308-04) installed in 2003 to provide water for dust control; and active groundwater monitoring wells MW-1B, MW-1C, and MW-2.

The four active groundwater monitoring wells (wells MW-1B, MW-1C, MW-2, and MW-3) are not listed on Table 1 because monitoring wells are not registered by the State. There are also three former groundwater monitoring wells at the site that have been sealed due to construction of landfill cells and the MRD facility. The sealed monitoring wells include MW-1, MW-1A, and MW-4. Monitoring wells MW-1B and MW-1C replaced these sealed wells.

There are 15 other wells registered with DLNR located within one-half mile of PVT ISWMF, including two industrial wells, three irrigation wells, six unused wells, one sealed well, and three other use wells (DLNR, 2018). As shown in Table 1, the maximum chloride concentration of groundwater from these 15 wells ranges from 1,150 to 2,370 parts per million (ppm), indicating that the wells are considered brackish water wells (freshwater typically has a chloride concentration less than 250 ppm (Mink and Lau, 1990)).



Legend

- 1/2 Mile Radius from PVT ISWMF
- Existing PVT ISWMF Property Boundary
- Project Site Property Boundary
- Other Well
- PVT Monitoring Wells
- Injection Well
- Potable Well
- UIC Line

Basemap Reference: Delorme, 1985; DOH, 1984.

Approved by: JKH
Drawn by: LBM
Date: February 2018

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Figure 13
Well Location Map

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Table 1: Registered Wells within One-Half Mile of PVT ISWMF

Well Number	Well Name	Year Drilled	Owner / User	Ground Elev. (ft)	Well Depth (ft)	Initial Head (ft MSL)	Max. Chloride (ppm)*	Geology	Use
2308-02	Lualualei-PVT	1952	PVT Land Company, Ltd.	115	154	3.7	292	Intrusive rocks (dikes), Wai'anae Volcanics	Unused
2308-03	Lualualei-PVT 1 (PW-1)	1990	PVT Land Company, Ltd.	136	200	7.0	1300	Lava flows, Wai'anae Volcanics, Lualualei Member	Irrigation - Landscape
2308-04	Perimeter Road (PW-2)	2003	PVT Land Company, Ltd.	67	110	0.47	3500	Calcareous reef rock	Industrial - Dust Control
2408-01	Lualualei	1949	Ernesto Anacleto	33	55	2.0	1410	Consolidated calcareous marine sediments	Unused
2408-02	Lualualei	1950	Kirk N. & Joanne N. Oshiro	59	75	2.2	1850	Consolidated calcareous marine sediments	Irrigation
2408-03	Lualualei	1951	Chizuko Shigeta Trust	46	66	2.1	1422	Consolidated calcareous marine sediments	Irrigation
2408-04	Lualualei	1951	Kirk N. & Joanne N. Oshiro	42	63	2.1	1700	Consolidated calcareous marine sediments	Unused
2408-05	Lualualei	1957	Everett Nakata	62	86	2.1	2370	Consolidated calcareous marine sediments	Other
2408-06	Lualualei	1962	JGTT LLC	40	93	NL	NL	Consolidated non-calcareous deposits	Industrial
2408-07	Lualualei	1962	JGTT LLC	40	93	NL	1980	Consolidated non-calcareous deposits	Industrial
2408-08	Maile Irr 1	1989	Kabushiki Kaisha Oban	145	220	5.0	1570	Wai'anae Volcanic Series	Sealed
2408-10	Lualualei GC2	1996	Tropic Land LLC	75	100	NL	NL	Consolidated calcareous marine sediments	Unused
2408-11	North Well	2017	PVT Land Company, Ltd.	216	246	2.3	3660	Consolidated non-calcareous deposits (colluvium)	Industrial - Dust Control
2409-05	Lualualei	1951	Tomita Joint Family Trust	49	76	1.4	1520	Consolidated calcareous marine sediments	Irrigation
2409-06	Lualualei	1951	Tomita Joint Family Trust	49	64	1.4	1150	Consolidated calcareous marine sediments	Unused
2409-15	Maili	1954	Raymond T. Takushi Trust	47	47	1.8	1580	Consolidated calcareous marine sediments	Unused
2409-17	Maili	1955	Charlotte Yamane	45	60	1.2	1690	Consolidated calcareous marine sediments	Unused
2409-19	Maili	1955	Rodney M. Oshiro Trust	55	80	1.4	1270	Consolidated calcareous marine sediments	Other
2409-20	Maili	1955	Janice C. Tsuchitori Trust	51	60	1.6	1950	Consolidated calcareous marine sediments	Other

Reference: DLNR, 2018. NL = Not Listed in the DLNR database.

* = If maximum chloride concentration is NL, initial or test chloride concentration is shown, ppm = parts per million.

Data on Well 2408-11 was obtained during well installation and is not from DLNR database.

Table 2: Permitted Injection Well Facilities within One-Half Mile of PVT ISWMF

Permit Number	Facility	Operator	TMK	Location	Use	Current Status
UO-2956	Willys Enterprises	Wilbert Ho c/o Lani Properties Corp	1-8-7-008-077	87-2402 Farrington Hwy	Sewage	Closed cesspool replaced w/septic tank
UO-2058	Former Texaco Facility #61-100-0093, Nanakuli	B.C. Oil Ventures, Inc.	1-8-7-031-064	87-1942 Farrington Hwy	Industrial	Closed
UO-2963	Ulehawa Beach Park Area No. 1	Department of Parks & Recreation, City & County of Honolulu	1-8-7-007-001	87-1581 Farrington Hwy	Sewage	Closed
UO-2223	Farrington Highway Drainage Improvements, Lualei Place to Princess Kahanu Avenue	Highways Division, Department of Transportation, State of Hawaii	NL	NL	Storm Runoff	Expired approval to construct 9 drainage wells
UO-2321	Nanakuli High & Intermediate School	Department of Education, State of Hawaii	1-8-9-007-009	NL	Sewage	Proposed cesspool closure – not complete
UO-2312	Nanakuli Beach Park (FORAC)	Department of Parks & Recreation, City & County of Honolulu	1-8-9-001-002	NL	Sewage	Proposed cesspool closure – not complete
UO-2313	Nanakuli Beach Park	Department of Parks & Recreation, City & County of Honolulu	1-8-9-001-002	89-269 Farrington Hwy	Sewage	Closed
UO-2536	Nanakuli Beach Park (School Site)	Department of Parks & Recreation, City & County of Honolulu	1-8-9-001-002	NL	Sewage	Closed
UO-2537	Nanakuli Beach Park (Cove Site)	Department of Parks & Recreation, City & County of Honolulu	1-8-9-006-001	NL	Sewage	Closed

Reference: DOH, 2018. NL = Not Listed in the DOH database.

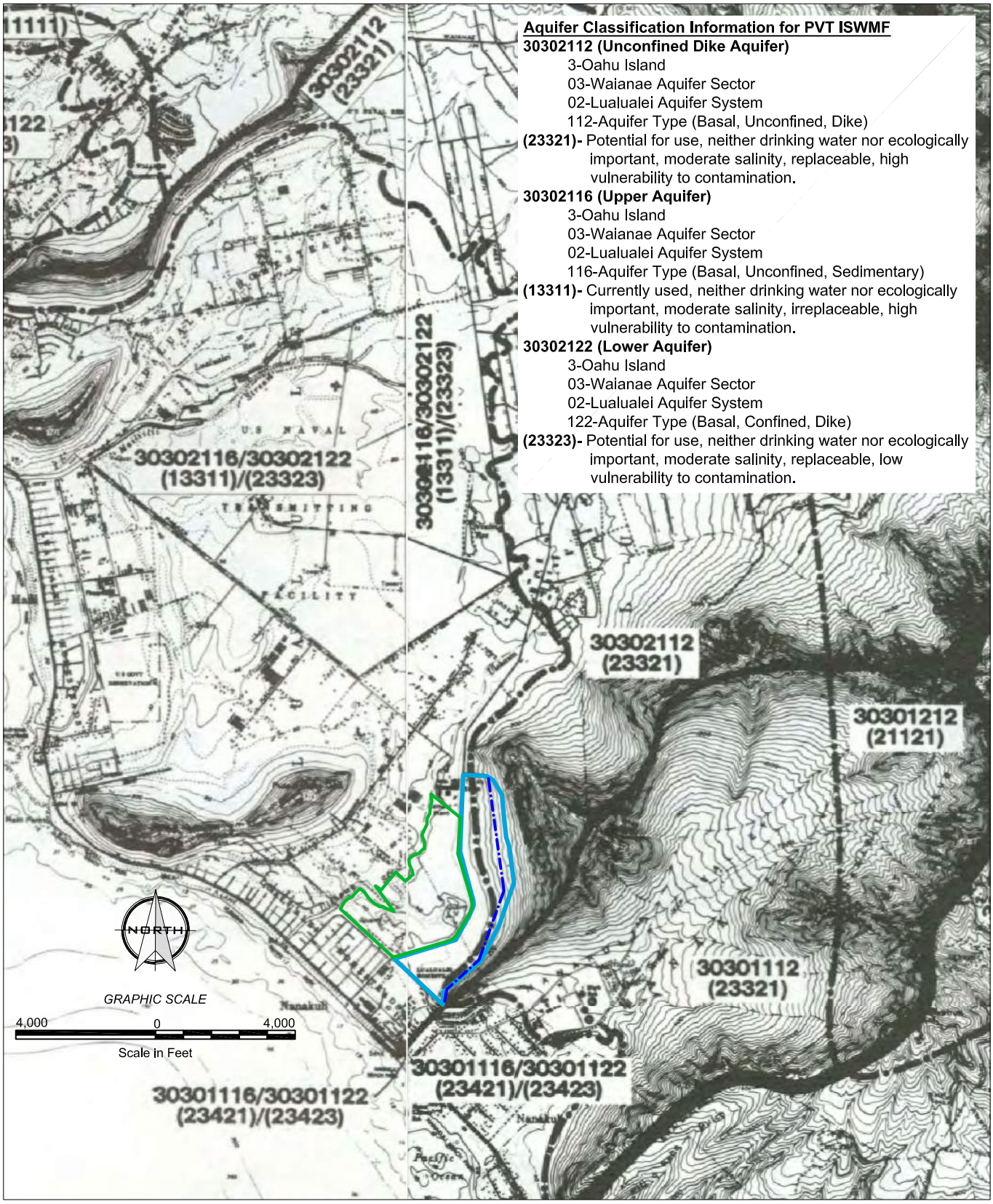
There are nine permitted injection well facilities within one-half mile of PVT ISWMF as shown on Figure 13 and listed in Table 2. These facilities include five facilities that had sewage cesspools that are now closed; one industrial wastewater cesspool that is now closed; two facilities that have sewage cesspools that have not completed closure; and one facility where approval was granted to construct nine storm water injection wells, but the approval expired.

5.3 Groundwater Aquifers at the Site

Groundwater at the site occurs within coralline, alluvial/colluvial, and volcanic materials. According to the aquifer identification and classification for Oʻahu (Mink and Lau, 1990), three aquifers occur at the site, as shown on Figure 14. All three aquifers are classified within the Lualualei Aquifer System of the Waiʻanae Aquifer Sector.

In the developed portion of the site west of Lualualei Naval Road there are two aquifers, one overlying the other. The upper aquifer is a sedimentary caprock aquifer, which overlies a deeper volcanic aquifer (Mink and Lau, 1990). The sedimentary caprock aquifer, Aquifer Code 30302116, occurs within coralline and alluvial/colluvial material at the site. This aquifer is a basal aquifer, which means that fresh water is in contact with seawater. The aquifer is unconfined, where the water table is the upper surface of the saturated aquifer, and the aquifer is currently used for purposes other than drinking water, such as for irrigation or industrial purposes, including dust control and wastewater/storm water injection. In addition, the aquifer is not classified as ecologically important. Salinity in the aquifer is moderate, having 1,000 to 5,000 milligrams per liter (mg/l) or ppm of chloride. The aquifer is also classified as irreplaceable and highly vulnerable to contamination (Mink and Lau, 1990). Based on measurements taken from the groundwater monitoring wells at PVT ISWMF, the water level or head in this aquifer is approximately 1 to 3 feet above MSL (approximately 30 to 60 feet below the ground surface at the monitoring well locations). Extended groundwater level monitoring using pressure transducers indicated that the groundwater in the caprock aquifer is weakly influenced by tidal fluctuations (Joseph, 2004). Inland of the tidal reach, the bottom of the channel of Ulehawa Stream has a thick layer of silt and clay. This results in minimal permeability in Ulehawa Stream and limits the amount and rate of seepage from the stream into the caprock aquifer that lies beneath the site. This also causes the water level in Ulehawa Stream to be different than the groundwater levels beneath the site (Joseph, 2004).

The lower aquifer at the site occurs within volcanic rocks directly beneath the coralline and alluvial/colluvial sediments at depths on the order of 300 feet or more (Macdonald et al., 1983). This basal aquifer, Aquifer Code 30302122, is confined by the sedimentary materials lying above it, and occurs in volcanic rocks within compartments formed by dikes. The aquifer is not currently used; however, it does have potential for use as a source of non-drinking water. The salinity of this aquifer is moderate, 1,000 to 5,000 mg/l chloride, and the aquifer is not classified as ecologically important. This aquifer is further classified as replaceable with a low vulnerability to contamination (Mink and Lau, 1990).



Legend

- Existing PVT ISWMF Property Boundary
- Project Site Property Boundary
- Aquifer Sector
- Aquifer System Per Mink and Lau (1990)
- Aquifer System Based on Observed Field Conditions

Basemap Reference: Mink and Lau, 1990.

Approved by: JKH
Drawn by: LBM
Date: February 2019

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Figure 14
Aquifer Classification Map

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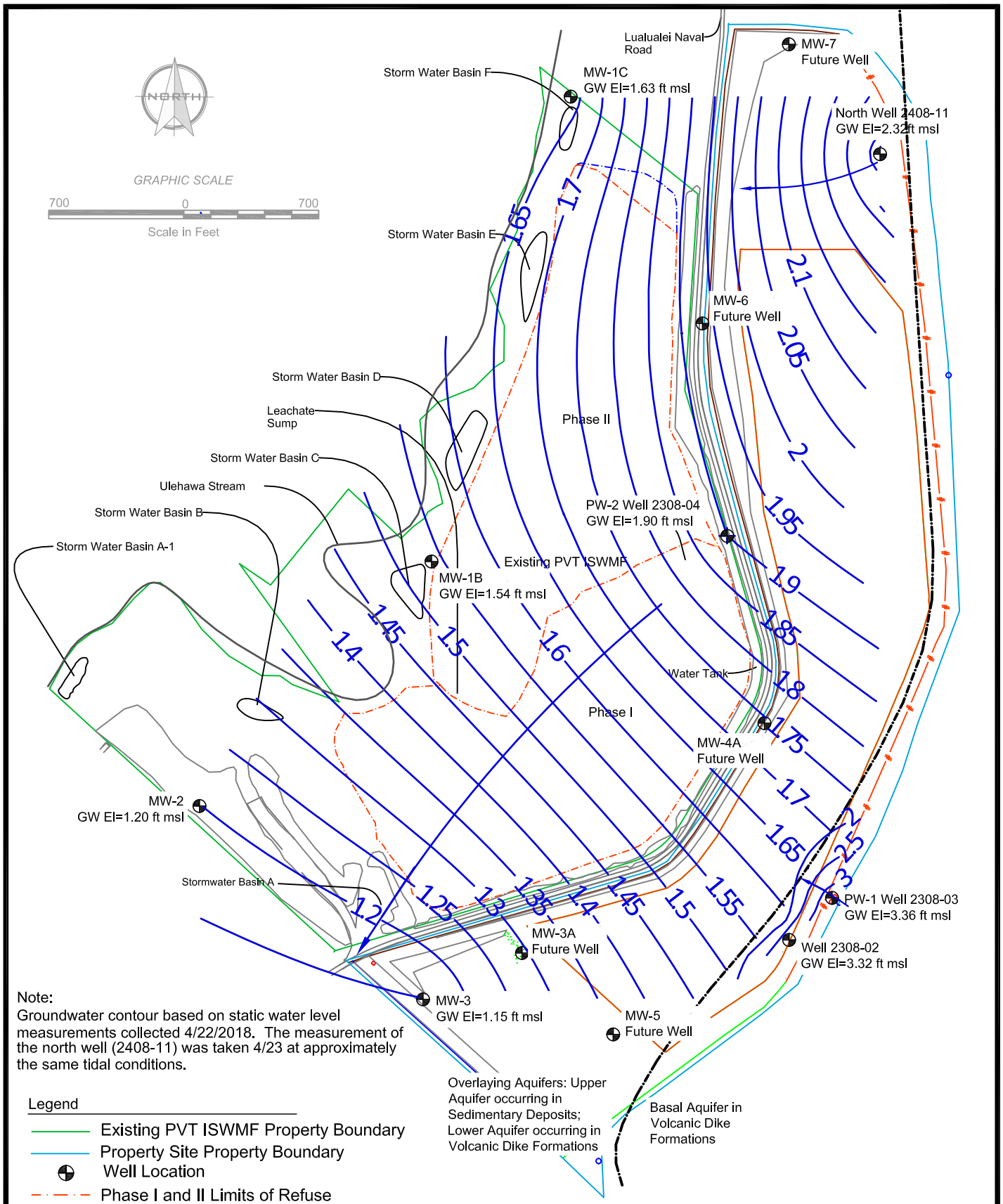
These two aquifers located beneath the developed portion of the site also extend beneath the Project Site, along the lower slopes of Puʻu Heleakalā, as shown on Figure 14. At the Project Site along the upper slopes of Puʻu Heleakalā lies the third aquifer, Aquifer Code 30302112 (Mink and Lau, 1990). This aquifer occurs in dike-impounded volcanic rock with no overlying sedimentary aquifer. Aquifer 30302112, which is unconfined and basal, is classified as having potential use but not as a source of drinking water, nor is it considered ecologically important. The aquifer is classified as having a moderate salinity with chloride concentrations between 1,000 and 5,000 mg/l. The aquifer is also classified as replaceable with a high vulnerability to contamination since there is no overlying aquifer (Mink and Lau, 1990). PVT ISWMF's well PW-1 is located in this aquifer. Based on measurements taken at well PW-1, the groundwater surface is 132 feet below the ground surface at an elevation of approximately 4 feet above MSL.

5.4 Groundwater Flow Direction and Gradient

The groundwater monitoring wells at PVT ISWMF, production well PW-2, and the North Well located in northern portion of the Project Site tap the sedimentary caprock aquifer (Aquifer Code 30302116). The groundwater flow direction and gradient in this aquifer is monitored semiannually as part of PVT ISWMF's groundwater monitoring program. The flow direction and gradient in this aquifer has been consistent over the years and is well documented (Mountain Edge Environmental, Inc., 2004, 2005, 2006a, 2006b; Element Environmental, LLC, 2007a, 2007b, 2008a, 2008b, 2009a, 2009b, 2010a, 2010b, 2011a, 2011b, 2012a, 2012b; and Juturna LLC, 2013a, 2013b, 2014a, 2014b, 2015a, 2015b, 2016a, 2016b, 2017b, 2018a, 2018b, 2018c). Groundwater flows in a south to southwest direction with a very flat gradient, as shown on Figure 15. The groundwater velocity is estimated to be in the range of 1.6 to 2.4 feet per day (Joseph, 2004). The flow is low, and the maximum range of groundwater elevation change measured in the wells since 1995 is less than two feet (see Table 3). The groundwater gradient map shown on Figure 15 was generated using groundwater elevations measured in the four monitoring wells and in well PW-2 on April 22, 2018, and in the North Well on April 23, 2018. Table 3 lists the groundwater elevations measured on April 22, 2018, as well as data collected over the last 14 years. The groundwater elevation at the North Well measured on April 23, 2018 was 2.32 feet MSL.

Groundwater elevations in the wells on April 22 and 23, 2018 ranged from 1.15 feet to 2.32 feet MSL, and the groundwater gradient averaged approximately 2.95×10^{-4} foot/foot across the site. The gradient map (Figure 15) shows that well MW-1C and the North Well are upgradient wells and that wells MW-1B, MW-2 and MW-3 are downgradient.

Two wells (well 2308-02 [PW-1] and well 2308-03) are located in the volcanic dike aquifer (Aquifer Code 30302112), which occurs at the Project Site along the upper slopes of Pu'u Heleakalā. Head levels in this aquifer are significantly higher (50 to 63 percent) than those in the sedimentary caprock aquifer (Element Environmental, LLC, 2007c). Monthly water level measurements taken in well PW-1 from March 2013 through June 2018 ranged from 2.9 to 3.8 feet MSL. The groundwater flow direction and gradient in the volcanic dike aquifer has not been previously measured; however, based on static water level measurements in well PW-1



Note:
Groundwater contour based on static water level measurements collected 4/22/2018. The measurement of the north well (2408-11) was taken 4/23 at approximately the same tidal conditions.

Legend

- Existing PVT ISWMF Property Boundary
- Property Site Property Boundary
- Well Location
- Phase I and II Limits of Refuse
- C&D Landfill (Phase III)
- Roads
- Rockfall Catchment Barrier/Security Fence
- Groundwater Contour (ft msl)
- Groundwater Flow Direction
- Aquifer Type Boundary based on Mink and Lau (1990) and field conditions

Basemap Reference: A-Mehr, 2018.

Approved by: JKH
Drawn by: LBM
Date: March 2019

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Figure 15
Groundwater Gradient Map

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and on the geologic structure and aquifer boundaries documented in the literature (Mink and Lau, 1990; Macdonald, et al., 1983; Stearns, 1938), the groundwater is anticipated to flow toward the boundary with the sedimentary caprock aquifer. It is likely that groundwater from the volcanic dike aquifer discharges into the sedimentary caprock aquifer along the aquifer boundaries. However, it is possible that individual dike compartments could have a significant role in controlling the localized groundwater flow patterns at the site.

Table 3: Groundwater Elevations in PVT ISWMF Wells

Date	Well Number / Groundwater Elevation (feet MSL)						
	MW-1*	MW-1A*	MW-1B	MW-1C*	MW-2	MW-3	PW-2
5/21/2004	1.75	1.90	----	----	1.44	1.41	1.82
6/27/2005	1.55	1.89	----	----	1.40	1.46	NM
12/27/2005	1.62	1.81	----	----	1.54	1.49	NM
10/20/2006	3.34	3.44	----	----	2.72	2.70	NM
12/19/2006	3.13	3.21	----	----	2.52	2.52	NM
6/29/2007	2.85	2.94	----	----	2.17	2.18	NM
12/12/2007	3.30	3.39	----	----	2.67	2.69	NM
6/25/2008	3.00	3.09	----	----	2.30	2.33	NM
12/9/2008	3.04	3.11	----	----	2.44	2.42	NM
6/17/2009	2.71	2.77	----	----	2.02	2.00	NM
12/9/2009	2.95	3.03	----	----	2.00	2.28	NM
6/30/2010	1.51	1.67	----	----	1.33	1.35	NM
12/30/2010	1.90	2.03	----	----	1.81	1.79	NM
6/30/2011	1.50	1.67	----	----	1.37	1.37	NM
12/28/2011	sealed	1.50	1.38	----	1.17	1.20	NM
6/14/2012	sealed	1.59	1.49	----	1.25	1.27	NM
12/26/2012	sealed	1.92	1.78	----	1.66	1.72	NM
6/26/2013	sealed	1.69	1.57	----	1.43	1.43	NM
1/23/2014	sealed	sealed	1.65	----	1.42	1.42	NM
6/6/2014	sealed	sealed	1.72	1.78	1.46	1.34	NM
1/12/2015	sealed	sealed	1.54	1.78	1.31	1.23	1.44
6/29/2015	sealed	sealed	1.66	1.74	1.39	1.28	NM
12/29/2015	sealed	sealed	1.61	1.80	1.52	1.43	NM
7/28/2016	sealed	sealed	1.69	1.80	1.40	1.32	NM
1/3/2017	sealed	sealed	1.79	1.94	1.65	1.51	NM
6/27/2017	sealed	sealed	1.89	1.99	1.59	1.65	NM
4/22/2018	sealed	sealed	1.54	1.63	1.20	1.15	1.90
7/9/2018	sealed	sealed	1.83	1.93	1.39	1.35	NM

NM = Not Measured on indicated date. ---- = Well was not yet constructed on indicated date. * = Well is/was located upgradient of landfill activities.

Note: An electronic water level indicator was used to measure the depth to groundwater from the known elevations at the top of the well casings. On each day, static water levels were measured within a one-hour period so that changes caused by tidal influence were minimized. Obtaining water level measurements in the pump wells is difficult because it involves turning the pumps off and allowing the water levels to equilibrate which takes several hours, and the pumps need to be running during landfill operating hours; therefore, water levels are not routinely measured in the pump wells.

Reference: Mountain Edge Environmental, Inc., 2004, 2005, 2006a, 2006b; Element Environmental, LLC, 2007a, 2007b, 2008a, 2008b, 2009a, 2009b, 2010a, 2010b, 2011a, 2011b, 2012a, 2012b; Juturna LLC, 2013a, 2013b, 2014a, 2014b, 2015a, 2015b, 2016a, 2016b, 2017b, 2018a, 2018b, 2018c.

No data is available on the groundwater flow direction and gradient in the deeper volcanic dike aquifer (Aquifer Code 30302122) located below the sedimentary caprock aquifer.

5.5 Groundwater Quality

5.5.1 *Summary of Previous Sampling Events*

The groundwater quality at PVT ISWMF in the sedimentary caprock aquifer has been monitored since 1992 initially following the guidelines set forth in the Groundwater Protection and Monitoring Plan prepared by Belt Collins (Belt Collins Hawaii, 1998), then following the Groundwater Monitoring Plan prepared by Mountain Edge Environmental, Inc. (2004) and the Groundwater and Leachate Monitoring Plan prepared by Juturna LLC in 2015 and updated in 2018 (Juturna LLC, 2018d). According to the 1998 plan, sampling and analysis of groundwater from wells MW-1A, MW-1, MW-2 and MW-3 was undertaken twice in 1992 and annually thereafter. In 1996, three rounds of groundwater sampling were completed to provide the minimum amount of samples needed for statistical data analysis. Samples were collected annually in 1997 and 1998, then in 1999 and 2000 three to four samples were collected per year to provide the minimum amount of samples needed for statistical analysis for new detection monitoring parameters. From 2001 to present, groundwater sampling and analysis has occurred semiannually, in June or July during the dry season and in December or January during the rainy season.

Well MW-1, which was located upgradient of the C&D landfill, was permanently closed in August 2011 to allow for construction of landfill Cell 8. Well MW-1B was installed in December 2011 to replace MW-1. Well MW-1A, which was the primary upgradient monitoring well, was permanently closed in August 2013 to allow for construction of the recycling and materials recovery facility and a new storm water basin. Well MW-1C, which is now the only upgradient monitoring well, was installed in March 2014 to replace MW-1A. Additional groundwater samples from wells MW-1B and MW-1C were collected outside the standard semiannual sampling events to obtain the minimum number of samples needed for statistical analysis. Well MW-4, which was located upgradient of wells MW-2 and MW-3, was permanently closed in August 1995 due to expansion of the working landfill area and was replaced with well MW-1A (Belt Collins Hawaii, 2005).

In accordance with PVT's Groundwater and Leachate Monitoring Plan (Juturna LLC, 2018d), groundwater at the site is tested for the parameters listed in Table 4. The results of the groundwater sampling events from 1992 through 2018 are presented in reports prepared by Belt Collins Hawaii (1998), Masa Fujioka & Associates (1998 to 2003), Mountain Edge Environmental, Inc. (2004 to 2006), Element Environmental, LLC (2007 to 2012), and Juturna LLC (2012 to 2018); and a summary of these groundwater quality results is provided in the following sections.

The production wells at PVT ISWMF, PW-1 and PW-2, are sampled monthly for chloride concentration in accordance with their DLNR permits. In addition, PW-1, which is located in the

volcanic dike aquifer on the Project Site, has been sampled twice for additional analytes, once on February 25, 2005 and again on April 12, 2007. In addition, wells PW-1 and PW-2 were sampled on April 27, 2017 for cations and anions. A summary of the groundwater quality results from these sampling events is also provided in the following sections.

Table 4: Groundwater Monitoring Parameters

Analyte	Fequency of Testing
Volatile Organic Compounds (VOCs)	Semiannually
Total Dissolved Solids (TDS)	Semiannually
Chloride, Sulfate	Semiannually
Alkalinity as Calcium Carbonate ($CaCO_3$), Bicarbonate	Semiannually
Calcium, Magnesium, Potassium, Sodium	Semiannually
Arsenic, Cadmium, Chromium, Iron, Lead	Every Five Years
Extractable Petroleum Hydrocarbons – Diesel Range Organics (DRO)	Every Five Years
Total Organic Carbon (TOC)	Every Five Years
Field Measured Temperature, Conductivity, pH and Water Level	Semiannually

Reference: Juturna LLC, 2018d.

5.5.2 *Historical Organic Compound Detections*

Three volatile organic compounds (VOCs) have been historically detected in the two former upgradient groundwater monitoring wells at the site (wells MW-1A and MW-1), and now new upgradient well MW-1C has had VOC detections. In addition, trace levels of one of the VOCs have been periodically detected in downgradient well MW-3. A list of historical VOC detections in the sedimentary caprock aquifer is provided in Table 5. Organic compounds have not been detected in groundwater from well PW-1 in the volcanic dike aquifer.

As shown on Table 5, groundwater samples collected in May 1993 through December 2006 and in June 2010 from upgradient well MW-1 (upgradient of PVT's C&D landfill) have contained the VOC trichloroethene (TCE), except for the first semiannual monitoring event for 2006 where TCE was not detected above the reporting limit. The detected TCE concentrations in well MW-1 ranged from 0.0042 to 0.0459 mg/l. Low concentrations of TCE (0.0006 to 0.00813 mg/l) were also detected in groundwater collected from downgradient well MW-3 in 1999, 2002, 2010, and 2011, but have not been detected since 2011. Some of these TCE concentrations are considered estimated concentrations since they were detected below the laboratory reporting limit. Low concentrations of TCE (0.0042 to 0.007 mg/l) have also been detected in new upgradient well MW-1C, which is located in the northernmost corner of the site, upgradient of all site activities. Also detected in MW-1C have been low concentrations of tetrachloroethene (PCE) (0.004 to 0.0076 mg/l) and cis-1,2-dichloroethene (cis-1,2-DCE) (0.0027 to 0.0056 mg/l), which have not been previously detected in the wells at PVT ISWMF. TCE and PCE were used as dry-cleaning chemicals and as solvents to remove grease from metal parts (United States Environmental Protection Agency [US EPA], 2014). TCE is also a breakdown product of PCE, and cis-1,2-DCE is a breakdown product of TCE (US EPA, 2014). The source of these VOCs is suspected to be from an unlined wastewater pond at the Lualualei

Naval Reservation, which is located upgradient of PVT ISWMF and was found to contain PCE (Belt Collins Hawaii, 2005). The concentrations of VOCs encountered in the wells at the site are an order of magnitude or more below DOH Environmental Action Levels (EALs), as shown on Table 5 (DOH, 2011).

Table 5: Historical Volatile Organic Compound Detections

Constituent	Units	Well	Date	Result	DOH EAL	Laboratory Reporting Limit
Trichloroethene	mg/L	MW-1*	5/28/1993	0.0048	0.360	0.00025
Trichloroethene	mg/L	MW-1*	6/27/1994	0.0066	0.360	0.0005
Trichloroethene	mg/L	MW-1*	6/14/1995	0.012	0.360	0.002
Trichloroethene	mg/L	MW-1*	8/7/1995	0.013	0.360	0.0005
Trichloroethene	mg/L	MW-1*	6/27/1996	0.015	0.360	0.0005
Trichloroethene	mg/L	MW-1*	8/29/1996	0.022	0.360	0.005
Trichloroethene	mg/L	MW-1*	9/23/1996	0.019	0.360	0.0005
Trichloroethene	mg/L	MW-1*	7/2/1997	0.021	0.360	0.005
Trichloroethene	mg/L	MW-1*	11/12/1998	0.018	0.360	0.005
Trichloroethene	mg/L	MW-1*	4/23/1999	0.017	0.360	0.005
Trichloroethene	mg/L	MW-1*	9/27/1999	0.018	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/2/1999	0.016	0.360	0.005
Trichloroethene	mg/L	MW-1*	2/2/2000	0.0157	0.360	0.005
Trichloroethene	mg/L	MW-1*	5/25/2000	0.0137	0.360	0.005
Trichloroethene	mg/L	MW-1*	8/25/2000	0.0158	0.360	0.005
Trichloroethene	mg/L	MW-1*	11/29/2000	0.0131	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/21/2001	0.0150	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/6/2001	0.0148	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/10/2002	0.0133	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/3/2002	0.0459	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/26/2003	0.0113	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/4/2003	0.0108	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/9/2004	0.00802	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/20/2004	0.00767	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/27/2005	0.00695	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/22/2005	0.0069	0.360	0.005
Trichloroethene	mg/L	MW-1*	12/19/2006	0.00524	0.360	0.005
Trichloroethene	mg/L	MW-1*	6/30/2010	0.0042	0.360	0.001
1,2-dichloroethane	mg/L	MW-1A*	8/7/1995	0.016	0.160	0.0005
1,2-dichloroethane	mg/L	MW-1A*	6/27/1996	0.013	0.160	0.0005
1,2-dichloroethane	mg/L	MW-1A*	8/29/1996	0.015	0.160	0.0005
1,2-dichloroethane	mg/L	MW-1A*	9/23/1996	0.026	0.160	0.0005
1,2-dichloroethane	mg/L	MW-1A*	7/2/1997	0.017	0.160	0.005
1,2-dichloroethane	mg/L	MW-1A*	11/12/1998	0.014	0.160	0.005
1,2-dichloroethane	mg/L	MW-1A*	4/23/1999	0.014	0.160	0.005
1,2-dichloroethane	mg/L	MW-1A*	9/27/1999	0.0078	0.160	0.005
1,2-dichloroethane	mg/L	MW-1A*	12/2/1999	0.002	0.160	0.005

Constituent	Units	Well	Date	Result	DOH EAL	Laboratory Reporting Limit
1,2-dichloroethane	mg/L	MW-1A*	8/25/2000	0.00565	0.160	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	4/23/1999	0.005	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	9/27/1999	0.0056	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	2/2/2000	0.00612	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	5/25/2000	0.00542	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	8/25/2000	0.00612	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	6/21/2001	0.00515	1.800	0.005
Methyl tert-butyl ether	mg/L	MW-1A*	12/3/2002	0.00644	1.800	0.005
Cis-1,2-dichloroethene	mg/L	MW-1C*	6/6/2014	0.0052	0.590	0.005
Cis-1,2-dichloroethene	mg/L	MW-1C*	7/23/2014	0.0056	0.590	0.005
Cis-1,2-dichloroethene	mg/L	MW-1C*	1/2/2018	0.0032	0.590	0.001
Cis-1,2-dichloroethene	mg/L	MW-1C*	7/9/2018	0.0027	0.590	0.001
Tetrachloroethene	mg/L	MW-1C*	6/6/2014	0.0076	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	7/23/2014	0.007	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	1/12/2015	0.0065	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	4/28/2015	0.0055	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	6/29/2015	0.0065	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	11/13/2015	0.0058	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	12/29/2015	0.0058	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	4/27/2016	0.0065	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	7/28/2016	0.0052	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	1/3/2017	0.0058	0.120	0.005
Tetrachloroethene	mg/L	MW-1C*	1/2/2018	0.0041	0.120	0.001
Tetrachloroethene	mg/L	MW-1C*	7/9/2018	0.0040	0.120	0.001
Trichloroethene	mg/L	MW-1C*	6/6/2014	0.0064	0.360	0.005
Trichloroethene	mg/L	MW-1C*	7/23/2014	0.007	0.360	0.005
Trichloroethene	mg/L	MW-1C*	1/12/2015	0.006	0.360	0.005
Trichloroethene	mg/L	MW-1C*	4/28/2015	0.0054	0.360	0.005
Trichloroethene	mg/L	MW-1C*	6/29/2015	0.0059	0.360	0.005
Trichloroethene	mg/L	MW-1C*	11/13/2015	0.0055	0.360	0.005
Trichloroethene	mg/L	MW-1C*	12/29/2015	0.0058	0.360	0.005
Trichloroethene	mg/L	MW-1C*	4/27/2016	0.0058	0.360	0.005
Trichloroethene	mg/L	MW-1C*	1/3/2017	0.0054	0.360	0.005
Trichloroethene	mg/L	MW-1C*	6/27/2017	0.0051	0.360	0.001
Trichloroethene	mg/L	MW-1C*	1/2/2018	0.0045	0.360	0.001
Trichloroethene	mg/L	MW-1C*	7/9/2018	0.0042	0.360	0.001
Trichloroethene	mg/L	MW-3	4/23/1999	0.0006	0.360	0.005
Trichloroethene	mg/L	MW-3	9/27/1999	0.0008	0.360	0.005
Trichloroethene	mg/L	MW-3	12/2/1999	0.001	0.360	0.005
Trichloroethene	mg/L	MW-3	12/3/2002	0.00813	0.360	0.005
Trichloroethene	mg/L	MW-3	6/30/2010	0.0020	0.360	0.001
Trichloroethene	mg/L	MW-3	12/28/2011	0.0016	0.360	0.001

Reference: Juturna LLC, 2018c; DOH, 2011. EALs are for sites where groundwater is not a current or potential source of drinking water and is located less than 150 meters from a surface water body (DOH, 2011). * = Well is/was located upgradient of landfill activities.

The VOCs 1,2-dichloroethane (DCA) and methyl tert-butyl ether (MTBE) have been detected in groundwater collected from former upgradient well MW-1A. Like PCE, DCA is also a metal degreaser (US EPA, 2015a), while MTBE is used as a fuel additive to motor gasoline (US EPA, 2015b). Concentrations of DCA ranging from 0.002 to 0.026 mg/l were detected in MW-1A from 1995 to 2000; and concentrations of MTBE ranging from 0.005 to 0.00644 mg/l were detected in MW-1A from 1999 to 2002. No VOCs were detected in groundwater collected from well MW-1A from 2002 until 2014 when the well was sealed. The source of the DCA is suspected to be from the unlined wastewater pond at the Lualualei Naval Reservation (Belt Collins Hawaii, 2005). The source of the MTBE is suspected to be from abandoned buses and 55-gallon drums that were dumped in Ulehawa Stream on an adjacent property, but were removed in 2001 (Belt Collins Hawaii, 2005).

In 1994, the semivolatile organic compound benzo(a)pyrene was detected in well MW-3. However, benzo(a)pyrene was not detected in any well samples since 1994 (Belt Collins Hawaii, 1998; Masa Fujioka & Associates, 1998 to 2003; Mountain Edge Environmental, Inc., 2004 to 2006; Element Environmental, LLC, 2007 to 2012; and Juturna LLC, 2013 to 2018).

Total petroleum hydrocarbons (TPH) as diesel was detected in all wells during the June 10, 2002 sampling event and in well MW-1A in the December 3, 2002 sampling event (Masa Fujioka & Associates, 2002). The fact that TPH-diesel had not been previously detected in these wells and that the levels encountered during the June 2002 sampling event had similar concentrations, suggests that there may have been cross-contamination during sampling. This cross-contamination perhaps resulted from inadequately decontaminated field sampling equipment. The TPH-diesel concentration encountered in well MW-1A during the December 2002 sampling event was likely remaining contamination from the previous sampling event. TPH-diesel has not been detected in groundwater above reporting limits before or after the 2002 sampling events.

Every five years total organic carbon (TOC) is monitored in the groundwater monitoring wells at the site. TOC in groundwater can originate from decaying natural organic matter and from synthetic chemicals, such as pesticides, fertilizers, and detergents, for example. TOC concentrations in the wells have ranged from 0.92 to 550 mg/l. TOC was last tested in wells MW-1B, MW-2, and MW-3 in 2015 and in well MW-1C in 2016 with concentrations of 1.08 mg/l in MW-1B, 1.05 mg/l in MW-1C, 3.47 mg/l in MW-2, and 0.92 mg/l in MW-3.

5.5.3 *Inorganic Groundwater Geochemistry*

In addition to organic compounds, the following inorganic analytes are monitored semiannually in the groundwater at the site: total dissolved solids (TDS), chloride, sodium, potassium, magnesium, calcium, sulfate, and alkalinity (bicarbonate). These inorganic analytes are cations and anions, which occur naturally in groundwater, and are monitored semiannually so that small changes or trends in groundwater geochemistry can be detected. Every five years groundwater is also analyzed for the metals arsenic, cadmium, chromium, iron, and lead.

Table 6 shows the concentrations of the cations and anions detected in the groundwater monitoring wells during the latest sampling event in July 2018. Also shown in Table 6 are the results for samples collected in 2017 for PW-2, and in 2005, 2007, and 2017 from well PW-1, which is located in the volcanic dike aquifer in the eastern part of the Project Site. Additional water quality data from well PW-1 is shown on Table 7.

Table 6: Inorganic Groundwater Quality Results – Cations and Anions

Analyte	Units	Well Number / Date Sampled							
		MW-1B 7/2018	MW-1C* 7/2018	MW-2 7/2018	MW-3 7/2018	PW-1* 2/2005	PW-1* 4/2007	PW-1* 4/2017	PW-2 4/2017
Calcium	mg/l	271	237	172	205	163	83.2	68.5	219
Magnesium	mg/l	267	229	72.2	235	399	119	103	291
Potassium	mg/l	54.4	32.1	15.3	40.4	13.5	14.1	10.7	40.0
Sodium	mg/l	1670	1120	328	1180	432	530	383	1430
Bicarbonate as $CaCO_3$	mg/l	386	354	355	259	149	120	127	273
Chloride	mg/l	3010	2850	609	2640	924	1100	894	3130
Sulfate	mg/l	606	526	260	407	109	130	109	445
Total Dissolved Solids	mg/l	5950	4700	1930	4730	2400	2300	NA	NA

NA = Not Analyzed for listed constituent. * = Well is located upgradient of landfill activities.
Reference: Juturna LLC, 2017b, 2018c; Element Environmental, LLC, 2007d; GE Infrastructure Water & Process Technologies, 2005.

The inorganic analytes listed in Table 6 and the additional water quality parameters listed in Table 7 are constituents that occur naturally in groundwater, and the concentrations detected are typical of naturally occurring concentrations. As shown in Table 6, groundwater from well PW-1 generally has lower concentrations of almost all of the inorganic analytes than groundwater from monitoring wells MW-1B, MW-1C, and MW-3, and pump well PW-2. Concentrations of these inorganic analytes would typically be lower in groundwater from a volcanic dike aquifer as compared to groundwater from a sedimentary caprock aquifer. However, the concentrations of magnesium, sodium, chloride and TDS in well MW-2 from the sedimentary caprock aquifer are significantly lower than in well PW-1 from the volcanic dike aquifer. Well MW-2 has been historically fresher (less brackish) than the other wells in the sedimentary caprock aquifer, due to its location in PVT ISWMF's tree nursery, which is irrigated with potable water, in addition to documented leaks in subsurface potable water lines in the vicinity of the well. The large majority of the constituent concentrations in MW-2 have been steadily increasing since July 2016, which suggests that MW-2 is becoming more brackish again after repair of the second potable water line leak (Juturna LLC, 2018c).

Chloride concentrations are measured monthly in production wells PW-1, located in the volcanic dike aquifer, and PW-2, located in the sedimentary caprock aquifer. From March 2013 through June 2018 chloride concentrations in well PW-1 have ranged from 75 to 3,400 mg/l, averaging 1,081 mg/l, while chloride concentrations in well PW-2 have ranged from 1,100 to 3,500 mg/l, averaging 3,000 mg/l.

In addition to the cations and anions, which are analyzed in the groundwater monitoring wells semiannually, the metals arsenic, cadmium, chromium, iron, and lead are analyzed every five years. Table 8 summarizes the results for these metals in the groundwater monitoring wells.

Table 7: Additional Groundwater Monitoring Results for PW-1, February 2005

Analyte	PW-1 2/25/2005	Analyte	PW-1 2/25/2005
Ammonia, Free, as N	< 0.3	Chromium, Hexavalent	< 0.01
Ammonia, Fixed Organic, as N	< 0.4	Fluoride	< 0.4
Ammonia, Free and Fixed, as N	< 0.3	Phosphate, Filtered Total	< 0.4
pH (pH units)	7.9	Phosphate, Filtered Total Inorganic	< 0.2
Specific Conductance at 25° C (μmhos/cm)	3380	Arsenic, Total	< 0.01
Hardness, Total, as $CaCO_3$	586	Arsenic, Filtered	< 0.1
Magnesium Hardness, Total, as $CaCO_3$	424	Boron, Filtered	0.12
Barium, Total	0.008	Beryllium	< 0.005
Strontium, Total	0.81	Boron	0.12
Hardness, Filtered, as $CaCO_3$	562	Cadmium, Filtered	< 0.01
Barium, Filtered	< 0.01	Cadmium	< 0.005
Strontium, Filtered	0.81	Chromium, Total	< 0.01
Copper, Total	0.003	Chromium, Filtered	< 0.03
Copper, Filtered	< 0.05	Cobalt, Filtered	< 0.01
Iron, Total	0.017	Cobalt, Total	< 0.005
Iron, Filtered	< 0.05	Lead, Filtered	< 0.05
Lithium	0.003	Lead, Total	< 0.005
Zinc, Total	0.01	Molybdenum, Filtered	< 0.06
Zinc, Filtered	< 0.04	Nickel, Filtered	< 0.01
Aluminum, Total	< 0.01	Nickel, Total	< 0.005
Aluminum, Filtered	< 0.1	Selenium, Total	0.01
Manganese, Total	< 0.005	Selenium, Filtered	< 0.1
Manganese, Filtered	< 0.01	Tin, Total	< 0.01
Nitrate	6.5	Titanium, Total	0.006
Molybdenum	<0.006	Titanium, Filtered	< 0.01
Phosphate, Total	< 0.4	Vanadium, Total	0.041
Phosphate, Total Inorganic	0.2	Vanadium, Filtered	0.04
Phosphate, Ortho	0.2	Zirconium, Total	0.012
Phosphate, Filtered Ortho	< 0.2	Thallium, Total	< 0.05
Silica, Colloidal	< 17	Tin, Filtered	< 0.05
Silica, Total	84	Total Organic Carbon	< 1
Silica, Filtered	83	Chemical Oxygen Demand as O_2	7980
Silica, Reactive	83	Turbidity (NTU)	0.8
Total Suspended Solids	< 10		

Reference: GE Infrastructure Water & Process Technologies, 2005.

As shown in Table 8, the metal arsenic was detected in wells MW-2 and MW-3 in 1992 right at the laboratory reporting limit (RL) but has not been detected in any of the wells since then. Likewise, the metal cadmium was detected in wells MW-2 and MW-3 in 1992 and in well

MW-1A in 1996 and 1997, but has not been detected in any of the wells since then. Prior to 1998 the metal chromium was detected periodically in wells MW-1, MW-1A, MW-2, and MW-3 but has not been detected in any of the wells since July 1997. The metal iron was detected once in well MW-1A in 2000, and has been detected more recently in wells MW-1B, MW-1C, and MW-3 just above the RL. Lastly, the metal lead has only been detected once, in well MW-1B in 2011. The concentrations of metals detected in the monitoring wells at the site are typical of naturally-occurring levels of metals in groundwater.

Table 8: Inorganic Groundwater Quality Results - Metals

Well Number	Analyte (mg/l)				
	Arsenic	Cadmium	Chromium	Iron	Lead
MW-1*	All ND	All ND	0.04 in 6/1992 All Others ND	All ND	All ND
MW-1A*	All ND	0.008 in 6/1996 0.012 in 7/1997 All Others ND	0.72 in 6/1996 0.46 in 8/1996 0.36 in 9/1996 0.56 in 7/1997 All Others ND	0.396 in 8/2000 All Others ND	All ND
MW-1B	All ND	All ND	All ND	0.04 in 12/2012 0.03 in 12/2012 0.031 in 4/2015 All Others ND	0.0062 in 12/2011 All Others ND
MW-1C*	All ND	All ND	All ND	0.043 in 12/2015 0.02 in 4/2016 All Others ND	All ND
MW-2	0.8 in 2/1992 2.9 in 6/1992 All Others ND	0.001 in 2/1992 All Others ND	0.025 in 2/1992 0.066 in 8/1996 0.061 in 9/1996 All Others ND	All ND	All ND
MW-3	1.0 in 6/1992 All Others ND	0.001 in 2/1992 All Others ND	0.018 in 2/1992 0.04 in 6/1992 0.081 in 8/1996 All Others ND	0.027 in 4/2015 All Others ND	All ND
DOH EAL	0.036	0.003	0.074	No EAL	0.0056
Lab RL	0.01	0.001	0.004	0.02	0.005

* = Well is/was located upgradient of landfill activities. ND = Not Detected above Laboratory Reporting Limit. Lab RL = Laboratory Reporting Limit for majority of samples. EALs are for sites where groundwater is not a current or potential source of drinking water and is located less than 150 meters from a surface water body (DOH, 2011).

As part of PVT ISWMF's groundwater monitoring program, the groundwater monitoring data from 1992 to present is input into a statistical analysis program. The program generates Shewhart-CUSUM (cumulative sum) intra-well control charts that show the concentrations of each of the analytes detected in groundwater in each of the four monitoring wells plotted over time. The intra-well control charts include a line, called the control limit, for each of the sample points and analytes. Concentrations plotted above the control limit line indicate a statistical

exceedance and the possibility that a release from the landfill may have occurred. If there is a statistical exceedance, PVT ISWMF's Groundwater and Leachate Monitoring Plan (Juturna LLC, 2018d) outlines specific steps to follow to determine if a release from the landfill may have occurred. These specific steps are based on the State of Hawai'i Landfill Groundwater Monitoring Guidance Document (DOH, 2002).

In the last 26 years of groundwater monitoring, there have been a few statistical exceedances in the intra-well control charts; however, none of the statistical exceedances were attributed to a release from the landfill. In 2010 and 2011, the CUSUM statistical analysis exceeded the control limit for calcium, chloride, magnesium, potassium, sodium, and TDS in well MW-2, and individual concentrations of magnesium, potassium, and sodium exceeded the control limits. As stated previously, groundwater in well MW-2 has consistently been fresher (less brackish) than the other wells; however, beginning in 2007, the groundwater in well MW-2 was becoming more brackish, as the concentrations of these constituents were increasing. This increase was likely due to a leaking old potable water line running adjacent to MW-2 that was replaced with a new line in 2007. The leaking old water line was causing the groundwater around well MW-2 to become fresher, then when the old water line was replaced with a new line, the groundwater became more brackish. The groundwater in well MW-2 became fresher again in early 2016 due to increased irrigation in the plant nursery coupled with another potable water line leak. The large majority of the constituent concentrations in MW-2 have been steadily increasing since 2016, which suggests that MW-2 is becoming more brackish again after repair of the second potable water line leak. However, there have been no statistical exceedances in MW-2 since 2011.

In addition to previous statistical exceedances in well MW-2, in 2015 well MW-1B began experiencing increases in the concentrations of calcium, chloride, magnesium, potassium, sodium, sulfate, and TDS, and had verified statistical exceedances of most of these constituents in 2016. If statistically significant increases over background in a detection monitoring parameter are detected and verified, assessment monitoring is required, and the first step of assessment monitoring is to evaluate if an alternate source (i.e., natural change or spatial variability, upgradient source, manmade cause, etc.) could explain the exceedance. An alternate source investigation for well MW-1B was conducted in 2016. The alternate source investigation concluded that landfill leachate is not the source of the exceedances in MW-1B. Rather, the increases in calcium, chloride, magnesium, potassium, sodium, sulfate, and TDS concentrations in MW-1B are due to the groundwater becoming more brackish in the vicinity of MW-1B, most likely as a result of seawater intrusion, possibly due to rises in sea level, which would cause Ulehawa Stream and more brackish groundwater to extend further inland. In fact, leachate could not cause the verified statistically significant increase in chloride in well MW-1B because the chloride concentration of the leachate is much less than the chloride concentration of the groundwater in MW-1B.

After completion of the alternate source investigation for MW-1B, statistical exceedances for calcium, chloride, magnesium, potassium, sodium, sulfate, and TDS were still occurring in 2017. During the first monitoring event of 2018, sand and grass were present on the water

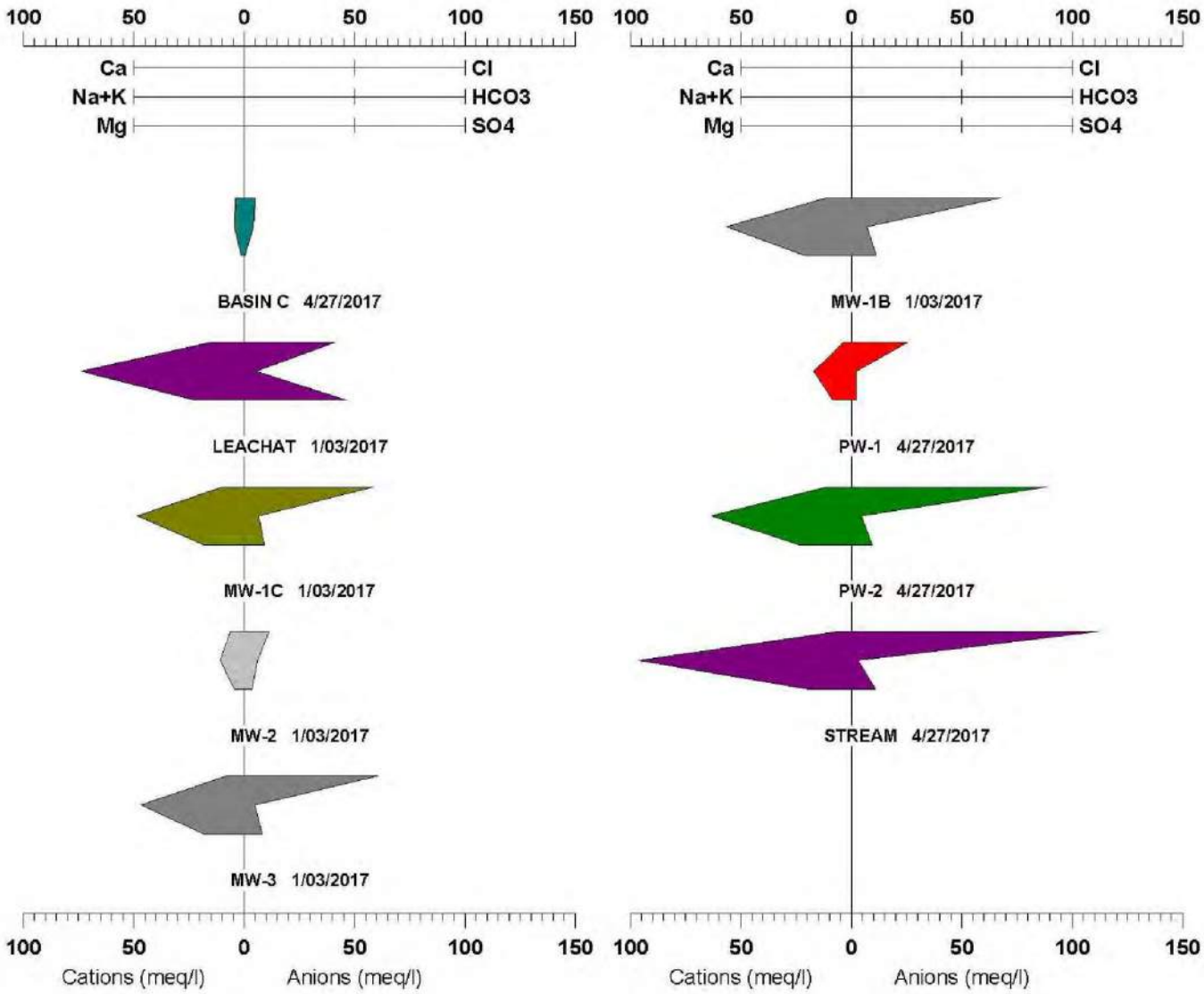
level indicator when it was removed from well MW-1B, and the purge water from well MW-1B was slightly cloudy and did not become clearer as purging continued. Since there appeared to be an issue with well MW-1B, the pump was removed and inspected. The top of the pump was covered with roots and well-rounded sand grains, which appeared to originate from the filter pack material around the well screen in the well annulus. A down-hole video confirmed that roots were penetrating into the well through the well screen, and that the bottom of the well was filled with three feet of tan clayey silt particles originating from the coralline formation that were probably brought into the well with the roots. To address the roots and silt in MW-1B, in August 2018 PVT hired a well drilling company to disinfect and redevelop well MW-1B, and the other three monitoring wells. Only well MW-1B had roots built up around the pump, there were no signs of roots in any of the other wells although some silt was evident in MW-1C.

Groundwater sampling for the first monitoring period of 2018 was conducted in July 2018, prior to disinfecting and redeveloping the four monitoring wells. The intra-well control charts prepared for this event showed statistical exceedances for calcium, chloride, magnesium, potassium, sodium, sulfate, and TDS in well MW-1B; calcium and chloride in upgradient well MW-1C; and calcium, chloride, magnesium, sodium, and sulfate in MW-3. While well MW-1B is the closest well to the tidal reaches of Ulehawa Stream, well MW-3 is the closest well to the ocean. In addition to seawater intrusion, the presence of roots, sand, and clayey silt in well MW-1B definitely contributed to the statistically significant increases in concentrations of cations, anions, and TDS encountered in the groundwater from MW-1B. Results from the second monitoring event for 2018, which will show conditions after disinfection and redevelopment of the wells, will be available later in 2019.

The groundwater monitoring reports for PVT ISWMF have concluded that because sea level is expected to continue to rise in the future (NOAA, 2017), if statistically significant increases continue to occur, some parameter(s), particularly those that are elevated in saltwater, may need to be eliminated from the routine detection monitoring program (Juturna LLC, 2017b and 2018a,b,c). The naturally-occurring cations and anions, which were selected as monitoring parameters so that small changes or trends in groundwater geochemistry can be detected early, are for the most part higher in saltwater than in leachate from PVT ISWMF, making them not well suited for detecting releases from the landfill in locations close to the ocean.

However, cation and anion concentration data, displayed graphically in Stiff diagrams, provide an excellent tool to make a quick visual comparison of water from different sources. In Figure 16 Stiff diagrams are used to show differences and similarities in water quality between the various wells, leachate, Ulehawa Stream, and Storm Water Basin C. A Stiff diagram developed from a particular sample is similar to a water quality "fingerprint" of the sample.

As evident in Figure 16 the Stiff diagrams of Ulehawa Stream, PW-2, MW-1B, MW-1C, and MW-3 have the same shape, which indicates that these samples derive from the same water source, in this case the brackish water aquifer that is connected to the ocean. The Stiff diagrams of wells PW-2, MW-1B, MW-1C, and MW-3 are very similar; whereas, the Stiff diagram of the stream has the same general shape but the chloride, sodium, and potassium



Approved by: JKH
Drawn by: LBM
Date: February 2019

Figure 16
Stiff Diagrams

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Reference: Juturna LLC 2017b.

concentrations are much greater. The larger chloride, sodium, and potassium concentrations in the stream are due to the stream having a more direct connection to the ocean, whereas the brackish groundwater in the wells connects to the ocean through the coralline aquifer.

Figure 16 also shows that the Stiff diagrams of well PW-1, well MW-2, leachate, and Storm Water Basin C differ from each other and from the other diagrams discussed above (PW-2, MW-1B, MW-1C, MW-3, and the stream). The differences are more pronounced in the shapes of the leachate and Basin C Stiff diagrams as compared to the other diagrams, indicating that the water in Basin C originates from a separate source, as does the leachate. The source of the water from Basin C is rainwater and storm water runoff, and the leachate source is rainfall and dust control water percolating through the waste.

The Stiff diagrams for wells MW-2 and PW-1 differ from the other wells. The MW-2 Stiff diagram looks more similar to the Basin C Stiff diagram than to the Stiff diagrams of the other wells, which indicates that MW-2 is being influenced by freshwater, as discussed above. The Stiff diagram for pump well PW-1 has a shape falling somewhere in between the MW-2 Stiff diagram and the Stiff diagrams of the other wells, suggesting that the source of this water is groundwater, but it is fresher than the majority of the wells tapping the brackish water aquifer. The cation and anion concentrations in well PW-1 are significantly lower than in wells PW-2, MW-1B, MW-1C, and MW-3, and the Stiff diagram for PW-1 is significantly smaller; however, the PW-1 Stiff diagram retains somewhat of the same shape as the diagrams from wells PW-2, MW-1B, MW-1C, and MW-3.

The fact that the Stiff diagrams of the wells, stream, and Basin C are completely different than those of the leachate indicates that the leachate is not influencing groundwater, the stream, or the storm water runoff into Basin C. In other words, the Stiff diagrams show that the source of the statistically significant increases in groundwater parameters in the monitoring wells is not the leachate. More likely, the stream or more brackish groundwater (seawater intrusion) seems to be influencing the groundwater monitoring wells. The Stiff diagrams for the stream and pump well PW-2, which is more brackish due to pumping water from deeper in the brackish water aquifer, have the same shape as the Stiff diagram for wells MW-1B, MW-1C, and MW-3, but are larger with higher sodium and chloride concentrations than in the monitoring wells.

In addition to Stiff diagrams, a trilinear (or Piper) diagram was prepared for the samples from the leachate sump, Basin C, Ulehawa Stream, the pump wells, and the monitoring wells, as shown on Figure 17. The trilinear diagram graphically displays the cation and anion data from several samples on three plots. In all three plots shown on Figure 17, the samples from upgradient monitoring well MW-1C and downgradient monitoring well MW-1B plot on top of each other indicating that the water chemistry of these samples is the same. The samples from downgradient monitoring well MW-3 plot on top of wells MW-1B and MW-1C on two of the plots, and immediately adjacent on the third plot, indicating that the water chemistry of MW-3 is very similar to wells MW-1B and MW-1C. Likewise, the samples from pump wells PW-1 and PW-2 are clustered near monitoring wells MW-1B, MW-1C, and MW-3 on the three plots, with PW-2 located slightly closer to the monitoring wells than PW-1. The trilinear diagram shows

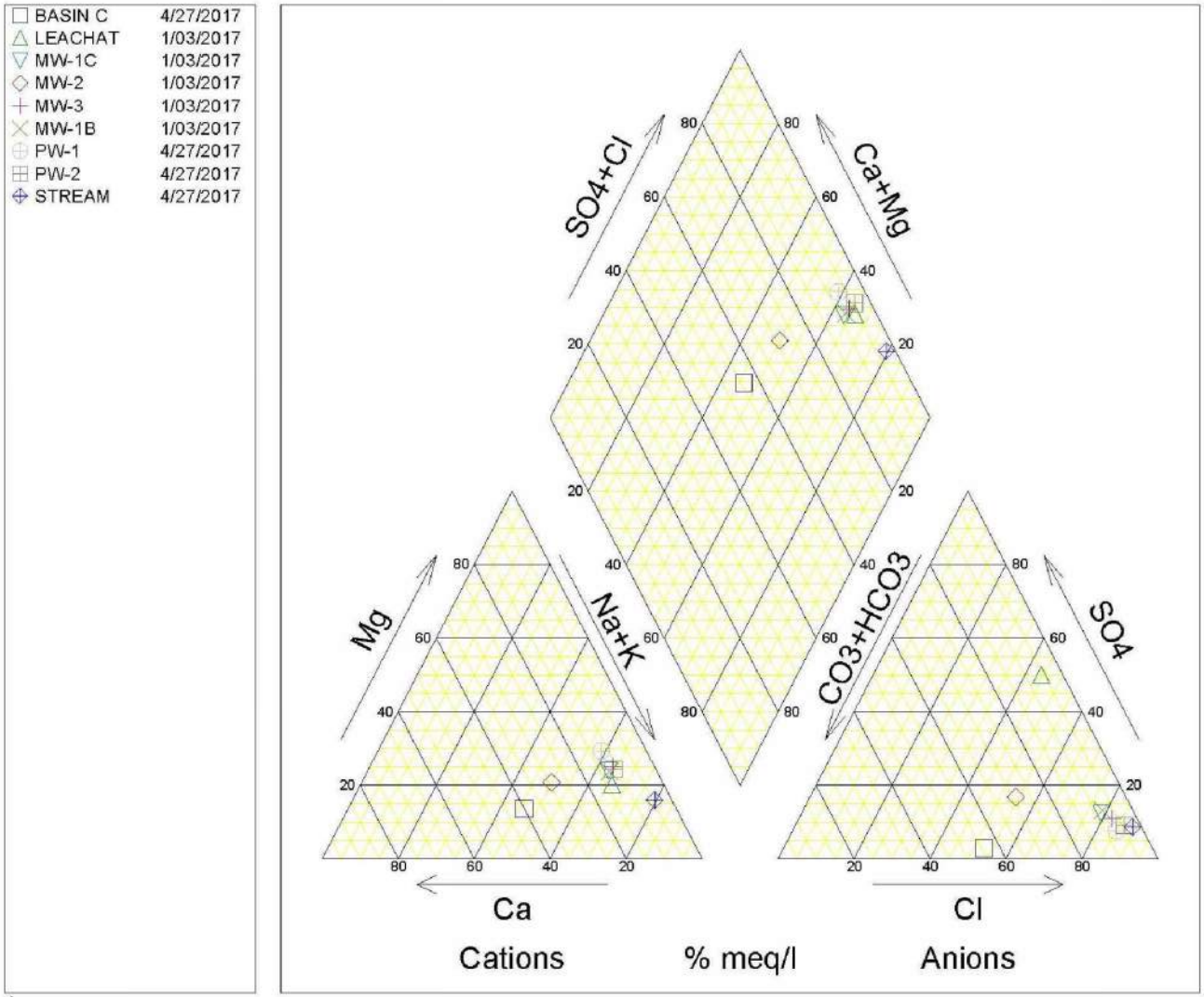

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Figure 17
Trilinear Diagram

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Reference: Juturna LLC 2017b.

that the groundwater samples have very similar water chemistry except for the sample from monitoring well MW-2, which plots away from the other wells in all three plots. Also plotting away from the groundwater samples is the sample from Basin C. The trilinear diagram shows that the water chemistry of the samples from well MW-2 and Basin C are quite different than the samples from the other monitoring wells and the pump wells.

The sample from the stream plots in the cluster of groundwater samples in one of the three graphs of the trilinear diagram, and plots nearby on the other two graphs, indicating some similarities between the brackish groundwater and the brackish water in the stream. The leachate sample plots in the cluster of groundwater samples in two of the three graphs, but is quite far from the cluster in the third graph. On trilinear diagrams, a water sample that is a mixture of two different waters will plot on a straight line between both end members in allthree parts of the trilinear diagram. If a straight line is drawn connecting the data points between upgradient and downgradient wells, the leachate data points do not fall on this line, indicating that the leachate is not mixing with the groundwater. In other words, the leachate is not mixing with the groundwater in the monitoring wells and therefore, cannot be the source of the statistically significant increases in groundwater parameters.

5.6 Results of Leachate Analyses

Leachate generated within the disposal cells of Phase II of the C&D landfill at PVT ISWMF is collected in the gravel leachate collection system and flows by gravity to a leachate collection sump. The sump is designed to contain leachate to a depth of four feet below the adjacent cell floor (A-Mehr, Inc., 2011). In accordance with the Groundwater and Leachate Monitoring Plan (Juturna LLC, 2018d), samples of leachate are collected from the leachate collection sump annually during the second semiannual sampling period for the constituents listed in Table 9. Table 9 also shows the leachate sample results for the last 12 years.

As shown on Table 9, most of the analytes in the leachate have fluctuated over the last 12 years without any apparent trend in the data. Concentrations of Diesel Range Organic (DRO) compounds / Total Petroleum Hydrocarbons (TPH) Diesel, however, steadily increased from 0.0896 mg/l in 2009 to 2.1 mg/l in 2015, but then decreased to 0.45 mg/l in 2018. Cadmium has not been detected in the leachate, while arsenic was detected for the first time in January 2018 at a concentration of 0.0079 mg/l. Lead was detected once in December 2012 just at the reporting limit, and has not been detected since. Chromium concentrations in the leachate have been non-detectable in some years and detectable in other years ranging from 0.009 mg/l to 0.151 mg/l. Likewise, concentrations of iron have varied from non-detect to 6.02 mg/l. The variation in analyte concentrations in the leachate is likely due to the nature of waste that has been placed in the landfill over the years and variations in the amount of rainfall. It should be noted that even though the leachate is contained within the landfill's leachate collection system and is not in contact with any groundwater, most of the concentrations of analytes detected in the leachate over the last 12 years have been below the State of Hawai'i EALs for groundwater beneath the site (DOH, 2011).

Table 9: Leachate Sample Results

Analyte	Units	Leachate Sample Date											
		Jun. 2006	Dec. 2007	Dec. 2008	Dec. 2009	Dec. 2010	Dec. 2011	Dec. 2012	Jan. 2014	Jan. 2015	Dec. 2015	Jan. 2017	Jan. 2018
TDS	mg/l	10,900	3840	3850	6600	7200	6730	6120	7380	6650	7040	6900	4870
TOC	mg/l	28.0	6.6	3.5	7.6	7.3	15	9.4	14.2	10.5	19.2	13.8	10
Chloride	mg/l	5400	1700	1500	1500	1800	2130	1570	2420	1920	1740	1450	1530
Sulfate	mg/l	1380	730	640	2500	2000	2090	1950	2230	1860	2540	2220	1510
Arsenic	mg/l	NA	NA	ND	ND	ND	ND	ND	ND	<0.01	<0.010	<0.011	0.0079
Cadmium	mg/l	NA	NA	ND	ND	ND	ND	ND	ND	<0.001	<0.0010	<0.0011	<0.005
Calcium	mg/l	428	84.4	90.7	390	550	495	451	538	472	354	306	290
Chromium	mg/l	NA	NA	ND	ND	0.011	ND	0.151	0.009	0.019	0.0166	0.0743	0.010
Iron	mg/l	NA	NA	ND	1.9	ND	5.3	6.02	1.02	2.37	0.898	2.39	1.1
Lead	mg/l	NA	NA	ND	ND	ND	ND	0.01	ND	<0.01	<0.010	<0.011	<0.005
Magnesium	mg/l	557	105	87.4	250	370	243	187	272	222	236	272	148
Potassium	mg/l	88.9	46.1	37.7	380	160	432	530	285	239	231	345	312
Sodium	mg/l	3230	1040	972	950	1100	1150	878	1310	1250	1440	1490	923
DRO / TPH Diesel	mg/l	NA	NA	NA	0.0896	0.0947	0.210	0.270	0.820	0.33 *	2.1 *	1.7**	0.45^
Bicarbonate	mg/l	582	200	208	160	96	173	359	340	367	363	323	383
Temperature	°C	NA	NA	30.7	37.3	35.5	37.1	37.7	38.9	39.1	35.5	41.0	39.2
Conductivity	mS/cm	NA	61	5.12	8.4	10.3	9.41	7.78	10.15	9.21	9.6	8.7	6.0
pH	pH unit	NA	7.77	10.1	7.26	7.3	7.15	7.13	7.06	7.11	6.70	7.44	7.20

* The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.

** The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.

^ The chromatogram of this sample is mainly higher boiling hydrocarbons.

<# = Not detected at or above the indicated laboratory reporting limit.

ND = Not Detected at or above the reporting limit used by the laboratory.

NA = Not Analyzed for listed constituent.

Temperature, conductivity, and pH are measured in the field.

°C = degrees Celsius; mS/cm = millisiemens per centimeter.

Reference: Element Environmental, LLC, 2007a, 2008a, 2009a, 2011a; and Juturna LLC, 2014a, 2018b.

As discussed above in Section 5.5.3, Figure 16 compares a Stiff diagram of the leachate to Stiff diagrams of the wells at the site, Ulehawa Stream, and Storm Water Basin C. The Stiff diagram of the leachate is a completely different shape than the Stiff diagrams of the wells, stream, and Basin C, indicating that the leachate is not influencing groundwater, the stream, or the storm water runoff into Basin C. Likewise, the trilinear diagram, discussed in Section 5.5.3 and presented on Figure 17, shows that the leachate is not mixing with the groundwater at the site.

5.7 Proposed Groundwater and Leachate Monitoring at the Project Site

The current Groundwater and Leachate Monitoring Plan for the existing PVT ISWMF (Juturna LLC, 2018d) will be modified and updated to incorporate additional groundwater monitoring wells and leachate monitoring at the Project Site. Five new groundwater wells are proposed for the Project Site, as shown on Figures 2, 3, and 15. The proposed new wells include MW-3A, located northeast of existing well MW-3; MW-4A, located along Lualualei Naval Road, east of former well MW-4; MW-5, located in the southeast portion of the Project Site; MW-6, located along Lualualei Naval Road, north of MW-4A; and MW-7, located in the northernmost portion of the Project Site. Wells MW-3A, MW-4A, and MW-5 are downgradient of the proposed new C&D landfill location at the Project Site; well MW-6 is located downgradient of the proposed new MRD facility; and well MW-7 is located upgradient of all site activities at the Project Site.

The new groundwater monitoring wells will be installed prior to placement of C&D material in the new C&D landfill so that background water quality data can be attained. The frequency of sampling will likely remain the same as specified in the existing Groundwater and Leachate Monitoring Plan – semiannually for the groundwater monitoring wells and annually for leachate, as recommended in the State of Hawaiʻi Landfill Groundwater Monitoring Guidance Document (DOH, 2002).

Section 6 Surface Water Hydrology

6.1 Regional Surface Water Hydrology

Lualualei Valley is comprised of two watersheds: Ulehawa to the east and Māʻiliʻili to the west. The Ulehawa watershed, where PVT ISWMF and the Project Site are located, is five square miles in area and has a maximum elevation of 2,844 feet (Hawaii Division of Aquatic Resources and Bishop Museum, 2015). Ulehawa Stream, which drains the watershed, is a perennial stream with a total length of 5.1 miles (Hawaii Division of Aquatic Resources and Bishop Museum, 2015). As shown on Figures 1 and 2, Ulehawa Stream borders PVT ISWMF to the west, and discharges to the ocean approximately 2,000 feet southwest of the site.

The Māʻiliʻili watershed, which encompasses 19.2 square miles and has a maximum elevation of 3,127 feet, is much larger than the Ulehawa watershed (Hawaii Division of Aquatic Resources and Bishop Museum, 2015). Māʻiliʻili Stream, which drains the Māʻiliʻili watershed, is also a

perennial stream with a total length of 20.9 miles (Hawaii Division of Aquatic Resources and Bishop Museum, 2015).

6.2 Site Surface Water Hydrology

Rainfall runoff at PVT ISWMF eventually reaches Ulehawa Stream. Hawaii Administrative Rules (HAR) Chapter 11-54 classifies Ulehawa Stream as a Class 2 Inland Water (DOH, 2014). Class 2 Inland Waters are protected for recreational purposes, support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation. HAR Chapter 11-54 states that all uses of Class 2 Inland Waters need to be compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters (DOH, 2014).

Surface water runoff from the northern portion of undeveloped Project Site and upslope locations surrounding the Project Site currently drains down slope via overland flow to a storm drainage channel along Lualualei Naval Road, where it is directed through a drainage culvert beneath the road and into a concrete-lined drainage channel between the existing PVT ISWMF and the Pine Ridge Farms, Inc. property to the north. The concrete-lined drainage channel discharges to Ulehawa Stream north of the existing PVT ISWMF. Surface water runoff in the southern portion of the undeveloped Project Site and upslope locations also drains down slope via overland flow to a storm drainage channel along Lualualei Naval Road, where it enters a concrete-lined drainage channel located southwest of the Project Site, behind the shopping center (see Figure 1). The concrete-lined drainage channel runs parallel to Farrington Highway through the residential development, and eventually discharges into Ulehawa Stream.

Storm water runoff at the existing PVT ISWMF is collected in a system of surface ditches, channels, pipes, and basins designed by PVT ISWMF's engineering consultants (A-Mehr, Inc., 2011). The storm water management system is designed and constructed to manage runoff from a 25-year, 24-hour storm. The system will carry runoff from the design storm without flooding or excessive erosion from the site, and will retain a significant volume of water to minimize off-site runoff impacts and allow sediment in the runoff to be intercepted and removed before discharge from the site. Figure 2 shows the location of the storm water basins for collection of storm water and removal of silt. There are seven storm water basins and six discharge points which discharge storm water into Ulehawa Stream. All six discharge points are permitted under PVT ISWMF's National Pollutant Discharge Elimination System (NPDES) permit for discharge of storm water associated with industrial activities (DOH, 2008). One of the storm water basins (Basin A) does not have a discharge point because the limited amount of storm water that collects in this basin percolates into the ground resulting in no discharge off site or flows into Basin A-1, which does have a discharge point. The basins with discharge points are equipped with floating skimmers that slowly drain water from the surface of the basins during storm events. This maximizes sediment settlement before water is discharged to Ulehawa Stream. Typically, run-off entering the sediment basins evaporates before it can be discharged into Ulehawa Stream.

Storm water in the C&D disposal area at the PVT ISWMF (Landfill Phases I and II) is managed by controlled grading on the surface of the landfill and by maintaining an engineered system of drainage ditches, channels, pipes, and basins. Drainage is managed to:

- prevent run-on of surface water to the active disposal face or uncovered refuse;
- prevent run-off of water that has contacted the exposed active disposal face;
- minimize erosion in all areas of the site;
- maintain roads and other ancillary facilities in useable condition under all weather conditions; and
- prevent excessive runoff or sedimentation impacts to neighboring properties or receiving bodies of water (A-Mehr, Inc., 2011).

The landfill top deck and other areas in the vicinity of active disposal areas are graded at a slope of 2% to 5% away from the active area. Earth berms are constructed upgradient of the active area if needed to prevent run-on from contacting the waste, and to divert drainage around any exposed waste (A-Mehr, Inc., 2011).

Similarly, berms are constructed downgradient of exposed waste to prevent the runoff of any precipitation that has contacted waste. Such water is retained within the waste, for collection and management as leachate. No runoff of precipitation that has contacted waste is discharged into Ulehawa Stream.

The storm water control system is inspected and maintained as needed after each significant storm event. Inspections focus on locating and repairing any areas of excessive erosion, ensuring that skimmers installed in sedimentation basins are working properly, and that no pipe inlets are plugged or blocked with sediment or debris. Sediment is removed from ditches and basins at least once each year.

6.3 Storm Water Runoff Water Quality

In accordance with the requirements of their NPDES permit, PVT ISWMF collects storm water samples and flow measurements annually. The storm water samples are collected after a representative storm event. A representative storm is a rainfall event that accumulates more than 0.1 inches of rain and occurs at least 72 hours after the previous measurable (greater than 0.1 inch) rainfall event. The storm water samples are collected using an automatic Vortox sampler, which is mounted in concrete and is located at the end of the drainage pipe at each discharge point. The sampler automatically collects the sample when there is a discharge from the sedimentation basin. After the storm water is collected, the Vortox sampler is removed from the concrete mount and the storm water sample is poured into the sample containers and delivered to an approved laboratory. A Discharge Monitoring Report (DMR) form is submitted

annually to the DOH Clean Water Branch whether there is a storm event or not. If there were no discharges during the monitoring period, the DMR so states.

The Notice of General Permit Coverage (NGPC) for PVT ISWMF's NPDES Permit specifies the facility's storm water monitoring and testing requirements and storm water discharge limitations (DOH, 2008). The NGPC requires that storm water discharge from all six discharge points be tested annually for the first 16 parameters listed in Table 10, and that storm water from discharge point D-3, which is downgradient of the equipment maintenance area, be tested for five additional parameters, also listed on Table 10.

In addition to the storm water monitoring requirements and discharge limitations, Table 10 also summarizes the monitoring results for the last 11 years, from 2007 to 2018. For the 2007 and 2008 annual monitoring periods, samples were only collected at discharge point D-2 because there was no discharge at discharge point D-1 and the other basins were not yet constructed (PVT Land Company, Ltd., 2008, 2009). For the 2009 annual monitoring period, there was no storm water discharge from any of the discharge points (PVT Land Company, Ltd., 2010a). For the 2010 and 2011 annual monitoring periods, samples were collected from discharge points D-2, D-3, D-4, and D-5, as there was no discharge observed at D-1, and D-6 was not yet constructed (PVT Land Company, Ltd., 2010b and 2012). For the 2012 annual monitoring period, samples were collected from discharge points D-2 and D-5 only, because there was no discharge observed at D-1, D-3, and D-4, and D-6 was not yet constructed (PVT Land Company, Ltd., 2013). For the 2013 annual monitoring period, samples were collected from discharge points D-3 and D-5, as no discharge was observed at the other points and D-6 was not yet constructed (PVT Land Company, Ltd., 2014). For the 2014 annual monitoring period, samples were collected from discharge point D-3 and new discharge point D-6; no discharge was observed at D-1, D-2, D-4, and D-5 (PVT Land Company, Ltd., 2015). For 2015, 2016, and 2017 there was no storm water discharge from any of the discharge points (PVT Land Company Ltd., 2016, 2017, and 2018). For 2018, samples were collected from discharge points D-3 and D-6; no discharge was observed at D-1, D-2, D-4, and D-5 (PVT Land Company, Ltd., 2019).

As shown on Table 10, the concentration of total recoverable iron in the March 2011, March 2012, and October 2013 storm water samples from discharge point D-5 and the October 2013 storm water sample from discharge point D-3 exceeded the effluent limitation of 1,000 micrograms per liter (µg/l). The iron in the storm water runoff is a result of naturally occurring, iron-rich surface soils (reddish brown clay and silt) running off the unpaved roadways at the site during heavy rain. To address these exceedances PVT ISWMF implemented additional best management practices (BMPs) to reduce iron concentrations in the storm water runoff. The primary BMP to reduce iron concentrations in the runoff consisted of paving the roadway in the vicinity of sedimentation Basin E where discharge point D-5 is located, and paving the entire parking area and the roadways that drain into Basin B where discharge point D-3 is located. After the roadways and parking areas were paved, iron concentrations in storm water from discharge point D-3 decreased significantly from 2,900 µg/l in October 2013 to 930 µg/l in October 2014. In October 2014 there was no discharge from discharge point D-5;

Table 10: Storm Water Discharge Monitoring Results

Parameter	Limit	Storm Water Sample Discharge Point and Sampling Date								
		D-2 Nov. 2007	D-2 Dec. 2008	D-2 Mar. 2010	D-3 Mar. 2010	D-4 Mar. 2010	D-5 Mar. 2010	D-2 Mar. 2011	D-3 Mar. 2011	D-4 Mar. 2011
Flow (cubic feet per second)	No Limit	1.1	0.05	0.25	0.3	0.53	0.24	0.25	0.3	0.53
Biochemical Oxygen Demand (mg/l)	No Limit	< 2.00	< 2.00	< 2.00	3.44	< 2.00	11.3	< 2.00	< 2.00	< 2.00
Chemical Oxygen Demand (mg/l)	No Limit	82	25	141	29.7	37.4	56.1	22	22	< 20
Total Suspended Solids (mg/l)	No Limit	15.0	20.0	7.33	14.6	25.8	47.2	< 10	< 10	< 10
Total Phosphorus (mg/l)	No Limit	0.21	0.058	0.417	0.206	1.12	0.722	< 0.050	< 0.050	< 0.050
Total Nitrogen (mg/l)	No Limit	7.53	2.48	207	4.70	17.4	26.4	< 0.00	< 0.00	< 0.00
Ammonia Nitrogen (mg/l)	No Limit	0.90	< 0.50	< 0.050	0.143	< 0.050	6.26	< 0.50	< 0.50	< 0.50
Nitrate + Nitrite Nitrogen (mg/l)	No Limit	1.93	0.28	204	0.909	15.2	0.111	< 0.050	< 0.050	< 0.050
Oil and Grease (mg/l)	15	< 5.00	< 5.0	< 5.00	< 5.00	< 5.00	< 5.00	< 5.4	< 5.0	< 5.5
pH Range (standard units)	5.5 – 8.0	7.76	7.42	7.3	7.3	7.3	7.2	7.3	7.5	7.5
Total Recoverable Iron (µg/l)	1000	556	202	858	77.9	198	311	< 40	40	170
Turbidity (NTU)	No Limit	4.83	27.4	17.0	6.09	21.4	34.2	0.270	0.520	2.32
Dissolved Oxygen (mg/l)	No Limit	7.51	8.84	7.07	1.86	3.89	1.35	8.26	8.44	8.25
Oxygen Saturation (%)	No Limit	72.9	95.3	77.8	21.7	41.9	14.6	98.4	106	104
Temperature (°C)	No Limit	22	23.1	21.2	21.3	21.3	21.3	23.5	23.3	23.3
Specific Conductance (µmhos/cm)	No Limit	2430	994	2000	1070	1760	551	2000	2000	990
Polynuclear Aromatic Hydrocarbons (µg/l)*	No Limit	NA	NA	NA	< 0.216	NA	NA	NA	< 0.227	NA
Benzene (µg/l)*	1800	NA	NA	NA	< 2.00	NA	NA	NA	< 2.00	NA
Toluene (µg/l)*	5800	NA	NA	NA	< 2.00	NA	NA	NA	< 2.00	NA
Ethylbenzene (µg/l)*	11,000	NA	NA	NA	< 2.00	NA	NA	NA	< 2.00	NA
Xylenes (µg/l)*	No Limit	NA	NA	NA	< 2.00	NA	NA	NA	< 2.00	NA

No Limit = No limitation at this time. Only monitoring and reporting is required.
< = Not Detected at or above the indicated reporting limit.
* = Only Discharge Point D-3 is required to be monitored for this parameter. NA = Not Analyzed for listed parameter.
µmhos/cm = micromhos per centimeter. µg/l = micrograms per liter. NTU = Nephelometric Turbidity Units.
Reference: PVT Land Company, Ltd., 2008, 2009, 2010a, 2010b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019.

Table 10: Storm Water Discharge Monitoring Results, Continued

Parameter	Limit	Storm Water Sample Discharge Point and Sampling Date								
		D-5 Mar. 2011	D-2 Mar. 2012	D-5 Mar. 2012	D-3 Oct. 2013	D-5 Oct. 2013	D-3 Oct. 2014	D-6 Oct. 2014	D-3 Oct. 2018	D-6 Oct. 2018
Flow (cubic feet per second)	No Limit	0.24	0.25	0.24	0.3	0.24	0.3	0.24	0.3	0.24
Biochemical Oxygen Demand (mg/l)	No Limit	< 2.00	< 2.00	2.02	6.34	4.77	< 2.00	6.00	2.4	3.1
Chemical Oxygen Demand (mg/l)	No Limit	< 20	37	< 20	27	34	14	83	<10	<10
Total Suspended Solids (mg/l)	No Limit	17	24	38	27	26	12	8.3	9.1	8.4
Total Phosphorus (mg/l)	No Limit	0.057	0.088	0.096	0.093	0.40	0.091	0.12	0.054	0.081
Total Nitrogen (mg/l)	No Limit	0.300	0.30	0.39	1.4	4.7	1.2	2.9	1.3	1.7
Ammonia Nitrogen (mg/l)	No Limit	< 0.50	< 1.0	< 1.0	0.035	0.26	0.20	0.29	0.37	0.38
Nitrate + Nitrite Nitrogen (mg/l)	No Limit	0.300	0.298	0.385	0.81	2.5	0.76	0.072	0.34	0.64
Oil and Grease (mg/l)	15	< 5.0	< 5.1	< 5.0	< 5.1	< 5.0	< 5.4	< 5.8	<1.5	<1.4
pH Range (standard units)	5.5 – 8.0	7.1	7.3	7.6	7.43	7.65	8.01	7.61	7.22	7.00
Total Recoverable Iron (µg/l)	1000	1300	820	1700	2900	2100	930	470	580	120
Turbidity (NTU)	No Limit	24.0	29.3	50.4	40.6	27.8	18.9	9.55	15	15
Dissolved Oxygen (mg/l)	No Limit	8.11	8.47	7.06	6.55	5.16	8.02	6.15	2.49	2.50
Oxygen Saturation (%)	No Limit	93.7	70.6	57.6	81.9	64.5	86.0	59.1	NA	NA
Temperature (°C)	No Limit	23.2	22.3	19.1	26.8	28	25.5	26.2	30.5	29.6
Specific Conductance (µmhos/cm)	No Limit	1500	3100	1100	720	1399	884	2620	1100	1300
Polynuclear Aromatic Hydrocarbons (µg/l)*	No Limit	NA	NA	NA	< 0.21	NA	< 0.21	NA	<1.0	NA
Benzene (µg/l)*	1800	NA	NA	NA	< 2.00	NA	< 2.00	NA	<0.60	NA
Toluene (µg/l)*	5800	NA	NA	NA	< 2.00	NA	< 2.00	NA	<0.46	NA
Ethylbenzene (µg/l)*	11,000	NA	NA	NA	< 2.00	NA	< 2.00	NA	<0.51	NA
Xylenes (µg/l)*	No Limit	NA	NA	NA	< 2.00	NA	< 2.00	NA	<0.48	NA

No Limit = No limitation at this time. Only monitoring and reporting is required.
< = Not Detected at or above the indicated reporting limit.
* = Only Discharge Point D-3 is required to be monitored for this parameter. NA = Not Analyzed for listed parameter.
µmhos/cm = micromhos per centimeter. µg/l = micrograms per liter. NTU = Nephelometric Turbidity Units.
Reference: PVT Land Company, Ltd., 2008, 2009, 2010a, 2010b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019.

however, the iron concentration in storm water from discharge point D-6 was 470 µg/l, well below the effluent limitation of 1,000 µg/l. For the sampling from discharge points D-3 and D-6 in October 2018, iron concentrations have remained below the effluent limitation.

Besides total recoverable iron, the only other effluent limitation exceedance over the last 12 years was one pH reading from discharge point D-3 in October 2014. The pH concentration in storm water from discharge point D-3 was measured at 8.01 and the effluent limitation is 8.0. The pH reading of 8.01 was taken in the field with a handheld pH meter that is not always accurate to the hundredth decimal point. This reading may be an outlier, as the next highest pH value over the last 12 years was 7.76. The pH readings over the last 12 years ranged from 7.00 to 8.01 with an average value of 7.42. No other storm water effluent limits have been exceeded at the PVT ISWMF.

An additional BMP that PVT ISWMF has implemented to improve the quality of storm water runoff is constructing a covered facility for vehicle and equipment maintenance and for storage of oil and grease. As shown on Table 10, concentrations of oil and grease and the petroleum-related parameters polynuclear aromatic hydrocarbons, benzene, toluene, ethylbenzene, and xylenes have never been detected in storm water discharge from the site.

6.4 Proposed Storm Water Improvements at the Project Site

As with the existing PVT ISWMF, storm water in the new C&D disposal area at the Project Site (Landfill Phase III) will be managed by controlled grading on the surface of the landfill and by maintaining an engineered system of drainage ditches, channels, pipes, and basins. Drainage will be managed to:

- prevent run-on of surface water onto the landfill footprint from adjacent slopes;
- minimize storm water contact with the exposed active landfill disposal face;
- prevent run-off of water that has contacted the exposed active landfill face;
- minimize erosion in all areas of the site;
- maintain roads and other ancillary facilities in useable condition under all weather conditions;
- implement storm water retention systems to ensure storm water discharge from the developed facility does not exceed the historical rate of discharge from the currently undeveloped property; and
- prevent excessive sedimentation impacts to neighboring properties or receiving bodies of water.

As with the existing PVT ISWMF, the landfill top deck and other areas in the vicinity of active disposal areas will be graded at a slope of 2% to 5% away from the active area. Diversions will be constructed upgradient of the active area if needed to prevent run-on from contacting waste and divert drainage around any exposed waste. Similarly, diversions will be constructed downgradient of exposed waste to prevent the runoff of any precipitation that has contacted waste. Such water will be retained within the waste, for collection and management as leachate.

The storm water management systems will be designed and constructed to manage runoff from a 25-year, 24-hour storm. Storm water runoff from the adjacent undeveloped slopes to the east and storm water run-off from the Phase III landfill will be collected in a system of surface ditches, channels, and pipes. These systems will collect run-off from the adjacent undeveloped slopes and convey it around the Phase III development and prevent the run-off from being impacted by the proposed ISWMF activities.

Storm water runoff from approximately the north third of the undeveloped slopes will be conveyed around the north end of the Phase III landfill development and down the west side of the Project Site, parallel to Lualualei Naval Road, where it will discharge into sedimentation/retention basins located in the southern portion of the Project Site. The south two thirds of the undeveloped slopes will be similarly diverted around the south end of the Phase III landfill development, and into the sedimentation/retention basins. Likewise, storm water runoff from the developed areas of the Project Site (the landfill, MRD area, entrance facilities, and the perimeter access roads) will also be collected in a series of channels located around the perimeter of the developed area, which will convey the water to the sedimentation/retention basin located near the southwest corner of the Project Site, closest to Lualualei Naval Road.

The sedimentation/retention basins at higher elevations in the southeast corner of the Project Site will drain to the storm water basin closest to Lualualei Naval Road. Storm water will then discharge through a culvert crossing under Lualualei Naval Road and into a new drainage channel that will run parallel to the southwestern property line of the existing ISWMF property, where it will discharge into existing Storm Basin A-1, and eventually into Ulehawa Stream via existing Discharge Point D-1. The storm water retention basin will retain storm water run-off, meter its release to prevent inundation of downstream properties and reduce sediment loading of the storm water prior to off property release. The basin will be designed to manage the 25-year, 24-hour storm event, and preliminary analysis indicates the basin will have a capacity of approximately 30 to 35 acre-feet.

The existing NPDES permit for PVT ISWMF will be updated and modified to include storm water discharge from the Project Site. No new discharge points are planned – the storm water discharge from the Project Site will flow to an existing storm water basin (Basin A-1) and enter an existing permitted discharge point along Ulehawa Stream (Discharge Point D-1).

Section 7 Impact of the Proposed Improvements on Water Quality

As stated in Section 3, the proposed improvements at the PVT ISWMF Project Site include: (1) relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations; (2) relocation, modernization and enhancement of recycling operations (e.g. installation of two MRD process lines); and (3) installation of renewable energy facilities to power PVT operations (e.g. one 1,000-kilowatt hour enclosed gasification unit or anaerobic digestion system and approximately seven acres of photovoltaic panels). The impact of these proposed improvements on groundwater and surface water quality should be minimal, provided the design, construction, and operation incorporates the storm water and leachate management system controls currently in place at the existing PVT ISWMF site, as proposed. Based on years of storm water and groundwater quality testing, the current operations at the existing PVT ISWMF have not negatively impacted groundwater or surface water quality. Since there will be no increase in the amount of waste, maximum daily truck trips, or hours of operation, the relocation of operations to the Project Site should also not negatively impact groundwater or surface water quality, provided the storm water and leachate management system controls are implemented as planned.

As part of the relocation of the C&D waste receiving, materials sorting/recycling, and C&D disposal operations, the equipment maintenance facility will be relocated to the Project Site. PVT ISWMF's current NPDES permit requires additional monitoring parameters for storm water flowing from the present equipment maintenance area into Basin C (Discharge Point D-3). Storm water runoff from the relocated equipment maintenance facility will flow into Basin A-1 (Discharge Point D-1); therefore, additional monitoring parameters will need to be added to the storm water sampling requirements for Basin A-1 (Discharge Point D-1). If the relocated equipment maintenance facility and oil and grease storage areas are covered, as they are currently, there should be minimal impact on storm water quality.

Relocation of the C&D disposal operations requires the installation of additional groundwater monitoring wells. Five additional groundwater monitoring wells are planned. Existing monitoring well MW-3 may need to be closed and replaced with well MW-3A since MW-3 is located close to the new storm water sedimentation/retention basin. If possible, well MW-3 will remain in service; however, the groundwater in MW-3 may be influenced by the storm water retention basin causing the groundwater to become fresher (less brackish) due to infiltration of rainwater runoff. This may counteract the current trend in MW-3 of becoming more brackish due to seawater intrusion.

Relocation, modernization and enhancement of the recycling operations (e.g. installation of two MRD process lines) should have minimal impact on surface water quality and very minimal, if any, impact on groundwater quality. Storing recycling materials and feedstock in bins, or other types of covered storage, would reduce potential impacts to surface water quality. Depending on the type of equipment and materials which may come in contact with rain

and/or rainfall runoff, additional monitoring parameters may need to be added to the storm water sampling requirements for Basin A-1 (Discharge Point D-1), where storm water runoff from the relocated recycling and materials recovery area enters Ulehawa Stream.

The proposed renewable energy improvements, such as an enclosed gasification unit that uses processed feedstock or an enclosed anaerobic digestion system and approximately seven acres of photovoltaic panels, should have minimal impact on surface water quality and very minimal, if any, impact on groundwater quality. Potential surface water quality impacts can be mitigated by incorporating the design of the renewable energy improvements into the ISWMF's existing storm water management system, as proposed.

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APPENDIX B
Air Quality Impact Report (AQIR)

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AIR QUALITY IMPACT REPORT (AQIR)

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

PREPARED FOR:

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PREPARED BY:

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22 April 2019

1. INTRODUCTION

The PVT Land Company (PVT) is proposing to relocate its existing integrated solid waste management facility (ISWMF) at Nanakuli on the island of Oahu to a new site east of its current location (Figure 1). This relocation is necessitated by the continuing large quantity of construction and demolition (C&D) debris being generated on Oahu and the closure of the existing landfill after it reaches its capacity.

The purpose of this report is to assess the potential air quality impact of fugitive dust associated with landfill operations at the new site. Emissions from a proposed gasification unit or anaerobic digestion system, if not exempt, would be required to demonstrate compliance with state and federal ambient air quality standards as part of the air permitting requirements of Hawaii Administrative Rules Chapter 11-60.1.

2. METHODOLOGY

The U.S. Environmental Protection Agency (EPA) recommended computer model AERMOD[1, 2] was used to assess the ambient air quality impact of operations at changing elevations throughout the life of the project. Input to the model included:

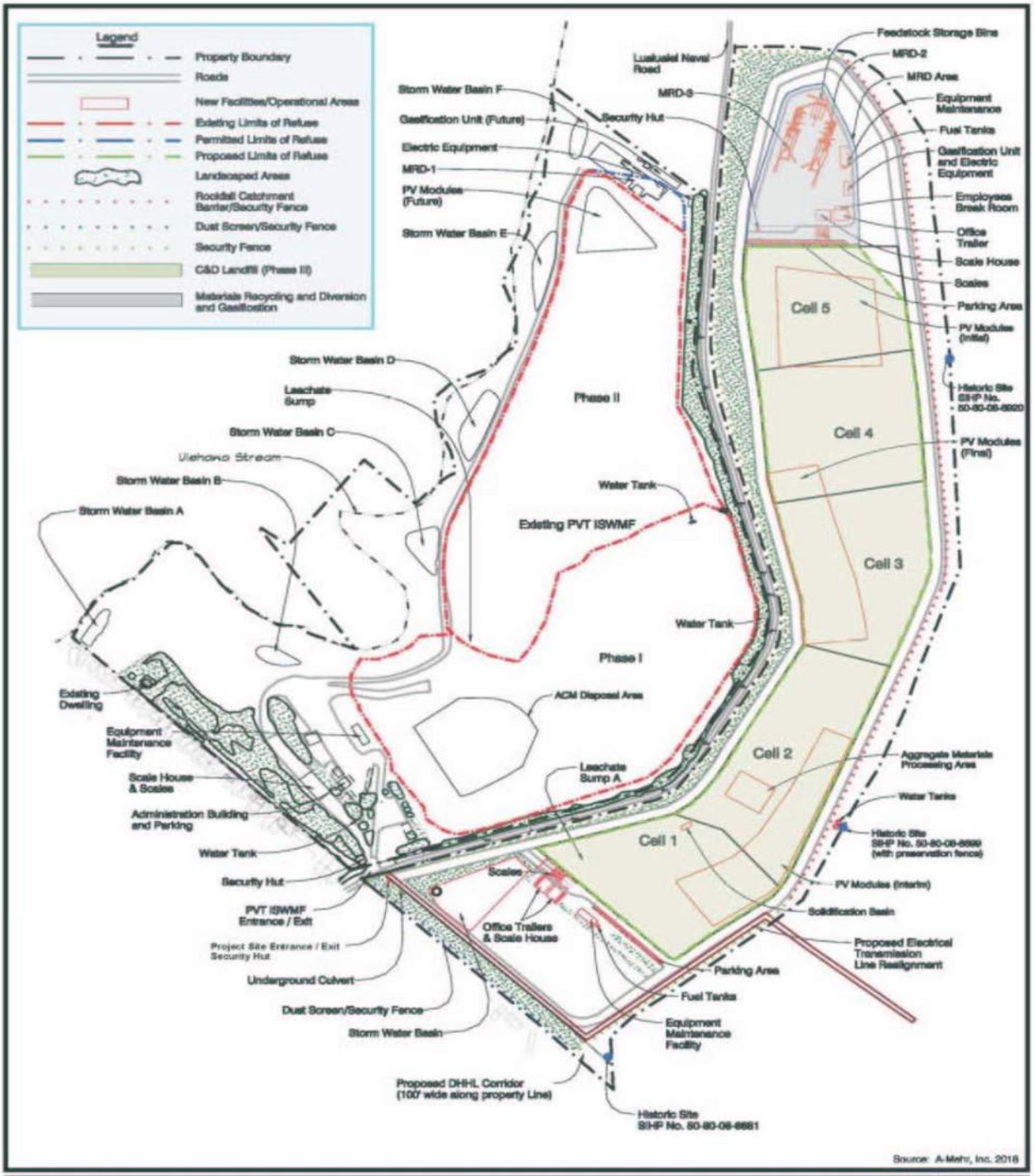
- dimensions and elevations of the five (5) landfill operational cells at the proposed site (Figure 2).
- an emission factor for fugitive dust, i.e., particulate matter, in grams per square meter per second ($g/m^2/sec$) derived from a heavy construction (including ground excavation and other earth moving operations) emission factor obtained from EPA's Compilation of Air Pollutant Emission Factors (AP-42).[3]
- wind speed and direction data from one (1) year (2016) of onsite meteorological monitoring at PVT combined with the same year of data from the Kalaeloa Airport to replace any missing onsite data, and upper air data from the Lihue Airport.
- an array of 198 receptors with 30-meter spacing along the new site property boundary.

Since the EPA emission factor was based on total suspended particulate matter (TSP) for which there is no longer an air quality standard, the factor was adjusted to estimate emission rates for particulate matter with effective aerodynamic diameters of 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$) for which there are current air quality standards (Table 1). Based on previous measurement studies, one can estimate PM_{10} by multiplying the TSP value by a factor of 0.51.[4] Similarly, $PM_{2.5}$ can be estimated by multiplying the PM_{10} value by a factor of 0.10.[5] Dust control by water spray is a routine activity at PVT and a conservative control efficiency of 70% was assumed based on past experience as evidenced by the low TSP levels measured during recent monitoring studies at the existing PVT landfill.[6, 7]

The model was run for each year from 2022 through 2040, with each model run including the elevation at the beginning and end of the year for those cells being "worked" in the given year. After the first year (2022), the PM concentration at the "start" of each year would be the same as the "end"

FIGURE 1

PROJECT LOCATION



Project Site Development Plan
Nanakuli, Waianae District, Oahu, Hawaii

Figure 2

of the preceding year except in the case where a new cell had commenced operation and was therefore included. The nearest Hawaii Department of Health air monitoring site is at Kapolei, and the most recent available (2015) PM_{10} and $PM_{2.5}$ data [8] were used as background values to be combined with the AERMOD modeling results.

TABLE 1

SUMMARY OF STATE OF HAWAII AND FEDERAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER [9, 10]

POLLUTANT	AVERAGING PERIOD	NAAQS PRIMARY	NAAQS SECONDARY	HAWAII STANDARDS
PM_{10}	24-hr Annual	150 --	-- --	150 50
$PM_{2.5}$	24-hr Annual	25 12	35 15	--- ---

KEY: NAAQS - national ambient air quality standards
PM_{10} - particulate matter ≤ 10 microns
$_{2.5}$- particulate matter ≤ 2.5 microns

All concentrations in micrograms per cubic meter ($\mu g/m^3$).

3. RESULTS AND CONCLUSIONS

The results of the modeling analysis are summarized in Tables 2 and 3 and Figures 3 and 4 indicate compliance with federal and state ambient air quality standards. The mix of "excavate", "fill" and "cover" operations over time in the cells with various ground elevations results in a fairly wide range of predicted airborne particulate matter concentrations. Predicted concentrations including background of maximum 24-hour PM_{10} ranged from 40.2 to 134 micrograms per cubic meter ($\mu g/m^3$). Similarly, maximum 24-hour $PM_{2.5}$ concentrations ranged 14.5 to 23.9 $\mu g/m^3$. Annual averages again including background ranged 15.9 to 30.2 and 4.1 to 5.5 $\mu g/m^3$, respectively, for PM_{10} and $PM_{2.5}$.

The modeling results are also comparable to the results of a recent 1-year onsite monitoring program conducted at the existing PVT site. [7] Concentrations of total suspended particulate matter (TSP) were recorded which when converted to PM_{10} ranged 12.3 to 84.3 $\mu g/m^3$ for 24-hour maxima and 33.1 to 43.7 $\mu g/m^3$ for annual values, thus being of the same order of magnitude as the modeled PM_{10} concentrations presented herein. We therefore conclude that PVT's proposed relocation of operations will not have a significant impact on existing air quality.

TABLE 2

AERMOD PM_{10} MODELING RESULTS

			Maximum Concentration (ug/m^3) [2]					
Year	Landfill Cells Working [1]	Elevations (ft)	Model 24-hr	DOH Background [3]	Total 24-hr	Model Annual	DOH Background [3]	Total Annual
2022 Start	C-1	74	55.1	32.0	**87.1**	2.6	15.8	**18.4**
2022 End	"	48	34.1	32.0	**66.1**	1.6	15.8	**17.4**
2023 End	C-1	21	8.2	32.0	**40.2**	1.3	15.8	**17.1**
2024 End	C-1	51	39.2	32.0	**71.2**	1.7	15.8	**17.5**
2025 End	C-1	81	59.9	32.0	**91.9**	2.9	15.8	**18.7**
2026 End	C-1	112	70.8	32.0	**102.8**	3.1	15.8	**18.9**
2027 Start	C-1 + C-2	112 / 84	102.0	32.0	**134.0**	4.1	15.8	**19.9**
2027 End	"	142 / 57	69.6	32.0	**101.6**	4.1	15.8	**19.9**
2028 End	C-1 + C-2	173 / 30	56.1	32.0	**88.1**	3.8	15.8	**19.6**
2029 End	C-1 + C-2	202 / 55	68.8	32.0	**100.8**	3.8	15.8	**19.6**
2030 End	C-1 + C-2	202 / 80	87.2	32.0	**119.2**	3.9	15.8	**19.7**
2031 End	C2	105	46.6	32.0	**78.6**	1.6	15.8	**17.4**
2032 End	C2	129	53.2	32.0	**85.2**	1.8	15.8	**17.6**
2033 Start	C-2 + C-3	129 / 128	71.4	32.0	**103.4**	2.0	15.8	**17.8**
2033 End	"	154 / 77	59.7	32.0	**91.7**	2.3	15.8	**18.1**
2034 End	C-2 + C-3	179 / 26	63.5	32.0	**95.5**	2.7	15.8	**18.5**
2035 End	C-2 + C-3	204 / 58	67.4	32.0	**99.4**	3.6	15.8	**19.4**
2036 End	C-2 + C-3	204 / 90	67.4	32.0	**99.4**	3.6	15.8	**19.4**
2037 End	C-3	122	18.2	32.0	**50.2**	0.1	15.8	**15.9**
2038 Start	C-3 + C-4	122 / 162	36.0	32.0	**68.0**	14.4	15.8	**30.2**
2038 End	C-3 + C-4	154 / 98	36.0	32.0	**68.0**	14.4	15.8	**30.2**
2039 End	C-3 + C-4	186 / 34	36.0	32.0	**68.0**	14.4	15.8	**30.2**
2040 End	C-3 + C-4	218 / 66	36.0	32.0	**68.0**	14.4	15.8	**30.2**

Notes:
1. See Figure 2 for cell locations
2. ug/m^3 - micrograms per cubic meter
3. Kapolei Monitoring Site (Reference 9)

TABLE 3

AERMOD $PM_{2.5}$ MODELING RESULTS

			Maximum Concentration (ug/m^3) [2]					
Year	Landfill Cells Working [1]	Elevations (ft)	Model 24-hr	DOH Background [3]	Total 24-hr	Model Annual	DOH Background [3]	Total Annual
2022 Start	C-1	74	5.5	13.7	**19.2**	0.3	4.1	**4.4**
2022 End	"	48	3.4	13.7	**17.1**	0.2	4.1	**4.3**
2023 End	C-1	21	0.8	13.7	**14.5**	0.1	4.1	**4.2**
2024 End	C-1	51	3.9	13.7	**17.6**	0.2	4.1	**4.3**
2025 End	C-1	81	6.0	13.7	**19.7**	0.3	4.1	**4.4**
2026 End	C-1	112	7.1	13.7	**20.8**	0.3	4.1	**4.4**
2027 Start	C-1 + C-2	112 / 84	10.2	13.7	**23.9**	0.4	4.1	**4.5**
2027 End	"	142 / 57	7.0	13.7	**20.7**	0.4	4.1	**4.5**
2028 End	C-1 + C-2	173 / 30	5.6	13.7	**19.3**	0.4	4.1	**4.5**
2029 End	C-1 + C-2	202 / 55	6.9	13.7	**20.6**	0.4	4.1	**4.5**
2030 End	C-1 + C-2	202 / 80	8.7	13.7	**22.4**	0.4	4.1	**4.5**
2031 End	C2	105	4.7	13.7	**18.4**	0.2	4.1	**4.3**
2032 End	C2	129	5.3	13.7	**19.0**	0.2	4.1	**4.3**
2033 Start	C-2 + C-3	129 / 128	7.1	13.7	**20.8**	0.2	4.1	**4.3**
2033 End	"	154 / 77	6.0	13.7	**19.7**	0.2	4.1	**4.3**
2034 End	C-2 + C-3	179 / 26	6.4	13.7	**20.1**	0.3	4.1	**4.4**
2035 End	C-2 + C-3	204 / 58	6.7	13.7	**20.4**	0.4	4.1	**4.5**
2036 End	C-2 + C-3	204 / 90	6.7	13.7	**20.4**	0.4	4.1	**4.5**
2037 End	C-3	122	1.8	13.7	**15.5**	0.0	4.1	**4.1**
2038 Start	C-3 + C-4	122 / 162	3.6	13.7	**17.3**	1.4	4.1	**5.5**
2038 End	C-3 + C-4	154 / 98	3.6	13.7	**17.3**	1.4	4.1	**5.5**
2039 End	C-3 + C-4	186 / 34	3.6	13.7	**17.3**	1.4	4.1	**5.5**
2040 End	C-3 + C-4	218 / 66	3.6	13.7	**17.3**	1.4	4.1	**5.5**

Notes:
1. See Figure 2 for cell locations
2. ug/m^3 - micrograms per cubic meter
3. Kapolei Monitoring Site (Reference 8)

FIGURE 3

MODELED 24-HR PM10 CONCENTRATIONS (WITH BACKGROUND)

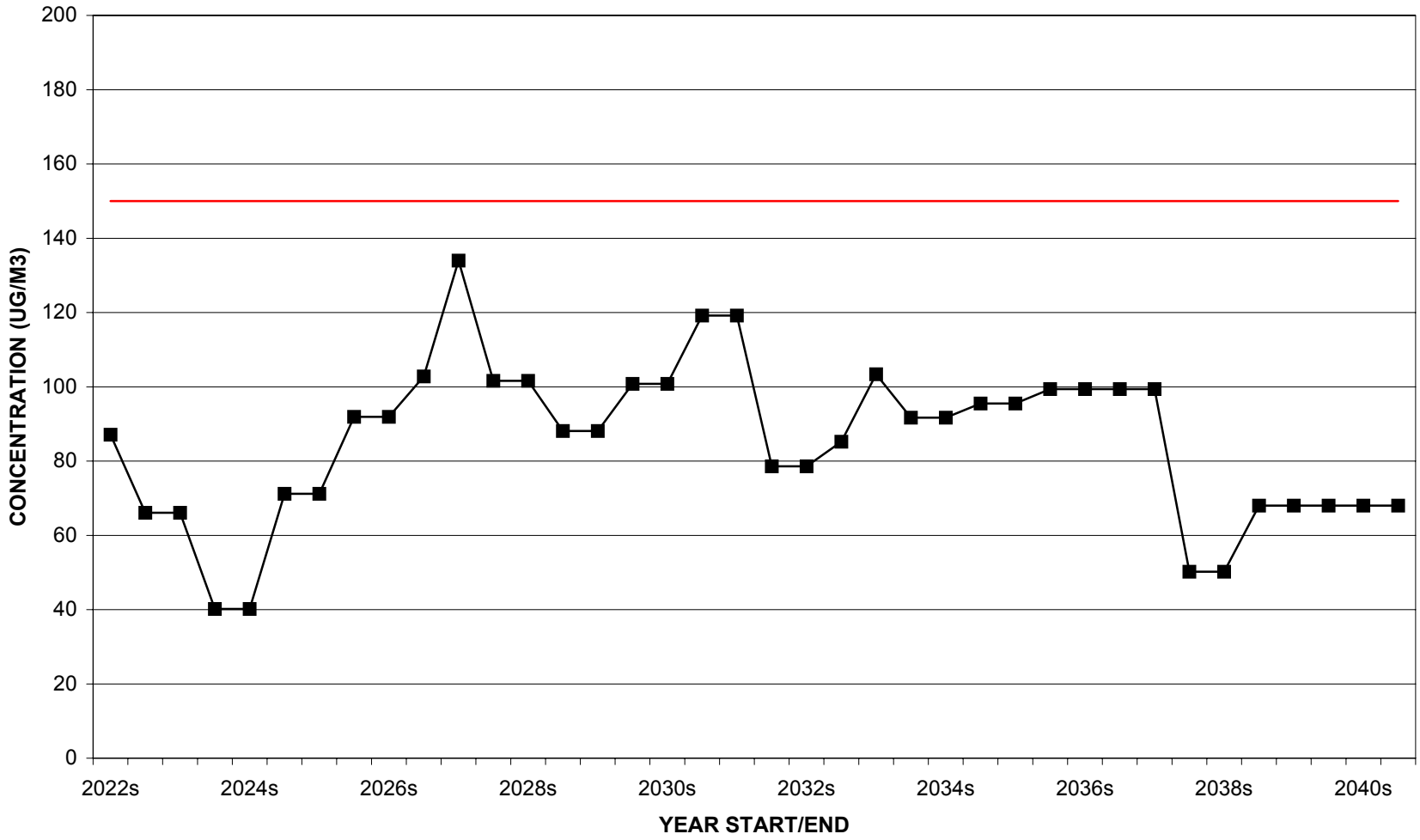
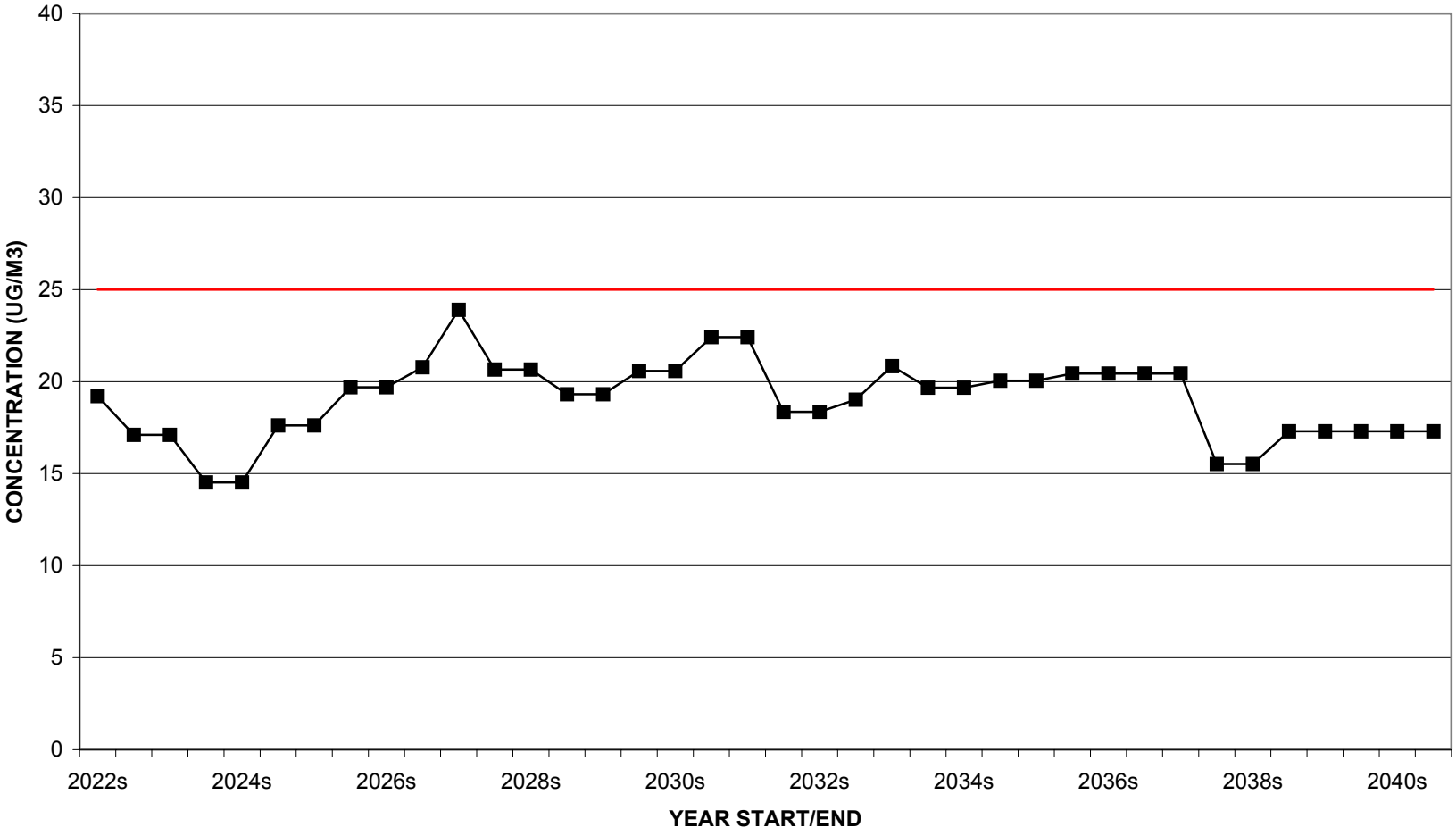


FIGURE 4

MODELED 24-HOUR PM2.5 CONCENTRATIONS (WITH BACKGROUND)



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APPENDIX C
Nanakuli Dust Study

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NANAKULI DUST STUDY

TECHNICAL EVALUATION AND RECOMMENDATIONS

Prepared for:

HAWAII STATE DEPARTMENT OF HEALTH

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Solid and Hazardous Waste Branch
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Prepared by:

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Tetra Tech Project No. 103S1902901
December 20, 2011

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Figure 2: Nanakuli Dust Study Location Map

Figure 3: HECO Lualualei Met Station Wind Rose

Figure 4: HECO Waianae Met Station Wind Rose

Appendices

Appendix A: Photographic Log

Appendix B: DOH Summary Sheet and Maps of Dust Survey Questionnaire Responses

Acronyms and Abbreviations

$\mu g/m^3$	Micrograms per cubic meter
C&D	Construction and demolition
CUP	Conditional use permit
DOH	Hawaii Department of Health, Environmental Protection Division
EPA	U.S. Environmental Protection Agency
HECO	Hawaii Electric Company
MDL	Method detection limit
$PM_{2.5}$	Particulate matter less than 2.5 microns
PM_{10}	Particulate matter less than 10 microns
ppb	Part per billion
PVT	PVT Land Company
RCRA	Resource Conservation and Recovery Act
Tetra Tech	Tetra Tech Inc.
TSP	Total Suspended Particulate
USNETI	U.S. National Emissions Trends Inventory
WOA	West Oahu Aggregate

1.0 INTRODUCTION

On behalf of the State of Hawaii Department of Health (DOH), Solid and Hazardous Waste Branch, Tetra Tech EM Inc. (Tetra Tech) completed a dust study and evaluation of potential dust sources that may affect the Nanakuli community and surrounding areas. The study was focused on identifying potential sources of dust and providing recommendations regarding feasible and realistic alternatives to reduce the dust.

The Nanakuli area is located on the leeward side of Oahu and is prone to arid conditions, especially during the dry season. Historically, the area is home to a number of large-scale industrial facilities, including an electric generation facility, two landfills, a Navy base, service and retail businesses, restaurants, and several developed residential subdivisions. The weather and wind are significant factors in the formation and transport of fugitive dust. Furthermore, the complex terrain adds to the complexity of dust movement throughout the area.

As part of this study, Tetra Tech completed a comprehensive review of all available sources of air quality data and performed other field-related and research-oriented tasks in an effort to: identify and evaluate the level of dust in the area; evaluate potential health concerns related to dust; and, to compare dust concentrations with other areas on Oahu.

This study has specific limitations that must be identified and discussed. Dust on the leeward side of Oahu cannot be avoided altogether. Depending on the time of year and uncontrollable weather conditions, exposed areas of surface soil will result in airborne dust. As a result, the potential sources of dust that have been identified in this report focus on human activity that can be identified and addressed.

The scope of this study was specifically focused on reviewing existing air quality and meteorological data and other existing available information to provide conclusions. Collection of additional air quality or meteorological data was not within the scope of this study.

Background information related to this issue and a discussion of permitted facilities is presented in Section 2; a list of the technical documents reviewed for this study is provided in Section 3; air quality and meteorological data are presented in Section 4; a description of the on-site reconnaissance is provided in Section 5; homeowner interviews appear in Section 6; and a list of conclusions and recommendations is presented in Section 8.

2.0 BACKGROUND

The purpose of this section is to provide a general background, and the general scope of the Nanakuli dust study.

2.1 General Regional Background

The issue of dust on the Nanakuli coast has been an ongoing concern for many years. The area is located on the leeward site of Oahu and is prone to arid conditions during the dry season. This dust study is focused on the area generally bounded by Hakimo Road, Lualuailei Road, and Farrington Highway. Refer to Figure 1 – DOH Dust Assessment Area Map for a generalized location map. The neighborhoods are bordered on the east by the PVT Land Company, LTD, construction and demolition (C&D) landfill (PVT Landfill), beyond which is West Oahu Aggregate (WOA), which operates a stone and gravel crushing and processing operation. Both facilities operate under existing permits from DOH. The PVT Landfill has been in operation since July 1985, and WOA has been in operation since 2002. Refer to Figure 2-Nanakuli Dust Study Location Map for a more detailed illustration presenting the various neighborhoods and larger commercial/industrial facilities.

On May 5, 2011, DOH issued a Solid Waste Management Permit Modification and Renewal (Permit No. LF-0152-09) to PVT. The permit modification allowed PVT to begin mining and recycling of existing and incoming waste. The permit also allows PVT to continue to accept up to 2,000 tons of C&D waste per day, and up to 500 tons of asbestos-contaminated waste per week. No limits were imposed on the number of incoming trucks per day or week. The facility is prohibited from accepting municipal solid waste, commercial and industrial waste (excluding C&D waste from commercial/industrial generators), regulated hazardous waste, and Toxic Substances Control Act (TSCA)-regulated polychlorinated biphenyls (PCB)-contaminated materials.

The area has undergone significant growth and development over the last 20 years, which is evidenced by the volume of vehicle traffic on Farrington Highway. The area can be described as residential, surrounded by commercial business and light and heavy industrial facilities.

The weather and wind patterns affect the transport and deposition of windblown dust in the area. The daily onshore and offshore winds contribute to this transport. In addition, the arid climate in this region facilitates growth of low shrubs and dry grasses that do not provide complete ground cover on undisturbed ground surfaces.

As additional background, Tetra Tech notes that in September 2010, DOH conducted a public meeting to allow for comments related to a permit modification for the PVT Landfill. More than 100 residents attended the meeting. Several community members offered oral testimony, with concerns regarding levels of dust in their neighborhoods, with many suggesting that the origin of the dust affecting their neighborhoods was the PVT Landfill operation. Many of those offering testimony requested that action be taken to resolve the dust issue in the community. In addition, many residents who have lived in the neighborhood for many years described how the dust problem had steadily increased over the years. DOH acknowledged these concerns and began the process of working to address this issue.

The September 2010 testimony at this public meeting was effectively the impetus for DOH to request an objective dust study to evaluate potential sources of dust that may be affecting the surrounding Nanakuli neighborhoods.

On August 28, 2011, DOH again conducted a public meeting to inform the residents about the upcoming dust study. At this meeting, many residents reiterated the same concerns about the dust and air quality issues.

In response to the residents' concerns, and an ongoing dialogue with DOH regarding the dust issues, PVT Attorney Lisa Woods-Munger submitted a letter to DOH on August 23, 2011, listing specific steps PVT had completed over the last 10 years to address and reduce dust emissions from the PVT site. Ms. Woods-Munger indicated in her letter that these steps appear to have helped with the dust issues, stating that PVT did not receive any dust complaints during 2011. DOH has noted that their office has since received two additional dust complaints, on September 7, 2011 and November 4, 2011. Both complaints were investigated by DOH, but were not found to be a result of dust violations from any nearby facilities.

2.2 Scope of Dust Study

Tetra Tech initiated the dust study in November 2010. At that time, Tetra Tech and DOH identified key tasks that would be completed in an effort to evaluate the presence of dust in Nanakuli, which would result in identification of potential specific actions that could be taken to reduce the impact of dust to the neighborhood.

The tasks completed by Tetra Tech to date to evaluate dust concerns in Nanakuli include the following:

- Reviewed all existing pertinent air quality data that has been collected near the Nanakuli area and the greater Oahu Island.
- Completed on-site reconnaissance of the neighborhood and areas with potential for dust emissions, including PVT WOA, Lualualei Road, and Farrington Highway.
- Worked with DOH to develop a questionnaire that would allow residents the opportunity to describe how they are affected by dust and their thoughts regarding the origin of the dust.
- Based on responses from the questionnaire, completed follow-up interviews with homeowners to hear their concerns and answer specific questions.
- Reviewed permits for nearby commercial/industrial sources to evaluate whether they are in compliance with applicable permits rules and requirements.
- Based on the information collected, provided recommendations to reduce dust impacts to the residents of the Nanakuli area.

Figure 2 contains a detailed aerial photo showing the project location, surrounding neighborhoods, surrounding facilities (including PVT and WOA), the locations of PVT and Hawaii Electric Company (HECO) air monitoring stations, and other areas of interest.

3.0 REVIEW OF TECHNICAL DOCUMENTS

As part of this dust study Tetra Tech reviewed numerous technical documents that may pertain to dust issues in the Nanakuli area. These documents included: state, city, and county permits, air quality monitoring data, human health risk assessments, and technical and regulatory correspondence between PVT and the City and County of Honolulu and DOH staff.

In addition, other technical documents were reviewed as necessary to gain insights to the nature of dust issues on Oahu and related to the PVT Landfill operations. The air quality data consisted of data collected by DOH, HECO, and PVT.

This list serves to document the level of review that was required for this study. A review of air quality data is presented in the following section.

Documents Reviewed by Tetra Tech

- State of Hawaii Department of Health Solid Waste Permit No LF-0152-09 PVT Integrated Solid Waste Management Facility, Including Landfill, Recycling, and Materials Recovery, Solidification Operations, Waianae, Oahu, Hawaii.

- Hawaii Department of Health Response to Comments PVT Land Company Integrated Solid Waste Management Facility Draft Solid Waste Management Permit, dated December 14, 2010.

- Letter from Stuart Yamada, P.E. Chief, Environmental Management Division, to the Honorable Dwight Takamine, Director, Department of Labor and Industrial Relations et al. RE: September 2, 2010, Public hearing and public comment period PVT Land Company Integrated Solid Waste Management Facility Draft Solid Waste Management Permit.

- State of Hawaii Department of Health Solid Waste Management Permit No RY-0029-10 Uncontaminated Concrete/Asphalt Recycling West Oahu Aggregate Company, Inc.

- State of Hawaii Department of Health Clean Air Branch 2009 Hawaii Air Quality Data Book.

- URS Traffic Impact Study, Nanakuli area on Farrington Highway and adjoining streets, dated July 20, 2007.

- Hawaii Department of Transportation Highways Division Highways Planning Survey Section Vehicle Classification Data Summary 2009; Farrington Highway.

- Air Monitoring PVT Land Company, LTD. Nanakuli, HI, Summary Report (monthly reports from November 2009 through November 2010).

- Limited Human Health Risk Assessment Construction Debris Recycling, PVT Landfill dated July 2010; prepared and submitted by AMEC Earth and Environmental, Inc.

- Letter from David Tanoue, Director Department of Planning and Permitting, City and County of Honolulu, dated March 24, 2011 RE: Minor Modification approval notice to PVT Land Company.

- Correspondence letter from attorney Lisa Woods Munger to Gary Gill, Deputy Director of DOH Environmental Health Administration, dated August 23, 2011, RE: dust control measure implemented b PVT Land Company from 2001 to 2011.

- Human Health Risk Assessment of Fugitive Dust and Surface Soils, PVT Landfill, dated June 2005; prepared and submitted by AMEC Earth and Environmental, Inc.

- PVT Landfill, Human Health Risk Assessment of AES Conditional Ash, dated February 2010; prepared and submitted by AMEC Earth and Environmental, Inc.

- Baseline Air Monitoring, PVT Land Company, Airborne Metals Analysis, October – November 2010 and May – June 2011.

- HECO ambient air quality data collected at the Waianae and Nanakuli monitoring stations from July 1, 2010, through June 30, 2011.

4.0 AIR QUALITY DATA

Tetra Tech completed a technical review of all available air quality and meteorological data to assess short- and long-term air quality trends. The air quality review was focused on particulate matter less than 10 microns (PM_{10}) and total suspended particulate (TSP) data from PVT, HECO, and DOH. It is noted that the PVT and HECO are the only entities which actively perform air monitoring in the immediate area surrounding the Nanakuli neighborhoods.

4.1 General Overview of Dust, EPA Regulations, and Air Monitoring Methods

Dust typically originates from large exposed earth surfaces that have low moisture content under conditions of elevated wind (typically in excess of 15 miles per hour). The wind blows across the surface and entrains the small and light fractions of soil particles. The dust that becomes airborne is common referred to as *fugitive dust*. Airborne dust originating from geologic material is typically deposited less than 1 mile from the source (EPA).

Dust particles from geologic sources typically range in size from 5 to 40 microns. Smaller particles can be formed from burning, fossil fuel combustion, and industrial sources. These particles can range in size from 0.1 to 10 microns. Additionally, combustion gases, such as nitrogen oxides and sulfur oxides, can undergo secondary reactions in the atmosphere that condense these gases, forming fine particulate matter that can range in size from 0.01 to 2.5 microns. A size distribution chart of typical particles that can become airborne is presented in Table 1.

Table 1: Particle Size Range for Various Materials that can become Airborne

Particle	Particle Size *(microns)*
dot (.)	615
Beach Sand	100 - 10000
Fertilizer	10 - 1000
Pollens	10 - 1000
Textile Fibers	10 - 1000
Atmospheric Dust	5 - 40
Fiberglass Insulation	1 - 1000
Dust Mites	100 - 300
Saw Dust	30 - 600
Ground Limestone	10 - 1000
Cement Dust	3 - 100
Combustion-related - motor vehicles, wood burning, open burning, industrial processes	0.1 to 2.5
Fly Ash	1 - 1000
Coal Dust	1 - 100
Asbestos	0.7 - 90
Metallurgical Dust	0.1 - 1000
Carbon Black Dust	0.2 - 10
Burning Wood	0.2 - 3

Particle	Particle Size *(microns)*
Tobacco Smoke	0.01 - 4

The U.S. Environmental Protection Agency (EPA) promulgated regulations in 1971 to address public health risks from airborne dust. EPA created a federal air quality standard for dust that was named TSP. Based on research and health-based studies, EPA created a daily 24-hour and annual weight-based standard for TSP. These standards were based on a mass measurement of TSP that would be collected on a substrate (a filter) that would be weighed by a standardized laboratory process.

Part of the creation of this standard included development of air monitoring methods and associated equipment that would be used to collect samples and compare the results with the standards. In 1987, EPA further promulgated regulations that focused on particles that were less than 10 microns in diameter, referred to as PM_{10}. EPA determined that the smaller size particles presented a more significant health concern. Larger dust particles typically are filtered in the nose, whereas smaller particles less than 10 microns can be carried and deposited into the throat and lungs.

With implementation of the federal PM_{10} standards, EPA phased out the TSP standards. The TSP data collected by EPA, states, and regulated industrial sources helped to characterize particulate concentrations in cities and rural areas. In 1997, EPA created new 24-hour and annual federal standards for fine particulate matter less than 2.5 microns in diameter. This standard is referred to as $PM_{2.5}$.

Over the last 30 years, Hawaii DOH has collected TSP, PM_{10}, and $PM_{2.5}$ data at sites across the state.

4.2 PVT Air Quality Data

On March 24, 2011, the City and County of Honolulu issued a Minor Modification of Conditional Use Permit (CUP) Number 85/CUP-6 to PVT. In May 2011, DOH issued Operating Permit Number LF-0152-09 to PVT, which is in effect from May 5, 2011, through May 4, 2016. This permit will allow “mining” and shredding of recyclable wood materials, which can be used as feedstock for energy production.

In an effort to characterize their dust mitigation measures, PVT voluntarily initiated a TSP sampling program in November 2009, which focused on collecting TSP samples at three sites along the fence line that abuts the Nanakuli neighborhood which is generally bounded by Mohihi Street, on the western boundary of the landfill. Refer to Figure 2 (inset) for the air monitoring station locations. The sample program was designed to collect 24-hour TSP samples at each of the three sites along the fence line, with each of the sample collection systems affixed near the top of the fence. The samples were collected on a frequency of once every 6 days (referred to as 1-in-6), from midnight to midnight, based on the EPA Monitoring Schedule (http://www.epa.gov/ttnamti1/files/ambient/pm25/CALENDAR2009.pdf and http://www.epa.gov/ttnamti1/files/ ambient/pm25 /CALENDAR 2010. pdf).

Referring to Figure 2, PVT air monitoring Station #1 is located near the PVT entrance, immediately adjacent to Lualualei Road; Station #2 is located in the central portion of the fence boundary between PVT and the abutting the neighborhood, near Auyong Homestead Road;

and, Station #3 is located near the western boundary of fenced boundary between PVT, abutting the neighborhood near Mohihi Street.

The sampling program was continued through November 2010 as a result of negotiations with DOH. PVT also agreed to additional air monitoring requirements, as specified in the current permit.

The TSP sampling program that was stipulated in PVT's current permit was separated into two (2) phases, as follows:

- 1. One year of TSP sampling from November 2009 through October 2010 (Section C, Part 16, Subsection a, Subpart i).
- 2. One year of TSP sampling ***after*** landfill mining begins (Section C, Part 16, Subsection a, Subpart ii).

In addition to analyzing the samples for TSP, additional air samples were required to be analyzed for seven metal compounds that are contained in the Resource Conservation and Recovery Act (RCRA), consisting of arsenic, barium, cadmium, chromium, lead, mercury, and selenium.

The RCRA 7 Metals Sampling Program, as stipulated in PVT's current permit, was separated into four phases as follows:

- 1. Prior to landfill mining in Phase I, and secondary shredding, collect at least two multi-day samples covering at least 10 24-hour periods; completed October – November 2010, and May – June 2011 (Permit Section C, Part 16, Subsection b, Subpart i).
- 2. At or near the start of landfilling mining in Phase I, collect at least two multi-day samples covering at least 10 24-hour periods when landfill mining is occurring (Permit Section C, Part 16, Subsection b, Subpart ii).
- 3. After the start of secondary shredded feedstock production, collect at least two multi-day samples covering at least 10 24-hour periods when landfill mining is occurring (Permit Section C, Part 16, Subsection b, Subpart iii).
- 4. At the end of the first year of landfilling mining in Phase I, collect at least two multi-day samples, covering at least 10 24-hour periods when landfill mining is occurring (Permit Section C, Part 16, Subsection b, Subpart iv).

As of the date of this report, PVT has completed the following sampling requirements:

- Phase 1 of TSP sampling (Permit Section C, Part 16, Subsection a, Subpart i); and,
- Phase 1 of the RCRA 7 Metals Sampling Program (Permit Section C, Part 16, Subsection b, Subpart i).

A brief summary of each of phase of the air sampling program is presented below.

4.2.1 PVT TSP Data

As discussed above, PVT completed TSP sampling on a 1-in-6 frequency from November 2009 through November 2010. The data were presented to DOH in monthly data reports, with statistical analysis and a description of wind patterns.

Tetra Tech reviewed 13 monthly reports and compiled a summary of results that is presented in Table 2.

Table 2: Summary of PVT TSP Data, 24-Hour Samples November 2009 through November 2010

PVT Station No.	Number of samples	Minimum Concentration ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)	Average Concentration ($\mu g/m^3$)
1 [nearest Lualualei Road and PVT entrance]	63	16.6	88.9	34.1
2 [central portion of fenced boundary between PVT and neighborhood]	63	9	55.4	24.8
3 [westernmost station]	63	7.3	42.7	19.1

µg/m³ = micrograms per cubic meter (parts per billion [ppb] equivalent)

The data presented in Table 2 demonstrate that TSP concentrations over the 1-year monitoring period were well below the health-based 24-hour and annual standards for PM_{10} (a subset of TSP) of 150 µg/m^3 and 50 µg/m^3. However, it must be noted that these samples were collected over a 24-hour continuous period. PVT operates from 7:30 a.m. to 5:00 p.m.; therefore, any emissions from the facility, as a result of active facility operations, are not occurring between the following times during each sample event: midnight to 7:30 a.m. and 5:00 p.m. to midnight.

During a review of the TSP data, it was observed that TSP concentrations at Site #1 (monitoring station nearest Lualualei Road) were consistently higher than Sites #2 and #3. On average, Site #1 TSP concentrations were approximately 38 percent higher than at Site #2, and approximately 78 percent higher than Site #3 (monitoring station furthest from Lualualei Road). It is suspected that this increase in TSP concentrations is caused by impacts from trucks entering and exiting the PVT facility, and road dust from Lualualei Road.

The results from the TSP sampling before landfill mining demonstrate that TSP concentrations are <u>well below</u> any health-based standards, and do not pose a health concern for residents of the Nanakuli area.

4.2.2 PVT Metals Data

In November 2010 through December 2010, and again in May 2011 through June 2011, PVT completed particulate metals sampling. This sampling program was designed to collect air samples that would be analyzed for TSP, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver, before landfill mining.

Samples were collected over a 5-day continuous period to accumulate enough particles on the filters to achieve a meaningful sample. In total, four samples were collected from each of the three air sample sites along the fence line. The samples were analyzed using standardized EPA methods, and results were reported in $\mu g/m^3$. The results from the sampling demonstrate that particulate metal emissions from PVT before landfilling are well below any health-based standards and do not pose a health concern for residents of the Nanakuli area.

In fact, the results from the May to June 2011 sampling event show that only chromium and lead were detected in measureable concentrations, marginally above the minimum laboratory method detection limit (MDL). The remaining five metals (arsenic, barium, cadmium, mercury, and selenium) were not detected on any samples.

The technical approach for the October to November 2010 sampling events appears to be somewhat different, but shows similar results to the May to June 2011 event. The sample event consisted of five 24-hour sample events, whereas the later event consisted of collecting one 5-day (or 120-hour) event. These results also show that arsenic and mercury were not detected in any samples and the remaining metals (chromium, selenium, cadmium, barium, and lead) were all detected at concentrations marginally above the MDL, well below any health-based standards, and do not pose a health concern for the residents of the Nanakuli area.

The metals concentrations recorded from PVT are similar to metals concentrations at air monitoring stations operated by the DOH. Figure 2 shows the location of the PVT TSP and metals air sampling locations.

4.2.3 Future Air Sampling

As previously discussed, PVT will be required to complete several additional phases of air monitoring after landfill mining and secondary shredded feedstock production begin. Each of these phases of air sampling is designed to evaluate resultant emissions from each of these phases of PVT's operations.

Based on correspondence with PVT's contractor (Dr. Jim Morrow, DrPH), Tetra Tech was provided the following schedule:

- TSP Sampling, Phase 2 (*Section 16,a, ii*): 1 year of TSP sampling at or near the beginning of landfill mining in Phase I – expected to begin in early 2012.
- RCRA 7 Metals Sampling, Phase 2 (*Section 16,b, ii*): Collect multi-day samples for metals at or near the start of landfill mining in Phase I – expected to begin in early 2012.
- RCRA 7 Metals Sampling, Phase 3 (*Section 16,b, iii*): Collect multi-day samples for metals at or near the start of secondary shredded feedstock operations – no timeframe established, but will be completed after landfill mining starts.
- RCRA 7 Metals Sampling, Phase 4 (*Section 16,b, iv*): Collect multi-day samples for metals at the end of the first year of landfill mining in Phase I – no timeframe established, but will be completed after one year of landfill mining has been completed

As these different phases of the air sampling program begin, it is expected that PVT will notify DOH. At the conclusion of each phase, PVT will provide data to DOH for review and comment. DOH will thoroughly review and assess the data.

4.3 HECO Air Quality Data

Tetra Tech was provided with data from the HECO Lualualei and Waianae air quality and meteorological monitoring stations. For reference, the Lualualei meteorological station is located approximately 2.9 miles south of the dust study area, and the Waianae meteorological station is located approximately 6.5 miles north of the dust study area. The meteorological station locations are indicated on the inset provided in Figure 2. Both datasets included data for PM_{10}, wind speed, wind direction, temperature, and precipitation from July 1, 2010, through June 30, 2011.

The monitoring system used to collect PM_{10} data at both HECO sites measures data continuously using EPA-approved monitoring systems. Therefore, a PM_{10} concentration is measured each hour and reported in $\mu g/m^3$ and also averaged over a 24-hour period for comparison to air quality standards.

The PM_{10} data from the Lualualei and Waianae air quality and meteorological stations help to establish the existing PM_{10} concentrations that are present in the Nanakuli area, and evaluate whether emissions from other industrial sources demonstrated an increase in PM_{10}. A statistical analysis was completed on this dataset and is summarized in Table 3, below.

Table 3: HECO Lualualei Station PM_{10} 24-Hour Data July 1, 2010 – June 30, 2011

Number of Valid hours	Minimum Concentration ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)	Average Concentration ($\mu g/m^3$)
7,560	6.00	62.05	21.36

The data presented in Table 3 show that no state or federal air quality standards were violated at the Lualualei meteorological station and that the overall concentration of PM_{10} is similar to other air monitoring sites on Oahu.

The PM_{10} data from the Waianae meteorological station help to establish the existing PM_{10} concentrations at a site which is not in the immediate vicinity of Nanakuli and evaluate whether emissions from other industrial sources demonstrate an increase in PM_{10}. A statistical analysis was completed on this dataset and is summarized in Table 4, below.

Table 4: HECO Waianae Station PM_{10} 24-Hour Data July 1, 2010 – June 30, 2011

Number of Valid hours	Minimum Concentration ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)	Average Concentration ($\mu g/m^3$)
8,638	4.75	47.96	12.38

The data presented in Table 4 show that the no state or federal air quality standards were violated at the Waianae meteorological station and that the overall concentration of PM_{10} is

similar to other air monitoring sites on Oahu. Figure 2 (inset) shows the location of the two HECO sites in relationship to the dust study area.

5.0 METEOROLOGICAL DATA

Tetra Tech also reviewed meteorological data from the HECO Lualualei meteorological station and PVT to evaluate how wind patterns in the area may affect dust transport and deposition. Tetra Tech generated two wind rose plots from the HECO Lualualei and Waianae meteorological stations, which are provided in Figure 3 and Figure 4, respectively.

The wind rose from the Lualualei station illustrates that the predominant wind direction in the area near the station is from the south and west, with little wind coming from the north and east. This wind pattern appears to be directly affected by the complex terrain (adjacent steep mountain slope) in the immediate vicinity of this location.

The wind rose from the Waianae station illustrates that the predominant wind direction in the area near this station is from the east and west, with little or no wind coming from the north and south. This pattern is consistent with the more traditional fluctuating Hawaii offshore-onshore winds that are frequent in the leeward side of Oahu.

Please note that the meteorological data that were initially provided for the PVT site were contained in tables presented with the monthly TSP report. However, that format did not allow for direct comparison with the HECO dataset; therefore, Tetra Tech was not able to compare the data from the HECO meteorological stations to the PVT stations in this report.

Tetra Tech submitted a request to PVT's contractor (Dr. Jim Morrow, DrPH) for an electronic file containing the meteorological data, and on November 29, 2011, Dr. Morrow provided an electronic version of the PVT meteorological data collected between 2006 and 2011. This data, which requires significant formatting and manipulation to allow for evaluation and generation of a wind rose, will be reviewed by DOH to better understand wind patterns in the dust study area.

It is unclear how the exact dynamics of the wind in the Nanakuli area affect transport and deposition of dust. However, based on the HECO Waianae wind rose and discussions with residents, it appears that the majority of intense winds are from the east. If these patterns prevail near the community, it may help to explain how potential dust emissions from PVT, WOA, Lualualei Road, or other sources are transported to the neighborhood. However, additional wind data in the immediate area would be required to accurately confirm the manner in which the wind patterns facilitate dust transport.

6.0 ON-SITE RECONNAISSANCE

A key component of the dust study included a site visit to Nanakuli to evaluate the area and collect information for this evaluation. Tetra Tech completed reconnaissance of PVT, WAO, and the surrounding neighborhoods. Each of these site visits and observations is presented below. Figure 2 provides the locations of the areas discussed below.

6.1 PVT Land Company

On Tuesday, August 28, 2011, Tetra Tech accompanied DOH on a site visit and tour of the PVT Landfill. Tetra Tech met with Stephen Joseph (Vice President/General Manager) and Albert Shigemura (President) at the PVT office and discussed the nature of the site visit, reviewed aerial photos of the site, and discussed the PVT air monitoring program. Tetra Tech and DOH accompanied Mr. Joseph in his vehicle for a site tour. The tour began by driving along the access road adjacent to the facility's western fence line, which abuts the residential neighborhood. The PVT representatives showed the location of the three air monitoring stations and recent site improvements in this area.

The group then traveled up the newly paved access road to the active portion of the landfill. At the time of the site visit, crews were installing a white liner in a new cell near the easternmost portion of the landfill. The group was shown the materials recycling area and observed the various piles of sorted material and the sorting system itself. The tour then proceeded to the waste-receiving area. Mr. Joseph informed the group that the waste was be received and stored prior to sorting. Several trucks were observed offloading waste. While the trucks were unloading, PVT personnel were applying a large volume of water spray to the incoming waste, and a track-mounted compactor was re-working the waste. Several additional water trucks were driving slowly around the site applying water from mounted spray guns. The waste that Tetra Tech observed being unloaded appeared to consist of general C&D waste with metal, wood, and insulation.

The tour then proceeded up and over the top of the compacted and capped section of the landfill to an area where PVT accepts asbestos waste. Tetra Tech was informed that PVT accepts asbestos waste only on specific days of week; however, no asbestos waste was delivered on the day of the visit. Tetra Tech did not observe open or exposed areas containing asbestos waste. Tetra Tech observed the concrete crushing area, truck wheel wash station, and the scale area where trucks are weighed when they enter and exit the facility.

During the site visit, the site appeared to be well watered, and there was no visible dust coming from the roads or the waste debris. There is a 5 mile per hour speed limit on the facility, and trucks passing through the facility were observed to be adhering to slow speed restrictions. PVT reportedly uses a radar gun on site to maintain speed controls. Minimal dust was observed to be generated from vehicles passing through the facility during Tetra Tech's site inspection. Several clouds of visible fugitive dust were observed to be emanating from the eastern-facing slope of the capped sections of the landfill. The dust was not extreme, but was visible, and was being picked up by fairly low wind speeds.

The PVT site visit concluded with a follow-up meeting at the office. Tetra Tech met with Dr. Morrow, DrPH (Doctor of Public Health), an independent environmental management consultant who coordinates collection of air samples for PVT, maintains and calibrates the sampling equipment, and prepares the data analytical reports. Dr. Morrow discussed the technical aspects of the air monitoring program, and demonstrated the equipment programming and

operation. He also discussed sample handling procedures used for collecting the particulate and metals samples. Based on Dr. Morrow's presentation, it is Tetra Tech's opinion that Dr. Morrow follows sound scientific methods, in accordance with the professional standards of care that would provide representative air quality data.

Furthermore, the PVT samples were analyzed by Desert Research Institute (Reno, Nevada), which is a nationally recognized and certified laboratory for analysis of air samples.

6.2 West Oahu Aggregate

On Thursday, August 30, 2011, Tetra Tech accompanied DOH on a site visit and tour of WOA. Tetra Tech met with Shelby Alvaro at the WAO front office who was managing the entrance area. Ms. Alvaro agreed to accompany Tetra Tech and DOH on a walking tour of the site. However, it was lunchtime, so no active crushing or loading and unloading operations were occurring during the site visit. Tetra Tech inspected the crushing operations and observed the various piles of crushed and sorted material. The access roads were still wet from a recent watering. The group then returned to the entrance and departed.

After Tetra Tech departed the site, Tetra Tech proceeded north, toward the entrance to the Lualualei naval base entrance, to observe conditions at the entrance. There was no visible dust along the road between the entrance to WOA and the base entrance. Tetra Tech then proceeded back down Lualualei road, toward WOA. When Tetra Tech approached the side fence of WOA, the crusher was observed to be in operation. Tetra Tech stopped along the fence line and observed that there was no visible dust emanating from the crusher or material piles. Several photos were taken from the vehicle to document the conditions. Shortly thereafter, Tetra Tech proceeded farther south on Lualualei Road, and just after the entrance to WOA, observed a water truck spraying Lualualei Road. The truck entered WOA; therefore, it was assumed the truck was operated by WOA.

Tetra Tech was informed that on a subsequent visit to WOA, DOH observed visible dust emissions coming from the site. It was unclear exactly where the dust was emanating from but appeared to be from materials handling or crushing within the facility.

6.3 Lualualei Naval Road and Dirt Shoulder

The Lualualei Naval Road serves as a key access point to the PVT Landfill, WOA, and the Lualualei Navy Base. Traffic consists of heavy trucks containing C&D waste or other material headed to and from PVT or WOA, as well as vehicles that access the base. URS Inc. (URS) completed a traffic study in July 2007, and estimated that the average daily traffic volume is 8,950 vehicles per day on Lualualei Road. This is a two-lane road, with large unpaved areas (berms) on either side that extend from just east of Farrington Highway to the entrance of PVT. Vehicle access to and from Lualualei Road is from Farrington Highway. Beyond the entrance to the PVT Landfill and extending generally northerly, up to the Navy base entrance, the road berms have grass ground cover on either side of the road. This ground cover appears to help minimize dust and also helps to prevent vehicles from pulling off the road. As of the date of this report, Tetra Tech was unable to confirm who completed these improvements or maintains the roadway or shoulder.

The unpaved areas along either side of Lualualei Road between the entrance to PVT and Farrington Highway are commonly used for temporary parking, as evidenced by vehicle tracks up and down the either side of the road, and the lack of vegetation. This area appears to pose the potential for significant dust emissions based on the composition of the exposed soil (fine

grain silt and sand), the amount of vehicle tracks observed on the dirt, and volume of vehicles and trucks that access this Lualualei Road. Based on numerous site reconnaissance visits completed by Tetra Tech and DOH, as well as homeowner interviews, a significant volume of traffic along Lualualei Road between the PVT entrance and the strip mall near the intersection with Farrington Highway is heavy trucks.

Tetra Tech was not able to obtain information from PVT or WOA on the actual number of trucks that travel to the facilities on a daily basis; however, the estimates would likely be in the hundreds. The volume of traffic, combined with the dynamics of the road, appear to contribute significantly to fugitive dust emissions. The unpaved road shoulder is commonly used as temporary parking for commercial trucks and other vehicles for various reasons.

There is evidence that when vehicles pull off of Lualualei Road, they may kick up dust immediately, or they carry dirt onto the road as they pull back onto the paved roadway. This dirt is further crushed and carried on vehicle tires and eventually kicked into the air as road dust.

Refer to the photographs provided in Appendix A for documentation regarding the berm conditions and evidence of mud tracking within Lualualei Road.

The posted speed limit on Lualualei Road is 25 miles per hour (mph). However, Tetra Tech observed numerous trucks and vehicles that appeared to be traveling well above the speed limit. In addition, DOH has observed trucks and vehicles which appear to be exceeding the speed limit on numerous occasions. It is suspected that that Lualualei Road is a source of road dust, and EPA AP-42 emission factor data shows that vehicle speeds are proportional to the rate of road dust emissions.

6.4 Nanakuli Neighborhoods to the West and North of PVT

During the period of August 28 to 30, 2011, Tetra Tech completed a reconnaissance of the neighborhoods west and north of PVT. An initial visit to the neighborhood west and immediately adjacent to PVT, generally bounded by Mohihi Street, was completed to obtain a visual perspective on the location of the neighborhood with respect PVT and to view the PVT Landfill from within the neighborhood (identified on Figure 2 as “Primary Neighborhood of Concern”).This neighborhood is subdivided with curb, gutter, and sidewalk construction. The homes primarily consisted of single-family dwellings with street access. Additional visits were conducted on August 29 and 30 while homeowners were interviewed. During the site visit, Tetra Tech observed a number of homes with bare ground yards (no grass or ground cover) that may serve as a potential source of fugitive dust.

A site visit to the neighborhood to the north of PVT (identified on Figure 2 as “Area of Mixed Use”), along Hakimo Road, was conducted on August 30. This is an area of mixed residential, commercial, and agricultural uses. The homes in this neighborhood were not part of a subdivision, and varied greatly in size and structure. Many homes appeared to be in varying states of disrepair, and may have some forms of commercial and non-commercial activities ongoing, such as livestock operations (pig and chicken farms), commercial agriculture, and materials storage, with much of the yard area on many properties consisting of bare ground (no grass or groundcover; notably the areas with livestock).

Several homes appeared to have large stockpiles of what appear to be junk or discarded materials and equipment. Tetra Tech notes that the area along Hakimo Road could also be a source of fugitive dust in the area, given the mixed commercial and agricultural uses, and significant unvegetated areas.

7.0 COMMUNITY OUTREACH

The scope of work for this project included assisting the DOH with development and distribution of a survey questionnaire that was mailed to residents in the Nanakuli focus study area. One of the survey questions asked if residents would be interested in participating in an interview with DOH and their consultant. Therefore, following the survey distribution, 10 respondents participated in an interview. This section also presents the results of the resident interviews.

7.1 Dust Survey and Summary of Results

DOH developed and mailed out 1,100 copies of a dust survey to residents living in the neighborhoods bounded by Lualualei Road, Hakimo Road, and Farrington Highway. DOH received 72 total responses (out of the 1,100 mailed), and the majority of respondents were from the two neighborhoods immediately west of PVT, with limited responses from the area of mixed use (see Figure 2). The survey questionnaire presented questions to residents in an effort to obtain information regarding the dust issue, and the responses were plotted on a figure showing the location of the respondent. The following nine (9) questions were presented with 4 possible answers for each question:

1. How long have you lived here?
2. Describe the amount of dust.
3. (has the dust) changed over time?
4. Side (of neighborhood) with more dust?
5. Time of day with more dust?
6. Wind direction?
7. See dust blowing onto property?
8. Interested in a visit?
9. Want updates?

A summary of the survey results is presented below. A summary sheet and series of eight (8) maps that detail the respondent survey results is provided in Appendix B.

<u>Summary of Dust Survey Results</u>

- 78% of respondents lived at site for more than 10 years.
- 44% describe their situation as a lot of dust, while 40% describe it as a greater than average amount of dust.
- 53% report that the amount of dust has increased over time.
- 44% report that the dust is from the Mauka side, while 46% report it is the same all over.
- 38% report that the dust is the same at all times of day, while 31% are not sure.
- 53% report that dust is worst with trade winds, while 36% are not sure.
- 60% report that dust can be seen blowing onto their property, and 38% report a source.
- 30 of the respondents were interested in a visit.
- 35 requested updates.

In addition to providing the dust survey questionnaire to residents, DOH also solicited a request for residents to participate in a photo brigade whereas any photos showing dust would be provided to DOH. It is noted that to date, one neighborhood resident has submitted photos to the DOH. These photos are also included in Appendix A.

7.2 Homeowner Interviews

DOH identified and confirmed 10 homeowners who agreed to meet, and discuss their concerns regarding dust issues and on August 29 and 30, 2011, Tetra Tech and DOH conducted these visits. Tetra Tech was unable to make contact with one homeowner; therefore, a total of nine interviews were conducted.

The length of time these residents lived in the neighborhood varied from just a few years to more than 40 years. The names of the individuals and their addresses will be kept confidential; however, information obtained from the site visits has been summarized below. The homes were all located in the neighborhood generally bounded by Hakimo Street, Lualualei Road, Farrington Highway, and the southwest boundary of the PVT Landfill.

Several generalized questions were presented to each of the homeowners, such as:

- Has the dust problem gotten worse, better, or remained unchanged over the past 10 (or so) years?
- Where is the dust coming from?
- Is dust worse at certain times of day?
- Is dust worse at certain times of the year?
- Any other concerns or questions?
- The responses and concerns provided by residents are presented below.

Resident #1

- Length of time at this address – over 40 years.
- Described dust as coming from east side of house, and believes it is from truck traffic along Lualualei Road.
- Did not see any differences in dust during different times of the year.
- Described how dust was always getting into the carpet, so resident had it removed.

Resident #2

- Length of time at this address – 37 years.
- Described always having dust in Nanakuli, and that it comes from the east side of the house from the direction of the PVT Landfill.
- Called a state agency 3 years ago to seek assistance cleaning house because of the overwhelming amount of dust. (Refer to Photo No.1, in Appendix A.)
- Described that dust seemed to have decreased some over “the last year or so”.
- Dust problem worse during daytime, when activity at PVT is occurring.

- Described traffic as not dramatically increased over the last few years, but there always seem to be a considerable number of trucks.
- Described how daughter has asthma and has difficulty breathing when dust is bad.

Resident #3

- Length of time at this address – 20 years.
- Described that dust comes from trucks traveling on Lualualei Road, and is worse during PVT Landfill business hours.
- Dust problem has gotten worse over last 10 years.
- Every Sunday has to wash vehicles because there is so much dust on them.
- Described how son has asthma and wondered if it was caused by the dust.
- Expressed concern as to whether the dust particles are harmful.

Resident #4

- Not at home.

Resident #5

- Length of time at this address – 41 years.
- Described that the dust comes from trucks along Lualualei Road, and is worse during morning hours.
- Dust is “bad”, not better or worse.

Resident #6

- Length of time at this address – more than 1 year.
- Described that dust comes from trucks traveling on Lualualei Road, and can see dust as the trucks enter and leave the PVT site (resident has a view of PVT from her property).
- Described how the red dust clogged the street drains.
- Described that when wind is blowing dust is bad in the afternoon; she can see dust coming from the trucks.
- Said neighbors always complain about how they have always had a problem with the dust.

Resident #7

- Length of time at this address – 2 years.
- Described that dust is all over the house.

- Dust problem has gotten worse over the years.
- Does not know where dust is coming from because he cannot see PVT from his house.
- Described how wife was getting regular nose bleeds and eye irritation; wondered if it was from the dust.
- Expressed concern if the dust particles are harmful.

Resident #8

- Length of time at this address – 19 years.
- Dust problem has gotten worse over the years.
- Described that dust is coming from PVT Landfill in varying intensities depending on activities and wind.
- Described how dust is everywhere inside his home.

Resident #9

- Length of time at this address – 15 years; previously lived at other location in neighborhood for 32 years.
- Described how dust problem is getting worse.
- Dust blows from the east.
- Described that dust comes from trucks traveling on Lualualei Road, and within the PVT Landfill, and is worse during business hours.
- Described how Lualualei Road was watered in the past, but is not watered anymore (note: resident's property abuts Lualualei Road; therefore, has direct view of street).
- Believes that the trucks are a major source of dust and debris (blowout out of trucks).

Resident #10

- Length of time at this address – 16 years.
- Described how dust problem has gotten worse over last 10 years.
- Described how dust accumulates over time.
- Described how windows on east side of house (the side toward Lualualei Road) get a lot of dust accumulation.
- Concerned about what is in the dust and if it is harmful; grandson has asthma and wonders if dust is making it worse.

General Summary of Homeowner Interviews

It was apparent from these interviews that the residents of the neighborhood feel that the dust is coming from the PVT Landfill and the trucks as they enter and exit the site, and as they travel along Lualualei Road. The opinions expressed by the residents could not be verified or confirmed. In addition, no medical records were provided to support any health-related claims.

Many of the residents are concerned because they do not know if the dust is harmful and have not been provided any information to support an argument as to whether the dust is or is not a potential health concern.

A summary of the primary concerns that were expressed by most residents includes the following:

- Dust appears to be worse during business hours, and has generally become worse over the past several years.
- Dust appears to be coming from the general direction of the PVT Landfill, and can be seen coming from trucks entering and exiting the site.
- Trucks traveling to and from the PVT Landfill, along Lualualei Road are a source of dust.
- Concern: Is the dust harmful?
- Concern: Several residents reported knowing someone who is sick, and are concerned whether the dust may be affecting their health.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The section below presents Tetra Tech's conclusions and recommendations, resulting from the Nanakuli Dust Study.

8.1 Conclusions

Tetra Tech completed the tasks presented above in an effort to identify the potential sources of dust in the Nanakuli area and offer specific recommendations to reduce dust. Air quality data from the immediate and surrounding areas were reviewed to compare with EPA standards. A comprehensive document review was completed in an effort to understand the context and basis for this issue. Site visits and reconnaissance were completed in an effort to observe and document on-site conditions that may lead to the formation and transport of dust. A questionnaire and homeowner interviews were conducted so that residents had the opportunity to express their concerns, ask questions, and discuss this issue.

The study has identified the following potential sources of dust:

- Commercial and industrial sources, located along Lualualei Road, including PVT and WOA;
- Roadway sources, predominantly along Lualualei Road, between Farrington Highway and PVT Landfill;
- Residential yards which are unvegetated (bare dirt), including the focus neighborhood.
- Other commercial, agricultural, and residential areas with unvegetated properties in the mixed use area along Hakimo Road.

As a result of these tasks and a review of the air quality data provided, Tetra Tech offers the following conclusions:

- Dust presents a nuisance for the residents of Nanakuli when wind conditions facilitate transport and deposition from potential dust sources. However, based upon a review of all available data, and a review of the on-site conditions, the dust does not pose a health concern.
- Some of the dust appears to be tied directly or indirectly to emissions from Lualualei Road, PVT, WOA, and commercial agriculture. Site visits performed during this study, including PVT and WOA, indicated that there are dust emissions as a result of these operations.
- As indicated in this report, air monitoring data provided by PVT indicates that dust in the vicinity of the fenced boundary between PVT and the abutting neighborhood to the west does not pose a health concern. Further, a review of the data and methods indicates that the data is collected in accordance with sound scientific principles, applicable EPA methods, and professional standards of care, resulting in representative air quality data.
- The current operations at PVT are focused on C&D waste disposal and recycling. However, in the near future, PVT plans to begin landfill mining and secondary shredding feedstock operations. The permit issued by DOH requires additional air monitoring at

the start of these operations to confirm that PVT's increased activities do not result in an increase in air pollution and emissions.

8.2 Recommendations

The recommendations presented below are not directly tied to any permitting requirements, nor are they legally binding in any way. They are offered as steps to help reduce potential fugitive dust emissions, and allow the DOH to work closely with the Nanakuli community to begin addressing this issue through regular community outreach programs and ongoing technical input.

Recommendation #1 – Lualualei Naval Road Improvements and Maintenance

Tetra Tech recommends that DOH work closely with the community in conjunction with PVT and the Navy base to initiate a plan to address the bare dirt pullout sections (berm) on either side of Lualualei Road. This area could be addressed by planting ground cover and installing obstructions, such as a curb or guardrail that will prevent trucks and cars from pulling off the road.

Based on the site visit and homeowner interviews, this area may be a significant source of dust resulting from trucks traveling to and from the PVT site along Lualualei Road. Trucks and vehicles may be directly emitting dust and debris from their vehicles as they drive onto and off the shoulder. In addition, the dirt may be tracked and deposited onto the roadway, where it they can then be emitted as road dust.

Homeowners stated that they observe dust coming from the trucks, and also on numerous occasions have seen trucks pulled over on the side of the road. All of these activities, combined with low soil moisture and high winds blowing from the east and southeast, may contribute to dust that is transported to the neighborhoods.

In addition, regular maintenance, such as street sweeping and cleaning of the road, will help to further reduce dust emissions.

Recommendation #2 – Enforcement of Speed Limit on Lualualei Naval Road

Tetra Tech recommends that the Navy enforce the 25 mph speed limit. Based on a site visit and a review of the URS traffic study, on average more than 8,000 vehicles travel this road on a daily basis. EPA has developed emission factor data (AP-42) for road dust emissions, and numerous air quality studies have been completed on the rate of dust that is emitted from vehicles traveling on paved roads that contain varying amount of dirt. The U.S. National Emissions Trends Inventory (USNETI) for 1997 estimated that nearly two-thirds of all fugitive dust results from road dust (USNETI 1997).

The dynamics and formation of road dust result from small dirt particles that are deposited on public roadways. Vehicles traveling on the road further crush and entrain these dirt particles onto tires and kick them up into the air. Because of the small size fraction, these particles are easily transported with even low wind speeds. This problem is further exacerbated by large trucks with multiple-wheel axles and industrial-size tires.

Enforcing the speed limit on this stretch of roadway, along with reduced dirt tracking onto the roadway (from the shoulder), will help to reduce road dust.

This issue and hypothesis is supported by the 1 year of monitoring data collected by PVT at Station #1, which is located near the entrance to PVT, along Lualualei Road. On average, Station #1 TSP concentrations were 38 percent than at Station #2, and 78 percent higher than Station #3. It is suspected that this increase in TSP concentrations is the result of impacts from trucks entering and exiting the site, and road dust from Lualualei Road.

Recommendation #3 – Reduce Emissions at Entrance to PVT

Tetra Tech recommends that PVT evaluate alternatives to better control dust emissions from vehicles near the site entrance.

Numerous residents described how they observed trucks and vehicles entering and exiting the PVT facility, and that these trucks were generating visible dust. This may be a result of trucks and vehicles traveling on the shoulder or other unpaved (or underpaved) sections of roadways near the entrance to PVT. Tetra Tech recommends that DOH work with PVT to identify if there are areas near the entrance that may have the potential for dust emissions and address this issue.

It is recommended that PVT take the following actions, including, but not limited to: prohibiting vehicles from driving on dirt shoulders; determine if unpaved areas can be paved; and, applying water to exposed areas on a routine basis which results in dust reduction.

Recommendation #4 – Reduce Emissions on Capped Landfill Sections at PVT

Tetra Tech recommends that PVT evaluate alternatives to reduce dust emissions from the capped sections of the landfill, using either ground cover or a geo-membrane on the semi-permanent slopes. During the site visit, Tetra Tech and DOH observed that access roads and incoming waste were well watered.

However, several of the inactive and semi-permanent slopes were barren of any groundcover, and dust was observed blowing off the slope and becoming airborne. Clean Air Branch rules require reasonable dust control measure on visible dust. In addition, the PVT Permit Section A, Part 11, and Section B, Parts 23 and 43 require that PVT adequately address dust and erosion control on slopes and exposed areas of the landfill.

Dust control measures must be continually implemented PVT, and Tetra Tech recommends that DOH work closely with the facility to ensure that adequate measures are being taken on a daily basis to minimize dust emissions.

Recommendation #5 – Evaluate Reasonable Dust Controls on Other Surrounding Industrial, Commercial, and Agricultural Areas

Tetra Tech recommends that the DOH work with the remaining surrounding commercial, industrial, and agricultural areas, to evaluate whether “reasonable controls” are in place with regard to fugitive dust emissions. This includes the WOA facility, as well as the mixed use area along Hakimo Road.

During a DOH site reconnaissance of WOA, dust emissions were observed to be coming from the facility. WOA’s permits with the Solid and Hazardous Waste Branch and Clean Air Branch require dust control measures. Dust control measures to address crushing

operations and fugitive dust from site operations must be continually implemented at the WOA facility, and Tetra Tech recommends that DOH work closely with the facility to ensure that adequate measures are being taken on a daily basis to minimize dust emissions.

Similarly, periodic DOH area reconnaissance is recommended for the area along Hakimo Road, to evaluate whether commercial and agricultural activities in that area are implementing "reasonable controls" to minimize dust emissions from their operations, which could be impacting surrounding neighborhoods. This would also include follow-up to any activities identified by neighborhood community members via reports of nuisance dust, or photo-brigade reports showing activities generating visible dust.

Recommendation #6 – DOH Community Involvement

Tetra Tech recommends that DOH continue to provide the Nanakuli residents with updates and new information on this issue through e-mail notices and flyer mailings. Based on resident interviews and attendance at the public meeting, it is clear that many homeowners do not understand the permitting process and available air quality data. Community outreach could include providing information on how to obtain available and relevant air monitoring and permit data, and guidance on understanding interpretation of available data and related information.

Recommendation #7 – Review Recently Obtained Electronic Meteorological Data Provided

On November 29, 2011, Dr. Morrow provided the PVT meteorological data in electronic format. Tetra Tech recommends that this data be reviewed and formatted to generate a wind rose for the area specific to PVT, to better understand the immediate local wind patterns.

The data that were obtained from the HECO Lualualei and Waianae meteorological stations present potentially conflicting data regarding the wind patterns in the immediate vicinity of the Nanakuli dust study area. The terrain at the HECO Waianae station is more consistent with the terrain at the dust study area, and appears to more closely reflect wind conditions at that location.

A detailed review of wind data from PVT will help DOH to assess the wind patterns and further assess dust transport and deposition.

Recommendation #8 – Neighborhood Awareness and Improvement Plan

Tetra Tech recommends that DOH and the local Nanakuli neighborhood evaluate whether a neighborhood awareness and improvement plan could be developed to help residents understand the importance of keeping their lots watered and maintained.

During the site reconnaissance, Tetra Tech observed a number of homes with bare dirt lots and no landscaping whatsoever. During the dry season or drought conditions, this lack of vegetation may contribute to fugitive dust within the immediate neighborhood.

In addition, a number of homes on the northwest end of Hakimo Road were observed having potentially unpermitted commercial activities that may be contributing to dust

emissions in the area. Tetra Tech recommends that DOH investigate this area to confirm whether any unpermitted activity is occurring that may contribute fugitive dust in the area.

9.0 BIBLIOGRAPHY

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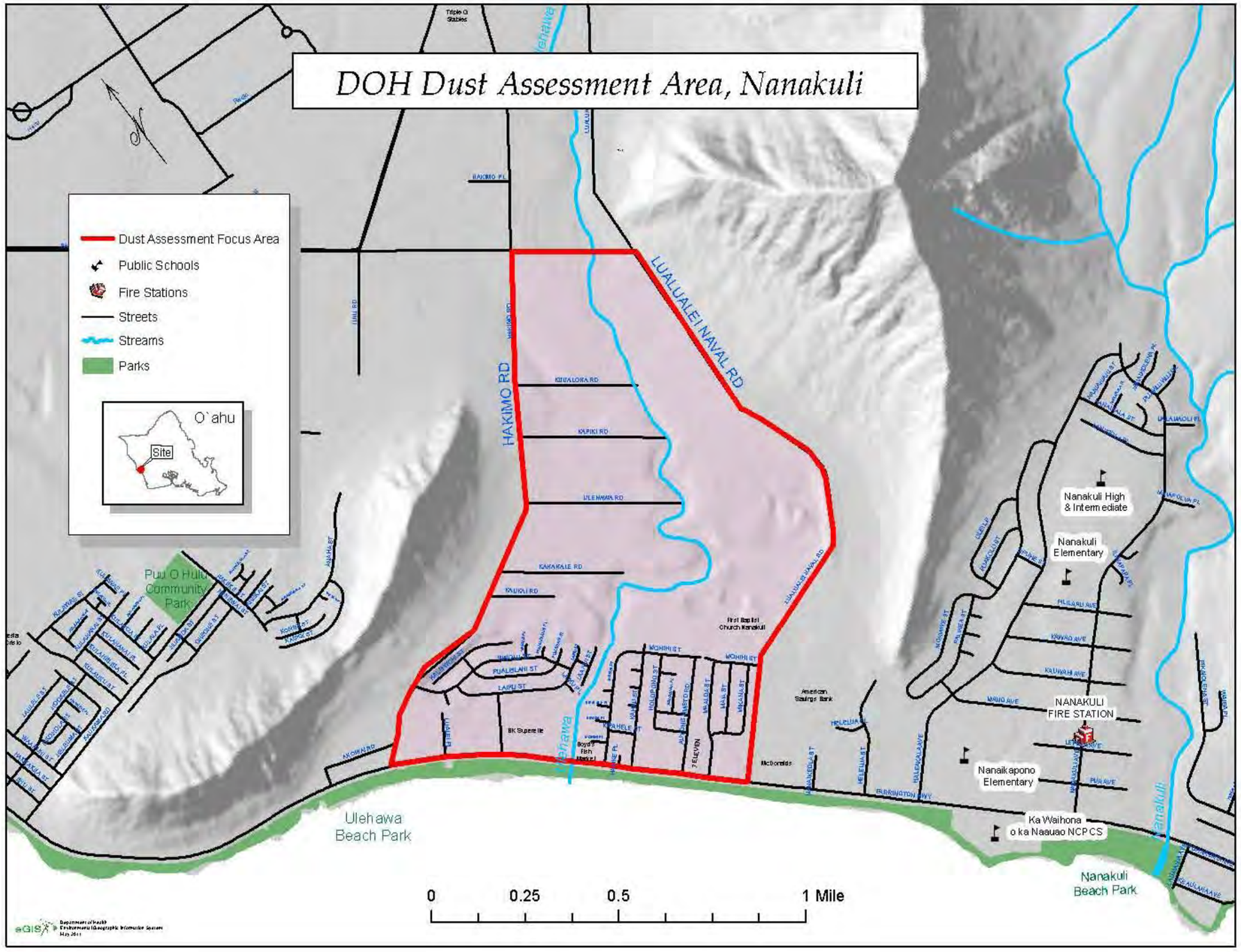
FIGURES



State of Hawaii Department of Health
Solid and Hazardous Waste Branch

FIGURE 1
NANAKULI DUST STUDY
DOH DUST ASSESSMENT AREA MAP

TETRA TECH

HECO AIR QUALITY MONITORING STATIONS

State of Hawaii Department of Health
Solid and Hazardous Waste Branch

FIGURE 2
NANAKULI DUST STUDY LOCATION MAP

TETRA TECH

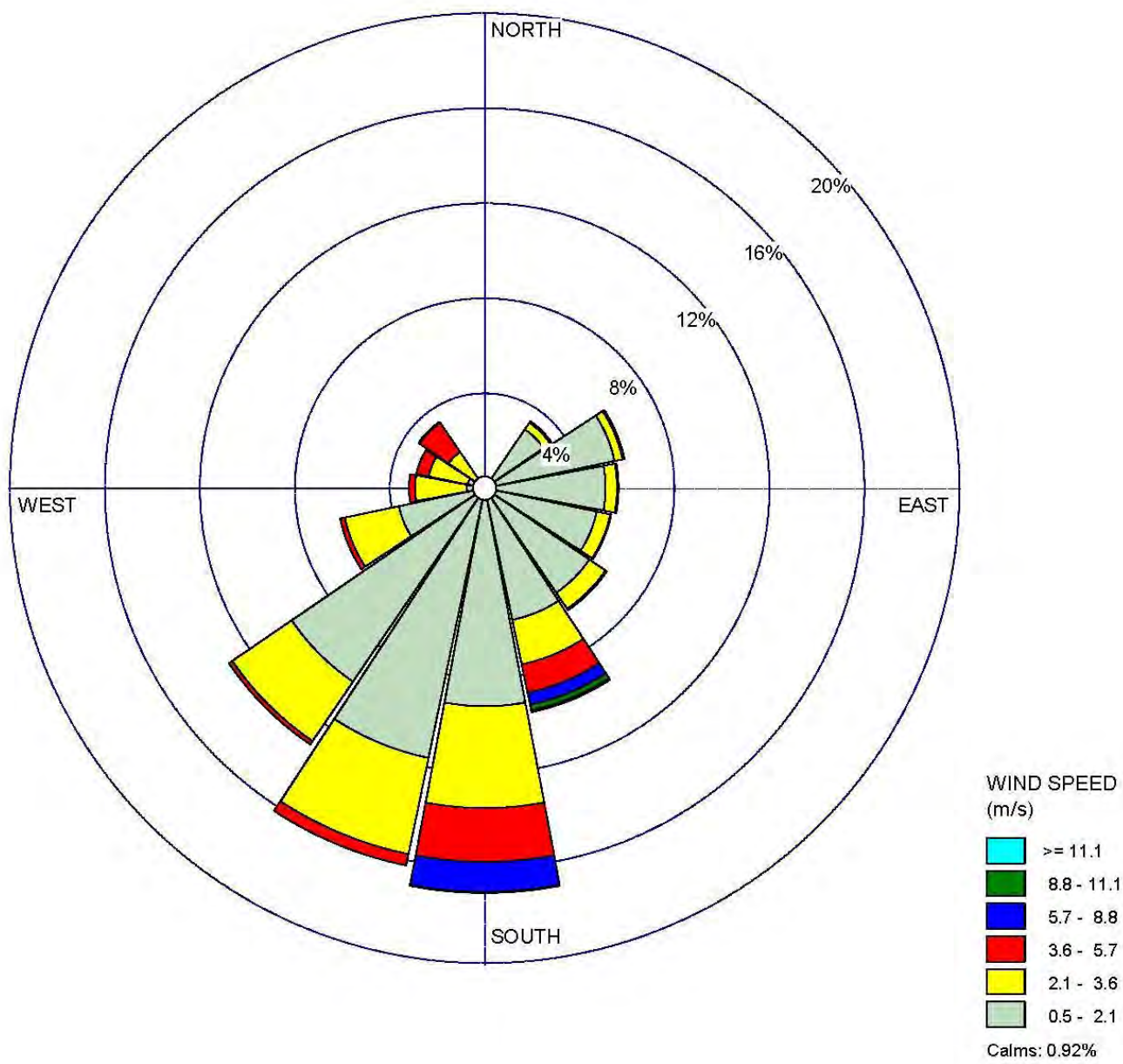
R:\Clients\Nanakuli, HI_Figure 2 Nanakuli Dust Study Location.dwg 12/08/2011 deborah.ford DN

WIND ROSE PLOT:

FIGURE 3 - HECO Lualualei Met Station Wind Rose Plot
July 1, 2010 Through June 30, 2011

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:		COMPANY NAME: **Tetra Tech**	
		MODELER: **D. Herlocker**	
	CALM WINDS: **0.92%**	TOTAL COUNT: **7582 hrs.**	
	AVG. WIND SPEED: **1.93 m/s**	DATE: **11/22/2011**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

State of Hawaii Department of Health
Solid and Hazardous Waste Branch

FIGURE 3
NANAKULI DUST STUDY
HECO LUALUALEI MET STATION
WIND ROSE

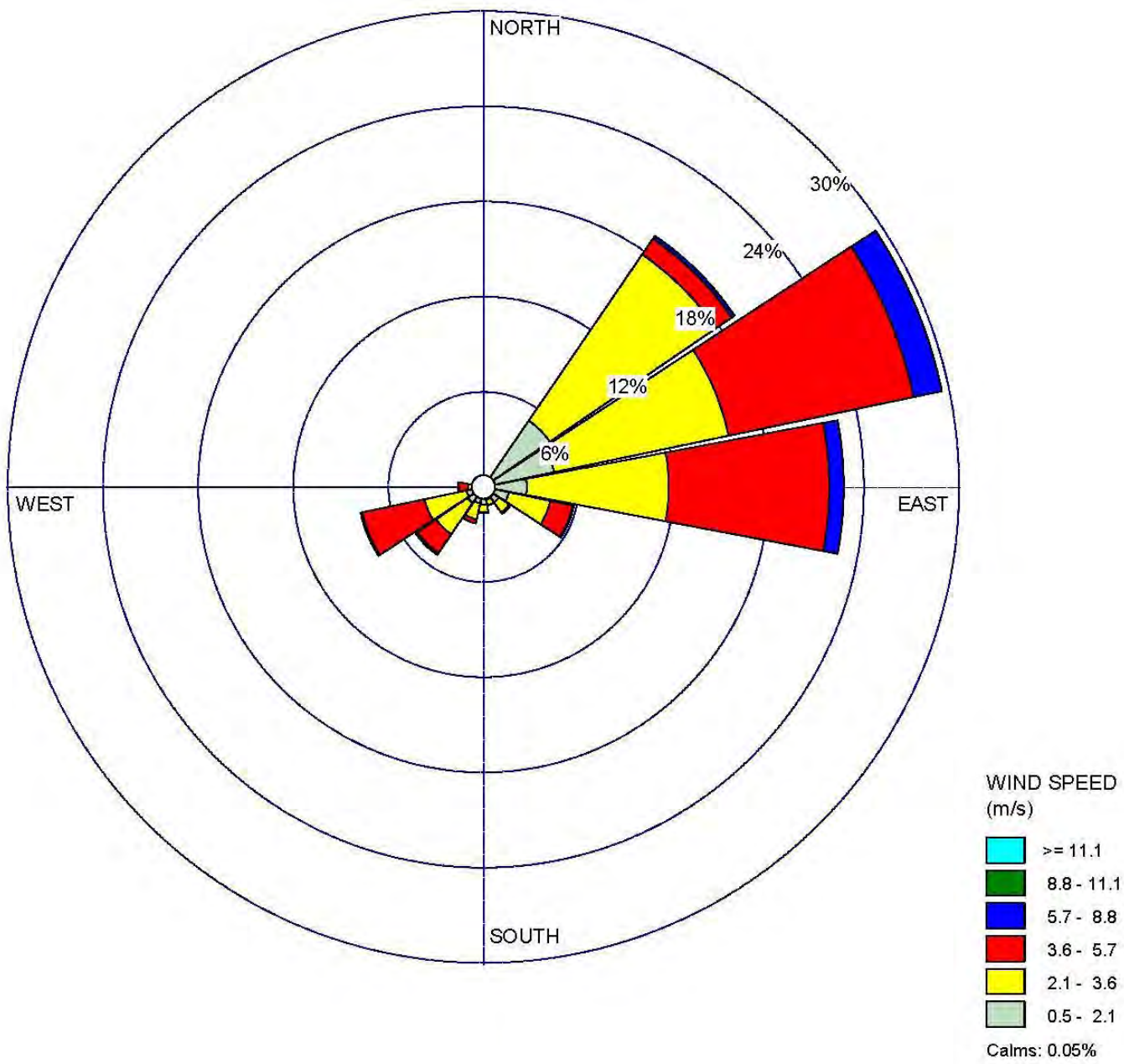
TETRA TECH

WIND ROSE PLOT:

FIGURE 4 - HECO Waianae Met Station Wind Rose Plot
July 1, 2010 Through June 30, 2011

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:		COMPANY NAME: **Tetra Tech**	
		MODELER: **D. Herlocker**	
	CALM WINDS: **0.05%**	TOTAL COUNT: **8663 hrs.**	
	AVG. WIND SPEED: **3.11 m/s**	DATE: **11/22/2011**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

State of Hawaii Department of Health
Solid and Hazardous Waste Branch

FIGURE 4
NANAKULI DUST STUDY
HECO WAIANAE MET STATION WIND ROSE

TETRA TECH

APPENDIX A
PHOTOGRAPHIC LOG

PHOTOGRAPHIC RECORD

Photo No. 1.	
Date: August 29, 2011	
Description: East side of house in Nanakuli neighborhood showing evident of dust staining on siding.	

Photo No. 2.	
Date: August 30, 2011	
Description: Side view of West Oahu Aggregate Facility facing north.	

TETRA TECH

PHOTOGRAPHIC RECORD

Photo No. 3.	
Date: August 30, 2011	
Description: Lualualei Road near entrance to West Oahu Aggregate looking west; truck watering roadway.	

Photo No. 4.	
Date: October 31, 2011	
Description: View of Lualualei Road near entrance to PVT Land Company looking east.	

TETRA TECH

PHOTOGRAPHIC RECORD

Photo No. 5.

Date: October 31, 2011

Description: View of dirt shoulder along Lualualei Road looking west; evidence of vehicle tracks and dirt being carried onto roadway.

Photo No. 6.

Date: October 31, 2011

Description: View of dirt shoulder along Lualualei Road looking east; evidence of vehicle tracks and dirt being carried onto roadway.

TETRA TECH

PHOTOGRAPHIC RECORD

Photo No. 7.	
Date: October 31, 2011	
Description: View of dirt shoulder along Lualualei Road looking east; evidence of vehicle tracks and dirt being carried onto roadway.	

Photo No. 8.	
Date: October 31, 2011	
Description: View of grass shoulder along Lualualei Road east of entrance to PVT, facing east.	

TETRA TECH

PHOTOGRAPHIC RECORD

Photo No. 9.

Date: October 31, 2011

Description: View of dirt shoulder along Lualualei Road looking east adjacent to West Oahu Aggregate; evidence of dust emissions blowing off-site.

Photo No. 10.

Date: October, 2011

Description: View of dirt shoulder along Lualualei Road facing west; evidence of vehicle tracking dirt onto roadway

Photographs on following 2 pages were provided by a Nanakuli resident living in the neighborhood adjacent to PVT. Photos were taken on August 8, 2011.

Aug 8th 2011
8:30 AM

Aug 8th 2011
8:20 AM

APPENDIX B
DOH SUMMARY SHEET AND MAPS OF DUST SURVEY QUESTIONNAIRE RESPONSES

ADDRESS	Response	Mail	1. How long have you lived here?				2. Describe the amount of dust				3. Changed over time?									4. Side with more dust						5. Time of day with more dust?						6. Wind direction?				7. See dust blowing onto property?			Interested in a visit?				8. Want updates?
	Date	Returned	<1 yr	1-5 yrs	5-10 yrs	> 10 yrs	A lot	> Average	Average	Little	Yes	No	Increase	Decrease	Within yr	1-5 yrs	5-10 yrs	> 10 yrs	Not sure	Mauka	Makai	Ewa	Dhead	Same	*None*	Morning	Afternoon	Night	All the time	Not sure	*None*	Trades	Kona	Not sure	*No*	Yes	No	From where	Yes	No	Contact name	Phone	Email address
TOTAL RESPONSES	72	157	0	6	10	56	32	29	8	2	46	17	38	3	9	10	7	6	11	32	6	6	7	33	1	10	19	2	27	22	1	38	11	26	1	43	27	27	30	1	30	31	35
% TOTAL RESPONSES	7.63%		0.0 %	8.3 %	13.9 %	77.8 %	44.4 %	40.3 %	11.1 %	2.8 %	63.9 %	23.6 %	52.8 %	4.2 %	12.5 %	13.9 %	9.7 %	8.3 %	15.3 %	44.4 %	8.3 %	8.3 %	9.7 %	45.8 %	1.4 %	13.9 %	26.4 %	2.8 %	37.5 %	30.6 %	1.4 %	52.8 %	15.3 %	36.1 %	1.4 %	59.7 %	37.5 %	37.5 %	41.7 %	1.4 %	41.7 %	43.1 %	48.6%

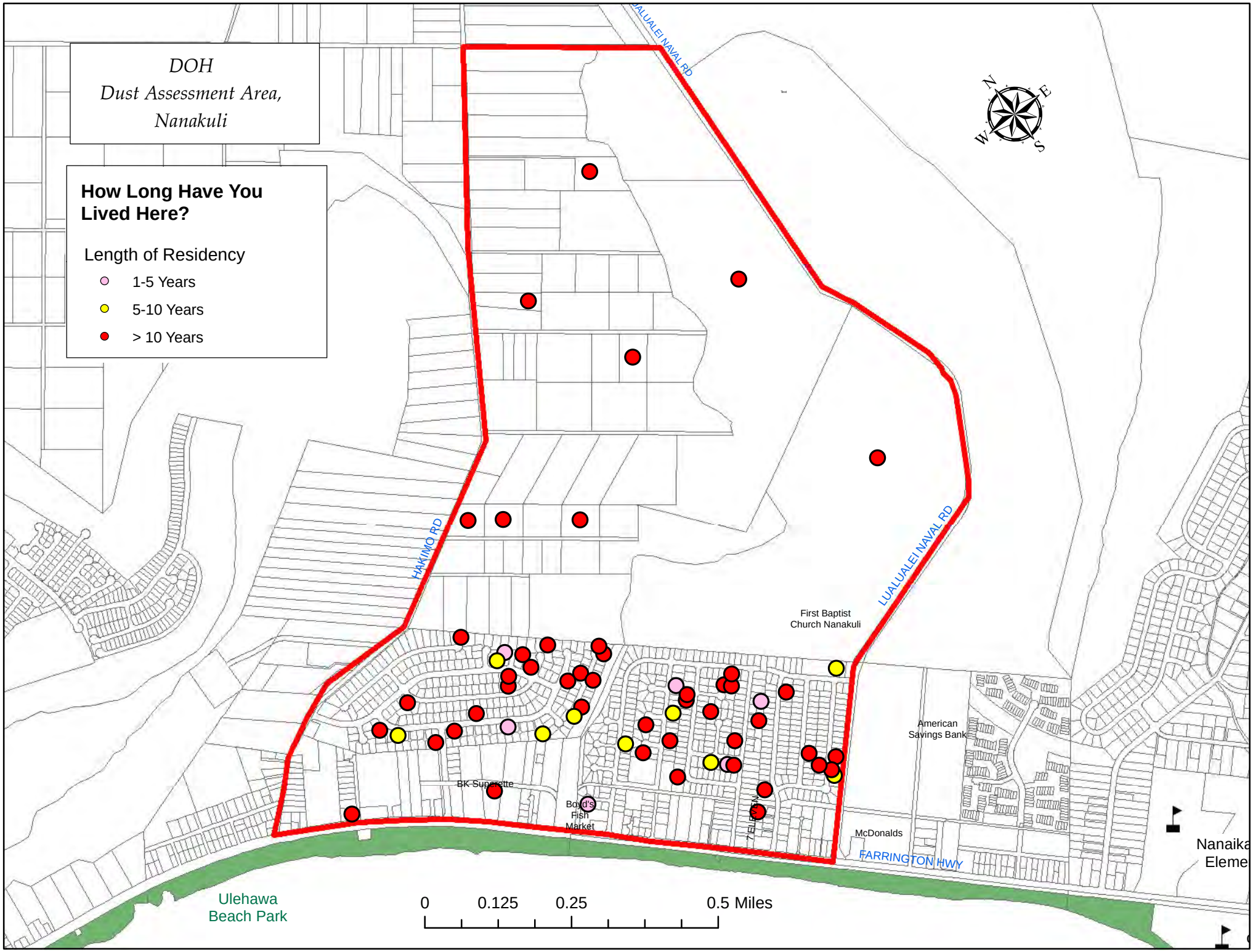
Summary:

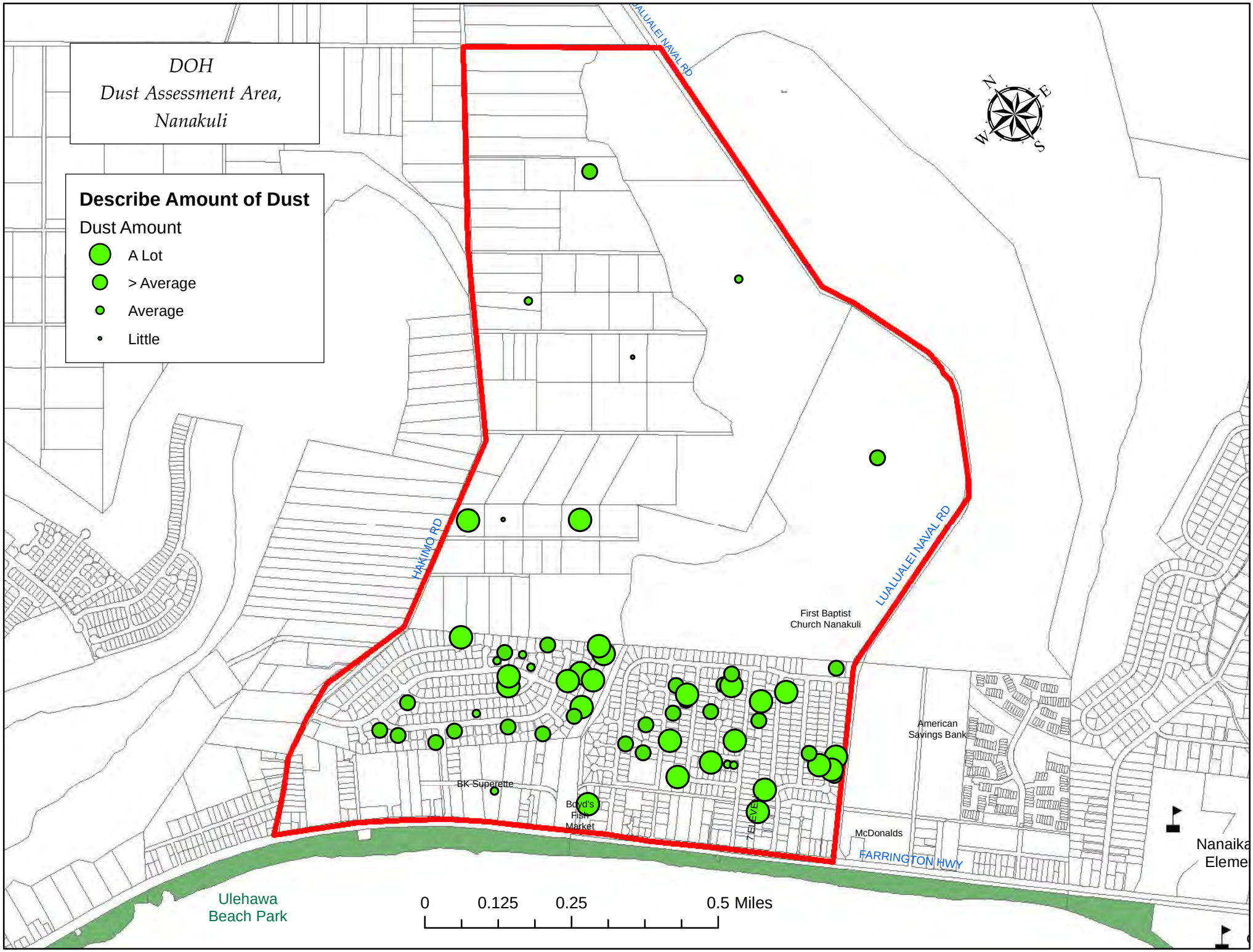
DOH mailed out 1,100 surveys in July 2011

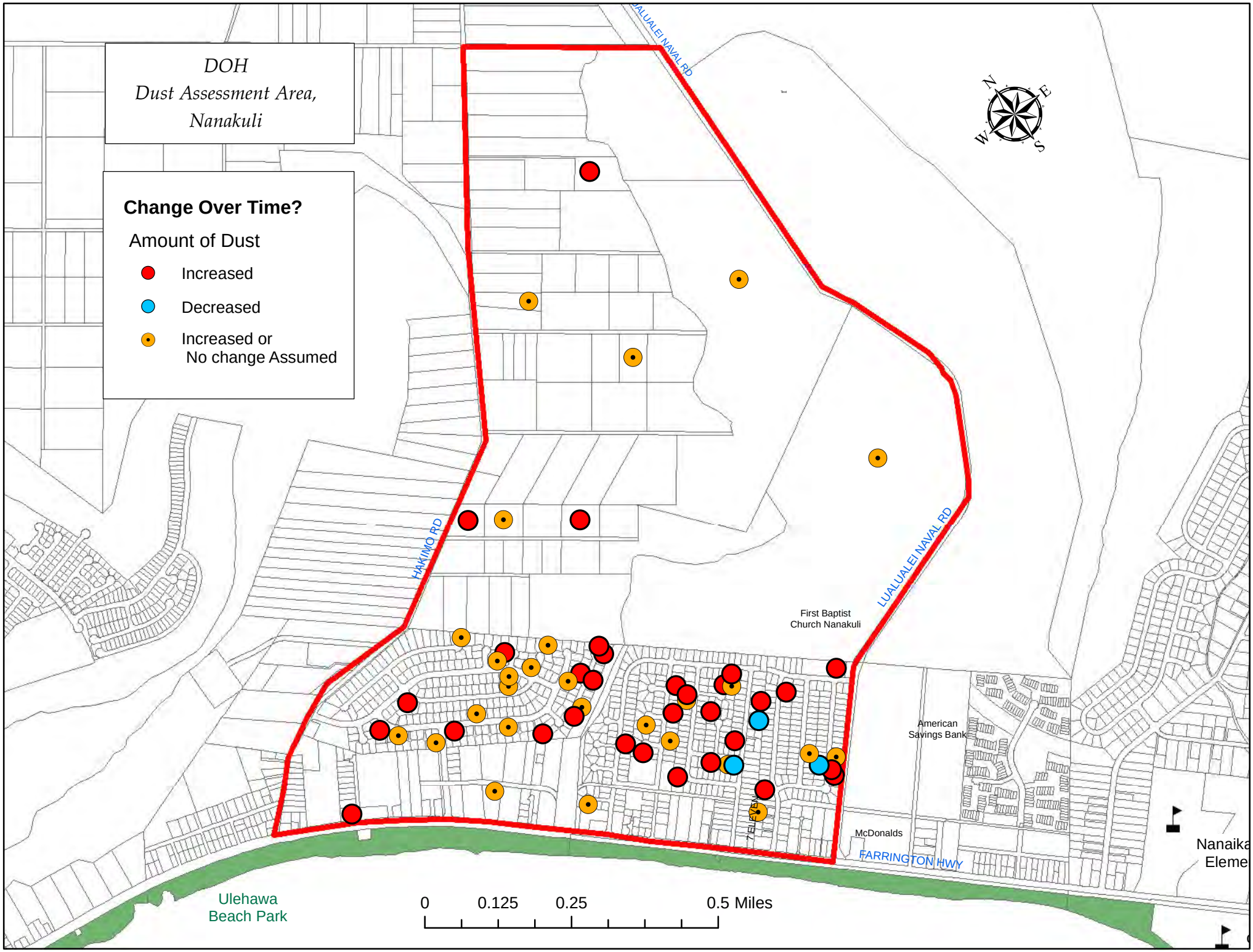
1. Surveys were due July 31, 2011
2. 157 were undeliverable by the post office
3. 72 responses, 7.63% response rate

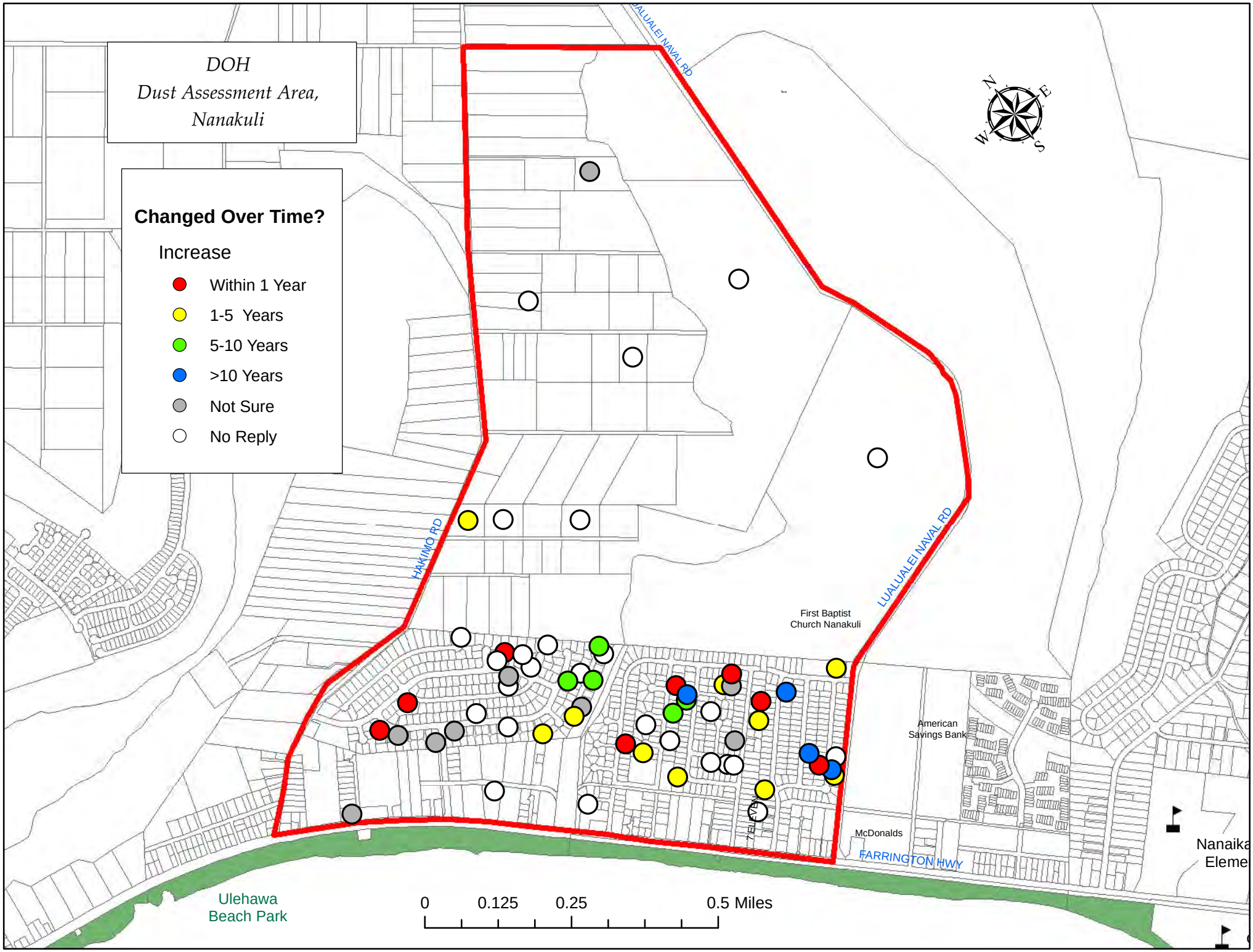
Results

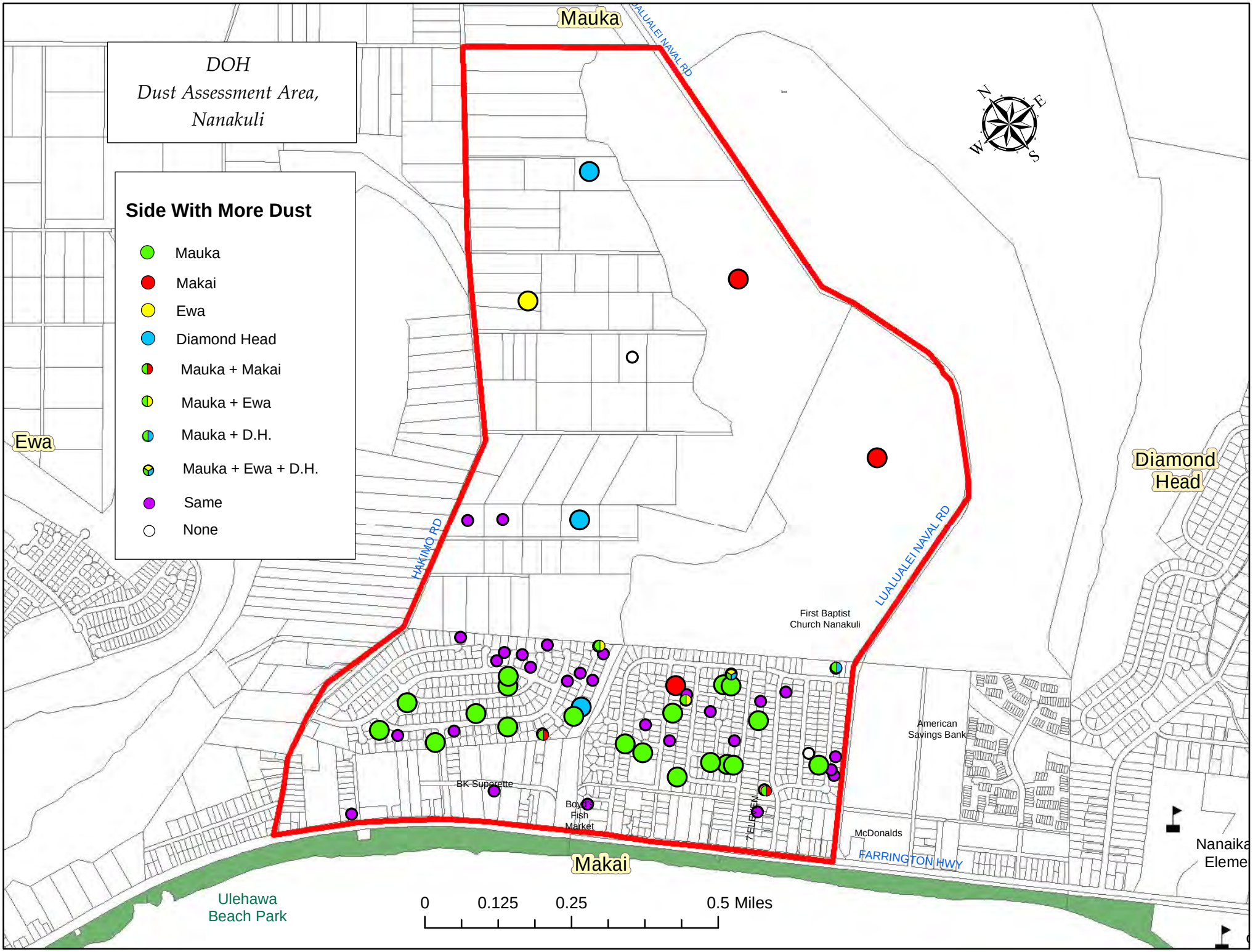
1. 78% of respondents lived at site for more than 10 years
2. 44% describe their situation as a lot of dust, while 40% describe it as a greater than average amount of udst
3. 53% report that the amount of dust has increased over time
4. 44% report that the dust is from the Mauka side, while 46% report it is the same all over
5. 38% report that the dust is the same at all times of day, while 31% are not sure
6. 53% report that dust is worst with tradewinds, while 36% are not sure
7. 60% report that dust can be seen blowing onto their property, and 38% report a source
8. 30 of the respondents were interested in a visit
9. 35 requested updates.

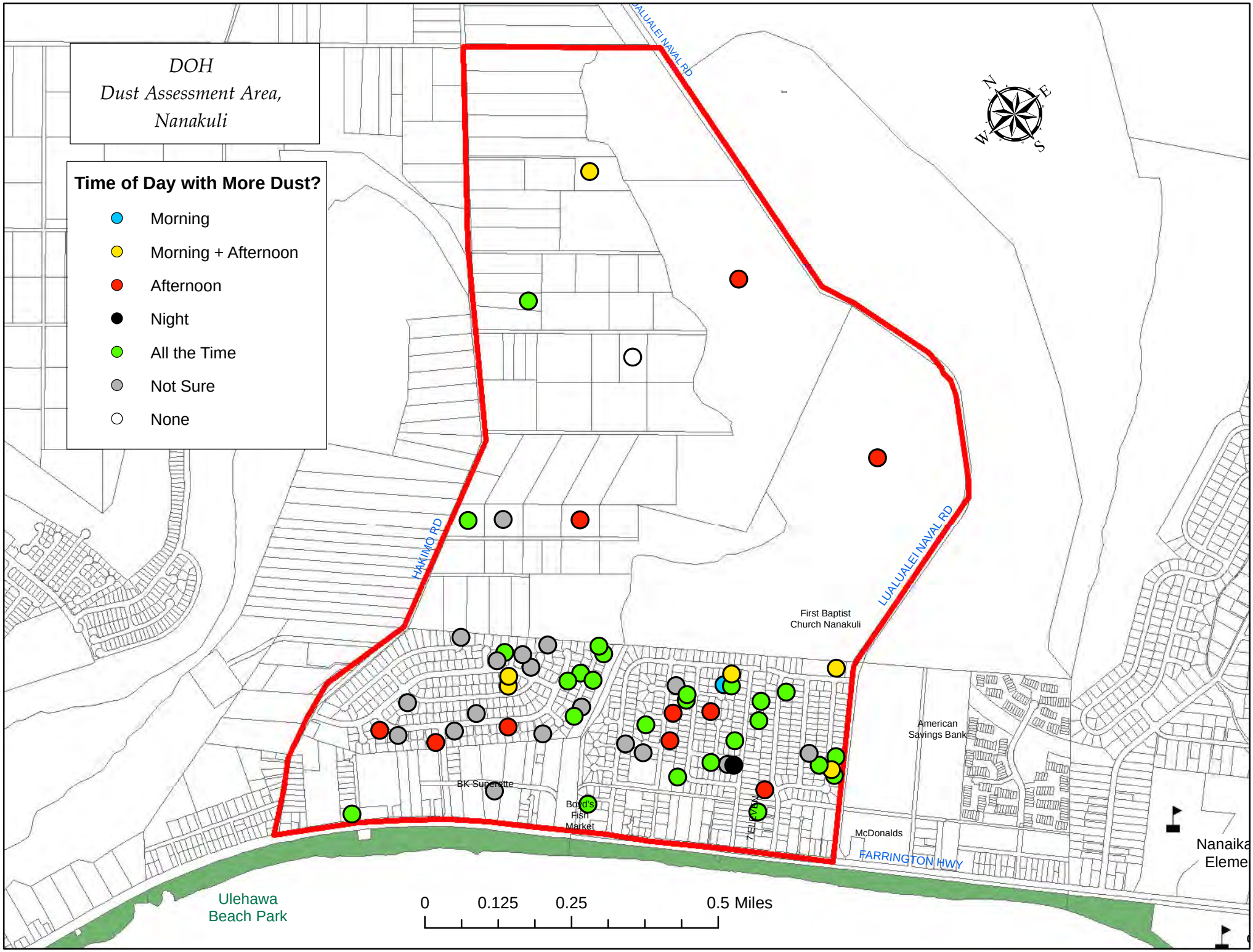

DOH
Dust Assessment Area,
Nanakuli
How Long Have You Lived Here?
Length of Residency
1-5 Years
5-10 Years
> 10 Years
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
LUALUALEI NAVAL RD
First Baptist Church Nanakuli
American Savings Bank
BK Superette
Boyd's Fish Market
McDonalds
FARRINGTON HWY
Ulehawa Beach Park
0
0.125
0.25
0.5 Miles

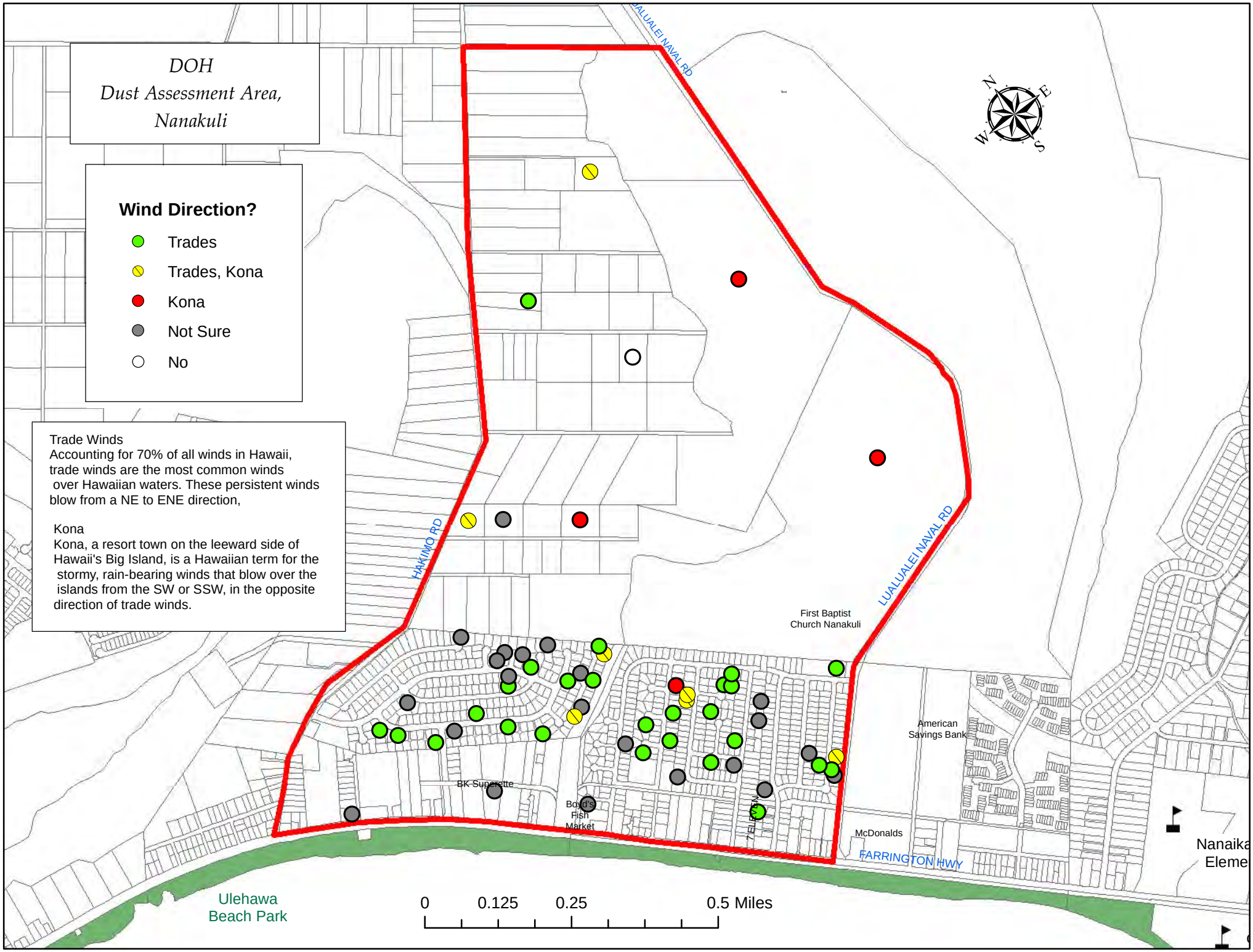

DOH
Dust Assessment Area,
Nanakuli
Describe Amount of Dust
Dust Amount
A Lot
> Average
Average
Little
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
First Baptist
Church Nanakuli
American
Savings Bank
BK Superette
Boyd's
Fish
Market
McDonalds
FARRINGTON HWY
Ulehawa
Beach Park
0
0.125
0.25
0.5 Miles

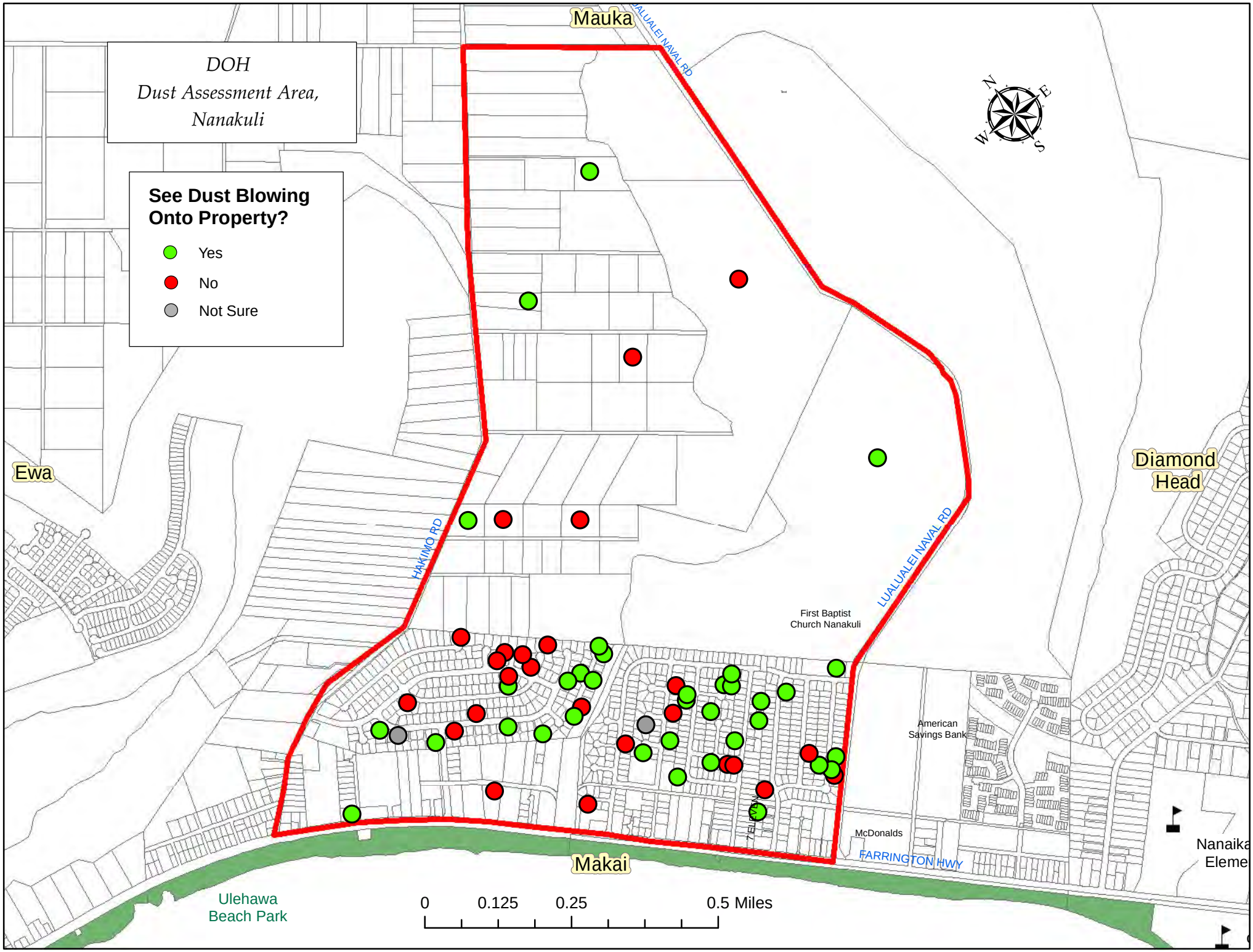

DOH
Dust Assessment Area,
Nanakuli
Change Over Time?
Amount of Dust
Increased
Decreased
Increased or
No change Assumed
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
LUALUALEI NAVAL RD
First Baptist
Church Nanakuli
American
Savings Bank
McDonalds
FARRINGTON HWY
Ulehawa
Beach Park
0
0.125
0.25
0.5 Miles


DOH
Dust Assessment Area,
Nanakuli
Changed Over Time?
Increase
Within 1 Year
1-5 Years
5-10 Years
>10 Years
Not Sure
No Reply
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
LUALUALEI NAVAL RD
First Baptist
Church Nanakuli
American
Savings Bank
McDonalds
FARRINGTON HWY
Ulehawa
Beach Park
0
0.125
0.25
0.5 Miles


DOH
Dust Assessment Area,
Nanakuli
Side With More Dust
Mauka
Makai
Ewa
Diamond Head
Mauka + Makai
Mauka + Ewa
Mauka + D.H.
Mauka + Ewa + D.H.
Same
None
Mauka
Ewa
Diamond Head
Makai
LUALUALEI NAVAL RD
HAKIMO RD
FARRINGTON HWY
First Baptist Church Nanakuli
American Savings Bank
BK Superette
Boyd's Fish Market
McDonalds
Nanaika Eleme
Ulehawa Beach Park
0
0.125
0.25
0.5 Miles


DOH
Dust Assessment Area,
Nanakuli
Time of Day with More Dust?
Morning
Morning + Afternoon
Afternoon
Night
All the Time
Not Sure
None
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
LUALUALEI NAVAL RD
First Baptist
Church Nanakuli
American
Savings Bank
BK Superette
Boyd's
Fish
Market
McDonalds
FARRINGTON HWY
Ulehawa
Beach Park
0
0.125
0.25
0.5 Miles


DOH
Dust Assessment Area,
Nanakuli
Wind Direction?
Trades
Trades, Kona
Kona
Not Sure
No
Trade Winds
Accounting for 70% of all winds in Hawaii, trade winds are the most common winds over Hawaiian waters. These persistent winds blow from a NE to ENE direction,
Kona
Kona, a resort town on the leeward side of Hawaii's Big Island, is a Hawaiian term for the stormy, rain-bearing winds that blow over the islands from the SW or SSW, in the opposite direction of trade winds.
N
E
S
W
LUALUALEI NAVAL RD
HAKIMO RD
First Baptist
Church Nanakuli
American
Savings Bank
BK Superette
Boyd's
Fish
Market
McDonalds
FARRINGTON HWY
Ulehawa
Beach Park
0
0.125
0.25
0.5 Miles


DOH
Dust Assessment Area,
Nanakuli
See Dust Blowing Onto Property?
Yes
No
Not Sure
Mauka
Makai
Ewa
Diamond Head
HAKIMO RD
LUALUALEI NAVAL RD
FARRINGTON HWY
First Baptist Church Nanakuli
American Savings Bank
McDonalds
Ulehawa Beach Park
0
0.125
0.25
0.5 Miles

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APPENDIX D
Environmental Noise Assessment Report

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Environmental Noise Assessment Report
PVT Integrated Solid Waste Management Facility Relocation

Nanakuli, Island of Oahu, Hawaii

December 2018

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LIST OF ACRONYMS

C&D	Construction and Demolition
HDOH	Hawaii Department of Health
ISO	International Standards Organization
ISWMF	Integrated Solid Waste Management Facility
MRD	Material Recovery and Diversion
PV	Photovoltaic

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Appendix B	Photographs at Measurement Locations

1.0 EXECUTIVE SUMMARY

1.1 The PVT Integrated Solid Waste Management Facility (ISWMF) is located in Nanakuli, Oahu approximately 1600 feet northeast of the intersection of Farrington Highway and Lualualei Naval Road. The site presently has approximately 200 acres of land used for construction and demolition (C&D) debris recycling and landfill operations west of Lualualei Naval Road. The current ISWMF is bordered by an aggregate recycling facility operation to the north, agricultural zoned area to the west, residentially zoned development to the south and southwest, and undeveloped area to the east. Key factors of the proposed project are (1) relocate the C&D operations; (2) relocate and modernize the recycling operations; and (3) install new renewable energy operations (a gasification unit and/or photovoltaic panels). The relocated and new operations would occur on a privately-owned, 179-acre site, east of the existing PVT ISWMF site opposite Lualualei Naval Road (Project Site).

1.2 This assessment focuses on evaluating the noise impacts from the proposed relocation to the new site and accounts for operational noise and estimated traffic volumes.

1.3 Noise from the PVT site must comply with the Hawaii Department of Health (HDOH) Community Noise Control Rule, which stipulates maximum permissible noise limits at the property line based on zoning. The operations of the facility will only take place during what the HDOH considers “daytime” hours (7:00 AM-10:00 PM), so only the daytime operational noise were assessed. HDOH maximum permissible daytime noise levels are 70 dBA for a Class C industrial/agricultural zoned area.

1.4 Long term noise measurements of the current operations were conducted near the southern ends of both the existing and proposed new PVT sites. The measurement data is used to validate the sound propagation model developed to calculated noise levels of the current and proposed operations. The measurements show a peak LA_{eq} of 58 dBA during operation hours at the southern end of the existing site near the scale house. At the residential development near the south end of the new Project Site, an peak hourly LA_{eq} of 55 was measured.

1.5 Most of the operations at the existing landfill will be moved to the new site. While noise exposure based on the new operations will vary significantly based on location, duration, and type of equipment being used, the noise impact on the properties east and north of the existing PVT site is expected to decrease. A sound propagation model was developed to predict the likely noise effects of the operational changes on the surrounding areas. The model assesses two scenarios: Current Operations and Future Operations at the new site. The modeling methodology is similar to the previous analysis provided for the PVT ISWMF in 2015 and calculates the maximum noise level expected at various receiver locations around the site, including the designated receiver locations and surrounding developments previously analyzed as well as additional receiver locations at the housing development directly south of the proposed Project Site. The sound propagation models were created with a conservative approach that assumed worst case scenarios. Parameters were set for predictions of noise levels based on all sources of noise operating simultaneously and continuously through the operational time period.

1.6 Noise levels are projected to comply with the HDOH maximum permissible noise limit for Class C agricultural/industrial zoned land at all property lines. Overall, noise levels from PVT at most surrounding properties are expected to decrease compared to existing conditions, due to the relocation of PVT activities to the new Project Site, which is further from most surrounding occupied properties. The lone area where the noise level is calculated to increase is the housing complex directly south of the new PVT scale house

area, which is not expected to be significant, i.e., less than 3 dB. For reference, a 3 dB increase in sound level is generally considered to be barely perceptible. A 5-6 dB increase is considered clearly noticeable.

1.7 Noise mitigation due to the proposed project will not be required. However, mitigation methods have been provided for informational purposes as “best practices” to reduce noise within the site and to neighboring properties.

2.0 PROJECT DESCRIPTION

The PVT Integrated Solid Waste Management Facility (ISWMF) is located in Nanakuli, Oahu, approximately 1600 feet northeast of the intersection of Farrington Highway and Lualualei Naval Road. The site presently has approximately 200 acres of land used for C&D debris recycling and landfill operations west of Lualualei Naval Road. The currently operational part of the site is bordered by an aggregate recycling facility operation to the north, agricultural zoned area to the west, residentially zoned developments to the south and southwest, and undeveloped area to the east.

Key factors of the proposed project are (1) relocate the C&D operations; (2) relocate and modernize the recycling operations; and (3) install new renewable energy operations (a gasification unit and/or photovoltaic panels). The relocated and new operations would occur on a privately-owned, 179-acre site, east of the existing PVT ISWMF site opposite Lualualei Naval Road from the current operations (Project Site). This assessment focuses on evaluating the noise impacts from the relocation and potential changes in traffic volume due to the proposed PVT ISWMF relocation.

The new site will include two (2) materials recycling and diversion (MRD) lines near the north end of the new Project Site. The existing site includes one (1) MRD line, which will be available to provide backup services (approximately twice per year) after the expansion. Otherwise, the MRD-1 line will mostly remain inactive. PVT proposes to install and operate a 1000 kW gasification unit, which will be located in the MRD area. The new site will also include 7-acres of photovoltaic panels (PV). Both renewable energy systems will be used to power PVT operations.

PVT is not proposing to increase the daily 3,000 tons C&D waste limit, therefore no increase in the current maximum of 300 truck trips per day is expected.

3.0 NOISE STANDARDS

Various local and federal agencies have established guidelines and standards for assessing environmental noise impacts and set noise limits as a function of land use. A brief description of common acoustic terminology used in these guidelines and standards is presented in Appendix A. For this project, the most important and applicable guidelines are those presented below in section 3.1 pertaining to the Hawaii Department of Health Title 11 Chapter 46.

3.1 State of Hawaii, Community Noise Control (HDOH)

The State of Hawaii Community Noise Control Rule [Reference 1] defines three classes of zoning districts and specifies corresponding maximum permissible sound levels due to *stationary* noise sources such as air-conditioning units, exhaust systems, generators, compressors, pumps, etc. The Community Noise Control Rule does not address most *moving* sources, such as vehicular traffic noise, aircraft noise, or rail transit noise. However, the Community Noise Control Rule does regulate noise related to agricultural, construction, and industrial activities, which may not be stationary.

The maximum permissible noise levels for stationary mechanical equipment are enforced by the HDOH for any location at or beyond the property line and shall not be exceeded for more than 10 percent (%) of the time during any 20-minute period. The specified noise limits which apply are a function of the zoning and time of day as shown in Figure 1. With respect to mixed zoning districts, the rule specifies that the primary land use designation shall be used to determine the applicable zoning district class and the maximum permissible sound level. In determining the maximum permissible sound level, the background noise level is taken into account by HDOH.

3.2 Community Response to Change in Noise Level

Human sensitivity to changes in sound pressure level is highly individualized. Sensitivity to sound depends on frequency content, time of occurrence, duration, and psychological factors such as emotions and expectations. However, the average ability of an individual to perceive changes in noise levels is well documented and has been summarized in Table 1 [Reference 2, 3]. These guidelines permit direct estimation of an individual's probable perception of changes in noise levels.

Table 1. Average Ability to Perceive Changes in Noise Level

Sound Level Change (dB)	Human Perception of Sound
0	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	Two times (or 1/2) as loud
20	Four times (or 1/4) as loud

A commonly applied criterion for estimating a community's response to changes in noise level is the 'community response scale' proposed by the International Standards Organization (ISO) of the United Nations [Reference 4]. The scale, shown in Table 2, relates changes in noise level to the degree of community response and allows for direct estimation of the probable response of a community to a predicted change in noise level.

Table 2. Community Response to Increases in Noise Levels

Sound Level Change (dB)	Category	Response Description
0	None	No observed reaction
5	Little	Sporadic Complaints
10	Medium	Widespread Complaints
15	Strong	Threats of Community Action
20	Very Strong	Vigorous Community Action

The values stated in Tables 1 and 2 should not be considered regulatory requirements because they are not associated with a specific governing document for this project. However, these tables are very useful in assessing the human perception to changes in sound levels and they are considered to be supplemental information to the governing State of Hawaii Community Noise Control Rule, which does not discuss community response to changes in noise levels.

4.0 EXISTING ACOUSTICAL ENVIRONMENT

Continuous long-term noise level measurements were conducted to assess the existing acoustical environment of the project site. Long-term measurements (taken continuously over the course of multiple days) offer a baseline for establishing existing noise levels in the area and are used for verifying the validity and accuracy of the acoustical model being used to predict future noise levels and noise levels under various operational conditions.

The methodology, location, and results for each of the measurements are described below. The measurement locations are indicated in Figure 2. Photographs of the measurement locations are included in Appendix B.

4.1 Long Term Noise Measurements

4.1.1 Long-Term Noise Measurement Procedure

Noise level measurements were conducted in two different locations from November 2, 2018 to November 15, 2018. Continuous, hourly equivalent sound levels, L_{eq}, were recorded at each location. The measurements were taken using a Larson-Davis, Model 831, Type 1 Sound Level Meter together with a Larson-Davis, Model 377B20 Type 1 Microphone. Calibration was checked before and after the measurements with a Larson-Davis Model CAL200 calibrator. The sound level meters and the calibrators have been certified by the manufacturer within the recommended 2-year calibration period. The microphones were mounted on tripods, approximately 5 feet above grade. A windscreen covered each microphone during the entire measurement period. The sound level meters were secured in weather-resistant cases.

4.1.2 Long-Term Noise Measurement Locations

Location L1: The sound level meter was located at the south end of the existing PVT site near the property line, approximately 300 feet southwest of the scale house along the entrance and exit way that commercial traffic takes when utilizing the site. This is the same measurement location used during the 2015 vertical expansion noise study. During the daytime, dominant noise sources included vehicular traffic to and from the scale house/landfill area. Secondary noise sources included traffic from the Lualualei Naval Road. During non-operation times, noise sources included environmental sources such as wind and birds. Duration: November 2, 2018 to November 8, 2018.

Location L2: The sound level meter was located near the south end of the proposed new Project Site, approximately 35 feet north of the northernmost residential building. During the day, the primary noise sources were observed to be mostly environment and wildlife (wind, rain, birds, dogs, etc.). Distant traffic could be heard. Duration: November 8, 2018 to November 15, 2018.

4.1.3 Long-Term Noise Measurement Results

The measured overall A-weighted LA_{eq} is graphically presented in Figures 3 and 4 for each location. The range of LA_{eq} during operational days and non-operational days between the hours of 7:00 AM and 3:00 PM are summarized for each location in Table 3 below. The LA_{eq} was also averaged for the same time range over the operational days and non-operational days and is presented in the table.

Table 3. Summary of Long Term Noise Measurement Results (dBA)

	Operational Days (7:00 AM – 3:00 PM)		**Non-Operational Days (7:00 AM – 3:00 PM)**	
Measurement Location	**LA_{eq} Range**	**Average LA_{eq}**	**LA_{eq} Range**	**Average LA_{eq}**
L1 – Near Scale House	54-58	56	46-55	51
L2 – South of Project Site	45-55	48	42-52	48

5.0 SOUND PROPAGATION MODEL

5.1 Sound Propagation Model Overview

The operations of the existing PVT ISWMF and proposed future operations will utilize various types of equipment operating in multiple locations at various times. The actual sound levels that will be experienced in the vicinity of the project site will vary greatly and are a function of the distance from the noise source, the duration of the activities, and the quantity and types of equipment used. The CadnaA noise prediction software by DataKustik GMBH [Reference 5] was used to predict the likely operational noise effects to receptor locations surrounding the project site. The software is based on the international standard ISO 9613, Part 2, which is a standard for calculating outdoor noise propagation. The input parameters for the sound propagation model are summarized in Table 4 below.

Table 4. Sound Propagation Model Calculation Parameters

Input Parameter	Source
Calculation Standard	ISO-9613
Site Topography	Surrounding Area – State Office of Planning Project Site – Provided by PVT
Ground Absorption	Hard packed soil – Ground Absorption = 0.0
Meteorological Conditions	Downwind 9.84 ft/s (3 m/s) per ISO-9613, 70° F, 64% relative humidity per PVT Operations Plan and Oahu historical weather data
Receptor Height	5 feet
Num. of Reflections	2
Bitmap	Provided by PVT
Sound Source Quantity and Location	Operations plan and figures provided by PVT, refer to Table 6

The topography of the site is incorporated into the model; therefore, line-of-sight and any shielding effects are considered in the model. Additionally, the trees and foliage to the west side of the existing PVT ISWMF are included in the acoustical model at an average height of approximately 15 feet about ground level.

5.2 Site Operations Overview

Two sound propagation models were created to simulate the project site under the various operating stages. The two operational stages are summarized as follows.

A. Current Operations – Landfill operates at existing PVT ISWMF site.

B. Relocation – Relocation of the primary operations (C&D waste receiving, materials sorting/recycling, C&D disposal, MRD lines, gasification unit, and PV system) to Project Site.

PVT ISWMF is typically in operation between 7:00 AM and 4:00 PM, which is within the daytime hours defined by the HDOH. In this case nighttime and evening noise calculations are not needed. The proposed project will maintain the current hours of

operation. However, if the site extends its hours of operation before 7:00 AM or beyond 10:00 PM, nighttime evaluations may be required.

A site plan of the proposed Project Site after relocation provided by PVT is shown in Figure 5.

5.3 Source Sound Data

The sound power data for the various equipment utilized for each activity is described in Table 5 below. All sound power levels shown are un-weighted linear decibel levels (dB). The mobile equipment sound power levels were obtained from UK Department of Environment, Food, and Rural Affairs Noise Database for Prediction of Noise on Construction and Open Sites [Reference 6]. This database includes individual octave band measurement data, which provide a more accurate noise spectrum than individual dBA values with equal octave contribution assumptions or at limited octave band inclusion. The sound power levels included in the model are all converted from the sound pressure measurement data at known distances, and assuming hemispherical radiation from the source.

Individual equipment noise levels in the database that matched parameters of specific pieces of equipment on the proposed site, such as the general equipment type and horsepower, are taken directly from the reported sound pressure levels in the database. More generalized equipment such as the external over the road trucks and dump trucks are based on values arithmetically averaged among all reported data sets of a similar equipment type in the database. Noise levels from dump trucks, heavy trucks, and water trucks are taken from the pass-by levels provided in the database. Pass-by data points are the un-weighted octave band L_{max} levels from the equipment pass-by. All other equipment noise levels were taken from the non-pass-by operating conditions, which are more relevant for stationary and semi-mobile activities and operations (as will be the case on the project site for most of the heavy equipment). Non-pass-by data points provided in the database are the un-weighted octave band L_{eq} levels.

Sound power levels for the existing MRD were obtained from linear weighted slow response field measurements taken at the existing site in 2014. Due to the MRD's elongated size, they are treated as line sources in the model. Eight noise measurements were taken in 40-foot increments at both 40 ft. and 70 ft. distance parallel to the MRD equipment down the length of the equipment on both sides. The data was then logarithmically averaged after being converted to sound power from sound pressure at known distances, assuming hemispherical radiation. Our analysis assumes each of the two new sets of MRD equipment will produce sound levels approximately equal to the existing MRD-1.

The sound levels for the gasification unit are based on the frequency spectrum of a similar unit taken from field measurements conducted by DLAA on a Community Power Corporation BioMax unit in Colorado. The frequency spectrum was then calibrated to match an overall A-weighted sound pressure level of 85 dBA at 3 meters, per the equipment noise information provided by PVT.

A photovoltaic system will be utilized as part of the renewable energy portion of the proposed project. The photovoltaic panels themselves are not expected to make any noise, but we anticipate the system will utilize at least one inverter which will have some noise associated with it. Depending on the specifics of the photovoltaic system utilized, multiple inverters may be required. It is expected that the inverters will be located relatively close to the gasification unit. Inverter noise is typically noise driven by the 60 Hz voltage cycling producing low frequency noise at 60 Hz and a larger peak at 120 Hz and then higher frequency noise at harmonics of these frequencies. Additionally,

depending on the unit itself, it may come with internal cooling fans, which will produce their own noise. The specific noise of the unit will depend on the manufacturer and model selected. Due to the lack of the information necessary to accurately identify the specific noise levels of the photovoltaic equipment, the noise model does not include any potential noise from this system. However, if there is any excessive noise from the inverters, it can easily be addressed as the design is finalized by the application of barrier walls or earth berm acoustical barriers installed in the noise pathway between the inverters and the closest receiving positions to them.

Table 5. Sound Power Levels for Site Activities

		Sound Power Level (dB)[N1]						
Activity	**Equipment (Qty)**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Cell #1, Active Landfill Ops	Bulldozer (1)	105	109	107	107	104	101	95
	Compactor (1)	100	108	109	102	107	98	96
	Water Truck (1)	108	109	103	107	101	102	98
Cell #2, Excavation	Excavator (1)	105	114	108	104	100	98	94
	Haul Truck (1)	124	106	107	105	106	103	98
MRD Area	MRD L_{Amax}[N2] (1)	124	126	118	117	113	110	108
	Loader (2)	117	112	107	108	103	100	94
	Haul Truck (1)	124	106	107	105	106	103	98
	Gasification Unit (1)	110	110	111	104	97	92	88
Cell #4, Aggregate Materials Processing	Excavator (1)	105	114	108	104	100	98	94
	Pulverizer (1)	105	102	101	103	100	99	96
	Impact Crusher (1)	123	116	109	111	105	101	96
	Loader (1)	117	112	107	108	103	100	94
On-Site Traffic	Water Truck (1)	108	109	103	107	101	102	98
	Heavy Truck (varies)	113	106	105	105	101	99	96

Notes:
N1. The sound power levels for each equipment type represent a unit of equipment.
N2. MRD L_{Amax} levels are based on $L_{Amax\ x}$ octave band measurement values attained from measurements and are used in the Loudest Event acoustical model to simulate the noise levels that to be expected from the loudest individual moments of the equipment operations.

5.4 Vehicular Traffic

Vehicular traffic noise from the primary roadways near the project site is incorporated into the sound propagation model. The noise analysis for traffic external to the PVT site is based on the average of the existing hourly traffic volumes from the turning movement data tables provided by the Traffic Consultant at the intersections of Farrington Highway and Haleakala Ave, Farrington Highway and Lualualei Naval Road, and Lualualei Naval Road and the PVT Site Access Driveway. The same traffic volumes at nearby roads are used in both the Current Operations and Relocation models, since the proposed project does not plan to increase the maximum quantity of daily truck trips (300).

Commercial traffic internal to the PVT site are also modeled based on the PVT Site Access Driveway traffic count provided by the Traffic Consultant. In order to approximate the maximum noise levels from the commercial traffic inside the site, the heavy truck traffic data for the PVT Site Access Driveway is used. The same traffic volume is used for both the Current Operations and Relocation models, since the proposed project does not plan to increase the maximum quantity of daily truck trips.

5.5 Noise Receptor Locations

The sound propagation model calculates noise levels at multiple receptor locations in the vicinity of the Project Site, as seen in Figure 6. Receiver locations R1 through R9 are consistent with the receiver locations assessed during the 2015 study. Receiver locations R10 and R11 have been added to assess the potential impact of the residential development nearest the proposed Project Site. Two receptors are located at the long term measurement locations L1 and L2, as seen in Figure 2, and are used to verify the results produced by the sound propagation model.

R1 Residence on Mohihi Street near Lualualei Naval Road
R2 Residence on Mohihi Street near PVT scale house
R3 Agricultural lot at end of Ulehawa Road
R4 Agricultural lot at end of Kapiki Road
R5 Agricultural lot at end of Kuualoha Road
R6 Northern property line near MRD
R7 Residence on Lualualei Naval Road
R8 Residence on Farrington Highway (south of Lualualei Naval Road)
R9 Residence on Farrington Highway (north of Lualualei Naval Road)
R10 North corner of housing development directly south of Project Site
R11 East corner of housing development directly south of Project Site

Sound levels at the receptor locations have been calculated at approximately 5 feet above ground. This is representative of an average standing ear height and typically measurements would most often be made this height if testing for compliance with the HDOH Community Noise Control Rule.

5.6 Validation of Sound Propagation Model

In order to validate the results of the sound propagation model, the measured ambient noise environment in the vicinity of the project site was compared to the results of the sound propagation model under the “Current Operations” condition. The LA_{eq} range measured on site (shown in Table 3) when the waste facility is operational was used as the metric for comparison.

The results of the sound propagation model show good conformance between the measurements conducted at the long term measurement locations and the calculated values of the current conditions. At Location L1, the calculated maximum operational noise level is 59 dBA which is slightly higher than the measured range during operation (54-58 dBA) but an acceptable amount of error to consider the model valid. At Location L2, the calculated level is 51 dBA which is within the range of the measured levels.

5.7 Predicted Noise Levels due to Site Operations

Maximum operating noise levels (LA_{max}) are calculated at each receptor location for each of the key operational stages. Although most of the stationary equipment (e.g., MRD lines) are not expected to run continuously for extended periods of time, the LA_{max} is calculated assuming continuous operation of the equipment. For the non-stationary equipment (e.g., heavy trucks, excavation equipment), the LA_{max} is calculated based on a moving point source. Maximum operating noise levels represent the maximum noise levels at any one moment in time that a receptor would expect to experience from the landfill based on typical daily operations. In addition, worst case conditions were assumed for each stage, meaning that the equipment for each activity runs simultaneously in all of the designated areas for that operational stage. In reality, site operations will only occur in fractional sections (or cells) of the active landfill site which will move over time based on reaching the maximum fill for that cell. The model assumes MRD-2 and MRD-3 are both operational, but not -MRD 1, as this scenario most

accurately reflects expected typical conditions since MRD-1 will rarely be used for backup purposes.

Table 7 below summarizes the results of the staged operational noise analysis calculations for each of the noise receptor locations. The table also presents the change in future noise levels for the community due to the proposed action.

Table 7. Operational Noise Analysis Results

		Max. Operational Noise per Stage (dBA)		Change due to Proposed Project (dB)
ID	**Receptor Location**	**Existing**	**Relocation**	**(Relocation - Existing)**
R1	Mohihi St (SE)	63	59	-4
R2	Mohihi St (NW)	59	53	-6
R3	Ulehawa Rd	56	47	-9
R4	Kapiki Rd	56	50	-6
R5	Kuualoha Rd	62	51	-11
R6	North property line	71	58	-13
R7	Lualualei Naval Rd	67	67	0
R8	Farrington Hwy (N)	71	71	0
R9	Farrington Hwy (S)	71	71	0
R10	Housing Dev. (N)	51	52	+1
R11	Housing Dev. (E)	51	52	+1

In addition to the receptor locations above, maximum noise level area contours were calculated throughout the project site and the surrounding community for each of the operational stages. These contours are shown graphically in Figures 7 and 8.

6.0 POTENTIAL SOUND IMPACTS

6.1 Predicted Noise due to Site Operations Noise

A sound impact due to the proposed PVT ISWMF site operations may occur if the sound levels generated by the project exceed applicable standards and regulations. However, the sound level alone cannot determine if a sound impact occurs. The noise receptor or typical listener must also be considered, along with the land use, to determine the compatibility of the sound and sound receiver. Even if the sound level complies with all standards and regulations, the sound generated by the project may still be audible at the noise receptor. However, most regulations regarding sound levels are written with the intent to limit excessive sound levels for which the general public may be adversely affected.

6.1.1 Residential Receptor Locations Southwest of the Project Site (R1, R2, R7, and R8)

The results in the residential zoned area located on the southeastern portion of Mohihi Street near Lualualei Naval Road show existing noise levels in excess of the HDOH maximum daytime noise limit for residentially zoned areas (55 dBA) for all operational stages. The primary noise source for these areas is vehicular traffic, which is not enforced by the HDOH.

At the Mohihi Street residences near the existing PVT boundary (such as R1 and R2), the noise levels are expected to decrease 4-6 dB due to the reduction in truck traffic along the southwestern PVT roadway due to the relocation of most operations to the new site.

6.1.2 Agriculture/Industrial Zoned Receptor Locations West of the Existing Site (R3, R4, and R5)

The properties to the west of the project site are zoned for agricultural use, although there appear to be some dwellings built on these properties. The HDOH considers agricultural zoned land to be a Class C zoning and the requirements for this type of land use is a maximum noise level of 70 dBA. All of the properties to the west of the project site are in compliance with the 70 dBA maximum noise levels for this particular zoning.

As with the Mohihi Street residences, noise levels are expected to decrease by as much as 11 dB at western receptors due to the redistribution of PVT truck traffic. Noise levels at these locations are calculated to be below HDOH limits for both agricultural and residential zones after relocation. When MRD-1 is active (approximately twice per year), noise levels will likely be similar to the existing conditions.

6.1.3 Agriculture/Industrial Zoned Receptor Location North of the Site (R6)

The property to the north of the project site is also zoned for agricultural/industrial uses and is currently utilized as an aggregate recycling facility. Noise levels generated from PVT operations are expected to decrease significantly (13 dB) due to the reduction of truck traffic and regular MRD-1 operation. However, overall combined noise levels at locations north of the existing PVT landfill will likely stay relatively the same after relocation due to noise generated by industrial activities at the neighboring property to the north.

6.1.4 Residential Receptor Locations South of the Project Site (R10 and R11)

The results in the residential development area directly south on the Project Site show a slight increase (+1 dB) in noise level due to the relocated PVT operations, but resultant levels are expected to stay below the HDOH maximum daytime noise limit for residentially zoned areas. The increase is mostly due to the truck traffic on the new access and scale house road near the southern end of the Project Site. At residential buildings and neighborhoods further south of the northernmost multi-family buildings, no noticeable noise impact is expected.

6.2 Operational Noise vs. Vibration

Heavy equipment activities generate not only audible airborne sounds, but can also result in varying degrees of ground vibration depending on the equipment and methods employed. While the previous section of this report evaluates the airborne sound of operational activities at the project site, it does not assess human or structural responses to potential ground borne vibration due to these activities.

Vibration induced by the specific mobile equipment utilized for this project would not usually result in adverse effects on people or structures. During the site operations, noise from the C&D debris moving equipment will likely be more noticeable than any perceived vibration. The MRD equipment itself does operate with a large shaker section that produces large vibrations in the equipment. The concrete pad that supports the MRD equipment meets similar standards that the federal aviation administration (FAA) requires for airport runway, taxiway, and apron areas at airports. This increased standard for design and construction of the MRD (i.e. higher quality Portland cement, seamless thicker pad) provides added sound vibration damping qualities as a PVT best practices measure. It is not expected that this equipment will produce any adverse effects to the surrounding area, but the vibration produced by this equipment was not part of the acoustical modeling and are therefore not included in the results in this report.

7.0 NOISE IMPACT MITIGATION

7.1 Mitigation of Operational Noise

The predicted operational noise levels from the PVT relocation comply with the HDOH maximum permissible noise limits at the property line for Class C zoning. At residences east of Lualualei Naval Road, the relocation of PVT activities to the Project Site is calculated to reduce noise levels. In general, the overall noise impact on the surrounding area will be reduced, as the new operations will be more remote from most of the nearest residential properties.

At the residential area south of the new Project Site, a slight increase in noise level is expected, but not enough to provide a noticeable noise impact. While not required to meet HDOH requirements or prevent a significant noise impact, the mitigation methods described below are provided for informational purposed as “best practices” to reduce noise.

- Require all site owned and customer owned vehicles traveling internally on the site to be operating with fully functional mufflers and in a state of good repair.
- Encourage quiet operating techniques and practices.
- Maintain the commonly traveled pathways to keep a smooth evenly sloped surface free from major bumps and potholes that cause noise when traveled over.
- Grade all pathways at a low enough slopes that they do not require excessive throttle to navigate.
- Post signage to inform drivers of “no engine braking” and “no horn unless emergency” areas close to noise critical areas.

REFERENCES

1. Chapter 46, *Community Noise Control*, Department of Health, State of Hawaii, Administrative Rules, Title 11, September 23, 1996.

2. *Highway Noise Policy and Abatement Guidelines*, Department of Transportation, Highways Division, State of Hawaii, April 25, 2011.

3. M. David Egan, *Architectural Acoustics*, McGraw-Hill Book Company, 1998

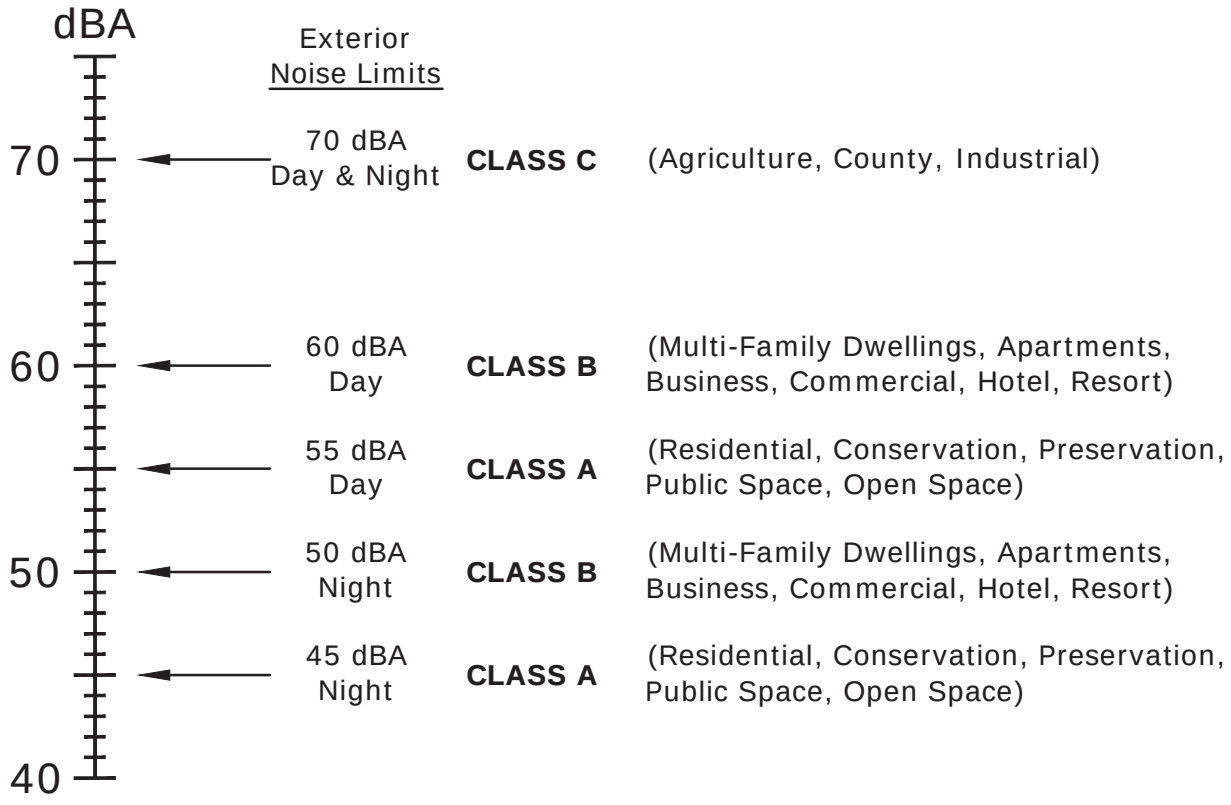
4. International Standards Organization ISO/TC 43, *Noise Assessment with Respect to Community Responses*, New York: United Nations, November 1969.

5. *DataKustik CadnaA software program*, Version 4.4.146; DataKustik GmbH, 2014.

6. *Update of Noise Database for Prediction of Noise on Construction and Open Sites*, Department for Environment, Food and Rural Affairs, United Kingdom 2005.

HAWAII DEPARTMENT OF HEALTH MAXIMUM PERMISSIBLE SOUND LEVELS FOR VARIOUS ZONING DISTRICTS

Zoning District	**Day Hours** (7 AM to 10 PM)	**Night Hours** (10 PM to 7 AM)
CLASS A Residential, Conservation, Preservation, Public Space, Open Space	55 dBA (Exterior)	45 dBA (Exterior)
CLASS B Multi-Family Dwellings, Apartments, Business, Commercial, Hotel, Resort	60 dBA (Exterior)	50 dBA (Exterior)
CLASS C Agriculture, Country, Industrial	70 dBA (Exterior)	70 dBA (Exterior)



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PROJECT:	PVT Integrated Solid Waste Management Facility Relocation	
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 1

Site Location and Noise Measurement Locations

Legend

PVT Project Site

Noise Measurement Location

L1: 300 feet southwest of PVT scale house along the commercial truck entrance and exit roadway

L2: 450 feet south of Northern property line

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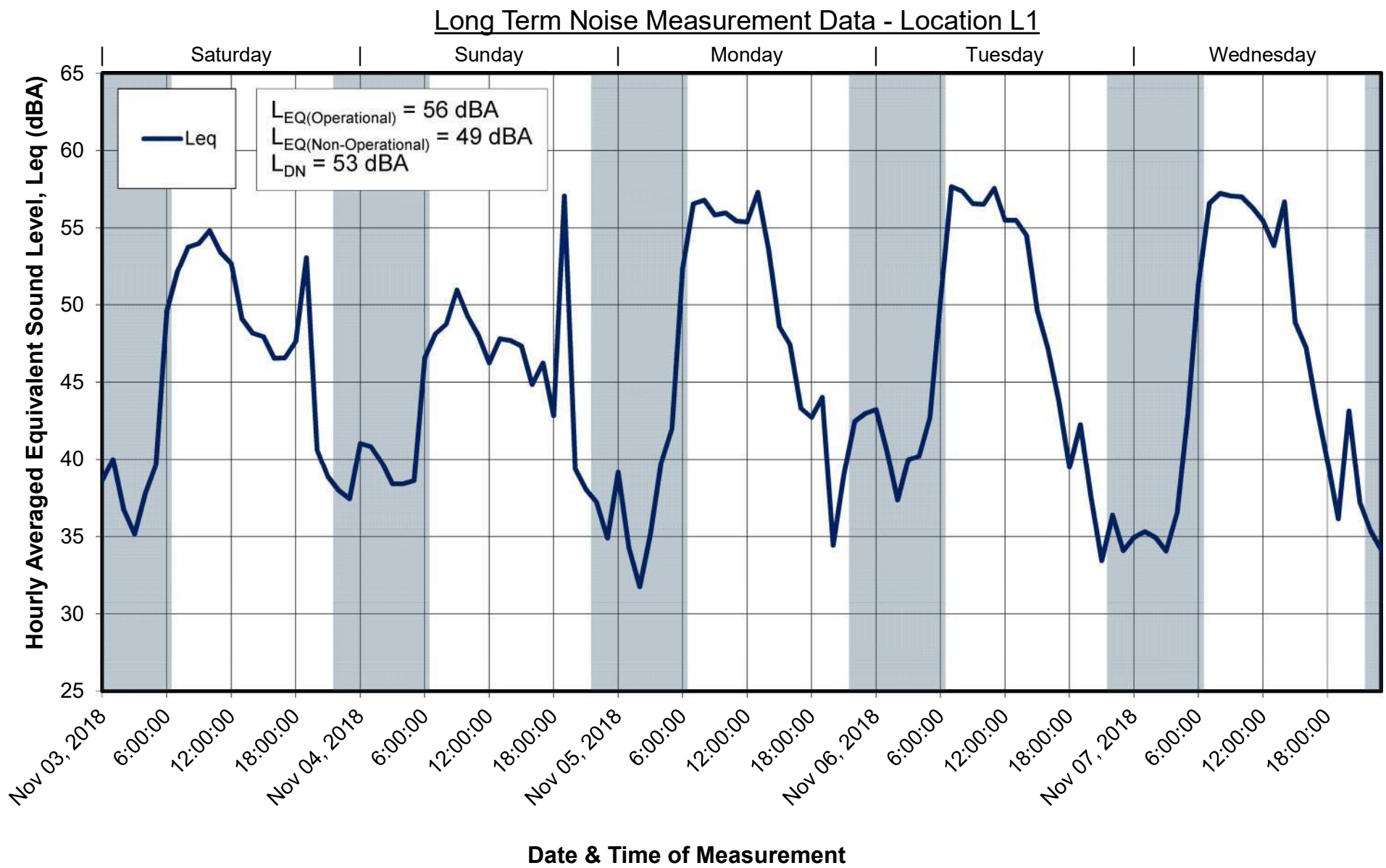
PROJECT:		
PVT Integrated Solid Waste Management Facility Relocation		
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 2



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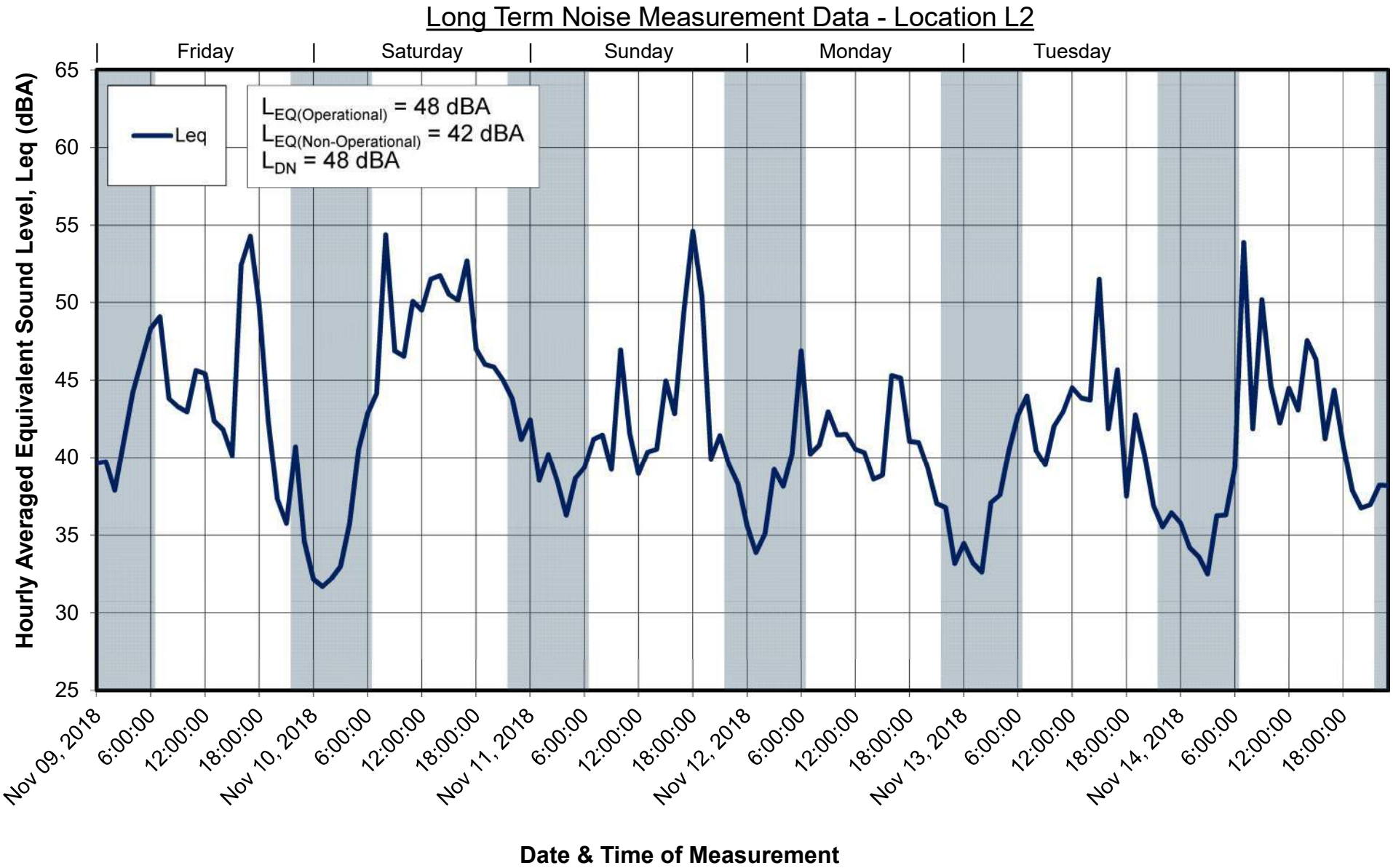
PROJECT:		
PVT Integrated Solid Waste Management Facility Relocation		
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 3



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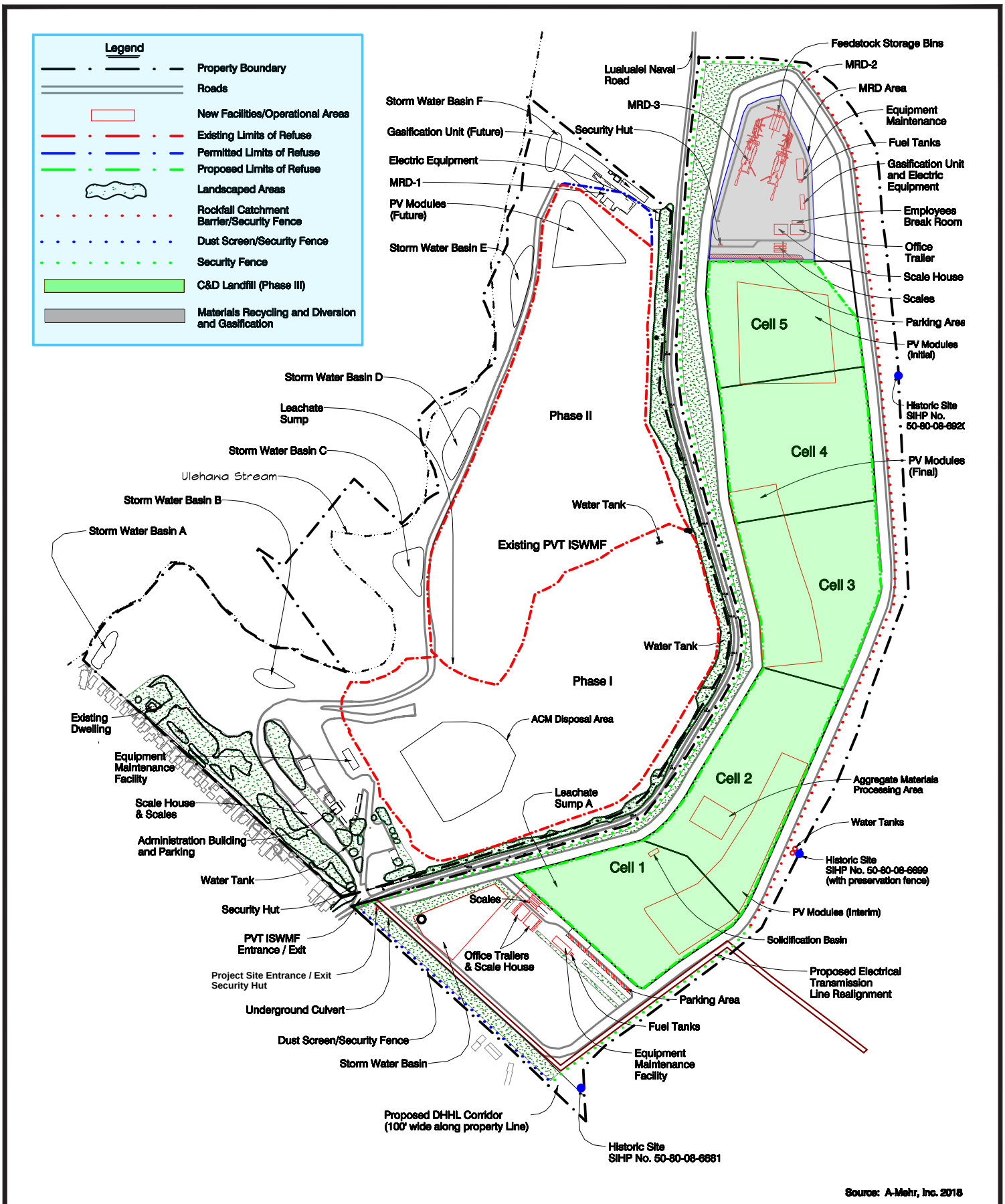
PROJECT:		
PVT Integrated Solid Waste Management Facility Relocation		
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 4



Source: A-Mehr, Inc. 2018

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PROJECT:	PVT Integrated Solid Waste Management Facility Relocation	
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 5

Noise Model Receiver Locations

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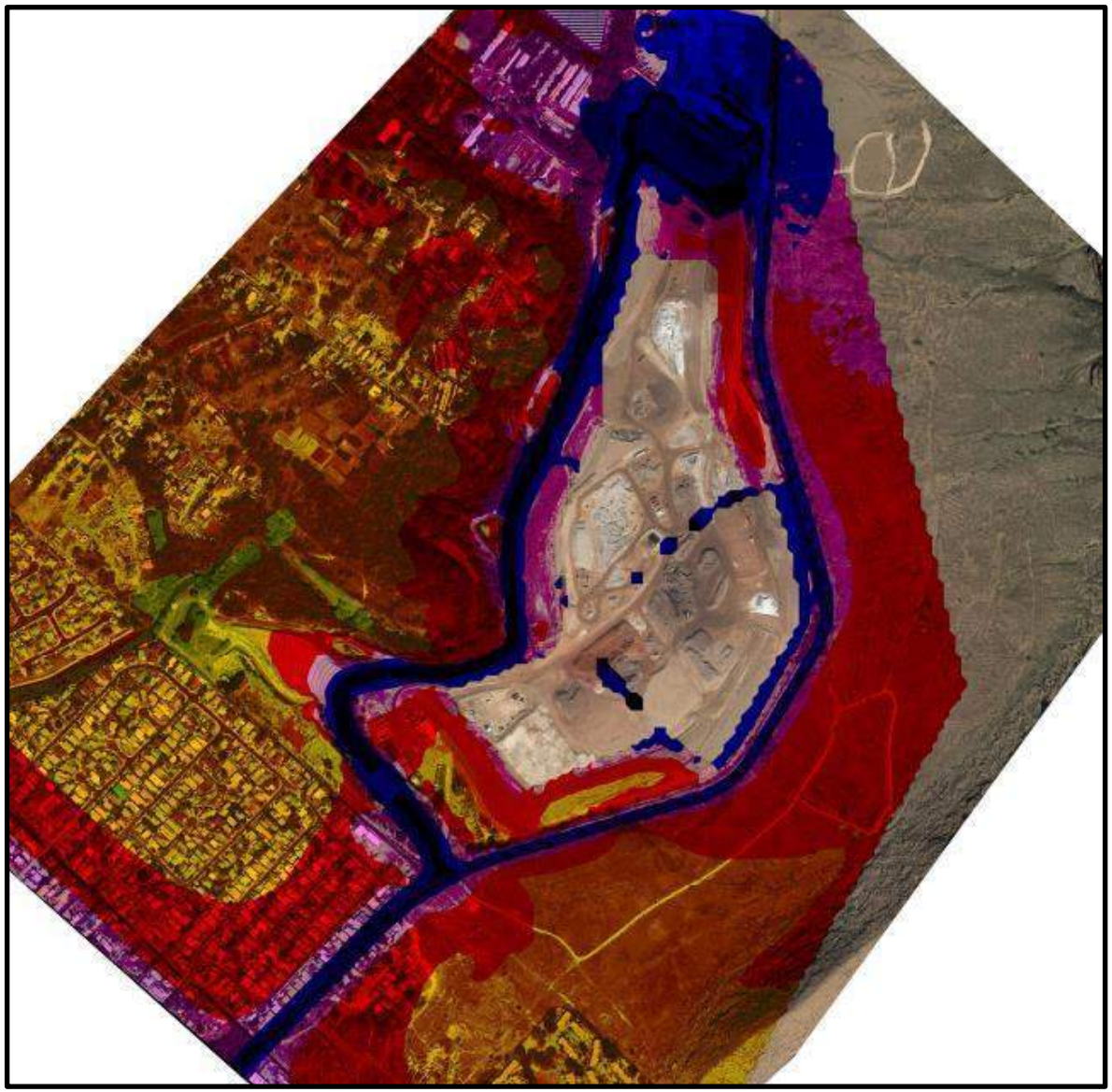
PROJECT:		
PVT Integrated Solid Waste Management Facility Relocation		
PROJECT NO: 18-036	DATE: December 2018	FIGURE: 6

Calculated Noise Contours – Current Location



Noise Level Contour Key (dBA)

- > 40.0
- > 45.0
- > 50.0
- > 55.0
- > 60.0
- > 65.0
- > 70.0
- > 75.0

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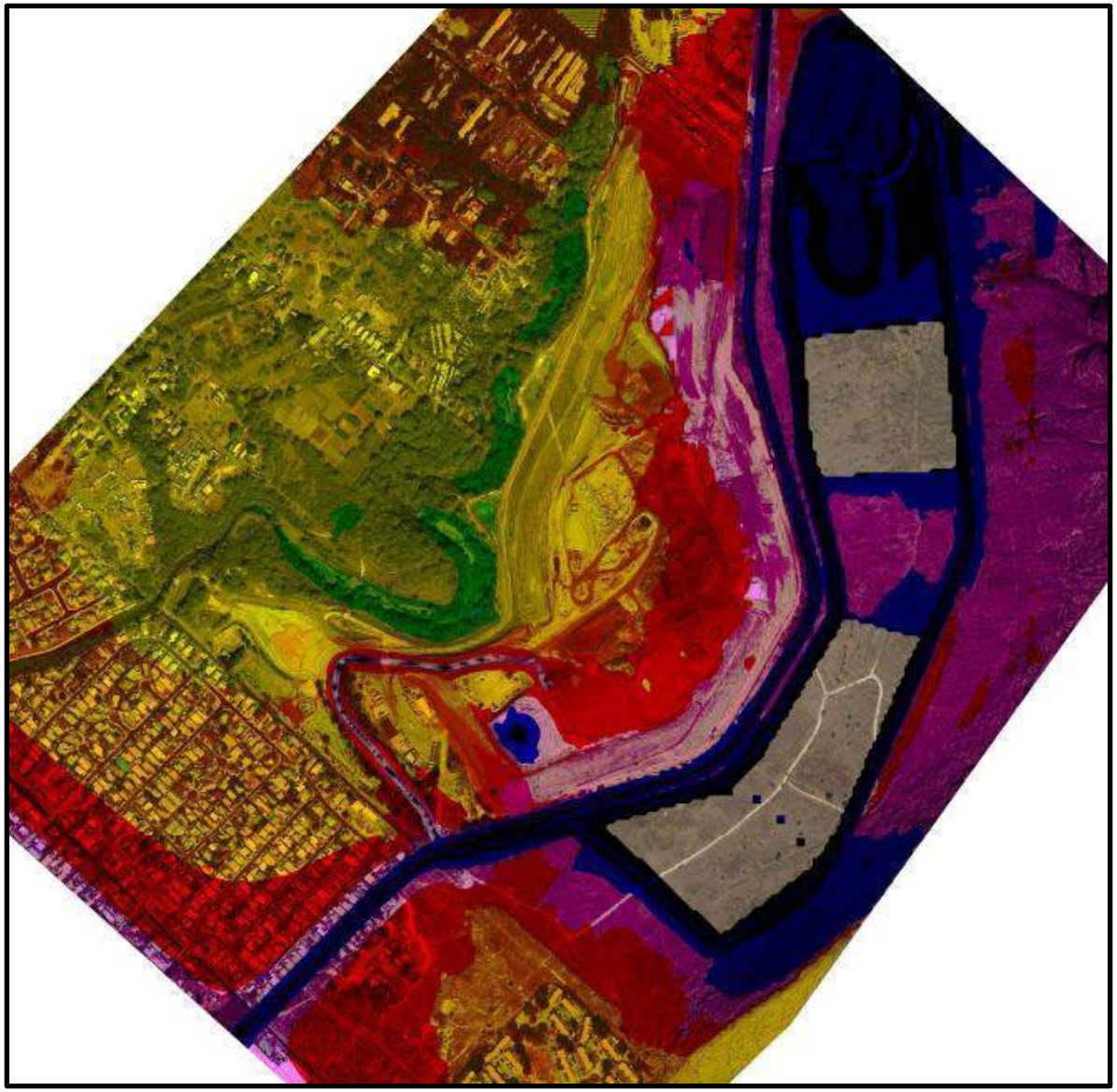
PVT Integrated Solid Waste Management Facility Relocation

PROJECT NO:	DATE:	FIGURE:
18-036	December 2018	7

Calculated Noise Contours – After Relocation



Noise Level Contour Key (dBA)

- > 40.0
- > 45.0
- > 50.0
- > 55.0
- > 60.0
- > 65.0
- > 70.0
- > 75.0

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PVT Integrated Solid Waste Management Facility Relocation

PROJECT NO:	DATE:	FIGURE:
18-036	December 2018	8

APPENDIX B

Photographs at Project Site

Location L1

Microphone mounted on a tripod near the southern border of the current PVT ISWMF approximately 300 feet south of the scale house.

Location L2

Microphone mounted on fence near the southern side of the Project Site, approximately 35 feet north of nearest residence.

APPENDIX E
Biological Surveys Report

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Biological Surveys Conducted for the PVT-ISWMF Relocation Project, Lualualei, Waiʻanae District, Island of Oʻahu

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July 6, 2018

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Introduction

PVT Land Company, Ltd. (PVT) is proposing to relocated their existing integrated solid waste management facility (ISWMF) to a vacant, privately-owned parcel (Tax Map Key [TMK] 8-7-009:007) located east of the existing PVT ISWMF and Lualualei Naval Road (See Figure 1-1).

This report describes the methods used and the results of the botanical, avian and terrestrial mammalian surveys conducted on the subject property as part of the environmental disclosure process associated with the proposed project.

The primary purpose of the surveys was to determine if there are any floral, avian or mammalian species currently listed, or proposed for listing under either federal or State of Hawaiʻi endangered species statutes within or adjacent to the study area. The federal and State of Hawaiʻi listed species status follows species identified in the following referenced documents: (Department of Land and Natural Resources (DLNR) 2015; U. S. Fish & Wildlife Service (USFWS) 2017). Fieldwork was conducted on May 22 and 23, 2018.

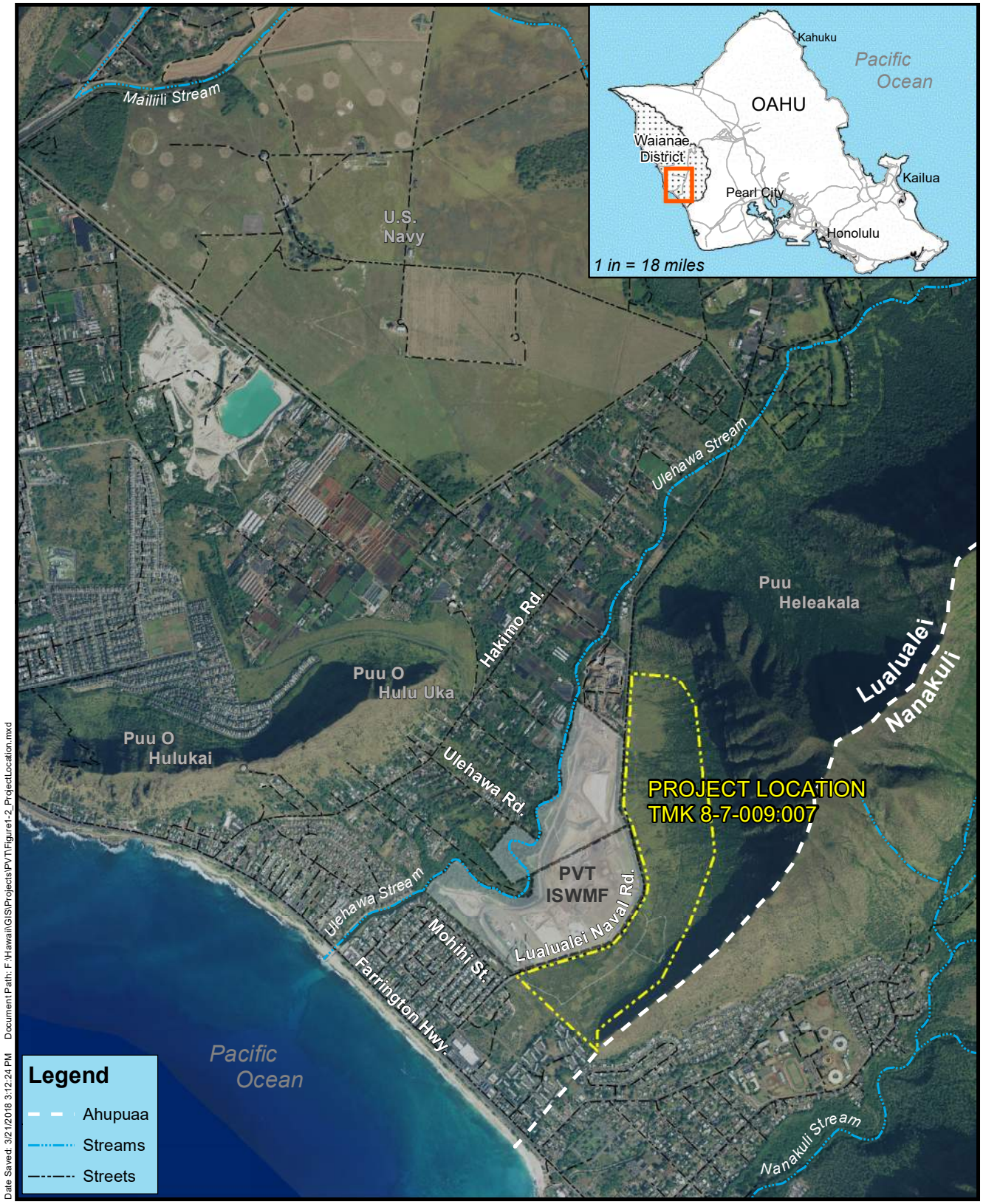
Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, are included at the end of the narrative text.

General Project and Site Description

PVT proposes improvements to its operations to provide adequate landfill capacity to accept future construction and demolition (C&D) waste generated on Oahu. The key components of the proposed action include:

- Relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations;
- Relocation, modernization and enhancement of recycling operations [e.g. installation of two materials recovery and diversion (MRD) process lines]; and
- Installation of renewable energy facilities to power PVT operations [e.g. one 1000-kilowatt hour (kWh) enclosed gasification unit and approximately seven acres of photovoltaic (PV) panels].

The property is largely undeveloped apart from some unpaved roads/paths, two non-potable brackish water industrial supply wells, one PVT groundwater monitoring well, and two 25,000-gallon storage tanks, which are used to supply operational water to the existing ISWMF operation.



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N

Feet 0 1,000 2,000

0 500 1,000 Meters

Project Location

PVT ISWMF Relocation

Lualualei, Waianae District, Oahu, Hawaii

Figure **1-1**

Source: DPP 2017. Aerial photograph provided by Hexagon Imagery Program Data.

The land on the east side of Lualualei Naval Road is low-sloping and open grassland that rises gradually towards the southwest slope of Heleakalā, a prominent ridgeline and peak that separates lower Ulehawa (east Lualualei) Valley from Nānākuli Valley. Steepness of the site increases substantially from Lualualei Naval Road across alluvium and up the colluvium accumulated along the base of the ridgeline and, beyond the east and north property boundaries, rises even more steeply in a series of cliffs and ledges typical of eroded valley slopes of the Waianae shield volcano.

The vegetation on the site is mostly a dry shrubland: grassland invaded by several species of shrubs (Figure 2). Grassland (former pastureland) covers much of the valley bottom along Lualualei Naval Road. Widely scattered *kiawe* trees (*Prosopis pallida*) occur across the property.

Figure 2 – Dry shrubland is the typical vegetation on the site 2018 (compare with Figure 4 taken in 2003).

Methods

Botanical Survey Methods

The botanical survey was conducted on May 22-23, 2018, the early dry season on O'ahu; although April and May were generally wet months on the Island and a few plants were just showing signs of stress. A small part of the subject parcel at the extreme southern end was surveyed on May 2, 2018 for a different project (Guinther, 2018). The botanical survey entailed a wandering pedestrian transect that traversed the property in a series of broad loops that entailed climbing up to the upper (east) property boundary and then descending to the grassy flats along the west property boundary. A handheld GNSS unit (Trimble, GeoXH 6000 Series) was used to record the progress track of the botanist and provide real time feedback on survey area coverage. The GNNS unit provided an opportunity to mark the locations of any features of special interest (such as rare native plants), if any was encountered.

Plant species were identified as they were encountered. For a few species not immediately recognized in the field, photographs were taken and/or material collected for identification in the laboratory. Field notations were recorded to develop a qualitative sense of individual species abundance as the survey progressed.

Plant names used herein follow Manual of the Flowering Plants of Hawai'i (Wagner, Herbst, & Sohmer, 1990; Wagner & Herbst, 1999) for native and naturalized flowering plants and A Tropical Garden Flora (Staples & Herbst, 2005) for ornamental plants. More recent name changes for naturalized plant species follow Imada (2012).

Avian Survey Methods

Ten count stations were sited roughly 300m apart from each other within the project site. A single eight-minute avian point count was made at each count station. Field observations were made with the aid of Leica 8 X 42 binoculars and by listening for vocalizations. The point counts were conducted between 7:45 and 10:30 am, the period when birds are most active and vocal. Time not spent counting the point count stations was used to search the rest of the site for species and habitats not detected during the point counts.

The avian phylogenetic order and nomenclature used in this report follows the *AOU Check-List of North American Birds* (American Ornithologists' Union, 1998), and the 42nd through the 58th supplements to the Check-List (American Ornithologists' Union, 2000; Banks et al., 2002, 2003, 2004, 2005, 2006, 2007, 2008; Chesser *et al*., 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017). Mammal scientific names follow (Wilson and Reeder, 2005)). Place names follow (Pukui et al., 1976).

Mammalian Survey Methods

With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *ʻōpeʻapeʻa* as it is known locally, all terrestrial mammals currently found on the Island of Oʻahu are alien species, and most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all terrestrial vertebrate mammalian species detected within the project area during the time spent on the site.

Results

Botanical Survey

The results of the botanical survey are a description of the vegetation typifying the site and any unusual physiographic features and a listing (flora) of all the species of vascular plants encountered (Table 1). The total number of species listed in this flora listing is 48, a rather small number for a parcel of approximately 180 ac (73 ha). Of these 48 species, five (10%) are indigenous species and one (2%) is an endemic native plant. No early Polynesian introduction was observed.

The native species recorded from the PVT site are, for the most part, fairly common and the percentage of natives (12%) is typical for lowland areas on Oʻahu. The Hawaiʻi endemic, *maʻo* or Hawaiian cotton plant (*Gossypium tomentosum*), is no longer widespread on Oʻahu, but was once listed as "vulnerable" by IUCN (Wagner & Herbst, 1990 after Lucas & Synge, 1978) and later as "rare" (IUCN, 1997). Present IUCN Red Book (IUCN, 2017-3) does not include this species. The Hawaiian cotton is not a listed species by USFWS (2017). The species first appears in the USFWS provided Federal Register resources (USFWS, 1980) as a "3C" species: "[t]axa that have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat." The second author recalls seeing Hawaiian cotton on the west side of Lualualei Naval Road in 1991 (AECOS, 1992) and it is descrbed in that report as common in the "pasture land area" but not discussed further. Not present now, but previously reported by AECOS (1992) as rare—most likely on slopes above the PVT property line—is the Hawaiian endemic, *Santalum ellipticum* (*ʻiliahialoʻe* or coast sandalwood).

Table 1 - Listing of plants (flora) for the PVT ISWMF Relocation Site Lualualei, West O'ahu

Species listed by family	*Common name*	*Status*	*Abundance*	*Notes*
	FLOWERING PLANTS			
	DICOTYLEDONES			
AMARANTHACEAE				
Alternanthera pungens Kunth	khaki weed	Nat	*p*	<1>
Amaranthus spinosus L.	spiny amaranth	Nat	*p*	<1>
ASCLEPIADACEAE				
Stapelia gigantea N.E. Brown	giant toad plant	Nat	O	
ASTERACEAE (COMPOSITAE)				
Flaveria trinervia (Spreng.) C. Mohr	---			
Pluchia carolinensis (Jacq.) G. Don	sourbush	Nat	R	
Sonchus oleraceus L.	sow thistle	Nat	*p*	<1>
Tridax procumbens L.	coat buttons	Nat	*p*	<1>
BIGNONIACEAE				
Tecoma stans (L.) Juss. ex Kunth	yellow elder	Nat	U	
CHENOPODIACEAE				
Atriplex cf. *suberecta* Verd.	saltbush	Nat	*p*	<1>
Chenopodium cf. *album* L.	lamb's quarters	Nat	*p*	<1><2>
Salsola tragus L.	Russian thistle	Nat	*p*	<1>
CONVOLVULACEAE				
Ipomoea obscura (L.) Ker-Gawl.	---	Nat	*p*	<1>
Ipomoea triloba L.	little bell	Nat	*p*	<1>
CUCURBITACEAE				
Cucumus dipsaceus Ehrenb. ex. Spach	teasel gourd	Nat	*p*	<1>
EUPHORBIACEAE				
Euphorbia albomarginata Torr. & A. Gray	rattlesnake weed	Nat	*p*	<1>
Euphorbia hirta L.	garden spurge	Nat	*p*	<1>
Euphorbia hypericifolia L.	graceful spurge	Nat	*p*	<1>
Ricinus communis L.	castor bean	Nat	*p*	<1>
FABACEAE				
Crotalaria incana L.	fuzzy rattlepod	Nat	*p*	<1>
Desmanthus virgatus (L.) Willd.	virgate mimosa	Nat	AA	
Leucaena leucocephala (Lam.) deWit	*koa haole*	Nat	AA	

Table 1 – continued.

Species listed by family	***Common name***	***Status***	***Abundance***	***Notes***
Indigofera hendecaphylla Jacq.	prostrate indigo	Nat	*p*	<1>
Macroptilium atropurpureum (DC.) urb.	---	Nat		
Macroptilium lathyroides (L.) Urb.	cow pea	Nat	*p*	<1>
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth	*kiawe*	Nat	U	
Vachellia farnesiana (L.) Wight & Arn.	*klu*	Nat	O	
LAMIACEAE				
Hyptis pectinata (L.) Poit.	comb hyptis	Nat	*p*	<1>
Leonotis nepetifolia (L.) R. Br.	lion's ear	Nat	*p*	<1>
MALVACEAE				
Abutilon incanum (Link) Sweet	*koʻoloa keokeo, maʻo*	**Ind**	O	
Gossypium tomentosum Nut. ex Seem.	*maʻo*	**End**	U	
Malva parviflora L.	cheeseweed	Nat	*p*	<1>
Malvastrum coromandelianum (L.) Garck	false mallow	Nat	*p*	<1>
Sida ciliaris L.	---	Nat	*a*	<1>
Sida fallax Walp.	*`ilima*	**Ind**	U	
Sida spinosa L.	prickly sida	Nat	*p*	<1>
Waltheria indica L.	*ʻuhaloa*	**Ind**	U	
NYCTAGINACEAE	MYOPORACEAE			
Boerhavia coccinea Mill.	false *alena*	Nat	*p*	<1>
PASSIFLORACEAE				
Passiflora sp.	---	Nat	R	<2>
SAPINDACEAE				
Dodonaea viscosa Jacq.	*ʻaʻaliʻi*	**Ind**	O	
SOLANACEAE				
Solanum americanum Mill.	*pōpolo*	**Ind**	*p*	<1>
	MONOCOTYLEDONES			
POACEAE				
Bothriochloa pertusa (L.) A, Camus	pitted beardgrass	Nat	O	
Cenchrus ciliaris L.	buffelgrass	Nat	AA	
Chloris barbata (L.) Sw.	swollen fingergrass	Nat	*a*	<1>
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat	*p*	<1>
Dactyloctenium aegyptium (L.) Willd.	beach wiregrass	Nat	*p*	<1>
Eleusine indica (L.) Gaertn.	wiregrass	Nat	*p*	<1>
Megathyrsus maximus (Jacq.) B.K. Simon & W.L. Jacobs	Guinea grass	Nat	AA	
Sporobolus pyramidatus (Lam.) Hitch.	---	Nat	*p*	<1>

Key to Table 1:

STATUS = distributional status for the Hawaiian Islands:
End = endemic; native to Hawaii and found naturally nowhere else.
I**nd** = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.

ABUNDANCE = occurrence ratings for plants by area:
R – Rare - seen in only one or perhaps two locations.
U - Uncommon- seen at most in several locations
O - Occasional - seen with some regularity
C - Common - observed numerous times during the survey
A - Abundant - found in large numbers; may be locally dominant.
AA - Very abundant - abundant and dominant; defining vegetation type.
a – common to abundant in disturbed areas (unimproved roads) only
p – present (rare to occasional in disturbed areas (unimproved roads) only.

NOTES: <1> – Exclusively or almost exclusively in disturbed areas: roads, graded areas, etc.
<2> – Plant lacking flowers or fruit; identification uncertain.

Avian Survey

A total of 233 individual birds of 19 species, representing 13 separate families, were recorded during point counts. All nineteen species recorded are alien to the Hawaiian Islands (Table 2). No avian species proposed or currently listed under either state or federal endangered species statutes were recorded on the property. (Department of Land and Natural Resources (DLNR) 2015; U. S. Fish & Wildlife Service (USFWS) 2017)

Avian diversity and densities were low, but in keeping with the location and vegetation present on the site. Three introduced species, Scaly-breasted Munia (*Lonchura punctulata*) Red-vented Bulbul (*Pycnonotus cafer*) and House Finch (*Haemorhous mexicanus*) accounted for 50-percent of the total number of birds recorded. Scaly-breasted Munia was the most commonly tallied species, which accounted for 48 percent of the birds recorded during point counts.

Table 2 – Avian Species Detected During Point Counts PVT ISWMF Relocation Site, Lualualei, West O'ahu			
Common Name	***Scientific Name***	***ST***	***RA***
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Gray Francolin	*Francolinus pondicerianus*	A	0.50
Domestic Chicken	*Gallus* sp.	A	0.10
Indian Peafowl	*Pavo cristatus*	A	0.10
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	0.80
Zebra Dove	*Geopelia striata*	A	2.70
	PELECANIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	0.70
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Eurasian Skylark	*Alauda arvensis*	A	0.50
	PYCNONOTIDAE - Bulbuls		
Red-vented Bulbul	*Pycnonotus cafer*	A	4.40
	ZOSTEROPIDAE - White-eyes		
Japanese White-eye	*Zosterops japonicus*	A	0.70
	MIMIDAE - Mockingbirds & Thrashers		
Northern Mockingbird	*Mimus polyglottos*	A	O.10
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	1.70
	FRINGILLIDAE - Fringilline and Carduline Finches & Allies		
	Carduelinae - Carduline Finches and Hawaiian Honeycreepers		
House Finch	*Haemorhous mexicanus*	A	2.30
	PASSERIDAE - Old World Sparrows		
House Sparrow	*Passer domesticus*	A	0.90
	CARDINALIDAE - Cardinals & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	0.50
	THRAUPIDAE - Tanagers		
	Thraupinae - Core Tanagers		
Red-crested Cardinal	*Paroaria coronata*	A	0.10
	ESTRILDIDAE - Estrildid Finches		
Common Waxbill	*Estrilda astrild*	A	0.40
African Silverbill	*Euodice cantans*	A	1.70
Java Sparrow	*Lonchura oryzivora*	A	0.30
Scaly-breasted Munia	*Lonchura punctulata*	A	4.80

Key to table 2

ST Status

A Alien – Introduced to the Hawaiian Islands by humans

RA Relative Abundance - Number of birds detected divided by the number of point counts (~10)

Mammalian Survey

We recorded four terrestrial mammalian species on the site during the course of this survey. Three dogs (*Canis familiaris*) were seen within the site, and numerous others were heard barking from the housing areas located to the west of the site. Several small Indian Mongooses (*Herpestes auropunctatus*) were seen within the site as was scat of this near ubiquitous species. One cat (*Felis catus*) was seen on the western end of the site adjacent to the housing located west of the site. Sign of goat (*Capra hircus*) bark browsing was seen on a clump of *koa haole* (*Leucaena leucocephala*) located near the highest point on the site, midway along the property.

No mammalian species currently proposed for listing or listed under either the federal or State of Hawaiʻi endangered species statutes was recorded on this site (DLNR 2015; USFWS, 2017).

Discussion

Previous Biological Surveys of the Site

There have been three faunal surveys conducted on the site by the lead author (David, 2004, 2007, 2008). Additionally several botanical surveys have also been conducted on the property by the botanist over a long period of time (*AECOS*, 1992; Guinther, 2003, 2007).

Botanical Resources

One of the more extensive non-native plant assemblages in the lowlands of the Hawaiian Islands is the *kiawe* (*Prosopis*) savanna. This vegetation type is termed an inland Kiawe Forest subtype of the *Kiawe* (*Prosopis*) *Forest* (Gagne and Cuddihy, 1990, p. 62), described by those authors as: "often ha[ving] an open woodland aspect…occurs in low [elevation], warm areas, especially in dry situations near the coasts on all the main islands, primarily below 300 m elevation, particularly on Oʻahu and Maui. Because the understory of grass (typically buffelgrass [*Cenchrus ciliaris*]) is so dominant and the forest usually quite open (*kiawe* does not create deep shade where the trees are spaced apart inland from the coastal zone), the term savanna is more appropriate a descriptor than forest for this vegetation type as found across the dry, leeward lowlands. Surveying a property further into Lualualei Valley, Char (1990) identified the vegetation type there as a "Kiawe-Buffel Grass Association". Mueller-Dombois and Fosberg (1998, p. 496-7) provide additional insight into the *Prosopis Forest and Savanna*, describing the wide range of tree densities present from dense to the exclusion of understory growth to savanna and from scrubby growth to tall trees.

Another extensive vegetation type described by Gagne & Cuddihy (1990, p.61) and Mueller-Dombois & Fosberg (1998) is the *Koa Haole* (*Leucaena*) Shrubland or *Leucaena Scrub-Forest*, marked by "[e]xtensive thickets of *koa haole* (*Leucaena leucocephala*)… [found] especially on abandoned grazing lands." Mueller-Dombois & Fosberg (1998, p. 498) note: "*Leucaena* scrub became the most dominant vegetation type throughout most of the dry lowlands of Oʻahu and Kauaʻi", to which we can now add: and on all of the other islands, especially Moku o Kiawe (Hawaiʻi). Figures 2 and 3 show scrubland in the survey area in 2018. The low stature of the *koa haole* shrubs is fairly universal across the site, so it is uncertain if these plants represent regeneration from the seed bank after the last major fire or recovery of plants not killed and more or less close to their size limit for the local climate and edaphic conditions.

Figure 3. – Buffelgrass grassland being invaded by *koa haole* shrubs.

Mueller-Dombois & Fosberg (1998, p. 491) also describe some thirteen dry-grassland types (mostly after Kartawinata and Mueller-Dombois, 1972). Buffelgrass is only mentioned in passing as becoming widespread in the lowlands of northeast Hawaiʻi and Kahoʻolawe. The situation today is far different; buffelgrass grassland or buffelgrass as the dominant understory in *kiawe* savanna and *koa haole* scrubland is now the predominant lowland dry scrubland type across much of the Hawaiian Islands. A larger grass—Guinea grass (*Megathyrsus maximus*)—replaces buffelgrass in slightly less dry circumstances, and is the dominant grass in open lowland mesic habitats.

These vegetation types or classifications are discussed here because the PVT site provides an excellent example of their current status on leeward Oʻahu, demonstrating how the types are very much interrelated as stages in a progressive transition of site vegetation from grassland, through scrubland, to savanna and how external factors, such as cattle grazing and fire, influence this successional process. The present survey reveals the survey site as comprising grassland in the lowest areas and shrubland or scrub on the colluvial slopes. *Kiawe* occurs scattered across the site, but barely or not at all reaching a density comporting to a savanna, with isolated copses associated with shallow gulches upslope of the PVT property line. The lower grassland may be a product of cattle grazing formerly undertaken on the site, and this area is now actively under invasion by shrubs, mostly *koa haole* with lesser numbers of *klu*. However, the likely dominant factor affecting site vegetation is wild fire. The *kiawe* trees that formerly made these slopes a savanna have been mostly burned out, and the patchy scrub is recovering from the last burn.

The PVT site is not entirely covered by buffelgrass. Patches of pitted beardgrass (*Bothriochloa pertusa*) are scattered about in the lower areas and Guinea grass becomes the dominant grass on the upper slope of the colluvium, particularly towards the north end of the parcel. The dominant vegetation over the site is the shrubland, and *koa haole* is far and away the major component. However, several other species are present, namely (roughly in order of decreasing occurrence) *klu* (*Vachellia farnesiana*), virgate mimosa (*Desmanthus virgatus*), *koʻoloa keokeo* (*Abutilon incanum*), giant toad plant (*Staplia gigantea*), *ʻaʻaliʻi* (*Dodonaea viscosa*), *ʻuhaloa* (*Waltheria indica*) *ʻilima* (*Sida fallax*), and *maʻo* (*Gossypium tomentosum*); the latter two uncommon on the site.

The PVT parcel that is the subject of our survey presents an interesting history of vegetation changes that provides insight into the factors that relate these various grassland, shrubland, and savanna vegetation types together in a successional series. As mentioned, two stressors are prominent in this location on the slope below the terraced face of Haleakalā: 1) At one time, the accessible slopes and gently sloped bottom land were utilized for cattle grazing, and 2) the property has been subjected to wild fires over the years. Both stressors can be viewed as setting back the vegetation to one dominated by grasses and are detrimental to maintenance of any remnant native dryland plant community. Pasturing cattle is no longer undertaken on the site, and we do not know it where and when the last major fire occurred here. However, it is evident that the site is presently undergoing transition from grassland (or severely burned scrubland, to scrubland as shown by comparing the photo in Figure 4 with that in Figure 2 looking at the same line of electrical poles but from the north).

An interesting result of the current botanical survey is the presence of several native shrubs that are spreading within the expanding dry shrub vegetation. If the grassland is a fire sere, these native species—*koʻoloa keokeo, ʻaʻaliʻi*, and *maʻo*—may be species capable of surviving the fire(s). However, only *koʻoloa keokeo* is likely a fire survivor. Observations made during

a survey at nearby Makaīwa (gulch just west of Makakilo; David & Guinther, 2005) following a fire that burned the area 4 months prior, showed *koʻoloa keokeo* as a conspicuous early colonizer. Guinea grass and buffelgrass also returned quickly to the burned area, but presumably from established stems that were not completely killed by the fire. As for *ʻaʻaliʻi* at the PVT site, the plants observed there now more likely established after a fire from windblown fruit (a dry, winged capsule) on the assumption this species populates the steep sides of Heleakalā upslope and upwind of the survey area. For the most part, the clusters of *ʻaʻaliʻi* occur in more open areas of buffelgrass grassland and not shrubland dominated by *koa haole*. Present, seems to be three (or possibly four) year classes of this shrub, possibly representing successful wet season germinations in 2017-8, 2016-7, and 2015-6 and/or a little older. On this site, *maʻo* is restricted to the very southern part of the property, an area that may have a different fire history than the majority of the site. This southern area was shrubland in a 2004 Google Earth image, when the majority of the site was clearly grassland and firebreak bulldozer cuts were evident across much of the site.

Figure 4 – Dry grassland, here across the middle of the parcel looking north, was the dominant vegetation on the site in 2003. Note a near absence of shrubs on the alluvial slopes.

The 1991 survey (AECOS, 1992) of the PVT site listed the following plant species as "locally abundant in disturbed areas (road and fire trail cuts)" in rough order from most to least

abundant: *Waltheria indica*, *Malvastrum coromandelianum*, *Sida fallax*, and *Abutilon incanum*. These species may be the most successful early colonizers following a fire in this area, although not implied is that these species are the only ruderal plants present. In any event, bulldozer cuts are a different and more ground-disturbing impact than fire, but the cuts are now overgrown with buffelgrass or Guinea grass (location dependent) and *koa haole*.

Intriguing and contributory to the relatively low number of species encountered in our survey is the distribution of the plant species recorded. A vast majority of the survey area is covered by only 16 species; 14 if two species seen only once each (rare) are excluded. Only four of these are abundant (the "AA" species listed in Table 1); no others among the 16 are regarded as even common. The remaining 32 species are very limited in occurrence to the roadways and a few other places of highly disturbed ground. This distribution pattern seems another outcome of the fire sere favoring recovery of a limited number of species that easily dominate the land to the exclusion of typical ruderal species that might be better represented under other types of catastrophic ground disturbance.

In these drier areas on Oʻahu subjected to fires with some regularity of occurrence, buffelgrass and Guinea grass dominate, becoming self-preserving by increasing the intensity of fires that occur, yet capable of regrowth from basal stems when rains return (Hughes, Vitousek, and Tunison,1991; Tix, undated; Latz, 1991). *Abutilon incanum*, at least, shows some resilience in the face of wild fires. However, most native Hawaiian plants are not adapted to fire and gradually eliminated from areas subjected to repeated burns (Mueller-Dombois, 1981).

Avian Resources

The findings of this latest avian survey are consistent with the current habitat present within the survey area, and with three other faunal surveys conducted on the property by the lead author in 2004, 2007 and 2008 (David, 2004, 2007, 2008). As previously mentioned we recorded 19 avian species, all nineteen species recorded are alien to the Hawaiian Islands (Table 2). Unlike the very interesting and dynamic succession seen in the flora of the site, the bird species recorded on four surveys of the site are almost identical, although densities have changed over time, periodically favoring one estrildid species over another depending on the amount and type of grass seed present across the site. (David, 2004, 2007, 2008; this report)

Although no seabirds were detected during the course of this survey, several seabird species potentially overfly the site on occasion. The primary cause of mortality in resident seabirds is thought to be predation by alien mammalian species at the nesting colonies (USFWS 1983; Simons and Hodges 1998; Ainley et al., 2001). Collision with man-made structures is considered to be the second most significant cause of mortality in locally nesting seabird species in Hawaiʻi. Nocturnally flying seabirds, especially fledglings on their

way to sea in the summer and fall, can become disoriented by exterior lighting. When disoriented, seabirds often collide with manmade structures, and if they are not killed outright, the dazed or injured birds are easy targets of opportunity for feral mammals (Hadley 1961; Telfer 1979; Sincock 1981; Reed et al., 1985; Telfer et al., 1987; Cooper and Day, 1998; Podolsky et al. 1998; Ainley et al., 2001; Hue et al., 2001; Day et al 2003).

The O‘ahu population of White-Tern (*Gygis alba*) is listed as an endangered species by the State of Hawaii‘; it is not listed under federal statute. This ephemeral species was not recorded during this survey, nor was it expected. The current resident population of White Terns on O’ahu is found on the leeward side of the Island concentrated in the Waikiki area.

No owl species were recorded during this survey. There are two resident owl species on O‘ahu; the introduced Barn Owl (*Tyto alba*) and the indigenous endemic sub-species of the Short-eared Owl, or *Pue‘o* as it is locally know (*Asio flammeus sandwichesis*). This species has become increasingly scarce on the Island; the O‘ahu population is listed as an endangered species by the State of Hawai‘I; it is not listed under federal statute. It is probable that this resident indigenous species occasionally uses resources in the general project area on a seasonal basis. This species is not habitat restricted on O‘ahu, though there certainly is less suitable nesting habitat than there once was. This species faces daunting odds on an Island as heavily populated as O‘ahu – they are a ground nesting diurnal species, the shear number and densities of mammalian predator on the Island make it very difficult for this species to successfully nest except within protected areas that have a strong mammalian predator control program in place.

Mammalian Resources

The findings of the mammalian survey are consistent with the current habitat present on the site, and with three other faunal surveys conducted on the property by the lead author in 2004, 2007 and 2008 (David, 2004, 2007, 2008).

All four mammalian species detected during the course of this survey, and for that matter, the three previously mentioned surveys conducted on the property are alien to the Hawaiian Islands (David, 2004, 2007, 2008). Although no rodents were recorded during the course of this survey, it is likely that one or more of the other four established alien Murida*e* found on O‘ahu - European house mouse (*Mus musculus domesticus*), roof rat (*Rattus rattus*), brown rat (*Rattus norvegicus*), and black rat (*Rattus exulans hawaiiensis*) - use various resources found within the general project area on a seasonal basis. These human commensal species are drawn to areas of human habitation and activity. All of these introduced rodents are deleterious to native ecosystems and the native faunal species dependent on them.

No Hawaiian hoary bats were detected during the course of this survey. It is only in recent years that this species is being recorded on a regular basis on the Island of O‘ahu. It is within the realm of possibility that this species may forage over the site on a seasonal basis. There are no trees suitable for roosting bats on the property.

Potential Impacts to Protected Species

Botanical Resources

The site reflects a more or less complete destruction of the lowland native plant community that once dominated the Waiʻanae area over two centuries ago. Only a few remnant species of that assemblage occur here now, although these plants are showing some resilience in the face of cattle grazing, fire, and invasive non-native plants.

Short-eared Owl (pueo)

Short-eared Owls are a ground nesting diurnal species. Ground nesting birds are threatened by a full complement of alien mammalian predators in the Hawaiian Islands as they are on all islands. Ground nesting birds can also be disturbed by habitat modification and direct physical damage to an occupied nest. It is within the realm of possibility that if the grass on the site were to remain fairly short that the habitat could be used by a Short-eared Owls to nest in.

Seabirds

The principal potential impact that the construction of the project poses to protected seabirds is the increased threat that birds will be downed after becoming disoriented by lights associated with the proposed action during the nesting season. The two main areas that outdoor lighting could pose a threat to these nocturnally flying seabirds are; a) during construction, if it is deemed expedient, or necessary to conduct night-time construction activities – currently no nighttime construction is anticipated; b) following build-out, the potential use of streetlights or other exterior lighting during the seabird fledging season which runs from September 15 through December 15th.

Critical Habitat

No part of the PVT property is included in a federally designated Critical Habitat Unit. There is no equivalent statute under state law.

Recommendations

If the following minimization measures are incorporated into the project it is not expected that the re-development of the site will result in deleterious impacts to any avian or mammalian species currently listed or proposed for listing under either the federal or state of Hawaiʻi endangered species statutes:

- If streetlights or exterior facility lighting is installed in conjunction with the project, it is recommended that the lights be shielded to reduce the potential for interactions of nocturnally flying seabirds with external lights and man-made structures (Reed et al., 1985; Telfer et al., 1987).

- Immediately prior to clearing and grading a qualified biologist should conduct a nesting Short-eared Owl survey of the site.

Glossary

Alien – Introduced to Hawaiʻi by humans
Alluvium – Material deposited in an area by the action of water.
Colluvium – Basaltic material eroding off the mountain slope by gravity and water flow and accumulating as a moderately steep apron below
Commensal – Animals that share humans' food and lodgings, such as rats and mice.
Diurnal – Daytime, an animal that hunts and feeds during daylight hours, the opposite of Nocturnal
Edaphic - of, produced by, or influenced by the soil.
Endangered – Listed and protected under the Endangered Species Act of 1973, as amended (ESA) as an endangered species
Endemic – Native to the Hawaiian Islands and unique to Hawaiʻi
Estrildid - The estrildid finches are small passerine birds of the Old World tropics and Australasia. They are generally classified as the family Estrildidae (Waxbills, Munias and allies).
Indigenous – Native to the Hawaiian Islands, but also found elsewhere naturally
Makai – Towards the ocean
Mesic – An environment o habitat containing a moderate amount of moisture
Phylogenetic – The evolutionary order that organisms are arranged by
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles
Sere – A serial community or plant assemblage that is an intermediate stage in ecological succession.
Sign – Biological term referring tracks, scat, rubbing, odor, marks, nests, and other signs created by animals by which their presence may be detected
Threatened – Listed and protected under the ESA as a threatened species

Ac – Acre
DLNR – Hawaiʻi State Department of Land & Natural Resources
ESA – Endangered Species Act of 1973, as amended
Ha - Hectare
ISWMF - Integrated Solid Waste Management Facility
IUCN – International Union for Conservation of Nature
MRD - Materials Recovery Devise
USFWS – United State Fish & Wildlife Service

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APPENDIX F
Traffic Impact Analysis Report

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TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

PREPARED FOR

PVT LAND COMPANY

JUNE 18, 2019

PREPARED BY

THE TRAFFIC MANAGEMENT CONSULTANT

TRANSPORTATION IMPACT ANALYSIS REPORT

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JUNE 18, 2019

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HAWAII, U.S.A.

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION.

SIGNATURE

4/30/2020
EXPIRATION DATE OF LICENSE

TMC

THE TRAFFIC MANAGEMENT CONSULTANT

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TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

I. Introduction

A. Project Description

PVT Land Company (PVT) proposes to relocate the operations at its solid waste management facility in Nanakuli, Oahu, Hawaii to a site immediately across from its current facility on Lualualei Naval Road. Figure 1 depicts the project location.

The existing PVT Integrated Solid Waste Management Facility (ISWMF) is currently located on the north side of Lualualei Naval Road, about 0.35-mile mauka (east) of Farrington Highway. The existing PVT ISWMF processes up to 3,000 tons of construction and demolition wastes per day. The existing operation generates up to 300 trucks per day. Beyond the Year 2025, the existing PVT ISWMF will be able to process only up to 1,500 tons per day and generate up to 150 trucks per day. Currently, PVT ISWMF employs 60 full-time employees and 20 temporary employees for a total of 80 employees. The start time for most of the workers is 7:00 AM. The existing PVT ISWMF is depicted on Figure 2.

The proposed PVT ISWMF Relocation will be located on a 179.109-acre site, which is identified as Tax Map Key: (1) 8-7-009:007. The proposed project will be able to continue to process up to 3,000 tons per day of construction and demolition wastes to the Year 2030. The PVT ISWMF Relocation operation is expected to continue to generate up to 300 trucks per day and require a total of 80 personnel. The PVT ISWMF Relocation access will be provided by a driveway, which will be located immediately opposite the existing PVT ISWMF driveway. Figure 3 depicts the PVT ISWMF Relocation site plan.

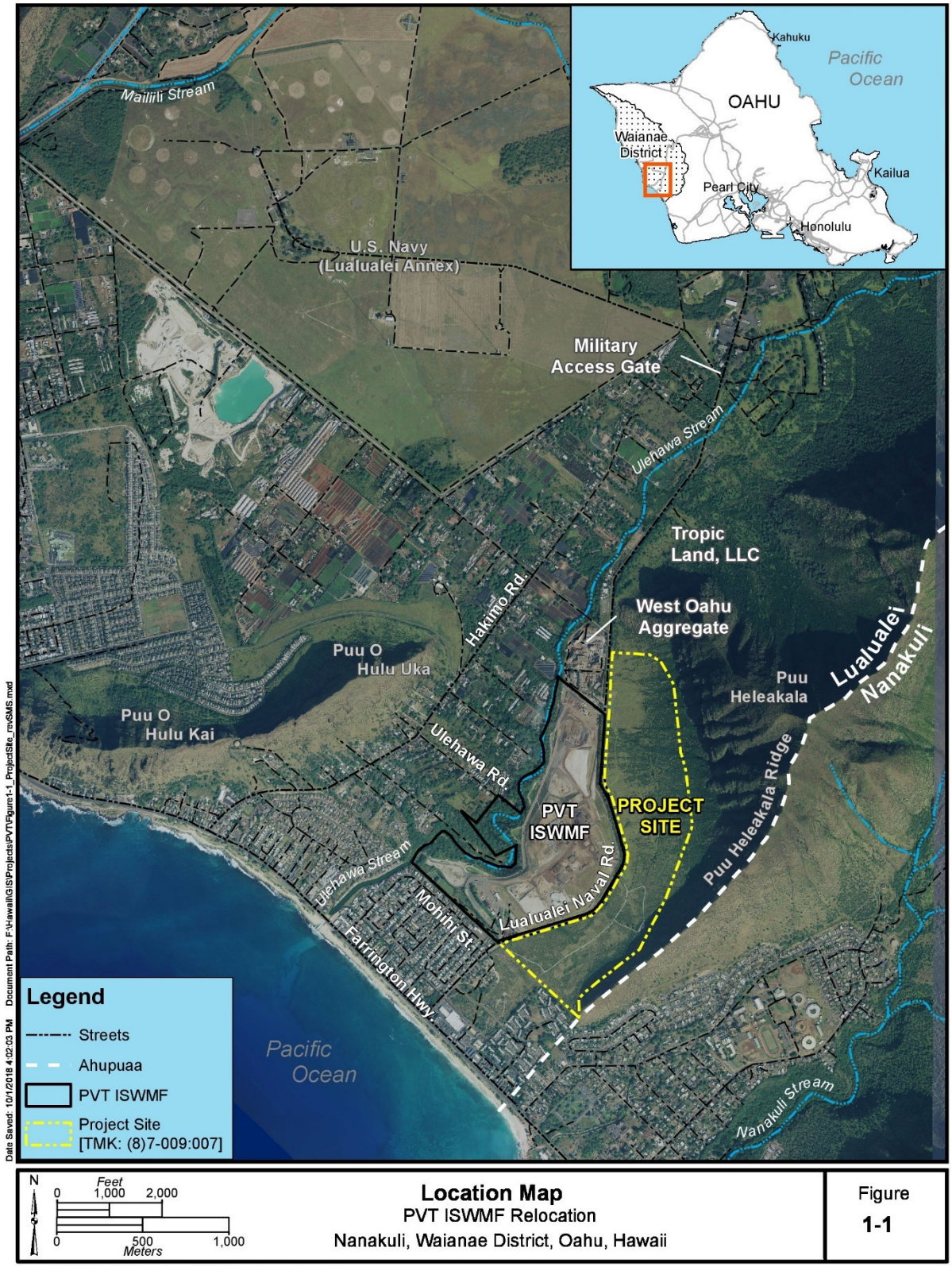

Figure 1. Location Map

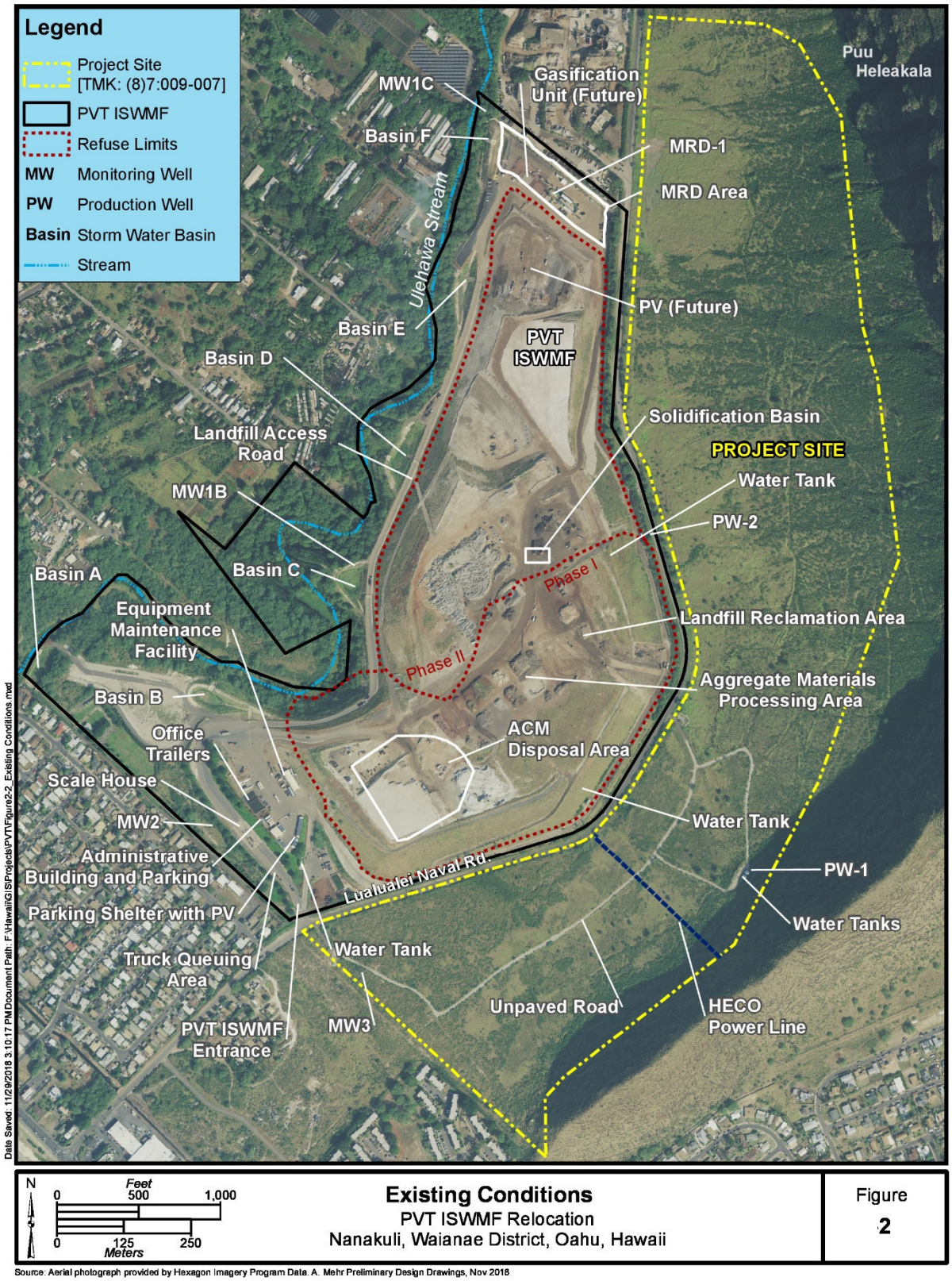

Figure 2. Existing PVT ISWMF Site Plan

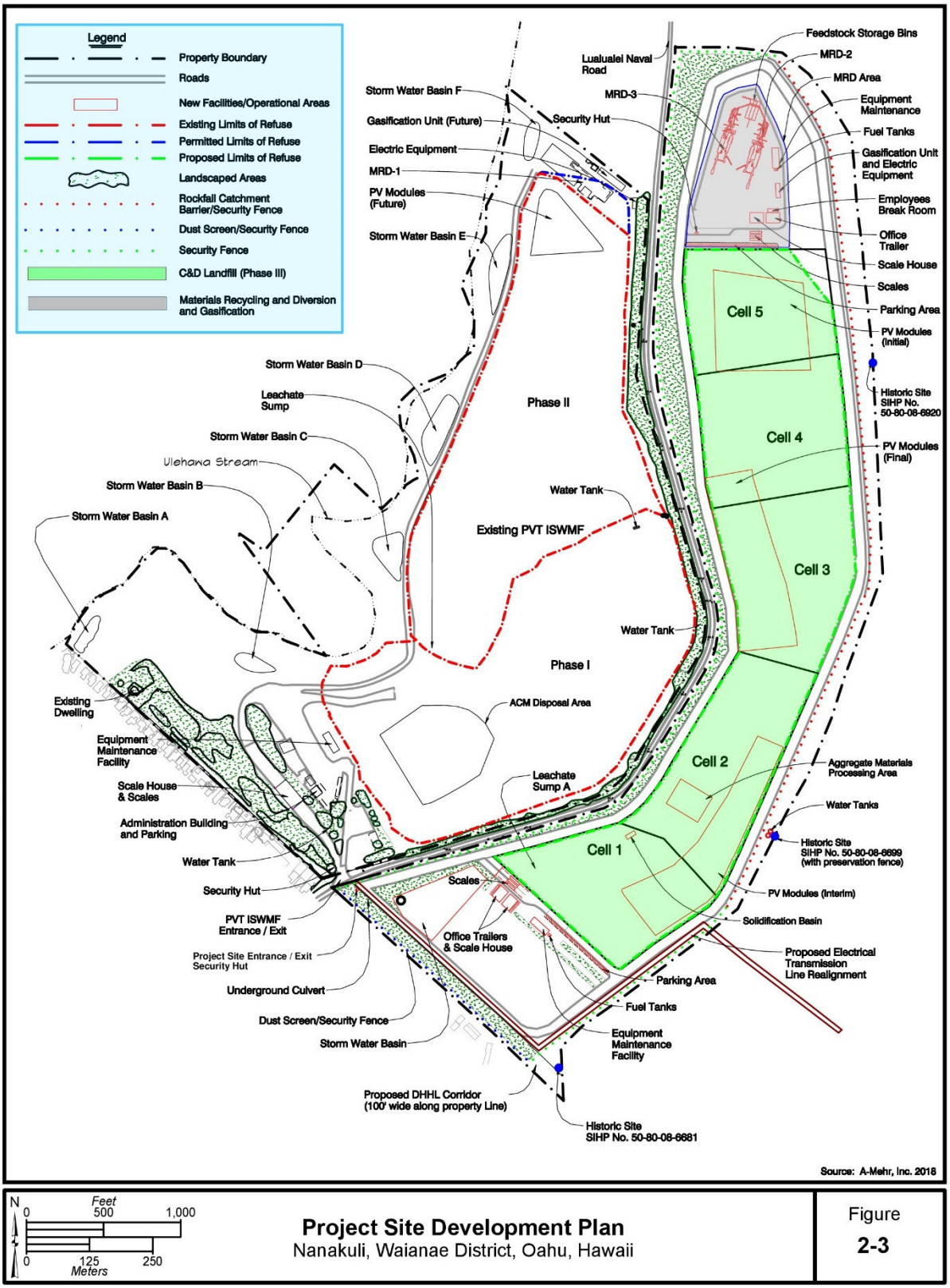

Figure 3. Proposed PVT ISWMF Relocation Site Plan

B. Purpose and Scope of the Study

The purpose of this study is to analyze the transportation impacts resulting from the proposed action at the PVT Integrated Solid Waste Management Facility. This report presents the findings and recommendations of the study, the scope of which includes:

1. Description of the proposed action.
2. Evaluation of existing roadways and traffic conditions.
3. Analysis of the Year 2030 traffic conditions without the proposed action.
4. Development of trip generation characteristics of the proposed action.
5. Identification and analysis of the transportation impacts resulting from the proposed action.
6. Recommendations of improvements that would mitigate the transportation impacts identified in this study.

C. Methodologies

1. Capacity Analysis Methodology

The highway capacity analysis, performed in this study, is based upon procedures presented in the Highway Capacity Manual 6th Edition (HCM), published by the Transportation Research Board. HCM defines the Level of Service (LOS) as "a quantitative stratification of a performance measure or measures representing quality of service." HCM defines the six (6) Levels of Service from the traveler's perspective, ranging from the best LOS "A" to the worst LOS "F". LOS translates the complex mathematical results of highway capacity analysis into an A through F grading system for the purpose of simplifying the roadway performance for the decision makers.

LOS's "A", "B", and "C" are considered satisfactory Levels of Service. LOS "D" is generally considered a "desirable minimum" operating Level of Service. LOS's "E" and "F" are undesirable conditions. Intersection LOS is primarily based upon average delay (d) in seconds per vehicle (sec/veh). The delays at unsignalized intersections, which includes stop-controlled intersections and roundabouts, are generally longer than signalized intersections, due to the drivers' expectation and acceptance of longer delays at higher-volume signalized intersections. Table 1 summarizes the LOS criteria.

Table 1. Intersection Level of Service Criteria (HCM)			
LOS	**Signalized Control**	**Unsignalized Control**	**Description**
A	d≤10	d≤10	Control delay is minimal.
B	10<d ≤20	10<d≤15	Control delay is not significant.
C	20<d≤35	15<d≤25	Stable operation. Queuing begins to occur.
D	35<d≤55	25<d≤35	Less stable condition. Increase in delays, decrease in travel speeds.
E	55<d≤80	35<d≤50	Unstable operation, significant delays.
F	d>80	d>50	High delays, extensive queuing.

The "volume-to-capacity" ratio (v/c) is a measure, which indicates the relative traffic demand to the roadway's carrying capacity. HCM defines capacity as the maximum number of vehicles that can pass a given point during a specified period under prevailing roadway conditions. A v/c ratio of 0.50 indicates that the traffic demand is utilizing 50 percent of the roadway's capacity.

HCM utilizes a peak hour factor (PHF) to convert the peak 15-minute traffic into an hourly volume. For the purpose of this study, the peak hour traffic analysis is based directly upon the peak 15-minute traffic flows entering the study intersection, which is multiplied by four (4) to convert the 15-minute peak volumes into the peak hour volumes.

Synchro is a traffic analysis software that was developed by Trafficware Corporation. Synchro is an intersection analysis program that is based upon HCM methodology. Synchro was used to calculate the Levels of Service, v/c ratios, and the delays at the intersections in the study area. Worksheets for the capacity analysis, performed throughout this study, are compiled in the Appendix.

2. Trip Generation Methodology

The trip generation methodology is based upon generally accepted techniques developed by the Institute of Transportation Engineers (ITE) and published in Trip Generation.

Site-specific trip generation rates were developed from the existing PVT Integrated Solid Waste Management Facility in Nanakuli, Hawaii. The site-specific trip generation rates were developed by correlating the total vehicle trip generation data with the number of employees, i.e., vehicle trips per hour (vph) per employee. The trip generation characteristics for the proposed action are based upon the site-specific trip rates.

3. Pedestrian, Bicycle, and Transit Methodologies

The field investigation indicated that the pedestrian traffic to and from the PVT ISWMF was minimal. It was assumed that the pedestrian traffic between the PVT ISWMF and TheBus stops indicated low transit usage, as well. Bicycle traffic to and from the PVT ISWMF also was minimal. The expected use of the non-automobile modes of travel are not expected to be significant. Therefore, this Transportation Impact Analysis Report does not include a multi-modal capacity analysis.

II. Existing Conditions

A. Roadways

Farrington Highway is the primary arterial highway on the Leeward coast of Oahu, which carries about 50,000 vehicles per day, total for both directions. Farrington Highway is a two-way, four-lane highway, which is generally oriented in the north-south directions. Paved shoulders and/or sidewalks are provided on both sides of Farrington Highway for pedestrians and bicycles. An exclusive left-turn lane is not provided on southbound Farrington Highway at Lualualei Naval Road. The posted speed on Farrington Highway is 35 miles per hour (mph) in the vicinity of the project.

Lualualei Naval Road is a two-lane, two-way roadway, which provides access to the U. S. Navy Radio Transmitter Facility in Lualualei. Lualualei Naval Road is signalized at its Tee-intersection with Farrington Highway. The Lualualei Naval Road approach at Farrington Highway provides separate left-turn and right-turn lanes. An unpaved shoulder is provided on the north side of Lualualei Naval Road for pedestrians. The posted speed on Lualualei Naval Road varies between 25 mph and 45 mph.

The PVT ISWMF Access Driveway is stop-controlled at its Tee-intersection with Lualualei Naval Road.

Princess Kahanu Avenue is a two-way, two-lane roadway, which provides access to the Princess Kahanu Estate subdivision. Princess Kahanu Avenue is signalized at its four-legged intersection, opposite the Ulehawa Beach Park Driveway, with Farrington Highway. The Princess Kahanu Avenue approach at Farrington Highway operates with a shared left-turn/through lane and an exclusive right-turn lane. Exclusive left-turn lanes are provided in both directions on Farrington Highway at Princess Kahanu Avenue.

Haleakala Avenue is a two-way, two-lane collector roadway, which provides access to Nanakuli. Southbound Farrington Highway was recently widened to provide an exclusive left-turn lane at Haleakala Avenue. Haleakala Avenue is signalized at its Tee-intersection with Farrington Highway. The Haleakala Avenue approach at Farrington Highway operates with separate left-turn and right-turn lanes.

Nanakuli Avenue is a two-way, two-lane collector roadway, which also provides access to Nanakuli. Farrington Highway was also widened to provide exclusive left-turn lanes in both directions at Nanakuli Avenue. Nanakuli Avenue is signalized at its four-legged

intersection with Farrington Highway, opposite the Nanakuli Beach Park Driveway. The Nanakuli Avenue approach at Farrington Highway operates with separate left-turn and right-turn lanes.

B. Public Transit

TheBus stops are located on both sides of Farrington Highway at Lualualei Naval Road. TheBus Routes 40, C, 403, and 93 provide transit service to Nanakuli.

C. Existing Traffic Volumes and Operating Conditions

1. Field Investigation and Data Collection

Turning movement traffic count surveys were conducted during the AM and PM peak periods of traffic, on September 4-7, 2018 along Farrington Highway at the following intersections:

- Farrington Highway and Lualualei Naval Road
- Farrington Highway and Princess Kahanu Avenue
- Farrington Highway and Haleakala Avenue
- Farrington Highway and Nanakuli Avenue

Peak period turning movement traffic count surveys were conducted at the PVT Driveway on Lualualei Naval Road. Pedestrian and bicycle traffic count surveys also were conducted on the PVT Driveway during the peak periods of traffic. A vehicle-type classification survey was conducted at the existing PVT Driveway from 5:00 AM to 6:00 PM. The traffic data are presented in the Appendix.

2. Existing AM Peak Hour Traffic

The AM peak hour of traffic on Farrington Highway varied between 7:00 AM to 8:45 AM. Farrington Highway carried between 2,900 and 3,300 vehicles per hour (vph), total for both directions. The AM peak direction of traffic on Farrington Highway was southbound (60 percent). Lualualei Naval Road carried a total of about 400 vph at Farrington Highway, during the existing AM peak hour of traffic. At the project site, the traffic volume on Lualualei Naval Road decreased to 135 vph. Princess Kahanu Avenue carried about 230 vph, during the existing AM peak hour of traffic. Haleakala Avenue carried 760 vph, while Nanakuli Avenue carried about 600 vph, total for both directions.

The intersection of Farrington Highway and Lualualei Naval Road operated at an overall Level of Service “C”, during the existing AM peak hour of traffic. Southbound Farrington Highway at Lualualei Naval Road operated at LOS “D”. The left-turn movement from Lualualei Naval Road onto Farrington Highway operated at LOS “F”. The other traffic movements at the intersection operated at satisfactory Levels of Service, i.e., LOS “C” or better.

The PVT Driveway operated at LOS "A" at Lualualei Naval Road. The PVT ISWMF generated a total of 85 vph, which included 67 trucks, during the existing AM peak hour of traffic. Three (3) pedestrians and zero (0) bicycles entered the PVT site, during the existing AM peak period of traffic. Zero (0) pedestrians and bicycles exited the PVT site, during the AM peak period of traffic.

The intersection of Farrington Highway and Princess Kahanu Avenue operated at LOS "B". Princess Kahanu Avenue operated at LOS "F". The Ulehawa Beach Park Driveway operated at LOS "D". The other traffic movements at the intersection operated at satisfactory Levels of Service.

During the existing AM peak hour of traffic, Farrington Highway and Haleakala Avenue operated at LOS "C". The left-turn and right-turn movements on Haleakala Avenue operated at LOS "F" and LOS "E", respectively. The other traffic movements at the intersection operated at satisfactory Levels of Service.

The Nanakuli Avenue intersection at Farrington Highway operated at LOS "D". Both approaches of Nanakuli Avenue operated at LOS "F" at Farrington Highway. The other traffic movements operated at satisfactory Levels of Service. Figure 4 depicts the existing AM peak hour traffic volumes.

3. Existing PM Peak Hour Traffic

The median lane on Farrington Highway was coned to provide a contra-flow lane in the northbound direction between 3:30 PM and 6:30 PM from Nanakuli Avenue to Haleakala Avenue. During the contra-flow operation, the left-turn movements from Farrington Highway were prohibited.

The PM peak hour of traffic varied between 3:00 PM and 4:45 PM. Farrington Highway carried between 3,000 vph and 3,200 vph, total for both directions. The PM peak direction of traffic on Farrington Highway was northbound (56 percent). Lualualei Naval Road carried about 400 vph, during the existing PM peak hour of traffic. At the project site, the traffic volume on Lualualei Naval Road decreased to about 130 vph. Princess Kahanu Avenue carried over 200 vph, during the existing PM peak hour of traffic. Haleakala Avenue carried about 350 vph, while Nanakuli Avenue carried about 500 vph, total for both directions.

During the existing PM peak hour of traffic, the intersection of Farrington Highway and Lualualei Naval Road operated at an overall LOS "B". The Lualualei Naval Road approach operated at LOS "F" at Farrington Highway. The other traffic movements at the intersection operated at satisfactory Levels of Service.

The PVT Driveway operated at LOS "A". The PVT ISWMF generated a total of 65 vph, which included six (6) trucks, during the existing PM peak hour of traffic. Two (2) pedestrians and zero (0) bicycles exited the PVT site, during the existing PM peak period of traffic. Zero (0) pedestrians and bicycles entered the PVT site, during the PM peak period of traffic.

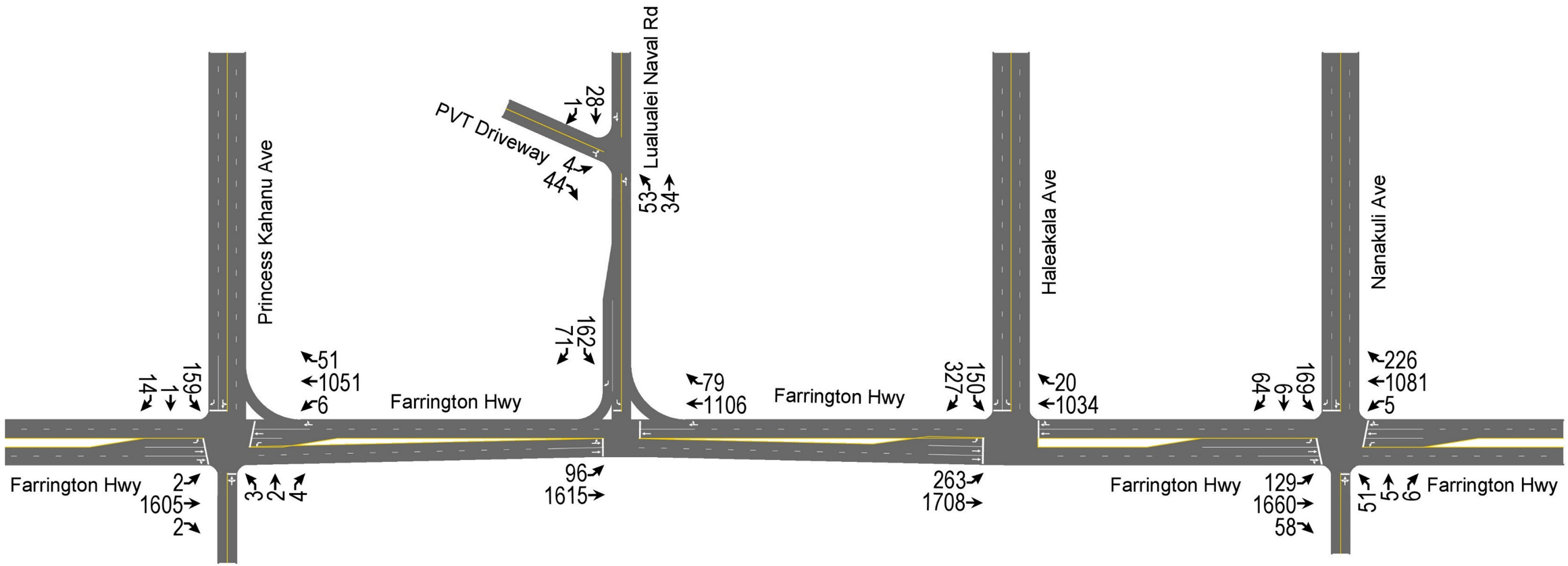

Figure 4. Existing AM Peak Hour Traffic

The intersection of Farrington Highway and Princess Kahanu Avenue operated at LOS "A". Princess Kahanu Avenue operated at LOS "F". The other traffic movements at the intersection operated at satisfactory Levels of Service.

Farrington Highway and Haleakala Avenue operated at LOS "A", during the existing PM peak hour of traffic. The left-turn movement from Haleakala Avenue onto Farrington Highway operated at LOS "F". The other traffic movements at the intersection operated at satisfactory Levels of Service.

The Nanakuli Avenue intersection at Farrington Highway operated at LOS "A". The makai bound approach of Nanakuli Avenue operated at LOS "F" at Farrington Highway. The other traffic movements at the intersection operated at satisfactory Levels of Service. The existing PM peak hour traffic volumes are depicted on Figure 5.

D. Existing Trip Generation

The existing peak hour trip generation characteristics for the PVT Integrated Solid Waste Management Facility are based upon the two-day average of peak hour traffic and the average of 57 employees, which were reported by PVT Land Company on the days of the field investigation. Table 2 summarizes the existing trip generation at the PVT Integrated Solid Waste Management Facility.

Table 2. Trip Generation Rates

Peak Hour	Trips/Trip Rates	Enter	Exit	Total
AM	**Vehicle Trips**	46	39	85
	Observed Trips/Employee	0.81	0.68	1.48
PM	**Vehicle Trips**	12	56	68
	Observed Trips/Employee	0.20	0.98	1.18

Over the full workday, PVT ISWMF generated a total of 712 vehicle trip ends, i.e., vehicles entering and exiting the work site. About 62 percent of the site traffic consisted of trucks, i.e., 443 truck trips. About 75 percent of the truck traffic arrived and departed the PVT site during the off-peak period of traffic, i.e. 9:00 AM to 3:00 PM.

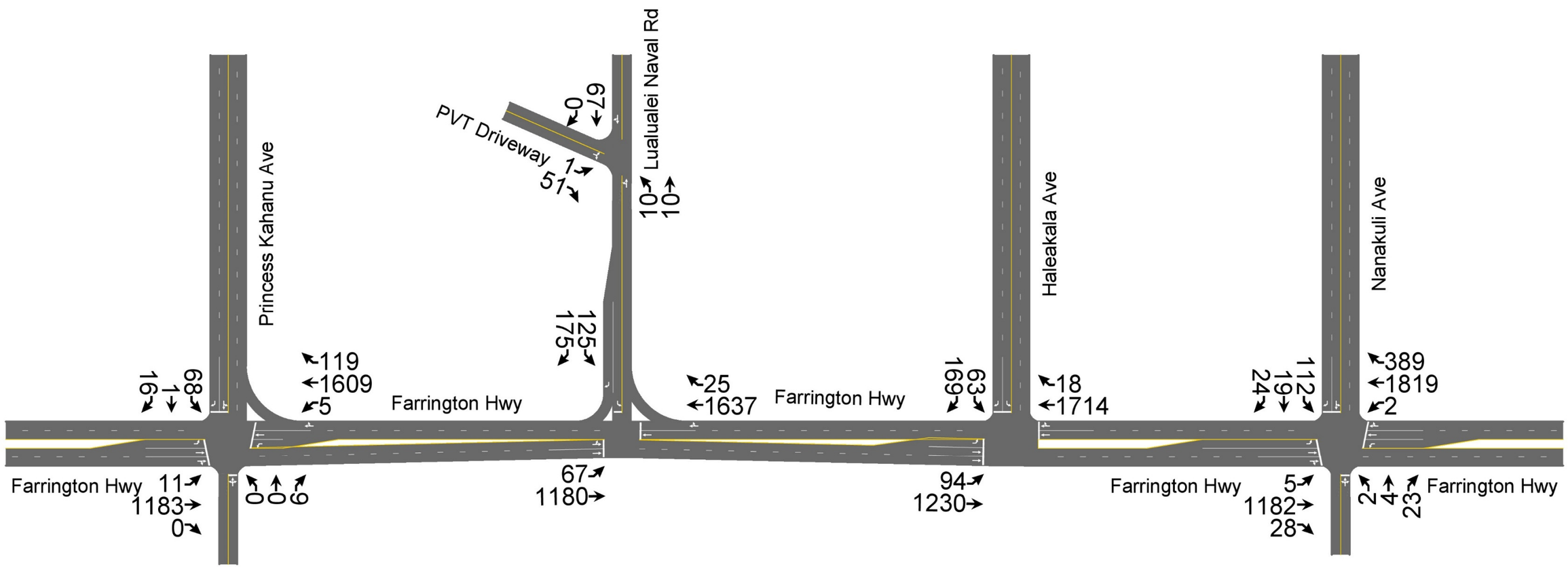

Figure 5. Existing PM Peak Hour Traffic

III. Future Traffic Conditions

A. Oahu Transportation Regional Plan

The Oahu Regional Transportation Plan (ORTP), was prepared for the Oahu Metropolitan Planning Organization (OMPO). The ORTP socio-economic forecasts estimated about a 0.6 percent annual increase in population on the Waianae coast. Based upon the ORTP population forecast, an annual growth in traffic of 0.6 percent was uniformly applied to the existing peak hour traffic to estimate the Year 2030 peak hour traffic demands without the proposed action.

B. Site Traffic Without Proposed Action

Without the proposed action, the PVT ISWMF is expected to decrease from 80 employees to 57 employees. The truck traffic volumes also are expected to decrease by 50 percent to 150 trucks per day, without the proposed action.

C. Year 2030 AM Peak Hour Traffic Analysis Without Proposed Action

The intersection of Farrington Highway and Lualualei Naval Road is expected to operate at an overall Level of Service "D", during the AM peak hour of traffic without the proposed action. Southbound Farrington Highway at Lualualei Naval Road is expected to operate at LOS "E". The left-turn movement from Lualualei Naval Road onto Farrington Highway is expected to operate at LOS "F". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service.

The PVT Driveway is expected to operate at LOS "A" at Lualualei Naval Road, during the AM peak hour of traffic without the proposed action.

During the AM peak hour without the proposed action, the intersection of Farrington Highway and Princess Kahanu Avenue is expected to operate at LOS "B". Princess Kahanu Avenue is expected to operate at LOS "F". The Ulehawa Beach Park Driveway is expected to operate at LOS "D". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service.

Farrington Highway and Haleakala Avenue is expected to operate at LOS "D", during the AM peak hour of traffic without the proposed action. The through movement on southbound Farrington Highway is expected to operate at LOS "D", The left-turn and right-turn movements on Haleakala Avenue are expected to continue to operate at LOS "F" and LOS "E", respectively.

The Nanakuli Avenue intersection at Farrington Highway is expected to operate at LOS "D". Both approaches of Nanakuli Avenue are expected to operate at LOS "F" at Farrington Highway. The other traffic movements are expected to operate at satisfactory Levels of Service. Figure 6 depicts the AM peak hour traffic without the proposed action.

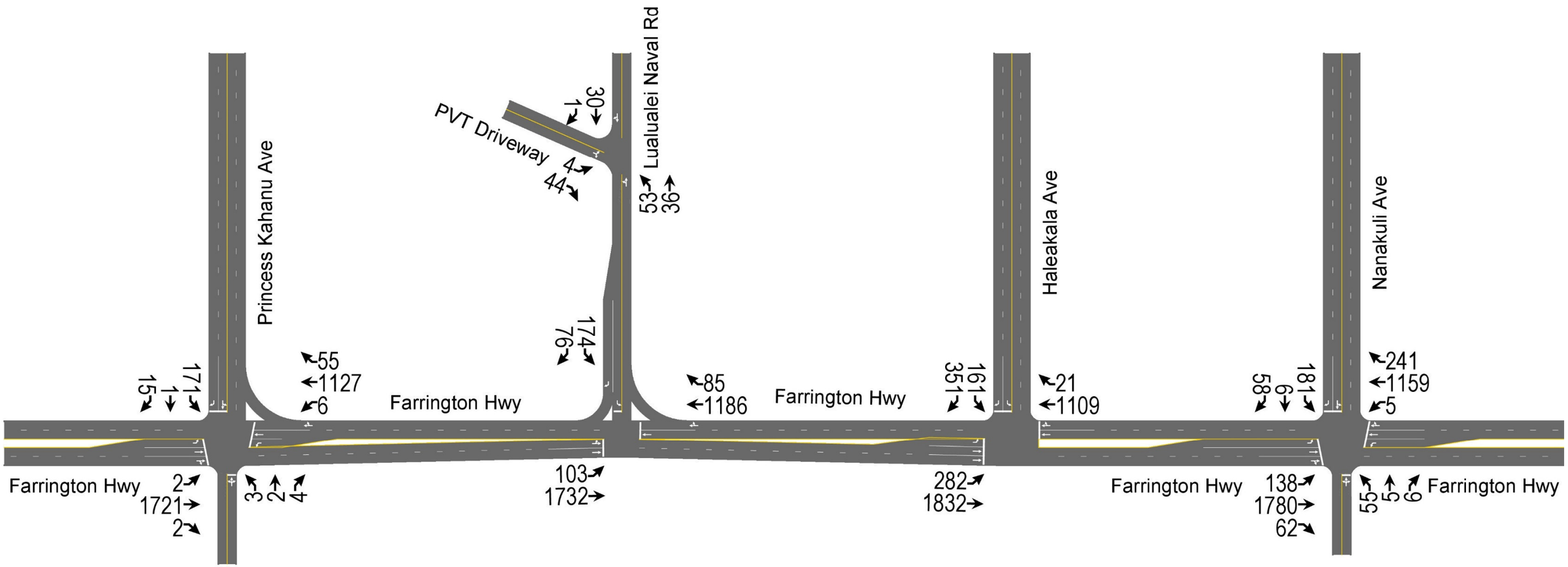

Figure 6. AM Peak Hour Traffic Without Proposed Action

D. Year 2030 PM Peak Hour Traffic Analysis Without Proposed Action

During the PM peak hour of traffic without the proposed action, the intersection of Farrington Highway and Lualualei Naval Road is expected to operate at an overall LOS "C". Lualualei Naval Road is expected to operate at LOS "F" at Farrington Highway. The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service.

The PVT Driveway is expected to operate at LOS "A" at Lualualei Naval Road, during the PM peak hour of traffic without the proposed action.

The intersection of Farrington Highway and Princess Kahanu Avenue is expected to operate at LOS "B". Princess Kahanu Avenue is expected to operate at LOS "F". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service, during the PM peak hour of traffic without the proposed action..

The Farrington Highway and Haleakala Avenue intersection is expected to operate at LOS "A", during the PM peak hour of traffic without the proposed action. The left-turn movement from Haleakala Avenue onto Farrington Highway is expected to operate at LOS "F". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service.

The Nanakuli Avenue intersection at Farrington Highway is expected to operate at LOS "C". Makai bound Nanakuli Avenue is expected to operate at LOS "F" at Farrington Highway. The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service. The PM peak hour traffic without the proposed action at the PVT ISWMF is depicted on Figure 7.

IV. Transportation Impact Analysis

A. Site-Generated Traffic

Access to PVT ISWMF Relocation project site will provided by a driveway, which will be located immediately opposite the existing PVT Driveway on Lualualei Naval Road. The increase in site traffic is based upon the additional 23 employees, over the 57 employees without the proposed action. The truck traffic is expected to remain at the existing 300 trucks per day. Table 3 summarizes the PVT trip generation characteristics.

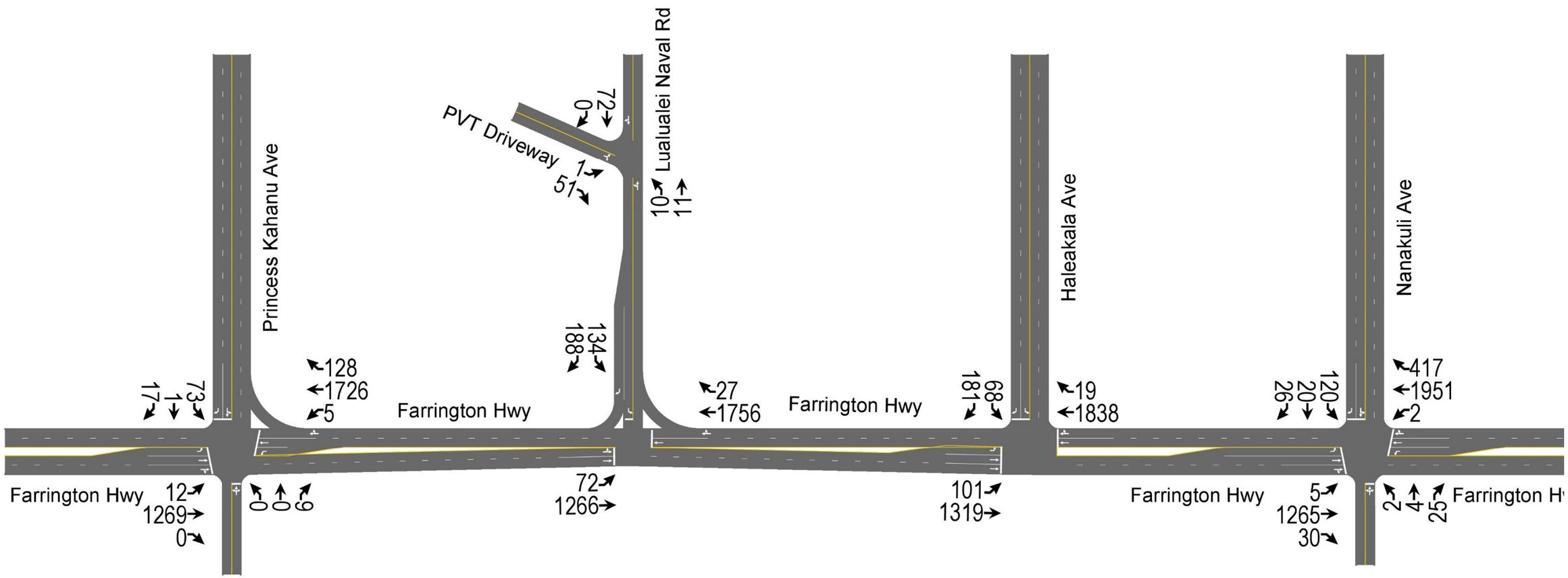

Figure 7. PM Peak Hour Traffic Without Proposed Action

Table 3. PVT Trip Generation Characteristics With Proposed Action				
Peak Hour	**Trips/Trip Rates**	**Enter**	**Exit**	**Total**
AM	**Vehicle Trips With Proposed Action**	73	64	137
	Vehicle Trips Without Proposed Action	54	48	102
	Increase in Trips With Proposed Action	19	16	35
PM	**Vehicle Trips With Proposed Action**	15	75	90
	Vehicle Trips Without Proposed Action	10	52	62
	Increase in Trips With Proposed Action	5	23	28

The traffic assignment is based upon the existing PVT employee distribution, as reported by PVT Land Company, i.e., 57 percent of the employees reside north of Lualualei Naval Road and 43 percent reside south of Lualualei Naval Road. Figures 8 and 9 depict the AM and PM peak hour site traffic assignments, respectively.

B. AM Peak Hour Transportation Impact Analysis With Proposed Action

The intersection of Farrington Highway and Lualualei Naval Road is expected to operate at an overall LOS "E", during the AM peak hour of traffic with the proposed action. Southbound Farrington Highway and the left-turn movement from Lualualei Naval Road are expected to operate at LOS "F". The other traffic movements at the intersection are expected to operate at the same Levels of Service as during the AM peak hour of traffic without the proposed action.

The PVT Driveway is expected to operate at LOS "B" at Lualualei Naval Road, during the AM peak hour of traffic with the proposed action.

Southbound Farrington Highway is expected to operate at LOS "E" at Haleakala Avenue. The other traffic movements at the intersection are expected to operate at the same Levels of Service as during the AM peak hour of traffic without the proposed action.

The other intersections in the study area are expected to operate at the same Levels of Service as during the AM peak hour of traffic without the proposed action. Figure 10 depicts the AM peak hour traffic with the proposed action at the PVT ISWMF.

C. PM Peak Hour Transportation Impact Analysis With Proposed Action

During the PM peak hour of traffic with the proposed action at the PVT ISWMF, the intersection of Farrington Highway and Lualualei Naval Road is expected to operate at LOS "C". Southbound Farrington Highway is expected to operate at LOS "D". The other traffic movements at the intersection are expected to operate at the same Levels of Service as during the PM peak hour of traffic without the proposed action.

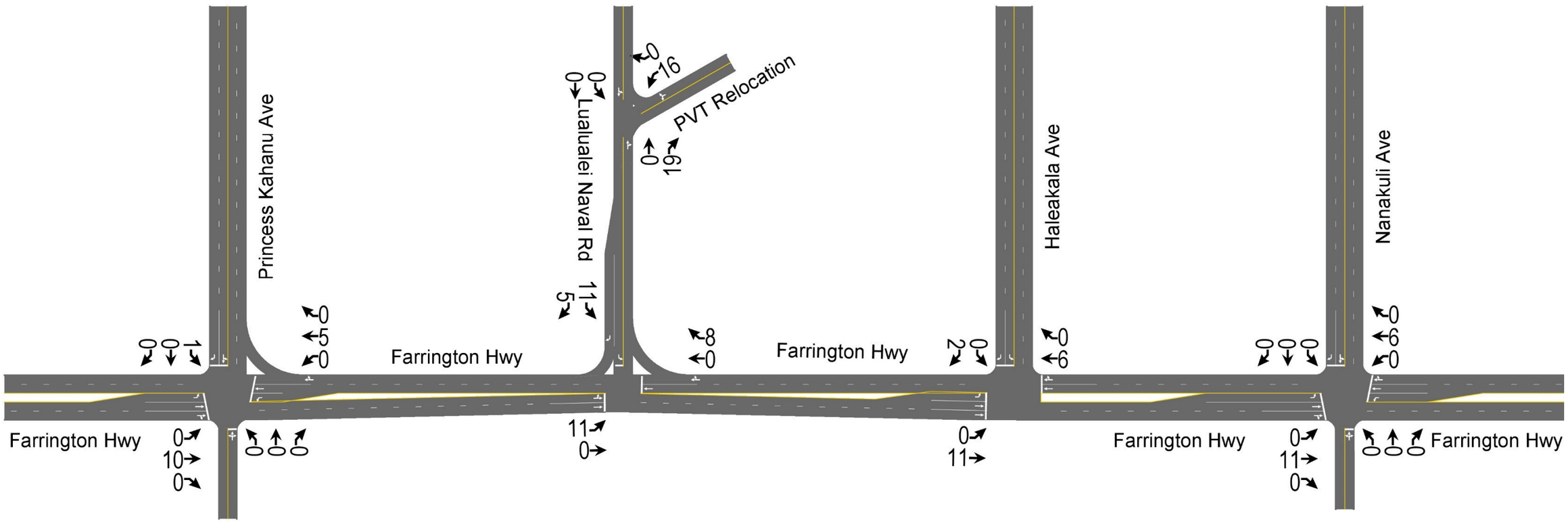

Figure 8. AM Peak Hour Site Traffic Assignment

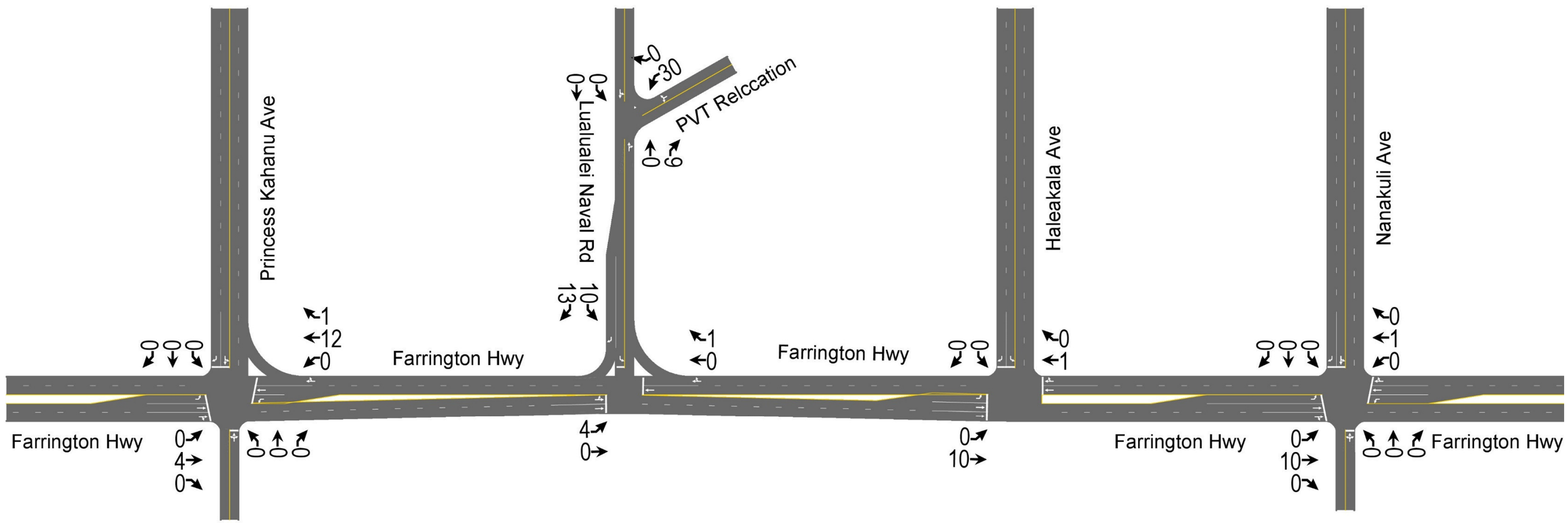

Figure 9. PM Peak Hour Site Traffic Assignment

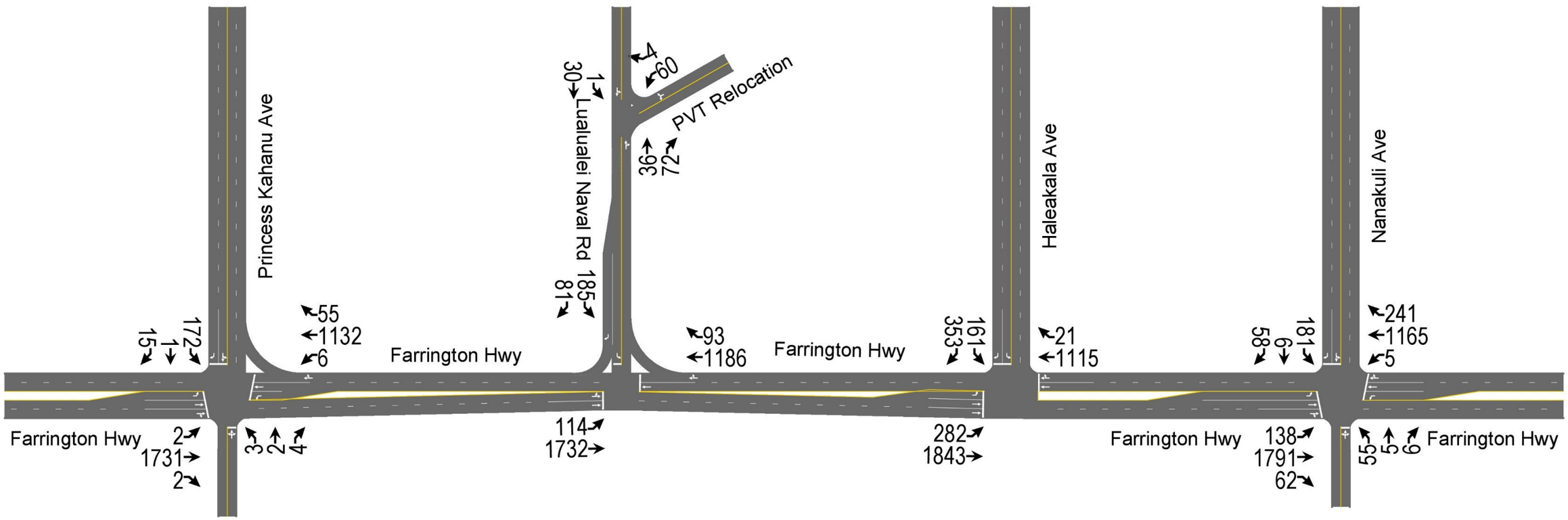

Figure 10. AM Peak Hour Traffic With Proposed Action

The other intersections in the study area are expected to operate at the same Levels of Service as during the PM peak hour of traffic without the proposed action. The PM peak hour traffic with the proposed action at the PVT ISWMF is depicted on Figure 11.

V. Recommendations and Conclusions

A. Recommendations Without the Proposed Action

The following traffic improvements are recommended at the intersection of Farrington Highway and Lualualei Naval Road, without the proposed action, to mitigate the existing traffic congestion:

1. Widen southbound Farrington Highway at Lualualei Naval Road to provide an exclusive left-turn storage lane (minimum 125-foot storage length).
2. Modify traffic signal timing at the intersection of Farrington Highway and Lualualei Naval Road, as necessary.
3. Modify the traffic signal coordination along Farrington Highway, as necessary.

B. Recommendations With the Proposed Action

The recommendations in the previous section are expected to improve the AM peak hour traffic operations with the proposed action at the intersection of Farrington Highway and Lualualei Naval Road from LOS "E" to LOS "B". Southbound Farrington Highway is expected to improve from LOS "F" to LOS "A" by providing an exclusive left-turn storage lane, which will prevent the left-turn queue from blocking the through traffic lane.

During the PM peak hour of traffic with the proposed action, the aforementioned improvements at the intersection of Farrington Highway and Lualualei Naval Road are expected to improve traffic operations from LOS "C" to LOS "B". Southbound Farrington Highway is expected to improve from LOS "D" to LOS "A". Additional traffic mitigation measures are <u>not</u> recommended at this time.

C. Conclusions

The existing traffic congestion at the intersection of Farrington Highway and Lualualei Naval Road is a result of the traffic turning left from the shared through/left-turn lane on southbound Farrington Highway into Lualualei Naval Road. The left-turn movement reduces the through capacity of southbound Farrington Highway to a single lane, resulting in LOS "E" conditions, during the existing AM peak hour of traffic.

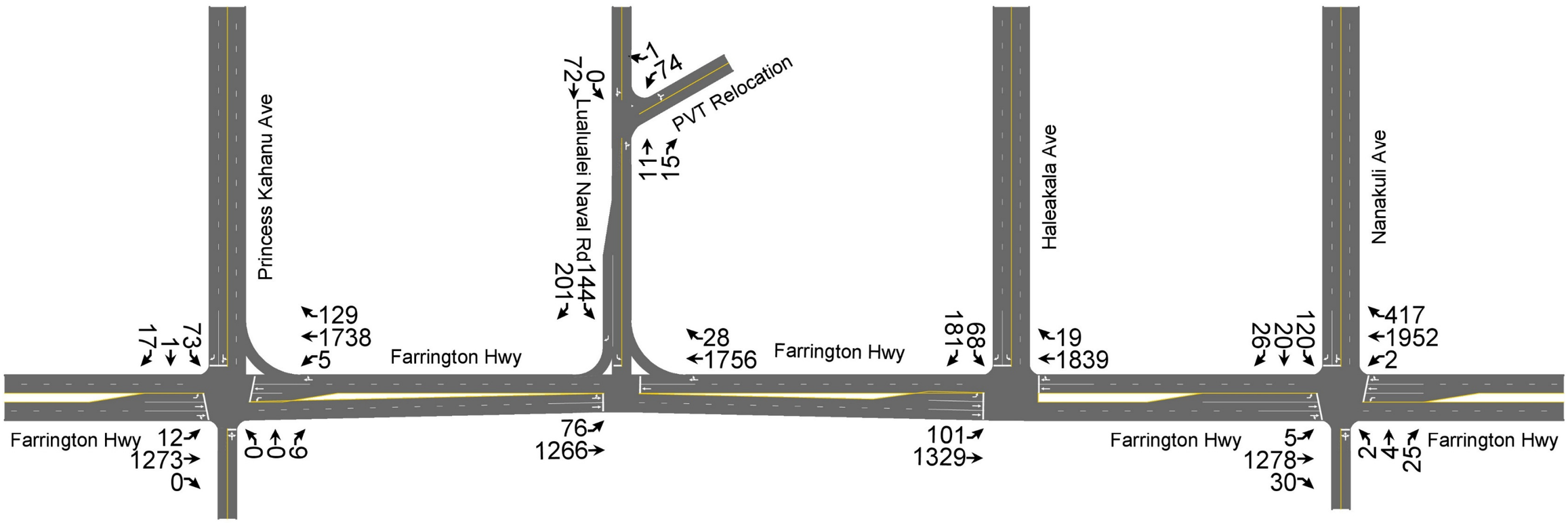

Figure 11. PM Peak Hour Traffic With Proposed Action

The trip generation for the proposed relocation of the PVT ISWMF is expected to increase the existing site trips by 35 vph and 28 vph, during the AM and PM peak hours of traffic, respectively.

The proposed action at the PVT Integrated Solid Waste Management Facility is expected to increase the traffic at the intersection of Farrington Highway and Lualualei Naval Road by about 1.0 and 0.8 percent, during the AM and PM peak hours of traffic, respectively. Beyond the Lualualei Naval Road intersection, the site-generated traffic is expected to increase peak hour traffic at the study intersections along Farrington Highway by 0.5 percent or less.

ITE suggested thresholds for requiring traffic access and impact studies, which were published in Traffic Access and Impact Studies for Site Development, A Recommended Practice, 1991. The ITE thresholds for traffic studies are 100 vph increase in the peak direction of peak hour traffic or a five (5) percent increase in traffic demands over prevailing traffic conditions. The increase of 35 vph in trip generation from the proposed relocation of the PVT ISWMF and the relative increase in traffic demands of 1.0 percent in the study area are well below the ITE thresholds. The traffic improvements, recommended herein, are expected to mitigate the transportation impacts of the proposed PVT Integrated Solid Waste Management Facility Relocation. Table 4 summarizes the Level of Service analysis for the intersections in study area.

Table 4. Summary of Capacity Analysis

Scenario	Intersection	MOE	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Intersection
Existing AM Peak Hour Traffic	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	B	N/A	A		D		N/A	C
		Delay	N/A	N/A	N/A	136.9	N/A	15.9	N/A	4.7		40.8		N/A	31.0
		v/c	N/A	N/A	N/A	0.83	N/A	0.37	N/A	0.44		0.99		N/A	0.99 (max.)
	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	D			F		A	A	A		A	B		B
		Delay	51.6			134.8		4.3	3.0	3.4		6.0	13.5		16.3
		v/c	0.07			0.85		0.07	0.02	0.41		0.00	0.66		0.85 (max.)
	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	E	N/A	B		A	B	N/A	C
		Delay	N/A	N/A	N/A	99.0	N/A	71.2	N/A	14.6		9.7	16.8	N/A	25.9
		v/c	N/A	N/A	N/A	0.63	N/A	0.93	N/A	0.47		0.53	0.70	N/A	0.93 (max.)
	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	F			F		B	A	B		A	A		D
		Delay	551.8			207.2		19.8	3.8	11.0		4.7	6.6		34.9
		v/c	2.00			1.17		0.23	0.02	0.52		0.43	0.66		2.00 (max.)
	Lualualei Naval Rd & PVT ISWMF	LOS	A	A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	N/A	A	A
		Delay	8.2	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.9	N/A	9.9	5.7
		v/c	0.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.08	N/A	0.08	N/A
Existing PM Peak Hour Traffic	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	F	N/A	A		B		N/A	B
		Delay	N/A	N/A	N/A	120.9	N/A	98.3	N/A	5.2		15.7		N/A	18.9
		v/c	N/A	N/A	N/A	0.69	N/A	0.85	N/A	0.59		0.83		N/A	0.85 (max.)
	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	A			F		B	A	B		A	A		A
		Delay	0.4			142.5		16.7	2.8	11.3		3.7	5.0		8.8
		v/c	0.04			0.73		0.15	0.01	0.65		0.12	0.45		0.73 (max.)
	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	C	N/A	A		A	A	N/A	A
		Delay	N/A	N/A	N/A	134.6	N/A	28.9	N/A	2.4		6.4	2.3	N/A	5.5
		v/c	N/A	N/A	N/A	0.58	N/A	0.64	N/A	0.58		0.54	0.47	N/A	0.64 (max.)
	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	C			F		C	A			A			A
		Delay	28.9			151.8		30.6	6.2			2.9			2.4
		v/c	0.21			0.85		0.12	0.62			0.48			0.85 (max.)
	Lualualei Naval Rd & PVT ISWMF	LOS	A	A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	N/A	A	A
		Delay	7.5	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.1	N/A	9.1	2.4
		v/c	0.01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04	N/A	0.04	N/A

Table 4. Summary of Capacity Analysis (Cont'd.)

Scenario	Intersection	MOE	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Intersection
AM Peak Hour Traffic Without the Proposed Action	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	B	N/A	A		E		N/A	D
		Delay	N/A	N/A	N/A	135.9	N/A	15.0	N/A	5.3		77.3		N/A	51.8
		v/c	N/A	N/A	N/A	0.84	N/A	0.37	N/A	0.48		1.12		N/A	1.11 (max.)
AM Peak Hour Traffic Without Project	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	D			F		A	A	A		A	B		B
		Delay	50.2			133.6		4.9	3.0	3.5		7.0	16.1		17.8
		v/c	0.06			0.86		0.07	0.02	0.44		0.00	0.71		0.86 (max.)
AM Peak Hour Traffic Without the Proposed Action	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	E	N/A	B		B	D	N/A	D
		Delay	N/A	N/A	N/A	90.9	N/A	74.8	N/A	19.0		11.5	54.2	N/A	45.7
		v/c	N/A	N/A	N/A	0.57	N/A	0.94	N/A	0.53		0.63	0.78	N/A	0.94 (max.)
AM Peak Hour Traffic Without the Proposed Action	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	F			F		B	A	B		A	A		D
		Delay	831.6			225.6		16.8	3.8	11.8		5.4	5.4		43.7
		v/c	2.64			1.24		0.21	0.03	0.56		0.50	0.70		2.64 (max.)
AM Peak Hour Traffic Without the Proposed Action	Lualualei Naval Rd & PVT ISWMF	LOS	A	A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	B	N/A	B	A
		Delay	9.6	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14.7	N/A	14.7	8.7
		v/c	0.33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14	N/A	0.14	N/A
PM Peak Hour Traffic Without the Proposed Action	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	F	N/A	A		C		N/A	C
		Delay	N/A	N/A	N/A	113.4	N/A	104.8	N/A	6.8		31.5		N/A	26.3
		v/c	N/A	N/A	N/A	0.65	N/A	0.87	N/A	0.65		0.96		N/A	0.96 (max.)
PM Peak Hour Traffic Without Project	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	A			F		B	A	A		A	A		A
		Delay	0.4			142.1		18.8	2.5	7.0		4.5	5.7		9.8
		v/c	0.04			0.75		0.16	0.01	0.69		0.15	0.48		0.75 (max.)
PM Peak Hour Traffic Without the Proposed Action	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	C	N/A	A		B	A	N/A	A
		Delay	N/A	N/A	N/A	135.0	N/A	27.9	N/A	3.2		14.2	2.7	N/A	6.3
		v/c	N/A	N/A	N/A	0.60	N/A	0.65	N/A	0.63		0.63	0.50	N/A	0.65 (max.)
PM Peak Hour Traffic Without the Proposed Action	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	C			F		C	C			A			C
		Delay	27.4			156.0		30.0	23.2			2.6			20.1
		v/c	0.22			0.89		0.13	0.94			0.36			0.94 (max.)
PM Peak Hour Traffic Without the Proposed Action	Lualualei Naval Rd & PVT ISWMF	LOS	A	A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	N/A	A	A
		Delay	7.5	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.1	N/A	9.1	2.3
		v/c	0.01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04	N/A	0.04	N/A

Table 4. Summary of Capacity Analysis (Cont'd.)

Scenario	Intersection	MOE	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Intersection
AM Peak Hour Traffic With the Proposed Action	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	B	N/A	A		F		N/A	E
		Delay	N/A	N/A	N/A	134.8	N/A	14.4	N/A	5.6		95.7		N/A	62.2
		v/c	N/A	N/A	N/A	0.85	N/A	0.38	N/A	0.49		1.16		N/A	1.16 (max.)
AM Peak Hour Traffic With the Proposed Action	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	D			F		A	A	A		A	B		B
		Delay	50.1			133.5		4.9	3.3	3.5		7.0	16.6		18.1
		v/c	0.06			0.86		0.07	0.02	0.45		0.00	0.72		0.86 (max.)
AM Peak Hour Traffic With the Proposed Action	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	E	N/A	B		B	E	N/A	D
		Delay	N/A	N/A	N/A	89.7	N/A	75.2	N/A	19.4		10.3	64.5	N/A	50.9
		v/c	N/A	N/A	N/A	0.56	N/A	0.94	N/A	0.54		0.63	0.78	N/A	0.94 (max.)
AM Peak Hour Traffic With the Proposed Action	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	F			F		B	A	B		A	A		D
		Delay	831.6			225.6		16.8	3.8	11.9		5.4	5.4		43.5
		v/c	2.64			1.24		0.21	0.03	0.56		0.50	0.71		2.64 (max.)
AM Peak Hour Traffic With the Proposed Action	Lualualei Naval Rd & PVT ISWMF	LOS	N/A	N/A	N/A	A	A	N/A	B	N/A	B	N/A	N/A	N/A	A
		Delay	N/A	N/A	N/A	8.5	0.0	N/A	10.5	N/A	10.5	N/A	N/A	N/A	3.4
		v/c	N/A	N/A	N/A	N/A	N/A	N/A	0.09	N/A	0.09	N/A	N/A	N/A	N/A
PM Peak Hour Traffic With the Proposed Action	Farrington Hwy & Lualualei Naval Rd	LOS	N/A	N/A	N/A	F	N/A	F	A	A		D		N/A	C
		Delay	N/A	N/A	N/A	110.6	N/A	105.4	0.0	7.3		40.6		N/A	30.8
		v/c	N/A	N/A	N/A	0.64	N/A	0.87	0.00	0.66		0.99		N/A	0.99 (max.)
PM Peak Hour Traffic With the Proposed Action	Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave	LOS	A			F		B	A	A		A	A		A
		Delay	0.4			142.1		18.8	2.5	6.9		4.5	5.8		9.7
		v/c	0.04			0.75		0.16	0.01	0.70		0.15	0.48		0.75 (max.)
PM Peak Hour Traffic With the Proposed Action	Farrington Highway/Farrington Hwy & Haleakala Ave	LOS	N/A	N/A	N/A	F	N/A	C	N/A	A		B	A	N/A	A
		Delay	N/A	N/A	N/A	135.0	N/A	27.9	N/A	3.2		14.1	2.8	N/A	6.3
		v/c	N/A	N/A	N/A	0.60	N/A	0.65	N/A	0.63		0.63	0.51	N/A	0.65 (max.)
PM Peak Hour Traffic With the Proposed Action	Farrington Highway & Nanakuli Beach Park/Nanakuli Ave	LOS	C			F		C	C			A			C
		Delay	27.4			156.0		30.0	23.2			4.8			20.0
		v/c	0.22			0.89		0.13	0.94			0.37			0.94 (max.)
PM Peak Hour Traffic With the Proposed Action	Lualualei Naval Rd & PVT ISWMF	LOS	N/A	N/A	N/A	A	N/A	N/A	A	N/A	A	N/A	**N/A**	**N/A**	A
		Delay	N/A	N/A	N/A	0.0	N/A	N/A	9.3	N/A	9.3	N/A	N/A	N/A	2.2
		v/c	N/A	N/A	N/A	-	N/A	N/A	0.00	N/A	0.00	N/A	N/A	N/A	N/A

Table 4. Summary of Capacity Analysis (Cont'd.)

Scenario	Intersection	MOE	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Intersection
AM Peak Hour Traffic With the Proposed Action With Improvements	**Farrington Hwy & Lualualei Naval Rd**	**LOS**	N/A	N/A	N/A	F	N/A	B	N/A	B		A	A	N/A	B
		Delay	N/A	N/A	N/A	135.1	N/A	14.4	N/A	10.1		6.3	5.2	N/A	13.2
		v/c	N/A	N/A	N/A	0.85	N/A	0.38	N/A	0.53		0.45	0.66	N/A	0.85 (max.)
PM Peak Hour Traffic With the Proposed Action With Improvements	**Farrington Hwy & Lualualei Naval Rd**	**LOS**	N/A	N/A	N/A	F	N/A	E	N/A	A		B	A	N/A	B
		Delay	N/A	N/A	N/A	132.3	N/A	72.6	N/A	5.2		10.5	3.6	N/A	13.5
		v/c	N/A	N/A	N/A	0.79	N/A	0.82	N/A	0.68		0.43	0.51	N/A	0.82 (max.)

Legend

MOE–Measure of Effectiveness LOS –Level of Service Delay–Average Delay (seconds/vehicle) v/c–Volume-to-Capacity Ratio	EBL–Eastbound Left-Turn Movement EBT–Eastbound Through Movement EBR–Eastbound Right–Turn Movement	WBL–Westbound Left-Turn Movement WBT–Westbound Through Movement WBR–Westbound Right-Turn Movement	NBL–Northbound Left-Turn Movement NBT–Northbound Through Movement NBR–Northbound Right-Turn Movement	SBL–Southbound Left-Turn Movement SBT–Southbound Through Movement SBR–Southbound Right-Turn Movement

References

1. Highway Capacity Manual, 6th Edition, Transportation Research Board of the National Academies, Washington D.C.
2. Trip Generation An ITE Informational Report, 10th Edition, Institute of Transportation Engineers, Washington, D.C.
3. Oahu Regional Transportation Plan, Oahu Metropolitan Planning Organization.
4. Traffic Access and Impact Studies for Site Development, A Recommended Practice, 1991, Institute of Transportation Engineers, Washington, D.C.

TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

APPENDIX A

TRAFFIC COUNT DATA

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Data

Start Time	Beach Eastbound					Lualualei Naval Rd Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
2:00 PM	0	0	0	0	0	38	0	21	4	59	0	322	17	0	339	16	261	0	1	277	675
2:15 PM	0	0	0	0	0	43	0	26	0	69	0	401	16	0	417	32	312	0	0	344	830
2:30 PM	0	0	0	0	0	40	0	29	2	69	0	402	11	0	413	19	321	0	0	340	822
2:45 PM	0	0	0	0	0	46	0	30	3	76	0	365	7	0	372	13	329	0	0	342	790
Hourly Total	0	0	0	0	0	167	0	106	9	273	0	1490	51	0	1541	80	1223	0	1	1303	3117
3:00 PM	0	0	0	1	0	28	0	30	2	58	0	418	9	0	427	14	300	0	1	314	799
3:15 PM	0	0	0	0	0	30	0	48	1	78	0	412	9	0	421	18	336	0	0	354	853
3:30 PM	0	0	0	2	0	35	0	45	3	80	0	412	2	0	414	17	304	0	3	321	815
3:45 PM	0	0	0	0	0	32	0	52	1	84	0	395	5	0	400	18	240	0	0	258	742
Hourly Total	0	0	0	3	0	125	0	175	7	300	0	1637	25	0	1662	67	1180	0	4	1247	3209
4:00 PM	0	0	0	0	0	31	0	37	2	68	0	453	3	0	456	13	214	0	0	227	751
4:15 PM	0	0	0	0	0	24	0	25	5	49	0	400	3	0	403	12	239	0	0	251	703
4:30 PM	0	0	0	0	0	21	0	30	0	51	0	402	4	0	406	16	252	0	1	268	725
4:45 PM	0	0	0	0	0	13	0	30	2	43	0	435	5	0	440	19	262	0	0	281	764
Hourly Total	0	0	0	0	0	89	0	122	9	211	0	1690	15	0	1705	60	967	0	1	1027	2943
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3:00 PM	0	0	0	0	0	34	0	31	0	65	0	259	6	0	265	19	273	0	0	292	622
3:15 PM	0	0	0	0	0	28	0	29	0	57	0	245	11	0	256	33	320	0	0	353	666
3:30 PM	0	0	0	0	0	51	0	24	1	75	0	364	11	0	375	20	280	0	0	300	750
3:45 PM	0	0	0	0	0	21	0	50	0	71	0	418	4	0	422	15	250	0	1	265	758
Hourly Total	0	0	0	0	0	134	0	134	1	268	0	1286	32	0	1318	87	1123	0	1	1210	2796
4:00 PM	0	0	0	0	0	30	0	44	0	74	0	450	5	0	455	16	247	0	0	263	792
4:15 PM	0	0	0	0	0	24	0	34	2	58	0	455	4	0	459	18	239	0	0	257	774
4:30 PM	0	0	0	0	0	22	0	41	1	63	0	420	4	0	424	18	237	0	0	255	742
4:45 PM	0	0	0	0	0	29	0	31	1	60	0	413	1	0	414	18	240	0	1	258	732
Hourly Total	0	0	0	0	0	105	0	150	4	255	0	1738	14	0	1752	70	963	0	1	1033	3040
5:00 PM	0	0	0	0	0	19	0	30	1	49	0	458	2	0	460	25	205	0	0	230	739
5:15 PM	0	0	0	0	0	21	0	45	5	66	0	400	4	0	404	20	199	0	0	219	689
5:30 PM	0	0	0	0	0	13	0	31	2	44	0	470	0	0	470	18	212	0	0	230	744
5:45 PM	0	0	0	0	0	20	0	42	1	62	0	411	3	0	414	17	179	0	1	196	672
Hourly Total	0	0	0	0	0	73	0	148	9	221	0	1739	9	0	1748	80	795	0	1	875	2844
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5:00 AM	0	0	0	0	0	16	0	6	1	22	0	64	2	0	66	17	510	0	0	527	615
5:15 AM	0	0	0	0	0	21	0	4	0	25	0	76	5	0	81	23	526	0	1	549	655
5:30 AM	0	0	0	0	0	13	0	4	0	17	0	69	3	0	72	20	494	0	0	514	603
5:45 AM	0	0	0	0	0	32	0	5	1	37	0	110	4	0	114	29	457	0	0	486	637
Hourly Total	0	0	0	0	0	82	0	19	2	101	0	319	14	0	333	89	1987	0	1	2076	2510
6:00 AM	0	0	0	0	0	35	0	6	1	41	0	117	8	0	125	12	382	0	1	394	560
6:15 AM	0	0	0	0	0	21	0	9	3	30	0	187	9	0	196	32	436	0	0	468	694
6:30 AM	0	0	0	0	0	29	0	14	6	43	0	216	19	0	235	20	423	0	0	443	721
6:45 AM	0	0	0	0	0	20	0	9	1	29	0	242	15	0	257	22	458	0	0	480	766

Hourly Total	0	0	0	0	0	105	0	38	11	143	0	762	51	0	813	86	1699	0	1	1785	2741
7:00 AM	0	0	0	0	0	22	0	22	2	44	0	241	19	0	260	28	431	0	1	459	763
7:15 AM	0	0	0	0	0	35	0	14	2	49	0	260	17	0	277	19	451	0	2	470	796
7:30 AM	0	0	0	0	0	40	0	7	3	47	0	284	19	0	303	23	390	0	0	413	763
7:45 AM	0	0	0	1	0	45	0	13	1	58	0	295	19	0	314	26	391	0	0	417	789
Hourly Total	0	0	0	1	0	142	0	56	8	198	0	1080	74	0	1154	96	1663	0	3	1759	3111
8:00 AM	0	0	0	0	0	47	0	13	2	60	0	300	22	0	322	14	377	0	1	391	773
8:15 AM	0	0	0	0	0	35	0	20	1	55	0	238	19	0	257	27	424	0	0	451	763
8:30 AM	0	0	0	0	0	35	0	25	0	60	0	273	19	0	292	29	423	0	1	452	804
8:45 AM	0	0	0	0	0	45	1	13	0	59	0	243	20	0	263	24	365	0	0	389	711
Hourly Total	0	0	0	0	0	162	1	71	3	234	0	1054	80	0	1134	94	1589	0	2	1683	3051
Grand Total	0	0	0	4	0	1184	1	1019	63	2204	0	12795	365	0	13160	809	13189	0	16	13998	29362
Approach %	0.0	0.0	0.0	-	-	53.7	0.0	46.2	-	-	0.0	97.2	2.8	-	-	5.8	94.2	0.0	-	-	-
Total %	0.0	0.0	0.0	-	0.0	4.0	0.0	3.5	-	7.5	0.0	43.6	1.2	-	44.8	2.8	44.9	0.0	-	47.7	-
Motorcycles	0	0	0	-	0	0	0	7	-	7	0	51	0	-	51	4	32	0	-	36	94
% Motorcycles	-	-	-	-	-	0.0	0.0	0.7	-	0.3	-	0.4	0.0	-	0.4	0.5	0.2	-	-	0.3	0.3
Cars	0	0	0	-	0	716	0	711	-	1427	0	8969	159	-	9128	584	10157	0	-	10741	21296
% Cars	-	-	-	-	-	60.5	0.0	69.8	-	64.7	-	70.1	43.6	-	69.4	72.2	77.0	-	-	76.7	72.5
Light Goods Vehicles	0	0	0	-	0	290	0	271	-	561	0	3363	45	-	3408	199	2555	0	-	2754	6723
% Light Goods Vehicles	-	-	-	-	-	24.5	0.0	26.6	-	25.5	-	26.3	12.3	-	25.9	24.6	19.4	-	-	19.7	22.9
Buses	0	0	0	-	0	3	0	5	-	8	0	177	3	-	180	4	186	0	-	190	378
% Buses	-	-	-	-	-	0.3	0.0	0.5	-	0.4	-	1.4	0.8	-	1.4	0.5	1.4	-	-	1.4	1.3
Single-Unit Trucks	0	0	0	-	0	102	0	19	-	121	0	194	120	-	314	17	201	0	-	218	653
% Single-Unit Trucks	-	-	-	-	-	8.6	0.0	1.9	-	5.5	-	1.5	32.9	-	2.4	2.1	1.5	-	-	1.6	2.2
Articulated Trucks	0	0	0	-	0	73	1	3	-	77	0	37	38	-	75	1	50	0	-	51	203
% Articulated Trucks	-	-	-	-	-	6.2	100.0	0.3	-	3.5	-	0.3	10.4	-	0.6	0.1	0.4	-	-	0.4	0.7
Bicycles on Road	0	0	0	-	0	0	0	3	-	3	0	4	0	-	4	0	8	0	-	8	15
% Bicycles on Road	-	-	-	-	-	0.0	0.0	0.3	-	0.1	-	0.0	0.0	-	0.0	0.0	0.1	-	-	0.1	0.1
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	13	-	-	-	-	0	-	-	-	-	1	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	20.6	-	-	-	-	-	-	-	-	-	6.3	-	-
Pedestrians	-	-	-	4	-	-	-	-	50	-	-	-	-	0	-	-	-	-	15	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	79.4	-	-	-	-	-	-	-	-	-	93.8	-	-

The Traffic Management Consultant
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Honolulu, Hawaii, United States 96813
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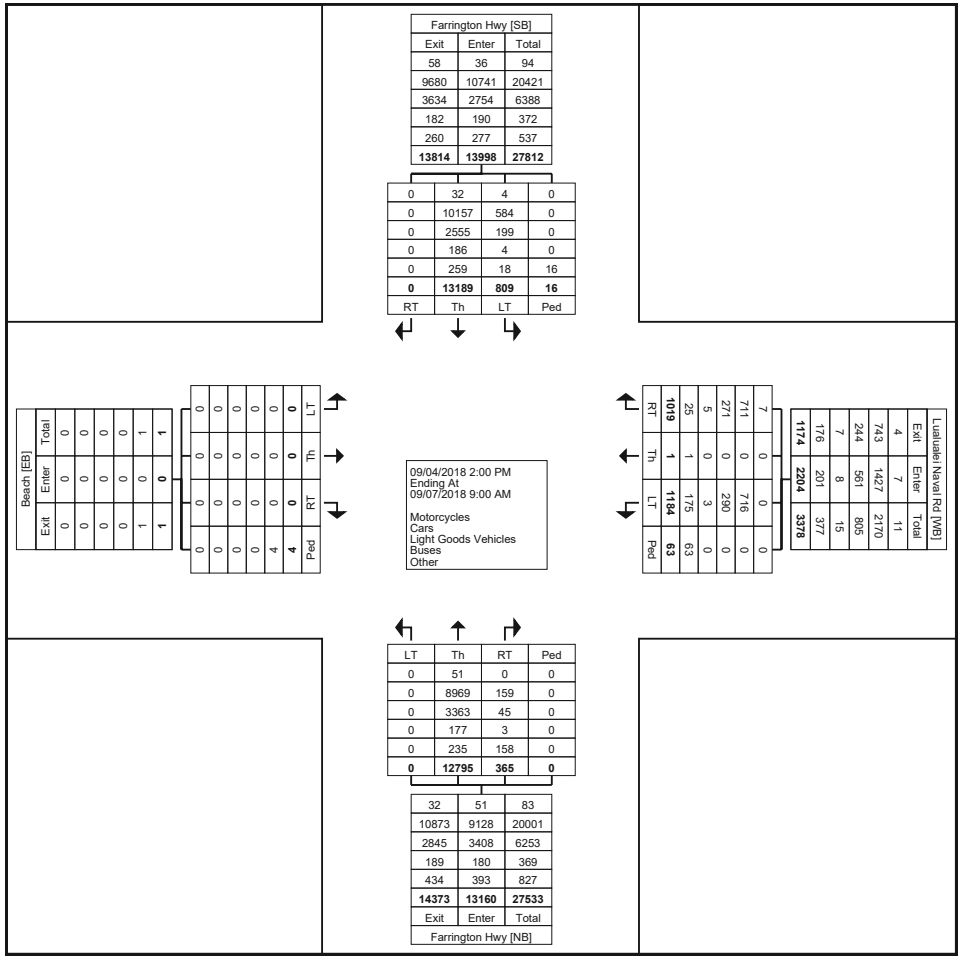
Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Data Plot

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Beach Eastbound					Lualualei Naval Rd Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:00 PM	0	0	0	1	0	28	0	30	2	58	0	418	9	0	427	14	300	0	1	314	799
3:15 PM	0	0	0	0	0	30	0	48	1	78	0	412	9	0	421	18	336	0	0	354	853
3:30 PM	0	0	0	2	0	35	0	45	3	80	0	412	2	0	414	17	304	0	3	321	815
3:45 PM	0	0	0	0	0	32	0	52	1	84	0	395	5	0	400	18	240	0	0	258	742
Total	0	0	0	3	0	125	0	175	7	300	0	1637	25	0	1662	67	1180	0	4	1247	3209
Approach %	0.0	0.0	0.0	-	-	41.7	0.0	58.3	-	-	0.0	98.5	1.5	-	-	5.4	94.6	0.0	-	-	-
Total %	0.0	0.0	0.0	-	0.0	3.9	0.0	5.5	-	9.3	0.0	51.0	0.8	-	51.8	2.1	36.8	0.0	-	38.9	-
PHF	0.000	0.000	0.000	-	0.000	0.893	0.000	0.841	-	0.893	0.000	0.979	0.694	-	0.973	0.931	0.878	0.000	-	0.881	0.941
Motorcycles	0	0	0	-	0	0	0	1	-	1	0	6	0	-	6	0	3	0	-	3	10
% Motorcycles	-	-	-	-	-	0.0	-	0.6	-	0.3	-	0.4	0.0	-	0.4	0.0	0.3	-	-	0.2	0.3
Cars	0	0	0	-	0	86	0	119	-	205	0	1115	9	-	1124	53	865	0	-	918	2247
% Cars	-	-	-	-	-	68.8	-	68.0	-	68.3	-	68.1	36.0	-	67.6	79.1	73.3	-	-	73.6	70.0
Light Goods Vehicles	0	0	0	-	0	28	0	52	-	80	0	474	7	-	481	13	261	0	-	274	835
% Light Goods Vehicles	-	-	-	-	-	22.4	-	29.7	-	26.7	-	29.0	28.0	-	28.9	19.4	22.1	-	-	22.0	26.0
Buses	0	0	0	-	0	0	0	1	-	1	0	17	1	-	18	0	25	0	-	25	44
% Buses	-	-	-	-	-	0.0	-	0.6	-	0.3	-	1.0	4.0	-	1.1	0.0	2.1	-	-	2.0	1.4
Single-Unit Trucks	0	0	0	-	0	10	0	2	-	12	0	22	7	-	29	1	20	0	-	21	62
% Single-Unit Trucks	-	-	-	-	-	8.0	-	1.1	-	4.0	-	1.3	28.0	-	1.7	1.5	1.7	-	-	1.7	1.9
Articulated Trucks	0	0	0	-	0	1	0	0	-	1	0	3	1	-	4	0	5	0	-	5	10
% Articulated Trucks	-	-	-	-	-	0.8	-	0.0	-	0.3	-	0.2	4.0	-	0.2	0.0	0.4	-	-	0.4	0.3
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	1	0	-	1	1
% Bicycles on Road	-	-	-	-	-	0.0	-	0.0	-	0.0	-	0.0	0.0	-	0.0	0.0	0.1	-	-	0.1	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	3	-	-	-	-	7	-	-	-	-	0	-	-	-	-	4	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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Count Name: Lualualei Naval Rd Farrington Hwy
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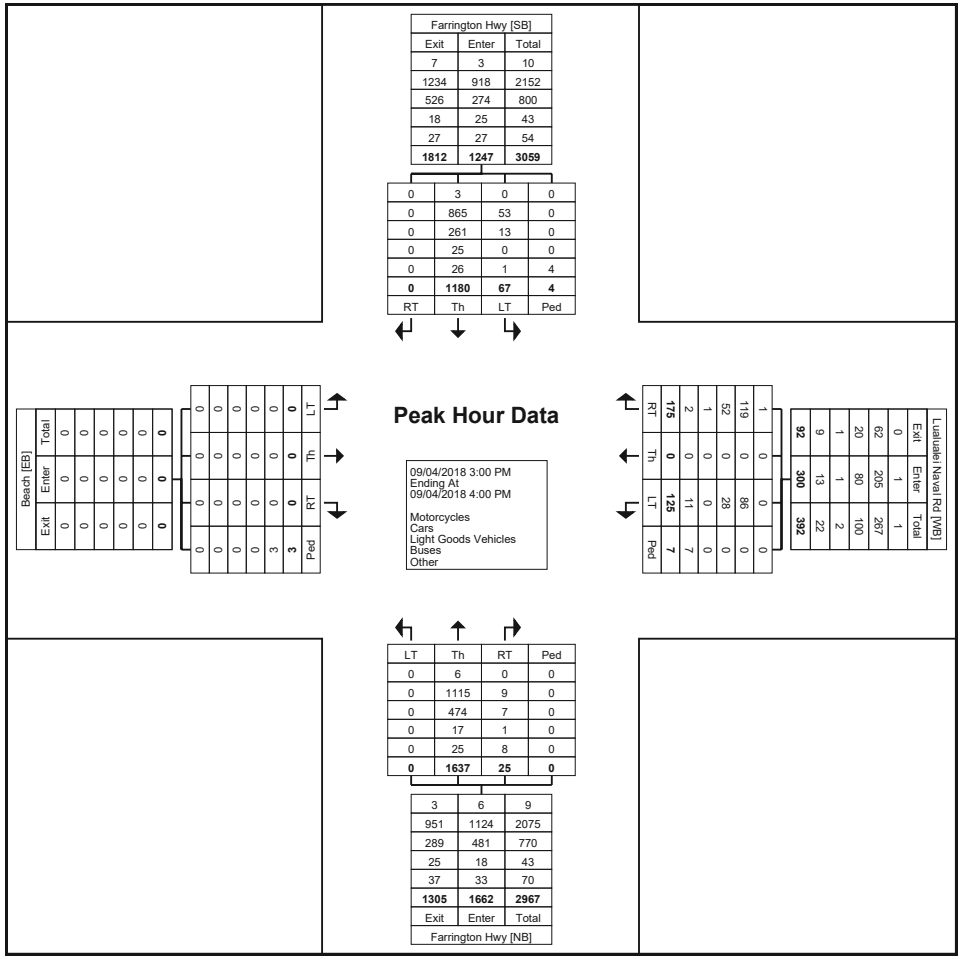
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 5



Turning Movement Peak Hour Data Plot (3:00 PM)

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:30 PM)

Start Time	Beach Eastbound					Lualualei Naval Rd Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:30 PM	0	0	0	0	0	51	0	24	1	75	0	364	11	0	375	20	280	0	0	300	750
3:45 PM	0	0	0	0	0	21	0	50	0	71	0	418	4	0	422	15	250	0	1	265	758
4:00 PM	0	0	0	0	0	30	0	44	0	74	0	450	5	0	455	16	247	0	0	263	792
4:15 PM	0	0	0	0	0	24	0	34	2	58	0	455	4	0	459	18	239	0	0	257	774
Total	0	0	0	0	0	126	0	152	3	278	0	1687	24	0	1711	69	1016	0	1	1085	3074
Approach %	0.0	0.0	0.0	-	-	45.3	0.0	54.7	-	-	0.0	98.6	1.4	-	-	6.4	93.6	0.0	-	-	-
Total %	0.0	0.0	0.0	-	0.0	4.1	0.0	4.9	-	9.0	0.0	54.9	0.8	-	55.7	2.2	33.1	0.0	-	35.3	-
PHF	0.000	0.000	0.000	-	0.000	0.618	0.000	0.760	-	0.927	0.000	0.927	0.545	-	0.932	0.863	0.907	0.000	-	0.904	0.970
Motorcycles	0	0	0	-	0	0	0	3	-	3	0	8	0	-	8	0	3	0	-	3	14
% Motorcycles	-	-	-	-	-	0.0	-	2.0	-	1.1	-	0.5	0.0	-	0.5	0.0	0.3	-	-	0.3	0.5
Cars	0	0	0	-	0	83	0	110	-	193	0	1181	9	-	1190	54	865	0	-	919	2302
% Cars	-	-	-	-	-	65.9	-	72.4	-	69.4	-	70.0	37.5	-	69.5	78.3	85.1	-	-	84.7	74.9
Light Goods Vehicles	0	0	0	-	0	40	0	36	-	76	0	461	6	-	467	15	109	0	-	124	667
% Light Goods Vehicles	-	-	-	-	-	31.7	-	23.7	-	27.3	-	27.3	25.0	-	27.3	21.7	10.7	-	-	11.4	21.7
Buses	0	0	0	-	0	0	0	0	-	0	0	12	0	-	12	0	18	0	-	18	30
% Buses	-	-	-	-	-	0.0	-	0.0	-	0.0	-	0.7	0.0	-	0.7	0.0	1.8	-	-	1.7	1.0
Single-Unit Trucks	0	0	0	-	0	2	0	2	-	4	0	19	7	-	26	0	18	0	-	18	48
% Single-Unit Trucks	-	-	-	-	-	1.6	-	1.3	-	1.4	-	1.1	29.2	-	1.5	0.0	1.8	-	-	1.7	1.6
Articulated Trucks	0	0	0	-	0	1	0	0	-	1	0	6	2	-	8	0	1	0	-	1	10
% Articulated Trucks	-	-	-	-	-	0.8	-	0.0	-	0.4	-	0.4	8.3	-	0.5	0.0	0.1	-	-	0.1	0.3
Bicycles on Road	0	0	0	-	0	0	0	1	-	1	0	0	0	-	0	0	2	0	-	2	3
% Bicycles on Road	-	-	-	-	-	0.0	-	0.7	-	0.4	-	0.0	0.0	-	0.0	0.0	0.2	-	-	0.2	0.1
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	1	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	33.3	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	2	-	-	-	-	0	-	-	-	-	1	-	-
% Pedestrians	-	-	-	-	-	-	-	-	66.7	-	-	-	-	-	-	-	-	-	100.0	-	-

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

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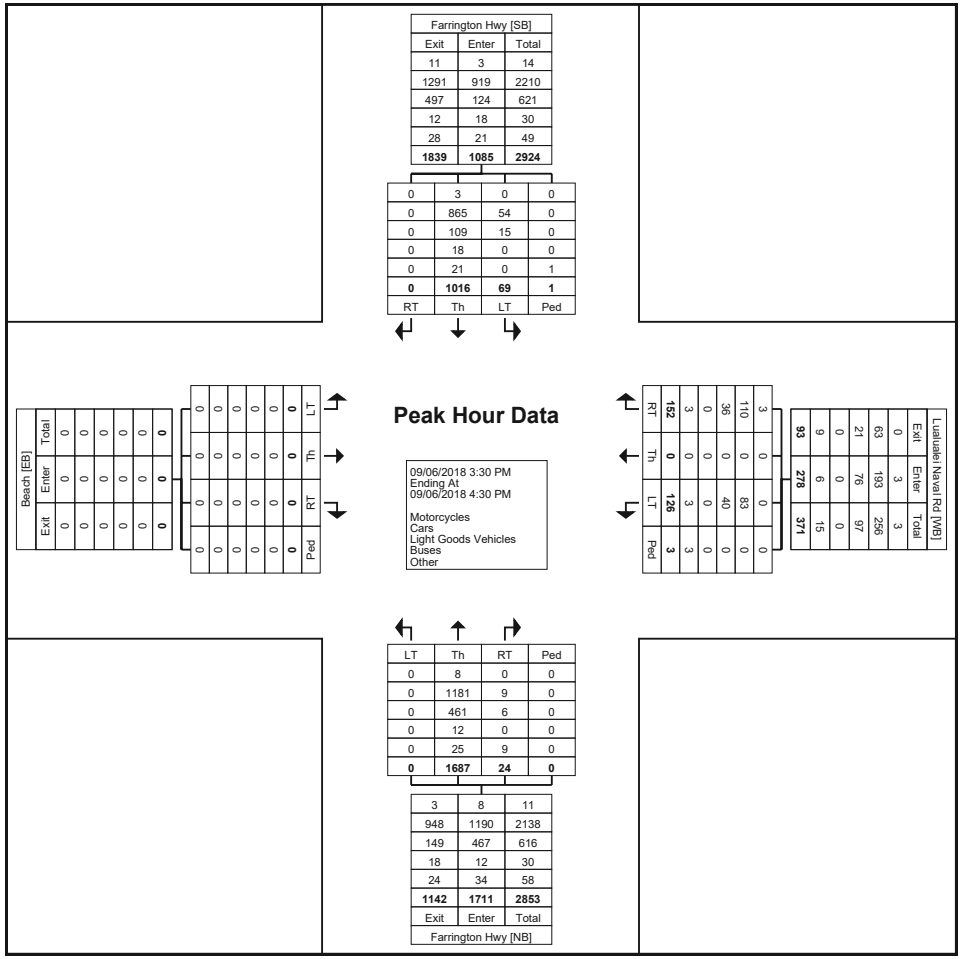
808-536-0223 tmchawaii@aol.com

Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 7



Turning Movement Peak Hour Data Plot (3:30 PM)

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
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Count Name: Lualualei Naval Rd Farrington Hwy
9-4, 7, 8-18
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:45 AM)

Start Time	Beach Eastbound					Lualualei Naval Rd Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
7:45 AM	0	0	0	1	0	45	0	13	1	58	0	295	19	0	314	26	391	0	0	417	789
8:00 AM	0	0	0	0	0	47	0	13	2	60	0	300	22	0	322	14	377	0	1	391	773
8:15 AM	0	0	0	0	0	35	0	20	1	55	0	238	19	0	257	27	424	0	0	451	763
8:30 AM	0	0	0	0	0	35	0	25	0	60	0	273	19	0	292	29	423	0	1	452	804
Total	0	0	0	1	0	162	0	71	4	233	0	1106	79	0	1185	96	1615	0	2	1711	3129
Approach %	0.0	0.0	0.0	-	-	69.5	0.0	30.5	-	-	0.0	93.3	6.7	-	-	5.6	94.4	0.0	-	-	-
Total %	0.0	0.0	0.0	-	0.0	5.2	0.0	2.3	-	7.4	0.0	35.3	2.5	-	37.9	3.1	51.6	0.0	-	54.7	-
PHF	0.000	0.000	0.000	-	0.000	0.862	0.000	0.710	-	0.971	0.000	0.922	0.898	-	0.920	0.828	0.952	0.000	-	0.946	0.973
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	7	0	-	7	0	1	0	-	1	8
% Motorcycles	-	-	-	-	-	0.0	-	0.0	-	0.0	-	0.6	0.0	-	0.6	0.0	0.1	-	-	0.1	0.3
Cars	0	0	0	-	0	81	0	47	-	128	0	788	35	-	823	68	1279	0	-	1347	2298
% Cars	-	-	-	-	-	50.0	-	66.2	-	54.9	-	71.2	44.3	-	69.5	70.8	79.2	-	-	78.7	73.4
Light Goods Vehicles	0	0	0	-	0	24	0	18	-	42	0	256	2	-	258	21	280	0	-	301	601
% Light Goods Vehicles	-	-	-	-	-	14.8	-	25.4	-	18.0	-	23.1	2.5	-	21.8	21.9	17.3	-	-	17.6	19.2
Buses	0	0	0	-	0	1	0	1	-	2	0	13	0	-	13	1	20	0	-	21	36
% Buses	-	-	-	-	-	0.6	-	1.4	-	0.9	-	1.2	0.0	-	1.1	1.0	1.2	-	-	1.2	1.2
Single-Unit Trucks	0	0	0	-	0	31	0	4	-	35	0	38	30	-	68	6	29	0	-	35	138
% Single-Unit Trucks	-	-	-	-	-	19.1	-	5.6	-	15.0	-	3.4	38.0	-	5.7	6.3	1.8	-	-	2.0	4.4
Articulated Trucks	0	0	0	-	0	25	0	1	-	26	0	4	12	-	16	0	6	0	-	6	48
% Articulated Trucks	-	-	-	-	-	15.4	-	1.4	-	11.2	-	0.4	15.2	-	1.4	0.0	0.4	-	-	0.4	1.5
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Bicycles on Road	-	-	-	-	-	0.0	-	0.0	-	0.0	-	0.0	0.0	-	0.0	0.0	0.0	-	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	1	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	50.0	-	-
Pedestrians	-	-	-	1	-	-	-	-	4	-	-	-	-	0	-	-	-	-	1	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	50.0	-	-

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Site Code: PVT ISWMF
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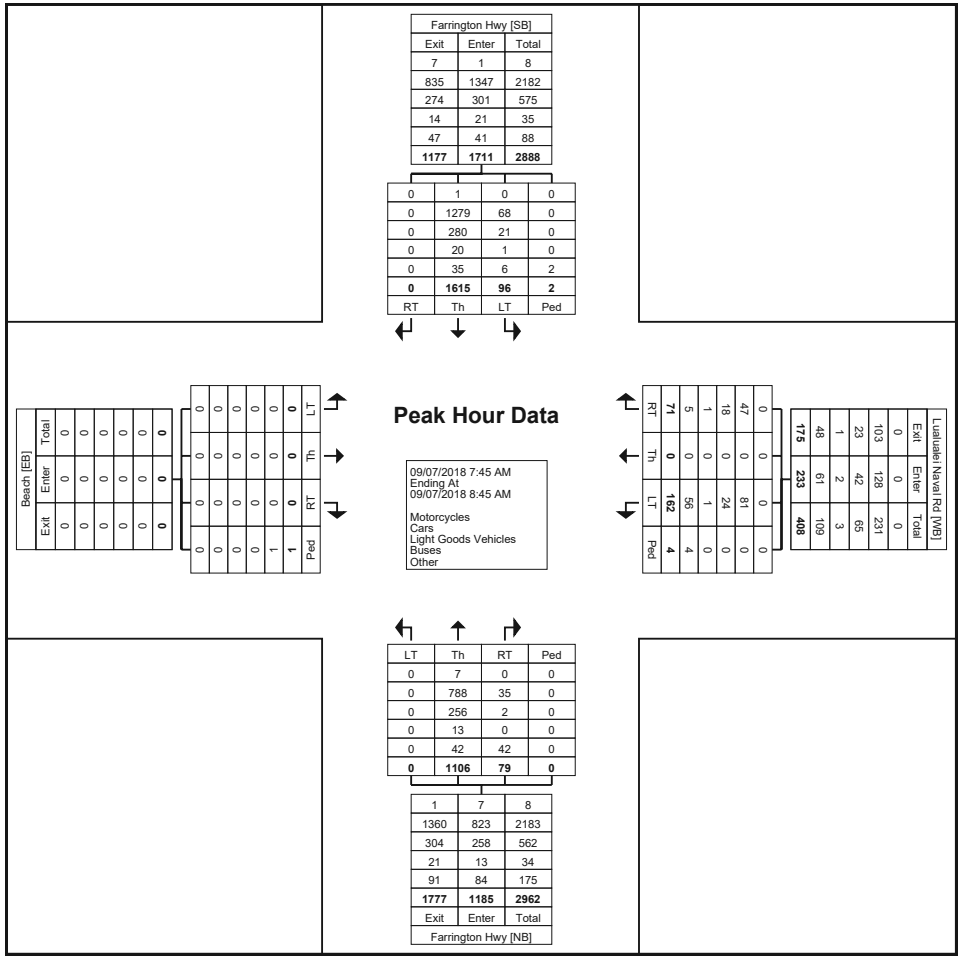
Page No: 9



Turning Movement Peak Hour Data Plot (7:45 AM)

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Data

Start Time	Ulehawa Beach Park Eastbound					Princess Kahanu Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
2:00 PM	0	0	1	1	1	12	0	5	3	17	1	293	13	0	307	1	262	1	1	264	589
2:15 PM	1	0	1	1	2	16	0	3	3	19	2	360	29	0	391	0	306	2	2	308	720
2:30 PM	0	0	1	0	1	30	0	8	7	38	0	386	31	0	417	1	320	1	2	322	778
2:45 PM	0	0	0	0	0	20	0	10	6	30	0	362	25	0	387	2	307	1	2	310	727
Hourly Total	1	0	3	2	4	78	0	26	19	104	3	1401	98	0	1502	4	1195	5	7	1204	2814
3:00 PM	0	0	3	0	3	21	0	4	3	25	2	356	29	0	387	0	306	0	5	306	721
3:15 PM	0	0	0	1	0	20	1	2	5	23	0	433	30	0	463	3	301	0	4	304	790
3:30 PM	0	0	2	4	2	19	0	6	1	25	1	423	26	0	450	6	323	0	0	329	806
3:45 PM	0	0	1	1	1	8	0	4	0	12	2	397	34	0	433	2	253	0	3	255	701
Hourly Total	0	0	6	6	6	68	1	16	9	85	5	1609	119	0	1733	11	1183	0	12	1194	3018
4:00 PM	1	0	1	0	2	12	0	4	7	16	1	415	21	0	437	3	242	0	0	245	700
4:15 PM	0	0	0	0	0	14	0	5	4	19	0	392	16	0	408	0	244	0	0	244	671
4:30 PM	0	0	0	1	0	14	0	4	6	18	0	395	30	0	425	0	205	0	1	205	648
4:45 PM	0	0	0	0	0	7	0	9	12	16	0	442	28	0	470	2	247	1	0	250	736
Hourly Total	1	0	1	1	2	47	0	22	29	69	1	1644	95	0	1740	5	938	1	1	944	2755
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5:00 AM	0	0	1	0	1	36	0	1	1	37	1	63	3	0	67	0	462	0	0	462	567
5:15 AM	0	0	0	0	0	20	0	3	0	23	0	50	4	0	54	1	545	0	0	546	623
5:30 AM	0	0	0	1	0	36	0	4	2	40	0	81	4	0	85	3	450	0	1	453	578
5:45 AM	0	0	0	0	0	16	0	6	0	22	0	91	5	0	96	0	430	1	0	431	549
Hourly Total	0	0	1	1	1	108	0	14	3	122	1	285	16	0	302	4	1887	1	1	1892	2317
6:00 AM	0	0	0	1	0	25	0	1	0	26	0	126	7	0	133	0	381	1	1	382	541
6:15 AM	0	0	3	1	3	27	1	1	4	29	0	150	5	0	155	1	401	1	1	403	590
6:30 AM	0	1	0	0	1	16	0	2	4	18	1	212	14	0	227	1	445	1	0	447	693
6:45 AM	2	0	2	1	4	38	0	2	1	40	0	258	7	0	265	1	415	3	1	419	728
Hourly Total	2	1	5	3	8	106	1	6	9	113	1	746	33	0	780	3	1642	6	3	1651	2552
7:00 AM	0	0	2	1	2	43	0	5	0	48	1	243	7	0	251	4	375	1	3	380	681
7:15 AM	0	0	1	1	1	38	0	4	2	42	3	265	11	0	279	1	439	0	3	440	762
7:30 AM	1	0	4	1	5	34	0	11	0	45	4	287	12	0	303	0	373	2	2	375	728
7:45 AM	1	0	0	0	1	25	0	8	1	33	1	234	13	0	248	1	352	0	0	353	635
Hourly Total	2	0	7	3	9	140	0	28	3	168	9	1029	43	0	1081	6	1539	3	8	1548	2806
8:00 AM	1	0	1	0	2	35	0	2	4	37	1	228	21	0	250	4	352	1	0	357	646
8:15 AM	1	0	1	0	2	27	0	2	6	29	0	274	19	0	293	3	316	1	2	320	644
8:30 AM	1	0	1	1	2	24	0	5	1	29	0	205	12	0	217	0	315	0	0	315	563
8:45 AM	0	0	0	3	0	11	0	4	4	15	0	209	17	0	226	2	300	1	3	303	544
Hourly Total	3	0	3	4	6	97	0	13	15	110	1	916	69	0	986	9	1283	3	5	1295	2397
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2:00 PM	0	0	1	0	1	14	0	2	4	16	2	353	28	0	383	2	258	0	0	260	660
2:15 PM	1	0	1	0	2	11	0	2	7	13	0	325	22	0	347	0	298	1	0	299	661
2:30 PM	1	0	0	0	1	28	0	5	1	33	0	359	22	0	381	3	299	0	0	302	717
2:45 PM	0	0	0	0	0	21	0	3	1	24	0	375	31	0	406	3	267	0	3	270	700

Hourly Total	2	0	2	0	4	74	0	12	13	86	2	1412	103	0	1517	8	1122	1	3	1131	2738
3:00 PM	0	0	1	0	1	19	0	5	1	24	2	396	32	0	430	0	278	1	0	279	734
3:15 PM	0	0	1	0	1	16	0	7	14	23	1	371	30	0	402	6	266	1	2	273	699
3:30 PM	0	0	1	0	1	28	0	4	8	32	1	394	16	0	411	0	319	0	0	319	763
3:45 PM	0	0	0	0	0	16	0	1	2	17	0	435	34	0	469	1	272	1	0	274	760
Hourly Total	0	0	3	0	3	79	0	17	25	96	4	1596	112	0	1712	7	1135	3	2	1145	2956
4:00 PM	1	0	0	2	1	13	0	3	1	16	0	399	22	0	421	1	263	0	0	264	702
4:15 PM	0	0	1	4	1	25	0	2	3	27	1	375	22	0	398	1	250	1	6	252	678
4:30 PM	0	0	2	2	2	15	0	3	1	18	1	390	32	0	423	1	204	1	2	206	649
4:45 PM	1	0	0	0	1	6	1	8	5	15	2	434	29	0	465	2	250	0	2	252	733
Hourly Total	2	0	3	8	5	59	1	16	10	76	4	1598	105	0	1707	5	967	2	10	974	2762
5:00 PM	2	0	0	1	2	21	0	16	4	37	1	396	35	0	432	1	251	0	1	252	723
5:15 PM	0	0	2	2	2	23	0	7	7	30	1	366	23	0	390	3	217	0	5	220	642
5:30 PM	0	1	1	0	2	17	1	3	5	21	1	405	20	0	426	1	168	0	0	169	618
5:45 PM	0	0	1	1	1	7	0	4	13	11	0	448	25	0	473	3	181	1	1	185	670
Hourly Total	2	1	4	4	7	68	1	30	29	99	3	1615	103	0	1721	8	817	1	7	826	2653
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7:00 AM	1	1	2	0	4	39	0	4	0	43	0	262	7	0	269	0	441	1	1	442	758
7:15 AM	1	0	1	0	2	44	1	2	0	47	1	273	11	0	285	1	385	0	1	386	720
7:30 AM	0	0	0	0	0	42	0	5	1	47	1	250	14	0	265	1	404	0	1	405	717
7:45 AM	1	1	1	0	3	34	0	3	3	37	4	266	19	0	289	0	375	1	2	376	705
Hourly Total	3	2	4	0	9	159	1	14	4	174	6	1051	51	0	1108	2	1605	2	5	1609	2900
8:00 AM	2	0	1	0	3	32	0	7	2	39	2	242	27	0	271	1	363	2	2	366	679
8:15 AM	1	0	3	0	4	33	0	5	2	38	1	275	17	0	293	4	322	1	0	327	662
8:30 AM	0	0	0	0	0	33	0	6	1	39	1	262	15	0	278	2	293	1	0	296	613
8:45 AM	0	0	2	0	2	18	0	2	1	20	1	225	9	0	235	2	307	2	0	311	568
Hourly Total	3	0	6	0	9	116	0	20	6	136	5	1004	68	0	1077	9	1285	6	2	1300	2522
Grand Total	21	4	48	32	73	1199	5	234	174	1438	45	15906	1015	0	16966	81	16598	34	66	16713	35190
Approach %	28.8	5.5	65.8	-	-	83.4	0.3	16.3	-	-	0.3	93.8	6.0	-	-	0.5	99.3	0.2	-	-	-
Total %	0.1	0.0	0.1	-	0.2	3.4	0.0	0.7	-	4.1	0.1	45.2	2.9	-	48.2	0.2	47.2	0.1	-	47.5	-
Motorcycles	0	0	0	-	0	3	0	1	-	4	0	67	5	-	72	0	62	3	-	65	141
% Motorcycles	0.0	0.0	0.0	-	0.0	0.3	0.0	0.4	-	0.3	0.0	0.4	0.5	-	0.4	0.0	0.4	8.8	-	0.4	0.4
Cars	12	3	26	-	41	861	1	186	-	1048	32	11945	717	-	12694	60	12058	14	-	12132	25915
% Cars	57.1	75.0	54.2	-	56.2	71.8	20.0	79.5	-	72.9	71.1	75.1	70.6	-	74.8	74.1	72.6	41.2	-	72.6	73.6
Light Goods Vehicles	7	1	16	-	24	291	2	40	-	333	12	3381	251	-	3644	18	3962	10	-	3990	7991
% Light Goods Vehicles	33.3	25.0	33.3	-	32.9	24.3	40.0	17.1	-	23.2	26.7	21.3	24.7	-	21.5	22.2	23.9	29.4	-	23.9	22.7
Buses	0	0	0	-	0	29	0	1	-	30	0	174	20	-	194	1	207	0	-	208	432
% Buses	0.0	0.0	0.0	-	0.0	2.4	0.0	0.4	-	2.1	0.0	1.1	2.0	-	1.1	1.2	1.2	0.0	-	1.2	1.2
Single-Unit Trucks	2	0	2	-	4	12	1	3	-	16	0	287	19	-	306	2	255	3	-	260	586
% Single-Unit Trucks	9.5	0.0	4.2	-	5.5	1.0	20.0	1.3	-	1.1	0.0	1.8	1.9	-	1.8	2.5	1.5	8.8	-	1.6	1.7
Articulated Trucks	0	0	2	-	2	1	0	0	-	1	1	49	3	-	53	0	48	0	-	48	104
% Articulated Trucks	0.0	0.0	4.2	-	2.7	0.1	0.0	0.0	-	0.1	2.2	0.3	0.3	-	0.3	0.0	0.3	0.0	-	0.3	0.3
Bicycles on Road	0	0	2	-	2	2	1	3	-	6	0	3	0	-	3	0	6	4	-	10	21
% Bicycles on Road	0.0	0.0	4.2	-	2.7	0.2	20.0	1.3	-	0.4	0.0	0.0	0.0	-	0.0	0.0	0.0	11.8	-	0.1	0.1
Bicycles on Crosswalk	-	-	-	6	-	-	-	-	8	-	-	-	-	0	-	-	-	-	7	-	-
% Bicycles on Crosswalk	-	-	-	18.8	-	-	-	-	4.6	-	-	-	-	-	-	-	-	-	10.6	-	-
Pedestrians	-	-	-	26	-	-	-	-	166	-	-	-	-	0	-	-	-	-	59	-	-
% Pedestrians	-	-	-	81.3	-	-	-	-	95.4	-	-	-	-	-	-	-	-	-	89.4	-	-

The Traffic Management Consultant
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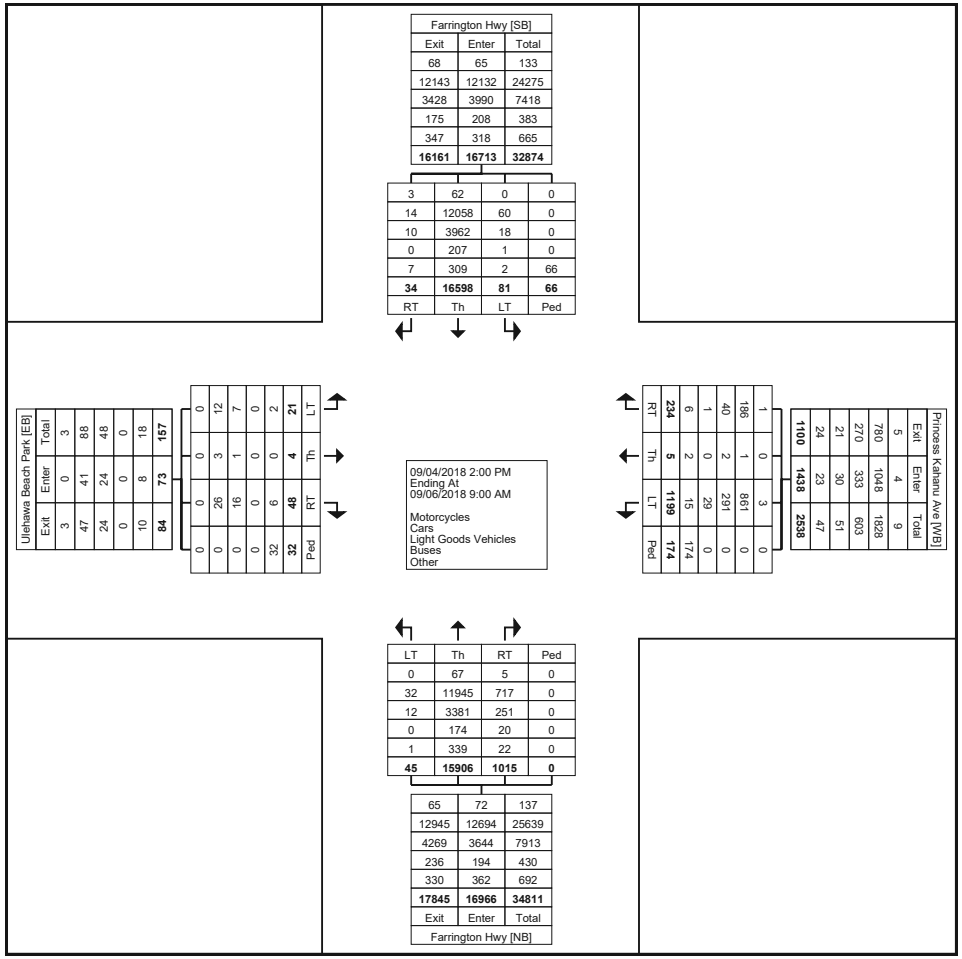
Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Data Plot

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Ulehawa Beach Park Eastbound					Princess Kahanu Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:00 PM	0	0	3	0	3	21	0	4	3	25	2	356	29	0	387	0	306	0	5	306	721
3:15 PM	0	0	0	1	0	20	1	2	5	23	0	433	30	0	463	3	301	0	4	304	790
3:30 PM	0	0	2	4	2	19	0	6	1	25	1	423	26	0	450	6	323	0	0	329	806
3:45 PM	0	0	1	1	1	8	0	4	0	12	2	397	34	0	433	2	253	0	3	255	701
Total	0	0	6	6	6	68	1	16	9	85	5	1609	119	0	1733	11	1183	0	12	1194	3018
Approach %	0.0	0.0	100.0	-	-	80.0	1.2	18.8	-	-	0.3	92.8	6.9	-	-	0.9	99.1	0.0	-	-	-
Total %	0.0	0.0	0.2	-	0.2	2.3	0.0	0.5	-	2.8	0.2	53.3	3.9	-	57.4	0.4	39.2	0.0	-	39.6	-
PHF	0.000	0.000	0.500	-	0.500	0.810	0.250	0.667	-	0.850	0.625	0.929	0.875	-	0.936	0.458	0.916	0.000	-	0.907	0.936
Motorcycles	0	0	0	-	0	1	0	1	-	2	0	6	1	-	7	0	2	0	-	2	11
% Motorcycles	-	-	0.0	-	0.0	1.5	0.0	6.3	-	2.4	0.0	0.4	0.8	-	0.4	0.0	0.2	-	-	0.2	0.4
Cars	0	0	3	-	3	47	0	10	-	57	5	1260	82	-	1347	7	880	0	-	887	2294
% Cars	-	-	50.0	-	50.0	69.1	0.0	62.5	-	67.1	100.0	78.3	68.9	-	77.7	63.6	74.4	-	-	74.3	76.0
Light Goods Vehicles	0	0	1	-	1	17	0	5	-	22	0	300	32	-	332	4	256	0	-	260	615
% Light Goods Vehicles	-	-	16.7	-	16.7	25.0	0.0	31.3	-	25.9	0.0	18.6	26.9	-	19.2	36.4	21.6	-	-	21.8	20.4
Buses	0	0	0	-	0	3	0	0	-	3	0	15	1	-	16	0	21	0	-	21	40
% Buses	-	-	0.0	-	0.0	4.4	0.0	0.0	-	3.5	0.0	0.9	0.8	-	0.9	0.0	1.8	-	-	1.8	1.3
Single-Unit Trucks	0	0	0	-	0	0	0	0	-	0	0	24	3	-	27	0	19	0	-	19	46
% Single-Unit Trucks	-	-	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	1.5	2.5	-	1.6	0.0	1.6	-	-	1.6	1.5
Articulated Trucks	0	0	1	-	1	0	0	0	-	0	0	4	0	-	4	0	5	0	-	5	10
% Articulated Trucks	-	-	16.7	-	16.7	0.0	0.0	0.0	-	0.0	0.0	0.2	0.0	-	0.2	0.0	0.4	-	-	0.4	0.3
Bicycles on Road	0	0	1	-	1	0	1	0	-	1	0	0	0	-	0	0	0	0	-	0	2
% Bicycles on Road	-	-	16.7	-	16.7	0.0	100.0	0.0	-	1.2	0.0	0.0	0.0	-	0.0	0.0	0.0	-	-	0.0	0.1
Bicycles on Crosswalk	-	-	-	1	-	-	-	-	1	-	-	-	-	0	-	-	-	-	1	-	-
% Bicycles on Crosswalk	-	-	-	16.7	-	-	-	-	11.1	-	-	-	-	-	-	-	-	-	8.3	-	-
Pedestrians	-	-	-	5	-	-	-	-	8	-	-	-	-	0	-	-	-	-	11	-	-
% Pedestrians	-	-	-	83.3	-	-	-	-	88.9	-	-	-	-	-	-	-	-	-	91.7	-	-

The Traffic Management Consultant
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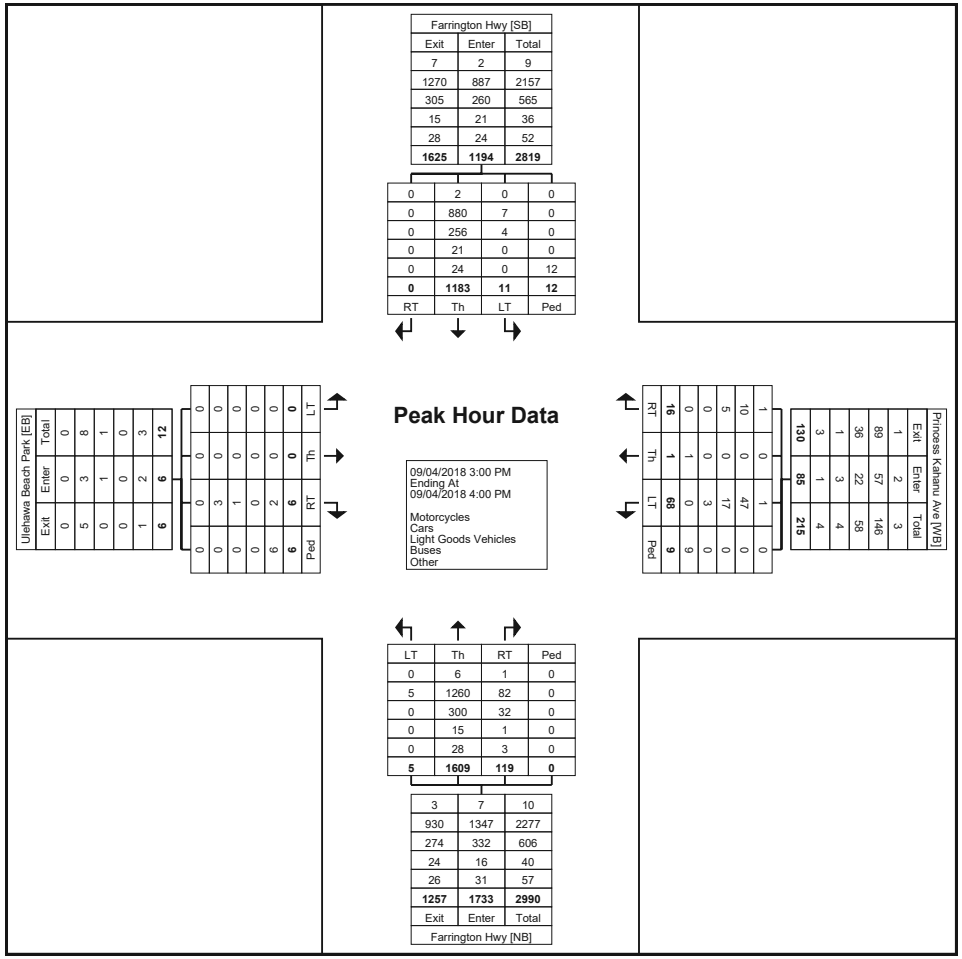
Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Peak Hour Data Plot (3:00 PM)

The Traffic Management Consultant
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Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (6:45 AM)

Start Time	Ulehawa Beach Park Eastbound					Princess Kahanu Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
6:45 AM	2	0	2	1	4	38	0	2	1	40	0	258	7	0	265	1	415	3	1	419	728
7:00 AM	0	0	2	1	2	43	0	5	0	48	1	243	7	0	251	4	375	1	3	380	681
7:15 AM	0	0	1	1	1	38	0	4	2	42	3	265	11	0	279	1	439	0	3	440	762
7:30 AM	1	0	4	1	5	34	0	11	0	45	4	287	12	0	303	0	373	2	2	375	728
Total	3	0	9	4	12	153	0	22	3	175	8	1053	37	0	1098	6	1602	6	9	1614	2899
Approach %	25.0	0.0	75.0	-	-	87.4	0.0	12.6	-	-	0.7	95.9	3.4	-	-	0.4	99.3	0.4	-	-	-
Total %	0.1	0.0	0.3	-	0.4	5.3	0.0	0.8	-	6.0	0.3	36.3	1.3	-	37.9	0.2	55.3	0.2	-	55.7	-
PHF	0.375	0.000	0.563	-	0.600	0.890	0.000	0.500	-	0.911	0.500	0.917	0.771	-	0.906	0.375	0.912	0.500	-	0.917	0.951
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	4	0	-	4	0	7	0	-	7	11
% Motorcycles	0.0	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.4	0.0	-	0.4	0.0	0.4	0.0	-	0.4	0.4
Cars	3	0	5	-	8	115	0	18	-	133	6	846	31	-	883	5	1183	4	-	1192	2216
% Cars	100.0	-	55.6	-	66.7	75.2	-	81.8	-	76.0	75.0	80.3	83.8	-	80.4	83.3	73.8	66.7	-	73.9	76.4
Light Goods Vehicles	0	0	3	-	3	31	0	4	-	35	2	175	4	-	181	1	369	1	-	371	590
% Light Goods Vehicles	0.0	-	33.3	-	25.0	20.3	-	18.2	-	20.0	25.0	16.6	10.8	-	16.5	16.7	23.0	16.7	-	23.0	20.4
Buses	0	0	0	-	0	5	0	0	-	5	0	13	2	-	15	0	21	0	-	21	41
% Buses	0.0	-	0.0	-	0.0	3.3	-	0.0	-	2.9	0.0	1.2	5.4	-	1.4	0.0	1.3	0.0	-	1.3	1.4
Single-Unit Trucks	0	0	1	-	1	2	0	0	-	2	0	14	0	-	14	0	15	1	-	16	33
% Single-Unit Trucks	0.0	-	11.1	-	8.3	1.3	-	0.0	-	1.1	0.0	1.3	0.0	-	1.3	0.0	0.9	16.7	-	1.0	1.1
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	1	0	-	1	0	5	0	-	5	6
% Articulated Trucks	0.0	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0	0.3	0.0	-	0.3	0.2
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	2	0	-	2	2
% Bicycles on Road	0.0	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.1
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	4	-	-	-	-	3	-	-	-	-	0	-	-	-	-	9	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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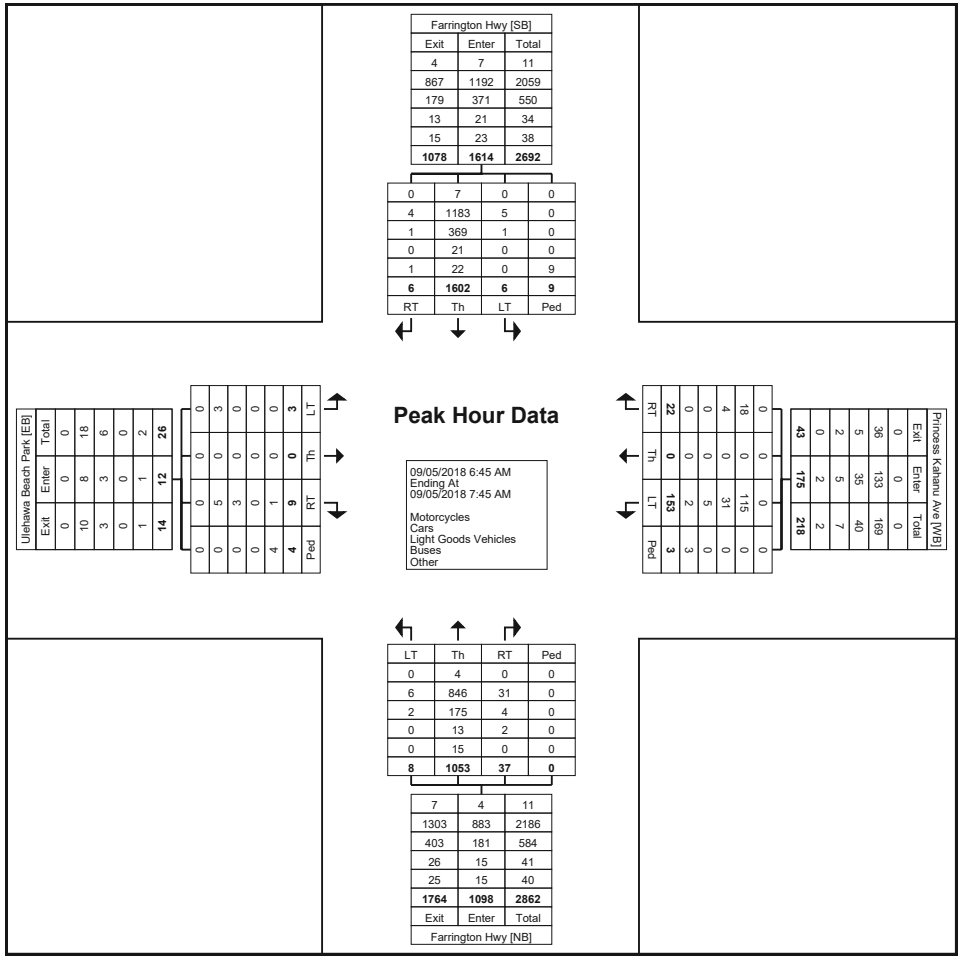
Start Date: 09/04/2018



Turning Movement Peak Hour Data Plot (6:45 AM)

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Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Ulehawa Beach Park Eastbound					Princess Kahanu Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:00 PM	0	0	1	0	1	19	0	5	1	24	2	396	32	0	430	0	278	1	0	279	734
3:15 PM	0	0	1	0	1	16	0	7	14	23	1	371	30	0	402	6	266	1	2	273	699
3:30 PM	0	0	1	0	1	28	0	4	8	32	1	394	16	0	411	0	319	0	0	319	763
3:45 PM	0	0	0	0	0	16	0	1	2	17	0	435	34	0	469	1	272	1	0	274	760
Total	0	0	3	0	3	79	0	17	25	96	4	1596	112	0	1712	7	1135	3	2	1145	2956
Approach %	0.0	0.0	100.0	-	-	82.3	0.0	17.7	-	-	0.2	93.2	6.5	-	-	0.6	99.1	0.3	-	-	-
Total %	0.0	0.0	0.1	-	0.1	2.7	0.0	0.6	-	3.2	0.1	54.0	3.8	-	57.9	0.2	38.4	0.1	-	38.7	-
PHF	0.000	0.000	0.750	-	0.750	0.705	0.000	0.607	-	0.750	0.500	0.917	0.824	-	0.913	0.292	0.889	0.750	-	0.897	0.969
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	10	0	-	10	0	1	0	-	1	11
% Motorcycles	-	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.6	0.0	-	0.6	0.0	0.1	0.0	-	0.1	0.4
Cars	0	0	2	-	2	69	0	13	-	82	3	1144	77	-	1224	5	864	1	-	870	2178
% Cars	-	-	66.7	-	66.7	87.3	-	76.5	-	85.4	75.0	71.7	68.8	-	71.5	71.4	76.1	33.3	-	76.0	73.7
Light Goods Vehicles	0	0	0	-	0	9	0	4	-	13	0	415	30	-	445	2	234	1	-	237	695
% Light Goods Vehicles	-	-	0.0	-	0.0	11.4	-	23.5	-	13.5	0.0	26.0	26.8	-	26.0	28.6	20.6	33.3	-	20.7	23.5
Buses	0	0	0	-	0	1	0	0	-	1	0	10	2	-	12	0	22	0	-	22	35
% Buses	-	-	0.0	-	0.0	1.3	-	0.0	-	1.0	0.0	0.6	1.8	-	0.7	0.0	1.9	0.0	-	1.9	1.2
Single-Unit Trucks	0	0	0	-	0	0	0	0	-	0	0	10	2	-	12	0	9	0	-	9	21
% Single-Unit Trucks	-	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.6	1.8	-	0.7	0.0	0.8	0.0	-	0.8	0.7
Articulated Trucks	0	0	1	-	1	0	0	0	-	0	1	7	1	-	9	0	3	0	-	3	13
% Articulated Trucks	-	-	33.3	-	33.3	0.0	-	0.0	-	0.0	25.0	0.4	0.9	-	0.5	0.0	0.3	0.0	-	0.3	0.4
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	2	1	-	3	3
% Bicycles on Road	-	-	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.2	33.3	-	0.3	0.1
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	25	-	-	-	-	0	-	-	-	-	2	-	-
% Pedestrians	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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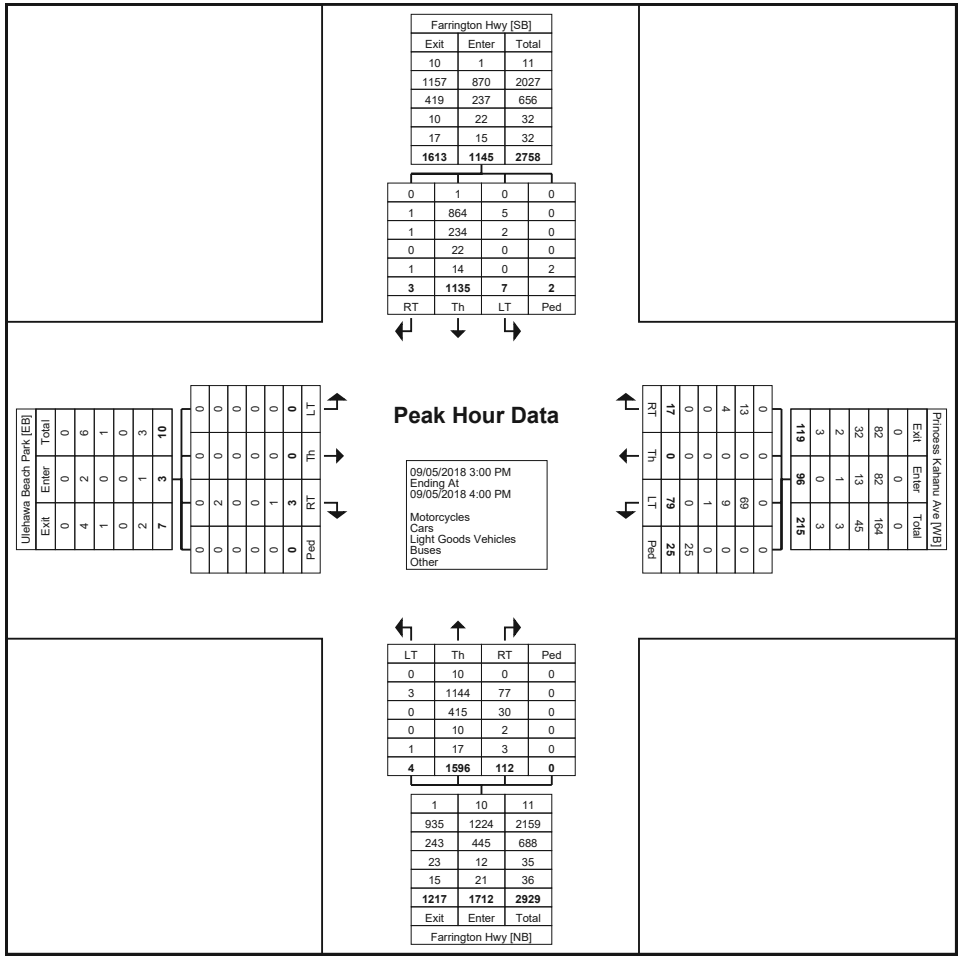
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Peak Hour Data Plot (3:00 PM)

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Count Name: Princess Kahanu Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:00 AM)

Start Time	Ulehawa Beach Park Eastbound					Princess Kahanu Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
7:00 AM	1	1	2	0	4	39	0	4	0	43	0	262	7	0	269	0	441	1	1	442	758
7:15 AM	1	0	1	0	2	44	1	2	0	47	1	273	11	0	285	1	385	0	1	386	720
7:30 AM	0	0	0	0	0	42	0	5	1	47	1	250	14	0	265	1	404	0	1	405	717
7:45 AM	1	1	1	0	3	34	0	3	3	37	4	266	19	0	289	0	375	1	2	376	705
Total	3	2	4	0	9	159	1	14	4	174	6	1051	51	0	1108	2	1605	2	5	1609	2900
Approach %	33.3	22.2	44.4	-	-	91.4	0.6	8.0	-	-	0.5	94.9	4.6	-	-	0.1	99.8	0.1	-	-	-
Total %	0.1	0.1	0.1	-	0.3	5.5	0.0	0.5	-	6.0	0.2	36.2	1.8	-	38.2	0.1	55.3	0.1	-	55.5	-
PHF	0.750	0.500	0.500	-	0.563	0.903	0.250	0.700	-	0.926	0.375	0.962	0.671	-	0.958	0.500	0.910	0.500	-	0.910	0.956
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	8	0	-	8	0	3	0	-	3	11
% Motorcycles	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.8	0.0	-	0.7	0.0	0.2	0.0	-	0.2	0.4
Cars	1	2	4	-	7	113	1	11	-	125	5	794	35	-	834	2	1232	1	-	1235	2201
% Cars	33.3	100.0	100.0	-	77.8	71.1	100.0	78.6	-	71.8	83.3	75.5	68.6	-	75.3	100.0	76.8	50.0	-	76.8	75.9
Light Goods Vehicles	2	0	0	-	2	41	0	0	-	41	1	197	13	-	211	0	328	0	-	328	582
% Light Goods Vehicles	66.7	0.0	0.0	-	22.2	25.8	0.0	0.0	-	23.6	16.7	18.7	25.5	-	19.0	0.0	20.4	0.0	-	20.4	20.1
Buses	0	0	0	-	0	3	0	0	-	3	0	11	2	-	13	0	15	0	-	15	31
% Buses	0.0	0.0	0.0	-	0.0	1.9	0.0	0.0	-	1.7	0.0	1.0	3.9	-	1.2	0.0	0.9	0.0	-	0.9	1.1
Single-Unit Trucks	0	0	0	-	0	2	0	1	-	3	0	34	1	-	35	0	24	1	-	25	63
% Single-Unit Trucks	0.0	0.0	0.0	-	0.0	1.3	0.0	7.1	-	1.7	0.0	3.2	2.0	-	3.2	0.0	1.5	50.0	-	1.6	2.2
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	6	0	-	6	0	3	0	-	3	9
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.6	0.0	-	0.5	0.0	0.2	0.0	-	0.2	0.3
Bicycles on Road	0	0	0	-	0	0	0	2	-	2	0	1	0	-	1	0	0	0	-	0	3
% Bicycles on Road	0.0	0.0	0.0	-	0.0	0.0	0.0	14.3	-	1.1	0.0	0.1	0.0	-	0.1	0.0	0.0	0.0	-	0.0	0.1
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	4	-	-	-	-	0	-	-	-	-	5	-	-
% Pedestrians	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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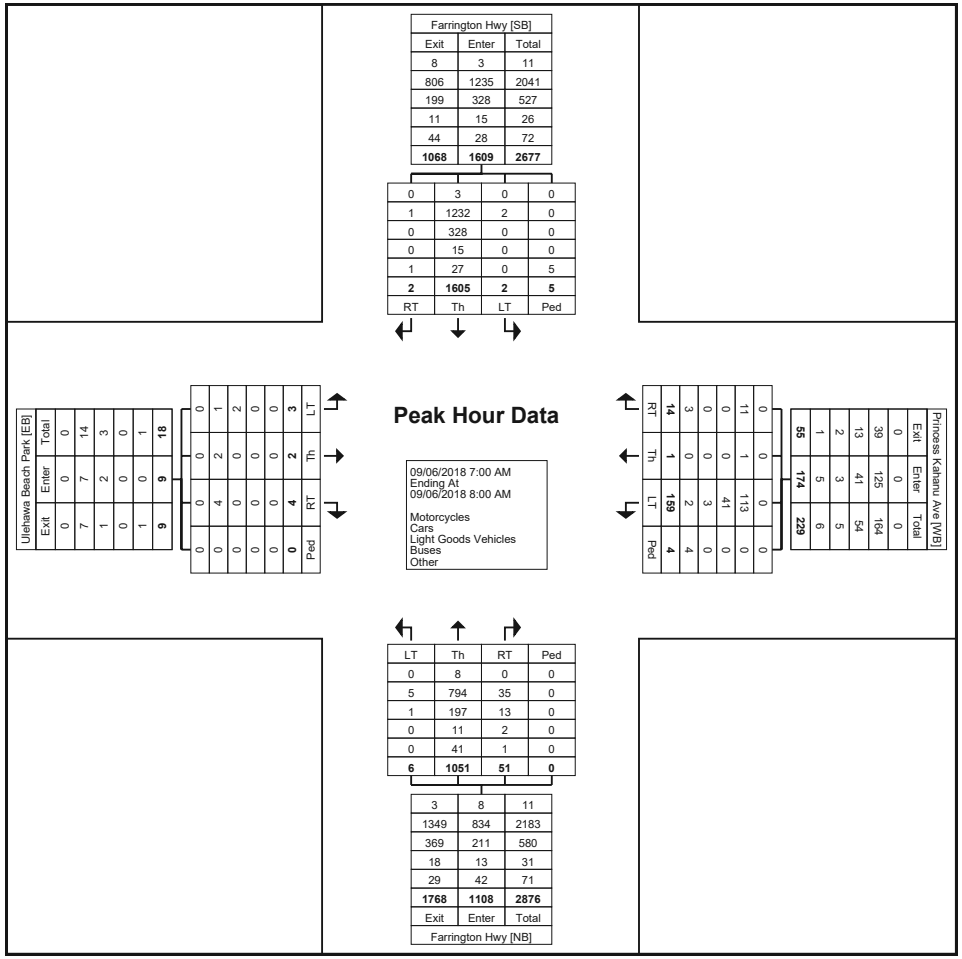
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Peak Hour Data Plot (7:00 AM)

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808-536-0223 tmchawaii@aol.com

Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 1

Turning Movement Data

Start Time	Haleakala Ave Westbound				Farrington Hwy Northbound				Farrington Hwy Southbound				
	Left-Turn	Right-Turn	Peds	App. Total	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Peds	App. Total	Int. Total
2:00 PM	10	74	41	84	322	9	0	331	52	263	7	315	730
2:15 PM	22	96	10	118	364	8	0	372	41	315	5	356	846
2:30 PM	21	57	4	78	411	2	0	413	31	331	8	362	853
2:45 PM	11	46	7	57	355	8	0	363	30	325	12	355	775
Hourly Total	64	273	62	337	1452	27	0	1479	154	1234	32	1388	3204
3:00 PM	23	53	5	76	402	5	0	407	31	305	2	336	819
3:15 PM	13	31	5	44	419	4	0	423	32	358	3	390	857
3:30 PM	18	51	1	69	409	4	0	413	26	293	5	319	801
3:45 PM	9	34	0	43	484	5	0	489	5	274	8	279	811
Hourly Total	63	169	11	232	1714	18	0	1732	94	1230	18	1324	3288
4:00 PM	9	31	3	40	433	4	0	437	0	276	1	276	753
4:15 PM	12	35	4	47	441	7	0	448	0	273	7	273	768
4:30 PM	8	33	1	41	395	3	0	398	0	281	8	281	720
4:45 PM	13	39	5	52	438	4	0	442	0	272	7	272	766
Hourly Total	42	138	13	180	1707	18	0	1725	0	1102	23	1102	3007
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-
5:00 AM	21	14	0	35	58	0	0	58	10	517	2	527	620
5:15 AM	26	7	0	33	69	1	0	70	11	591	1	602	705
5:30 AM	29	8	1	37	82	1	0	83	21	493	1	514	634
5:45 AM	7	20	0	27	98	1	0	99	15	566	0	581	707
Hourly Total	83	49	1	132	307	3	0	310	57	2167	4	2224	2666
6:00 AM	16	20	1	36	140	1	0	141	14	421	2	435	612
6:15 AM	22	27	0	49	177	1	0	178	20	493	0	513	740
6:30 AM	22	22	0	44	233	3	0	236	31	455	4	486	766
6:45 AM	15	34	1	49	259	3	0	262	58	417	1	475	786
Hourly Total	75	103	2	178	809	8	0	817	123	1786	7	1909	2904
7:00 AM	22	61	12	83	191	4	0	195	88	411	7	499	777
7:15 AM	36	81	13	117	271	4	0	275	91	399	4	490	882
7:30 AM	40	71	19	111	279	3	0	282	92	425	0	517	910
7:45 AM	58	115	16	173	235	8	0	243	63	426	5	489	905
Hourly Total	156	328	60	484	976	19	0	995	334	1661	16	1995	3474
8:00 AM	38	69	0	107	242	5	0	247	48	375	4	423	777
8:15 AM	12	74	0	86	268	4	0	272	28	386	5	414	772
8:30 AM	9	28	0	37	230	4	0	234	26	380	0	406	677
8:45 AM	7	30	3	37	225	3	0	228	40	336	3	376	641
Hourly Total	66	201	3	267	965	16	0	981	142	1477	12	1619	2867
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-
2:00 PM	7	38	0	45	335	2	0	337	30	264	7	294	676
2:15 PM	12	30	0	42	372	3	0	375	20	286	4	306	723
2:30 PM	21	36	1	57	405	6	0	411	25	335	5	360	828
2:45 PM	15	41	7	56	359	2	0	361	23	281	20	304	721

Hourly Total	55	145	8	200	1471	13	0	1484	98	1166	36	1264	2948
3:00 PM	26	47	0	73	433	6	0	439	22	304	4	326	838
3:15 PM	11	31	0	42	406	6	0	412	24	317	4	341	795
3:30 PM	16	40	4	56	412	5	0	417	24	290	6	314	787
3:45 PM	16	36	0	52	480	10	0	490	0	294	6	294	836
Hourly Total	69	154	4	223	1731	27	0	1758	70	1205	20	1275	3256
4:00 PM	15	34	1	49	426	15	1	441	1	298	3	299	789
4:15 PM	20	30	3	50	433	7	0	440	0	289	0	289	779
4:30 PM	19	25	2	44	421	3	0	424	0	275	2	275	743
4:45 PM	15	42	2	57	397	4	0	401	2	269	6	271	729
Hourly Total	69	131	8	200	1677	29	1	1706	3	1131	11	1134	3040
5:00 PM	14	30	1	44	438	2	0	440	0	271	4	271	755
5:15 PM	29	32	1	61	420	3	0	423	0	274	8	274	758
5:30 PM	24	43	2	67	416	9	0	425	0	267	3	267	759
5:45 PM	11	48	1	59	433	3	0	436	0	249	4	249	744
Hourly Total	78	153	5	231	1707	17	0	1724	0	1061	19	1061	3016
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-
7:00 AM	21	56	16	77	231	1	0	232	84	410	7	494	803
7:15 AM	32	66	13	98	252	0	0	252	98	411	5	509	859
7:30 AM	39	83	21	122	260	5	0	265	71	444	8	515	902
7:45 AM	47	100	21	147	255	8	0	263	52	453	5	505	915
Hourly Total	139	305	71	444	998	14	0	1012	305	1718	25	2023	3479
8:00 AM	32	78	5	110	267	7	0	274	42	400	2	442	826
8:15 AM	11	57	0	68	264	4	0	268	36	391	1	427	763
8:30 AM	7	41	0	48	279	3	0	282	17	346	2	363	693
8:45 AM	7	29	1	36	221	1	0	222	29	336	0	365	623
Hourly Total	57	205	6	262	1031	15	0	1046	124	1473	5	1597	2905
Grand Total	1016	2354	254	3370	16545	224	1	16769	1504	18411	228	19915	40054
Approach %	30.1	69.9	-	-	98.7	1.3	-	-	7.6	92.4	-	-	-
Total %	2.5	5.9	-	8.4	41.3	0.6	-	41.9	3.8	46.0	-	49.7	-
Motorcycles	3	6	-	9	55	2	-	57	4	47	-	51	117
% Motorcycles	0.3	0.3	-	0.3	0.3	0.9	-	0.3	0.3	0.3	-	0.3	0.3
Cars	744	1744	-	2488	10996	149	-	11145	1147	13783	-	14930	28563
% Cars	73.2	74.1	-	73.8	66.5	66.5	-	66.5	76.3	74.9	-	75.0	71.3
Light Goods Vehicles	252	547	-	799	4691	65	-	4756	320	3795	-	4115	9670
% Light Goods Vehicles	24.8	23.2	-	23.7	28.4	29.0	-	28.4	21.3	20.6	-	20.7	24.1
Buses	6	40	-	46	174	3	-	177	22	234	-	256	479
% Buses	0.6	1.7	-	1.4	1.1	1.3	-	1.1	1.5	1.3	-	1.3	1.2
Single-Unit Trucks	9	12	-	21	494	4	-	498	7	427	-	434	953
% Single-Unit Trucks	0.9	0.5	-	0.6	3.0	1.8	-	3.0	0.5	2.3	-	2.2	2.4
Articulated Trucks	0	2	-	2	135	1	-	136	3	125	-	128	266
% Articulated Trucks	0.0	0.1	-	0.1	0.8	0.4	-	0.8	0.2	0.7	-	0.6	0.7
Bicycles on Road	2	3	-	5	0	0	-	0	1	0	-	1	6
% Bicycles on Road	0.2	0.1	-	0.1	0.0	0.0	-	0.0	0.1	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	6	-	-	-	0	-	-	-	5	-	-
% Bicycles on Crosswalk	-	-	2.4	-	-	-	0.0	-	-	-	2.2	-	-
Pedestrians	-	-	248	-	-	-	1	-	-	-	223	-	-
% Pedestrians	-	-	97.6	-	-	-	100.0	-	-	-	97.8	-	-

The Traffic Management Consultant
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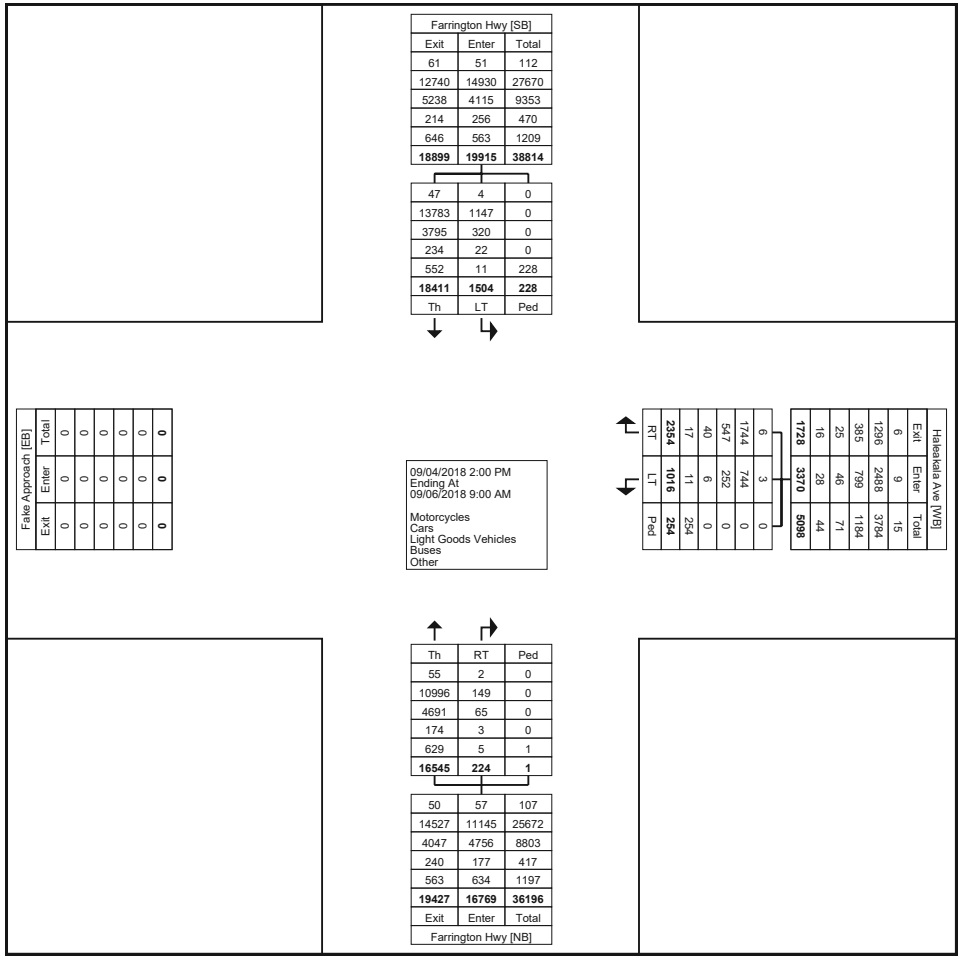
Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 3



Turning Movement Data Plot

The Traffic Management Consultant
1188 Bishop Street, Suite 1907

Honolulu, Hawaii, United States 96813
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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Haleakala Ave Westbound				Farrington Hwy Northbound				Farrington Hwy Southbound				
	Left-Turn	Right-Turn	Peds	App. Total	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Peds	App. Total	Int. Total
3:00 PM	23	53	5	76	402	5	0	407	31	305	2	336	819
3:15 PM	13	31	5	44	419	4	0	423	32	358	3	390	857
3:30 PM	18	51	1	69	409	4	0	413	26	293	5	319	801
3:45 PM	9	34	0	43	484	5	0	489	5	274	8	279	811
Total	63	169	11	232	1714	18	0	1732	94	1230	18	1324	3288
Approach %	27.2	72.8	-	-	99.0	1.0	-	-	7.1	92.9	-	-	-
Total %	1.9	5.1	-	7.1	52.1	0.5	-	52.7	2.9	37.4	-	40.3	-
PHF	0.685	0.797	-	0.763	0.885	0.900	-	0.885	0.734	0.859	-	0.849	0.959
Motorcycles	0	1	-	1	7	0	-	7	1	2	-	3	11
% Motorcycles	0.0	0.6	-	0.4	0.4	0.0	-	0.4	1.1	0.2	-	0.2	0.3
Cars	42	124	-	166	1125	11	-	1136	71	886	-	957	2259
% Cars	66.7	73.4	-	71.6	65.6	61.1	-	65.6	75.5	72.0	-	72.3	68.7
Light Goods Vehicles	20	37	-	57	533	6	-	539	19	279	-	298	894
% Light Goods Vehicles	31.7	21.9	-	24.6	31.1	33.3	-	31.1	20.2	22.7	-	22.5	27.2
Buses	0	6	-	6	11	0	-	11	1	24	-	25	42
% Buses	0.0	3.6	-	2.6	0.6	0.0	-	0.6	1.1	2.0	-	1.9	1.3
Single-Unit Trucks	1	1	-	2	35	1	-	36	1	34	-	35	73
% Single-Unit Trucks	1.6	0.6	-	0.9	2.0	5.6	-	2.1	1.1	2.8	-	2.6	2.2
Articulated Trucks	0	0	-	0	3	0	-	3	1	5	-	6	9
% Articulated Trucks	0.0	0.0	-	0.0	0.2	0.0	-	0.2	1.1	0.4	-	0.5	0.3
Bicycles on Road	0	0	-	0	0	0	-	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	0	-	-	-	0	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	0.0	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	11	-	-	-	0	-	-	-	18	-	-
% Pedestrians	-	-	100.0	-	-	-	-	-	-	-	100.0	-	-

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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 5

Farrington Hwy [SB]		
Exit	Enter	Total
8	3	11
1249	957	2206
570	298	868
17	25	42
39	41	80
1883	**1324**	**3207**

2	1	0
886	71	0
279	19	0
24	1	0
39	2	18
1230	**94**	**18**
Th	LT	Ped

Fake Approach [EB]		
Exit	Enter	Total
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	**0**	**0**

Peak Hour Data

09/04/2018 3:00 PM
Ending At
09/04/2018 4:00 PM

Motorcycles
Cars
Light Goods Vehicles
Buses
Other

RT	LT	Ped
169	**63**	**11**
1	1	11
6	0	0
37	20	0
124	42	0
1	0	0

Haleakala Ave [WB]		
Exit	Enter	Total
1	1	2
82	166	248
25	57	82
1	6	7
3	2	5
112	**232**	**344**

Th	RT	Ped
7	0	0
1125	11	0
533	6	0
11	0	0
38	1	0
1714	**18**	**0**

2	7	9
928	1136	2064
299	539	838
24	11	35
40	39	79
1293	**1732**	**3025**
Exit	Enter	Total
Farrington Hwy [NB]		

Turning Movement Peak Hour Data Plot (3:00 PM)

The Traffic Management Consultant
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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:00 AM)

Start Time	Haleakala Ave Westbound				Farrington Hwy Northbound				Farrington Hwy Southbound				
	Left-Turn	Right-Turn	Peds	App. Total	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Peds	App. Total	Int. Total
7:00 AM	22	61	12	83	191	4	0	195	88	411	7	499	777
7:15 AM	36	81	13	117	271	4	0	275	91	399	4	490	882
7:30 AM	40	71	19	111	279	3	0	282	92	425	0	517	910
7:45 AM	58	115	16	173	235	8	0	243	63	426	5	489	905
Total	156	328	60	484	976	19	0	995	334	1661	16	1995	3474
Approach %	32.2	67.8	-	-	98.1	1.9	-	-	16.7	83.3	-	-	-
Total %	4.5	9.4	-	13.9	28.1	0.5	-	28.6	9.6	47.8	-	57.4	-
PHF	0.672	0.713	-	0.699	0.875	0.594	-	0.882	0.908	0.975	-	0.965	0.954
Motorcycles	0	0	-	0	3	0	-	3	2	4	-	6	9
% Motorcycles	0.0	0.0	-	0.0	0.3	0.0	-	0.3	0.6	0.2	-	0.3	0.3
Cars	118	240	-	358	705	15	-	720	268	1341	-	1609	2687
% Cars	75.6	73.2	-	74.0	72.2	78.9	-	72.4	80.2	80.7	-	80.7	77.3
Light Goods Vehicles	37	78	-	115	196	3	-	199	57	249	-	306	620
% Light Goods Vehicles	23.7	23.8	-	23.8	20.1	15.8	-	20.0	17.1	15.0	-	15.3	17.8
Buses	0	6	-	6	13	0	-	13	6	18	-	24	43
% Buses	0.0	1.8	-	1.2	1.3	0.0	-	1.3	1.8	1.1	-	1.2	1.2
Single-Unit Trucks	1	4	-	5	40	1	-	41	1	39	-	40	86
% Single-Unit Trucks	0.6	1.2	-	1.0	4.1	5.3	-	4.1	0.3	2.3	-	2.0	2.5
Articulated Trucks	0	0	-	0	19	0	-	19	0	10	-	10	29
% Articulated Trucks	0.0	0.0	-	0.0	1.9	0.0	-	1.9	0.0	0.6	-	0.5	0.8
Bicycles on Road	0	0	-	0	0	0	-	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	1	-	-	-	0	-	-	-	1	-	-
% Bicycles on Crosswalk	-	-	1.7	-	-	-	-	-	-	-	6.3	-	-
Pedestrians	-	-	59	-	-	-	0	-	-	-	15	-	-
% Pedestrians	-	-	98.3	-	-	-	-	-	-	-	93.8	-	-

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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 7

Farrington Hwy [SB]		
Exit	Enter	Total
3	6	9
945	1609	2554
274	306	580
19	24	43
63	50	113
1304	**1995**	**3299**

4	2	0
1341	268	0
249	57	0
18	6	0
49	1	16
1661	**334**	**16**
Th	LT	Ped

Fake Approach [EB]		
Exit	Enter	Total
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	**0**	**0**

Peak Hour Data

09/05/2018 7:00 AM
Ending At
09/05/2018 8:00 AM

Motorcycles
Cars
Light Goods Vehicles
Buses
Other

RT	LT	Ped
4	1	60
6	0	0
78	37	0
240	118	0
0	0	0
328	**156**	**60**

Haleakala Ave [WB]		
Exit	Enter	Total
2	0	2
283	358	641
60	115	175
6	6	12
2	5	7
353	**484**	**837**

Th	RT	Ped
3	0	0
705	15	0
196	3	0
13	0	0
59	1	0
976	**19**	**0**

4	3	7
1459	720	2179
286	199	485
18	13	31
50	60	110
1817	**995**	**2812**
Exit	Enter	Total
Farrington Hwy [NB]		

Turning Movement Peak Hour Data Plot (7:00 AM)

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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Haleakala Ave Westbound				Farrington Hwy Northbound				Farrington Hwy Southbound				
	Left-Turn	Right-Turn	Peds	App. Total	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Peds	App. Total	Int. Total
3:00 PM	26	47	0	73	433	6	0	439	22	304	4	326	838
3:15 PM	11	31	0	42	406	6	0	412	24	317	4	341	795
3:30 PM	16	40	4	56	412	5	0	417	24	290	6	314	787
3:45 PM	16	36	0	52	480	10	0	490	0	294	6	294	836
Total	69	154	4	223	1731	27	0	1758	70	1205	20	1275	3256
Approach %	30.9	69.1	-	-	98.5	1.5	-	-	5.5	94.5	-	-	-
Total %	2.1	4.7	-	6.8	53.2	0.8	-	54.0	2.1	37.0	-	39.2	-
PHF	0.663	0.819	-	0.764	0.902	0.675	-	0.897	0.729	0.950	-	0.935	0.971
Motorcycles	1	0	-	1	9	0	-	9	0	0	-	0	10
% Motorcycles	1.4	0.0	-	0.4	0.5	0.0	-	0.5	0.0	0.0	-	0.0	0.3
Cars	56	106	-	162	1128	16	-	1144	45	880	-	925	2231
% Cars	81.2	68.8	-	72.6	65.2	59.3	-	65.1	64.3	73.0	-	72.5	68.5
Light Goods Vehicles	9	46	-	55	552	11	-	563	23	271	-	294	912
% Light Goods Vehicles	13.0	29.9	-	24.7	31.9	40.7	-	32.0	32.9	22.5	-	23.1	28.0
Buses	1	1	-	2	14	0	-	14	1	25	-	26	42
% Buses	1.4	0.6	-	0.9	0.8	0.0	-	0.8	1.4	2.1	-	2.0	1.3
Single-Unit Trucks	1	1	-	2	20	0	-	20	0	21	-	21	43
% Single-Unit Trucks	1.4	0.6	-	0.9	1.2	0.0	-	1.1	0.0	1.7	-	1.6	1.3
Articulated Trucks	0	0	-	0	8	0	-	8	1	8	-	9	17
% Articulated Trucks	0.0	0.0	-	0.0	0.5	0.0	-	0.5	1.4	0.7	-	0.7	0.5
Bicycles on Road	1	0	-	1	0	0	-	0	0	0	-	0	1
% Bicycles on Road	1.4	0.0	-	0.4	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	0	-	-	-	0	-	-	-	2	-	-
% Bicycles on Crosswalk	-	-	0.0	-	-	-	-	-	-	-	10.0	-	-
Pedestrians	-	-	4	-	-	-	0	-	-	-	18	-	-
% Pedestrians	-	-	100.0	-	-	-	-	-	-	-	90.0	-	-

The Traffic Management Consultant
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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 9

Farrington Hwy [SB]		
Exit	Enter	Total
9	0	9
1234	925	2159
598	294	892
15	26	41
29	30	59
1885	**1275**	**3160**

0	0	0
880	45	0
271	23	0
25	1	0
29	1	20
1205	**70**	**20**
Th	LT	Ped

Fake Approach [EB]		
Exit	Enter	Total
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	**0**	**0**

Peak Hour Data

09/05/2018 3:00 PM
Ending At
09/05/2018 4:00 PM

Motorcycles
Cars
Light Goods Vehicles
Buses
Other

RT	
154	**69**
1	2
1	1
46	9
106	56
0	1

LT	
4	**4**
4	0
0	0
0	0
0	0

Haleakala Ave [WB]		
Exit	Enter	Total
0	1	1
61	162	223
34	55	89
1	2	3
1	3	4
97	**223**	**320**

Th	RT	Ped
9	0	0
1128	16	0
552	11	0
14	0	0
28	0	0
1731	**27**	**0**

1	9	10
936	1144	2080
280	563	843
26	14	40
31	28	59
1274	**1758**	**3032**
Exit	Enter	Total
Farrington Hwy [NB]		

Turning Movement Peak Hour Data Plot (3:00 PM)

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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:15 AM)

Start Time	Haleakala Ave Westbound				Farrington Hwy Northbound				Farrington Hwy Southbound				
	Left-Turn	Right-Turn	Peds	App. Total	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Peds	App. Total	Int. Total
7:15 AM	32	66	13	98	252	0	0	252	98	411	5	509	859
7:30 AM	39	83	21	122	260	5	0	265	71	444	8	515	902
7:45 AM	47	100	21	147	255	8	0	263	52	453	5	505	915
8:00 AM	32	78	5	110	267	7	0	274	42	400	2	442	826
Total	150	327	60	477	1034	20	0	1054	263	1708	20	1971	3502
Approach %	31.4	68.6	-	-	98.1	1.9	-	-	13.3	86.7	-	-	-
Total %	4.3	9.3	-	13.6	29.5	0.6	-	30.1	7.5	48.8	-	56.3	-
PHF	0.798	0.818	-	0.811	0.968	0.625	-	0.962	0.671	0.943	-	0.957	0.957
Motorcycles	0	0	-	0	4	1	-	5	0	3	-	3	8
% Motorcycles	0.0	0.0	-	0.0	0.4	5.0	-	0.5	0.0	0.2	-	0.2	0.2
Cars	110	248	-	358	700	14	-	714	207	1260	-	1467	2539
% Cars	73.3	75.8	-	75.1	67.7	70.0	-	67.7	78.7	73.8	-	74.4	72.5
Light Goods Vehicles	38	70	-	108	226	3	-	229	52	358	-	410	747
% Light Goods Vehicles	25.3	21.4	-	22.6	21.9	15.0	-	21.7	19.8	21.0	-	20.8	21.3
Buses	1	6	-	7	6	1	-	7	3	26	-	29	43
% Buses	0.7	1.8	-	1.5	0.6	5.0	-	0.7	1.1	1.5	-	1.5	1.2
Single-Unit Trucks	1	2	-	3	74	0	-	74	1	44	-	45	122
% Single-Unit Trucks	0.7	0.6	-	0.6	7.2	0.0	-	7.0	0.4	2.6	-	2.3	3.5
Articulated Trucks	0	1	-	1	24	1	-	25	0	17	-	17	43
% Articulated Trucks	0.0	0.3	-	0.2	2.3	5.0	-	2.4	0.0	1.0	-	0.9	1.2
Bicycles on Road	0	0	-	0	0	0	-	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	0	-	-	-	0	-	-	-	1	-	-
% Bicycles on Crosswalk	-	-	0.0	-	-	-	-	-	-	-	5.0	-	-
Pedestrians	-	-	60	-	-	-	0	-	-	-	19	-	-
% Pedestrians	-	-	100.0	-	-	-	-	-	-	-	95.0	-	-

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Count Name: Haleakala Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Farrington Hwy [SB]		
Exit	Enter	Total
4	3	7
948	1467	2415
296	410	706
12	29	41
101	62	163
1361	**1971**	**3332**

3	0	0
1260	207	0
358	52	0
26	3	0
61	1	20
1708	**263**	**20**
Th	LT	Ped

Fake Approach [EB]		
Exit	Enter	Total
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	**0**	**0**

Peak Hour Data

09/06/2018 7:15 AM
Ending At
09/06/2018 8:15 AM

Motorcycles
Cars
Light Goods Vehicles
Buses
Other

RT	LT	Ped
0	0	0
248	110	0
70	38	0
6	1	0
3	1	60
327	**150**	**60**

Haleakala Ave [WB]		
Exit	Enter	Total
1	0	1
221	358	579
55	108	163
4	7	11
2	4	6
283	**477**	**760**

Th	RT	Ped
4	1	0
700	14	0
226	3	0
6	1	0
98	1	0
1034	**20**	**0**

3	5	8
1370	714	2084
396	229	625
27	7	34
62	99	161
1858	**1054**	**2912**
Exit	Enter	Total
Farrington Hwy [NB]		

Turning Movement Peak Hour Data Plot (7:15 AM)

The Traffic Management Consultant
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Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Data

Start Time	Nanakuli Beach Park Eastbound					Nanakuli Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
2:00 PM	3	3	0	0	6	33	1	24	0	58	2	336	40	0	378	12	230	3	1	245	687
2:15 PM	1	1	5	0	7	47	3	32	0	82	4	381	39	0	424	10	297	4	6	311	824
2:30 PM	3	0	2	0	5	38	3	11	3	52	7	377	51	0	435	20	301	13	15	334	826
2:45 PM	15	2	9	0	26	33	1	11	2	45	6	365	39	0	410	43	356	18	33	417	898
Hourly Total	22	6	16	0	44	151	8	78	5	237	19	1459	169	0	1647	85	1184	38	55	1307	3235
3:00 PM	20	3	6	0	29	40	5	9	1	54	1	335	46	0	382	24	309	12	8	345	810
3:15 PM	2	4	3	0	9	32	1	15	0	48	1	415	47	0	463	13	382	4	1	399	919
3:30 PM	4	1	1	0	6	34	6	12	1	52	1	385	57	0	443	18	310	14	8	342	843
3:45 PM	3	1	0	0	4	35	4	3	0	42	3	457	82	0	542	10	275	8	4	293	881
Hourly Total	29	9	10	0	48	141	16	39	2	196	6	1592	232	0	1830	65	1276	38	21	1379	3453
4:00 PM	0	1	6	0	7	27	3	7	0	37	1	462	102	0	565	1	266	6	6	273	882
4:15 PM	0	0	3	0	3	19	6	0	0	25	0	485	92	0	577	0	302	2	3	304	909
4:30 PM	0	0	7	0	7	32	1	1	0	34	0	437	116	0	553	0	289	2	2	291	885
4:45 PM	0	0	4	0	4	23	1	0	0	24	1	435	93	0	529	2	295	1	1	298	855
Hourly Total	0	1	20	0	21	101	11	8	0	120	2	1819	403	0	2224	3	1152	11	12	1166	3531
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5:00 AM	1	0	1	0	2	53	0	1	1	54	0	58	3	0	61	1	529	1	4	531	648
5:15 AM	0	2	1	0	3	50	0	3	0	53	0	81	13	0	94	5	562	4	1	571	721
5:30 AM	2	3	0	0	5	48	0	5	0	53	0	82	16	0	98	16	532	5	1	553	709
5:45 AM	0	1	2	0	3	30	0	5	0	35	0	84	17	0	101	11	586	3	4	600	739
Hourly Total	3	6	4	0	13	181	0	14	1	195	0	305	49	0	354	33	2209	13	10	2255	2817
6:00 AM	1	2	0	0	3	50	1	7	1	58	0	144	24	0	168	3	423	0	1	426	655
6:15 AM	1	1	2	0	4	52	1	6	0	59	0	175	19	0	194	7	496	0	1	503	760
6:30 AM	0	0	0	0	0	31	0	5	1	36	1	243	34	0	278	9	465	2	4	476	790
6:45 AM	3	1	1	0	5	43	0	7	3	50	2	254	41	0	297	10	410	2	8	422	774
Hourly Total	5	4	3	0	12	176	2	25	5	203	3	816	118	0	937	29	1794	4	14	1827	2979
7:00 AM	1	1	0	0	2	47	0	9	2	56	0	229	52	0	281	26	381	4	10	411	750
7:15 AM	3	0	0	0	3	50	0	8	0	58	1	260	75	0	336	19	383	4	2	406	803
7:30 AM	8	1	0	0	9	35	0	12	2	47	0	292	72	0	364	33	392	15	9	440	860
7:45 AM	22	1	1	0	24	51	0	14	2	65	3	248	38	0	289	38	408	22	7	468	846
Hourly Total	34	3	1	0	38	183	0	43	6	226	4	1029	237	0	1270	116	1564	45	28	1725	3259
8:00 AM	17	1	2	0	20	51	0	11	1	62	1	256	35	0	292	35	430	14	4	479	853
8:15 AM	7	0	1	0	8	49	0	8	0	57	1	243	26	0	270	29	406	4	1	439	774
8:30 AM	1	0	2	0	3	36	0	6	0	42	3	235	27	0	265	13	399	4	2	416	726
8:45 AM	2	2	5	0	9	34	1	5	0	40	4	200	28	0	232	4	337	2	5	343	624
Hourly Total	27	3	10	0	40	170	1	30	1	201	9	934	116	0	1059	81	1572	24	12	1677	2977
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3:00 PM	20	2	6	0	28	48	0	3	3	51	3	358	40	0	401	28	315	11	16	354	834
3:15 PM	4	3	1	0	8	32	1	8	1	41	3	411	68	0	482	15	307	9	4	331	862
3:30 PM	3	0	1	0	4	30	0	4	0	34	1	413	56	0	470	19	305	9	8	333	841
3:45 PM	2	4	2	0	8	38	3	7	0	48	2	458	79	0	539	4	293	7	5	304	899

Hourly Total	29	9	10	0	48	148	4	22	4	174	9	1640	243	0	1892	66	1220	36	33	1322	3436
4:00 PM	0	0	9	0	9	28	6	8	0	42	0	452	96	0	548	1	294	7	1	302	901
4:15 PM	0	0	9	0	9	22	5	5	0	32	0	472	117	0	589	0	312	11	1	323	953
4:30 PM	0	0	3	0	3	24	5	4	2	33	0	437	97	0	534	0	283	3	2	286	856
4:45 PM	0	1	3	0	4	20	4	10	0	34	0	429	101	0	530	0	276	2	0	278	846
Hourly Total	0	1	24	0	25	94	20	27	2	141	0	1790	411	0	2201	1	1165	23	4	1189	3556
5:00 PM	0	0	1	1	1	19	3	5	1	27	0	438	114	0	552	0	257	3	4	260	840
5:15 PM	0	0	5	0	5	23	2	8	1	33	0	441	118	0	559	0	283	5	2	288	885
5:30 PM	0	1	2	0	3	18	2	5	4	25	1	423	95	0	519	0	287	3	8	290	837
5:45 PM	0	0	1	0	1	31	5	4	1	40	1	454	115	0	570	0	285	4	9	289	900
Hourly Total	0	1	9	1	10	91	12	22	7	125	2	1756	442	0	2200	0	1112	15	23	1127	3462
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7:00 AM	2	0	0	0	2	52	0	4	2	56	2	258	49	0	309	18	404	0	4	422	789
7:15 AM	3	0	0	0	3	45	0	15	0	60	0	258	79	0	337	23	406	4	0	433	833
7:30 AM	9	1	3	0	13	37	3	16	1	56	3	262	72	0	337	28	434	13	5	475	881
7:45 AM	17	2	1	0	20	42	2	21	0	65	1	271	47	0	319	44	398	18	7	460	864
Hourly Total	31	3	4	0	38	176	5	56	3	237	6	1049	247	0	1302	113	1642	35	16	1790	3367
8:00 AM	22	2	2	0	26	45	1	12	0	58	1	290	27	0	318	34	422	23	5	479	881
8:15 AM	7	0	1	0	8	48	0	10	0	58	1	246	36	0	283	19	422	6	1	447	796
8:30 AM	2	0	1	0	3	30	3	11	0	44	0	248	19	0	267	9	368	3	2	380	694
8:45 AM	0	0	3	0	3	26	1	5	0	32	3	218	22	0	243	8	343	4	2	355	633
Hourly Total	31	2	7	0	40	149	5	38	0	192	5	1002	104	0	1111	70	1555	36	10	1661	3004
Grand Total	211	48	118	1	377	1761	84	402	36	2247	65	15191	2771	0	18027	662	17445	318	238	18425	39076
Approach %	56.0	12.7	31.3	-	-	78.4	3.7	17.9	-	-	0.4	84.3	15.4	-	-	3.6	94.7	1.7	-	-	-
Total %	0.5	0.1	0.3	-	1.0	4.5	0.2	1.0	-	5.8	0.2	38.9	7.1	-	46.1	1.7	44.6	0.8	-	47.2	-
Motorcycles	0	0	0	-	0	3	0	0	-	3	0	47	5	-	52	1	44	1	-	46	101
% Motorcycles	0.0	0.0	0.0	-	0.0	0.2	0.0	0.0	-	0.1	0.0	0.3	0.2	-	0.3	0.2	0.3	0.3	-	0.2	0.3
Cars	177	33	80	-	290	1286	59	327	-	1672	46	10806	2095	-	12947	466	12400	236	-	13102	28011
% Cars	83.9	68.8	67.8	-	76.9	73.0	70.2	81.3	-	74.4	70.8	71.1	75.6	-	71.8	70.4	71.1	74.2	-	71.1	71.7
Light Goods Vehicles	31	14	35	-	80	425	25	64	-	514	17	3642	618	-	4277	164	4276	78	-	4518	9389
% Light Goods Vehicles	14.7	29.2	29.7	-	21.2	24.1	29.8	15.9	-	22.9	26.2	24.0	22.3	-	23.7	24.8	24.5	24.5	-	24.5	24.0
Buses	3	0	0	-	3	31	0	5	-	36	0	162	26	-	188	30	194	2	-	226	453
% Buses	1.4	0.0	0.0	-	0.8	1.8	0.0	1.2	-	1.6	0.0	1.1	0.9	-	1.0	4.5	1.1	0.6	-	1.2	1.2
Single-Unit Trucks	0	0	3	-	3	15	0	6	-	21	2	423	26	-	451	1	410	1	-	412	887
% Single-Unit Trucks	0.0	0.0	2.5	-	0.8	0.9	0.0	1.5	-	0.9	3.1	2.8	0.9	-	2.5	0.2	2.4	0.3	-	2.2	2.3
Articulated Trucks	0	0	0	-	0	1	0	0	-	1	0	111	1	-	112	0	118	0	-	118	231
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	-	0.0	0.0	0.7	0.0	-	0.6	0.0	0.7	0.0	-	0.6	0.6
Bicycles on Road	0	1	0	-	1	0	0	0	-	0	0	0	0	-	0	0	3	0	-	3	4
% Bicycles on Road	0.0	2.1	0.0	-	0.3	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	1	-	-	-	-	0	-	-	-	-	3	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	2.8	-	-	-	-	-	-	-	-	-	1.3	-	-
Pedestrians	-	-	-	1	-	-	-	-	35	-	-	-	-	0	-	-	-	-	235	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	97.2	-	-	-	-	-	-	-	-	-	98.7	-	-

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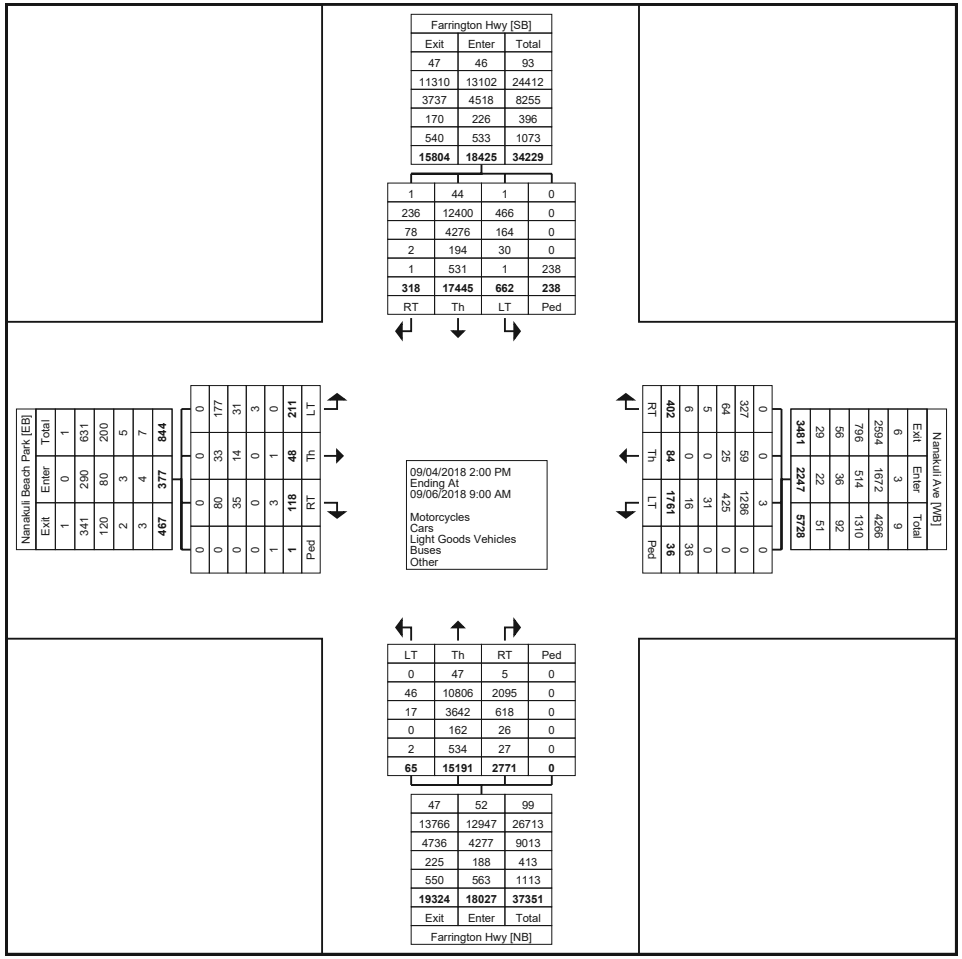
Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 3



Turning Movement Data Plot

The Traffic Management Consultant
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Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:45 PM)

Start Time	Nanakuli Beach Park Eastbound					Nanakuli Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:45 PM	3	1	0	0	4	35	4	3	0	42	3	457	82	0	542	10	275	8	4	293	881
4:00 PM	0	1	6	0	7	27	3	7	0	37	1	462	102	0	565	1	266	6	6	273	882
4:15 PM	0	0	3	0	3	19	6	0	0	25	0	485	92	0	577	0	302	2	3	304	909
4:30 PM	0	0	7	0	7	32	1	1	0	34	0	437	116	0	553	0	289	2	2	291	885
Total	3	2	16	0	21	113	14	11	0	138	4	1841	392	0	2237	11	1132	18	15	1161	3557
Approach %	14.3	9.5	76.2	-	-	81.9	10.1	8.0	-	-	0.2	82.3	17.5	-	-	0.9	97.5	1.6	-	-	-
Total %	0.1	0.1	0.4	-	0.6	3.2	0.4	0.3	-	3.9	0.1	51.8	11.0	-	62.9	0.3	31.8	0.5	-	32.6	-
PHF	0.250	0.500	0.571	-	0.750	0.807	0.583	0.393	-	0.821	0.333	0.949	0.845	-	0.969	0.275	0.937	0.563	-	0.955	0.978
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	7	2	-	9	0	3	0	-	3	12
% Motorcycles	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.4	0.5	-	0.4	0.0	0.3	0.0	-	0.3	0.3
Cars	2	1	10	-	13	85	7	10	-	102	3	1235	293	-	1531	5	863	12	-	880	2526
% Cars	66.7	50.0	62.5	-	61.9	75.2	50.0	90.9	-	73.9	75.0	67.1	74.7	-	68.4	45.5	76.2	66.7	-	75.8	71.0
Light Goods Vehicles	1	1	5	-	7	24	7	1	-	32	0	572	96	-	668	6	238	6	-	250	957
% Light Goods Vehicles	33.3	50.0	31.3	-	33.3	21.2	50.0	9.1	-	23.2	0.0	31.1	24.5	-	29.9	54.5	21.0	33.3	-	21.5	26.9
Buses	0	0	0	-	0	2	0	0	-	2	0	12	0	-	12	0	10	0	-	10	24
% Buses	0.0	0.0	0.0	-	0.0	1.8	0.0	0.0	-	1.4	0.0	0.7	0.0	-	0.5	0.0	0.9	0.0	-	0.9	0.7
Single-Unit Trucks	0	0	1	-	1	2	0	0	-	2	1	13	1	-	15	0	16	0	-	16	34
% Single-Unit Trucks	0.0	0.0	6.3	-	4.8	1.8	0.0	0.0	-	1.4	25.0	0.7	0.3	-	0.7	0.0	1.4	0.0	-	1.4	1.0
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	2	0	-	2	0	2	0	-	2	4
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0	0.2	0.0	-	0.2	0.1
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	15	-	-
% Pedestrians	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-

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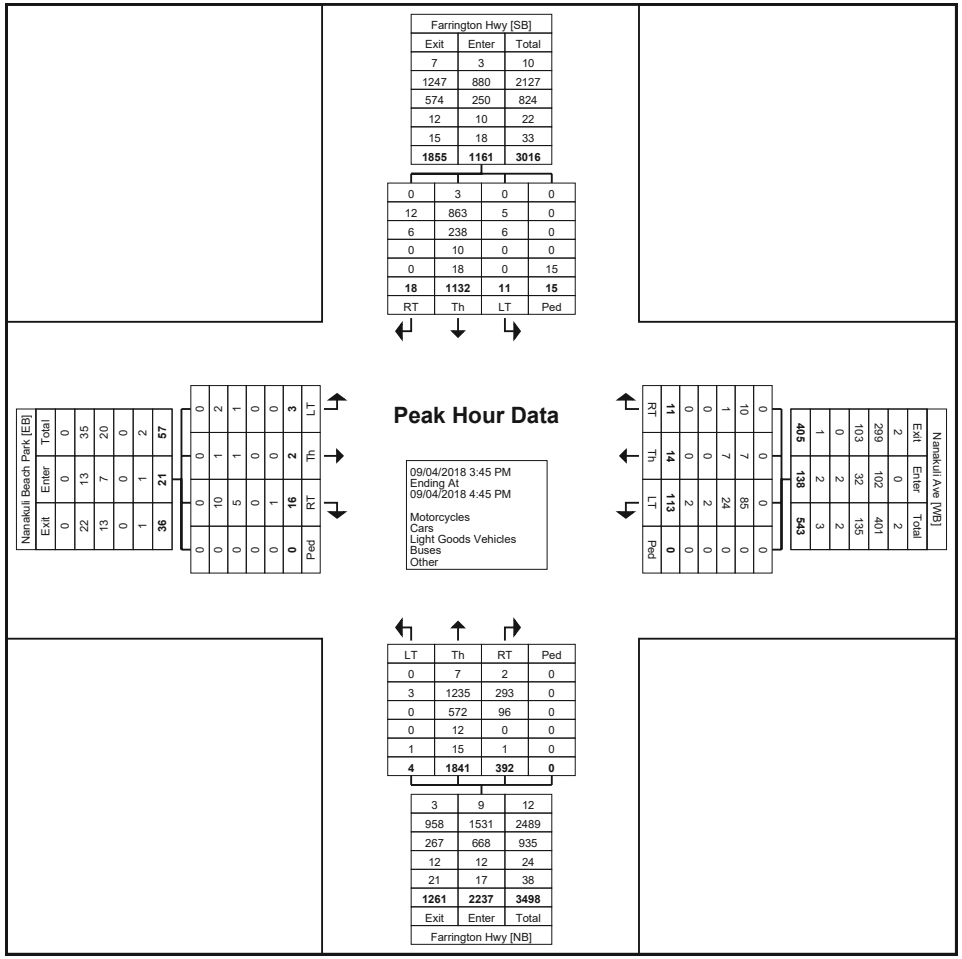
Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 5



Turning Movement Peak Hour Data Plot (3:45 PM)

The Traffic Management Consultant
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Honolulu, Hawaii, United States 96813
808-536-0223 tmchawaii@aol.com

Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:15 AM)

Start Time	Nanakuli Beach Park Eastbound					Nanakuli Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
7:15 AM	3	0	0	0	3	50	0	8	0	58	1	260	75	0	336	19	383	4	2	406	803
7:30 AM	8	1	0	0	9	35	0	12	2	47	0	292	72	0	364	33	392	15	9	440	860
7:45 AM	22	1	1	0	24	51	0	14	2	65	3	248	38	0	289	38	408	22	7	468	846
8:00 AM	17	1	2	0	20	51	0	11	1	62	1	256	35	0	292	35	430	14	4	479	853
Total	50	3	3	0	56	187	0	45	5	232	5	1056	220	0	1281	125	1613	55	22	1793	3362
Approach %	89.3	5.4	5.4	-	-	80.6	0.0	19.4	-	-	0.4	82.4	17.2	-	-	7.0	90.0	3.1	-	-	-
Total %	1.5	0.1	0.1	-	1.7	5.6	0.0	1.3	-	6.9	0.1	31.4	6.5	-	38.1	3.7	48.0	1.6	-	53.3	-
PHF	0.568	0.750	0.375	-	0.583	0.917	0.000	0.804	-	0.892	0.417	0.904	0.733	-	0.880	0.822	0.938	0.625	-	0.936	0.977
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	1	0	-	1	0	4	0	-	4	5
% Motorcycles	0.0	0.0	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0	0.2	0.0	-	0.2	0.1
Cars	43	3	2	-	48	142	0	36	-	178	4	778	193	-	975	92	1179	46	-	1317	2518
% Cars	86.0	100.0	66.7	-	85.7	75.9	-	80.0	-	76.7	80.0	73.7	87.7	-	76.1	73.6	73.1	83.6	-	73.5	74.9
Light Goods Vehicles	7	0	1	-	8	37	0	8	-	45	1	197	22	-	220	28	359	9	-	396	669
% Light Goods Vehicles	14.0	0.0	33.3	-	14.3	19.8	-	17.8	-	19.4	20.0	18.7	10.0	-	17.2	22.4	22.3	16.4	-	22.1	19.9
Buses	0	0	0	-	0	5	0	0	-	5	0	8	2	-	10	5	16	0	-	21	36
% Buses	0.0	0.0	0.0	-	0.0	2.7	-	0.0	-	2.2	0.0	0.8	0.9	-	0.8	4.0	1.0	0.0	-	1.2	1.1
Single-Unit Trucks	0	0	0	-	0	3	0	1	-	4	0	52	3	-	55	0	42	0	-	42	101
% Single-Unit Trucks	0.0	0.0	0.0	-	0.0	1.6	-	2.2	-	1.7	0.0	4.9	1.4	-	4.3	0.0	2.6	0.0	-	2.3	3.0
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	20	0	-	20	0	12	0	-	12	32
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	1.9	0.0	-	1.6	0.0	0.7	0.0	-	0.7	1.0
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	1	0	-	1	1
% Bicycles on Road	0.0	0.0	0.0	-	0.0	0.0	-	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	5	-	-	-	-	0	-	-	-	-	22	-	-
% Pedestrians	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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Count Name: Nanakuli Ave Farrington Hwy
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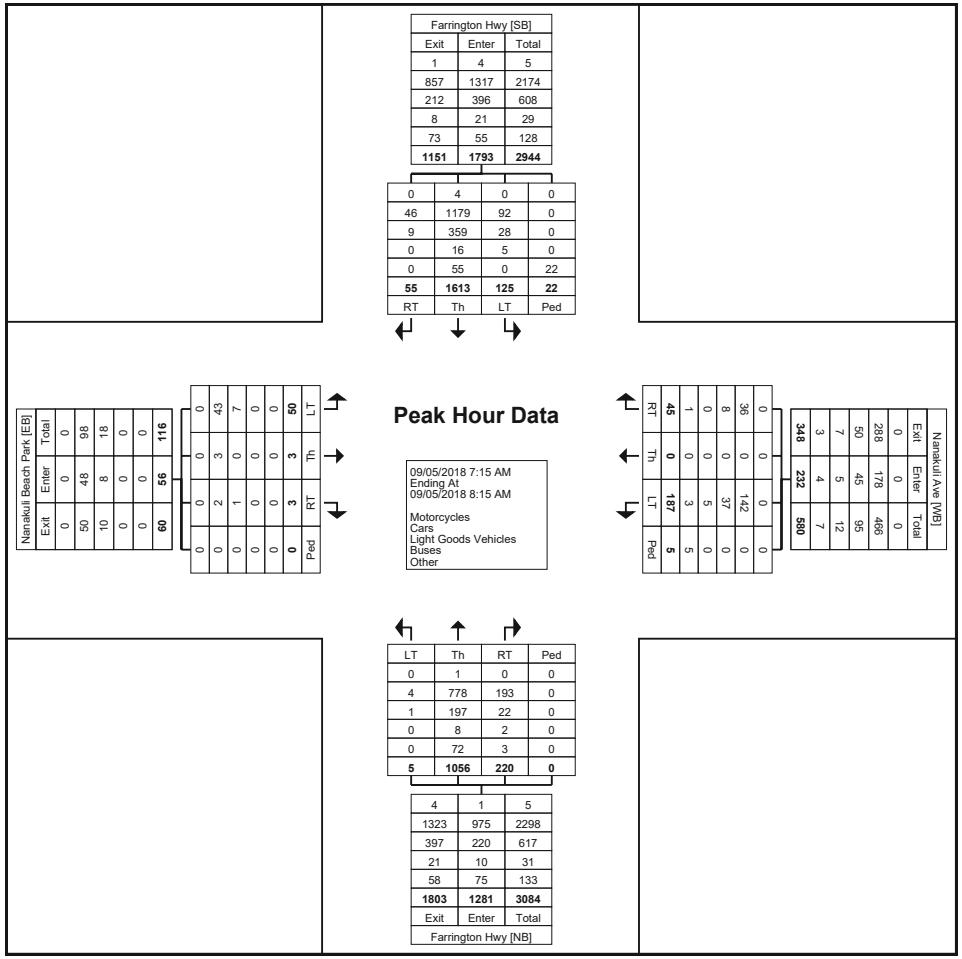

Turning Movement Peak Hour Data Plot (7:15 AM)

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Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:45 PM)

Start Time	Nanakuli Beach Park Eastbound					Nanakuli Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
3:45 PM	2	4	2	0	8	38	3	7	0	48	2	458	79	0	539	4	293	7	5	304	899
4:00 PM	0	0	9	0	9	28	6	8	0	42	0	452	96	0	548	1	294	7	1	302	901
4:15 PM	0	0	9	0	9	22	5	5	0	32	0	472	117	0	589	0	312	11	1	323	953
4:30 PM	0	0	3	0	3	24	5	4	2	33	0	437	97	0	534	0	283	3	2	286	856
Total	2	4	23	0	29	112	19	24	2	155	2	1819	389	0	2210	5	1182	28	9	1215	3609
Approach %	6.9	13.8	79.3	-	-	72.3	12.3	15.5	-	-	0.1	82.3	17.6	-	-	0.4	97.3	2.3	-	-	-
Total %	0.1	0.1	0.6	-	0.8	3.1	0.5	0.7	-	4.3	0.1	50.4	10.8	-	61.2	0.1	32.8	0.8	-	33.7	-
PHF	0.250	0.250	0.639	-	0.806	0.737	0.792	0.750	-	0.807	0.250	0.963	0.831	-	0.938	0.313	0.947	0.636	-	0.940	0.947
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	6	0	-	6	0	1	0	-	1	7
% Motorcycles	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	-	0.3	0.0	0.1	0.0	-	0.1	0.2
Cars	2	3	14	-	19	78	13	20	-	111	1	1290	262	-	1553	3	919	17	-	939	2622
% Cars	100.0	75.0	60.9	-	65.5	69.6	68.4	83.3	-	71.6	50.0	70.9	67.4	-	70.3	60.0	77.7	60.7	-	77.3	72.7
Light Goods Vehicles	0	1	8	-	9	31	6	4	-	41	0	491	125	-	616	2	234	11	-	247	913
% Light Goods Vehicles	0.0	25.0	34.8	-	31.0	27.7	31.6	16.7	-	26.5	0.0	27.0	32.1	-	27.9	40.0	19.8	39.3	-	20.3	25.3
Buses	0	0	0	-	0	1	0	0	-	1	0	16	1	-	17	0	9	0	-	9	27
% Buses	0.0	0.0	0.0	-	0.0	0.9	0.0	0.0	-	0.6	0.0	0.9	0.3	-	0.8	0.0	0.8	0.0	-	0.7	0.7
Single-Unit Trucks	0	0	1	-	1	2	0	0	-	2	1	11	1	-	13	0	17	0	-	17	33
% Single-Unit Trucks	0.0	0.0	4.3	-	3.4	1.8	0.0	0.0	-	1.3	50.0	0.6	0.3	-	0.6	0.0	1.4	0.0	-	1.4	0.9
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	5	0	-	5	0	1	0	-	1	6
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	-	0.2	0.0	0.1	0.0	-	0.1	0.2
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	1	0	-	1	1
% Bicycles on Road	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	-	0.1	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	2	-	-	-	-	0	-	-	-	-	9	-	-
% Pedestrians	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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Count Name: Nanakuli Ave Farrington Hwy
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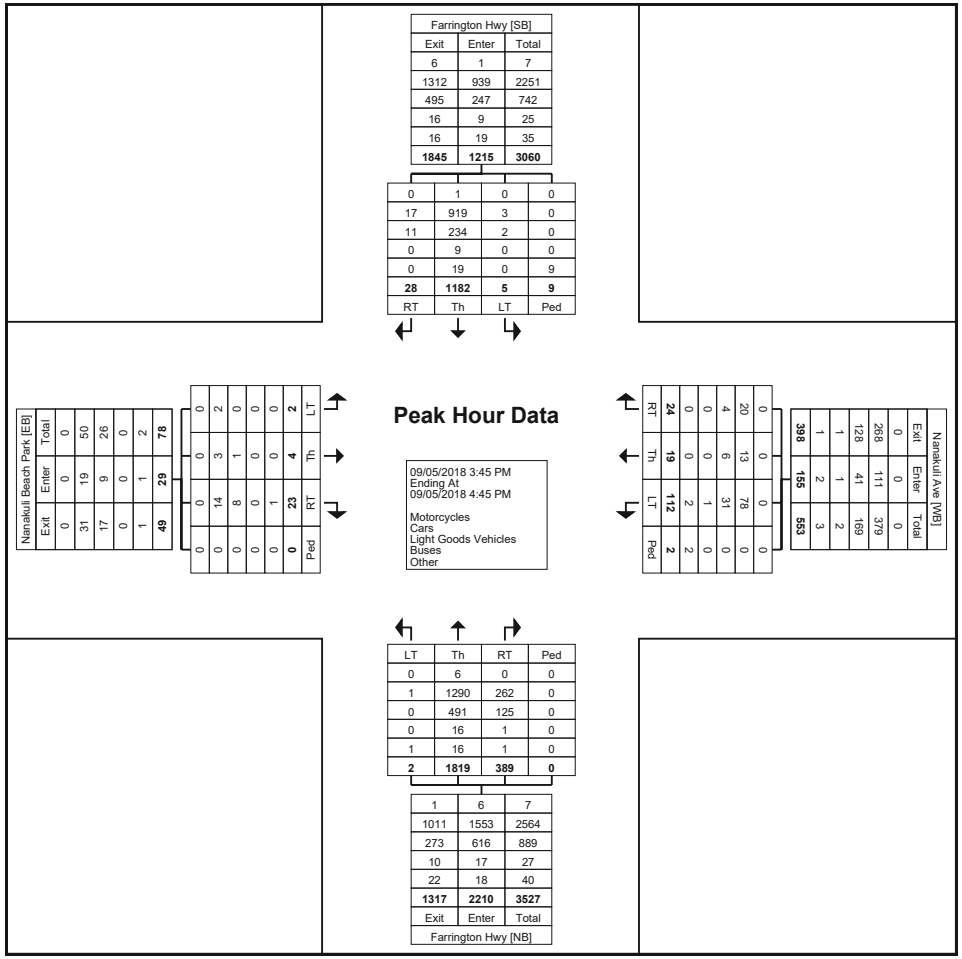
Page No: 9



Turning Movement Peak Hour Data Plot (3:45 PM)

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Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:15 AM)

Start Time	Nanakuli Beach Park Eastbound					Nanakuli Ave Westbound					Farrington Hwy Northbound					Farrington Hwy Southbound					
	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Left-Turn	Thru	Right-Turn	Peds	App. Total	Int. Total
7:15 AM	3	0	0	0	3	45	0	15	0	60	0	258	79	0	337	23	406	4	0	433	833
7:30 AM	9	1	3	0	13	37	3	16	1	56	3	262	72	0	337	28	434	13	5	475	881
7:45 AM	17	2	1	0	20	42	2	21	0	65	1	271	47	0	319	44	398	18	7	460	864
8:00 AM	22	2	2	0	26	45	1	12	0	58	1	290	27	0	318	34	422	23	5	479	881
Total	51	5	6	0	62	169	6	64	1	239	5	1081	225	0	1311	129	1660	58	17	1847	3459
Approach %	82.3	8.1	9.7	-	-	70.7	2.5	26.8	-	-	0.4	82.5	17.2	-	-	7.0	89.9	3.1	-	-	-
Total %	1.5	0.1	0.2	-	1.8	4.9	0.2	1.9	-	6.9	0.1	31.3	6.5	-	37.9	3.7	48.0	1.7	-	53.4	-
PHF	0.580	0.625	0.500	-	0.596	0.939	0.500	0.762	-	0.919	0.417	0.932	0.712	-	0.973	0.733	0.956	0.630	-	0.964	0.982
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	3	0	-	3	0	4	0	-	4	7
% Motorcycles	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	-	0.2	0.0	0.2	0.0	-	0.2	0.2
Cars	43	4	2	-	49	126	6	48	-	180	1	780	190	-	971	87	1212	49	-	1348	2548
% Cars	84.3	80.0	33.3	-	79.0	74.6	100.0	75.0	-	75.3	20.0	72.2	84.4	-	74.1	67.4	73.0	84.5	-	73.0	73.7
Light Goods Vehicles	8	1	4	-	13	37	0	13	-	50	4	194	27	-	225	34	358	9	-	401	689
% Light Goods Vehicles	15.7	20.0	66.7	-	21.0	21.9	0.0	20.3	-	20.9	80.0	17.9	12.0	-	17.2	26.4	21.6	15.5	-	21.7	19.9
Buses	0	0	0	-	0	6	0	1	-	7	0	7	3	-	10	8	18	0	-	26	43
% Buses	0.0	0.0	0.0	-	0.0	3.6	0.0	1.6	-	2.9	0.0	0.6	1.3	-	0.8	6.2	1.1	0.0	-	1.4	1.2
Single-Unit Trucks	0	0	0	-	0	0	0	2	-	2	0	73	4	-	77	0	47	0	-	47	126
% Single-Unit Trucks	0.0	0.0	0.0	-	0.0	0.0	0.0	3.1	-	0.8	0.0	6.8	1.8	-	5.9	0.0	2.8	0.0	-	2.5	3.6
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	24	1	-	25	0	21	0	-	21	46
% Articulated Trucks	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	2.2	0.4	-	1.9	0.0	1.3	0.0	-	1.1	1.3
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	1	-	-	-	-	0	-	-	-	-	17	-	-
% Pedestrians	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-

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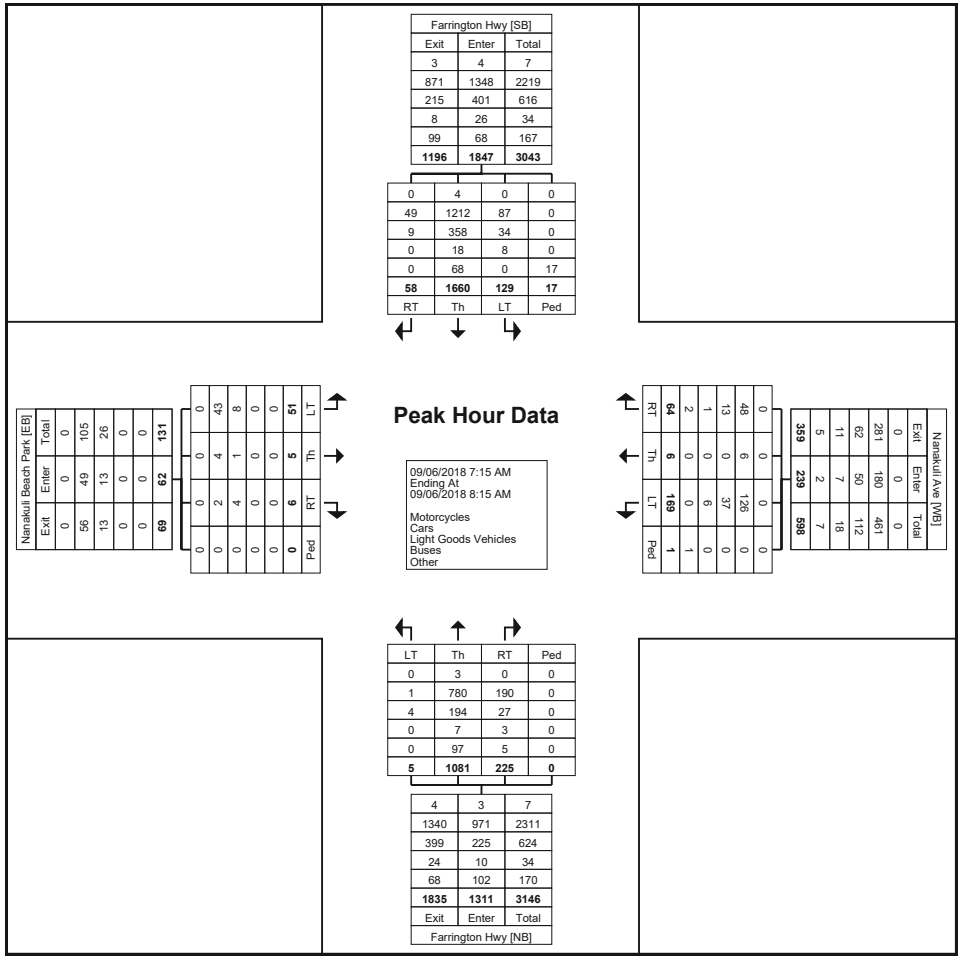
Count Name: Nanakuli Ave Farrington Hwy
Site Code: PVT ISWMF
Start Date: 09/04/2018



Turning Movement Peak Hour Data Plot (7:15 AM)

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Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Data

Start Time	Lualualei Naval Rd Eastbound			Lualualei Naval Rd Westbound			PVT Dwy Southbound			
	Left-Turn	Thru	App. Total	Thru	Right-Turn	App. Total	Left-Turn	Right-Turn	App. Total	Int. Total
3:00 PM	0	8	8	10	0	10	1	6	7	25
3:15 PM	5	5	10	4	0	4	0	4	4	18
3:30 PM	3	4	7	26	0	26	0	10	10	43
3:45 PM	4	3	7	10	1	11	0	31	31	49
Hourly Total	12	20	32	50	1	51	1	51	52	135
4:00 PM	0	3	3	12	0	12	0	12	12	27
4:15 PM	1	1	2	1	0	1	0	1	1	4
4:30 PM	0	0	0	2	0	2	0	1	1	3
4:45 PM	0	1	1	2	0	2	0	0	0	3
Hourly Total	1	5	6	17	0	17	0	14	14	37
*** BREAK ***	-	-	-	-	-	-	-	-	-	-
7:00 AM	11	7	18	6	0	6	0	2	2	26
7:15 AM	6	11	17	3	1	4	0	3	3	24
7:30 AM	12	6	18	8	0	8	0	9	9	35
7:45 AM	6	7	13	6	0	6	0	7	7	26
Hourly Total	35	31	66	23	1	24	0	21	21	111
8:00 AM	11	4	15	4	0	4	0	9	9	28
8:15 AM	8	10	18	3	1	4	0	5	5	27
8:30 AM	6	19	25	10	0	10	0	7	7	42
8:45 AM	5	9	14	15	0	15	0	9	9	38
Hourly Total	30	42	72	32	1	33	0	30	30	135
*** BREAK ***	-	-	-	-	-	-	-	-	-	-
3:00 PM	0	6	6	17	0	17	1	6	7	30
3:15 PM	2	2	4	16	0	16	0	5	5	25
3:30 PM	4	2	6	29	0	29	0	8	8	43
3:45 PM	4	0	4	5	0	5	0	32	32	41
Hourly Total	10	10	20	67	0	67	1	51	52	139
4:00 PM	1	0	1	4	0	4	0	9	9	14
4:15 PM	0	4	4	3	0	3	0	1	1	8
4:30 PM	2	0	2	1	0	1	0	1	1	4
4:45 PM	1	4	5	7	0	7	0	0	0	12
Hourly Total	4	8	12	15	0	15	0	11	11	38
*** BREAK ***	-	-	-	-	-	-	-	-	-	-
7:00 AM	11	10	21	4	0	4	0	2	2	27
7:15 AM	11	9	20	4	0	4	1	6	7	31
7:30 AM	6	11	17	4	1	5	0	7	7	29
7:45 AM	11	13	24	5	0	5	3	13	16	45
Hourly Total	39	43	82	17	1	18	4	28	32	132
8:00 AM	15	5	20	6	1	7	1	9	10	37
8:15 AM	16	11	27	4	0	4	0	8	8	39
8:30 AM	11	5	16	13	0	13	0	14	14	43

8:45 AM	6	12	18	9	0	9	0	9	9	36
Hourly Total	48	33	81	32	1	33	1	40	41	155
Grand Total	179	192	371	253	5	258	7	246	253	882
Approach %	48.2	51.8	-	98.1	1.9	-	2.8	97.2	-	-
Total %	20.3	21.8	42.1	28.7	0.6	29.3	0.8	27.9	28.7	-
Motorcycles	0	1	1	0	0	0	0	1	1	2
% Motorcycles	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.4	0.4	0.2
Cars	39	62	101	87	1	88	0	94	94	283
% Cars	21.8	32.3	27.2	34.4	20.0	34.1	0.0	38.2	37.2	32.1
Light Goods Vehicles	22	46	68	80	1	81	0	45	45	194
% Light Goods Vehicles	12.3	24.0	18.3	31.6	20.0	31.4	0.0	18.3	17.8	22.0
Buses	2	2	4	2	0	2	0	0	0	6
% Buses	1.1	1.0	1.1	0.8	0.0	0.8	0.0	0.0	0.0	0.7
Single-Unit Trucks	75	68	143	68	3	71	7	69	76	290
% Single-Unit Trucks	41.9	35.4	38.5	26.9	60.0	27.5	100.0	28.0	30.0	32.9
Articulated Trucks	41	13	54	16	0	16	0	37	37	107
% Articulated Trucks	22.9	6.8	14.6	6.3	0.0	6.2	0.0	15.0	14.6	12.1
Bicycles on Road	0	0	0	0	0	0	0	0	0	0
% Bicycles on Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The Traffic Management Consultant
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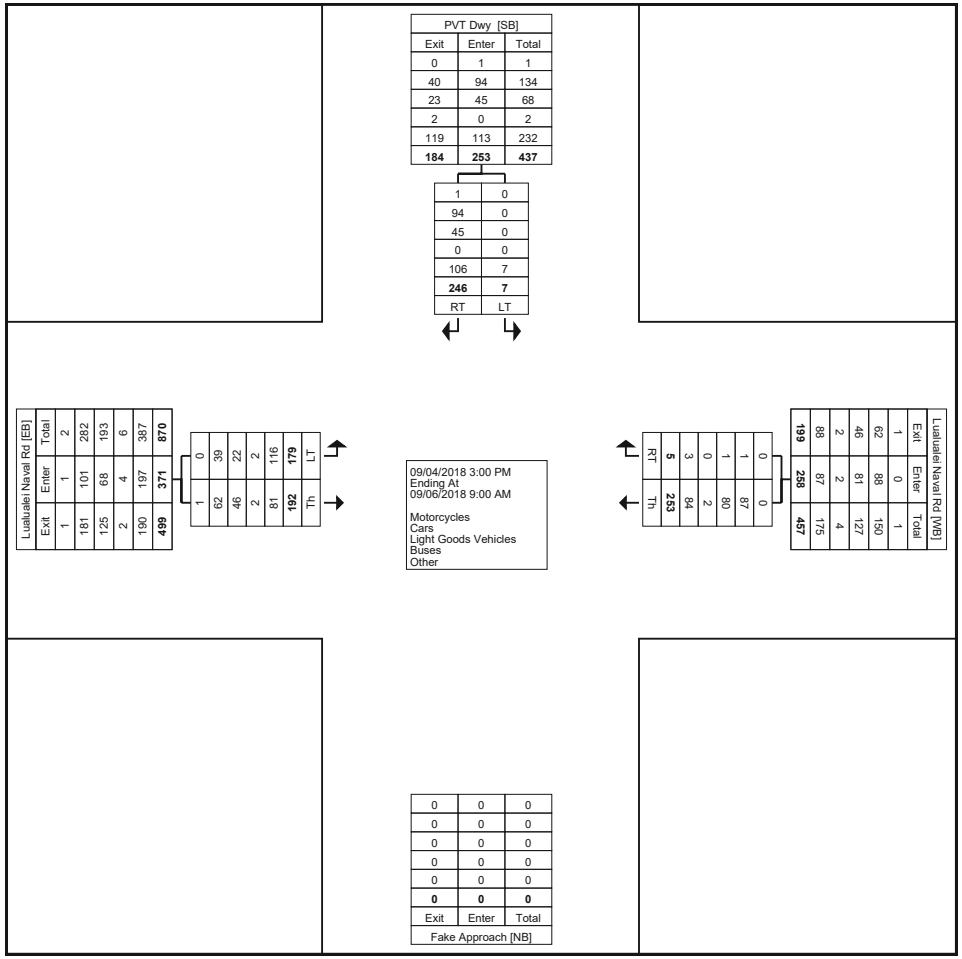
Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 3



Turning Movement Data Plot

The Traffic Management Consultant
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Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:15 PM)

Start Time	Lualualei Naval Rd Eastbound			Lualualei Naval Rd Westbound			PVT Dwy Southbound			
	Left-Turn	Thru	App. Total	Thru	Right-Turn	App. Total	Left-Turn	Right-Turn	App. Total	Int. Total
3:15 PM	5	5	10	4	0	4	0	4	4	18
3:30 PM	3	4	7	26	0	26	0	10	10	43
3:45 PM	4	3	7	10	1	11	0	31	31	49
4:00 PM	0	3	3	12	0	12	0	12	12	27
Total	12	15	27	52	1	53	0	57	57	137
Approach %	44.4	55.6	-	98.1	1.9	-	0.0	100.0	-	-
Total %	8.8	10.9	19.7	38.0	0.7	38.7	0.0	41.6	41.6	-
PHF	0.600	0.750	0.675	0.500	0.250	0.510	0.000	0.460	0.460	0.699
Motorcycles	0	0	0	0	0	0	0	0	0	0
% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
Cars	7	5	12	25	1	26	0	38	38	76
% Cars	58.3	33.3	44.4	48.1	100.0	49.1	-	66.7	66.7	55.5
Light Goods Vehicles	3	4	7	20	0	20	0	19	19	46
% Light Goods Vehicles	25.0	26.7	25.9	38.5	0.0	37.7	-	33.3	33.3	33.6
Buses	0	1	1	1	0	1	0	0	0	2
% Buses	0.0	6.7	3.7	1.9	0.0	1.9	-	0.0	0.0	1.5
Single-Unit Trucks	1	5	6	6	0	6	0	0	0	12
% Single-Unit Trucks	8.3	33.3	22.2	11.5	0.0	11.3	-	0.0	0.0	8.8
Articulated Trucks	1	0	1	0	0	0	0	0	0	1
% Articulated Trucks	8.3	0.0	3.7	0.0	0.0	0.0	-	0.0	0.0	0.7
Bicycles on Road	0	0	0	0	0	0	0	0	0	0
% Bicycles on Road	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0

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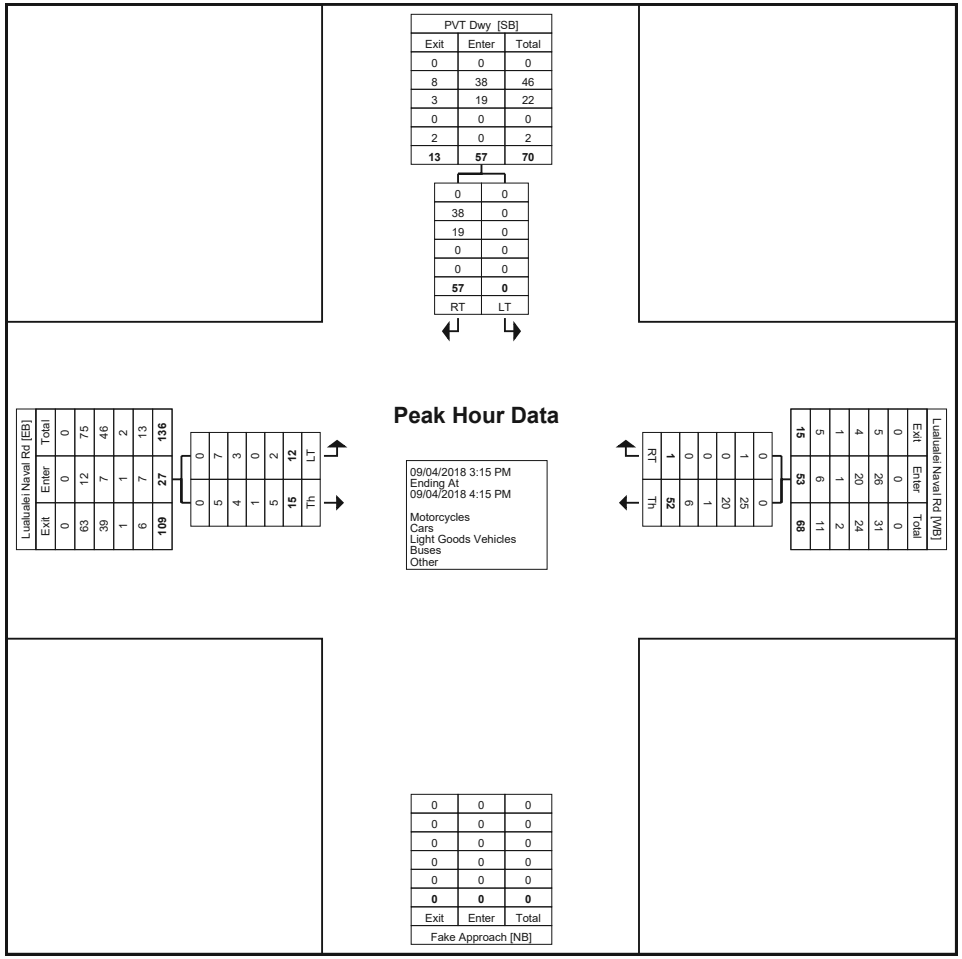
Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 5



Turning Movement Peak Hour Data Plot (3:15 PM)

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Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (8:00 AM)

Start Time	Lualualei Naval Rd Eastbound			Lualualei Naval Rd Westbound			PVT Dwy Southbound			
	Left-Turn	Thru	App. Total	Thru	Right-Turn	App. Total	Left-Turn	Right-Turn	App. Total	Int. Total
8:00 AM	11	4	15	4	0	4	0	9	9	28
8:15 AM	8	10	18	3	1	4	0	5	5	27
8:30 AM	6	19	25	10	0	10	0	7	7	42
8:45 AM	5	9	14	15	0	15	0	9	9	38
Total	30	42	72	32	1	33	0	30	30	135
Approach %	41.7	58.3	-	97.0	3.0	-	0.0	100.0	-	-
Total %	22.2	31.1	53.3	23.7	0.7	24.4	0.0	22.2	22.2	-
PHF	0.682	0.553	0.720	0.533	0.250	0.550	0.000	0.833	0.833	0.804
Motorcycles	0	0	0	0	0	0	0	0	0	0
% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
Cars	2	7	9	10	0	10	0	2	2	21
% Cars	6.7	16.7	12.5	31.3	0.0	30.3	-	6.7	6.7	15.6
Light Goods Vehicles	1	6	7	3	0	3	0	1	1	11
% Light Goods Vehicles	3.3	14.3	9.7	9.4	0.0	9.1	-	3.3	3.3	8.1
Buses	0	0	0	0	0	0	0	0	0	0
% Buses	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
Single-Unit Trucks	19	22	41	12	1	13	0	17	17	71
% Single-Unit Trucks	63.3	52.4	56.9	37.5	100.0	39.4	-	56.7	56.7	52.6
Articulated Trucks	8	7	15	7	0	7	0	10	10	32
% Articulated Trucks	26.7	16.7	20.8	21.9	0.0	21.2	-	33.3	33.3	23.7
Bicycles on Road	0	0	0	0	0	0	0	0	0	0
% Bicycles on Road	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0

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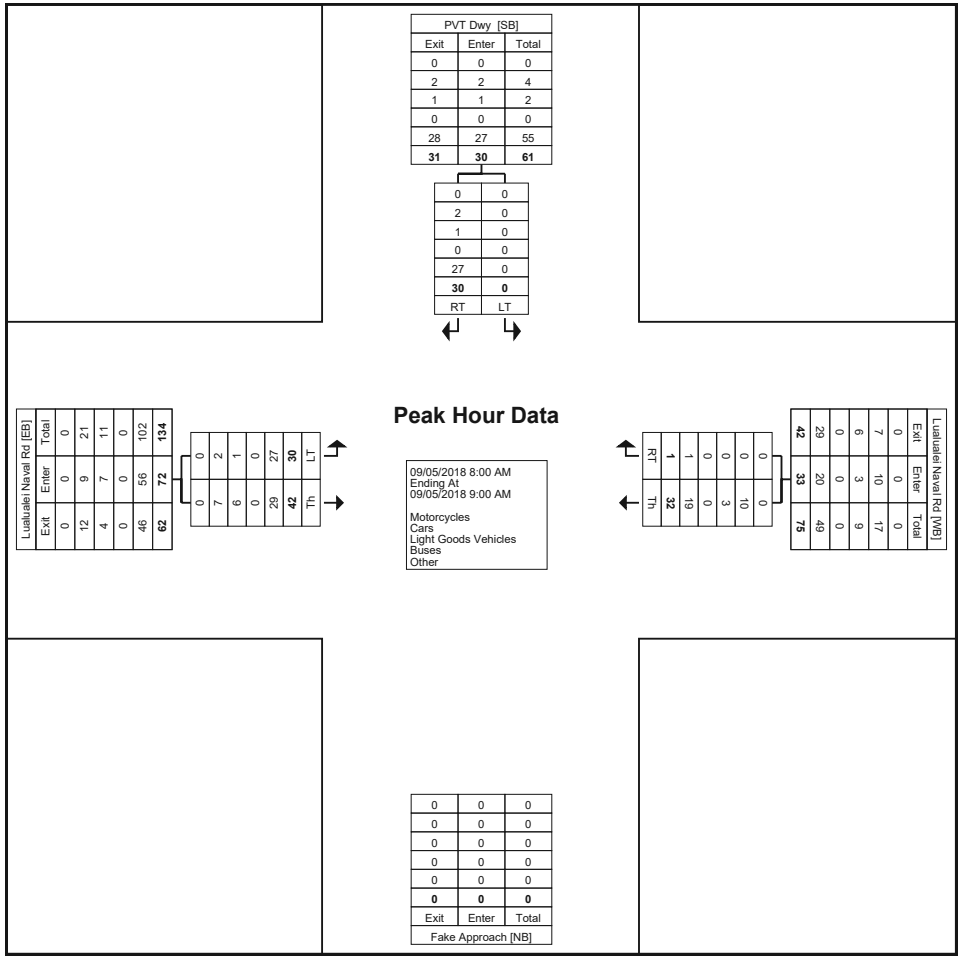
Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 7



Turning Movement Peak Hour Data Plot (8:00 AM)

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Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (3:00 PM)

Start Time	Lualualei Naval Rd Eastbound			Lualualei Naval Rd Westbound			PVT Dwy Southbound			
	Left-Turn	Thru	App. Total	Thru	Right-Turn	App. Total	Left-Turn	Right-Turn	App. Total	Int. Total
3:00 PM	0	6	6	17	0	17	1	6	7	30
3:15 PM	2	2	4	16	0	16	0	5	5	25
3:30 PM	4	2	6	29	0	29	0	8	8	43
3:45 PM	4	0	4	5	0	5	0	32	32	41
Total	10	10	20	67	0	67	1	51	52	139
Approach %	50.0	50.0	-	100.0	0.0	-	1.9	98.1	-	-
Total %	7.2	7.2	14.4	48.2	0.0	48.2	0.7	36.7	37.4	-
PHF	0.625	0.417	0.833	0.578	0.000	0.578	0.250	0.398	0.406	0.808
Motorcycles	0	0	0	0	0	0	0	1	1	1
% Motorcycles	0.0	0.0	0.0	0.0	-	0.0	0.0	2.0	1.9	0.7
Cars	8	0	8	19	0	19	0	30	30	57
% Cars	80.0	0.0	40.0	28.4	-	28.4	0.0	58.8	57.7	41.0
Light Goods Vehicles	2	1	3	35	0	35	0	14	14	52
% Light Goods Vehicles	20.0	10.0	15.0	52.2	-	52.2	0.0	27.5	26.9	37.4
Buses	0	0	0	0	0	0	0	0	0	0
% Buses	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Single-Unit Trucks	0	8	8	9	0	9	1	2	3	20
% Single-Unit Trucks	0.0	80.0	40.0	13.4	-	13.4	100.0	3.9	5.8	14.4
Articulated Trucks	0	1	1	4	0	4	0	4	4	9
% Articulated Trucks	0.0	10.0	5.0	6.0	-	6.0	0.0	7.8	7.7	6.5
Bicycles on Road	0	0	0	0	0	0	0	0	0	0
% Bicycles on Road	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0

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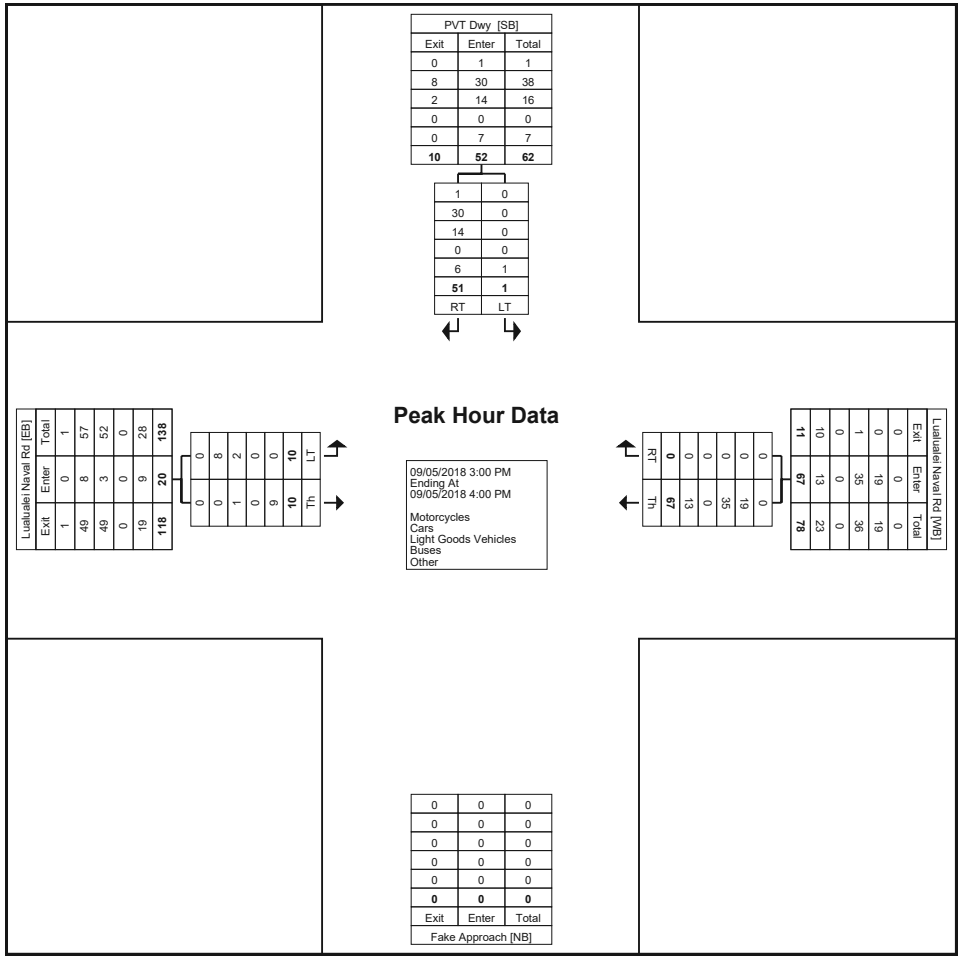
Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 9



Turning Movement Peak Hour Data Plot (3:00 PM)

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Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018

Turning Movement Peak Hour Data (7:45 AM)

Start Time	Lualualei Naval Rd Eastbound			Lualualei Naval Rd Westbound			PVT Dwy Southbound			
	Left-Turn	Thru	App. Total	Thru	Right-Turn	App. Total	Left-Turn	Right-Turn	App. Total	Int. Total
7:45 AM	11	13	24	5	0	5	3	13	16	45
8:00 AM	15	5	20	6	1	7	1	9	10	37
8:15 AM	16	11	27	4	0	4	0	8	8	39
8:30 AM	11	5	16	13	0	13	0	14	14	43
Total	53	34	87	28	1	29	4	44	48	164
Approach %	60.9	39.1	-	96.6	3.4	-	8.3	91.7	-	-
Total %	32.3	20.7	53.0	17.1	0.6	17.7	2.4	26.8	29.3	-
PHF	0.828	0.654	0.806	0.538	0.250	0.558	0.333	0.786	0.750	0.911
Motorcycles	0	0	0	0	0	0	0	0	0	0
% Motorcycles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cars	2	8	10	3	0	3	0	1	1	14
% Cars	3.8	23.5	11.5	10.7	0.0	10.3	0.0	2.3	2.1	8.5
Light Goods Vehicles	4	10	14	7	0	7	0	4	4	25
% Light Goods Vehicles	7.5	29.4	16.1	25.0	0.0	24.1	0.0	9.1	8.3	15.2
Buses	0	0	0	0	0	0	0	0	0	0
% Buses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Single-Unit Trucks	32	12	44	15	1	16	4	26	30	90
% Single-Unit Trucks	60.4	35.3	50.6	53.6	100.0	55.2	100.0	59.1	62.5	54.9
Articulated Trucks	15	4	19	3	0	3	0	13	13	35
% Articulated Trucks	28.3	11.8	21.8	10.7	0.0	10.3	0.0	29.5	27.1	21.3
Bicycles on Road	0	0	0	0	0	0	0	0	0	0
% Bicycles on Road	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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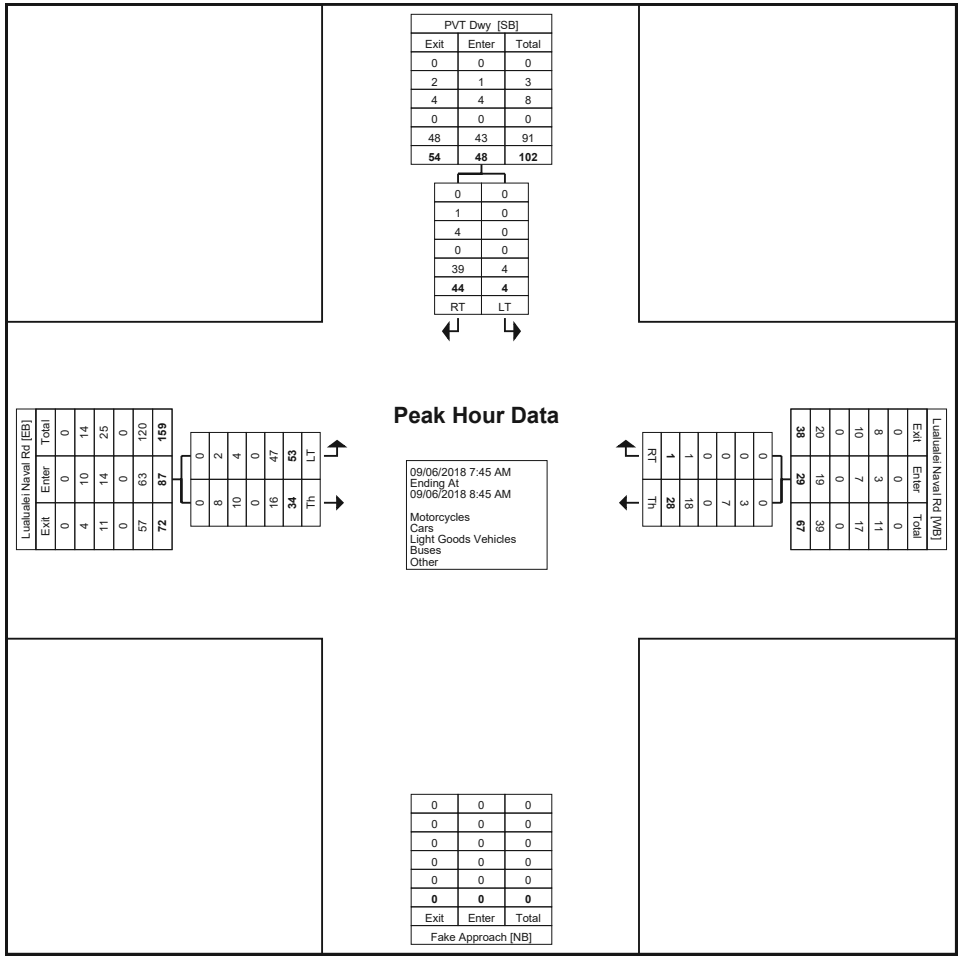
Count Name: PVT Dwy Lualualei Naval Rd
Site Code: PVT ISWMF
Start Date: 09/04/2018
Page No: 11



Turning Movement Peak Hour Data Plot (7:45 AM)

Study Name PVT ISWMF Dwy
Start Date 09/04/2018
Start Time 12:30 PM
Site Code PVT ISWMT

	Direction	Direction	Total Vehicles	
Start Time	Exit	Enter	15-Min Totals	Hourly Totals
09/04/18				
12:30 PM	9	7	16	53
12:45 PM	10	6	16	59
1:00 PM	4	7	11	60
1:15 PM	4	6	10	63
1:30 PM	8	14	22	**65**
1:45 PM	11	6	17	57
2:00 PM	11	3	14	48
2:15 PM	3	9	12	42
2:30 PM	8	6	14	38
2:45 PM	6	2	8	38
3:00 PM	8	0	8	66
3:15 PM	4	4	8	**70**
3:30 PM	11	3	14	64
3:45 PM	31	5	36	51
4:00 PM	12	0	12	15
4:15 PM	1	1	2	4
4:30 PM	1	0	1	2
4:45 PM	0	0	0	1
5:00 PM	1	0	1	2
5:15 PM	0	0	0	
5:30 PM	0	0	0	
5:45 PM	1	0	1	
09/05/18				
5:00 AM	1	1	2	16
5:15 AM	2	3	5	22
5:30 AM	0	3	3	36
5:45 AM	2	4	6	61
6:00 AM	3	5	8	80
6:15 AM	3	16	19	**85**
6:30 AM	3	25	28	76
6:45 AM	8	17	25	69
7:00 AM	2	11	13	57
7:15 AM	3	7	10	64
7:30 AM	9	12	21	69
7:45 AM	7	6	13	61
8:00 AM	9	11	20	64
8:15 AM	6	9	15	62
8:30 AM	7	6	13	64
8:45 AM	10	6	16	68
9:00 AM	11	7	18	70
9:15 AM	5	12	17	62
9:30 AM	9	8	17	72
9:45 AM	10	8	18	78
10:00 AM	3	7	10	82
10:15 AM	11	16	27	**93**
10:30 AM	9	14	23	83
10:45 AM	11	11	22	82
11:00 AM	13	8	21	83
11:15 AM	10	7	17	75
11:30 AM	13	9	22	77
11:45 AM	11	12	23	68
12:00 PM	8	5	13	57
12:15 PM	10	9	19	69
12:30 PM	8	5	13	67
12:45 PM	5	7	12	68
1:00 PM	12	13	25	67
1:15 PM	10	7	17	57
1:30 PM	8	6	14	55
1:45 PM	5	6	11	54
2:00 PM	4	11	15	53
2:15 PM	14	1	15	45
2:30 PM	7	6	13	37
2:45 PM	6	4	10	36
3:00 PM	7	0	7	62
3:15 PM	5	2	7	**65**
3:30 PM	8	4	12	59
3:45 PM	32	4	36	49
4:00 PM	9	1	10	14
4:15 PM	1	0	1	7
4:30 PM	1	1	2	6
4:45 PM	0	1	1	6
5:00 PM	3	0	3	7
5:15 PM	0	0	0	
5:30 PM	1	1	2	Daily Total
5:45 PM	1	1	2	712
09/06/18				
5:00 AM	0	0	0	13
5:15 AM	3	2	5	19
5:30 AM	0	5	5	27
5:45 AM	0	3	3	51
6:00 AM	2	4	6	75
6:15 AM	1	12	13	83
6:30 AM	6	23	29	**88**
6:45 AM	4	23	27	73
7:00 AM	3	11	14	72
7:15 AM	7	11	18	83
7:30 AM	7	7	14	89
7:45 AM	15	11	26	**100**
8:00 AM	9	16	25	88
8:15 AM	8	16	24	
8:30 AM	14	11	25	
8:45 AM	9	5	14	

Study Name PVT ISWMF Dwy
Start Date 09/04/2018
Start Time 12:30 PM
Site Code PVT ISWMT

	Direction	Direction	Total Trucks	
Start Time	Exit	Enter	15-Min Totals	Hourly Totals
09/04/18				
12:30 PM	6	6	12	43
12:45 PM	10	4	14	49
1:00 PM	3	5	8	46
1:15 PM	4	5	9	51
1:30 PM	4	14	18	**53**
1:45 PM	8	3	11	46
2:00 PM	10	3	13	42
2:15 PM	3	8	11	34
2:30 PM	6	5	11	23
2:45 PM	6	1	7	14
3:00 PM	5	0	5	7
3:15 PM	0	0	0	**2**
3:30 PM	1	1	2	2
3:45 PM	0	0	0	0
4:00 PM	0	0	0	0
4:15 PM	0	0	0	0
4:30 PM	0	0	0	0
4:45 PM	0	0	0	0
5:00 PM	0	0	0	1
5:15 PM	0	0	0	
5:30 PM	0	0	0	
5:45 PM	1	0	1	
09/05/18				
5:00 AM	1	0	1	1
5:15 AM	0	0	0	0
5:30 AM	0	0	0	3
5:45 AM	0	0	0	7
6:00 AM	0	0	0	10
6:15 AM	2	1	3	**15**
6:30 AM	1	3	4	17
6:45 AM	0	3	3	29
7:00 AM	0	5	5	36
7:15 AM	1	4	5	49
7:30 AM	8	8	16	59
7:45 AM	5	5	10	54
8:00 AM	8	10	18	55
8:15 AM	6	9	15	54
8:30 AM	7	4	11	53
8:45 AM	7	4	11	51
9:00 AM	11	6	17	56
9:15 AM	4	10	14	48
9:30 AM	5	4	9	60
9:45 AM	9	7	16	71
10:00 AM	2	7	9	74
10:15 AM	11	15	26	**83**
10:30 AM	9	11	20	69
10:45 AM	9	10	19	65
11:00 AM	11	7	18	61
11:15 AM	8	4	12	51
11:30 AM	10	6	16	56
11:45 AM	6	9	15	50
12:00 PM	5	3	8	46
12:15 PM	9	8	17	60
12:30 PM	6	4	10	58
12:45 PM	4	7	11	58
1:00 PM	10	12	22	55
1:15 PM	9	6	15	47
1:30 PM	6	4	10	44
1:45 PM	3	5	8	45
2:00 PM	4	10	14	42
2:15 PM	11	1	12	34
2:30 PM	6	5	11	23
2:45 PM	2	3	5	12
3:00 PM	6	0	6	7
3:15 PM	1	0	1	**1**
3:30 PM	0	0	0	0
3:45 PM	0	0	0	0
4:00 PM	0	0	0	0
4:15 PM	0	0	0	0
4:30 PM	0	0	0	0
4:45 PM	0	0	0	0
5:00 PM	0	0	0	0
5:15 PM	0	0	0	
5:30 PM	0	0	0	Daily Total
5:45 PM	0	0	0	443
09/06/18				
5:00 AM	0	0	0	1
5:15 AM	1	0	1	1
5:30 AM	0	0	0	0
5:45 AM	0	0	0	6
6:00 AM	0	0	0	14
6:15 AM	0	0	0	21
6:30 AM	3	3	6	**30**
6:45 AM	0	8	8	37
7:00 AM	1	6	7	52
7:15 AM	3	6	9	65
7:30 AM	7	6	13	76
7:45 AM	13	10	23	**87**
8:00 AM	8	12	20	78
8:15 AM	6	14	20	
8:30 AM	13	11	24	
8:45 AM	9	5	14	

Study Name **PVT Driveway Pedestrians**
Start Date **09/04/2018**
Start Time **2:30 PM**
Site Code **PVT ISWFM**

	PVT Driveway	PVT Driveway	Total Pedestrians	
Direction	Exit	Enter	15-Min Totals	Hourly Totals
Tuesday, September 04, 2018				
2:30 PM	0	0	0	0
2:45 PM	0	0	0	1
3:00 PM	0	0	0	1
3:15 PM	0	0	0	2
3:30 PM	1	0	1	2
3:45 PM	0	0	0	
4:00 PM	1	0	1	
4:15 PM	0	0	0	
Wednesday, September 05, 2018				
6:00 AM	0	0	0	2
6:15 AM	0	0	0	3
6:30 AM	0	1	1	3
6:45 AM	0	1	1	
7:00 AM	0	1	1	1
7:15 AM	0	0	0	0
7:30 AM	0	0	0	0
7:45 AM	0	0	0	
8:00 AM	0	0	0	0
8:15 AM	0	0	0	
8:30 AM	0	0	0	
8:45 AM	0	0	0	
Wednesday, September 05, 2018				
2:30 PM	0	0	0	0
2:45 PM	0	0	0	0
3:00 PM	0	0	0	0
3:15 PM	0	0	0	0
3:30 PM	0	0	0	0
3:45 PM	0	0	0	
4:00 PM	0	0	0	
4:15 PM	0	0	0	
Thursday, September 06, 2018				
6:00 AM	0	0	0	2
6:15 AM	0	0	0	2
6:30 AM	0	1	1	2
6:45 AM	0	1	1	1
7:00 AM	0	0	0	0
7:15 AM	0	0	0	0
7:30 AM	0	0	0	0
7:45 AM	0	0	0	0
8:00 AM	0	0	0	0
8:15 AM	0	0	0	
8:30 AM	0	0	0	
8:45 AM	0	0	0	

Study Name **PVT Driveway Bicycles**
Start Date **09/04/2018**
Start Time **2:30 PM**
Site Code **PVT ISWFM**

	PVT Driveway	PVT Driveway	Total Bicycles	
Direction	Exit	Enter	15-Min Totals	Hourly Totals
Tuesday, September 04, 2018				
2:30 PM	0	0	0	0
2:45 PM	0	0	0	0
3:00 PM	0	0	0	0
3:15 PM	0	0	0	0
3:30 PM	0	0	0	0
3:45 PM	0	0	0	
4:00 PM	0	0	0	
4:15 PM	0	0	0	
Wednesday, September 05, 2018				
6:00 AM	0	0	0	0
6:15 AM	0	0	0	0
6:30 AM	0	0	0	0
6:45 AM	0	0	0	
7:00 AM	0	0	0	0
7:15 AM	0	0	0	0
7:30 AM	0	0	0	0
7:45 AM	0	0	0	
8:00 AM	0	0	0	0
8:15 AM	0	0	0	
8:30 AM	0	0	0	
8:45 AM	0	0	0	
Wednesday, September 05, 2018				
2:30 PM	0	0	0	0
2:45 PM	0	0	0	0
3:00 PM	0	0	0	0
3:15 PM	0	0	0	0
3:30 PM	0	0	0	0
3:45 PM	0	0	0	
4:00 PM	0	0	0	
4:15 PM	0	0	0	
Thursday, September 06, 2018				
6:00 AM	0	0	0	0
6:15 AM	0	0	0	0
6:30 AM	0	0	0	0
6:45 AM	0	0	0	0
7:00 AM	0	0	0	0
7:15 AM	0	0	0	0
7:30 AM	0	0	0	0
7:45 AM	0	0	0	0
8:00 AM	0	0	0	0
8:15 AM	0	0	0	
8:30 AM	0	0	0	
8:45 AM	0	0	0	

TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

APPENDIX B

CAPACITY ANALYSIS WORKSHEETS

EXISTING TRAFFIC CONDITIONS

Intersection	
Int Delay, s/veh	5.7

Movement	EBL	EBT	WBT	WBR	SWL	SWR
Lane Configurations						
Traffic Vol, veh/h	53	34	28	1	4	44
Future Vol, veh/h	53	34	28	1	4	44
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	Free	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	89	47	64	100	100	89
Mvmt Flow	44	52	14	1	12	52

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	14	0	-	0	154	14
Stage 1	-	-	-	-	14	-
Stage 2	-	-	-	-	140	-
Critical Hdwy	4.99	-	-	-	7.4	7.09
Critical Hdwy Stg 1	-	-	-	-	6.4	-
Critical Hdwy Stg 2	-	-	-	-	6.4	-
Follow-up Hdwy	3.001	-	-	-	4.4	4.101
Pot Cap-1 Maneuver	1183	-	-	0	654	861
Stage 1	-	-	-	0	805	-
Stage 2	-	-	-	0	694	-
Platoon blocked, %		-	-			
Mov Cap-1 Maneuver	1183	-	-	-	629	861
Mov Cap-2 Maneuver	-	-	-	-	629	-
Stage 1	-	-	-	-	774	-
Stage 2	-	-	-	-	694	-

Approach	EB	WB	SW
HCM Control Delay, s	3.7	0	9.9
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	SWLn1
Capacity (veh/h)	1183	-	-	805
HCM Lane V/C Ratio	0.037	-	-	0.079
HCM Control Delay (s)	8.2	0	-	9.9
HCM Lane LOS	A	A	-	A
HCM 95th %tile Q(veh)	0.1	-	-	0.3

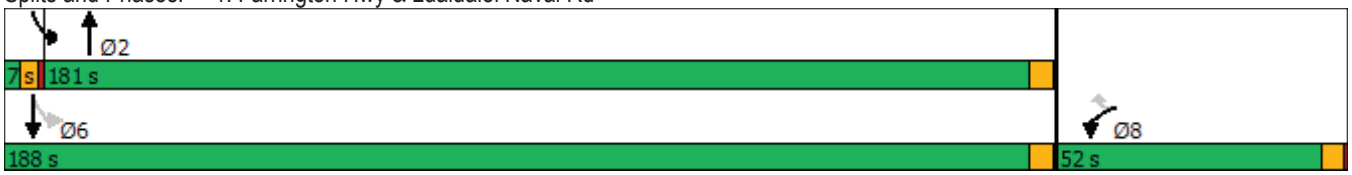
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	162	71	1106	79	96	1615
Future Volume (vph)	162	71	1106	79	96	1615
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	200		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1292	1446	3188	0	0	3369
Flt Permitted	0.950					0.654
Satd. Flow (perm)	1292	1418	3188	0	0	2210
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		100	8			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		2		4	4	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	86%	141%	99%	96%	121%	105%
Heavy Vehicles (%)	35%	8%	5%	53%	7%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	139	100	1171	0	0	1812
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	52.0	52.0	181.0		7.0	188.0
Total Split (%)	21.7%	21.7%	75.4%		2.9%	78.3%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	29.1	29.1	183.2			183.2
Actuated g/C Ratio	0.13	0.13	0.82			0.82
v/c Ratio	0.82	0.37	0.45			1.00
Control Delay	128.8	15.7	6.5			39.2
Queue Delay	0.0	0.0	1.1			31.8
Total Delay	128.8	15.7	7.5			71.1
LOS	F	B	A			E
Approach Delay	81.4		7.5			71.1
Approach LOS	F		A			E
Queue Length 50th (ft)	202	0	221			1214
Queue Length 95th (ft)	297	66	335			#1702
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		200				
Base Capacity (vph)	273	379	2629			1821
Starvation Cap Reductn	0	0	1119			152
Spillback Cap Reductn	0	0	0			0
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.51	0.26	0.78			1.09

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 222.3
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.00
Intersection Signal Delay: 48.7 Intersection LOS: D
Intersection Capacity Utilization 103.8% ICU Level of Service G
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



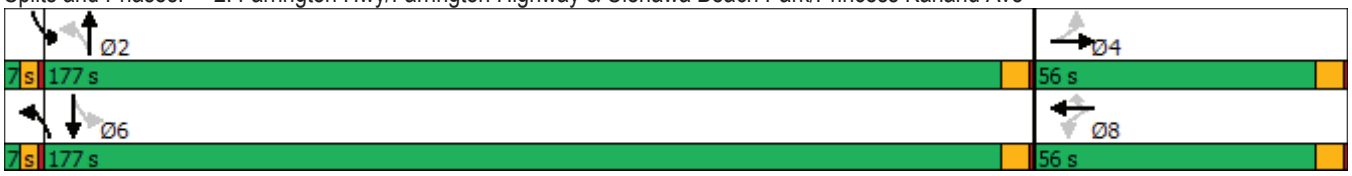
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	3	2	4	159	1	14	6	1051	51	2	1605	2
Future Volume (vph)	3	2	4	159	1	14	6	1051	51	2	1605	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1691	0	0	1700	1459	1745	3307	0	1745	3385	0
Flt Permitted		0.934			0.716		0.096			0.240		
Satd. Flow (perm)	0	1595	0	0	1277	1422	176	3307	0	441	3385	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		8				32		3				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	5					5			4	4		
Confl. Bikes (#/hr)									1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	133%	200%	200%	98%	100%	114%	50%	100%	55%	50%	110%	200%
Heavy Vehicles (%)	0%	0%	0%	3%	0%	7%	0%	5%	6%	0%	3%	50%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	16	0	0	157	16	3	1079	0	1	1770	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Max		None	Max	
Act Effct Green (s)		31.7			31.7	31.7	174.0	171.4		174.0	171.4	
Actuated g/C Ratio		0.15			0.15	0.15	0.80	0.79		0.80	0.79	
v/c Ratio		0.07			0.84	0.07	0.02	0.41		0.00	0.66	
Control Delay		49.6			124.3	4.2	6.0	8.3		6.0	12.6	
Queue Delay		0.0			0.0	0.0	0.0	0.9		0.0	0.0	
Total Delay		49.6			124.3	4.2	6.0	9.2		6.0	12.6	
LOS		D			F	A	A	A		A	B	
Approach Delay		49.6			113.2			9.2			12.6	
Approach LOS		D			F			A			B	
Queue Length 50th (ft)		10			220	0	1	218		0	508	
Queue Length 95th (ft)		39			328	8	5	380		2	856	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)							50			100		
Base Capacity (vph)		375			295	353	163	2619		372	2680	
Starvation Cap Reductn		0			0	0	0	1169		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.04			0.53	0.05	0.02	0.74		0.00	0.66	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 216.5
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 17.3 — Intersection LOS: B
Intersection Capacity Utilization 75.3% — ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



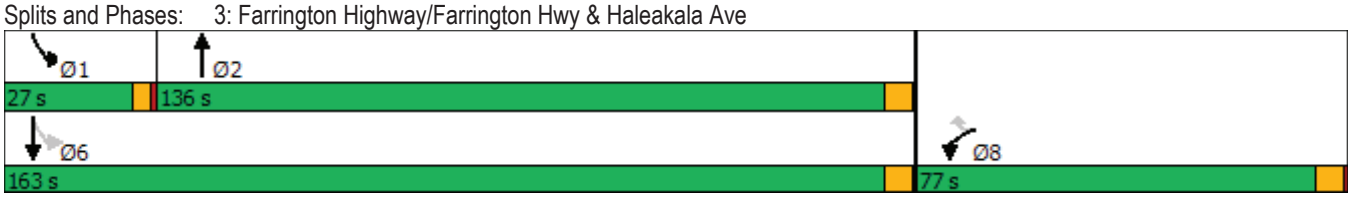
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	150	327	1034	20	263	1708
Future Volume (vph)	150	327	1034	20	263	1708
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1728	1546	3170	0	1745	3355
Flt Permitted	0.950				0.222	
Satd. Flow (perm)	1728	1428	3170	0	408	3355
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		219	2			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		20		60	60	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	125%	122%	99%	160%	79%	106%
Heavy Vehicles (%)	1%	1%	9%	5%	0%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	188	399	1056	0	208	1810
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	77.0	77.0	136.0		27.0	163.0
Total Split (%)	32.1%	32.1%	56.7%		11.3%	67.9%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	35.9	35.9	141.5		159.7	157.7
Actuated g/C Ratio	0.17	0.17	0.69		0.78	0.77
v/c Ratio	0.62	0.93	0.48		0.53	0.70
Control Delay	86.8	65.6	18.0		12.2	16.1
Queue Delay	0.0	0.0	0.8		0.0	8.3
Total Delay	86.8	65.6	18.8		12.2	24.3
LOS	F	E	B		B	C
Approach Delay	72.4		18.8			23.1
Approach LOS	E		B			C
Queue Length 50th (ft)	239	270	329		65	596
Queue Length 95th (ft)	331	425	562		139	998
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	599	638	2182		467	2572
Starvation Cap Reductn	0	0	739		0	737
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.31	0.63	0.73		0.45	0.99

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 205.6
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.93
Intersection Signal Delay: 29.8 — Intersection LOS: C
Intersection Capacity Utilization 74.3% — ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



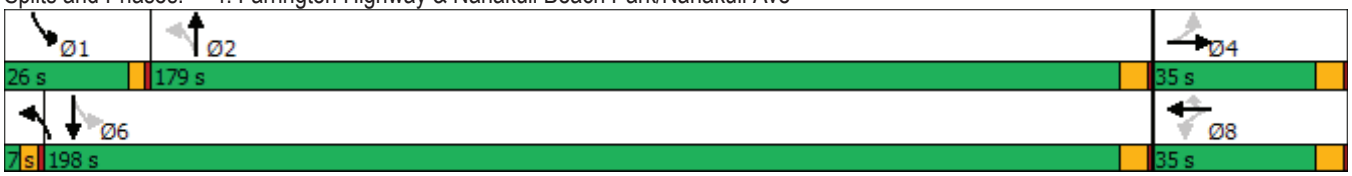
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	51	5	6	169	6	64	5	1081	226	129	1660	58
Future Volume (vph)	51	5	6	169	6	64	5	1081	226	129	1660	58
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1744	0	0	1684	1487	1745	3142	0	1646	3305	0
Flt Permitted		0.244			0.740		0.105			0.184		
Satd. Flow (perm)	0	434	0	0	1308	1388	193	3142	0	319	3305	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		1				50		11			8	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	17					17			1	1		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	173%	160%	133%	107%	67%	75%	80%	107%	50%	105%	102%	159%
Heavy Vehicles (%)	0%	0%	0%	4%	0%	5%	0%	10%	4%	6%	5%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	104	0	0	185	48	4	1270	0	135	1785	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	15.0		3.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	7.0	28.0		7.0	28.0	
Total Split (s)	35.0	35.0		35.0	35.0	35.0	7.0	179.0		26.0	198.0	
Total Split (%)	14.6%	14.6%		14.6%	14.6%	14.6%	2.9%	74.6%		10.8%	82.5%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Max		None	Max	
Act Effct Green (s)		29.0			29.0	29.0	185.4	180.4		195.4	192.0	
Actuated g/C Ratio		0.12			0.12	0.12	0.79	0.77		0.83	0.82	
v/c Ratio		1.93			1.15	0.22	0.02	0.52		0.43	0.66	
Control Delay		522.3			198.3	19.6	3.8	11.3		7.7	9.9	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	3.5	
Total Delay		522.3			198.3	19.6	3.8	11.3		7.7	13.3	
LOS		F			F	B	A	B		A	B	
Approach Delay		522.3			161.5			11.2			12.9	
Approach LOS		F			F			B			B	
Queue Length 50th (ft)		~243			~330	0	1	370		34	494	
Queue Length 95th (ft)		#412			#544	48	4	423		49	641	
Internal Link Dist (ft)		120			620			620			720	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Turn Bay Length (ft)							100			200		
Base Capacity (vph)		54			161	215	172	2421		390	2708	
Starvation Cap Reductn		0			0	0	0	0		0	808	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		1.93			1.15	0.22	0.02	0.52		0.35	0.94	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 234.4
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.93
Intersection Signal Delay: 37.1 Intersection LOS: D
Intersection Capacity Utilization 80.7% ICU Level of Service D
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



Intersection	
Int Delay, s/veh	2.4

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	10	10	67	0	1	51
Future Vol, veh/h	10	10	67	0	1	51
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	0	90	7	0	100	6
Mvmt Flow	16	8	116	0	1	32

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	116	0	-	0	156	116
Stage 1	-	-	-	-	116	-
Stage 2	-	-	-	-	40	-
Critical Hdwy	4.1	-	-	-	7.4	6.26
Critical Hdwy Stg 1	-	-	-	-	6.4	-
Critical Hdwy Stg 2	-	-	-	-	6.4	-
Follow-up Hdwy	2.2	-	-	-	4.4	3.354
Pot Cap-1 Maneuver	1485	-	-	-	652	926
Stage 1	-	-	-	-	714	-
Stage 2	-	-	-	-	781	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1485	-	-	-	645	926
Mov Cap-2 Maneuver	-	-	-	-	645	-
Stage 1	-	-	-	-	706	-
Stage 2	-	-	-	-	781	-

Approach	EB	WB	SB
HCM Control Delay, s	5	0	9.1
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1485	-	-	-	914
HCM Lane V/C Ratio	0.011	-	-	-	0.036
HCM Control Delay (s)	7.5	0	-	-	9.1
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q(veh)	0	-	-	-	0.1

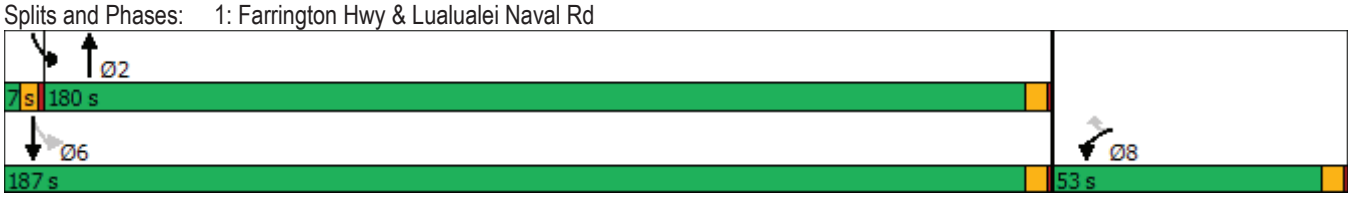
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	125	175	1637	25	67	1180
Future Volume (vph)	125	175	1637	25	67	1180
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	100		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1601	1531	3352	0	0	3350
Flt Permitted	0.950					0.613
Satd. Flow (perm)	1601	1507	3352	0	0	2060
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		68	2			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		1		7	7	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	96%	110%	101%	144%	107%	114%
Heavy Vehicles (%)	9%	2%	3%	36%	1%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	120	193	1689	0	0	1417
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	53.0	53.0	180.0		7.0	187.0
Total Split (%)	22.1%	22.1%	75.0%		2.9%	77.9%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	24.1	24.1	182.2			182.2
Actuated g/C Ratio	0.11	0.11	0.84			0.84
v/c Ratio	0.67	0.85	0.60			0.82
Control Delay	110.5	90.8	7.1			15.2
Queue Delay	0.0	0.0	2.2			5.2
Total Delay	110.5	90.8	9.3			20.4
LOS	F	F	A			C
Approach Delay	98.3		9.3			20.4
Approach LOS	F		A			C
Queue Length 50th (ft)	168	182	348			465
Queue Length 95th (ft)	251	289	539			797
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		100				
Base Capacity (vph)	355	387	2823			1734
Starvation Cap Reductn	0	0	947			259
Spillback Cap Reductn	0	0	0			0
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.34	0.50	0.90			0.96

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 216.3
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 22.0 — Intersection LOS: C
Intersection Capacity Utilization 105.6% — ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd

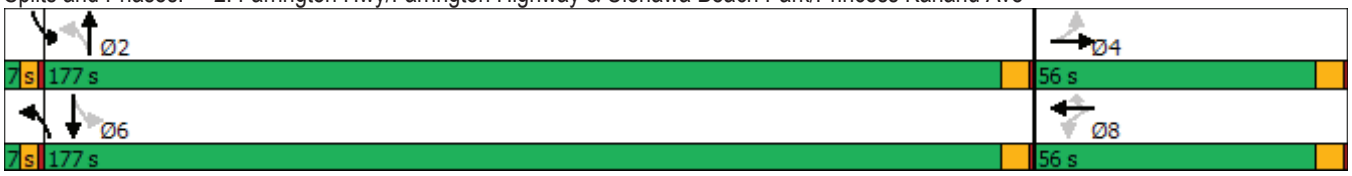


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	6	68	1	16	5	1609	119	11	1183	0
Future Volume (vph)	0	0	6	68	1	16	5	1609	119	11	1183	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		100	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1358	0	0	1684	1561	1745	3344	0	1745	3355	0
Flt Permitted					0.724		0.199			0.102		
Satd. Flow (perm)	0	1358	0	0	1279	1490	365	3344	0	187	3355	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		114				32		6				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	12					12	6		9	9		6
Confl. Bikes (#/hr)						1			1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	100%	100%	133%	112%	100%	150%	80%	105%	87%	218%	109%	100%
Heavy Vehicles (%)	0%	0%	17%	4%	0%	0%	0%	3%	3%	0%	4%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	8	0	0	77	24	4	1793	0	24	1289	0
Turn Type		NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Max		None	Max	
Act Effct Green (s)		17.7			17.7	17.7	175.6	171.2		178.0	175.4	
Actuated g/C Ratio		0.09			0.09	0.09	0.85	0.83		0.86	0.85	
v/c Ratio		0.04			0.71	0.15	0.01	0.65		0.13	0.45	
Control Delay		0.2			124.0	16.7	2.8	8.5		3.9	4.9	
Queue Delay		0.0			0.0	0.0	0.0	2.9		0.0	0.0	
Total Delay		0.2			124.0	16.7	2.8	11.3		3.9	4.9	
LOS		A			F	B	A	B		A	A	
Approach Delay		0.3			98.5			11.3			4.8	
Approach LOS		A			F			B			A	
Queue Length 50th (ft)		0			105	0	1	433		4	182	
Queue Length 95th (ft)		0			172	25	3	597		11	330	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)						100	50			100		
Base Capacity (vph)		415			310	385	330	2773		183	2849	
Starvation Cap Reductn		0			0	0	0	838		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.02			0.25	0.06	0.01	0.93		0.13	0.45	

Intersection Summary	
Area Type:	Other
Cycle Length: 240	
Actuated Cycle Length: 206.5	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.71	
Intersection Signal Delay: 11.4	Intersection LOS: B
Intersection Capacity Utilization 81.9%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



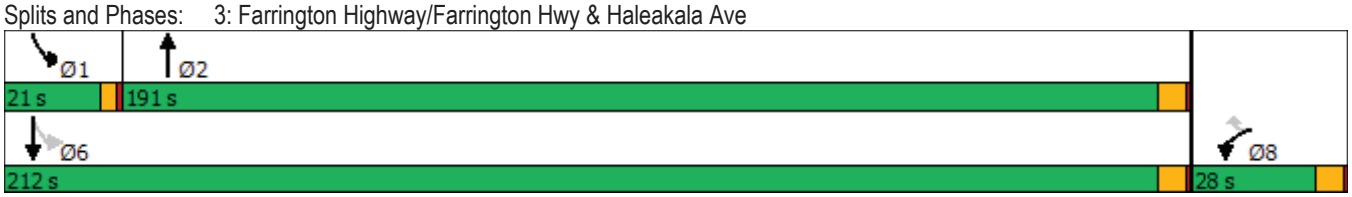
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	63	169	1714	18	94	1230
Future Volume (vph)	63	169	1714	18	94	1230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1711	1546	3415	0	1711	3388
Flt Permitted	0.950				0.118	
Satd. Flow (perm)	1711	1438	3415	0	212	3388
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		123	1			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		18		11	11	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	83%	73%	98%	89%	136%	116%
Heavy Vehicles (%)	2%	1%	2%	6%	2%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	52	123	1696	0	128	1427
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	28.0	28.0	191.0		21.0	212.0
Total Split (%)	11.7%	11.7%	79.6%		8.8%	88.3%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	12.4	12.4	194.7		208.0	206.0
Actuated g/C Ratio	0.05	0.05	0.85		0.90	0.89
v/c Ratio	0.57	0.64	0.59		0.54	0.47
Control Delay	129.6	28.5	6.7		9.7	2.9
Queue Delay	0.0	0.0	1.8		0.0	1.1
Total Delay	129.6	28.5	8.5		9.7	4.0
LOS	F	C	A		A	A
Approach Delay	58.6		8.5			4.5
Approach LOS	E		A			A
Queue Length 50th (ft)	79	0	365		16	166
Queue Length 95th (ft)	137	81	484		30	231
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	163	248	2885		301	3030
Starvation Cap Reductn	0	0	962		0	1268
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.32	0.50	0.88		0.43	0.81

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 230.4
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.64
Intersection Signal Delay: 9.2 — Intersection LOS: A
Intersection Capacity Utilization 78.8% — ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



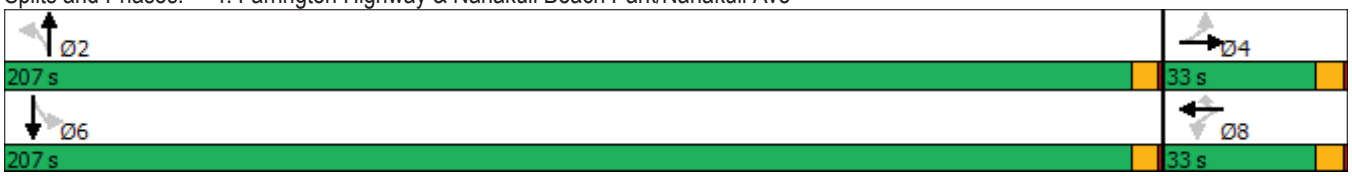
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	2	4	23	112	19	24	2	1819	389	5	1182	28
Future Volume (vph)	2	4	23	112	19	24	2	1819	389	5	1182	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	0		0	0		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1548	0	0	1723	1561	0	4748	0	0	3366	0
Flt Permitted		0.994			0.734			0.940			0.944	
Satd. Flow (perm)	0	1540	0	0	1316	1497	0	4463	0	0	3177	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		36				20		109			6	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	9					9			2	2		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	50%	50%	157%	79%	105%	83%	50%	104%	120%	50%	106%	157%
Heavy Vehicles (%)	0%	0%	4%	3%	0%	0%	50%	2%	1%	0%	2%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	6	0
Parking (#/hr)												0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	39	0	0	108	20	0	2360	0	0	1300	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	15.0	15.0		15.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	28.0	28.0		28.0	28.0	
Total Split (s)	33.0	33.0		33.0	33.0	33.0	207.0	207.0		207.0	207.0	
Total Split (%)	13.8%	13.8%		13.8%	13.8%	13.8%	86.3%	86.3%		86.3%	86.3%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		6.0			6.0	6.0		6.0			6.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	Max	Max		Max	Max	
Act Effct Green (s)		23.1			23.1	23.1		201.1			201.1	
Actuated g/C Ratio		0.10			0.10	0.10		0.85			0.85	
v/c Ratio		0.21			0.84	0.12		0.62			0.48	
Control Delay		28.9			148.9	30.6		6.2			5.3	
Queue Delay		0.0			0.0	0.0		0.0			1.0	
Total Delay		28.9			148.9	30.6		6.2			6.2	
LOS		C			F	C		A			A	
Approach Delay		28.9			130.4			6.2			6.2	
Approach LOS		C			F			A			A	
Queue Length 50th (ft)		4			169	0		375			250	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Length 95th (ft)		52			#272	34		414			292	
Internal Link Dist (ft)		120			620			620			720	
Turn Bay Length (ft)												
Base Capacity (vph)		208			150	189		3815			2705	
Starvation Cap Reductn		0			0	0		0			1046	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.19			0.72	0.11		0.62			0.78	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 236.2
Natural Cycle: 75
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.84
Intersection Signal Delay: 10.6 Intersection LOS: B
Intersection Capacity Utilization 76.9% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

APPENDIX C

CAPACITY ANALYSIS WORKSHEETS

PEAK HOUR TRAFFIC WITHOUT PROJECT

Intersection	
Int Delay, s/veh	5.3

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	53	36	30	1	4	44
Future Vol, veh/h	53	36	30	1	4	44
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	89	47	64	100	100	89
Mvmt Flow	44	55	21	1	12	52

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	22	0	-	0	165	22
Stage 1	-	-	-	-	22	-
Stage 2	-	-	-	-	143	-
Critical Hdwy	4.99	-	-	-	7.4	7.09
Critical Hdwy Stg 1	-	-	-	-	6.4	-
Critical Hdwy Stg 2	-	-	-	-	6.4	-
Follow-up Hdwy	3.001	-	-	-	4.4	4.101
Pot Cap-1 Maneuver	1174	-	-	-	644	851
Stage 1	-	-	-	-	797	-
Stage 2	-	-	-	-	692	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1174	-	-	-	619	851
Mov Cap-2 Maneuver	-	-	-	-	619	-
Stage 1	-	-	-	-	766	-
Stage 2	-	-	-	-	692	-

Approach	EB	WB	SB
HCM Control Delay, s	3.6	0	9.9
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1174	-	-	-	795
HCM Lane V/C Ratio	0.037	-	-	-	0.08
HCM Control Delay (s)	8.2	0	-	-	9.9
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q(veh)	0.1	-	-	-	0.3

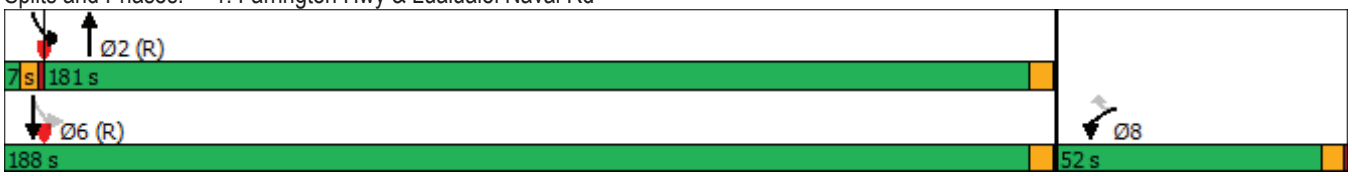
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	174	76	1186	85	103	1732
Future Volume (vph)	174	76	1186	85	103	1732
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	200		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1292	1446	3188	0	0	3369
Flt Permitted	0.950					0.629
Satd. Flow (perm)	1292	1418	3188	0	0	2126
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		107	8			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		2		4	4	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	86%	141%	99%	96%	121%	105%
Heavy Vehicles (%)	35%	8%	5%	53%	7%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	150	107	1256	0	0	1944
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	52.0	52.0	181.0		7.0	188.0
Total Split (%)	21.7%	21.7%	75.4%		2.9%	78.3%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	33.2	33.2	196.8			196.8
Actuated g/C Ratio	0.14	0.14	0.82			0.82
v/c Ratio	0.84	0.37	0.48			1.12
Control Delay	135.9	15.0	5.1			77.1
Queue Delay	0.0	0.0	0.1			0.2
Total Delay	135.9	15.0	5.3			77.3
LOS	F	B	A			E
Approach Delay	85.5		5.3			77.3
Approach LOS	F		A			E
Queue Length 50th (ft)	237	0	165			~1858
Queue Length 95th (ft)	321	68	213			#2048
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		200				
Base Capacity (vph)	253	363	2616			1743
Starvation Cap Reductn	0	0	389			0
Spillback Cap Reductn	0	0	0			131
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.59	0.29	0.56			1.21

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 150
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 51.8 Intersection LOS: D
Intersection Capacity Utilization 110.4% ICU Level of Service H
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



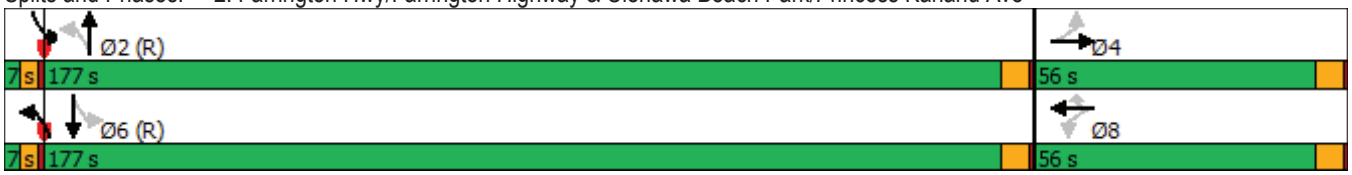
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	3	2	4	171	1	15	6	1127	55	2	1721	2
Future Volume (vph)	3	2	4	171	1	15	6	1127	55	2	1721	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1691	0	0	1700	1459	1745	3307	0	1745	3385	0
Flt Permitted		0.934			0.716		0.078			0.217		
Satd. Flow (perm)	0	1596	0	0	1277	1422	143	3307	0	399	3385	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		8				32		3				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	5					5			4	4		
Confl. Bikes (#/hr)									1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	133%	200%	200%	98%	100%	114%	50%	100%	55%	50%	110%	200%
Heavy Vehicles (%)	0%	0%	0%	3%	0%	7%	0%	5%	6%	0%	3%	50%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	16	0	0	169	17	3	1157	0	1	1897	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		37.1			37.1	37.1	192.1	189.3		192.1	189.3	
Actuated g/C Ratio		0.15			0.15	0.15	0.80	0.79		0.80	0.79	
v/c Ratio		0.06			0.86	0.07	0.02	0.44		0.00	0.71	
Control Delay		50.2			133.6	4.9	3.0	3.4		7.0	15.5	
Queue Delay		0.0			0.0	0.0	0.0	0.1		0.0	0.6	
Total Delay		50.2			133.6	4.9	3.0	3.5		7.0	16.2	
LOS		D			F	A	A	A		A	B	
Approach Delay		50.2			121.8			3.5			16.2	
Approach LOS		D			F			A			B	
Queue Length 50th (ft)		11			266	0	0	63		0	680	
Queue Length 95th (ft)		38			355	9	m1	90		2	1068	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)							50			100		
Base Capacity (vph)		338			266	321	149	2609		348	2670	
Starvation Cap Reductn		0			0	0	0	341		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	381	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.05			0.64	0.05	0.02	0.51		0.00	0.83	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 100
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.86
Intersection Signal Delay: 17.8 Intersection LOS: B
Intersection Capacity Utilization 79.3% ICU Level of Service D
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



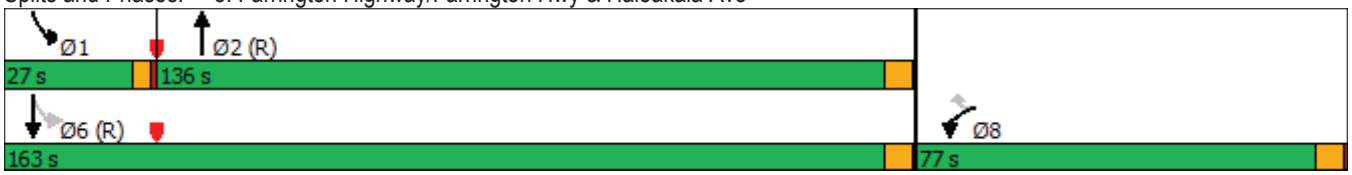
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	161	351	1109	21	282	1832
Future Volume (vph)	161	351	1109	21	282	1832
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1728	1546	3170	0	1745	3355
Flt Permitted	0.950				0.194	
Satd. Flow (perm)	1728	1428	3170	0	356	3355
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		210	2			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		20		60	60	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	125%	122%	99%	160%	79%	106%
Heavy Vehicles (%)	1%	1%	9%	5%	0%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	201	428	1132	0	223	1942
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	77.0	77.0	136.0		27.0	163.0
Total Split (%)	32.1%	32.1%	56.7%		11.3%	67.9%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	48.8	48.8	160.2		181.2	179.2
Actuated g/C Ratio	0.20	0.20	0.67		0.76	0.75
v/c Ratio	0.57	0.94	0.53		0.63	0.78
Control Delay	90.6	74.8	18.8		11.5	17.0
Queue Delay	0.0	0.0	0.2		0.0	37.2
Total Delay	90.6	74.8	19.0		11.5	54.2
LOS	F	E	B		B	D
Approach Delay	79.9		19.0			49.8
Approach LOS	E		B			D
Queue Length 50th (ft)	292	387	297		84	676
Queue Length 95th (ft)	354	507	m688		m96	m798
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	511	570	2116		402	2504
Starvation Cap Reductn	0	0	290		0	699
Spillback Cap Reductn	0	0	0		0	36
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.39	0.75	0.62		0.55	1.08

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 27 (11%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 80
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 45.7 Intersection LOS: D
Intersection Capacity Utilization 78.3% ICU Level of Service D
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	55	5	6	181	6	58	5	1159	241	138	1780	62
Future Volume (vph)	55	5	6	181	6	58	5	1159	241	138	1780	62
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1744	0	0	1684	1487	1745	3142	0	1646	3305	0
Flt Permitted		0.193			0.750		0.087			0.164		
Satd. Flow (perm)	0	344	0	0	1326	1388	160	3142	0	284	3305	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		1				50		11			8	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	17					17			1	1		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	173%	160%	133%	107%	67%	75%	80%	107%	50%	105%	102%	159%
Heavy Vehicles (%)	0%	0%	0%	4%	0%	5%	0%	10%	4%	6%	5%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	111	0	0	198	44	4	1361	0	145	1915	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	15.0		3.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	7.0	28.0		7.0	28.0	
Total Split (s)	35.0	35.0		35.0	35.0	35.0	7.0	179.0		26.0	198.0	
Total Split (%)	14.6%	14.6%		14.6%	14.6%	14.6%	2.9%	74.6%		10.8%	82.5%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		29.0			29.0	29.0	190.8	185.8		201.0	197.6	
Actuated g/C Ratio		0.12			0.12	0.12	0.80	0.77		0.84	0.82	
v/c Ratio		2.64			1.24	0.21	0.03	0.56		0.50	0.70	
Control Delay		831.6			225.6	16.8	3.8	11.8		5.4	4.9	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.6	
Total Delay		831.6			225.6	16.8	3.8	11.8		5.4	5.4	
LOS		F			F	B	A	B		A	A	
Approach Delay		831.6			187.7			11.8			5.4	
Approach LOS		F			F			B			A	
Queue Length 50th (ft)		~295			~386	0	1	419		6	496	
Queue Length 95th (ft)		#457			#586	39	4	479		m10	73	
Internal Link Dist (ft)		120			620			620			720	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Turn Bay Length (ft)							100			200		
Base Capacity (vph)		42			160	211	147	2434		362	2722	
Starvation Cap Reductn		0			0	0	0	0		0	386	
Spillback Cap Reductn		0			0	0	0	62		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		2.64			1.24	0.21	0.03	0.57		0.40	0.82	

Intersection Summary

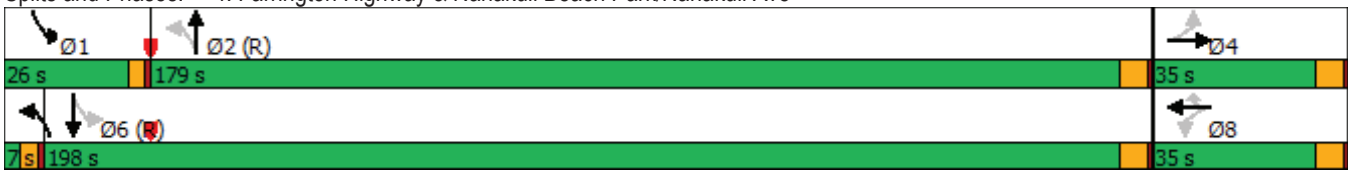
Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 26 (11%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 2.64
Intersection Signal Delay: 43.7 Intersection LOS: D
Intersection Capacity Utilization 84.6% ICU Level of Service E
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



Intersection						
Int Delay, s/veh	2.3					

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	10	11	72	0	1	51
Future Vol, veh/h	10	11	72	0	1	51
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	0	90	7	0	100	6
Mvmt Flow	16	9	125	0	1	32

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	125	0	-	0	166	125
Stage 1	-	-	-	-	125	-
Stage 2	-	-	-	-	41	-
Critical Hdwy	4.1	-	-	-	7.4	6.26
Critical Hdwy Stg 1	-	-	-	-	6.4	-
Critical Hdwy Stg 2	-	-	-	-	6.4	-
Follow-up Hdwy	2.2	-	-	-	4.4	3.354
Pot Cap-1 Maneuver	1474	-	-	-	643	915
Stage 1	-	-	-	-	706	-
Stage 2	-	-	-	-	780	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1474	-	-	-	636	915
Mov Cap-2 Maneuver	-	-	-	-	636	-
Stage 1	-	-	-	-	698	-
Stage 2	-	-	-	-	780	-

Approach	EB	WB	SB
HCM Control Delay, s	4.8	0	9.1
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1474	-	-	-	903
HCM Lane V/C Ratio	0.011	-	-	-	0.037
HCM Control Delay (s)	7.5	0	-	-	9.1
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q(veh)	0	-	-	-	0.1

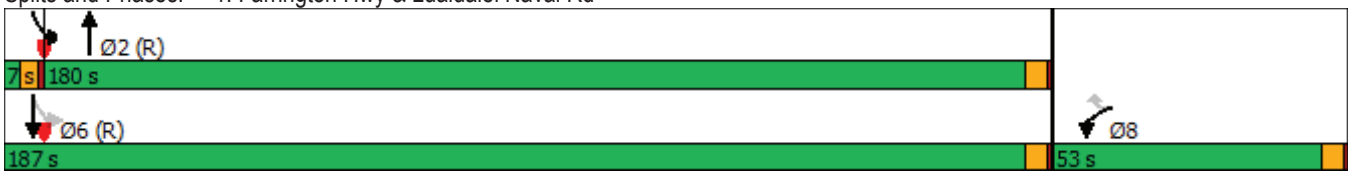
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	134	188	1756	27	72	1266
Future Volume (vph)	134	188	1756	27	72	1266
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	100		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1601	1531	3351	0	0	3350
Flt Permitted	0.950					0.568
Satd. Flow (perm)	1601	1507	3351	0	0	1909
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		58	2			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		1		7	7	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	96%	110%	101%	144%	107%	114%
Heavy Vehicles (%)	9%	2%	3%	36%	1%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	129	207	1813	0	0	1520
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	53.0	53.0	180.0		7.0	187.0
Total Split (%)	22.1%	22.1%	75.0%		2.9%	77.9%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	30.0	30.0	200.0			200.0
Actuated g/C Ratio	0.12	0.12	0.83			0.83
v/c Ratio	0.65	0.87	0.65			0.96
Control Delay	113.4	104.8	6.8			31.5
Queue Delay	0.0	0.0	0.0			0.0
Total Delay	113.4	104.8	6.8			31.5
LOS	F	F	A			C
Approach Delay	108.1		6.8			31.5
Approach LOS	F		A			C
Queue Length 50th (ft)	199	242	258			1023
Queue Length 95th (ft)	273	340	342			#1458
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		100				
Base Capacity (vph)	320	347	2792			1590
Starvation Cap Reductn	0	0	37			0
Spillback Cap Reductn	0	0	33			0
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.40	0.60	0.66			0.96

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 110
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.96
Intersection Signal Delay: 26.3 Intersection LOS: C
Intersection Capacity Utilization 112.4% ICU Level of Service H
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



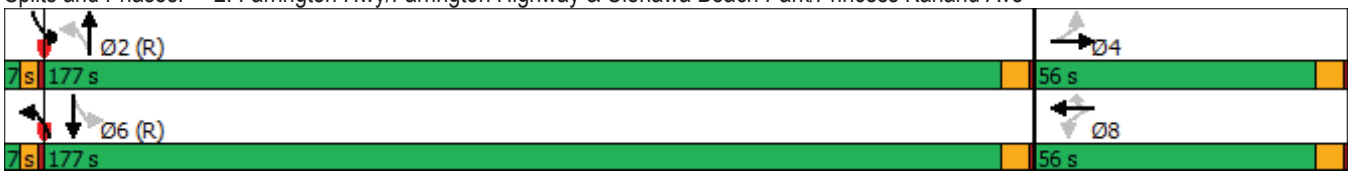
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	6	73	1	17	5	1726	128	12	1269	0
Future Volume (vph)	0	0	6	73	1	17	5	1726	128	12	1269	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		100	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1358	0	0	1684	1561	1745	3344	0	1745	3355	0
Flt Permitted					0.723		0.179			0.084		
Satd. Flow (perm)	0	1358	0	0	1277	1490	329	3344	0	154	3355	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		98				32		6				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	12					12	6		9	9		6
Confl. Bikes (#/hr)						1			1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	100%	100%	133%	112%	100%	150%	80%	105%	87%	218%	109%	100%
Heavy Vehicles (%)	0%	0%	17%	4%	0%	0%	0%	3%	3%	0%	4%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	8	0	0	83	26	4	1923	0	26	1383	0
Turn Type		NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		21.0			21.0	21.0	205.4	198.9		208.4	205.0	
Actuated g/C Ratio		0.09			0.09	0.09	0.86	0.83		0.87	0.85	
v/c Ratio		0.04			0.75	0.16	0.01	0.69		0.15	0.48	
Control Delay		0.4			142.1	18.8	2.5	6.9		4.5	5.6	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.1	
Total Delay		0.4			142.1	18.8	2.5	6.9		4.5	5.7	
LOS		A			F	B	A	A		A	A	
Approach Delay		0.4			112.7			6.9			5.7	
Approach LOS		A			F			A			A	
Queue Length 50th (ft)		0			131	0	1	527		5	232	
Queue Length 95th (ft)		0			200	29	m1	320		13	427	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)						100	50			100		
Base Capacity (vph)		360			266	335	314	2772		173	2866	
Starvation Cap Reductn		0			0	0	0	65		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	424	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.02			0.31	0.08	0.01	0.71		0.15	0.57	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 100
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 9.8 Intersection LOS: A
Intersection Capacity Utilization 85.6% ICU Level of Service E
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



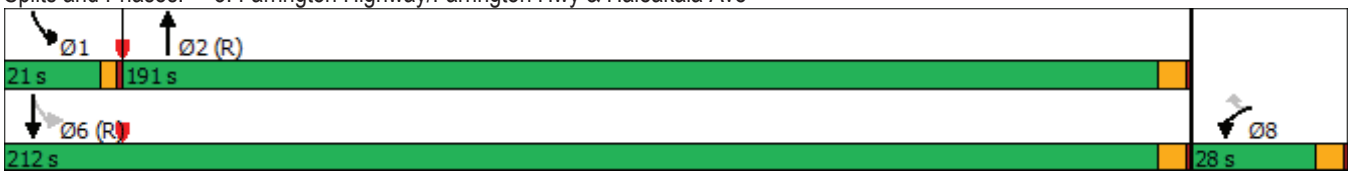
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	68	181	1838	19	101	1319
Future Volume (vph)	68	181	1838	19	101	1319
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1711	1546	3415	0	1711	3388
Flt Permitted	0.950				0.100	
Satd. Flow (perm)	1711	1438	3415	0	180	3388
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		132	1			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		18		11	11	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	83%	73%	98%	89%	136%	116%
Heavy Vehicles (%)	2%	1%	2%	6%	2%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	56	132	1818	0	137	1530
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	28.0	28.0	191.0		21.0	212.0
Total Split (%)	11.7%	11.7%	79.6%		8.8%	88.3%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	13.2	13.2	201.9		216.8	214.8
Actuated g/C Ratio	0.06	0.06	0.84		0.90	0.90
v/c Ratio	0.60	0.65	0.63		0.63	0.50
Control Delay	135.0	27.9	2.3		14.2	1.6
Queue Delay	0.0	0.0	0.8		0.0	1.0
Total Delay	135.0	27.9	3.2		14.2	2.7
LOS	F	C	A		B	A
Approach Delay	59.8		3.2			3.6
Approach LOS	E		A			A
Queue Length 50th (ft)	89	0	75		12	83
Queue Length 95th (ft)	149	85	137		m15	96
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	156	251	2872		271	3032
Starvation Cap Reductn	0	0	675		0	1146
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.36	0.53	0.83		0.51	0.81

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 21 (9%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 6.3 Intersection LOS: A
Intersection Capacity Utilization 82.8% ICU Level of Service E
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



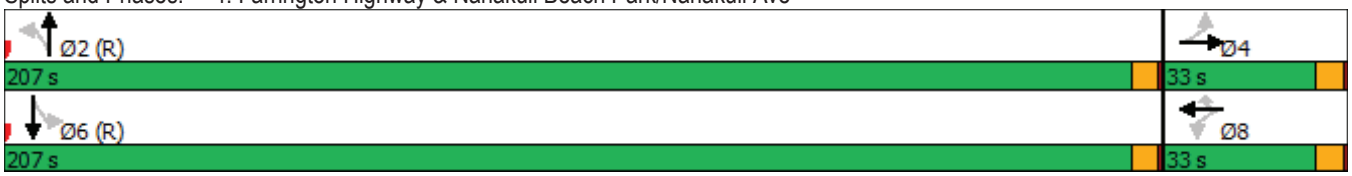
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	2	4	25	120	20	26	2	1951	417	5	1265	30
Future Volume (vph)	2	4	25	120	20	26	2	1951	417	5	1265	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	0		0	0		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1548	0	0	1723	1561	0	3304	0	0	4855	0
Flt Permitted		0.995			0.716			0.955			0.929	
Satd. Flow (perm)	0	1541	0	0	1284	1497	0	3156	0	0	4511	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		39				22		55			9	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	9					9			2	2		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	50%	50%	157%	79%	105%	83%	50%	104%	120%	50%	106%	157%
Heavy Vehicles (%)	0%	0%	4%	3%	0%	0%	50%	2%	1%	0%	2%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	6	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	42	0	0	116	22	0	2530	0	0	1391	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	15.0	15.0		15.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	28.0	28.0		28.0	28.0	
Total Split (s)	33.0	33.0		33.0	33.0	33.0	207.0	207.0		207.0	207.0	
Total Split (%)	13.8%	13.8%		13.8%	13.8%	13.8%	86.3%	86.3%		86.3%	86.3%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		6.0			6.0	6.0		6.0			6.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	C-Max	C-Max		C-Max	C-Max	
Act Effct Green (s)		24.6			24.6	24.6		203.4			203.4	
Actuated g/C Ratio		0.10			0.10	0.10		0.85			0.85	
v/c Ratio		0.22			0.89	0.13		0.94			0.36	
Control Delay		27.4			156.0	30.0		23.2			2.6	
Queue Delay		0.0			0.0	0.0		0.0			0.1	
Total Delay		27.4			156.0	30.0		23.2			2.6	
LOS		C			F	C		C			A	
Approach Delay		27.4			135.9			23.2			2.6	
Approach LOS		C			F			C			A	
Queue Length 50th (ft)		4			183	0		1501			79	
Queue Length 95th (ft)		53			#311	37		1613			88	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		120			620			620			720	
Turn Bay Length (ft)												
Base Capacity (vph)		207			144	187		2683			3824	
Starvation Cap Reductn		0			0	0		0			857	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.20			0.81	0.12		0.94			0.47	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 150
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 20.1 Intersection LOS: C
Intersection Capacity Utilization 102.0% ICU Level of Service G
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

APPENDIX D

CAPACITY ANALYSIS WORKSHEETS

PEAK HOUR TRAFFIC WITH PROJECT

Intersection	
Int Delay, s/veh	3.4

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	36	72	1	30	60	4
Future Vol, veh/h	36	72	1	30	60	4
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	47	89	100	64	89	100
Mvmt Flow	55	60	1	21	53	12

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	115	0	108	85
Stage 1	-	-	-	-	85	-
Stage 2	-	-	-	-	23	-
Critical Hdwy	-	-	5.1	-	7.29	7.2
Critical Hdwy Stg 1	-	-	-	-	6.29	-
Critical Hdwy Stg 2	-	-	-	-	6.29	-
Follow-up Hdwy	-	-	3.1	-	4.301	4.2
Pot Cap-1 Maneuver	-	-	1036	-	717	760
Stage 1	-	-	-	-	759	-
Stage 2	-	-	-	-	815	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1036	-	716	760
Mov Cap-2 Maneuver	-	-	-	-	716	-
Stage 1	-	-	-	-	759	-
Stage 2	-	-	-	-	814	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.4	10.5
HCM LOS			B

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	724	-	-	1036	-
HCM Lane V/C Ratio	0.09	-	-	0.001	-
HCM Control Delay (s)	10.5	-	-	8.5	0
HCM Lane LOS	B	-	-	A	A
HCM 95th %tile Q(veh)	0.3	-	-	0	-

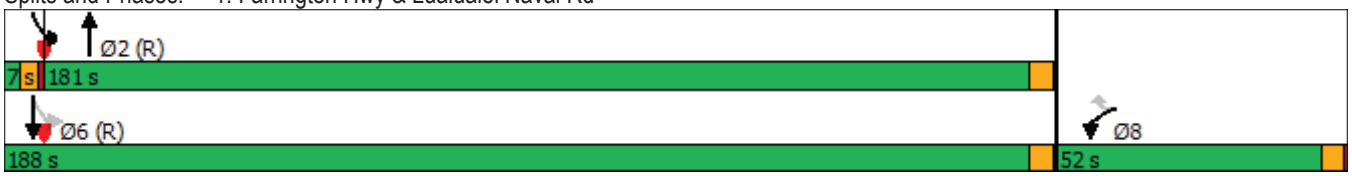
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	185	81	1186	93	114	1732
Future Volume (vph)	185	81	1186	93	114	1732
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	200		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1292	1446	3177	0	0	3365
Flt Permitted	0.950					0.616
Satd. Flow (perm)	1292	1418	3177	0	0	2081
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		114	9			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		2		4	4	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	86%	141%	99%	96%	121%	105%
Heavy Vehicles (%)	35%	8%	5%	53%	7%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	159	114	1263	0	0	1957
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	52.0	52.0	181.0		7.0	188.0
Total Split (%)	21.7%	21.7%	75.4%		2.9%	78.3%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	34.8	34.8	195.2			195.2
Actuated g/C Ratio	0.14	0.14	0.81			0.81
v/c Ratio	0.85	0.38	0.49			1.16
Control Delay	134.8	14.4	5.5			95.4
Queue Delay	0.0	0.0	0.1			0.3
Total Delay	134.8	14.4	5.6			95.7
LOS	F	B	A			F
Approach Delay	84.6		5.6			95.7
Approach LOS	F		A			F
Queue Length 50th (ft)	251	0	169			~1924
Queue Length 95th (ft)	336	68	216			#2113
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		200				
Base Capacity (vph)	253	369	2585			1692
Starvation Cap Reductn	0	0	379			0
Spillback Cap Reductn	0	0	0			133
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.63	0.31	0.57			1.26

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 150
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 1.16
Intersection Signal Delay: 62.2 Intersection LOS: E
Intersection Capacity Utilization 111.5% ICU Level of Service H
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



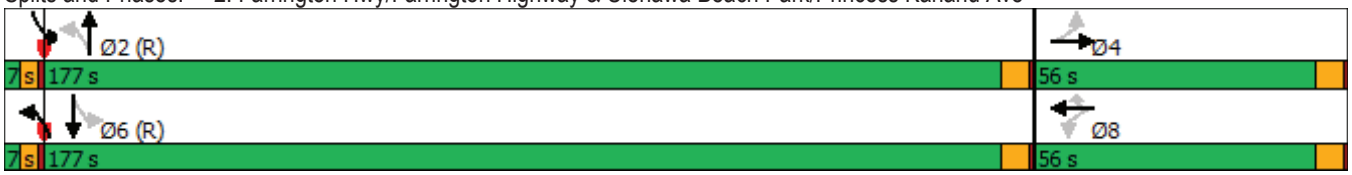
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	3	2	4	172	1	15	6	1132	55	2	1731	2
Future Volume (vph)	3	2	4	172	1	15	6	1132	55	2	1731	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1691	0	0	1700	1459	1745	3307	0	1745	3385	0
Flt Permitted		0.934			0.716		0.076			0.215		
Satd. Flow (perm)	0	1596	0	0	1277	1422	140	3307	0	395	3385	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		8				32		3				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	5					5			4	4		
Confl. Bikes (#/hr)									1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	133%	200%	200%	98%	100%	114%	50%	100%	55%	50%	110%	200%
Heavy Vehicles (%)	0%	0%	0%	3%	0%	7%	0%	5%	6%	0%	3%	50%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	16	0	0	170	17	3	1162	0	1	1908	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		37.2			37.2	37.2	192.0	189.2		192.0	189.2	
Actuated g/C Ratio		0.16			0.16	0.16	0.80	0.79		0.80	0.79	
v/c Ratio		0.06			0.86	0.07	0.02	0.45		0.00	0.72	
Control Delay		50.1			133.5	4.9	3.3	3.4		7.0	15.8	
Queue Delay		0.0			0.0	0.0	0.0	0.1		0.0	0.9	
Total Delay		50.1			133.5	4.9	3.3	3.5		7.0	16.6	
LOS		D			F	A	A	A		A	B	
Approach Delay		50.1			121.8			3.5			16.6	
Approach LOS		D			F			A			B	
Queue Length 50th (ft)		11			268	0	0	64		0	692	
Queue Length 95th (ft)		38			356	9	m1	93		2	1081	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)							50			100		
Base Capacity (vph)		338			266	321	147	2607		345	2668	
Starvation Cap Reductn		0			0	0	0	335		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	430	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.05			0.64	0.05	0.02	0.51		0.00	0.85	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 100
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.86
Intersection Signal Delay: 18.1 Intersection LOS: B
Intersection Capacity Utilization 79.7% ICU Level of Service D
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



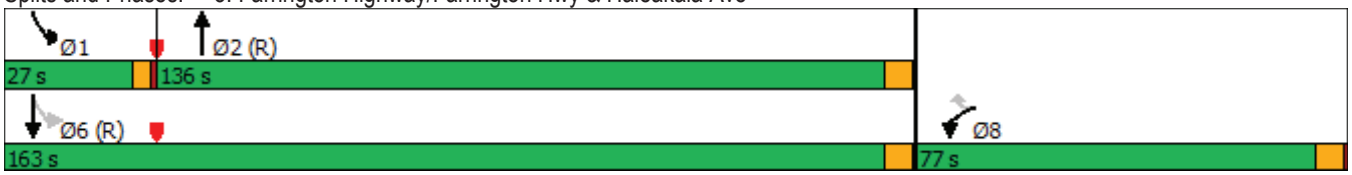
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	161	353	1115	21	282	1843
Future Volume (vph)	161	353	1115	21	282	1843
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1728	1546	3174	0	1745	3355
Flt Permitted	0.950				0.191	
Satd. Flow (perm)	1728	1428	3174	0	351	3355
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		209	2			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		20		60	60	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	125%	122%	99%	160%	79%	106%
Heavy Vehicles (%)	1%	1%	9%	5%	0%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	201	431	1138	0	223	1954
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	77.0	77.0	136.0		27.0	163.0
Total Split (%)	32.1%	32.1%	56.7%		11.3%	67.9%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	49.5	49.5	159.3		180.5	178.5
Actuated g/C Ratio	0.21	0.21	0.66		0.75	0.74
v/c Ratio	0.56	0.94	0.54		0.63	0.78
Control Delay	89.7	75.2	19.3		10.3	17.2
Queue Delay	0.0	0.0	0.2		0.0	47.4
Total Delay	89.7	75.2	19.4		10.3	64.5
LOS	F	E	B		B	E
Approach Delay	79.8		19.4			59.0
Approach LOS	E		B			E
Queue Length 50th (ft)	291	394	298		85	695
Queue Length 95th (ft)	353	514	m719		m94	m756
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	511	569	2107		398	2494
Starvation Cap Reductn	0	0	289		0	718
Spillback Cap Reductn	0	0	0		0	29
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.39	0.76	0.63		0.56	1.10

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 27 (11%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 50.9 Intersection LOS: D
Intersection Capacity Utilization 78.6% ICU Level of Service D
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	55	5	6	181	6	58	5	1165	241	138	1791	62
Future Volume (vph)	55	5	6	181	6	58	5	1165	241	138	1791	62
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1744	0	0	1684	1487	1745	3142	0	1646	3305	0
Flt Permitted		0.193			0.750		0.085			0.163		
Satd. Flow (perm)	0	344	0	0	1326	1388	156	3142	0	282	3305	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		1				50		11			8	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	17					17			1	1		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	173%	160%	133%	107%	67%	75%	80%	107%	50%	105%	102%	159%
Heavy Vehicles (%)	0%	0%	0%	4%	0%	5%	0%	10%	4%	6%	5%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	111	0	0	198	44	4	1368	0	145	1926	0
Turn Type	Perm	NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	15.0		3.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	7.0	28.0		7.0	28.0	
Total Split (s)	35.0	35.0		35.0	35.0	35.0	7.0	179.0		26.0	198.0	
Total Split (%)	14.6%	14.6%		14.6%	14.6%	14.6%	2.9%	74.6%		10.8%	82.5%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		29.0			29.0	29.0	190.8	185.8		201.0	197.6	
Actuated g/C Ratio		0.12			0.12	0.12	0.80	0.77		0.84	0.82	
v/c Ratio		2.64			1.24	0.21	0.03	0.56		0.50	0.71	
Control Delay		831.6			225.6	16.8	3.8	11.9		5.4	4.8	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.6	
Total Delay		831.6			225.6	16.8	3.8	11.9		5.4	5.4	
LOS		F			F	B	A	B		A	A	
Approach Delay		831.6			187.7			11.9			5.4	
Approach LOS		F			F			B			A	
Queue Length 50th (ft)		~295			~386	0	1	423		5	415	
Queue Length 95th (ft)		#457			#586	39	4	484		m10	72	
Internal Link Dist (ft)		120			620			620			720	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Turn Bay Length (ft)							100			200		
Base Capacity (vph)		42			160	211	143	2434		361	2722	
Starvation Cap Reductn		0			0	0	0	0		0	386	
Spillback Cap Reductn		0			0	1	0	67		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		2.64			1.24	0.21	0.03	0.58		0.40	0.82	

Intersection Summary

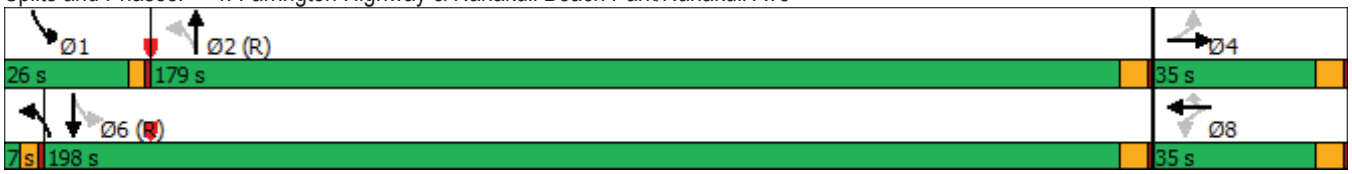
Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 26 (11%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 2.64
Intersection Signal Delay: 43.5 Intersection LOS: D
Intersection Capacity Utilization 84.9% ICU Level of Service E
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



Intersection	
Int Delay, s/veh	2.2

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	11	15	0	72	74	1
Future Vol, veh/h	11	15	0	72	74	1
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	-	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	100	100	100	100	100	100
Heavy Vehicles, %	90	0	0	7	6	100
Mvmt Flow	9	24	0	125	47	1

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	33	0	146	21
Stage 1	-	-	-	-	21	-
Stage 2	-	-	-	-	125	-
Critical Hdwy	-	-	4.1	-	6.46	7.2
Critical Hdwy Stg 1	-	-	-	-	5.46	-
Critical Hdwy Stg 2	-	-	-	-	5.46	-
Follow-up Hdwy	-	-	2.2	-	3.554	4.2
Pot Cap-1 Maneuver	-	-	1592	-	837	832
Stage 1	-	-	-	-	991	-
Stage 2	-	-	-	-	891	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1592	-	837	832
Mov Cap-2 Maneuver	-	-	-	-	837	-
Stage 1	-	-	-	-	991	-
Stage 2	-	-	-	-	891	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0	9.3
HCM LOS			A

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	832	-	-	1592	-
HCM Lane V/C Ratio	0.001	-	-	-	-
HCM Control Delay (s)	9.3	-	-	0	-
HCM Lane LOS	A	-	-	A	-
HCM 95th %tile Q(veh)	0	-	-	0	-

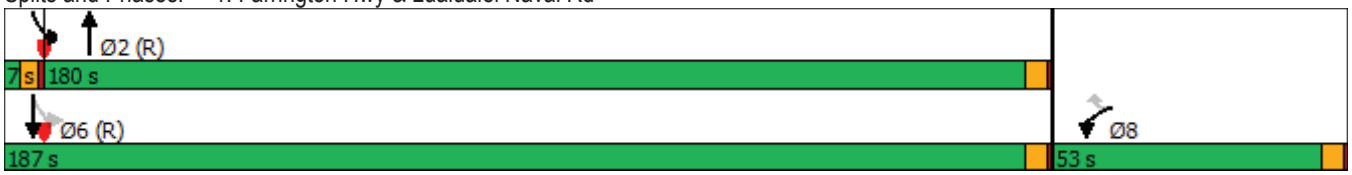
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	144	201	1756	28	76	1266
Future Volume (vph)	144	201	1756	28	76	1266
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	100		0	0	
Storage Lanes	1	1		0	0	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1601	1531	3351	0	0	3351
Flt Permitted	0.950					0.556
Satd. Flow (perm)	1601	1507	3351	0	0	1868
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		58	2			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		1		7	7	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	96%	110%	101%	144%	107%	114%
Heavy Vehicles (%)	9%	2%	3%	36%	1%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	138	221	1814	0	0	1524
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	53.0	53.0	180.0		7.0	187.0
Total Split (%)	22.1%	22.1%	75.0%		2.9%	77.9%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0			0.0
Total Lost Time (s)	5.0	5.0	5.0			5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	32.3	32.3	197.7			197.7
Actuated g/C Ratio	0.13	0.13	0.82			0.82
v/c Ratio	0.64	0.87	0.66			0.99
Control Delay	110.6	105.4	7.3			40.6
Queue Delay	0.0	0.0	0.0			0.0
Total Delay	110.6	105.4	7.3			40.6
LOS	F	F	A			D
Approach Delay	107.4		7.3			40.6
Approach LOS	F		A			D
Queue Length 50th (ft)	211	265	261			1162
Queue Length 95th (ft)	287	364	343			#1508
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		100				
Base Capacity (vph)	320	347	2760			1538
Starvation Cap Reductn	0	0	36			0
Spillback Cap Reductn	0	0	25			0
Storage Cap Reductn	0	0	0			0
Reduced v/c Ratio	0.43	0.64	0.67			0.99

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 120
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 30.8 Intersection LOS: C
Intersection Capacity Utilization 113.1% ICU Level of Service H
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



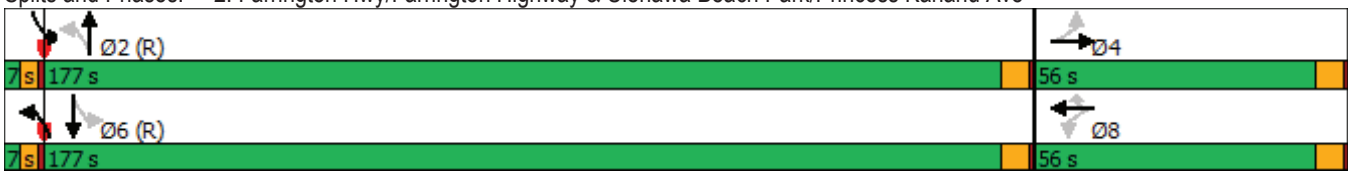
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	6	73	1	17	5	1738	129	12	1273	0
Future Volume (vph)	0	0	6	73	1	17	5	1738	129	12	1273	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		100	50		0	100		0
Storage Lanes	0		0	0		1	1		0	1		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1358	0	0	1684	1561	1745	3344	0	1745	3355	0
Flt Permitted					0.723		0.178			0.082		
Satd. Flow (perm)	0	1358	0	0	1277	1490	327	3344	0	151	3355	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		97				32		6				
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		217			700			700			491	
Travel Time (s)		4.2			13.6			13.6			9.6	
Confl. Peds. (#/hr)	12					12	6		9	9		6
Confl. Bikes (#/hr)						1			1			
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	100%	100%	133%	112%	100%	150%	80%	105%	87%	218%	109%	100%
Heavy Vehicles (%)	0%	0%	17%	4%	0%	0%	0%	3%	3%	0%	4%	0%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	8	0	0	83	26	4	1937	0	26	1388	0
Turn Type		NA		Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	3.0	7.0		3.0	7.0	
Minimum Split (s)	13.0	13.0		32.0	32.0	32.0	7.0	28.0		7.0	28.0	
Total Split (s)	56.0	56.0		56.0	56.0	56.0	7.0	177.0		7.0	177.0	
Total Split (%)	23.3%	23.3%		23.3%	23.3%	23.3%	2.9%	73.8%		2.9%	73.8%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	3.0	5.0		3.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		6.0			6.0	6.0	4.0	6.0		4.0	6.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	C-Max		None	C-Max	
Act Effct Green (s)		21.0			21.0	21.0	205.4	198.9		208.4	205.0	
Actuated g/C Ratio		0.09			0.09	0.09	0.86	0.83		0.87	0.85	
v/c Ratio		0.04			0.75	0.16	0.01	0.70		0.15	0.48	
Control Delay		0.4			142.1	18.8	2.5	6.8		4.5	5.6	
Queue Delay		0.0			0.0	0.0	0.0	0.1		0.0	0.1	
Total Delay		0.4			142.1	18.8	2.5	6.9		4.5	5.8	
LOS		A			F	B	A	A		A	A	
Approach Delay		0.4			112.7			6.9			5.8	
Approach LOS		A			F			A			A	
Queue Length 50th (ft)		0			131	0	1	459		5	233	
Queue Length 95th (ft)		0			200	29	m1	297		13	429	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		137			620			620			411	
Turn Bay Length (ft)						100	50			100		
Base Capacity (vph)		359			266	335	312	2772		170	2866	
Starvation Cap Reductn		0			0	0	0	66		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	488	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.02			0.31	0.08	0.01	0.72		0.15	0.58	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 7 (3%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 100
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 9.7 Intersection LOS: A
Intersection Capacity Utilization 86.0% ICU Level of Service E
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 2: Farrington Hwy/Farrington Highway & Ulehawa Beach Park/Princess Kahanu Ave



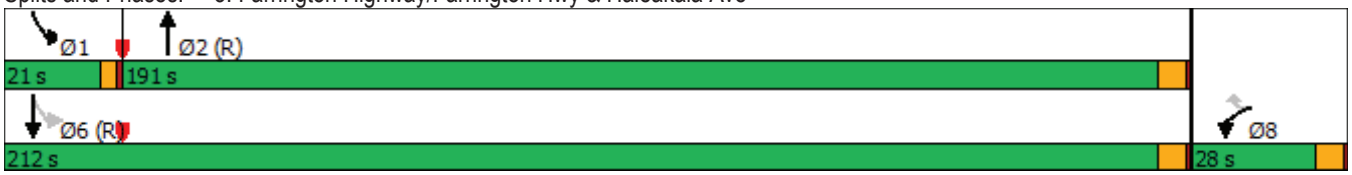
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	68	181	1839	19	101	1329
Future Volume (vph)	68	181	1839	19	101	1329
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	0		0	100	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1711	1546	3415	0	1711	3388
Flt Permitted	0.950				0.100	
Satd. Flow (perm)	1711	1438	3415	0	180	3388
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		132	1			
Link Speed (mph)	35		35			35
Link Distance (ft)	700		800			700
Travel Time (s)	13.6		15.6			13.6
Confl. Peds. (#/hr)		18		11	11	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	83%	73%	98%	89%	136%	116%
Heavy Vehicles (%)	2%	1%	2%	6%	2%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	56	132	1819	0	137	1542
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	28.0	28.0	29.0		7.0	21.0
Total Split (s)	28.0	28.0	191.0		21.0	212.0
Total Split (%)	11.7%	11.7%	79.6%		8.8%	88.3%
Yellow Time (s)	5.0	5.0	5.0		3.0	5.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0		4.0	6.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?			Yes		Yes	
Recall Mode	None	None	C-Max		None	C-Max
Act Effct Green (s)	13.2	13.2	201.9		216.8	214.8
Actuated g/C Ratio	0.06	0.06	0.84		0.90	0.90
v/c Ratio	0.60	0.65	0.63		0.63	0.51
Control Delay	135.0	27.9	2.3		14.1	1.7
Queue Delay	0.0	0.0	0.8		0.0	1.2
Total Delay	135.0	27.9	3.2		14.1	2.8
LOS	F	C	A		B	A
Approach Delay	59.8		3.2			3.8
Approach LOS	E		A			A
Queue Length 50th (ft)	89	0	75		13	91
Queue Length 95th (ft)	149	85	137		m15	m100
Internal Link Dist (ft)	620		720			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)					100	
Base Capacity (vph)	156	251	2872		271	3032
Starvation Cap Reductn	0	0	675		0	1168
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.36	0.53	0.83		0.51	0.83

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 21 (9%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 6.3 Intersection LOS: A
Intersection Capacity Utilization 82.8% ICU Level of Service E
Analysis Period (min) 15
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 3: Farrington Highway/Farrington Hwy & Haleakala Ave



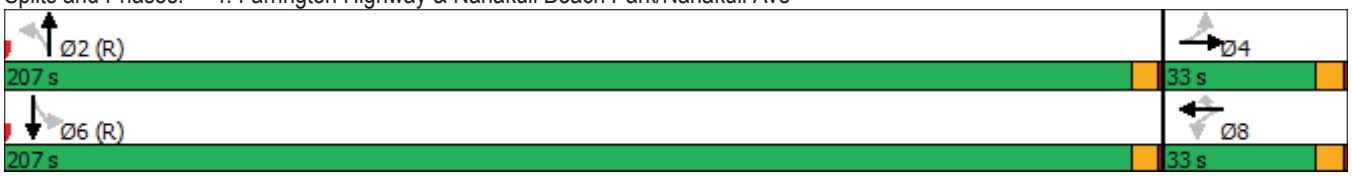
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	2	4	25	120	20	26	2	1952	417	5	1278	30
Future Volume (vph)	2	4	25	120	20	26	2	1952	417	5	1278	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	100		0	200		0
Storage Lanes	0		0	0		1	0		0	0		0
Taper Length (ft)	100			100			100			100		
Satd. Flow (prot)	0	1548	0	0	1723	1561	0	3304	0	0	4855	0
Flt Permitted		0.995			0.716			0.955			0.929	
Satd. Flow (perm)	0	1541	0	0	1284	1497	0	3156	0	0	4511	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		39				22		55			9	
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		200			700			700			800	
Travel Time (s)		3.9			13.6			13.6			15.6	
Confl. Peds. (#/hr)	9					9			2	2		
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	50%	50%	157%	79%	105%	83%	50%	104%	120%	50%	106%	157%
Heavy Vehicles (%)	0%	0%	4%	3%	0%	0%	50%	2%	1%	0%	2%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	6	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	42	0	0	116	22	0	2531	0	0	1405	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	7.0	7.0		7.0	7.0	7.0	15.0	15.0		15.0	15.0	
Minimum Split (s)	13.0	13.0		28.0	28.0	28.0	28.0	28.0		28.0	28.0	
Total Split (s)	33.0	33.0		33.0	33.0	33.0	207.0	207.0		207.0	207.0	
Total Split (%)	13.8%	13.8%		13.8%	13.8%	13.8%	86.3%	86.3%		86.3%	86.3%	
Yellow Time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0	
All-Red Time (s)	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	1.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		6.0			6.0	6.0		6.0			6.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	C-Max	C-Max		C-Max	C-Max	
Act Effct Green (s)		24.6			24.6	24.6		203.4			203.4	
Actuated g/C Ratio		0.10			0.10	0.10		0.85			0.85	
v/c Ratio		0.22			0.89	0.13		0.94			0.37	
Control Delay		27.4			156.0	30.0		23.2			2.6	
Queue Delay		0.0			0.0	0.0		0.0			0.1	
Total Delay		27.4			156.0	30.0		23.2			2.7	
LOS		C			F	C		C			A	
Approach Delay		27.4			135.9			23.2			2.7	
Approach LOS		C			F			C			A	
Queue Length 50th (ft)		4			183	0		1504			82	
Queue Length 95th (ft)		53			#311	37		1619			89	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Internal Link Dist (ft)		120			620			620			720	
Turn Bay Length (ft)												
Base Capacity (vph)		207			144	187		2683			3824	
Starvation Cap Reductn		0			0	0		0			853	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.20			0.81	0.12		0.94			0.47	

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 240
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 150
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 20.0 Intersection LOS: C
Intersection Capacity Utilization 102.1% ICU Level of Service G
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Farrington Highway & Nanakuli Beach Park/Nanakuli Ave



TRANSPORTATION IMPACT ANALYSIS REPORT

FOR THE PROPOSED

PVT INTEGRATED SOLID WASTE MANAGEMENT FACILITY RELOCATION

NANAKULI, OAHU, HAWAII

TAX MAP KEYS: (1) 8-7-009:007

APPENDIX E

CAPACITY ANALYSIS WORKSHEETS

PEAK HOUR TRAFFIC WITH PROJECT

WITH IMPROVEMENTS

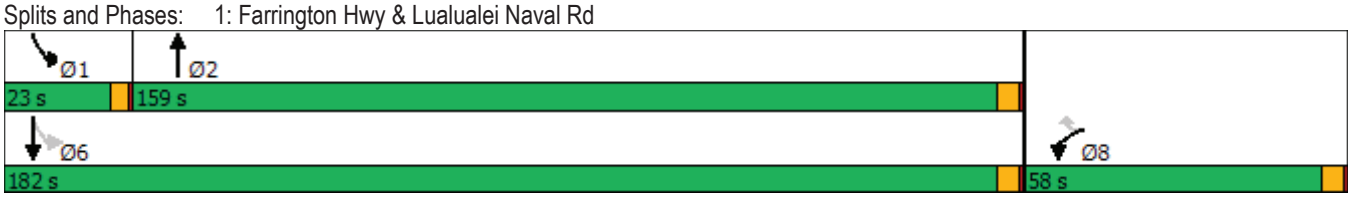
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	185	81	1186	93	114	1732
Future Volume (vph)	185	81	1186	93	114	1732
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	200		0	125	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1292	1446	3177	0	1631	3388
Flt Permitted	0.950				0.179	
Satd. Flow (perm)	1292	1418	3177	0	307	3388
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		114	6			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		2		4	4	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	86%	141%	99%	96%	121%	105%
Heavy Vehicles (%)	35%	8%	5%	53%	7%	3%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	159	114	1263	0	138	1819
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	58.0	58.0	159.0		23.0	182.0
Total Split (%)	24.2%	24.2%	66.3%		9.6%	75.8%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	5.0	5.0	5.0		4.0	5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	32.1	32.1	163.8		178.3	177.3
Actuated g/C Ratio	0.15	0.15	0.75		0.81	0.81
v/c Ratio	0.85	0.38	0.53		0.45	0.66
Control Delay	125.6	14.1	13.6		9.7	11.0
Queue Delay	0.0	0.0	1.9		0.0	5.1
Total Delay	125.6	14.1	15.5		9.7	16.2
LOS	F	B	B		A	B
Approach Delay	79.1		15.5			15.7
Approach LOS	E		B			B
Queue Length 50th (ft)	228	0	375		37	517
Queue Length 95th (ft)	328	67	556		73	760
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		200			125	
Base Capacity (vph)	312	429	2373		364	2737
Starvation Cap Reductn	0	0	901		0	847
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.51	0.27	0.86		0.38	0.96

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 219.4
Natural Cycle: 70
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.85
Intersection Signal Delay: 20.6 — Intersection LOS: C
Intersection Capacity Utilization 68.0% — ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



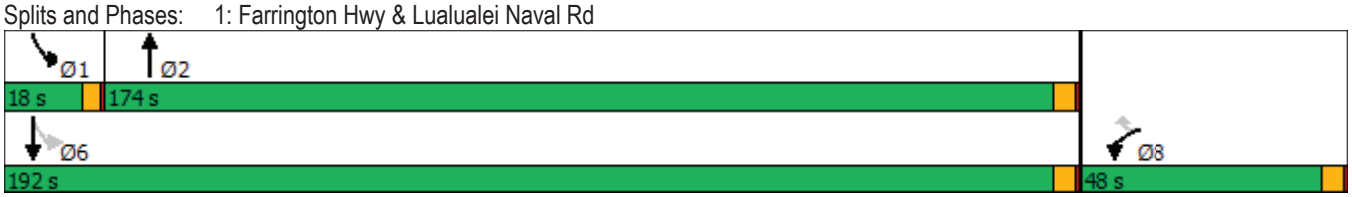
Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Volume (vph)	144	201	1756	28	76	1266
Future Volume (vph)	144	201	1756	28	76	1266
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0	100		0	125	
Storage Lanes	1	1		0	1	
Taper Length (ft)	100				100	
Satd. Flow (prot)	1601	1531	3351	0	1728	3355
Flt Permitted	0.950				0.090	
Satd. Flow (perm)	1601	1507	3351	0	164	3355
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)		116	2			
Link Speed (mph)	25		35			35
Link Distance (ft)	500		700			700
Travel Time (s)	13.6		13.6			13.6
Confl. Peds. (#/hr)		1		7	7	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	96%	110%	101%	144%	107%	114%
Heavy Vehicles (%)	9%	2%	3%	36%	1%	4%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	138	221	1814	0	81	1443
Turn Type	Prot	Perm	NA		pm+pt	NA
Protected Phases	8		2		1	6
Permitted Phases		8			6	
Detector Phase	8	8	2		1	6
Switch Phase						
Minimum Initial (s)	7.0	7.0	7.0		3.0	7.0
Minimum Split (s)	26.0	26.0	37.0		7.0	12.0
Total Split (s)	48.0	48.0	174.0		18.0	192.0
Total Split (%)	20.0%	20.0%	72.5%		7.5%	80.0%
Yellow Time (s)	4.0	4.0	4.0		3.0	4.0
All-Red Time (s)	1.0	1.0	1.0		1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)	5.0	5.0	5.0		4.0	5.0
Lead/Lag			Lag		Lead	
Lead-Lag Optimize?						
Recall Mode	None	None	Max		None	Max
Act Effct Green (s)	24.6	24.6	175.8		188.1	187.1
Actuated g/C Ratio	0.11	0.11	0.79		0.85	0.84
v/c Ratio	0.78	0.82	0.68		0.43	0.51
Control Delay	123.9	68.6	12.8		10.0	5.9
Queue Delay	0.0	0.0	7.3		0.0	1.4
Total Delay	123.9	68.6	20.0		10.0	7.3
LOS	F	E	C		B	A
Approach Delay	89.9		20.0			7.4
Approach LOS	F		C			A
Queue Length 50th (ft)	200	158	569		16	262
Queue Length 95th (ft)	291	271	814		36	395
Internal Link Dist (ft)	420		620			620

Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Turn Bay Length (ft)		100			125	
Base Capacity (vph)	310	385	2658		238	2831
Starvation Cap Reductn	0	0	807		0	1115
Spillback Cap Reductn	0	0	0		0	0
Storage Cap Reductn	0	0	0		0	0
Reduced v/c Ratio	0.45	0.57	0.98		0.34	0.84

Intersection Summary

Area Type: Other
Cycle Length: 240
Actuated Cycle Length: 221.7
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 21.6 — Intersection LOS: C
Intersection Capacity Utilization 74.5% — ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Farrington Hwy & Lualualei Naval Rd



APPENDIX G
Archaeological Report and Preservation Plan

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Archaeological Literature Review and Field Inspection Report for the PVT Integrated Solid Waste Management Facility Relocation Project, Lualualei Ahupuaʻa, Waiʻanae District, Oʻahu TMK: [1] 8-7-009:007

Prepared for
Pryzm Consulting LLC

Prepared by
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(Job Code: LUALUALEI 32)

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Management Summary

Reference	Archaeological Literature Review and Field Inspection Report for the PVT Integrated Solid Waste Management Facility Relocation Project, Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, TMK: [1] 8-7-009:007 (Shideler and Hammatt 2018)
Date	November 2018
Project Number(s)	Cultural Surveys Hawai‘i, Inc. (CSH), Job Code: LUALUALEI 32
Investigation Permit Number	CSH completed the fieldwork component of this study under archaeological fieldwork permit number 18-15, issued by the Hawai‘i State Historic Preservation Division (SHPD) per Hawai‘i Administrative Rules (HAR) §13-282.
Agencies	SHPD
Land Jurisdiction	Leeward Land Company, Ltd., affiliate of PVT
Project Proponent	PVT Land Company
Project Funding	PVT Land Company
Project Location	The project area is along the southwestern slopes of Pu‘u Heleakalā in Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, TMK: [1] 8-7-009:007, as depicted on portions of the 1998 Waianae and Schofield Barracks U.S. Geological Survey (USGS) 7.5-minute topographic quadrangles.
Project Description	The proposed project involves the relocation of an existing integrated solid waste management facility (ISWMF) to a vacant, privately owned parcel east of the PVT Land Company Ltd owned ISWMF and Lualualei Naval Road. In addition, the proposed project involves improvements to operations, including relocation of construction and demolition (C&D) waste receiving, materials sorting/recycling, and C&D disposal operations; modernization and enhancement of recycling operations (e.g., installation of two automated materials recovery devices); and installation of renewable energy facilities to power PVT operations (e.g., installations of one 1000-kWh enclosed gasification unit and approximately 7 acres of photovoltaic panels).
Project Acreage	179 acres (72.4 hectares)
Document Purpose	This investigation was designed—through historical, cultural, and archaeological background research and a field inspection of the project area—to determine the likelihood that historic properties may be affected by the project and, based on the results, consider cultural resource management recommendations. This document is intended to facilitate the project’s planning and support the project’s historic preservation and environmental review compliance. This investigation does not fulfill the requirements of an archaeological inventory survey investigation, per HAR §13-276.

Historic Preservation Context	CSH prepared a report titled *Archaeological Inventory Survey (AIS) of 200 Acres for the Proposed Nanakuli B Site Materials Recovery Facility and Landfill* (O'Leary and McDermott 2006), which was accepted by the SHPD in a letter dated 5 January 2006 (Log No.: 2007.0053, Doc. No.: 0701amj06; see Appendix A). Two historic properties were identified in the project area during the AIS: State Inventory of Historic Places (SIHP) #s 50-80-08-6699, traditional Hawaiian rock shelter, and -6681, World War II-era concrete bunker. Subsequently, CSH prepared an *Addendum to Archaeological Inventory Survey of 200 Acres for the Proposed Nanakuli B Site Materials Recovery Facility and Landfill* (Hammermeister and McDermott 2007). The addendum report was accepted by the SHPD in a letter dated 27 February 2008 (Log No.: 2007.3341, Doc. No.: 0802ED31; see Appendix A). One additional historic property was identified in the project area during the addendum AIS: SIHP # 50-80-08-6920, rock mound interpreted as a traditional Hawaiian marker. Additionally, CSH prepared a *Cultural Impact Assessment of 179 Acres for the Proposed Nanakuli B Composting and Solid Waste Landfill Facility* (Souza and Hammatt 2007). CSH prepared a preservation plan for SIHP # 50-80-08-6699 (Tulchin and Hammatt 2007) which was accepted by the SHPD in a letter dated 10 December 2007 (Log No.: 2007.1713, Doc. No.: 0712ED11; see Appendix A).
Fieldwork Effort	CSH archaeologists David Crowell, M.S., and David Shideler, M.A., accomplished fieldwork on 3 July 2018 under the general supervision of Principal Investigator Hallett H. Hammatt, Ph.D. This work required approximately 0.5 person-days to complete.
Results Summary	The fieldwork effort focused on locating the three previously identified historic properties (SIHP #s 50-80-08-6681, -6699, and -6920) within the project area (see O'Leary and McDermott 2006, Hammermeister and McDermott 2007) in order to assess their current conditions. They were found to be in much the same condition as documented during the prior studies. In addition, one historic property (Māui Rock, SIHP # 50-80-07-0148) and a *wahi pana* (legendary place; Hina's Cave, no SIHP number) outside the project area were also investigated and documented during the field inspection. These were also found to be free of recent disturbance, with no rubbish or offerings (e.g., *lei*) observed.
Recommendations	Both AIS studies recommended a project-specific effect determination of "no historic properties affected." Hammermeister and McDermott (2007) recommended no further historic preservation work for the historic property SIHP # 50-80-08-6920.

	However, due to the proximity of SIHP # 50-80-08-6699 to the project area, it was recommended that interim protection measures be installed to ensure no construction activities adversely affect the historic property. CSH prepared a preservation plan (Tulchin and Hammatt 2007) to protect the historic property from construction activity. The preservation plan recommended demarcation of an 8 m (26 feet [ft]) buffer zone surrounding the historic property for protection from construction activity. The suggested buffer zone would be established using a 35 m (115 ft) long steel post and wire or chain link fence. Additionally, natural vegetation will not be cleared from the historic property, further obscuring the rock shelter’s location as an additional means of protection. As there has been little to no change to the project area, and the current study has determined that the O’Leary and McDermott (2006) and Hammermeister and McDermott (2007) AIS’s for the project are sufficient for the purposes of historic property identification. The current report also concurs with the O’Leary and McDermott (2006) and Hammermeister and McDermott (2007) previous assessments and recommendations for all historic properties identified within the project area.

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Section 1 Introduction

1.1 Project Background

At the request of Pryzm Consulting LLC, Cultural Surveys Hawai‘i, Inc. (CSH), has prepared this archaeological literature review and field inspection report (LRFI) for the PVT Integrated Solid Waste Management Facility Relocation Project, Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, TMK: [1] 8-7-009:007. The project area is along the southwestern slopes of Pu‘u Heleakalā and comprises 179 acres (72.4 hectares). The project area is depicted on a portion of the 1998 Waianae and Schofield Barracks U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle (Figure 1), a tax map plat (Figure 2), and a 2013 aerial photograph (Figure 3).

The proposed project involves the relocation of an existing integrated solid waste management facility (ISWMF) to a vacant, privately owned parcel east of the PVT ISWMF and Lualualei Naval Road. In addition, the proposed project involves improvements to operations, including relocation of construction and demolition (C&D) waste receiving, materials sorting/recycling, and C&D disposal operations; modernization and enhancement of recycling operations (e.g., installation of two automated materials recovery devices); and installation of renewable energy facilities to power PVT operations (e.g., installations of one 1000-kWh enclosed gasification unit and approximately 7 acres of photovoltaic panels).

1.2 Document Purpose

This investigation was designed—through historical, cultural, and archaeological background research and a field inspection of the project area—to determine the likelihood that historic properties may be affected by the project and, based on findings, consider cultural resource management recommendations. This document is intended to facilitate the project’s planning and support the project’s historic preservation and environmental review compliance. This investigation does not fulfill the requirements of an archaeological inventory survey investigation, per HAR §13-276.

1.3 Historic Preservation Context

The entirety of the current project area has been previously surveyed through various archaeological studies. CSH previously conducted an *Archaeological Inventory Survey (AIS) of 200 Acres for the Proposed Nanakuli B Site Materials Recovery Facility and Landfill* (O’Leary and McDermott 2006). The AIS report was accepted in an SHPD §6E-42 review letter dated 5 January 2006 (Log No.: 2007.0053, Doc. No.: 0701amj06; Appendix A). Two historic properties were identified in the project area during the AIS: State Inventory of Historic Places (SIHP) #s 50-80-08-6699, small pre-Contact basalt rock shelter, and -6681, World War II-era concrete bunker.

Subsequently, CSH prepared an *Addendum to Archaeological Inventory Survey of 200 Acres for the Proposed Nanakuli B Site Materials Recovery Facility and Landfill* (Hammermeister and McDermott 2007). The addendum report was accepted in an SHPD §6E-42 review letter dated 27 February 2008 (Log No.: 2007.3341, Doc. No.: 0802ED31; see Appendix A).

CSH prepared a preservation plan for SIHP # 50-80-08-6699 which was accepted to SHPD in a letter dated 10 December 2007 (Log No.: 2007.1713, Doc. No.: 0712ED11; see Appendix A).

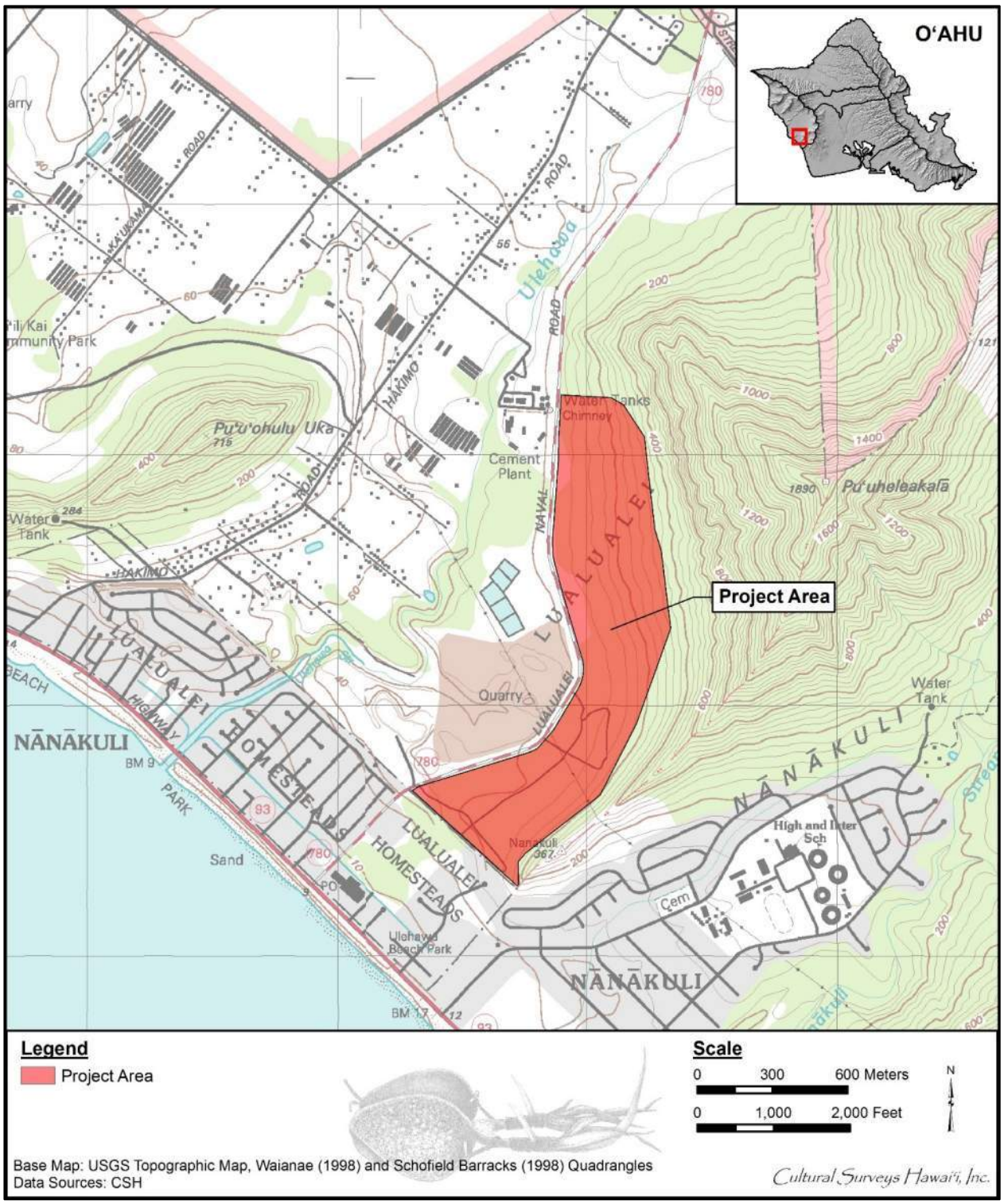

Figure 1. Portions of the 1998 Waianae and Schofield Barracks USGS 7.5-minute topographic quadrangles showing the project area

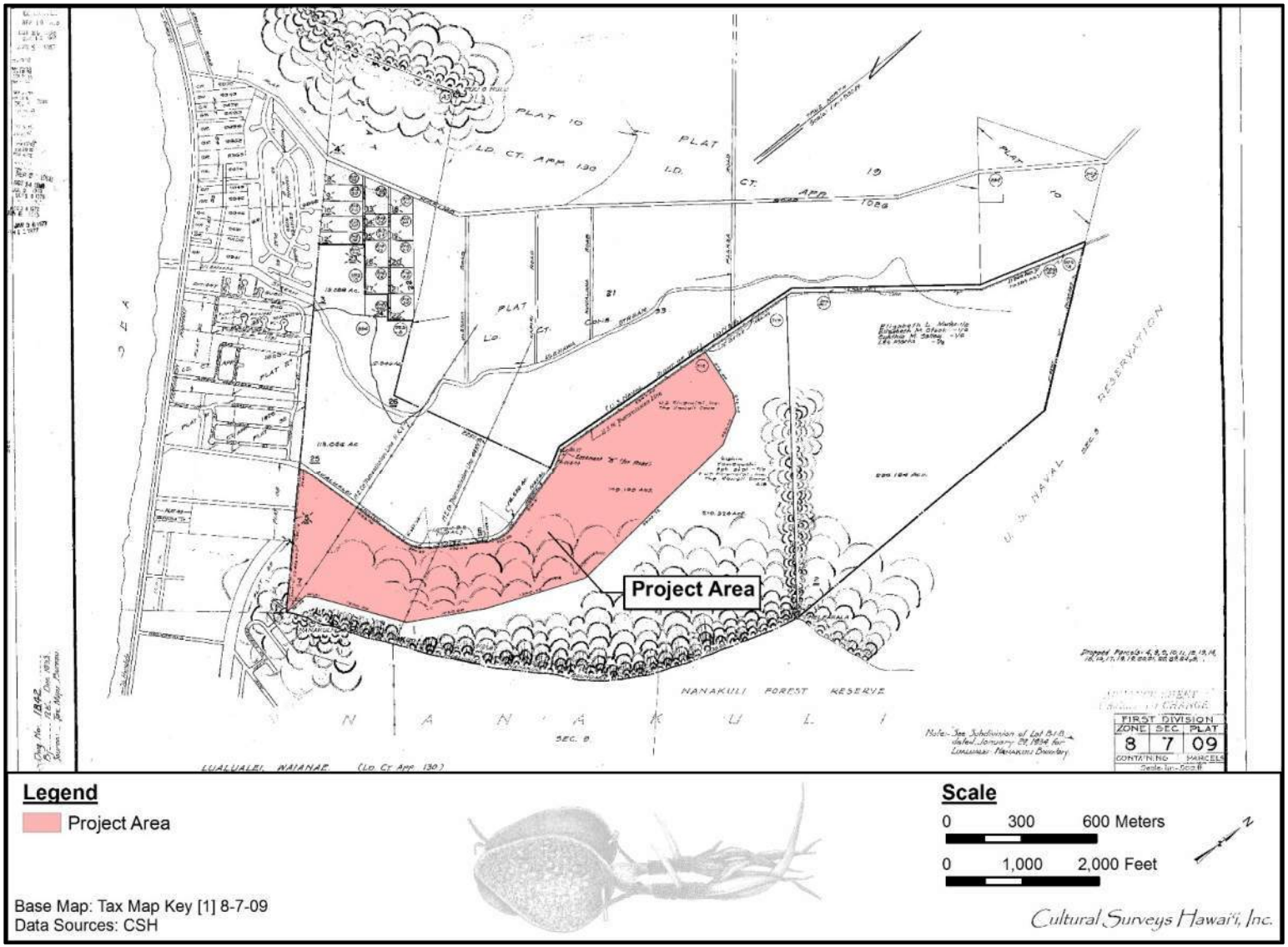

Figure 2. Tax Map Key (TMK) [1] 8-7-009 showing the project area (Hawai‘i TMK Service 2014)

Figure 3. Aerial photograph showing the project area (Google Earth 2013)

The preservation plan recommended demarcation of an 8 m (26 feet [ft]) buffer zone surrounding the historic property for protection from construction activity. The suggested buffer zone would be established using a 35 m (115 ft) long steel post and wire or chain link fence. Additionally, it was suggested that natural vegetation not be cleared from the historic property, further obscuring the rock shelter’s location as an additional means of protection.

1.4 Environmental Setting

1.4.1 Natural Environment

Lualualei is the largest leeward valley on O‘ahu. Composed of approximately 14,000 acres, Lualualei extends from the Wai‘anae Range to the ocean. To the south is the *ahupua‘a* (traditional land division) of Nānākuli and to the north is the *ahupua‘a* of Wai‘anae. Its southern border includes a portion of Pu‘u Heleakalā, and its northern boundary includes a portion of Pu‘u Pāhe‘ehe‘e. Lualualei Valley, like the other valleys in the Wai‘anae District, is characterized by its dry leeward climate. The prevailing winds in the area are the northeast trades that blow over the Ko‘olau mountains, then continue over the Wai‘anae Range and over the southwest portion of the island (Juvik and Juvik 1998:55). This wind pattern is responsible for the relatively low rainfall averages on the leeward side of the island. The winds cause the rain to hit the Ko‘olau Range, releasing most of their moisture there before continuing over the Wai‘anae Range and releasing what moisture may be left (Abbott et al. 1983:224).

The mean annual rainfall in the project area ranges between 616 mm (24.3 inches) and 677.5 mm (26.7 inches) (Giambelluca et al. 2013). The majority of precipitation occurs during the rainy season, between October and April. The mean annual temperature in the project area is 23.6–23.8° C (74.5–74.8° F) (Giambelluca et al. 2014). The project area is approximately 700 m (0.4 miles) inland from the coast, and elevations within the project area range from 2.9 m to 48.5 m (9.5 ft to 159.1 ft) above mean sea level.

According to Juvik and Juvik (1998:90), perennial streams are not found in leeward O‘ahu. Examination of the Schofield Barracks and Waianae USGS Qaudrangle maps shows that Ulehawa Stream is the closest intermittent stream northwest of the project area, and Nānākuli Stream is the closest intermittent stream to the southeast. Vegetation along this arid coast is sparse, and only the hardiest plants adapted to the coastal environments can thrive in these zones. The vegetation is typical of dry seashore environments in Hawai‘i and is dominated by alien species. Indigenous species include *hau* (*Hibiscus tiliaceous*), *koa* (*Cordia subcordata*), *kamani* (*Calophyllum inophyllum*), *naupaka* or *naupaka kahakai* (*Scaevola sericea*), *pa‘u o Hi‘iaka* (*Jacquemontia ovalifolia sandwicensis*), the native beach morning glory or *pōhuehue* (*Ipomea pes-caprae*), and the coconut (*niu*, *Cocos nucifera*). Introduced species found bordering Farrington Highway include sea grape (*Coccoloba uvifera*), *kiawe* trees (*Prosopis pallida*), Madagascar olive trees (*Noronhia emarginata*), and *koa haole* (*Leucaena leucocephala*) (Foote et al. 1972:93).

The project area lies along the lower slopes of the western slopes of Pu‘u Heleakalā. The southern end and southwest corner of the project area are composed of raised limestone, which is overlain by erosional sediments from the foothills of Pu‘u Heleakalā. According to the U.S. Department of Agriculture (USDA) Soil Survey Geographic (SSURGO) database (2001) and soil survey data gathered by Foote et al. (1972), the project area’s soils consist mainly of Lualualei extremely stony clay, 3 to 35% slopes (LPE), with smaller areas of Lualualei clay, 2 to 6 % slopes

(LuB), Mamala stony silty clay loam, 0 to 12% slopes (MnC), and Rock land (rRK) in the northwest, southwest, and southeast portions of the project area, respectively (Figure 4).

Lualualei soils are described as follows:

> This series consists of well-drained soils on the coastal plains, alluvial fans, and on 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 . . .
>
> These soils are used for sugarcane, truck crops, pasture, wildlife habitat, urban development, and military installations. [Foote et al. 1972:84]

Mamala soils are described as follows:

> This series consists of shallow, well-drained soils along the coastal plains on the islands of Oahu and Kauai. These soils formed in alluvium deposited over coral limestone and consolidated calcareous sand. They are nearly level to moderately sloping. Elevations range from nearly sea level to 100 feet on Oahu but extend to 850 feet on Kauai . . .
>
> These soils are used for sugarcane, truck crops, orchards, and pasture. The natural vegetation consists of kiawe, koa haole, bristly foxtain, and swollen fingergrass. [Foote et al. 1972:93]

Rock land is described as follows:

> Rock land (rRK) 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 are mainly basalt and andesite. This land type is nearly level to very steep. Elevations range from nearly sea level to more than 6,000 feet . . .
>
> Rock land is used for pasture, wildlife habitat, and water supply. The natural vegetation at the lower elevations consists mainly of kiawe, klu, piligrass, Japanese tea, and koa haole. Lantana, guava, Natal redtop, and molassesgrass are dominant at the higher elevations. This land type is also used for urban development. [Foote et al. 1972:119]

1.4.2 Built Environment

The southwest end of the project area is bordered by Lualualei Homesteads, where there are presently small apartment buildings within approximately 50 m of the edge of the project area. Lualualei Naval Road makes up the entire west side of project area. Across Lualualei Naval Road is a landfill managed by PVT Land Company Ltd.

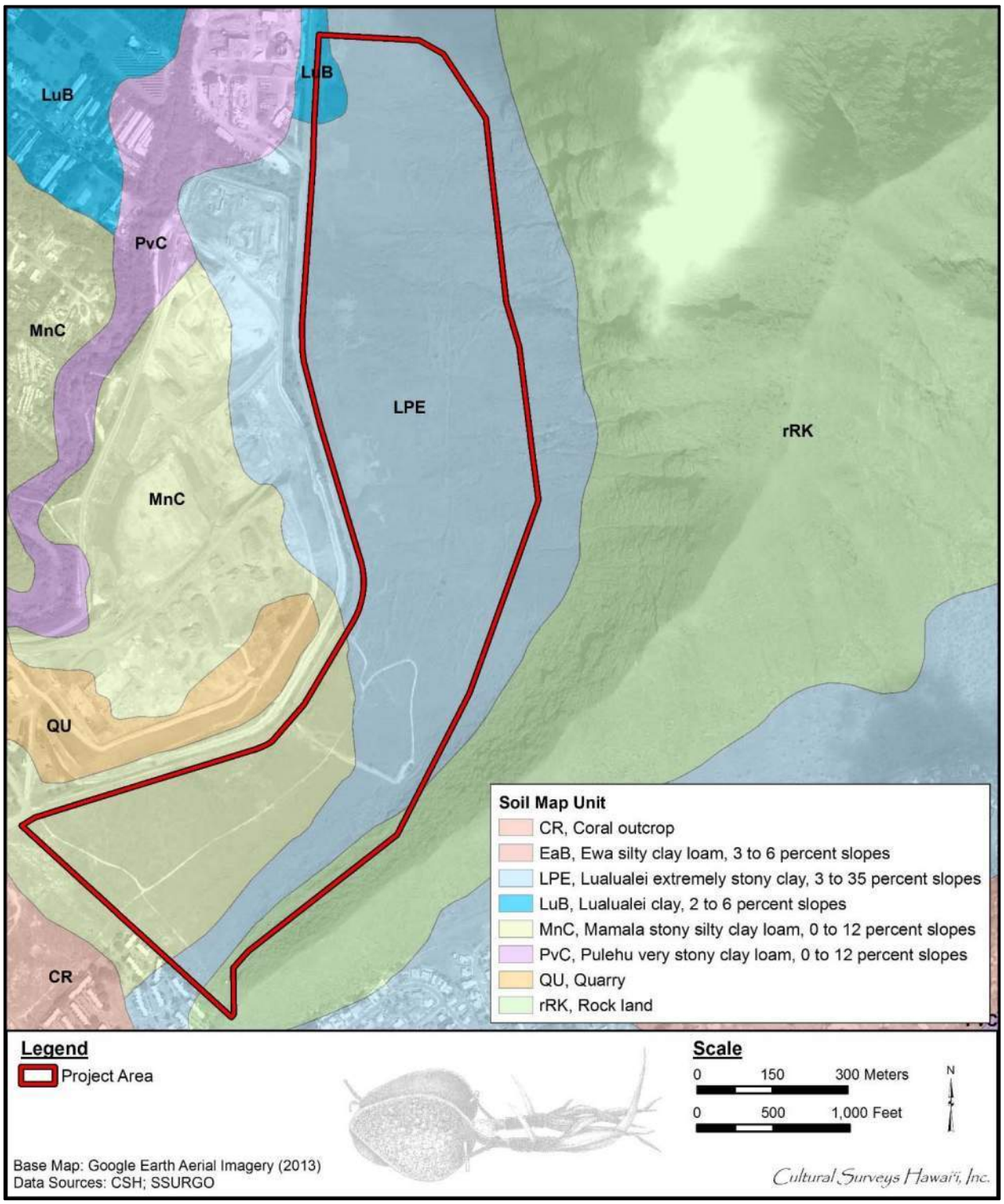

Figure 4. Aerial photograph (Google Earth 2013) with overlay of *Soil Survey of the State of Hawaii* (Foote et al. 1972), indicating soil types within and surrounding the project area (USDA SSURGO 2001)

Section 2 Methods

2.1 Field Methods

CSH completed the fieldwork component of this study under archaeological fieldwork permit number 18-15, issued by the SHPD pursuant to HAR §13-282. CSH archaeologists David Crowell, M.S., and David Shideler, M.A., conducted fieldwork on 3 July 2018 under the general supervision of Principal Investigator Hallett H. Hammatt, Ph.D. This work required approximately 0.5 person-days to complete.

In general, fieldwork included pedestrian inspection of the project area and GPS data collection. Specifically, the pedestrian inspection focused on relocating historic properties identified during the O'Leary and McDermott (2006) AIS and Hammermeister and McDermott (2007) addendum AIS to assess their current conditions.

2.2 Research Methods

Background research included a review of previous archaeological studies on file at the SHPD; review of documents at Hamilton Library of the University of Hawai‘i, the Hawai‘i State Archives, the Mission Houses Museum Library, the Hawai‘i Public Library, and the Bishop Museum Archives; study of historic photographs at the Hawai‘i State Archives and the Bishop Museum Archives; and study of historic maps at the Survey Office of the Department of Land and Natural Resources. Historic maps and photographs from the CSH library were also consulted. In addition, Māhele records were examined from the Waihona ‘Aina database (Waihona ‘Aina 2000).

This research provided the environmental, cultural, historic, and archaeological background for the project area. The sources studied were used to formulate a predictive model regarding the expected types and locations of historic properties in the project area.

Section 3 Background Research

The District of Wai‘anae extends from Nānākuli on the west coast of O‘ahu north to Ka‘ena Point and once incorporated eight *ahupua‘a*, including Lualualei (Figure 5 and Figure 6). In ancient times, the District of Wai‘anae was known for its multitude of fish and especially for deep-sea fishing off Ka‘ena, where the ocean currents meet. The meaning of Wai‘anae (mullet water) also implies an abundance of fish—*‘anae*, which is the full-grown mullet (*Mugil cephalus*) (Pukui et al. 1974). In 1840, Wilkes made the following comment: “The natives are much occupied in catching and drying fish, which is made a profitable business, by taking them to O‘ahu, where they command a ready sale” (Wilkes 1845:81–82). Handy and Handy (1972) attribute the naming of Wai‘anae to a large freshwater pond for mullet called Pueha (Puehu). Today, Wai‘anae is still considered one of the best fishing grounds on O‘ahu.

Wai‘anae was also known for the independent lifestyle and attitudes of its inhabitants, another trend that continues into the modern day. This independence was a factor in many of the political struggles of the pre- and early post-Contact periods, when the district was the scene of battles and rebellions and often the refuge of dissident and/or contentious factions. This independent spirit is often attributed to the conditioning of generations having to cope with marginal environments, as many areas of Wai‘anae, especially Lualualei, were notorious for their inhospitable climates.

3.1 Mythological and Traditional Accounts

There are two traditional meanings given to the name Lualualei. One meaning, “flexible wreath,” is attributed to a battle formation used by Mā‘ilikūkahi against four invading armies in the battle of Kīpapa in the early fifteenth century (Sterling and Summers, 1978:68). A second and perhaps more recent meaning offered by John Papa ‘Ī‘ī is “beloved one spared.” This meaning relates to a story of a relative who was suspected of wearing the king’s *malo* (loincloth). The punishment was death by fire. ‘Ī‘ī writes the following:

> The company, somewhat in the nature of prisoners spent a night at Lualualei. There was a fish pond there on the plain and that was where the night was spent . . .
>
> After several days had passed, the proclamation from the king was given by Kula‘inamoku, that there was no death and that Kalakua did not wear the king’s loin cloth. Thus was the family of Luluku spared a cruel death. For that reason, a child born in the family later was named Lualualei. [‘Ī‘ī 1959:23]

Mary Pukui believed the first meaning, “flexible wreath,” to be more appropriate for Lualualei (Sterling and Summers 1978:63). According to Kelley (1991:317), the fishpond on the plain is Puehu fishpond, which is actually just over the border in Wai‘anae. The fishpond no longer exists and was probably destroyed during the sugar plantation era. A third possible association for the name Lualualei is an older reference to one of Māui’s sisters, who went by the same name.

Numerous Hawaiian legends, in addition to archaeological evidence, reveal the Wai‘anae coast and *mauka* (toward the mountains) interior to be an important center of Hawaiian history. It is in Wai‘anae that the famous exploits of Māuiakalana (Māui) are said to have originated. Traditional accounts of Lualualei focus on the mischievous adventures of the demi-god Māui. It was there that Māui learned the secret of making fire for mankind and perfected his fishing skills. Other famous

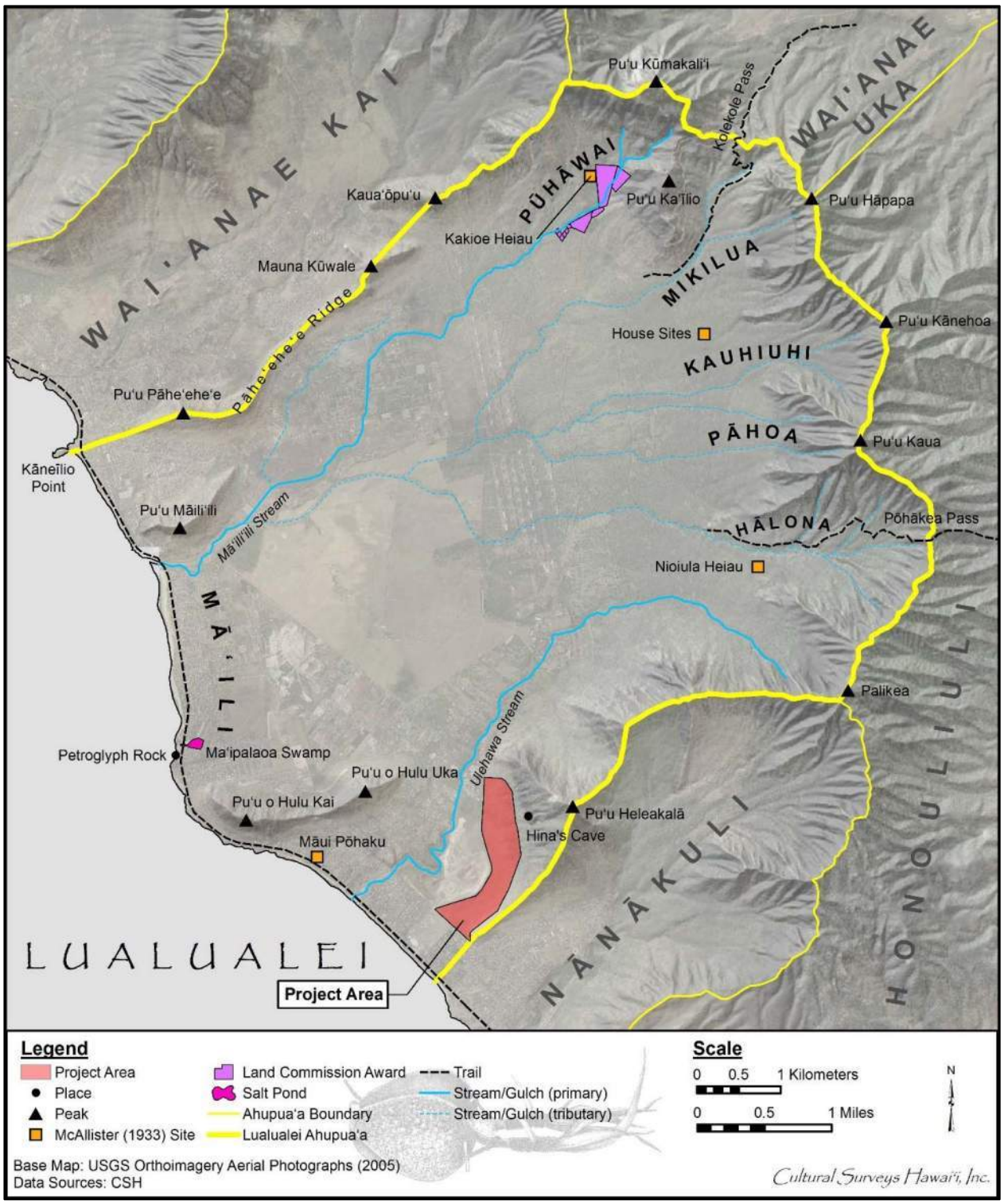

Figure 5. 2005 USGS orthoimagery aerial photograph showing notable places and place names of Lualualei

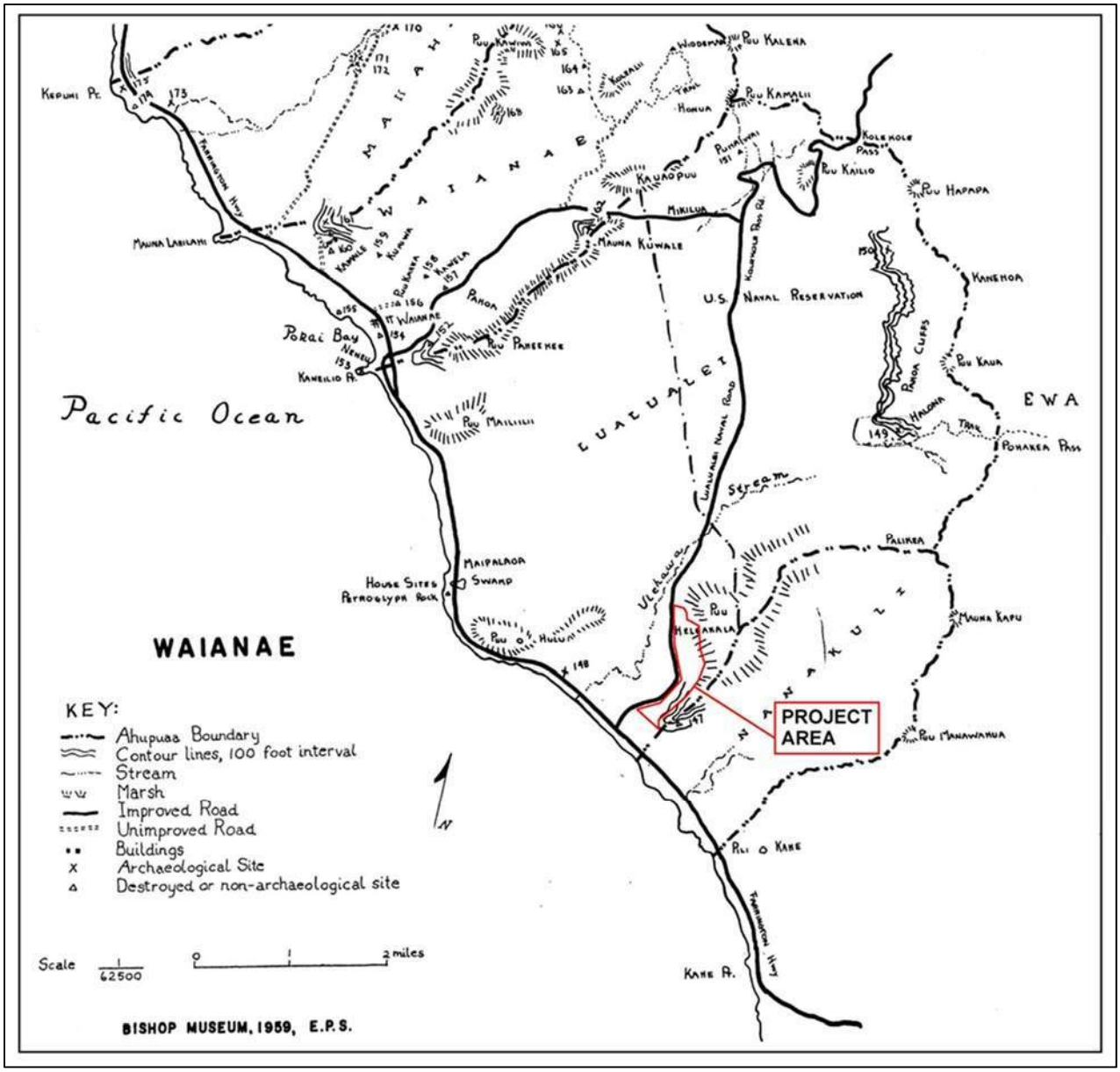

Figure 6. 1959 Bishop Museum map with place names showing the project area and identified archaeological sites

accounts tell of the place where Māui's adzes were made and of the magic fishhook, Mānaiakalani, as well as the snare for catching the sun and his kite-flying expedition.

Pu‘u Heleakalā is the ridge that separates Nānākuli from Lualualei. It was at Pu‘u Heleakalā where Hina, Māui's mother, lived in a cave and made her *kapa* (bark cloth) (Sterling and Summers 1978:62). Samuel Kamakau tells us that Māui's genealogy can be traced from the ‘Ulu line thru Nana‘ie as follows:

> Wawena lived with Hina-mahuia, and Akalana, a male, was born; Akalana lived with Hina-kawea, and Maui-mua, Maui-waena, Maui-ki‘iki‘i, and Maui-akalana, all males, were born.
>
> Ulehawa and Kaolae, on the south side of Waianae, Oahu, was their birthplace. There may be seen the things left by Maui-akalana and other famous things: the tapa-beating cave of Hina, the fishhook called Manai-a-kalani, the snare for catching the sun, and the places where Maui's adzes were made and where he did his deeds. However, Maui-akalana went to Kahiki after the birth of his children in Hawai‘i. [Kamakau 1991:135]

3.2 Historic Background Research

3.2.1 Early Post-Contact Period

In January 1778, Captain James Cook sighted Wai‘anae from a distance but chose to continue his journey and landed off Waimea, Kaua‘i instead. Fifteen years later, Captain George Vancouver approached the coast of Wai‘anae from Pu‘uloa and wrote the following in his log:

> The few inhabitants who visited us [in canoes] from the village earnestly entreated our anchoring . . . And [they] told us that, if we would stay until morning, their chief would be on board with a number of hogs and a great quantity of vegetables; but that he would not visit us then because the day was taboo poory [a *kapu* day]. The face of the country did not however, promise an abundant supply [of water]; the situation was exposed. [Vancouver quoted in McGrath et al. 1973:17]

Vancouver was not impressed with what he saw of the Wai‘anae coastline, stating in his log that the entire coast was "one barren, rocky, waste nearly destitute of verdure, cultivation or inhabitants."

Vancouver did not anchor at Wai‘anae. Had he done so, he would have been pleasantly surprised, at least by portions of the coastline. Even though the dry, arid coast presented a dismal forecast, the ocean provides an abundant supply of fish. The lowlands provided *‘uala* (sweet potato, *Ipomoea batatas*) and *niu* (coconut, *Cocos nucifera*), and the inland valley areas were planted in *kalo* (taro, *Colocasia esculenta*) and *wauke* (papyrus, *Broussonetia papyrifera*). The upland forest regions provided various woods needed for weapons and canoes.

By 1811, sandalwood merchants began actively exploiting the Hawai‘i market, and huge amounts of sandalwood were exported to China. Traditionally, Hawaiians used sandalwood for medicinal purposes and as a scent to perfume their *kapa*. Kamehameha I and a few other chiefs controlled the bulk of the sandalwood trade. Kamakau (1992:204) wrote, "The chiefs also were ordered to send out their men to cut sandalwood. The chief immediately declared all sandalwood to be the property of the government."

The sandalwood trade greatly impacted Hawaiian culture, and the traditional lifestyle Hawaiians had pursued was altered drastically. In an effort to acquire western goods, ships, guns and ammunition, the chiefs had acquired massive debts to the American merchants (‘Ī‘ī 1983:155). These debts were paid off in shiploads of sandalwood. When Kamehameha found out how valuable the sandalwood trees were, he ordered the people not to let the felled trees fall on the young saplings, to ensure their protection for future trade (Kamakau 1992:209–210). According to Samuel Kamakau:

> The debts were met by the sale of sandalwood. The chiefs, old and young, went into the mountains with their retainers, accompanied by the king and his officials, to take charge of the cutting, and some of the commoners cut while others carried the wood to the ships at the various landings; none was allowed to remain behind. Many of them suffered for food . . . and many died and were buried there. The land was denuded of sandalwood by this means. [Kamakau 1992:252]

Kamakau comments on the plight of the common people and the general state of the land during this time:

> This rush of labor to the mountains brought about a scarcity of cultivated food throughout the whole group. The people were forced to eat herbs and tree ferns, hence the famine called Hīlaulele, Hāhāpilau, Laulele, Pualele, ‘Ama‘u, or Hāpu‘u, from the wild plants resorted to. [Kamakau 1992:204]

In 1816, Boki Kama‘ule‘ule was made governor of O‘ahu (and chief of the Wai‘anae district) and served in that capacity until 1829, when he sailed to New Hebrides in search of sandalwood. ‘Ī‘ī writes, “It was Boki’s privilege to assign work, for he had been governor of the island of O‘ahu from the time Kamehameha I ordered all the chiefs to O‘ahu in 1816 to expel the Russians” (‘Ī‘ī 1983:145).

The sandalwood era was short-lived, and by 1829, the majority of the sandalwood trees had been harvested; the bottom fell out of the trade business. Although it is unclear how extensive Lualaulei’s sandalwood resources were, the effects of the sandalwood gathering, the population shifts, and disruption of traditional lifestyles and subsistence patterns would undoubtedly have affected the population of Lualualei.

The Reverend William Ellis visited the Hawaiian Islands in 1823. At that time, he estimated the population on the island of O‘ahu to be about 20,000 (Ellis 1974:19). The missionaries were the first to gather systematic figures regarding population throughout the various districts on each island. The first census figures were gathered from 1831-1832 and 1835-1836. Population figures for Lualualei were not given; however, population numbers given for all of Wai‘anae were 1,868 and 1,654, respectively (Schmitt 1973:9).

Following western encroachment into the Wai‘anae Coast, a swift decline in population occurred due to disease and a “tendency to move to the city where there was more excitement” (McGrath et al. 1973:25). The *‘ōku‘u* epidemic of 1804 (thought to be cholera) undoubtedly had a major effect on the native population, not only in Wai‘anae, but throughout the rest of the islands. John Papa ‘Ī‘ī (1983: 16) relates that the *‘ōku‘u* “broke out, decimating the armies of Kamehameha I [on O‘ahu].” Other diseases also took their toll. In 1835, a missionary census listed 1,654 residents on the Wai‘anae Coast. The population of the Wai‘anae Coast was decimated again by a

smallpox epidemic in late 1853. In 1855, the Wai‘anae tax collector recorded 183 taxpayers on the leeward coast, which is thought to represent a total population of about 800 people. This catastrophic depopulation facilitated the passing of large tracts of land into the hands of a few landholders and led to the decline of the traditional economy that once supported the region (Hammatt et al. 1993:10–11).

3.2.2 Mid-1800s: Land Commission Awards (LCAs)

The Organic Acts of 1845 and 1846 initiated the process of the Māhele—the division of Hawaiian lands that introduced private property into Hawaiian society. In 1848, the crown and the *ali‘i* (chiefly class) received their land titles. *Kuleana* awards to commoners for individual parcels within the *ahupua‘a* were subsequently granted in 1850. At the time of the Māhele, the *ahupua‘a* of Wai‘anae, which included Lualualei, was listed as Crown Lands and was claimed by King Kamehameha III as his personal property (Board of Commissioners 1929:28). As such, the land was under the direct control of the King. Many of the chiefs had run up huge debts to American merchants throughout the early post-Contact period, continuing into the mid-1800s. A common practice at the time was to lease or mortgage large portions of unused land to other high chiefs and foreigners to generate income and pay off these earlier debts. Until the passage of the Act of 3 January 1865, which made Crown Lands inalienable, Kamehameha III and his successors did as they pleased with the Crown Lands, selling, leasing, and mortgaging them at will (Chinen 1958:27).

In 1850, the Privy Council passed resolutions that affirmed the rights of the commoners or native tenants. To apply for fee-simple title to their lands, native tenants were required to file their claim with the Land Commission within the specified time period. The Kuleana Act of 1850 confirmed and protected the rights of native tenants. Under this act, the claimant was required to have two witnesses who could testify they knew the claimant and the boundaries of the land, knew that the claimant had lived on the land for a minimum of two years, and knew that no one had challenged the claim. The land also had to be surveyed.

Not everyone who was eligible to apply for *kuleana* lands did so, and not all claims were awarded. Some claimants failed to follow through and come before the Land Commission, while others failed to produce two witnesses or to have their land surveyed. For whatever reason, out of the potential 2,500,000 acres of Crown and Government lands “less than 30,000 acres of land were awarded to the native tenants” (Chinen 1958:31).

Twelve land claims were made in Lualualei; however, only six were awarded (Waihona ‘Aina 2000). All six awards were upland in the *‘ili* of Pūhāwai, far *mauka* of the current project area. No quiet land titles were claimed near the coast. From the claims, it can be determined that at least eight families were living in Pūhāwai at the time of the Māhele in 1848. Together, they cultivated a minimum of 163 *lo‘i* (wetland agricultural plots). The numerous *lo‘i* mentioned in the claims indicate the land was ideal for growing wetland taro, and that this livelihood was actively pursued by the awardees. In addition, dryland crops were grown on the *kula* (plains), and *wauke* was being cultivated. One claimant was making salt.

Information on occupation at Lualualei at the time of the Māhele, aside from the historical accounts of scattered coastal hamlets, is from archival records indicating there were nine taxpayers at Mā‘ili near the coast, and 11 taxpayers at Pūhāwai in the upper valley (Cordy 1998:36). Mā‘ili is along the eastern edge of the *ahupua‘a*, and Pūhāwai is well *mauka*. Based on these numbers,

Cordy estimates a population of 90 people for coastal Lualualei and 55 people for the upper valley in 1855 (Cordy 1998:36). Regardless of the population estimate, the existence of 20 taxpaying adults in Lualualei indicates the area was being inhabited and worked. In this case, the Māhele documents are only a partial reflection of the population and land use during that time.

3.2.3 Late 1800s

The first longhorn cattle were brought to O‘ahu from Hawai‘i Island in 1809 by John Young and Kamehameha I (Kamakau 1992:268). One of the first areas to be utilized for ranching on the Wai‘anae coast was Lualualei. Hawai‘i Bureau of Land Conveyances (1845-1869) records show that William Jarrett leased approximately 17,000 acres of land from Kamehameha III in 1851. This was the beginning of Lualualei Ranch. The lease was written for 30 years with a lease fee of $700 per year (DLNR, B.C. Liber 4:616–618.). It seems that Jarrett sold one-half of his interest in the ranch to Paul F. Marin, son of Don Francisco de Paula Marin. Marin lived on the ranch and managed it until 1864, when a dispute arose over the profits of the ranch. Apparently, Marin had never turned over any ranch profits to Jarrett during the time he managed it. After the dispute was settled, Jarrett took on George Galbraith as a new partner (B.C. Liber 18:31).

In 1869, Jarrett sold the remaining years of his son’s interest in Lualualei Ranch to James Dowsett (B. C. Liber 29:16–18). Dowsett was a descendant of a British sea captain and is noted for being the first Anglo-Saxon child born in Honolulu (Nakamura and Pantaleo 1994:21). Dowsett was an entrepreneur of sorts and dabbled in many different business ventures, including “a whaling fleet, a dairy, a salt works, an extensive trade in *awa* (a Hawaiian narcotic drink) and numerous land holdings . . . He also ran cattle at different times in Nānākuli, Mikilua and Lualualei” (McGrath et al. 1973:32).

In 1880, George Bowser traveled through Wai‘anae and wrote the following about Lualualei in his journal:

> Leaving Wai‘anae, a ride of about two miles brought me to the Lualualei Valley, another romantic place opening to the sea and surrounded in every direction by high mountains. This valley is occupied as a grazing farm by Messrs. Dowsett & Galbraith, who lease some sixteen thousand acres from the Crown. Its dimensions do not differ materially from those of the Wai‘anae Valley, except that it is broader—say, two miles in width by a length of six or seven miles. The hills which enclose it, however, are not so precipitous as those at Wai‘anae, and have, therefore, more grazing land on their lower slopes, a circumstance which adds greatly to the value of the property as a stock farm. Although only occupied for grazing purposes at present, there is nothing in the nature of the soil to prevent the cultivation of the sugar cane, Indian corn, etc. Arrangements for irrigation, however, will be a necessary preliminary to cultivation. [Bowser 1880:493–494]

Bowser’s comments imply that though water was still a problem, Lualualei seemed to have some potential for development.

In 1894, Link McCandless entered the ranching scene:

> . . . he and a man named Tom King chartered the brigantine Oakland in Seattle, filled her hole with cattle and the cabins with feed, and sailed for Hawai‘i. By the turn of the century, McCandless’ ranching empire covered much of the Wai‘anae

> Coast, including land at Nānākuli, 4,000 acres at Lualualei, San Andrews' property in Mākua and pastures toward Ka‘ena Point. [McGrath et al. 1973:31]

An 1894 description of Lualualei by the Commissioner of Crown Lands described the land as "one of the best and most valuable of the Crown lands on the Island of O‘ahu . . . surpassing any of the other lands for richness and great fertility of the soil" (Commissioner of Crown Lands 1894:36).

With strong financial backing from King Kalākaua, Hermann A. Widemann, a German immigrant, was able to initiate the Waianae Sugar Plantation in 1879. The sugar industry came to the Wai‘anae coast in 1878, when the first sugarcane was planted in upper Wai‘anae Valley. By 1892, at least 300 acres of cane were planted in Lualualei. In addition to the cultivated lands, a railroad, irrigation ditches and flumes, reservoirs, and plantation housing were constructed to support the sugar industry.

Although it was never a large-scale plantation by modern standards, it was one of the first and last to be served by a plantation railroad. Some 15 miles of 30-inch, narrow-gauge rail delivered harvested cane to the mill. All the sugar was shipped by inter-island vessels to Honolulu departing from Wai‘anae Landing, until the Oahu Railway and Land Company (OR&L) railroad was extended to Wai‘anae and beyond. The OR&L signed its charter on 4 February 1889. The Railway was the brainchild of Benjamin Franklin Dillingham. Along with James Castle and others, he had invested in large tracts of land for speculation and resale, but the idea was slow to catch on because "the land lay too far from Honolulu, at least 12 miles" (McGrath et al.1973:54) He foresaw an economic opportunity. The railway was a means to provide transportation to the country and promote development of unoccupied lands, as well as connect with the sugar plantations in ‘Ewa, Wai‘anae, Waialua, and Kahuku.

Construction on the railway began in March 1889. The first length of the railway was completed and opened to the public by 1 January 1890. Five years later, on 4 July 1895, the railway finally reached Wai‘anae. The OR&L railroad ran along the *makai* (toward the sea) side of Farrington Highway. The cane from the *mauka* areas of Lualualei was loaded onto a railroad and transported to the mill at Wai‘anae. The Railway served the Wai‘anae coast until 1946, when the Wai‘anae Sugar Plantation closed down. The J.M. Dowsett Estate sold the plantation to American Factors (now Amfac/JMB-Hawai‘i) in 1931, and the OR&L railroad closed in 1947.

3.2.4 Early 1900s to Present

By 1901, the Waianae Sugar Company had obtained a five-year lease on 3,332 acres of land at Lualualei to be used for raising cane, as well as for ranching (Commissioner of Crown Lands 1902). Sugar and ranching continued to dominate the Lualualei landscape during the early years of the twentieth century. The determining factor in the success of Lualualei for sugar production was always the water.

Throughout the first half of the twentieth century, the Waianae Sugar Company continued cultivating their sugar lands in Lualualei. By the 1940s, Waianae Sugar Company could no longer compete with foreign labor. This, in addition to drought problems, labor unions, and land battles, caused the undermining of the Wai‘anae Sugar Company. In 1946, the Company was liquidated, and the land was sold.

After the overthrow of the Hawaiian monarchy in 1893, the Crown Lands and Government Lands were combined to become Public Lands. The Crown Lands were no longer indistinguishable and inalienable. In 1895, the Republic of Hawai'i decided to open up lands for homesteading in the hopes of attracting a "desirable class of immigrants"—Americans and those of Caucasian decent (Kuykendall and Day 1961:204). In anticipation of the Dowsett-Galbraith lease expiring in 1901, the Government intended to auction off these lands to the highest bidder.

There were two waves of homesteading on the Wai‘anae Coast (McDermott and Hammatt 2000). The first impacted Lualualei and coincided with homesteading occurring at Wai‘anae Kai (Figure 7). In 1902, the government ran ads in the local newspapers stating their intent to open up land in Lualualei for homesteads (Kelly 1991:328). Due to the lack of water, the lots were classified as second-class pastoral land, rather than agricultural land. The homesteads were sold in three series between the years 1903 and 1912 (Figure 8). In Lualualei, the first series was for *mauka* lots purchased by McCandless, who ranched most of his land until 1929, subletting use rights to the Sandwich Island Honey Company. The second and third series were for lots in the lower valley and along the coast, *mauka* of the government road. By the early 1920s, about 40 families had settled on homestead lots in Lualualei (Kelly 1991:331–332) (Figure 9). The big-name families that obtained homestead lots at this time were Von Holt, McCandless, and Dowsett.

The government did not follow through on its promise to supply water. What little there was, was not enough to go around. Competition between the Wai‘anae plantation and the homesteaders for water caused friction within the community. The lack of water placed a hardship on the homesteaders. Water had to be carried in and many lost their crops. The Waianae Sugar Company had a lease with the government to take 2.5 million gallons of water daily from government lands, but even after their lease had expired, the plantation continued to take the water. In 1924, the government made an agreement with the plantation to release 112,000 gallons of water daily for the homesteaders.

Another major influence in Lualualei during the first half of the twentieth century was the military. By 1929, over 8,184 acres of the McCandless Cattle Ranch had been condemned and purchased by the U.S. Navy for the construction of a Naval Ammunition Depot for the ships of Pearl Harbor Naval Base.

The construction of Naval Magazine LLL and Radio Transmission Facility (RTF) took place in Lualualei between 1930 and 1935 (Kelly 1991:339–341). The number of troops stationed and trained on the Wai‘anae Coast during World War II at times reached 15,000 to 20,000 (McGrath et al. 1973:136). The beaches were fortified with barbed wire and concrete bunkers—many still visible today. Martial law severely curtailed the movements of the local population. In 1971, the Navy began sub-leasing some of their lands for agricultural uses, mainly for grazing and bee keeping. The presence of the military at Lualualei has boosted the economy of Lualualei by providing jobs to residents over the years. The lower portions of Lualualei Valley were developed into residential lots after World War II. The current study area lies outside of military lands.

Various historic maps and aerial photographs show the progression of development in the vicinity of the project area. A 1919 US Army War Department fire control map (Figure 10) shows no apparent development of the area, with the exception of the railroad line extending along the coast. Lands south of the project area are labelled as "U.S. Military Reservation". A 1936 U.S. Army War Department terrain map (Figure 11) shows the beginnings of the Lualualei Homesteads,

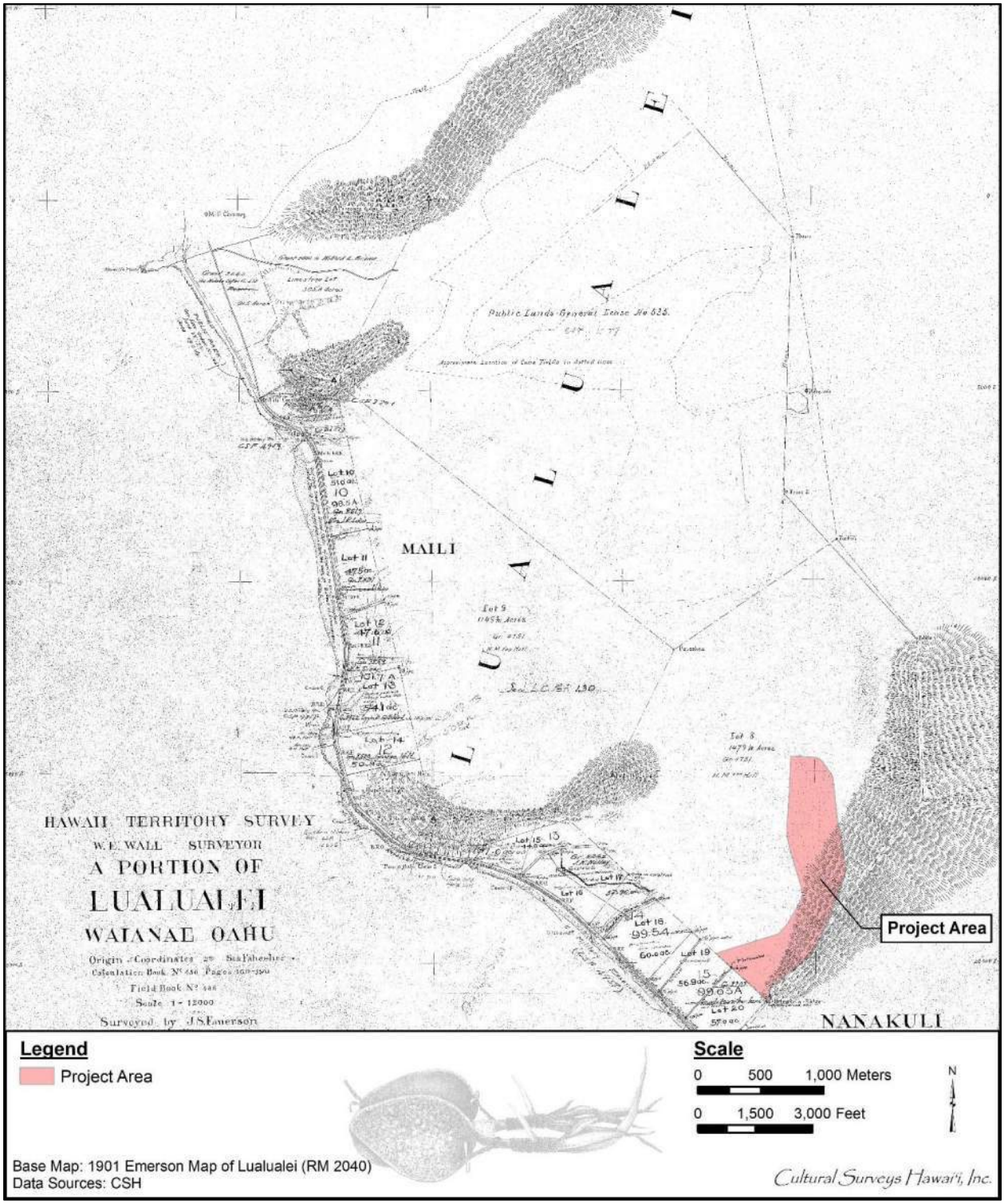

Figure 7. Portion of 1901 Emerson map of Lualualei showing location of project area

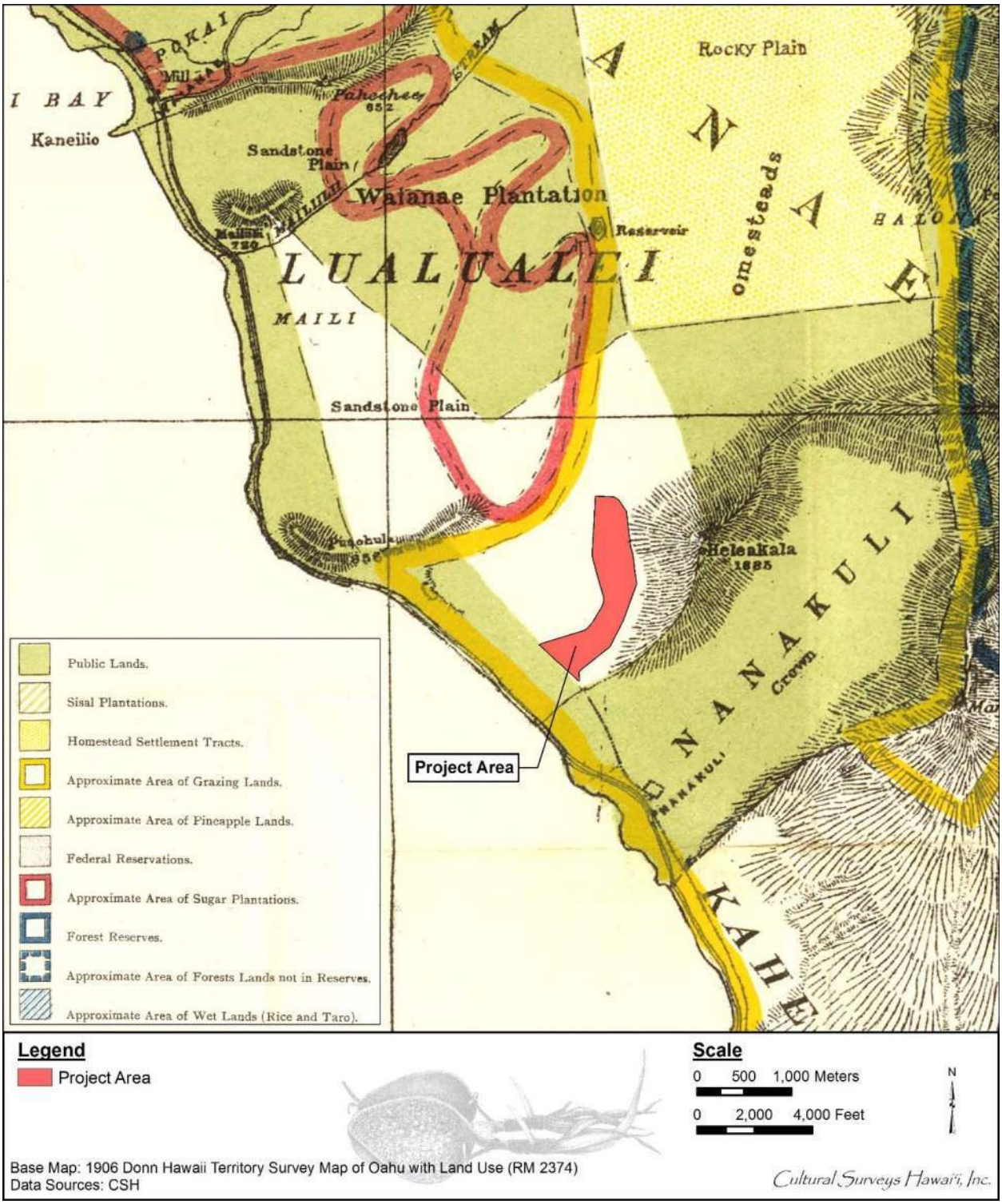

Figure 8. Portion of 1906 Donn Hawaii Territory Survey map of O‘ahu with land use showing project area

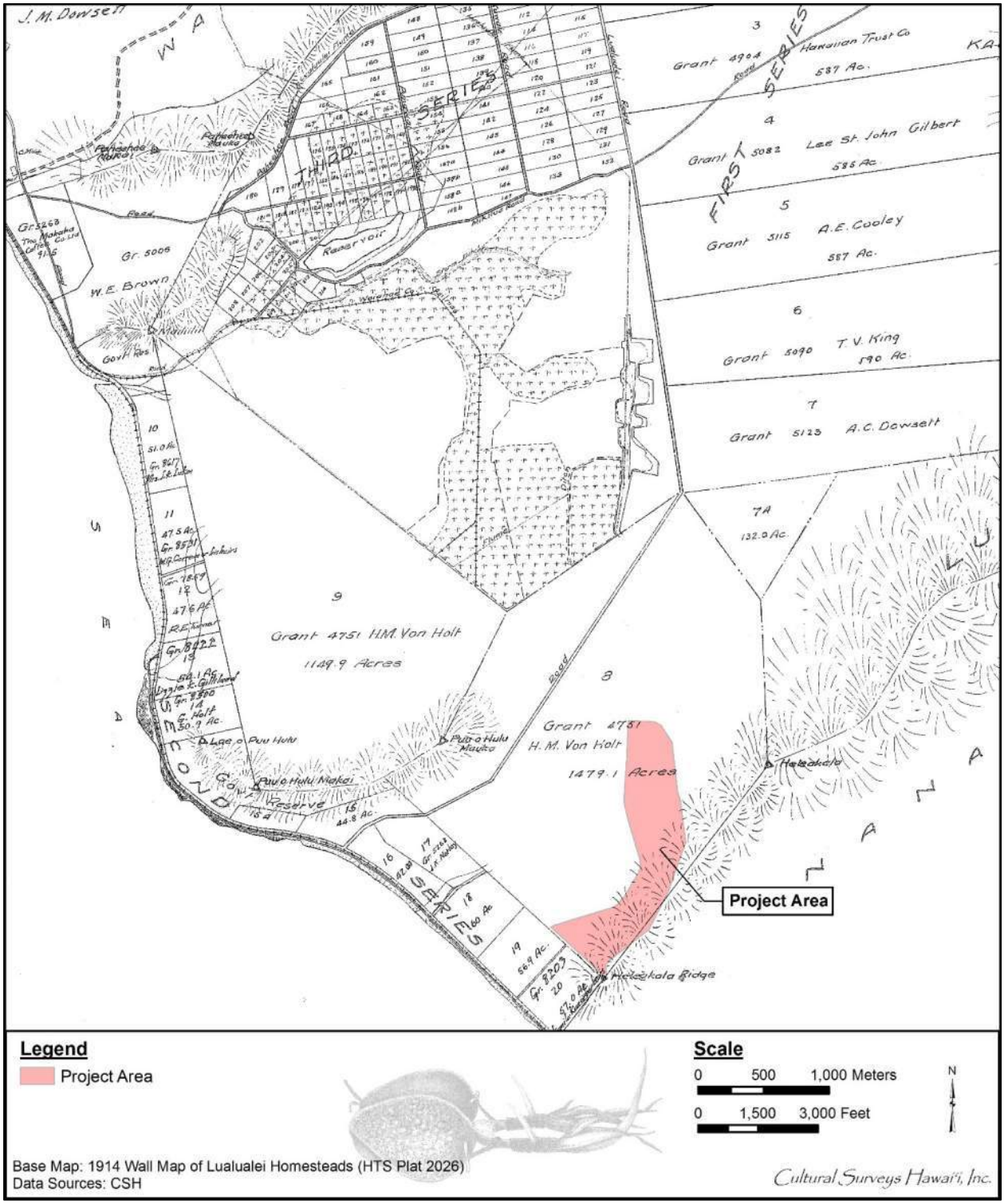

Figure 9. Portion of 1914 Wall map of Lualualei Homesteads, showing location of the project area

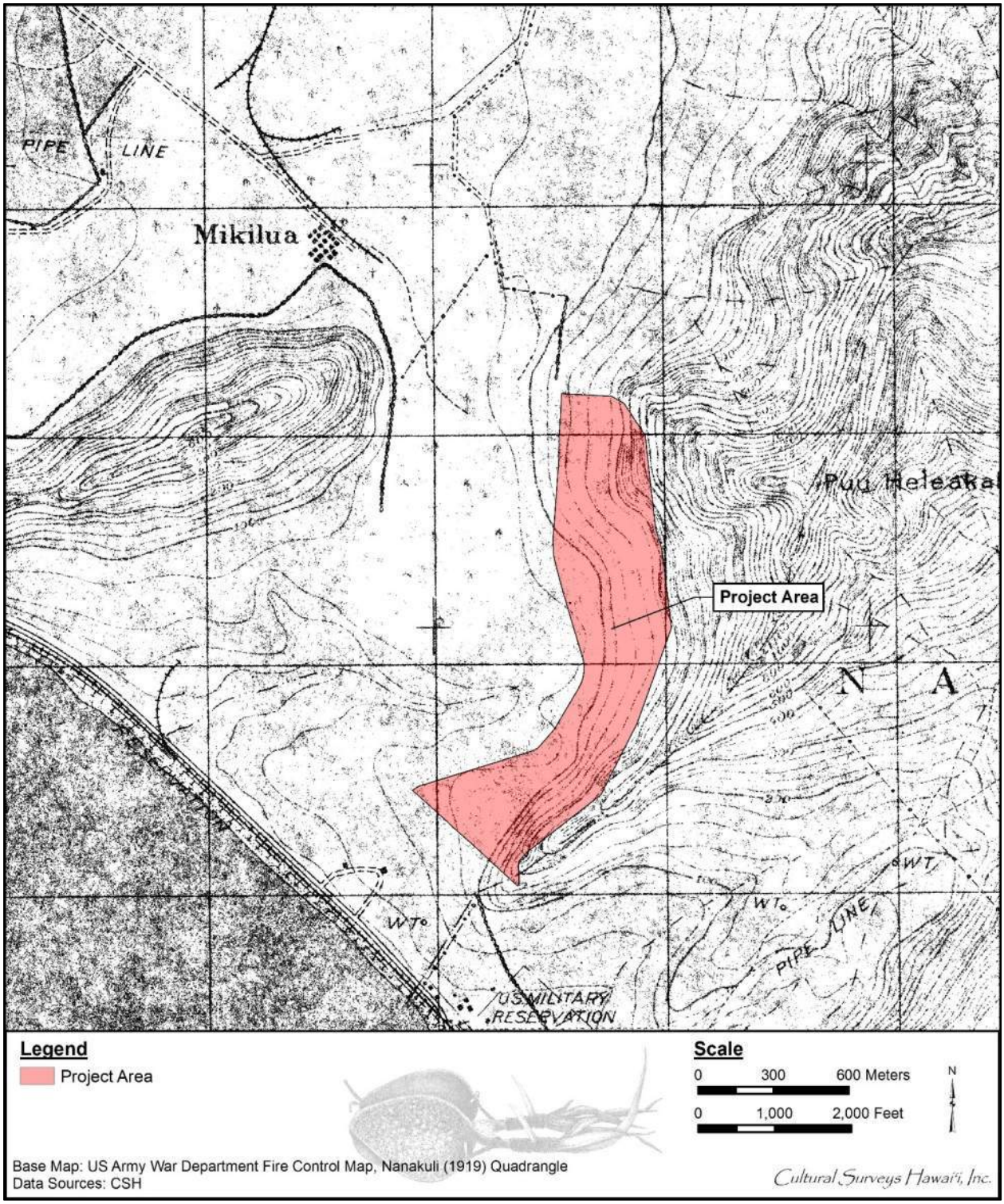

Figure 10. Portion of 1919 U.S. Army War Department fire control map, Nanakuli quadrangle showing the location of the project area

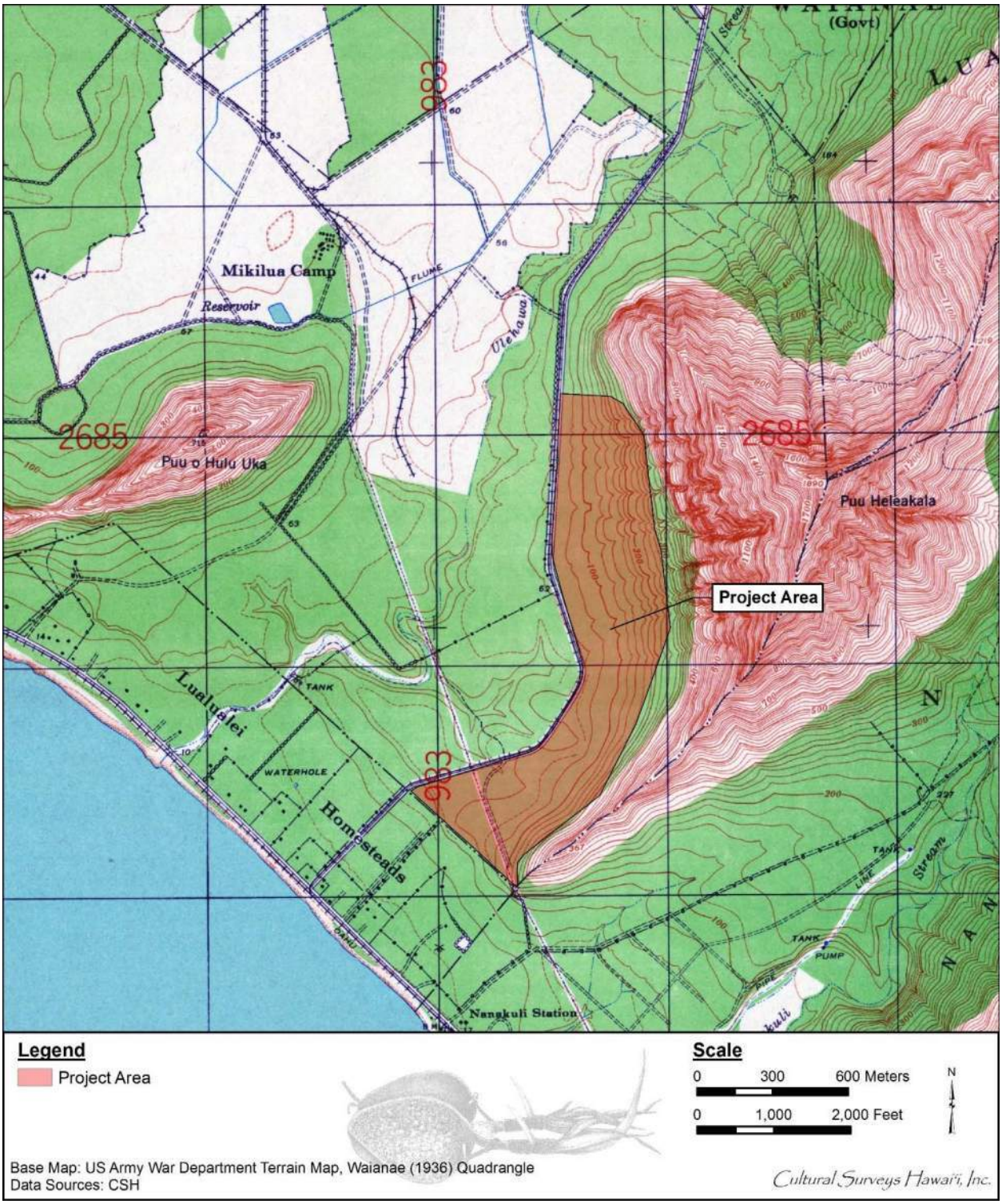

Figure 11. Portion of 1936 U.S. Army War Department terrain map, Waianae quadrangle showing location of project area

indicating sparse settlement, as well as Mikilua Camp northwest of the project area. The 1943 U.S. Army War Department terrain map (Figure 12) shows additional development of access roads inside and northwest of the project area, but the remainder of the area appears largely unchanged. The 1953 and 1954 USGS topographic map (Figure 13) shows greater density of residences in the Lualualei Homesteads and along Lualualei Road and surrounding areas, though the project area and areas immediately surrounding remain undeveloped. The 1963 and 1969 USGS topographic maps (Figure 14) depict increasing development throughout the region, with additional infrastructure features labelled, including water tanks, quarries, and a cement plant. A 1965 aerial photograph (Figure 15) depicts the residential development of the area, in which housing density southwest of the project area appears to have increased slightly. A 1977 aerial photograph (Figure 16) depicts a dramatic increase in cleared and developed land south and southeast of the project area. A 1993 aerial photograph (Figure 17) depicts the project area and surrounding areas as similar to their current condition, with residential and commercial development spanning much of the landscape west and south of the mountain ridgeline.

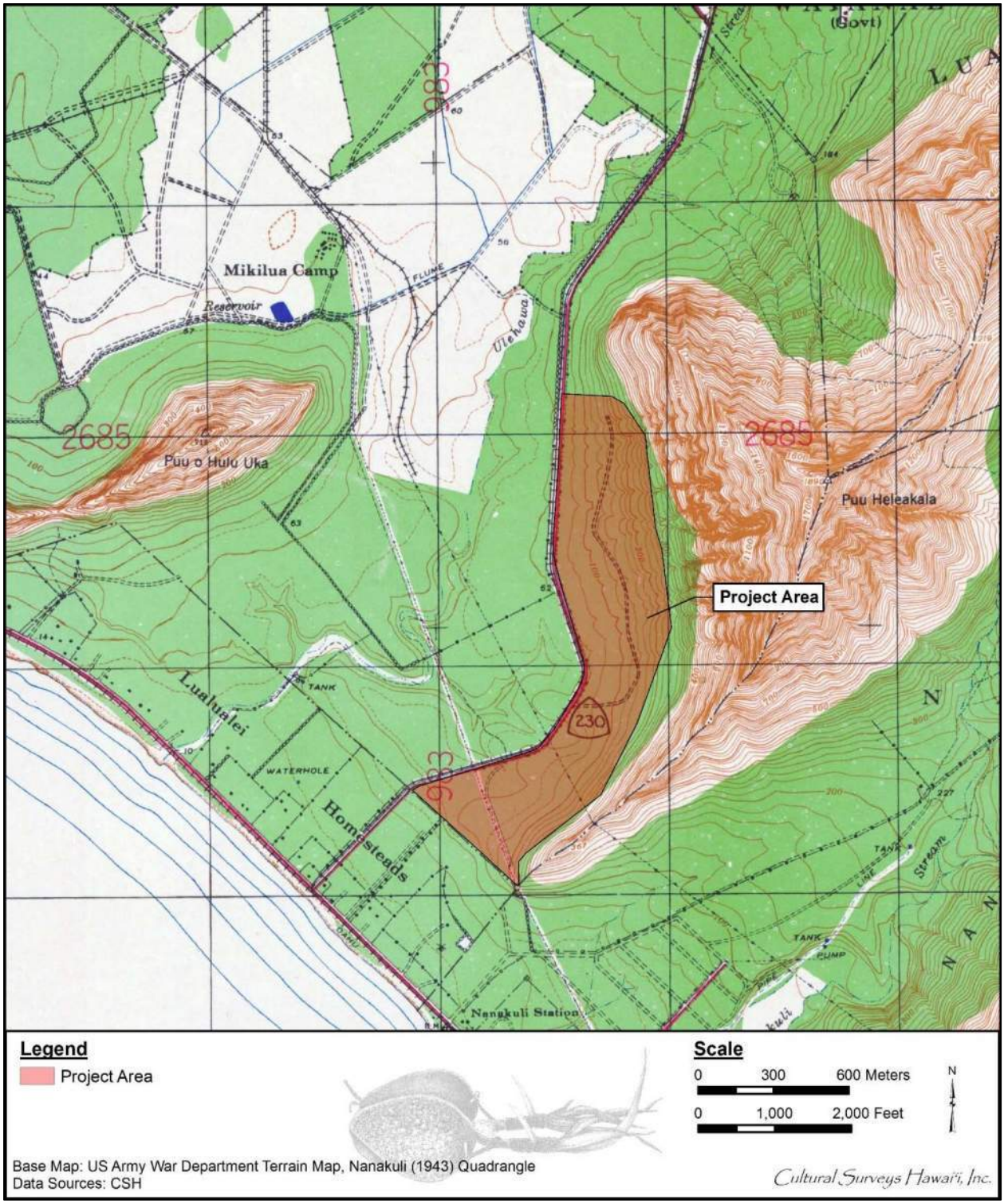

Figure 12. Portion of 1943 U.S. Army War Department terrain map, Nanakuli quadrangle showing location of project area

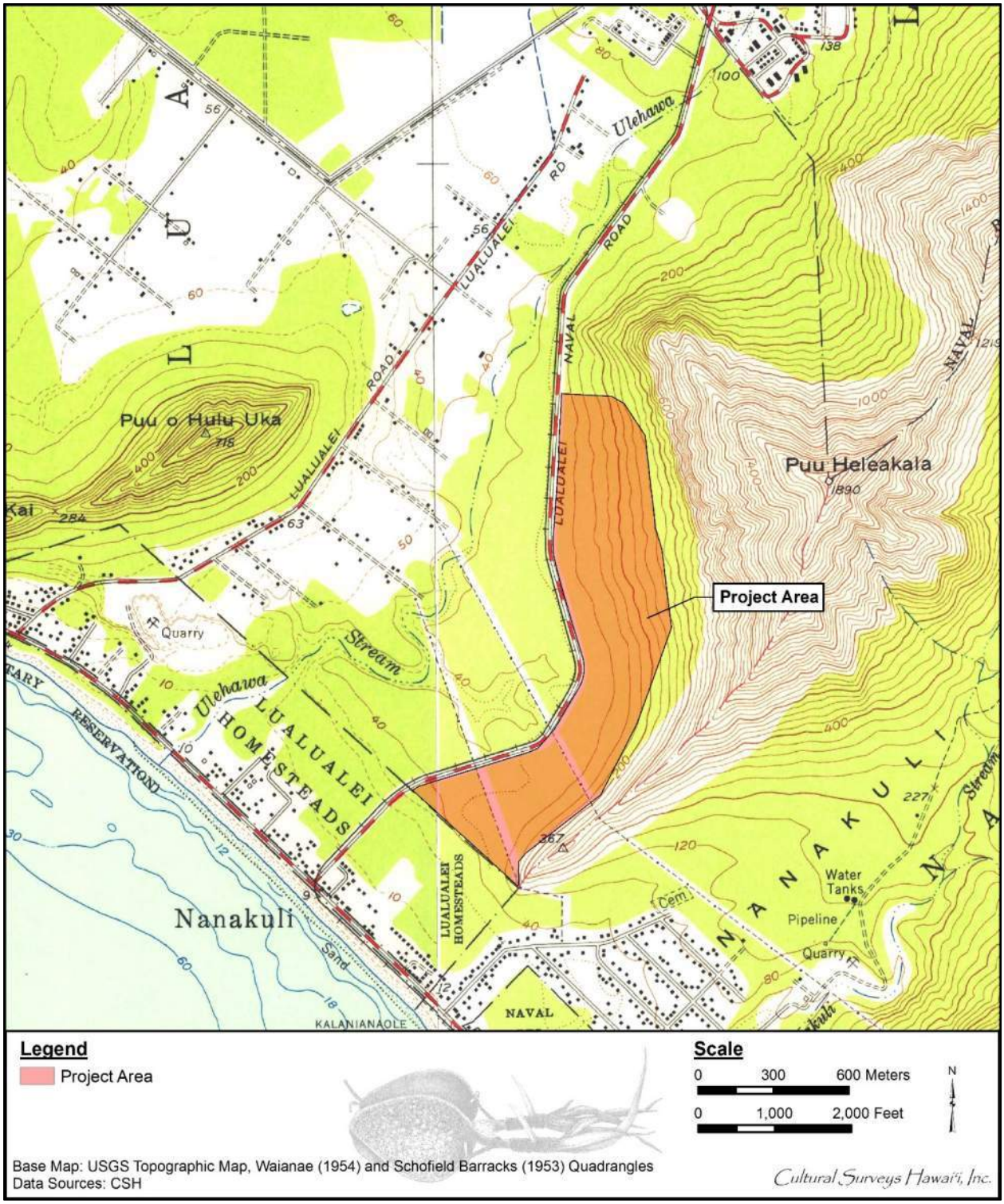

Figure 13. Portion of 1954 Waianae and 1953 Schofield Barracks USGS topographic quadrangles showing location of project area

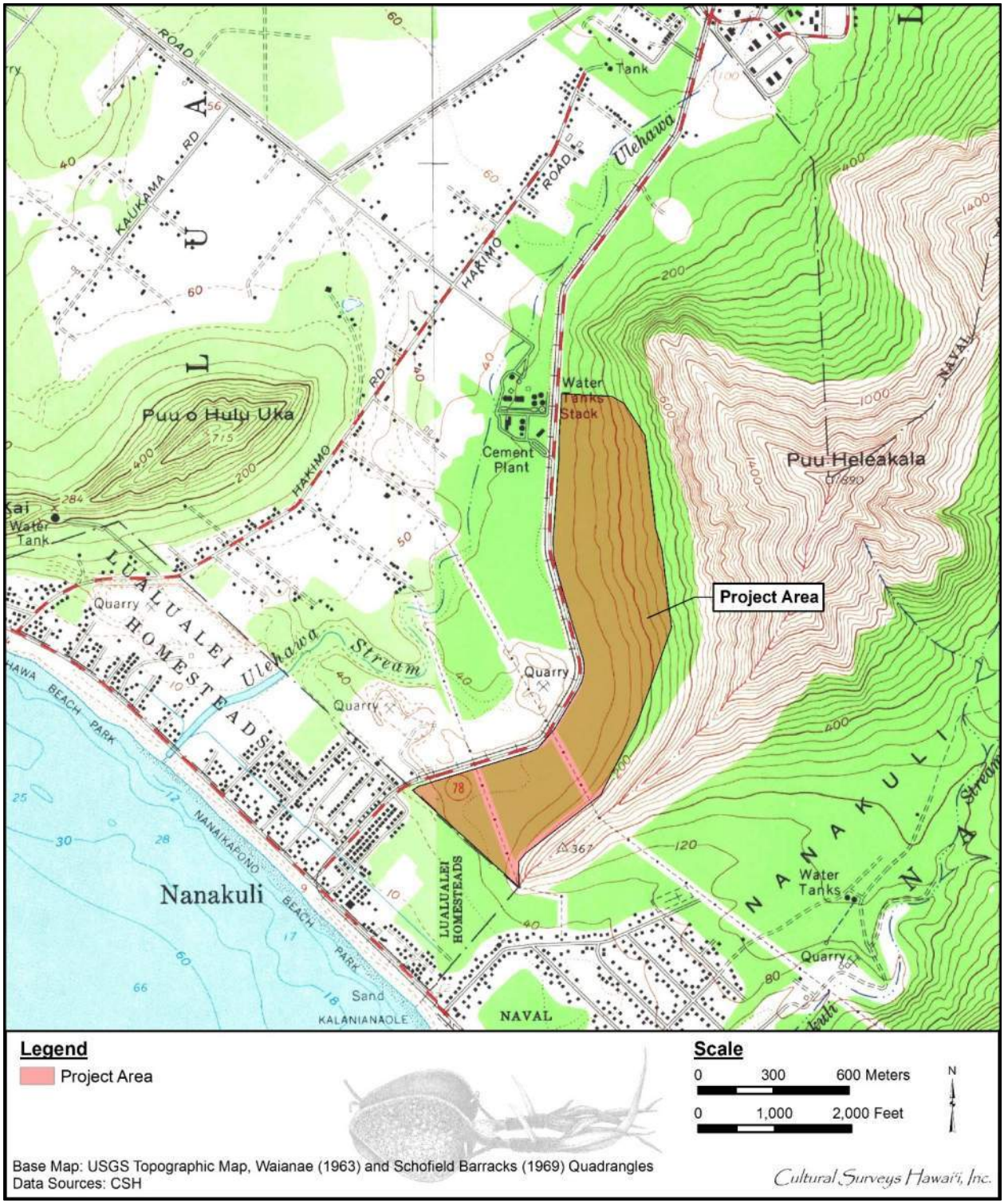

Figure 14. Portion of 1953 Waianae and 1969 Schofield Barracks USGS topographic quadrangles showing location of project area

Figure 15. 1965 USDA aerial photograph (UH MAGIS) showing location of project area

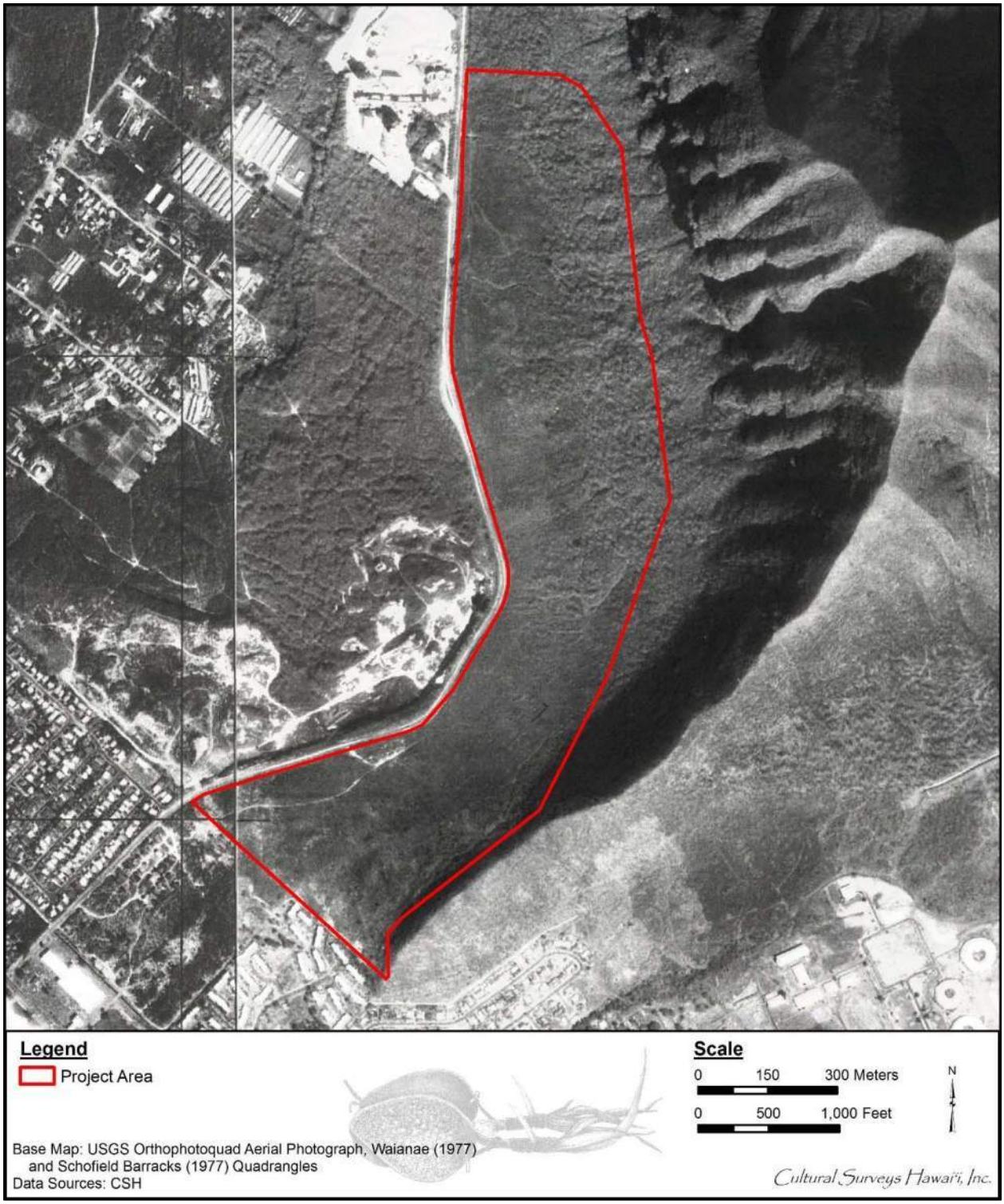

Figure 16. 1977 USGS Orthophotoquad aerial photograph, Waianae, and Schofield Barracks quadrangles showing location of project area

Figure 17. 1993 National Oceanic and Atmospheric Administration (NOAA) aerial photograph (UH MAGIS) showing location of project area

3.3 Previous Archaeological Research

Table 1 summarizes the previous archaeological studies conducted in Lualualei Ahupua‘a, and (illustrated in Figure 18). Previously identified historic properties in the vicinity of the project area are summarized in Table 2 and illustrated in Figure 19.

3.3.1 McAllister 1933

The earliest attempt to record archaeological historic properties in the nearby regions of Lualualei was in the 1930s by J. Gilbert McAllister. McAllister (1933) recorded eight historic properties (Sites 147–153 and 162) in or near Lualualei.

‘Ilihune Heiau, Site 147, was on the border with Nānākuli, south of the present project area. ‘Ilihune Heiau was destroyed by the time of McAllister’s (1933) survey. The locations of ‘Ilihune Heiau (Site 147) and the Māui Rock (Site 148) can be seen in relation to the present project area in Figure 19. McAllister’s (1933) descriptions of Sites 147 and 148 are presented below:

> Site 147. Approximate site of ‘Ilihune Heiau, Nanakuli, of which nothing remains. Thrum notes: ‘A small walled heiau of *pō‘okanaka* class; used about 1860 by Frank Manini as a cattle pen, for which natives prophesized his poverty and death.’
>
> Site 148. Large rock said to be named Maui, about 1.1 mile from Nanakuli station toward Pu‘u o Hulu.
>
> Northeast of the road on the property of E.P. Fogarty is a rock said to be named after the Hawaiian hero, Maui, who is said to have landed here when he first came to the Hawaiians islands from the south. This stone at the time was surrounded by water, and it was here that Maui reposed and sunned himself. In the bluff just northeast of the rock is a shelter in which he lived, and in the vicinity was a spring where he obtained water. The large rock is now split in half and adorned with many small, oddly-shaped rocks. It is said to be bad fortune to build one’s house across a line drawn directly from the rock to the shore. [McAllister 1933:110]

McAllister (1933) recorded three sites (Sites 149–151) in the *mauka* portion of Lualualei. Site 149 was Nioiula Heiau on Hālona Ridge, said to be of the *pō‘okanaka* class. Site 150 consisted of house sites or *heiau* at the foot of the cliffs in Pāhoa. Site 151 was Kakaio Heiau at Pūhāwai, which had a sacred spring where the sound of drums and conches could be heard on the nights of Kāne. McAllister’s (1933) descriptions of Sites 149–151 are presented below:

> Site 149. Nioliula heiau, Halona Ridge in Lualualei, just southwest of the Forest Reserve line.
>
> A paved and walled heiau said to have been of *pookanaka* class. The northern portion has been almost completely destroyed, the stones having been used for a cattle pen on the McCandless property. Since cattle put into the pen sickened and died, it was seldom used and is now abandoned. The heiau probably had three inclosures and three platforms open to the west side, but so little remains of the northern part of the heiau that it is difficult to discern inclosures and terraces. This is probably the heiau on which was placed the body of the boxer killed by Kewalo and offered as a sacrifice to the gods. The temple is said to have been very ancient, belonging to the chief, Kakuihewa.

Table 1. Previous archaeological investigations in Lualualei Ahupua‘a.

Reference	Nature of Study	Location	Results
McAllister 1933	Island-wide reconnaissance survey	Lualualei Ahupua‘a	Recorded eight sites in or near Lualualei: Site 147, ‘Ilihune Heiau; Site 148, Māui Rock; Site 149, Nioiula Heiau on Hālona ridge; Site 150, House sites or *heiau* at Pahoa cliffs; Site 151, Kakioe Heiau at Pūhāwai; Site 152, Pu‘u Pāhe‘ehe‘e Heiau; Site 153, Kū‘īlioloa Heiau; and Site 162, Mauna Kūwale burial cave
Bordner 1977	Reconnaissance survey	TMK: [1] 8-7-009	No historic properties identified
Chiogioji and Hammatt 1993	Archaeological survey and testing	TMK: [1] 8-7-021:017	No historic properties identified
Hammatt et al. 1993	Archaeological inventory survey	Lualualei Golf Course, TMKs: [1] 8-7-009:002; 8-7-010:006, 010; and 8-7-019:001	Identified eight historic properties: two traditional Hawaiian (habitation complex and remnants of a wall) and six post-Contact (cattle wall, furnace, wells, house lot, and cement foundation structure)
Sinoto and Pantaleo 1994a	Reconnaissance survey	TMKs: [1] 8-7-007, 8-7-008, 8-7-009, 8-7-021, and 8-7-022	No historic properties identified
Sinoto and Pantaleo 1994b	Reconnaissance survey	TMKs: [1] 8-7-6, 8-7-8, 8-7-033, and 8-9-002	No historic properties identified
Dega 1998	Reconnaissance survey	TMKs: [1] 8-7-006 and 8-7-007	Observed subsurface cultural layer and WWII era bunkers (no SIHP #s designated)
McDermott and Hammatt 2000	Archaeological inventory survey	‘Ulehawa Beach Park, TMKs: [1] 8-7-005:001, 003, and 005; 8-7-006:003; and 8-7-008:001, 026	Two subsurface cultural layers designated SIHP #s 50-80-07-5762 and -5763, consisting of midden (marine shell, fishbone) and traditional Hawaiian (fishhooks, volcanic and basalt flakes) and post-Contact (glass, metal, and concrete fragments) artifacts; layers likely date to late pre- or early post-Contact period

Reference	Nature of Study	Location	Results
Elmore and Kennedy 2001	Archaeological inventory survey	Mahina‘au Rd from Maiu‘u Rd to Kaulawaha Rd	Documented two historic properties: SIHP # 50-80-08-5949, subsurface cultural layer with associated features (including human remains), and SIHP # 50-80-08-5950, a portion of a sugar plantation camp and associated infrastructure features (water pumping station, foundations, and well)
Kennedy 2003	Addendum archaeological inventory survey	TMKs: [1] 8-7-008:076 and 077	No historic properties identified; documented three sinkholes, none determined to be significant
Ostroff and Desilets 2005	Archaeological monitoring	Farrington Hwy between Hakimo Rd and Haleakala Ave	Documented charcoal-enriched sand deposits possibly associated with SIHP # 50-80-07-5763 (subsurface cultural deposit)
Jones and Hammatt 2006	Archaeological monitoring	La‘ikū, Wai‘olu and Princess Kahanu Streets	No historic properties identified
O’Leary and McDermott 2006	Archaeological inventory survey	Proposed Nānākuli B Site Materials Recovery Facility and Landfill	Identified two historic properties: SIHP #s 50-80-08-6681, WWII-era concrete bunker, and 50-80-08-6699, likely pre-Contact basalt rock shelter
Souza and Hammatt 2006	Archaeological monitoring	Farrington Hwy between Nānākuli Ave and Hakimo Rd	No historic properties identified
Hammermeister and McDermott 2007	Addendum archaeological inventory survey	Proposed Nānākuli B Site Materials Recovery Facility and Landfill	Investigated a stacked stone mound, designated as SIHP # 50-80-08-6920
Hammatt and Shideler 2010	Supplemental archaeological inventory survey and interim protection measures implementation	TMK: [1] 8-7-009:002 por.	Further documentation and implemented preservation measures for SIHP # 50-80-08-4366, terrace remnants
Dagher and Spear 2011	Literature review and field inspection	Pacific Mall, TMK: [1] 8-7-008:012	No historic properties identified

Reference	Nature of Study	Location	Results
Mierzejewski and Hammatt 2014	Archaeological monitoring	Ulehawa Beach Park	No historic properties identified
Hammatt and Shideler 2015	Literature review and field inspection	TMK: [1] 8-7-007:005	No historic properties identified
Stark et al. 2015	Literature review and field inspection	TMKs: [1] 8-7-009:025 and 8-7-021:026	Two potential historic properties: CSH 1, dry-stacked historic (ca. 1936) rock wall, and CSH 2, linear pile of boulders
DeMaio Starr et al. 2016	Archaeological inventory survey	TMK: [1] 8-7-007:001	No historic properties identified
Hammatt and Shideler 2018	Reconnaissance survey	TMKs: [1] 8-7-033:001 and 027	No historic properties identified
Hammatt et al. 2018	Reconnaissance survey	TMK: [1] 8-7-033:001	No historic properties identified

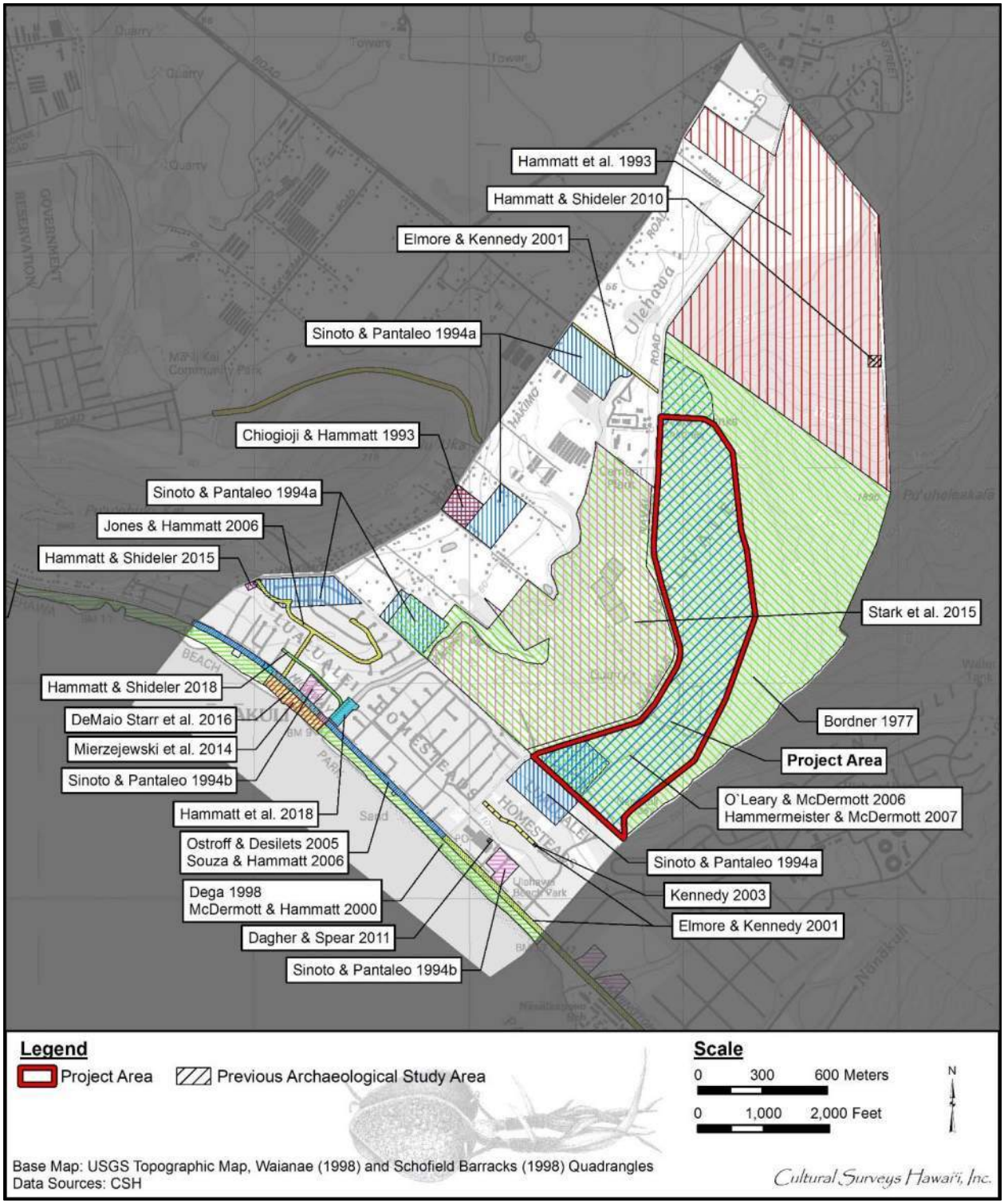

Figure 18. Portions of the 1998 Waianae and Schofield Barracks USGS 7.5-minute topographic quadrangles showing previous archaeological studies in the vicinity of the project area

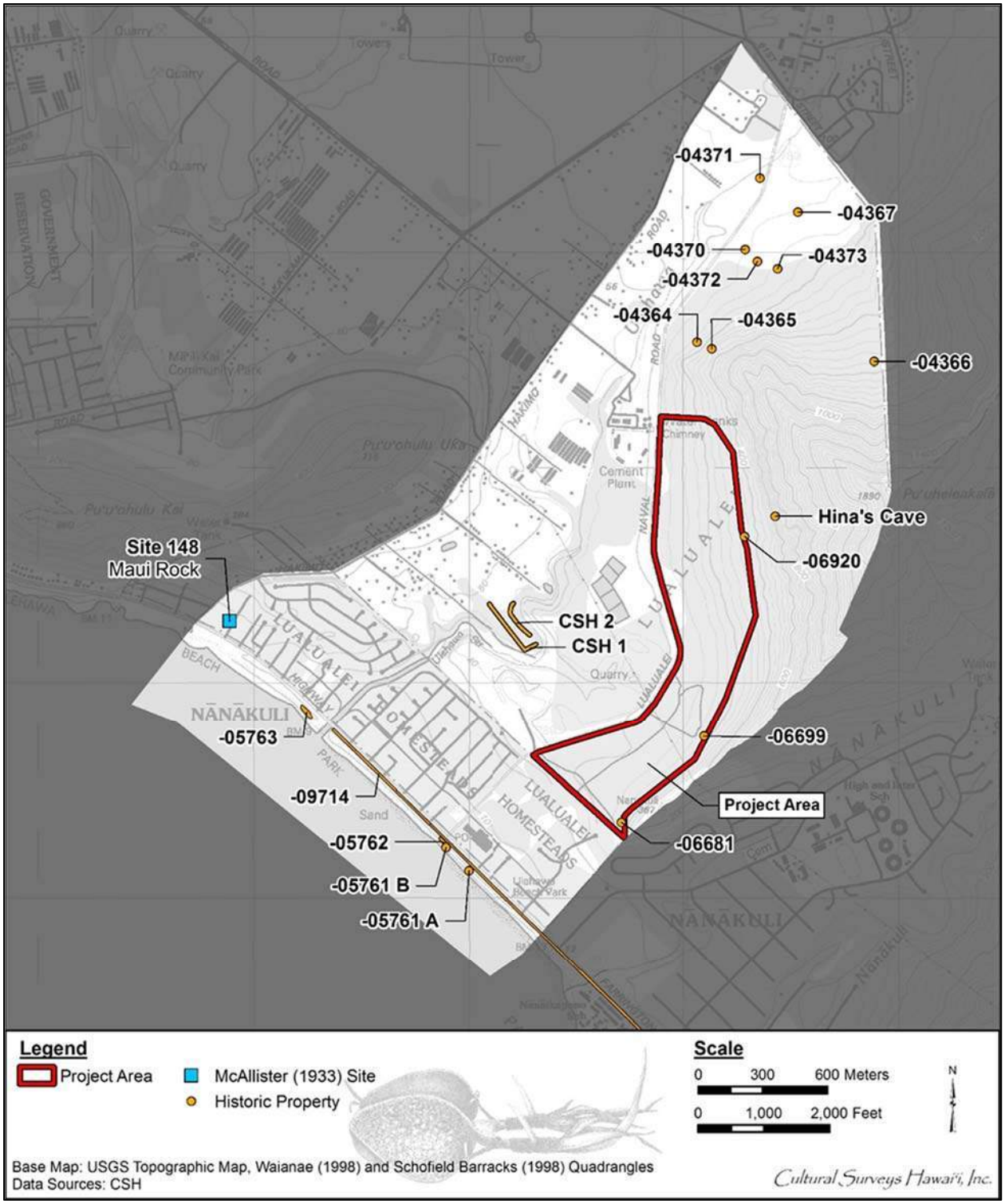

Figure 19. Portions of the 1998 Waianae and Schofield Barracks USGS 7.5-minute topographic quadrangles showing previously identified historic properties in the vicinity of the project area

Table 2. Previously identified historic properties in the vicinity of the project area

SIHP # 50-80-	Formal Type	Description	Source
07-148	Māui Rock	Large boulder	McAllister 1933:110
07-5761	Bunkers and slabs	WWII-era military	McDermott and Hammatt 2000:144–147
07-5762	Subsurface cultural layer	Pre- and/or early post-Contact	McDermott and Hammatt 2000:147
07-5763	Subsurface cultural layer	Pre- and/or early post-Contact	McDermott and Hammatt 2000:147–149
08-4364	Wall	Associated with ranching	Hammatt et al. 1993:25
08-4365	Shelter	Military	Hammatt et al. 1993:25
08-4366	Habitation complex	–	Hammatt et al. 1993:25
08-4367	Wall	Agricultural	Hammatt et al. 1993:25
08-4370	House lot	Associated with ranching	Hammatt et al. 1993:25
08-4371	Wells	Associated with ranching	Hammatt et al. 1993:25
08-4372	Foundation	Associated with ranching	Hammatt et al. 1993:25
08-4373	Incinerator	Associated with military/ranching	Hammatt et al. 1993:25
08-6681	Military infrastructure	WWII-era concrete bunker	O’Leary and McDermott 2006
08-6699	Rock shelter	Small pre-Contact basalt rock shelter	O’Leary and McDermott 2006
08-6920	Stone mound	Stacked stone mound interpreted as a traditional Hawaiian marker	Hammermeister and McDermott 2007
12-9714	OR&L railroad	Railroad bed	McDermott and Hammatt 2000:149
CSH 1	Wall	Dry-stacked historic (ca. 1936) rock wall	Stark et al. 2015
CSH 2	Linear pile of boulders	Possibly a result of mechanical bulldozer push	Stark et al. 2015

> Site 150. House sites or heiaus, middle of Lualualei at the foot of cliffs, Pahoa.
>
> Innumerable walls and small terraces that have been house sites or possibly very old heiaus whose sites have long since been forgotten by the natives are located on the ends of small ridges, the sea sides of most of which are covered with rough lava rocks. These small prominences have been leveled off and some have been walled and paved with smooth stones. None of the sites are sufficiently preserved to indicate a plan, for this has been a cattle range almost since the coming of Europeans, and the cattle have scattered many a wall and terrace in grazing.
>
> Site 151. Kakioe heiau was located at Puhawai, Lualualei. Thrum notes: ‘A small heiau of which nothing now remains but its sacred spring, and the sound of its drums and conchs on the nights of Kane.’ [McAllister 1933:110]

McAllister recorded three sites near the boundary of Lualualei and Wai‘anae, far north of the present project area. Site 152, Pu‘u Pāhe‘ehe‘e Heiau, consisted of a walled *heiau* on the slopes of Pāhe‘ehe‘e Ridge. It was destroyed by the time of McAllister’s (1933) survey. At the tip of Kāne‘īlio Point was Site 153, Kū‘īlioloa Heiau, which was surrounded by water on three sides and consisted of three platforms with evidence of terracing. Site 162 was a burial cave at Mauna Kūwale, which contained fragments of skeletal material. McAllister’s (1933) descriptions of Sites 152, 153, and 162 are presented below:

> Site 152. Puupaheehee heiau, on the sea end of Puupaheehee Ridge. Completely destroyed with the enlargement of the Oriental cemetery. According to Thrum it was of *luakini* class. Thrum adds:
>
> A walled heiau of two or three divisions, the upper section being 70 feet across, by 57 feet in its width; the lower ones not so well defined. Its slopes in ancient time, covered with slippery grass strewn for the purpose, was the scene of sledding contests, hence its name. Of late its north and western slopes have been assigned as a burial place for Orientals.
>
> Site 153. Kuilioloa heiau, on the extreme tip of Kaneilio Point.
>
> The heiau is surrounded on three sides by water. It has three platforms, with evidence of terracing. The most important platform, evidently is at the end of the point. It is the highest, and terraces once marked the three sides toward the sea. Sand and dirt have been filled in between large stones. The second platform is lower than the first and is slightly wider. The pavement is similar to the first and, like the first, the walls were made by standing large pieces of lava on end and filling in. The walls have a flat, even facing. The third platform is lower than the second and can only be distinguished from the ground to the north and west by a row of stones in the grass. It is evenly paved with sand and may possibly have been used for house sites, as suggested by Thrum. [McAllister 1933:112]

3.3.2 Bordner 1977

A 1977 reconnaissance survey for the proposed Nānākuli landfill recorded no archaeological historic properties (Bordner 1977). The survey area included land on both sides of Lualualei Naval Road, continuing up the slope to Pu‘u Heleakalā.

3.3.3 Chiogioji and Hammatt 1993

During an archaeological study conducted on a 5-acre parcel, formerly a basil farm, no archaeological historic properties were documented (Chiogioji and Hammatt 1993). The parcel is between Pu‘u o Hulu and ‘Ulehawa, north of the current study area.

3.3.4 Hammatt et al. 1993

An archaeological inventory survey of an approximately 170-acre parcel southeast of the Naval Magazine was conducted by CSH (Hammatt et al. 1993). The parcel is described as comprising “vacant, unused lands. It is undeveloped and contains several remnant and abandoned historic structures” (Hammatt et al. 1993:7). Eight archaeological historic properties were identified, including “two traditional Hawaiian sites and six historic sites related to ranching and military activities” (Hammatt et al. 1993:i). The two traditional Hawaiian sites are SIHP #s 50-80-08-4366, site complex, and -4367, wall remnant. SIHP # -4366 likely represents pre-Contact, recurrent habitation at the foothills of Pu‘u Heleakalā. This is primarily evidenced by the presence of a probable hearth feature within the site complex. The location of SIHP # 50-80-08-4367, adjacent to an intermittent streambed, suggests an agricultural usage; Hammatt et al. (1993) suggest it was constructed to retain or divert water. Given the weathered condition of the structure, SIHP # -4367 may be also be pre-Contact (Hammatt et al. 1993:28).

The paucity of Hawaiian sites within the study parcel, in comparison to the number within the large Naval Magazine study area to the north and *mauka*, suggested to Hammatt et al. (1993) that the parcel may represent, at most, the *makai*-most fringe of the inland settlement. The survey report concludes the following:

> The few traditional Hawaiian sites identified during the present study suggest that most of the project area was sparsely inhabited during prehistory and early history. This would be due primarily to the lack of fresh water resources in the vicinity . . . Although surface run-off and intermittent drainage present in the project area would allow some potential for seasonal agriculture, the attraction for settling in the wetter upland valleys would surely have been greater. [Hammatt et al. 1993:31]

3.3.5 Sinoto and Pantaleo 1994a

Aki Sinoto Consulting completed a reconnaissance level archaeological survey for six potential sites for the Nanakuli III Elementary School project. No historic properties were identified within the six candidate sites.

3.3.6 Sinoto and Pantaleo 1994b

Aki Sinoto Consulting completed a reconnaissance level archaeological survey for five potential sites for the Nanakuli Public Library project. No historic properties were identified within the five candidate sites.

3.3.7 Dega 1998

In 1998 Scientific Consulting Services, Inc. (SCS) provided a review of archival research and results of a reconnaissance survey completed within Ulehawa Beach Park. The author noted that SIHP # 50-80-12-9714 (OR&L Railroad line remnants) have been identified within the study area. During the reconnaissance survey, SCS documented a subsurface cultural layer with extensive

charcoal flecking and faunal osseous remains, as well as three World War II era bunkers. The features were noted briefly, though no SIHP # designations were provided.

3.3.8 McDermott and Hammatt 2000

In 1999, CSH (McDermott and Hammatt 2000) conducted an inventory survey on a 57.65-acre parcel of ‘Ulehawa Beach Park. Two subsurface cultural layers, designated as SIHP #s 50-80-07-5762 and 50-80-07-5763, were found during test excavations that covered approximately 2% of the project area. The deposits consisted of midden (marine shell, fish bone) and both traditional Hawaiian (fishhooks, volcanic and basalt flakes) and post-Contact (glass, metal, and concrete fragments) artifacts. Of particular interest was a nearly complete, barb-less pearl shell fishhook with an unusually deep V-bend reminiscent of Marquesan or Tahitian hooks. This type of fishhook is considered atypical for Hawaiian fishhooks. Both cultural layers appeared to date to the late pre-Contact or very early post-Contact period.

Also noted in this report is an area identified by a local informant to contain burials and cultural deposits (McDermott and Hammatt 2000:43). This area extends approximately from ‘Ulehawa Stream northwest. Mr. Walter Kamanā’s comments pertaining to the present project area follow:

> The land from the bathrooms, just north of ‘Ulehawa drainage, on around Mā‘ili point is all *kapu* (taboo) ground. The night marchers are active at this place. There have been problems associated with that area, including violence and tragedy, including car wrecks. There were lost souls at that place in Hawaiian times. It is likely that you will find Hawaiian remains in the area. There are burials there on the *makai* side of Farrington Highway. A testing crew went in there to test the area, but Mr. Kamana did not know what for. Bones were found, but the public was not informed.
>
> Just beyond Hakimo Road, on the *makai* side of Farrington Highway, is a place called by the Japanese “Takamina”, where the Japanese shrine stands today. [a “fishing marker” approximately 500 m north of Hakimo Road]. The Japanese shrine is not only important because of the Japanese culture and beliefs, but because of Hawaiian culture and beliefs as well. It was formerly a shrine area for the Hawaiians, but the shrine area has been largely forgotten by local Hawaiian residents. The shrine area should be respected at all times. Mr. Kamana mentions it as a ‘Point to Point (?) burial ground’. That place must be respected. [McDermott and Hammatt 2000:43]

A number of historic-era structures, such as concrete World War II bunkers, were also noted in the ‘Ulehawa Beach Park studies (Dega 1998:5; McDermott and Hammatt 2000:143–147). Two World War II-era concrete foundations were observed seaward of Farrington Highway.

3.3.9 Elmore and Kennedy 2001

Archaeological Consultants of the Pacific, Inc. completed an archaeological inventory survey along Mahina‘au Road from Maiu‘u Road to Kaulawaha Road. The survey included 100% pedestrian inspection and 36 test excavations. The AIS identified two historic properties: SIHP # 50-80-07-5949, subsurface cultural layer and associated features, including one human burial, and 50-80-07-5950, a portion of a sugar plantation camp and pumping station, including the water pumping station, foundations, and a well.

3.3.10 Kennedy 2003

Archaeological Consultants of the Pacific, Inc. completed an addendum archaeological inventory survey for the Wai‘anae Coast Emergency Access Road project. During the initial AIS investigation three potential cultural features were documented, all three possible sinkholes. The addendum AIS report determined the sinkholes not to be significant historic properties, and no additional historic properties were documented during the addendum investigation.

3.3.11 Ostroff and Desilets 2005

Garcia and Associates conducted archaeological monitoring for water line replacements along Farrington Highway between Hakimo Road and Halekala Avenue. The monitoring program documented five areas of charcoal-enriched sand deposits, one of which was suggested to be associated with SIHP # 50-80-07-5763 (subsurface cultural deposit). No additional historic properties were identified during the archaeological monitoring program.

3.3.12 Souza and Hammatt 2006

CSH conducted archaeological monitoring for the Fiber Optic Line project along Farrington Highway between the streets of Nānākuli Avenue and Hakimo Road. Documented stratigraphy was entirely composed of fill, and no historic properties were identified during the archaeological monitoring program.

3.3.13 Jones and Hammatt 2006

Jones and Hammatt (2006) completed a monitoring report for sections of La‘ikū, Wai‘olu and Princess Kahanu streets four a water main installation. No historic properties were identified during monitoring.

3.3.14 O’Leary and McDermott 2006

CSH (O’Leary and McDermott 2006) conducted an archaeological inventory survey of 200 acres for the proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua‘a; note this area largely overlaps with the current project area (it extended slightly farther north). Two historic properties were identified, both within the current project area:

- SIHP # 50-80-08-6699, small pre-Contact basalt rock shelter
- SIHP # 50-80-08-6681, World War II concrete bunker

Full historic property descriptions are presented in Section 8 of the current report.

O’Leary and McDermott (2006) describe the project area, which includes the present project area, as follows :

> There has been substantial ground disturbance within the project area at some point in the past, as large portions of the project area show signs of bulldozer activities. Within the project area, pushed up mounds of dirt and raised berms and banks were observed by the field personnel. Several of these appeared to have been cut into the hill in order to channel water run-off. It was not possible to tell when the bulldozing took place, but almost all of the moved earth had extensive grass growth. Numerous basalt boulders throughout the property have bulldozer scars on them, indicating that their current location is due to modern activities. The project area also has a

> developed dirt road, which is currently in use, that runs from an access gate at the very southwest corner of the property to the two large water tanks along the hill slope. The road is a graded mix of the sediment extending down from the hillside and broken up limestone. There are also several older roads that are overgrown with vegetation but are still visible in various places on the property…. This extensive previous modification is likely the reason that surface archaeological remains were not found over most of the property.
>
> At several locations within the project area, boulders that had been broken by bulldozers were observed to be of relatively fine-grained high quality basalt that could have served as raw material for stone tools. A large dike that crosscuts the regular stratigraphy of Pu‘u Hekeakalā is the possible source of these rocks. In a handful of locations within the project area, basalt flakes were observed during the AIS. Unfortunately, it is difficult to determine if these fine-grained basalt flakes are pre- and/r early post-Contact lithic reduction debitage or incidentally fractured stone related to modern bulldozer modifications.
>
> Overall, the extensive evidence of bulldozer activity suggests that any sites that may have been in the flatter sections of the project area have long since been destroyed. These observations correspond with the fact that the only two SIHP were found along the steeper edge of the project area.
>
> The only other non-natural objects observed on the landscape were a few scattered rusty barrels, two stripped and rusted cars, and numerous abandoned rusting appliances that have been dumped into the tall *koa haole* along Lualualei Naval Road at the southern end of the project area. [O’Leary and McDermott 2006:13]

3.3.15 Hammermeister and McDermott 2007

CSH (Hammermeister and McDermott 2007) returned to the proposed Nānākuli B Site Materials Recovery Facility and Landfill (see O’Leary and McDermott 2006 above) to investigate a stacked stone mound found on the project’s eastern upslope boundary. The feature was excavated and interpreted as a traditional Hawaiian marker. It is within the current project area and was assigned SIHP # 50-80-08-6920. A full historic property description is presented in Section 8 of the current report.

3.3.16 Hammatt and Shideler 2010

In 2010, CSH documented the condition of SIHP # 50-80-08-4366, which consists of a terrace, attached enclosure, and adjacent modified outcrop. Condition of the historic property appeared to be largely the same as when it was originally documented. CSH erected a continuous line of 4-ft tall plastic orange fencing around the site as a protective measure. The study did not document any additional historic properties.

3.3.17 Dagher and Spear 2011

SCS conducted a literature review and field inspection for AT&T telecommunications at the Pacific Mall (Dagher and Spear 2011). The field inspection noted no historic properties in close proximity to the cell tower in question.

3.3.18 Mierzejewski et al. 2014

From 2013 through 2014, CSH conducted archaeological monitoring for the Ulehawa Beach Park Wastewater Treatment Reconstruction project. Documented stratigraphy largely consisted of fills overlying natural alluvial deposits and natural marine sand. No historic properties were identified during the archaeological monitoring program.

3.3.19 Hammatt and Shideler 2015

In 2015 CSH conducted an archaeological literature review and field inspection for the Lualualei Line Booster System Improvements project. No surface historic properties were identified during the field inspection, and potential for subsurface historic properties was evaluated as low.

3.3.20 Stark et al. 2015

CSH (Stark et al. 2015) prepared an archaeological literature review and field inspection report for the PVT Integrated Solid Waste Management Facility (ISWMF)–Expanded Recycling, Landfill Grading and Renewable Energy project in Lualualei Ahupua‘a (TMKs: [1] 8-7-009:025 and 8-7-021:026). Two potential historic properties were described with temporary site designations:

- CSH 1 is a dry-stacked historic (ca. 1936) rock wall, 125 cm high by 80 cm wide and approximately 400 m long, extending beyond the project area to the northwest for several kilometers. CSH 1 is composed of dry-stacked coral limestone. The wall is bi-faced with in-fill and with a rectilinear cross section.
- CSH 2 is a linear pile of boulders meandering along the top margin of a break in slope so as to form a terrace and appears to have in-filling on the high side of the terrace. The pile of stones in CSH 2 is substantial (approximately 220 m long by 1.5 m wide) and appears to have been created either as a result of a mechanized bulldozer push and/or hand-piling along the top of the break in slope.

3.3.21 DeMaio Starr et al. 2016

In 2016, CSH conducted an archaeological inventory survey for the Farrington Highway Drainage Improvements project. No historic properties were identified within the project area.

3.3.22 Hammatt and Shideler 2018

In 2017, CSH completed an archaeological literature review and field inspection of a 0.34-acre area within the Waianae Flood Control Right-of-Way (U-1), for the proposed repair of a portion of the U-1 channel. Aside from the U-1 channel itself, no additional historic properties were documented.

3.3.23 Hammatt et al. 2018

In 2018, CSH completed an archaeological literature review and field inspection for the Ulehawa U-1 Channel Improvements project. Aside from the U-1 drainage ditch itself and the channelization of Ulehawa Stream, no additional historic properties were observed.

3.3.24 Other Relevant Studies

An archaeological study by Hammatt et al. (2001) evaluated the available data on burials in the vicinity of the present project area. The study notes that a document in SHPD Burials Program files entitled “Burial Sites and Grave Sites Graveyards and Cemeteries Case Inventory” (page 19) has the following line item:

* Ma‘ili - Cave Burials / ID (#584)

* human remains re-interred.

It is less than clear whether there are known remains in Mā‘ili Cave, or where this cave may be. This 2001 study also notes that a few historic properties in Lualualei are traditionally associated with human deaths. Nioiula Heiau on Hālona Ridge (Site 149; also known as Hālona Heiau) was said to have been of the po‘okanaka class (McAllister 1933:110, Westervelt 1915a:122, Westervelt 1915b:178, Thrum 1908:47), which suggests associations with human sacrifice; however, this site was at the south base of the Pāhoa Cliffs of the Wai‘anae Range. There are numerous accounts associating Kolekole Pass and vicinity with battles and mortal combat (Sterling and Summers 1978:67), but the area referred to is Pōhākea Pass. ‘Ilihune Heiau (Site 147, reported as destroyed by 1930), also said to be of *po‘okanaka* class (McAllister 1933:110, Thrum 1906:47), lay closer at the tip of the Heleakalā Ridge, southeast of the present project area. This 2001 study also notes that a Lualualei map by Emerson, dated October 1901 (Registered Map 2040), shows an annotation of “Maili Grave” on the seaward side of present-day Farrington Highway.

3.4 Summary of Settlement Patterns for the Region

Cordy (1998) provides a synthesis of the settlement patterns and traditional history of the Wai‘anae District, including Lualualei. This study places the settlement of Wai‘anae into the wider context of O‘ahu settlement as a whole. The proximity of expansive forest resources and well-watered agricultural lands to abundant marine resources made the windward side of O‘ahu most appealing to the early O‘ahu settlers and their descendants. However, foraging trips to the dryer areas of the island would have occurred and were most likely associated with recurrent, temporary habitation. The rich marine resources of the Wai‘anae District, particularly the fishing grounds off-shore, would have been a strong draw for early O‘ahu inhabitants. As population in the windward areas increased, permanent settlement began to spill over into the well-watered regions of the leeward side. Eventually, with further population expansion, permanent settlement spread to the less watered regions of the leeward side, which included much of the Wai‘anae District and all of the current project area (Cordy 1998:1–6). Settlement would most likely begin as temporary habitation along the coast in association with marine resource procurement. Later, permanent settlement would have developed in response to expanding populations in previously settled, better watered areas.

Pre-Contact land use in Lualualei was greatest at the sea, where marine resources were plentiful, and in the mountainous interior, where there was sufficient rainfall for agriculture and forest resources. The intervening lands between the sea and the mountains were a dry scrubland. Although potentially useful for dryland agriculture in the wet winter months, it is unlikely this area would have been largely utilized by Native Hawaiians. The settlement pattern prior to Western Contact for this region was likely dispersed residences concentrated at the sea and the mountains. Based on the season and the available resources, the resident population most likely used multiple

residences, perhaps one at the seaside and another *mauka*, to reduce resource transport time. It is also possible, as suggested by the account provided by Pukui (cited in McGrath et al. 1973:10), that there existed an informal exchange network whereby coastal dwellers traded marine resources for the agricultural and forest resources of the inland dwellers.

Archaeological surveys of the upper portion of Lualualei Valley have located the remains of traditional Hawaiian habitation, ceremonial, and agricultural structures. The extensive archaeological survey of the *mauka* portions of these valleys is offset by a paucity of archaeological investigation in their coastal portions. However, based on context, information from long-time residents of the area, and traditional accounts, it is likely the coastal areas of Lualualei contain cultural deposits related to habitation, including human burials.

Radiocarbon dates from inland Wai‘anae, apparently permanent habitation contexts, within Nānākuli indicate permanent settlement began by AD 1200-1400 (Cordy et al. 1997:9). Extensive archaeological survey of inland Lualualei has yielded radiocarbon dates from permanent habitation contexts dating to AD 1620, with earlier dates (mid-1400s) for apparently temporary habitation structures (Haun 1991:237). The only coastal dates for Lualualei are those reported by McDermott and Hammatt (2000) from the two coastal habitation deposits (SIHP #s 50-80-08-5762 and -5763) found during the inventory survey of the ‘Ulehawa Beach Park parcel. The three available dates from the survey span a broad temporal period, from 1460 to 1950. Considering the early coastal date from Haun (1991) and the *mauka* dates from Lualualei, it is certainly plausible that at least temporary coastal settlement took place within the first half of the 1460-1950 age range.

The population along the Wai‘anae coast may always have been quite low. The immediate vicinity lacked water for cultivation and was proverbial for its poverty. Vancouver in 1785 noted “few inhabitants” in “the barren, rocky waste.” Whitman in 1815 referred to the vicinity as an “uncultivated plain.” Oral history accounts emphasize the “crops were always poor and miserable.”

By the mid-1800s, the traditional Native Hawaiian lifestyle in the valley of Lualualei was in decline. The sandalwood trade, which ended ca. 1829, undoubtedly had a negative effect on the Native Hawaiian population. Beginning at this time, Lualualei began its cattle ranching period. The introduction of sugar plantations brought more foreigners and the OR&L railroad, which was linked to Wai‘anae in 1895. Based on the paucity of LCAs claimed within the area and the early population figures, it appears the Native Hawaiian population was quite low in the latter half of the nineteenth century.

Population numbers slowly increased when homesteading was instituted in the early 1900s, and military use of the land began in 1917. World War II greatly affected the landscape of the Wai‘anae coast by placing bunkers, gun emplacements, and barbed wire along the waterfront. As noted by local informants, tsunamis have also altered the landscape.

3.5 Background Summary and Predictive Model

Numerous archaeological investigations have taken place within Lualualei Valley on the Leeward side of O‘ahu. The studies have demonstrated a pattern of high intensity land use in the *mauka* and *makai* portions of Lualualei Valley, with a relative gap in archaeological remains in the middle sections. The studies of the *mauka* portions of the valley (Haun 1991, Ogden Environmental Services 1997) identified more than 500 archaeological historic properties, which

included well over 1,000 features. The identified features include “alignments, C-shapes, L-shapes, U-shapes, walls, terraces, enclosures, mounds, platforms, walled terraces and paved terraces” (Haun 1991:vii). These features related to habitation, agriculture, rituals, ceremonies, and the manufacture of stone tools.

Extensive evidence of traditional Hawaiian activity has also been recorded in *makai* sections of the *ahupua‘a*, immediately adjacent to the ocean (Hammatt and Shideler 1990, McDermott and Hammatt 2000). Hammatt and Shideler (1990) documented seven Native Hawaiian burials during improvements to the water system. McDermott and Hammatt (2000) identified two cultural layers that exhibited charcoal deposits, pit features, and midden associated with traditional Hawaiian occupation; fishhooks were also found.

In contrast to the abundance of traditional Hawaiian features encountered during the Bishop Museum survey of the *mauka* half of Lualualei, the surface historic properties recorded in the central section of Lualualei Valley at Mā‘ili were either post-Contact or of equivocal origin. In the one instance where excavation was attempted at a structure originally judged “quite possibly a *heiau*” (Site Ch-Oa-1), the site was established as modern, and no subsurface deposits were encountered. The lack of traditional Hawaiian sites in these areas may reflect not only the distortions of modern disturbances (including bulldozing, farming, and ranching) but also a general disuse during pre-Contact times. Population and activity in Lualualei may have been primarily focused in a narrow band along the coast and farther inland in the *mauka* reaches of this large valley.

Based upon the previous archaeological research conducted within the *ahupua‘a*, the land between the coastal and *mauka* zones is likely to be characterized by a fairly ephemeral archaeological record pointing to the intermittent use of locations such as trails, lithic scatters, and temporary habitation sites. Two historic properties were identified within the current project area during a 2006 AIS by O’Leary and McDermott and were revisited during the present study. These comprise a traditional Hawaiian rock shelter (SIHP # 50-80-08-6699) and World War II-era military bunker (SIHP # 50-80-08-6681). During an addendum AIS the following year, Hammermeister and McDermott (2007) identified a third historic property in the project area (also re-visited in the present study), SIHP # 50-80-08-6920. SIHP # -6920 is a rock mound interpreted as a traditional Hawaiian marker.

Section 4 Results of Fieldwork

CSH archaeologists David Crowell, M.S., and David Shideler, M.A., conducted fieldwork on 3 July 2018 under the general supervision of Principal Investigator Hallett H. Hammatt, Ph.D. The fieldwork, which included pedestrian inspection and GPS data collection, focused on relocating three historic properties (SIHP #s 50-80-08-6681, -6699, and -6920) identified during previous studies within the project area in order to assess their current conditions. SIHP #s -6681, World War II-era military bunker, and -6699, traditional Hawaiian rock shelter, were documented during a 2006 AIS by O'Leary and McDermott. SIHP # -6920, rock mound interpreted as a traditional Hawaiian marker, was documented during an addendum AIS by Hammermeister and McDermott the following year (2007). In addition, one historic property (Māui Rock, SIHP # 50-80-07-0148) and a *wahi pana* (Hina's Cave, no SIHP number) outside the present project area were also investigated and documented during the field inspection.

The pedestrian inspection generally proceeded from southwest to northeast (Figure 21 through Figure 23). The three historic properties previously identified within the project area were found to be in much the same condition as documented during the 2006 and 2007 studies. The concrete of SIHP # 50-80-08-6681, military bunker, is still in good condition; no significant damage or deterioration was noted, although additional graffiti was observed (Figure 24 through Figure 27). A small amount of modern rubbish was observed both inside and outside the bunker.

No indication of visitors, such as modern rubbish, was observed at the SIHP # 50-80-08-6699 rock shelter (Figure 28 and Figure 29). The soil on the rock shelter floor appeared undisturbed, and no rock fall was observed. A charred *kiawe* (*Prosopis pallida*) tree was noted approximately 1 m northwest of the rock shelter's opening, indicating a fire in the recent past. *Kiawe* saplings surround the opening.

The SIHP # 50-80-08-6920 rock mound was observed to contain small to large boulders with cobble infill (Figure 30). No signs of disturbance or visitors, including rubbish, were observed during the field inspection. Although grasses have grown around SIHP # -6920, the mound is still visible.

The Māui Rock (SIHP # 50-80-07-0148, named after the Hawaiian hero) and Hina's Cave (place where Māui's mother lived) were also found to be free of recent disturbance, with no rubbish or offerings (e.g., *lei*) observed. The view from Hina's Cave southwest toward the Māui Rock was found to be relatively clear, as the cave is sufficiently elevated above the filled land in between to maintain an unbroken view (Figure 31). However, the view from the rock northeast toward the cave is blocked by a residential duplex subdivision (Figure 32).

Detailed descriptions of SIHP #s 50-80-08-6681, -6699, and -6920 are presented in the following section.

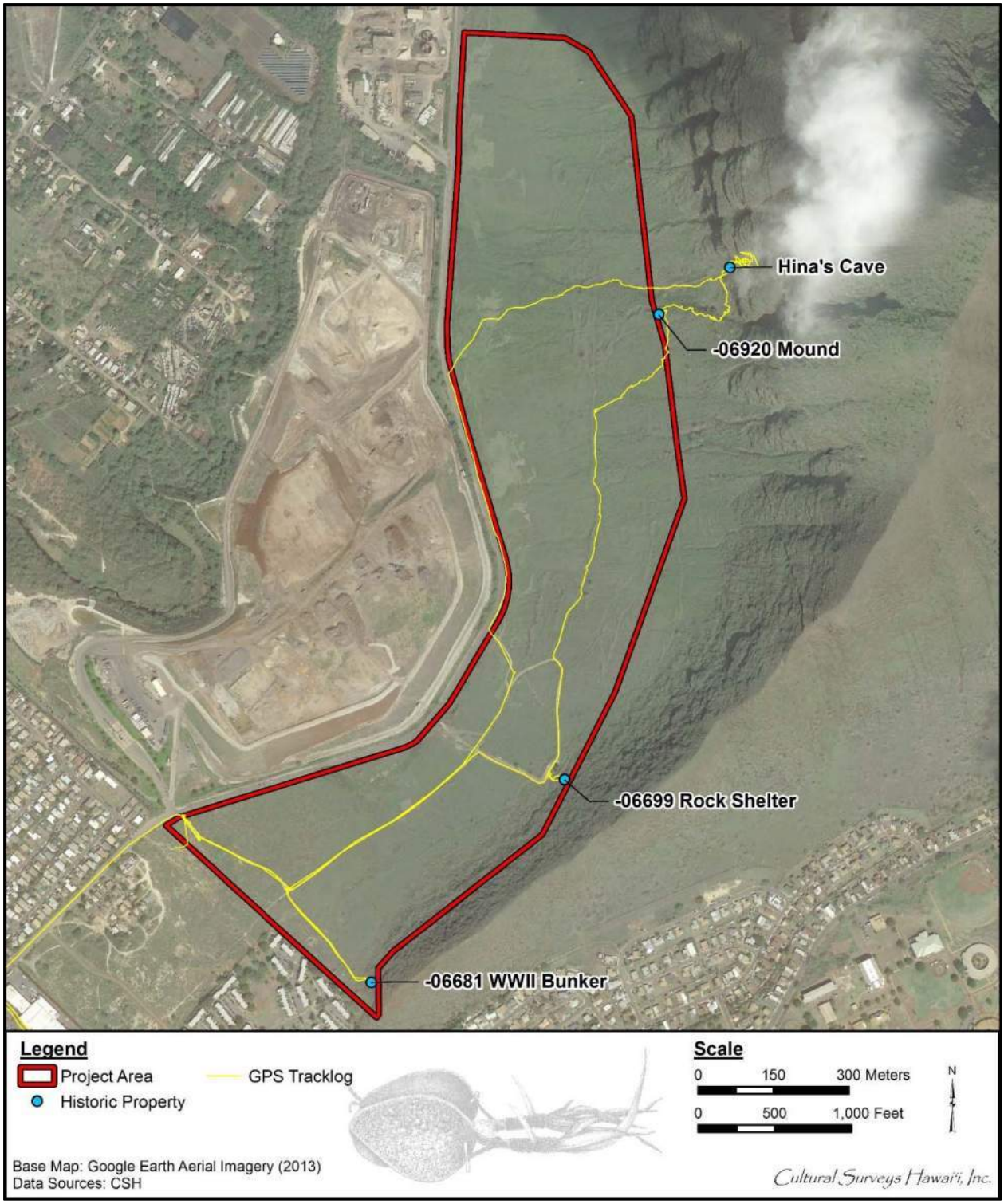

Figure 20. Aerial photograph with pedestrian inspection GPS track log, with marked locations of previously identified historic properties (Google Earth 2013)

Figure 21. View from SIHP # 50-80-08-6681, military bunker (visible at bottom), showing southwest portion of project area, view to northwest

Figure 22. View from SIHP # 50-80-08-6681, military bunker, showing southeast portion of project area, view to northeast

Figure 23. View from SIHP # 50-80-08-6699, rock shelter, showing north portion of project area, view to north

Figure 24. SIHP # 50-80-08-6681, military bunker, east wall, view to west

Figure 25. SIHP # 50-80-08-6681, military bunker, south wall, view to north

Figure 26. SIHP # 50-80-08-6681, military bunker, west wall, view to east

Figure 27. SIHP # 50-80-08-6681, military bunker, north wall, view to south

Figure 28. SIHP # 50-80-08-6699, rock shelter opening, view to east

Figure 29. Close-up of SIHP # 50-80-08-6699, rock shelter opening, view to south (clipboard for scale)

Figure 30. SIHP # 50-80-08-6920, mound (scale is 1 m)

Figure 31. View from Hina’s Cave looking toward SIHP # 50-80-07-0148, Māui Rock, view to southwest

Figure 32. View from SIHP # 50-80-07-0148, Māui Rock (on right), looking toward Hina’s Cave, view to northeast

Section 5 Historic Property Descriptions

Three previously identified historic properties (SIHP #s 50-80-08-6681, -6699, and -6920) were documented within the current project area during this field inspection. SIHP #s -6681, military bunker, and -6699, rock shelter, were initially documented during an AIS by O'Leary and McDermott (2006). SIHP # -6920 was documented during a subsequent addendum AIS by Hammermeister and McDermott (2007). These historic properties are summarized in Table 3, and their distributions are depicted on Figure 20. They are also described in detail below.

Table 3. Historic properties identified during the current field inspection

SIHP # 50-80-08	Formal Type	Function
-6681	Bunker	Military
-6699	Rock shelter	Temporary/intermittent habitation
-6920	Rock mound	Possible marker

5.1 SIHP # 50-80-08-6681

FORMAL TYPE:	Bunker
FUNCTION:	Military
NUMBER OF FEATURES:	1
AGE:	Post-Contact; likely World War II era
TEST EXCAVATIONS:	N/A
TAX MAP KEY:	[1] 8-7-009:007
LAND JURISDICTION:	PVT Land Company
PREVIOUS DOCUMENTATION:	O'Leary and McDermott 2006

SIHP # 50-80-08-6681 is close to the southernmost corner of the project area (see Figure 20). SIHP # -6681 is a concrete bunker measuring 3.9 m by 3.9 m, initially documented during the O'Leary and McDermott (2006) AIS. While the precise date of construction is not known, it is likely to have been constructed during the rapid build-up of coastal defensive fortifications in 1942 and 1943 during World War II.

5.1.1 Documentation of SIHP # 50-80-08-6681 by O'Leary and McDermott (2006)

O'Leary and McDermott (2006) described the bunker as being built into the *pāhoehoe* basalt hill and having a solid concrete slab roof approximately 75 cm thick. The bunker has a 1.95-m exposed vertical face on the seaward (west) side and 1.1 m on the uphill (east) side. The north, west, and south sides of the bunker have long, thin horizontal openings 25 cm tall and 3.3 m long. The exterior of the bunker has been vandalized liberally with spray paint, and modern trash was observed around the outside of the bunker. The entrance is along the east wall near the northeast corner of the bunker and measures 50 cm by 50 cm. There is approximately a 1-m drop from the bottom of the entrance to the dirt floor inside the bunker. The interior measures 3.0 m by 3.0 m and is 1.9 m tall. The inside of the bunker is also covered in spray paint. Basalt boulders have been

placed within the bunker, and there is evidence of modern fires and abundant trash. Metal armament mounting brackets are still in place beneath the bunker's window slits (see Figure 42). Figure 33 through Figure 42 show the outside and inside of the historic property as documented by O'Leary and McDermott (2006).

5.1.2 Documentation of SIHP # 50-80-08-6681 during the Current Study

During the current field inspection, SIHP # -6681 was found to be almost completely unchanged since the 2006 AIS by O'Leary and McDermott (see Figure 24 through Figure 27). The concrete is still in good condition, and no significant damage or deterioration was noted, although additional graffiti was observed on the exterior. A small amount of modern rubbish was observed both inside and outside of the bunker.

5.1.3 Significance Assessments and Previous Eligibility Evaluations

SIHP # 50-80-08-6681 was previously evaluated by O'Leary and McDermott (2006) as eligible for listing on the State of Hawai‘i Register of Historic Places (Hawai‘i Register) per HAR §13-198-8 under Criteria A (property reflects major trends or events in the history of the state or nation) and D (historic property has yielded or may be likely to yield information important in prehistory or history). O'Leary and McDermott (2006) assert that SIHP # -6681, a World War II-era bunker, is part of a pivotal point in both the history of the state of Hawai‘i as well as the United States. Its location is strategic, and when examined in the context of broader defensive fortifications such as Battery Arizona, can provide information on the military planning by the United States during the war. While the bunker has been covered with graffiti and trash, the site has not been structurally damaged and offers information about construction techniques of military defensive fortifications.

Based on the results of the current LRFI field inspection and the description and Hawai‘i Register eligibility evaluation by O'Leary and McDermott (2006), SIHP # 50-80-08-6681 is assessed as significant pursuant to HAR §13-284-6 under Criteria a (Be associated with events that have made an important contribution to the broad patterns of our history) and d (Have yielded, or is likely to yield, information important for research on prehistory or history) and retains sufficient integrity of location, design, materials, setting, and workmanship.

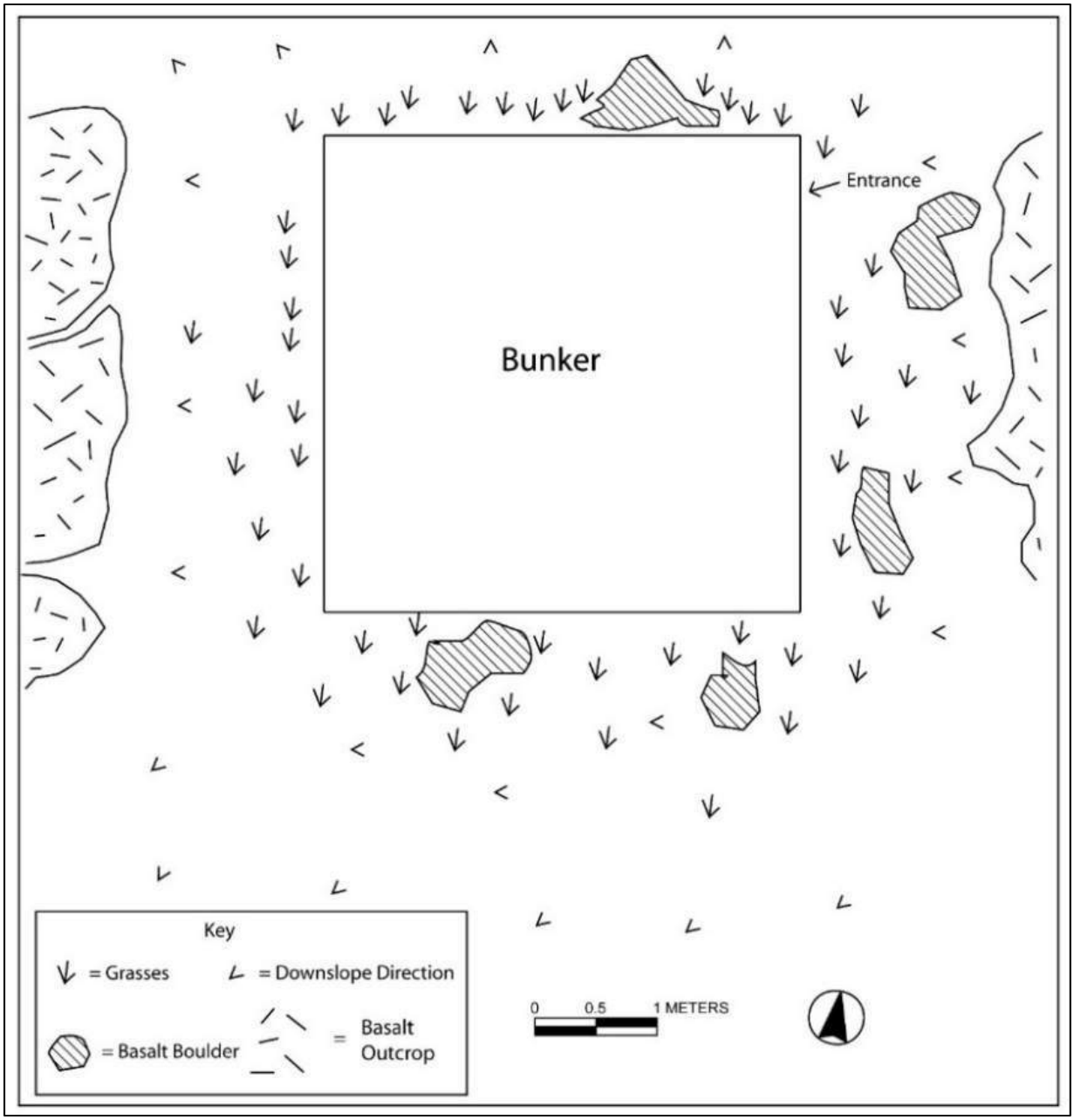

Figure 33. Plan map of SIHP # 50-80-08-6681, military bunker (O’Leary and McDermott 2006)

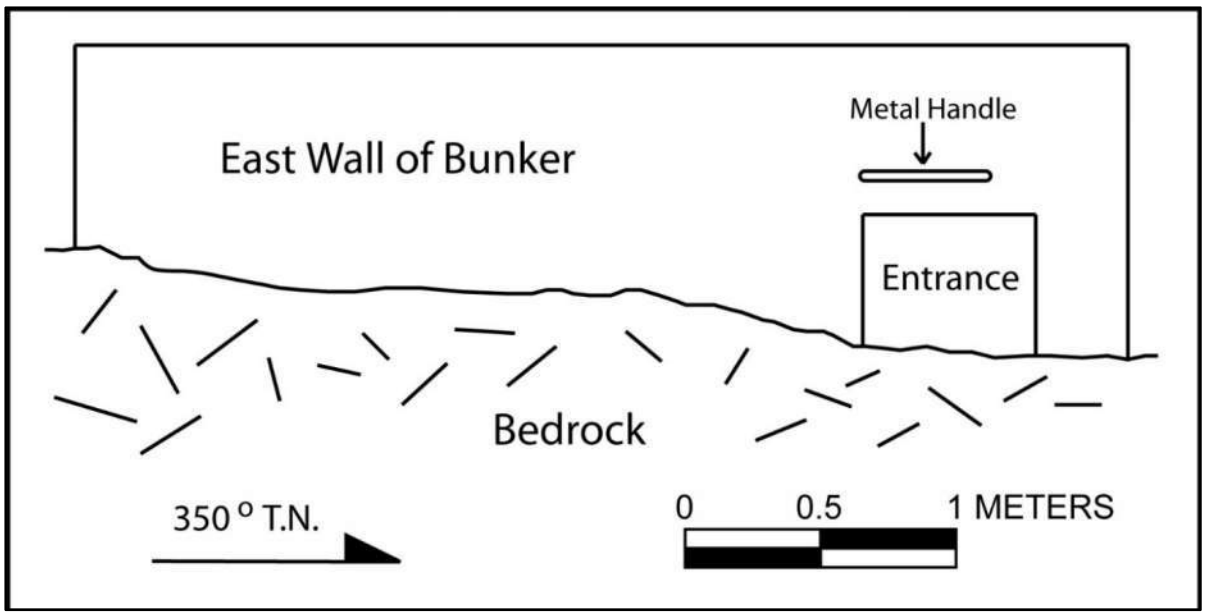

Figure 34. Profile of the east wall of SIHP # 50-80-08-6681 (O’Leary and McDermott 2006)

Figure 35. SIHP # 50-80-08-6681 east wall, view to west (O’Leary and McDermott 2006)

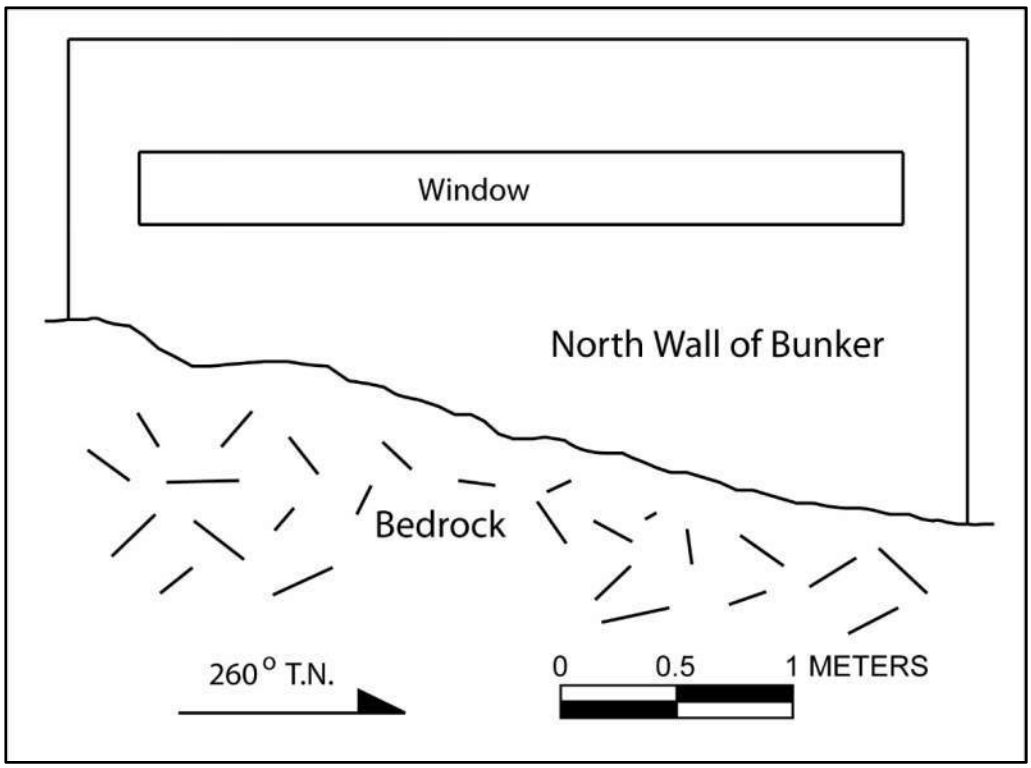

Figure 36. Profile of the north wall of SIHP # 50-80-08-6681 (O’Leary and McDermott 2006)

Figure 37. SIHP # 50-80-08-6681 north wall, view to south (O’Leary and McDermott 2006)

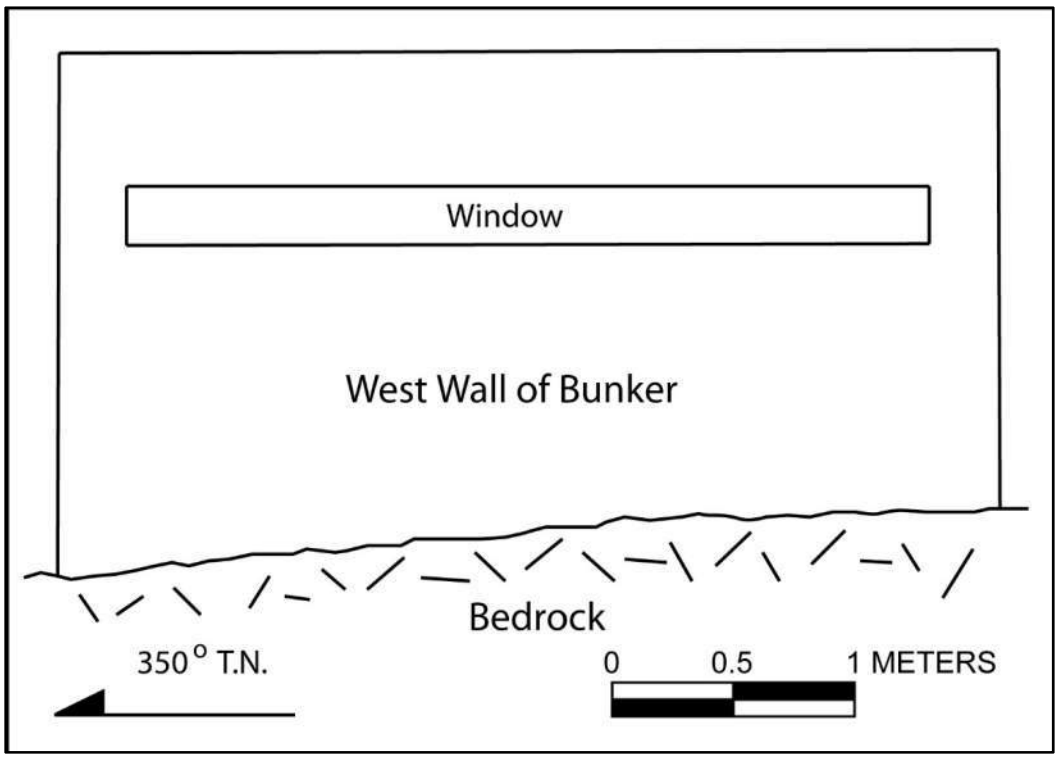

Figure 38. Profile of the west wall of SIHP # 50-80-08-6681 (O’Leary and McDermott 2006)

Figure 39. SIHP # 50-80-08-6681 west wall, view to east (O’Leary and McDermott 2006)

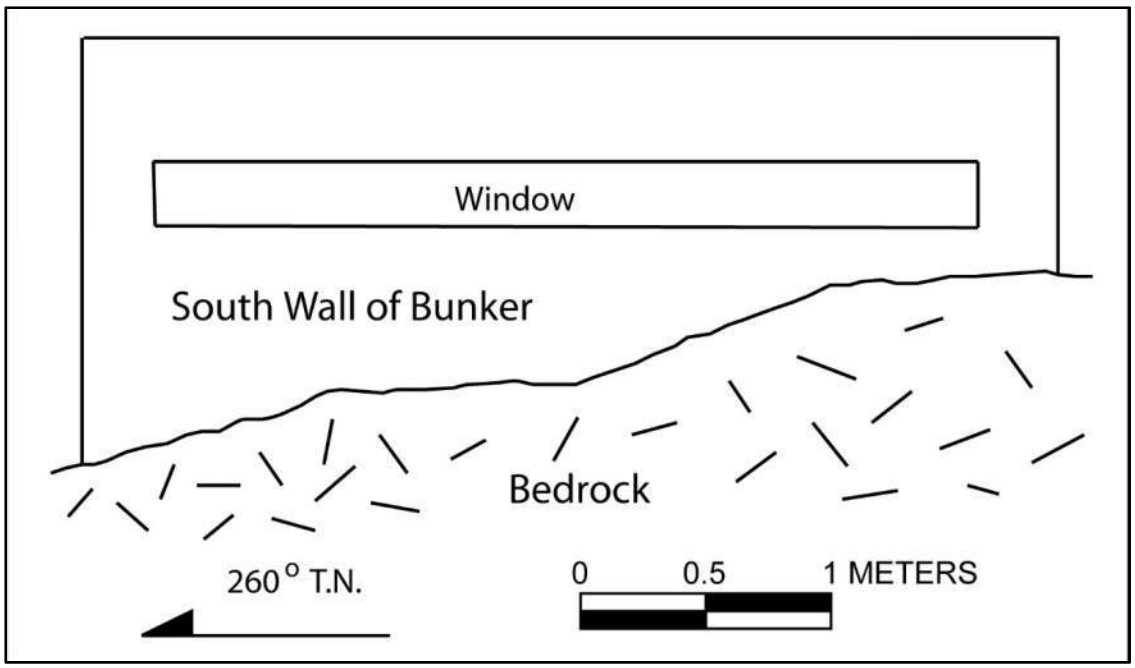

Figure 40. Profile of the south wall of SIHP # 50-80-08-6681 (O’Leary and McDermott 2006)

Figure 41. SIHP # 50-80-08-6681 south wall, view to northwest (O’Leary and McDermott 2006)

Figure 42. View looking out of the north window of SIHP # 50-80-08-6681 showing armament mounting brackets, view to northwest

5.2 SIHP # 50-80-08-6699

FORMAL TYPE:	Rock shelter
FUNCTION:	Habitation
NUMBER OF FEATURES:	2
AGE:	Likely late pre-Contact (1480-1680 cal AD [81.4%])
TEST EXCAVATIONS:	Test Units # 1 and 2 (O'Leary and McDermott 2006)
TAX MAP KEY:	[1] 8-7-009:007
LAND JURISDICTION:	PVT Land Company
PREVIOUS DOCUMENTATION:	O'Leary and McDermott 2006

SIHP # 50-80-08-6699 is a small *pāhoehoe* basalt rock shelter in the southeast portion of the project area (see Figure 20), initially documented during the O'Leary and McDermott (2006) AIS (Figure 43 and Figure 44).

5.2.1 Documentation of SIHP # 50-80-08-6699 by O'Leary and McDermott (2006)

The rock shelter's floor surface consisted of loose silty clay with numerous subangular basalt pebbles, cobbles, and boulders. Two basalt flakes were discovered on the surface, indicating the potential for subsurface cultural deposits. Two contiguous test units were excavated within the rock shelter to determine the presence or absence of, and collect appropriate samples from, any subsurface cultural deposits (Figure 45). The test units also provided the opportunity to investigate the rock shelter's depositional history.

5.2.1.1 Test Unit #1

Excavation dimensions: 1 m by 1 m

Test Unit #1 was placed centrally within the rock shelter and completely underneath the basalt overhang. All surface rocks were inspected to see if they were artifacts, and those that demonstrated evidence of human modification were collected; the rest were set aside. Two subsurface features were identified (Figure 46). Feature 1 is a small charcoal and ash concentration, and Feature 2 is a small scoop hearth measuring 35 cm by 40 cm. When the hearth was created, the depression was dug down into the culturally sterile Stratum IV, natural silty clay. The hearth contained a thick lens (4 cm) of charcoal above a thinner lens of ash (1–2 cm). These features are not shown in the stratigraphic profile of the northeast wall (Figure 47 and Figure 48) because both features were identified within the test unit floor (see Figure 46). Test Unit #1 stratigraphy was described as follows:

Stratum I: 0–4 cmbs	10 YR 2/2, very dark brown; very fine to fine silty clay; structureless; loose, dry consistence; plastic; no cementation; clear, smooth lower boundary. Very loose aeolian over a much more compact layer II. Contains animal bone, *kukui* nut, basalt flakes, marine shell, and charcoal.

Figure 43. SIHP # 50-80-08-6699, rock shelter, view to east (O’Leary and McDermott 2006)

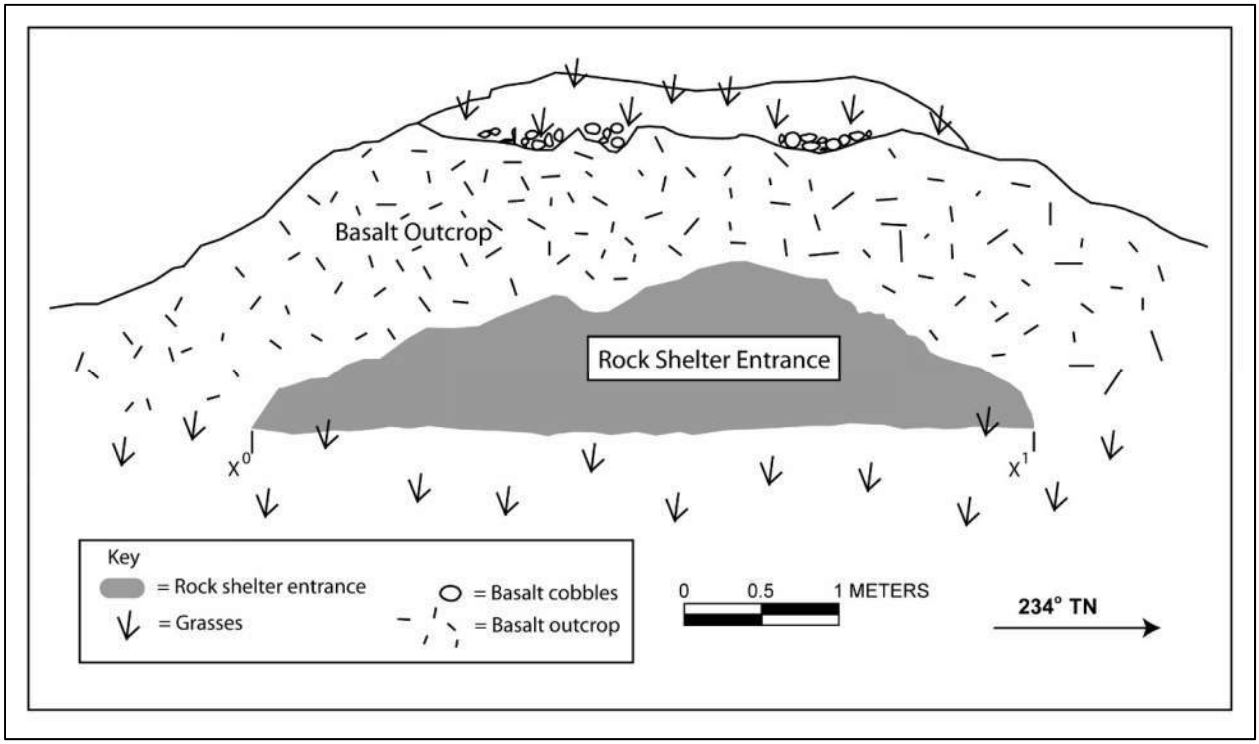

Figure 44. Cross-section of SIHP # 50-80-08-6699 rock shelter entrance

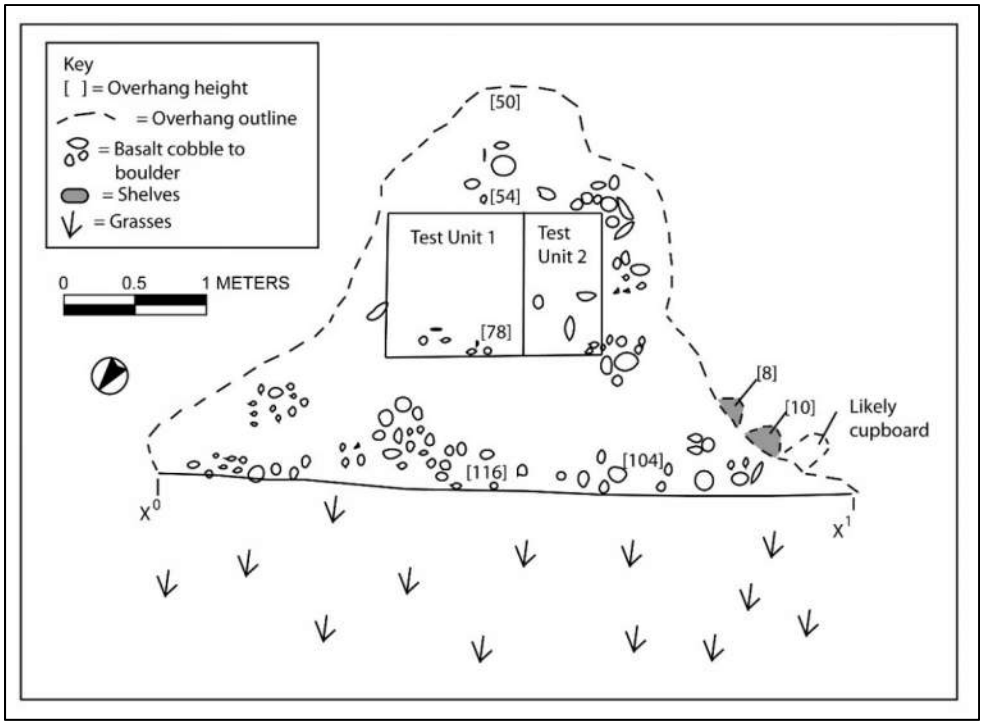

Figure 45. Plan map of SIHP # 50-80-08-6699, rock shelter, showing test unit locations (O’Leary and McDermott 2006)

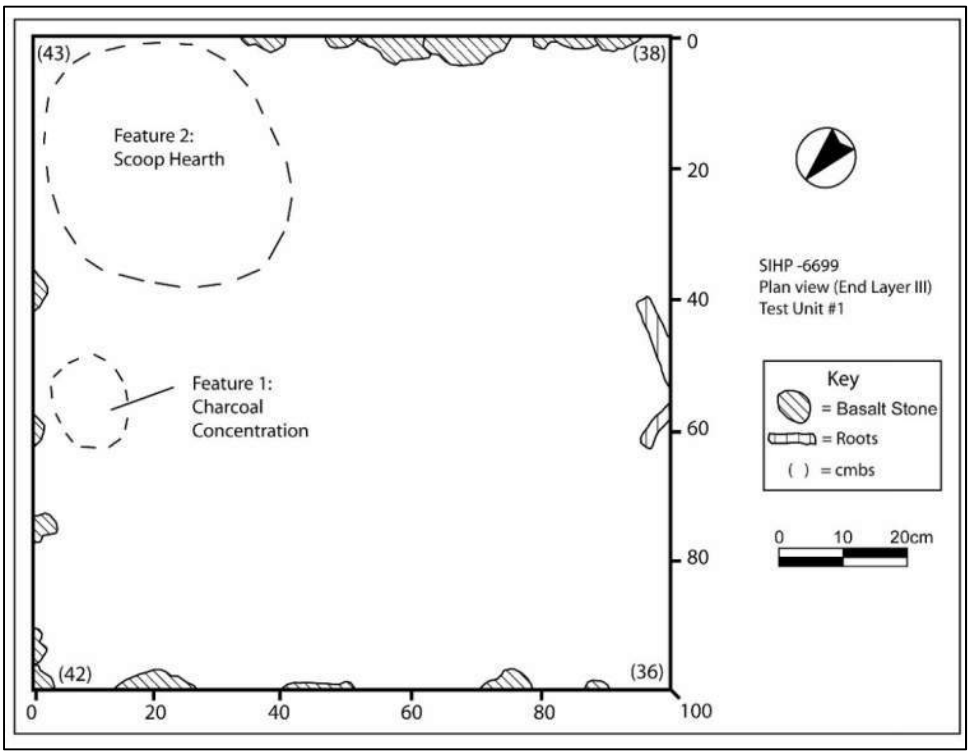

Figure 46. Plan map of Test Unit #1 showing SIHP # 50-80-08-06699 Features 1 (hearth) and 2 (charcoal concentration) (O’Leary and McDermott 2006)

Stratum II: 4–24 cmbs	A Horizon; 10 YR 2/2, very dark brown; very fine to fine silty clay; very coarse, subangular, blocky structure; very hard, dry consistence; plastic; strong cementation; abrupt, wavy lower boundary. Strong soil development with many gravel to cobble-sized basalt inclusions. Contains charcoal, marine shell, basalt flakes, animal bone, kukui nut, volcanic glass, and a shell preform.
Stratum III: 24–42 cmbs	B Horizon; 10 YR 3/3, dark brown; very fine to fine silty clay; weak, fine, crumb structure; hard, dry consistence; plastic; weak cementation; abrupt, wavy lower boundary. This layer contained Features 1 and 2, both of which were sampled and floated. A charcoal sample from Feature 2 was submitted for radiocarbon dating analysis. The sediment from the entire layer was bagged and wet screened through 1/8 inch mesh in the lab. Charcoal, basalt flakes, volcanic glass, animal bone, and shell were present.
Stratum IV: 42–43/50 cmbs	10 YR 3/4, dark yellowish brown; very fine to fine silty clay; structureless; extremely hard, dry consistence; plastic; indurated; very abrupt, broken lower boundary. This is a sterile clay layer with a very small amount of silt in it. The layer overlies the bedrock. This stratum is sterile of cultural material.

5.2.1.2 Test Unit #2

Excavation dimensions: 1 m by 0.5 m

The unexpectedly successful results of Test Unit #1 prompted the excavation of a second test unit within the rock shelter to recover further archaeological materials. Test Unit #2 was immediately adjacent to the southwest of Test Unit #1 (see Figure 45). The natural shape of the rock shelter constrained the size of the second test unit. The stratigraphy in Test Unit #2 exactly matched that of Test Unit #1, except that no hearths were uncovered (Figure 49 and Figure 50). The in-filled rodent burrow in the south corner of Strata III and IV was the only feature of note. Test Unit #2 stratigraphy was described as follows:

Stratum I: 0–4/8 cmbs	10 YR 2/2, very dark brown; very fine to fine silty clay; structureless; loose, dry consistence; plastic; no cementation; clear, smooth lower boundary. Very loose aeolian sediments over a much more compact layer II. Contains animal bone.
Stratum II: 4/8–28 cmbs	A Horizon; 10 YR 2/2, very dark brown; very fine to fine silty clay; very coarse, subangular, blocky structure; very hard, dry consistence; plastic; strong cementation; abrupt, wavy lower boundary. Strong soil development with many gravel to cobble-sized basalt inclusions. Contains charcoal, marine shell, basalt flakes, animal bone, coral, and volcanic glass.

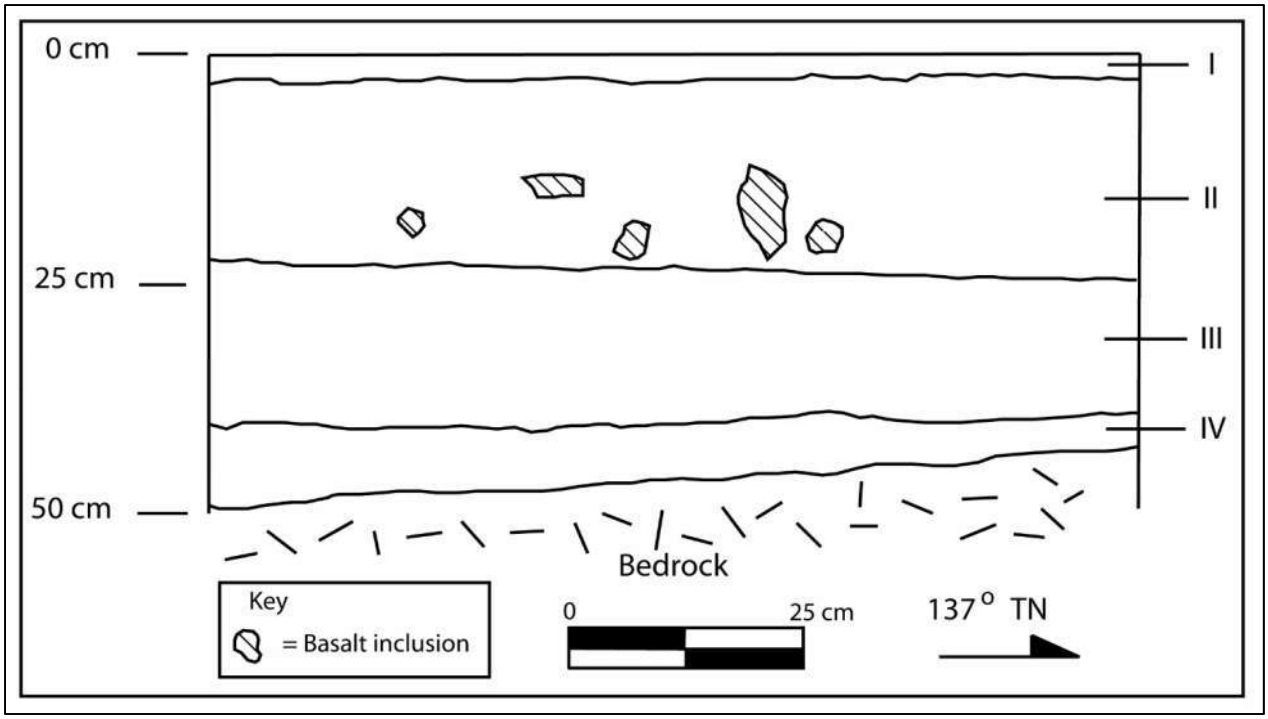

Figure 47. Test Unit # 1 northeast wall profile (O’Leary and McDermott 2006)

Figure 48. Test Unit # 1 northeast wall, view to northeast

Stratum III: 28–43 cmbs	B Horizon; 10 YR 3/3, dark brown; very fine to fine silty clay; weak, fine, crumb structure; hard, dry consistence; plastic; weak cementation; abrupt, wavy lower boundary. This layer contained an in-filled rodent burrow, charcoal, volcanic glass, basalt flake, coral, and animal bone.
Stratum IV: 43/50 cmbs	10 YR 3/4, dark yellowish brown; very fine to fine silty clay; structureless; extremely hard, dry consistence; plastic; indurated; very abrupt, broken lower boundary. This is a sterile clay layer with a very small amount of silt in it. The layer overlies the bedrock.

5.2.1.3 Summary of Excavation and Recovered Remains

Prior to human use of the rock shelter, a layer of silty clay (Stratum IV) accumulated, most likely through low energy aeolian mechanisms. At the time of first human use of the site, there would have been approximately 1.15 m between the floor and ceiling of the rock shelter. On at least one occasion, a shallow (3–5 cm) depression was excavated down into the sterile sediment to create a small scoop hearth (Feature 2). A fire was burnt, filling the scoop hearth with ash and charcoal. Remnants from the scoop hearth possibly account for the concentration of charcoal that makes up Feature 1. The ash lenses seen in the profile of Test Unit 2 are also possibly the result of the scoop hearth being cleaned out; alternatively, they could be separate combustion events.

Aeolian sediment (Stratum III) was deposited over time as people continued to periodically use the rock shelter, possibly building more small fires. Stratum III showed a small amount of soil formation in the form of fine, crumb-like peds. Stratum II was distinguishable from the underlying Stratum III largely because of its large, blocky peds, which indicate this sediment remained relatively undisturbed while soil formation occurred. Stratum II’s lack of evidence for in situ fires may indicate burning no longer took place within the cave as Stratum II accumulated; more likely based on the charcoal recovered from this layer, that burning took place in other portions of the rock shelter. Stratum I, which formed the floor of the rock shelter at the time of the 2006 AIS, was the same fine-grained silty clay that made up the matrix of the lower strata. Stratum I was very loosely compacted and had not undergone soil formation processes.

Artifacts found within the site suggest the rock shelter was used for temporary habitation on what was probably an infrequent basis. Coral, marine shell, and a single fish bone indicate materials were being transported approximately 1.25 miles from the nearby Wai‘anae coast. The large amount of rat (*Rattus exulans*) bone, none of which was burnt, and the in-filled rodent nest indicate rats were likely scavenging on the remains left behind by humans and later using the rock shelter as their home. The numerous rat bones also indicated bioturbation has possibly moved the archaeological materials within and between the deposits.

A small quantity of volcanic glass demonstrates that humans were using and manipulating tools within the cave. The overall small size (< 1.5 cm) of the volcanic glass flakes suggests tools were being reworked and retouched for further use, rather than being manufactured at the site. In addition, despite noting the presence of quality basalt for stone tools, very little of this material was present within the rock shelter.

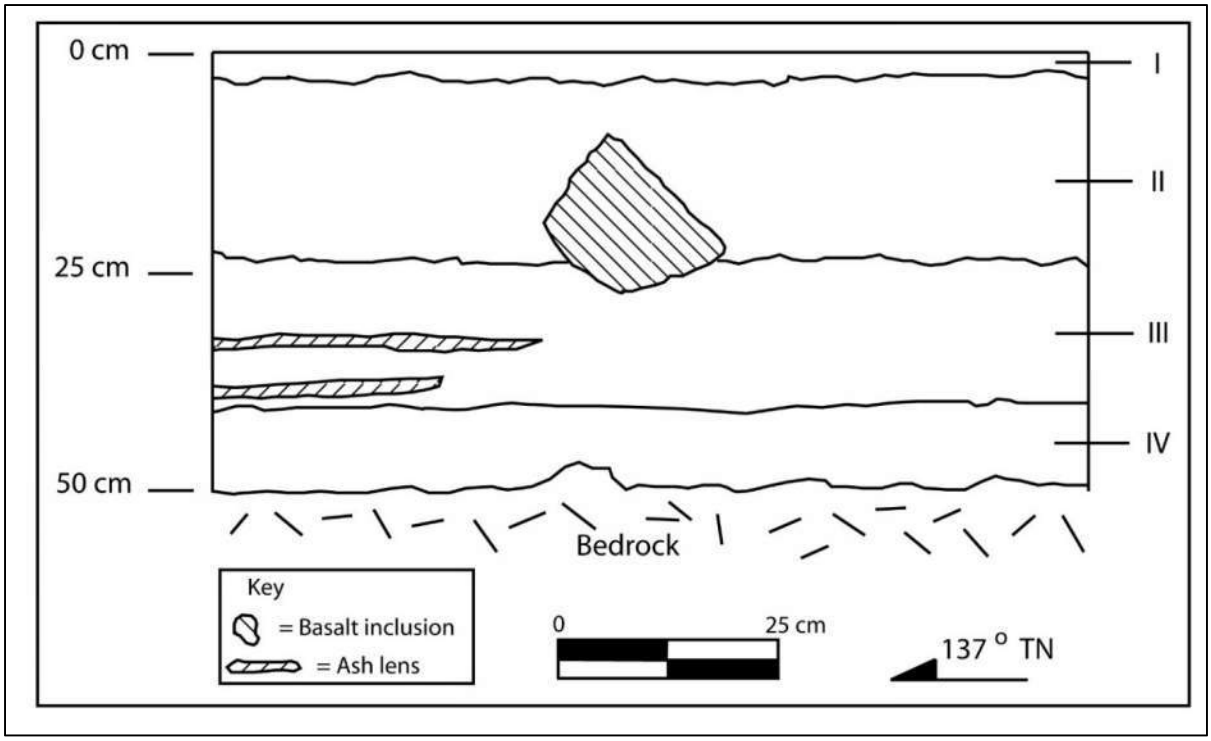

Figure 49. Test Unit #2 southwest wall profile (O’Leary and McDermott 2006)

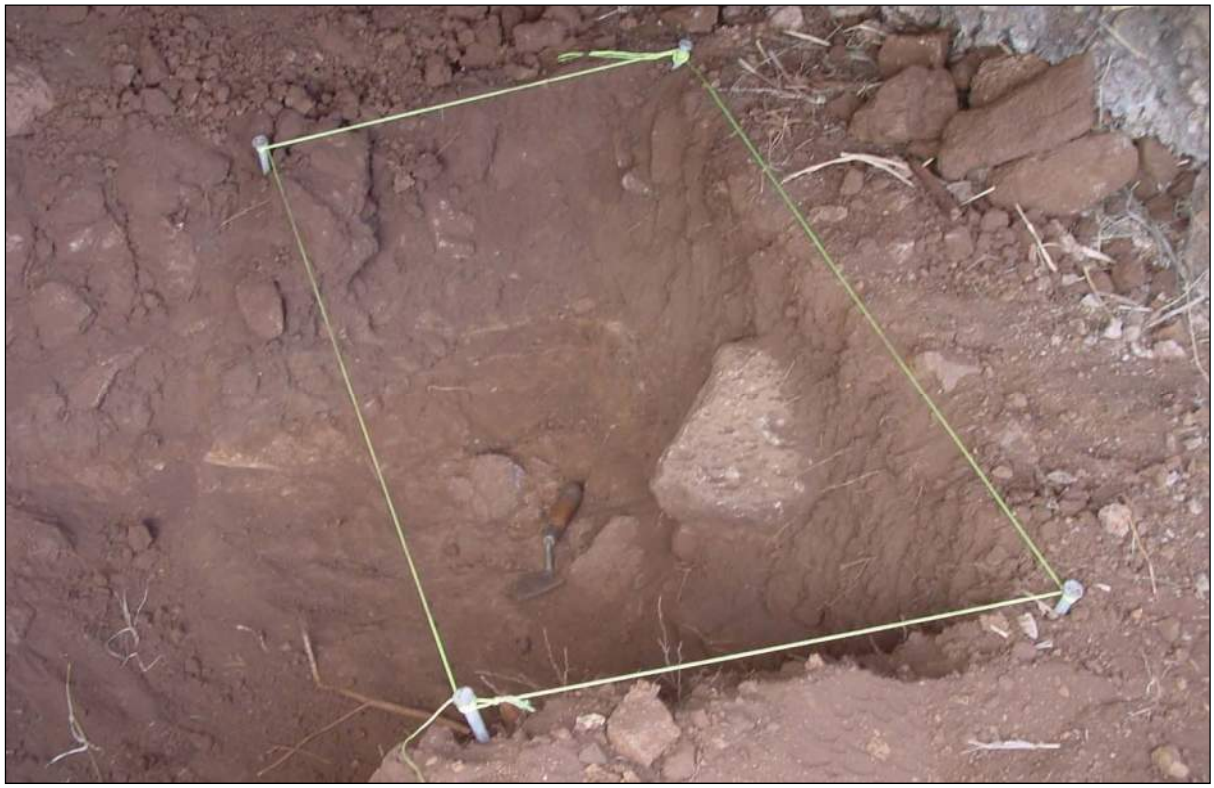

Figure 50. Test Unit #2 after excavation, view to south (profiled southwest wall on right)

The charcoal sample submitted to Beta Analytic for radiocarbon dating yielded two-sigma, calibrated date ranges of AD 1480-1680 (81.4%), AD 1730-1810 (11.8%), and AD 1930-1960 (2.2%). Taking into account the lack of post-Contact materials, the radiocarbon results indicate the lower layer of deposition in SIHP # -6699 is most likely not modern and dates to the late pre-Contact period.

5.2.2 Documentation of SIHP # 50-80-08-6699 during the Current Study

During the current field inspection, SIHP # -6699 was found to be almost completely unchanged since the 2006 AIS by O’Leary and McDermott. No indication of visitors, such as modern rubbish, was observed at the SIHP # -6699 rock shelter (see Figure 28 and Figure 29). The soil on the rock shelter floor appeared undisturbed, and no rock fall was observed. A charred *kiawe* (*P. pallida*) tree was noted approximately 1 m northwest of the rock shelter’s opening, indicating a fire in the recent past. *Kiawe* saplings surround the opening.

5.2.3 Significance Assessments and Previous Eligibility Evaluations

SIHP # -6699 was previously evaluated by O’Leary and McDermott (2006) as eligible for listing on the Hawai‘i Register per HAR §13-198-8 under Criterion D (historic property has yielded or may be likely to yield information important in prehistory or history. During the O’Leary and McDermott (2006) AIS, the historic property yielded general information concerning traditional Hawaiian land use in the project area. The location of this rockshelter—between the coast and *mauka* sections of Lualualei—is also significant because it is in an area of the leeward side of O‘ahu for which there is relatively little information. While many historic properties have been documented both along the coast and in the *mauka* portions of the *ahupua‘a*, SIHP # -6699 is in between those two areas. The intact layers of fine-grained sediments deposited in a low energy environment left cultural features, such as hearths, undisturbed within the rock shelter providing detailed information during the O’Leary and McDermott (2006) study.

Based on the results of the current LRFI field inspection and the description and Hawai‘i Register eligibility evaluation by O’Leary and McDermott (2006), SIHP # 50-80-08-6699 is assessed as significant pursuant to HAR §13-284-6 under Criterion d (Have yielded, or is likely to yield, information important for research on prehistory or history) and retains sufficient integrity of location, design, materials, setting, and workmanship.

5.3 SIHP # 50-80-08-6920

FORMAL TYPE:	Rock mound
FUNCTION:	Possible marker
NUMBER OF FEATURES:	1
AGE:	Likely Pre-Contact
TEST EXCAVATIONS:	Test Unit 1 (Hammermeister and McDermott 2007)
TAX MAP KEY:	[1] 8-7-009:007
LAND JURISDICTION:	PVT Land Company
PREVIOUS DOCUMENTATION:	Hammermeister and McDermott 2007

SIHP # 50-80-08-6920 consists of a small, roughly circular rock mound on the lower western slope of Pu‘u Heleakalā, approximately 420 m east of Lualualei Naval Road, on the eastern boundary of the project area (see Figure 20). It was initially documented during the Hammermeister and McDermott (2007) addendum AIS. While SIHP # -6920's function could not be determined definitively, Hammermeister and McDermott (2007) noted similar features from similar contexts had previously been interpreted as traditional Hawaiian markers (e.g., for trails or boundaries); hence, SIHP # -6920 is interpreted as a likely pre-Contact marker.

5.3.1 Documentation of SIHP # 50-80-08-6920 by Hammermeister and McDermott (2007)

SIHP # -6920 is composed of basalt boulders and cobbles piled aginst the sloping hillside (Figure 51, Figure 52). The basalt stones used for the site's construction are locally available from talus and exposures of bedrock along the surrounding eroding slope. The mound is roughly circular in plan view and approximately 2 m in diameter. Large boulders form the periphery, while small boulders and cobbles form the center. A small section of the mound's north side is faced, and its upper surface is gently sloping, roughly following the natural fall line of the surrounding hillside. No surface artifacts or cultural materials were observed on the mound or its vicinity.

5.3.1.1 Test Unit 1

A 0.5 by 1.0-m test excavation was excavated within the southern portion of SIHP # -6920 to better determine the age and function of the historic property (see Figure 52). The test unit was oriented to minimize disturbance and facilitate post-excavation reconstruction. The stratigraphy was composed primarily of boulder and cobble fill associated with the mound feature, with little fine-grained sediment. The natural decomposing bedrock (C horizon) was near the surface. The stratigraphy of Test Unit 1 was described as follows: "Stratum I, the boulder and cobble rock fill associated with the mound's construction; Stratum [sic] II and III, structureless silts; and Stratum IV, the decomposing bedrock C-horizon" (Hammermeister and McDermott 2007:5) (Figure 53 and Figure 54). No cultural material was observed during excavation of the test unit.

5.3.2 Documentation of SIHP # 50-80-08-6920 during the Current Study

During the current field inspection, SIHP # -6920 was found to be almost completely unchanged since the 2007 addendum AIS by Hammermeister and McDermott. The mound was observed to contain small to large boulders with cobble infill (see Figure 30). No signs of disturbance or recent visitors, including rubbish, were observed during the field inspection. Although grasses have grown around SIHP # -6920, the mound is still visible.

Figure 51. SIHP # 50-80-08-6920, mound, view to east (Hammermeister and McDermott 2007)

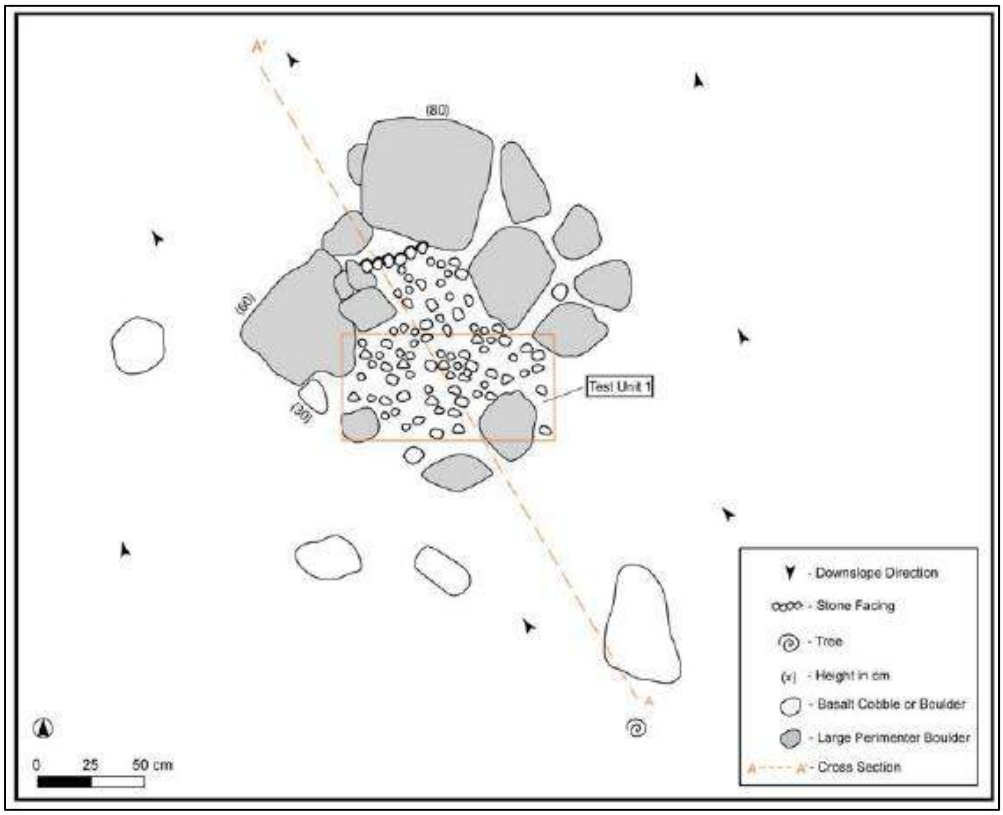

Figure 52. Plan map of SIHP # 50-80-08-6920, mound, showing test unit location (Hammermeister and McDermott 2007)

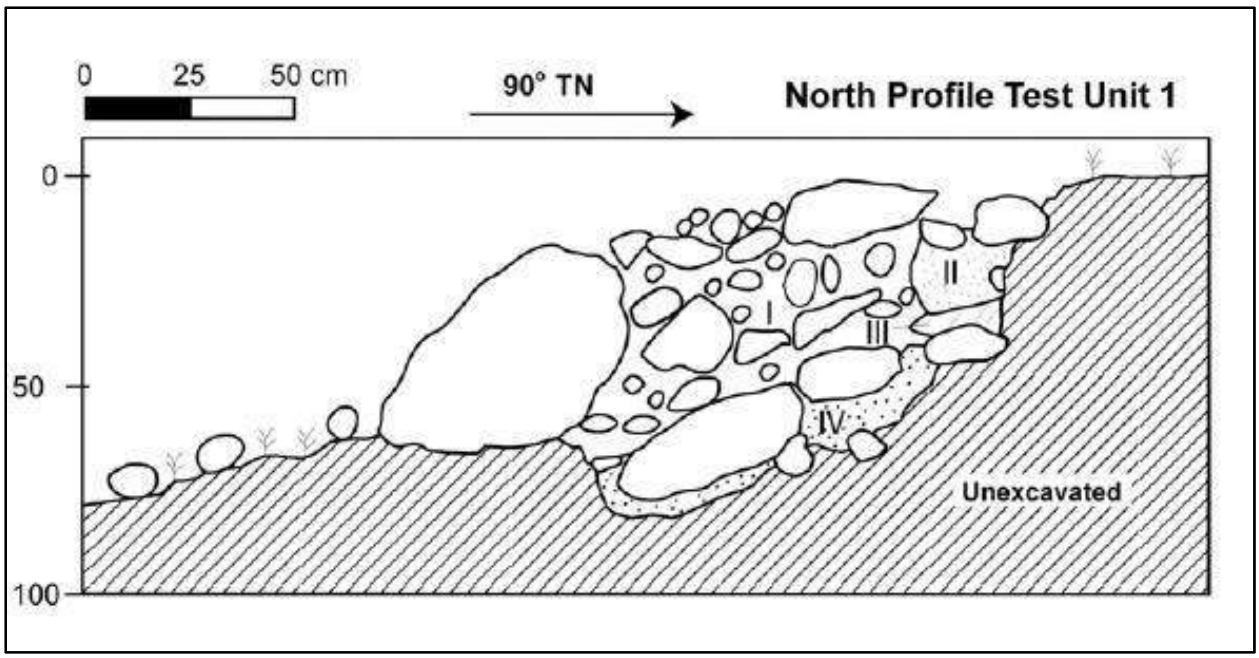

Figure 53. Test Unit 1 north wall profile (Hammermeister and McDermott 2007)

Figure 54. Test Unit 1 north wall, view to north (Hammermeister and McDermott 2007)

5.3.3 Significance Assessments and Previous Eligibility Evaluations

SIHP # -6699 was previously evaluated by Hammermeister and McDermott (2007) as eligible for listing on the Hawai‘i Register per HAR §13-198-8 under Criterion D (historic property has yielded or may be likely to yield information important in prehistory or history.

Based on the results of the current LRFI field inspection and the description and Hawai‘i Register eligibility evaluation by Hammermeister and McDermott (2007), SIHP # 50-80-08-6699 is assessed as significant pursuant to HAR §13-284-6 under Criterion d (Have yielded, or is likely to yield, information important for research on prehistory or history) and retains sufficient integrity of location, design, materials, setting and workmanship. The historic property significance assessment is based on the potential for the historic property to provide information about pre-Contact or early post-Contact activities in the area.

Section 6 Summary and Recommendations

The current field inspection focused on locating three historic properties (SIHP #s 50-80-08-6681, -6699, and -6920) identified during previous studies within the project area in order to assess their current conditions. SIHP #s -6681, World War II-era military bunker, and -6699, traditional Hawaiian rock shelter, were documented during a 2006 AIS by O'Leary and McDermott. SIHP # -6920, rock mound interpreted as a traditional Hawaiian marker, was documented during an addendum AIS by Hammermeister and McDermott (2007).

The three historic properties were found to be in much the same condition as documented during the 2006 and 2007 studies. SIHP # -6681, military bunker, was previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places under Criteria A (property reflects major trends or events in the history of the state or nation) and D (historic property has yielded or may be likely to yield information important in prehistory or history) by O'Leary and McDermott (2006). SIHP #s -6699, rock shelter, and -6920, rock mound, were previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places solely under Criterion D by O'Leary and McDermott (2006) and Hammermeister and McDermott (2007), respectively.

Based on the results of the current LRFI field inspection and the description and Hawai‘i Register eligibility evaluation by O'Leary and McDermott (2006), SIHP # 50-80-08-6681 is assessed as significant pursuant to HAR §13-284-6 under Criterion a and d, and SIHP # 50-80-08-6699 and -6920 are assessed as significant pursuant to HAR §13-284-6 only under Criterion d.

Both AIS studies recommended the project-specific effect determination for the archaeological historic properties to be "no historic properties affected". Hammermeister and McDermott (2007) recommended no further historic preservation work for SIHP #s -6681 and -6920.

However, due to the proximity of SIHP # -6699 to the project area, it was recommended that interim protection measures be installed to ensure no construction activities adversely affect the historic property. CSH prepared a preservation plan (Tulchin and Hammatt 2007) to protect the historic property from construction activity. The preservation plan recommended demarcation of an 8-m (26-ft) buffer zone surrounding the historic property for protection from construction activity. The suggested buffer zone would be established using a 35-m (115-ft) long steel post and wire or chain link fence. Additionally, natural vegetation will not be cleared from the historic property, further obscuring the rock shelter's location as an additional means of protection.

As there has been little to no change to the project area, and the current study has determined that the O'Leary and McDermott (2006) and Hammermeister and McDermott (2007) AIS's for the project are sufficient for the purposes of historic property identification. The current report also concurs with the O'Leary and McDermott (2006) and Hammermeister and McDermott (2007) AIS's previous assessments and recommendations for all historic properties identified within the project area.

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Appendix A SHPD Correspondence

SHPD Acceptance for the O’Leary and McDermott 2006 AIS

LUA-L6

LINDA LINGLE
GOVERNOR OF HAWAII

PETER T. YOUNG
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
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KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

January 5, 2006

Mr. Owen O’Leary
Cultural Surveys of Hawai‘i, Inc.
P.O. Box 1114
Kailua, Hawai‘i 96734

LOG NO: 2007.0053
DOC NO: 0701amj06
Archaeology

Dear Mr. O’Leary:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Revised Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Lualualei Ahupua‘a, Wai‘anae District, Island of O‘ahu
TMK: (1) 8-7-009:001 (portion)

Thank you for submitting the revised report by O’Leary and McDermott (2006), which we received on December 17, 2006. Two historic properties were identified in the project area: SIHP No. 50-80-08-6699, a small pre-Contact rockshelter, and SIHP No. 50-80-08-6681, a World War II concrete bunker. Site 6699 was tested (excavated), yielding basalt and volcanic-glass flakes and debitage, coral, and shell. One radiocarbon sample was dated to 270±50 BP, and calibrated to the pre-Contact period.

In a letter (LOG NO: 2006.3673, DOC NO: 0611amj04) dated November 3, 2006, we reviewed an earlier version of this report. We requested two minor changes and one more substantial revision (*i.e.,* regarding the mitigation of Site 6699). You have made the changes to our satisfaction.

You have assessed both sites (6681 and 6699) as eligible for the Hawai‘i Register of Historic Places under criterion D. Site 6681 is also eligible under criterion A. We concur with these significance assessments. You have changed the mitigation recommendation to preservation for Site 6699. We concur with this recommendation, and look forward to receipt of a preservation plan, which will need to be approved and implemented prior to any ground disturbance near the site.

The archaeological inventory survey is accepted in fulfillment of HAR 13-284 and 13-276.

Please contact Mr. Adam Johnson (O‘ahu Assistant Archaeologist) at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Melanie Chinen, Administrator
State Historic Preservation Division

amj:

SHPD Acceptance for the Hammermeister and McDermott 2006 Addendum AIS

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

LAURA H. THIELEN
CHAIRPERSON
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RUSSELL Y. TSUJI
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KEN C. KAWAHARA
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KAHOOLAWE ISLAND RESERVE COMMISSION
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STATE PARKS

February 27, 2008

Matt McDermott
Cultural Surveys Hawai‘i, Inc.
P.O. Box 1114
Kailua, Hawai‘i 96734

LOG NO: 2007.3341
DOC NO: 0802ED31
Archaeology

Dear Mr. McDermott:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Addendum to the Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Lualualei Ahupua‘a, Wai‘anae District, Island of O‘ahu
TMK: (1) 8-7-009:001 por.

Thank you for submitting the aforementioned report (O'Leary and McDermott, December 2006), which we received on September 8, 2007. We apologize for the delay in responding. Submitted to SHPD was the AIS report, accepted on January 5, 2007 (LOG NO: 2007.0053, DCO No: 0701amj06), and the addendum to the AIS report (Hammermeister and McDermott, May 2007).

This addendum adequately addresses the one minor change we requested of the previously submitted addendum. We accept this report as final.

Please contact Teresa Davan at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy McMahon, Acting Archaeology Branch Chief
State Historic Preservation Division

ED

Lualua 5

SHPD Acceptance for the Tulchin and Hammatt 2007 Preservation Plan

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

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December 10, 2007

Matt McDermott
Cultural Surveys Hawai'i, Inc.
P.O. BOX 1114
Honolulu, Hawai'i 96734

LOG NO: 2007.1713
DOC NO: 0712ED11
Archaeology

Dear Mr. McDermott:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Preservation Plan for SIHP No. 50-80-08-6699, Located in the 179-acre Project Area for the Proposed Nānākuli B Composting and Solid Waste Facility
Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 por.

Thank you for the submitting the aforementioned preservation plan by Tulchin and Hammatt (May 2007), which we received on May 22, 2007. We apologize for the delay in responding. The preservation plan outlines the interim and long-term protection measures for SIHP No. 50-80-08-6699, a pre-Contact rockshelter identified during an archaeological inventory survey conducted by CSH in 2006. Conservation (avoidance and protection) is the proposed mitigation measure for SIHP No. -6699.

SIHP No. -6699 is located eight meters upslope of an unimproved road used for fire control activities. According to the plan, construction activities are proposed more than 150 feet from SIHP No. -6699. Interim protection measures include erecting 35 meters of orange construction fencing upslope of the unimproved roadway, notification to the prime contractor of the site's preservation area, and demarcation of site and buffer on construction drawings. Long-term preservation includes installation of a 35-meter wire or chain link fence upslope of the unimproved roadway. It is believed that fencing erected specifically around the site would attract unwanted attention to the rockshelter that otherwise is obscured by the dense vegetation.

We concur with your mitigation recommendations and we accept this preservation plan as fulfilling the requirements of §13-277-3 Hawai'i Administrative Rules (HAR).

Mr. McDermott
Page 2

Please contact Teresa Davan at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy McMahon, Acting Archaeology Branch Chief
State Historic Preservation Division

ED

Preservation Plan for SIHP No. 50-80-08-6699, Located in the 179-acre Project Area for the Proposed Nānākuli B Composting and Solid Waste Facility, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i

TMK: [1] 8-7-09: por. 1

Prepared for

USR Corporation

Prepared by

Jon Tulchin, B.A.

and

Hallett H. Hammatt, Ph.D.

Cultural Surveys Hawai'i, Inc.

Kailua, Hawai'i

(Job Code: LUALU 4)

April 2007

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Management Summary

Reference	Preservation Plan for SIHP No. 50-80-08-6699, Located in the 179-acre Project Area for the Proposed Nānākuli B Composting and Solid Waste Facility, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i, TMK: [1] 8-7-09: por. 1 (Tulchin & Hammatt 2007)
Date	April 2007
Project Number (s)	Cultural Surveys Hawai'i (CSH) Job Code: LUALU 4
Investigation Permit Number	Any fieldwork for this investigation will likely be carried out under archaeological permit number 07-19, issued by the Hawai'i State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR), per Hawai'i Administrative Rules (HAR) Chapter 13-282.
Project Location	The project area is located along the southwestern slopes of Pu'u Heleakalā, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i, TMK 8-7-09 por: 1. The project area is depicted on a portion of the 1998 Schofield Barracks USGS 7.5-minute topographic quadrangle.
Land Jurisdiction	Leeward Land LLC owns the property and is the project proponent. URS Corporation is the consulting firm assisting Leeward Land LLC with its proposed project.
Agencies	State Historic Preservation Division / Department of Land and Natural Resources (SHPD/DLNR)
Project Description	The Nānākuli B Composting and Solid Waste Facility will be a flexible in-vessel municipal solid waste composting facility (using the "GORE™ Cover System") near Nānākuli that will meet and/or exceed Federal (40 CFR 258) and State (Chapter 11) regulations. The GORE™ Cover System will allow for the effective composting of organic materials, while continuously controlling odors, leachate generation, litter, and vectors (e.g., rodents, birds, insects, etc.). It is proposed that approximately 530 tons per day of incoming non-recyclable wastes will be composted at the proposed facility, thereby minimizing the amount of waste that will ultimately need to be directly disposed of in the proposed landfill. The proposed Nānākuli B Composting and Solid Waste Facility will accept municipal solid waste (MSW) composed of non-hazardous solid waste generated on the island of Oahu. The proposed facility will also receive certain other wastes managed under special permit requirements, by implementing specific operating procedures, including wastewater treatment sludge, non-friable asbestos material, and treated medical wastes. The proposed landfill will receive non-recyclable MSW collected by Honolulu Disposal Service Inc. and Honolulu Recovery Systems. The primary service area for these two companies is the island of Oahu, which had a population of approximately 880,000 in 2000. These

	companies primarily service commercial and industrial customers with a limited amount of residential customers. The City and County of Honolulu provides MSW collection service to the vast majority of residential customers on Oahu and operates its own facilities to handle and dispose of residential MSW. The total site capacity of the landfill will be approximately 11.0 million cubic yards, sufficient for disposal of approximately 7.7 million tons of solid waste. Based on current disposal rates, the proposed landfill is anticipating a disposal rate of up to 1,500 tons per day of MSW. The proposed landfill will ensure the availability of disposal capacity for non-hazardous MSW generated for a minimum of 15 years and possibly up to 20 years, depending on the volume collected by Honolulu Disposal Service and recycled by Honolulu Recovery Systems. The proposed landfill facility will consist of: a landfill entrance and scalehouse, a MSW receiving and processing building, a composting area with GORE™ Cover System windrows, and a series of Subtitle D (40 CFR 258) lined landfill cells. The proposed project will also include roadway improvements and access controls, a stormwater management system, a landfill liner and leachate management system, a groundwater monitoring program, a landfill gas monitoring program, an emergency plan, and a series of operational control measures to minimize visual impacts, as well as odor, dust, noise, litter, and vectors. The proposed project will also provide for the ultimate closure of the facility, which includes 30 years of post-closure monitoring per Federal and State requirements. All of these aspects of the project are further described in the sections below. controls, a stormwater management system, a landfill liner and leachate management system, a groundwater monitoring program, a landfill gas monitoring program, an emergency plan, and a series of operational control measures to minimize visual impacts, as well as odor, dust, noise, litter, and vectors. The proposed project will also provide for the ultimate closure of the facility, which includes 30 years of post-closure monitoring per Federal and State requirements.
Project Acreage	179-acres

Historic Preservation Regulatory Context	In 2006, CSH completed an archaeological inventory survey of the 200-acre project area for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill (O'Leary & McDermott 2006). Two historic properties were identified: SIHP No. 50-80-08-6699 (pre-Contact rockshelter) and SIHP No. 50-80-08-6681 (WWII concrete bunker). CSH's project-specific mitigation recommendation involved the preservation of SIHP No. -6699. Preservation would be in the form of avoidance and protection (conservation). No further work was recommended for SIHP No. -6681. However, if in the future, the projects design changes and avoidance of SIHP No. -6681 is not possible, CSH recommends that a data recovery program be developed and implemented. SHPD accepted the archaeological inventory survey and approved the project's mitigation measures [1-05-2007 letter from Melanie Chinen (SHPD) to Owen O'Leary, M.A. (CSH); LOG NO: 2007.0053 DOC NO: 0701amj06; see Appendix A]. This document was prepared to support the proposed project's historic preservation review under Hawai'i Revised Statutes (HRS) Chapter 6E-42 and Hawai'i Administrative Rules (HAR) Chapter 13-284. In consultation with the Hawai'i State Historic Preservation Division (SHPD), the preservation plan fulfills State requirements for such plans per HAR Chapter 13-13-277.
Historic Properties Addressed	The following historic property is recommended to be preserved through avoidance and protection (conservation): State Inventory of Historic Properties (SIHP) No. 50-80-08-6699; pre-Contact rockshelter

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Section 1 Introduction

1.1 Project Background

At the request of URS Corporation, Cultural Surveys Hawai'i, Inc. (CSH) prepared this preservation plan detailing preservation measures for State Inventory of Historic Properties (SIHP) No. 50-80-08-6699, a pre-Contact rockshelter, located in the 179-acre project area for the Proposed Nānākuli B Composting and Solid Waste Facility, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i (TMK: [1] 8-7-09: por. 1). The project area is located along the southwestern slopes of Pu'u Heleakalā (Figure 1, Figure 2, & Figure 3).

Prior to this preservation plan, the proposed Nānākuli B Composting and Solid Waste Facility consisted of a 200-acre project area. However, the development plan has been revised and 21-acres have been removed from the original project area (see Figure 1).

The Nānākuli B Composting and Solid Waste Facility will be a flexible in-vessel municipal solid waste composting facility (using the "GORE™ Cover System") near Nānākuli that will meet and/or exceed Federal (40 CFR 258) and State (Chapter 11) regulations. The GORE™ Cover System will allow for the effective composting of organic materials, while continuously controlling odors, leachate generation, litter, and vectors (e.g., rodents, birds, insects, etc.). It is proposed that approximately 530 tons per day of incoming non-recyclable wastes will be composted at the proposed facility, thereby minimizing the amount of waste that will ultimately need to be directly disposed of in the proposed landfill. The proposed Nānākuli B Composting and Solid Waste Facility will accept municipal solid waste (MSW) composed of non-hazardous solid waste generated on the island of Oahu. The proposed facility will also receive certain other wastes managed under special permit requirements, by implementing specific operating procedures, including wastewater treatment sludge, non-friable asbestos material, and treated medical wastes. The proposed landfill will receive non-recyclable MSW collected by Honolulu Disposal Service Inc. and Honolulu Recovery Systems. The primary service area for these two companies is the island of Oahu, which had a population of approximately 880,000 in 2000. These companies primarily service commercial and industrial customers with a limited amount of residential customers. The City and County of Honolulu provides MSW collection service to the vast majority of residential customers on Oahu and operates its own facilities to handle and dispose of residential MSW.

The total site capacity of the landfill will be approximately 11.0 million cubic yards, sufficient for disposal of approximately 7.7 million tons of solid waste. Based on current disposal rates, the proposed landfill is anticipating a disposal rate of up to 1,500 tons per day of MSW. The proposed landfill will ensure the availability of disposal capacity for non-hazardous MSW generated for a minimum of 15 years and possibly up to 20 years, depending on the volume collected by Honolulu Disposal Service and recycled by Honolulu Recovery Systems.

The proposed landfill facility will consist of: a landfill entrance and scalehouse, a MSW receiving and processing building, a composting area with GORE™ Cover System windrows, and a series of Subtitle D (40 CFR 258) lined landfill cells. The proposed project will also include roadway improvements and access controls, a stormwater management system, a landfill liner and leachate management system, a groundwater monitoring program, a landfill gas

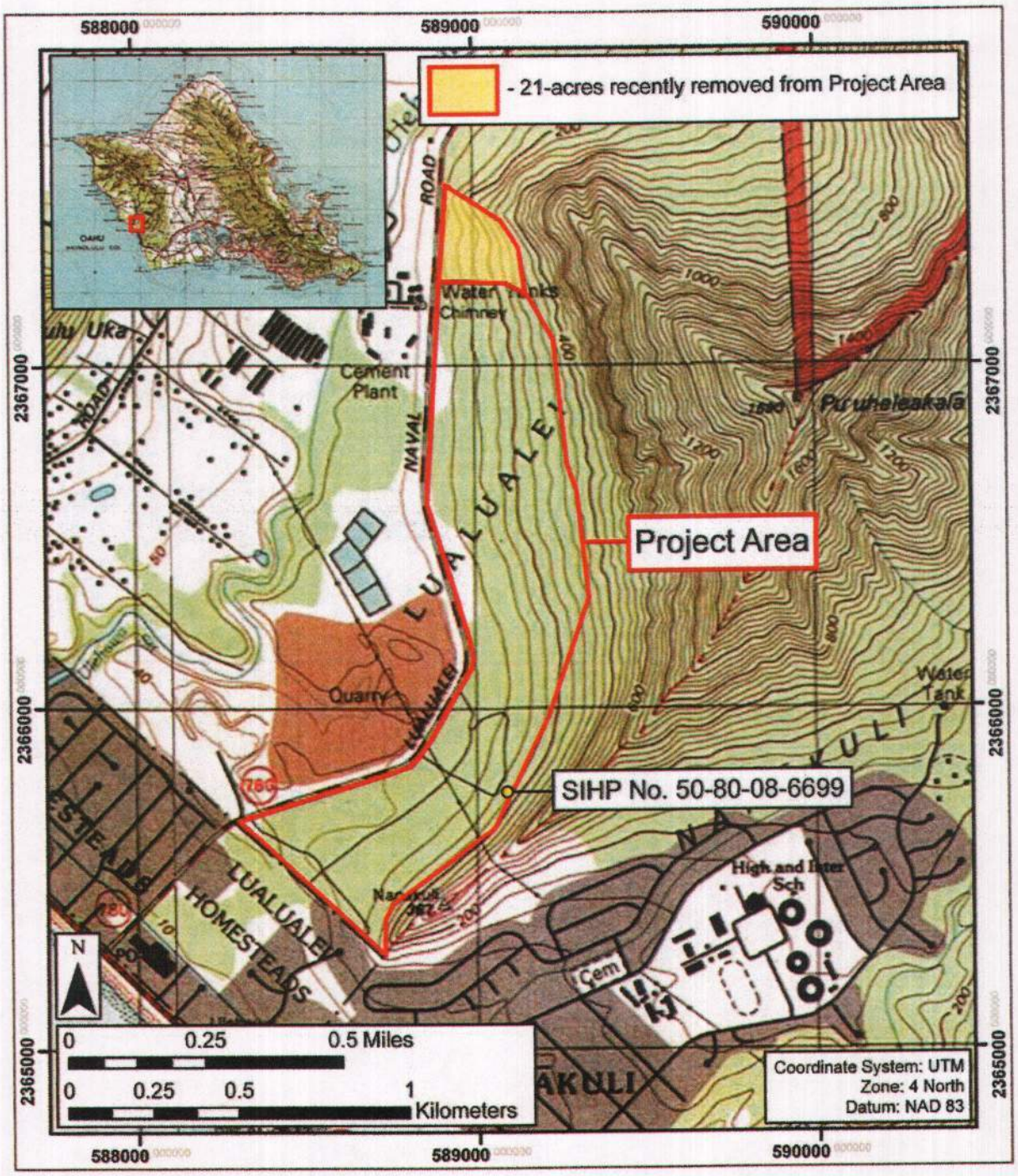

Figure 1. 1998 USGS 7.5 minute topographic map, Schofield Barracks Quadrangle, showing the location of the project area and SIHP No. 50-80-08-6699

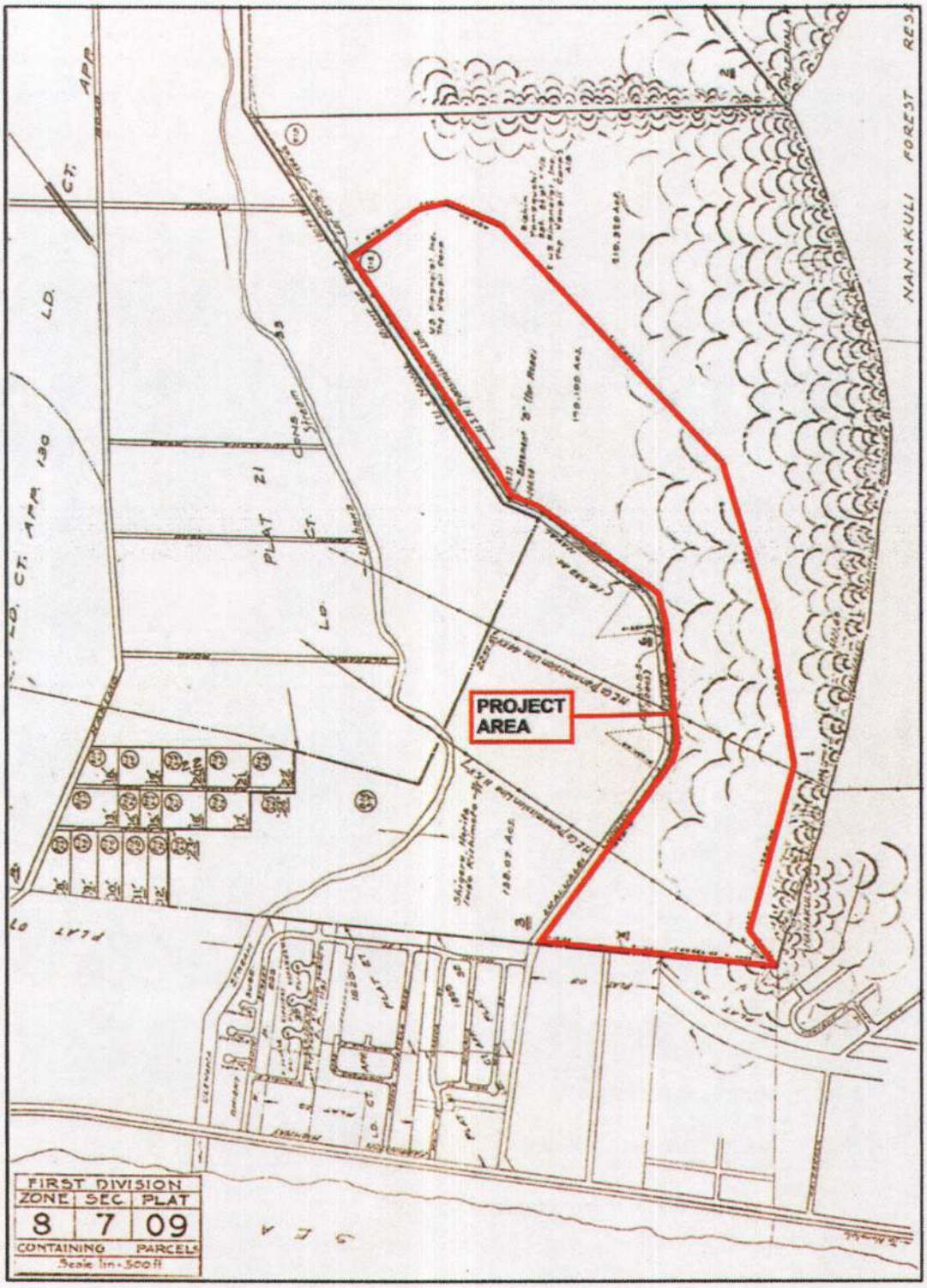

Figure 2. Tax Map Key (1) 8-7-09 showing project area location

Figure 3. Aerial photograph, showing the location of the project area and SIHP No. 50-80-08-6699 (source: USGS Orthoimagery 2005)

monitoring program, an emergency plan, and a series of operational control measures to minimize visual impacts, as well as odor, dust, noise, litter, and vectors. The proposed project will also provide for the ultimate closure of the facility, which includes 30 years of post-closure monitoring per Federal and State requirements.

In 2006, CSH completed an archaeological inventory survey of the 179-acre project area for the Proposed Nānākuli B Composting and Solid Waste Facility (O'Leary & McDermott 2006). Two historic properties were identified: SIHP No. 50-80-08-6699 (pre-Contact rockshelter) and SIHP No. 50-80-08-6681 (WWII concrete bunker).

CSH's project-specific mitigation recommendation involved the preservation of SIHP No. -6699. Preservation would be in the form of avoidance and protection (conservation). No further work was recommended for SIHP No. -6681. However, if in the future, the projects' design changes and avoidance of SIHP No. -6681 is not possible, CSH recommends that a data recovery program be developed and implemented. SHPD accepted the archaeological inventory survey and approved the project's mitigation measures [1-05-2007 letter from Melanie Chinen (SHPD) to Owen O'Leary, M.A. (CSH); LOG NO: 2007.0053 DOC NO: 0701amj06; see Appendix A].

This document was prepared to support the proposed project's historic preservation review under Hawai'i Revised Statutes (HRS) Chapter 6E-42 and Hawai'i Administrative Rules (HAR) Chapter 13-284. In consultation with the Hawai'i State Historic Preservation Division (SHPD), the preservation plan fulfills State requirements for such plans per HAR Chapter 13-13-277. CSH will likely complete any fieldwork component of the preservation plan under SHPD permit No. 07-19, per HAR Chapter 13-13-282.

1.2 Scope of Work

The scope of work for this preservation plan is based on Draft Hawai'i Administrative Rules, Title 13, Sub-Title 13, Chapter 277 "Rules Governing Requirements for Archaeological Site Preservation and Development." A suitable preservation plan must be approved by the State Historic Preservation Division/Department of Land and Natural Resources (SHPD/DLNR) prior to any development within the project area. The preservation plan will:

1. Identify for each significant historic property whether preservation will take the form of avoidance and protection (conservation) or exhibition (interpretation);
2. Specify the buffer zones around each significant historic property;
3. Specify short-term protection measures for each significant historic property that will be within or near a construction area;
4. Specify the long-term preservation measures to be undertaken at each significant historic property. This may be done with drawings or text, or both (Hawai'i Administrative Rules Title 13, Sub-Title 13, Chapter 277).

1.3 Environmental Setting

1.3.1 Natural Environment

Lualualei is the largest leeward valley on O'ahu. Comprised of approximately 14,000 acres, Lualualei extends from the Wai'anae Range to the ocean. To the south is the *ahupua'a of* Nānākuli and to the north is the *ahupua'a* of Wai'anae. Its southern border includes a portion of Pu'u Heleakalā, and its northern boundary includes a portion of Pu'u Pāhe'ehe'e. Lualualei Valley, like the other valleys in the Wai'anae District is characterized by its dry, leeward climate. The prevailing winds in the area are the northeast trades that blow over the Ko'olau mountains, then continue over the Wai'anae range and head out over the southwest portion of the island (Juvik and Juvik 1998: 55). This wind pattern is responsible for the relatively low rainfall averages on the leeward side of the island. The winds cause the rain to hit the Ko'olau Range, first releasing most of their moisture there, and then continuing on over the Wai'anae Range, releasing what moisture may be left (Abbott *et al.* 1983: 224). Based on data from the Rainfall Atlas of Hawai'i, the mean annual rainfall around the project area is less than 20 inches (Giambelluca *et al.* 1986: 138). The majority of precipitation occurs during the rainy season, October-April, and less precipitation occurs May-September. Temperatures in the area range from 43-88° Fahrenheit in January to 58-95° Fahrenheit in July (Armstrong 1973: 58).

Accoding to Juvik and Juvic (1998: 90) perennial streams are not found in leeward O'ahu. Examination of the Schofield Barracks and Wai'anae USGS Quadrangle maps shows that Ulehawa Stream is the closest intermittent stream to northwest of the project area and Nānākuli Stream is the closest intermittent stream to the southeast.

Vegetation along this arid coast is sparse. With 20 inches or less of rain annually, only the hardiest plants adapted to the coastal environments can thrive in these zones. The vegetation is typical of dry seashore environments in Hawai'i and is dominated by alien species. Indigenous species include *hau* (*Hibiscus tiliaceous*), *koa* (*Cordia subcordata*), *kamani* (*Calophyllum inophyllum*), *naupaka* or *naupaka kahakai* (*Scaevola sericea*), *pa'u o Hi'iaka* (*Jacquemontia ovalifolia sandwicensis*), the native beach morning glory or *pōhuehue* (*Ipomea pes-caprae*) and the coconut *niu* (*Cocos nucifera*). Introduced species found bordering Farrington Highway include sea grape (*Coccoloba uvifera*), *kiawe* trees (*Prosopis pallida*), Madagascar olive trees (*Noronhia emarginata*), and *koa haole* (*Leucaena leucocephala*) (Foote *et al.* 1972: 93).

The project area lies along the lower slopes of the western slopes of Pu'u Heleakalā. The southern end and southwest corner of the project are comprised of upraised limestone. This is overlain by erosional sediements from the foothills of Pu'u Heleakalā. The majority of the sediments are Lualualei extremely stony clay 3 to 35 percent slopes (LPE). The southwestern corner of the project area is Mamala stony silty clay loam, 0-12 percent slope with some Lualualei clay 2 to 6 percent slopes (LuB) in the very north corner of the project area long Lualualei Naval Road.

1.3.2 Built Environment

The project area is bounded to the north, northeast, and southeast by the ridges of Pu'u Heleakalā. The southwest end of the project area is bordered by Lualualei Homesteads where there are presently small apartment buildings within approximately 50 meters of the edge of the

project area boundary. Lualualei Naval Road makes up the entire west side of project area. Across Lualualei Naval Road is a landfill managed by PVT Land Company Ltd. that accepts construction debris, asbestos, and soil for bioremediation. On the west side of Lualualei Naval Road on the north end of the project there is a cement plant.

There has been substantial ground disturbance within the project some time in the past. Larger portions of the project area shows signs of bulldozer activities. Within the project area pushed up mounds of dirt and raised berms and banks were observed by the field personnel. Several of these appear to have been cut into the hill in order to channel water run off. It is not possible to tell when the bulldozing took place, but almost all of the moved earth has extensive grass growth. Numerous basalt boulders throughout the property have bulldozer scars on them, indicating that their current location is due to modern activities. The project area also has a developed dirt road, which is currently in use that runs from an access gate at the very southwest corner of the property to the two large water tanks along the hill slope. The road is a graded mix of the sediment extending down from the hillside and broken up limestone. There are also several older roads that are overgrown with vegetation, but still visible in various places on the property. This extensive previous modification is likely the reason that no prehistoric or historic cultural remains were found over most of the property.

At several locations within the project area boulders that had been broken by bulldozers were observed to be of relatively fine-grained high quality basalt that could have served as raw material for stone tools. A large dike that crosscuts the regular stratigraphy of Pu'u Hekeakalā is the possible source of these rocks. In a handful of locations within the project area basalt flakes were observed. Unfortunately, it is difficult to determine if these fine-grained basalt flakes are prehistoric lithic reduction debitage or incidentally-fractured stone related to modern bulldozer modifications.

Overall, the extensive evidence of bulldozer activity suggests that any sites that may have been located in the flatter sections of the project area have long since been destroyed. These observations correspond with the fact that the only two historic properties were found along the steeper edge of the project area.

The only other non-natural objects on the landscape are a few scattered rusty barrels, two stripped and rusted out cars and numerous abandoned rusting appliances that have been dumped into the tall *koa haole* along Lualualei Naval Road in the southern end of the project area.

1.4 Introduction to the Preservation Plan

This Long-Term Preservation Plan addresses concerns related to a single historic property described and recommended for preservation within an Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Composting and Solid Waste Facility, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i. (O'Leary & McDermott 2006), which has been reviewed and accepted by the State Historic Preservation Division (SHPD). This plan addresses one (1) historic property, SIHP No. 50-80-08-6699, to be preserved through avoidance and protection (located in Figure 1 & Figure 3 and summarized in Table 1).

As substantial development is to occur within the parcel, this preservation plan first outlines interim protection measures for the historic property during construction activities associated with the development of the parcel.

The present plan also outlines long-term preservation measures for the historic property. These measures may be amended or supplemented – following approval by the State Historic Preservation Division – based on inadvertent findings during construction activities within the parcel and/or design revisions for the 179-acre parcel.

Table 1. Historic Properties Recommended for Historic Preservation

SIHP No.	Site Type	Recommendation	Significance Assessment	Size	No. of Features	Period
-6699*	rockshelter	Preservation	D	5 m wide by 3m deep, with an average height of 87 cm	2	Pre-Contact

*SIHP No. Prefix = 50-80-08

Section 2 Descriptions of Historic Properties to be Preserved

2.1 SIHP No. 50-80-08-6699

FORMAL TYPE:	Rockshelter
FUNCTION:	Temporary Habitation
# OF FEATURES:	2
AGE:	Pre-Contact
DIMENSION:	5 m wide by 3m deep, with an average height of 87 cm
LOCATION:	Southern portion of project area. UTM coordinates = 589088mE; 2365754mN (NAD 83 Zone 4 North)
TAX MAP KEY:	TMK: [1] 8-7-09: 001
LAND JURISDICTION:	Private, Leeward Land LLC

State Inventory of Historic Properties (SIHP) No. 50-80-08-6699 is a small pāhoehoe basalt rock shelter with two subsurface features: a charcoal concentration (Feature #1) and a scoop hearth (Feature #2) (Figure 4, Figure 5, & Figure 6). SIHP No. -6699 is located on the slopes of the southwest ridge of Pu'u Heleakalā. The site is approximately 35 meters upslope of two large water tanks. The site's location [UTM coordinates = 589088mE; 2365754mN (NAD 83 Zone 4 North)] is shown in Figure 1 & Figure 3.

The rock shelter's floor surface consists of loose silty clay with numerous subangular basalt pebbles, cobbles, and boulders. Two basalt flakes were discovered on the surface indicating the potential for subsurface cultural deposits. Two contiguous test units (Test Unit 1 & Test Unit 2) were excavated within the soil floor of the rockshelter to determine the presence or absence of subsurface cultural deposits (see Figure 4).

Excavation resulted in the recovery of lithic materials, transported marine shell and coral, and numerous rat remains. Two subsurface features were observed during the excavation of Test Unit (TU) 1: a small charcoal concentration (Feature #1) and a small scoop hearth (Feature #2) (see Figure 4). Charcoal collected from the Feature #2 was submitted for radiocarbon analysis resulting in a date of 270 ± 50 BP. After calibration using OxCal, and taking into account that no historic materials were found within the excavations, the radiocarbon results indicate that the lower layer of deposition in SIHP No. -6699 dates to the late prehistoric period prior to European contact.

In summary, SIHP No. 50-80-08-6699 served as a temporary habitation site where native Hawaiians likely took refuge from the mid-day heat or sought shelter while traveling or procuring resources. It is possible that the rockshelter was used by the inhabitants of the *mauka* portions of Lualualei when they journeyed to the coast for fishing or shellfish gathering.

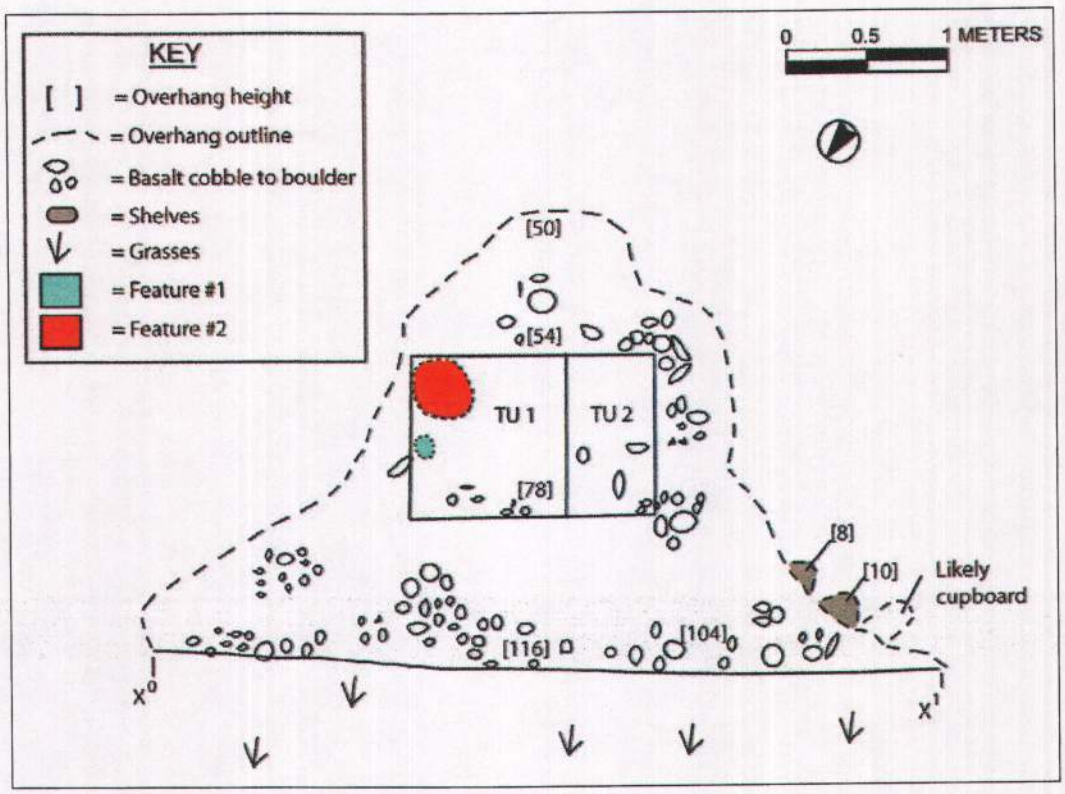

Figure 4. Plan view map of SIHP No. 50-80-08-6699, showing location of Test Units (TU) 1 & 2

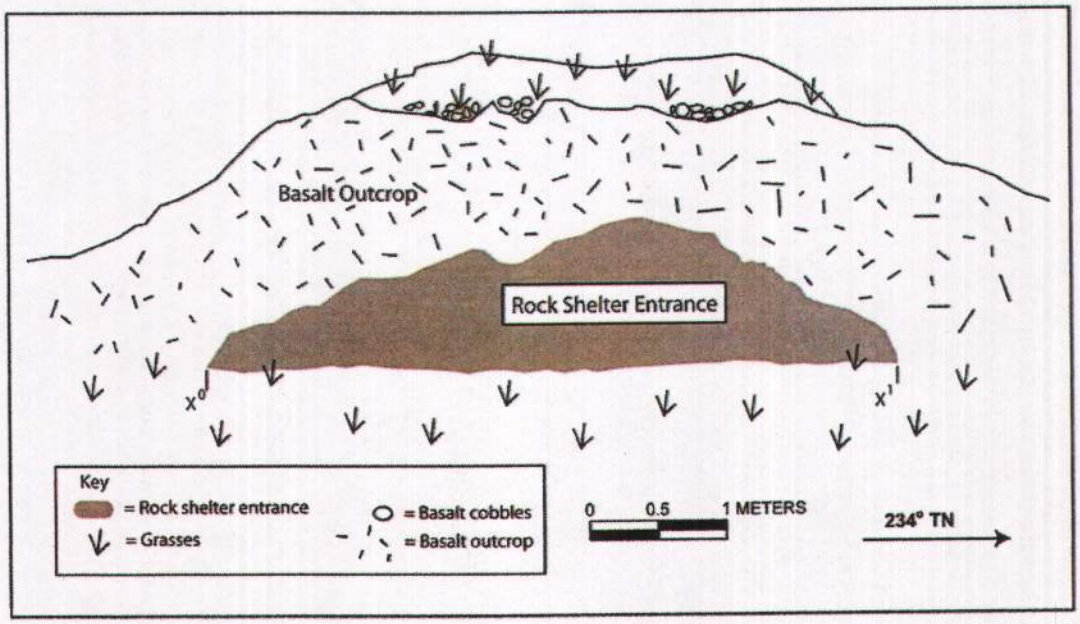

Figure 5. Cross section map of SIHP No. 50-80-08-6699

Figure 6. Photograph of SIHP No. 50-80-08-6699, view to east

Section 3 Proposed Preservation Measures

3.1 Layout of SIHP #50-80-08-6699 in Relation to the Surrounding Natural and Built Environment

The geographic situation of SIHP #50-80-08-6699 rock shelter is an important consideration when determining the best preservation measures (conservation--avoidance and protection) for the site. As shown on Figure 1, above, SIHP #50-80-08-6699, is located along the upslope margin of the project area. As depicted on Figure 7, below, the rock shelter is located adjacent and up slope from two large water tanks and a modern unimproved roadway, which provides occasional access to the up-slope portions of the project area to provide for fire management activities (e.g., mowing and watering activities). As shown on Figure 8 and Figure 9, below, the rock shelter location is largely indiscernible from other similar exposures of rock outcrop along the same slope. Because of the tall grass and other similar rock outcrops in the vicinity, the rock shelter location does not stand out. In fact, even someone looking for the rock shelter needs to be within a few meters of that particular rock outcrop before the rock shelter becomes visible.

As depicted on Figure 8 and Figure 9, below, the rock shelter is located 8 meters (26 feet) up a steep 45-degree slope from the access road. The rock shelter is 4-5 meters (12 to 15 feet) higher in elevation than the access road. This steep slope between the access road and the rock shelter effectively distances the rock shelter from the access road, much more so than 8 meters (26 feet) along a level surface.

The rock shelter is situated adjacent to the water tanks and the unimproved access road, which are modern features that will remain in place with the proposed project and will not be subject to grading or other major disturbance. Proposed project elements, including the landfill and the paved access road, will be located down slope of the water tanks, approximately 150 feet from the rock shelter, at the closest point. Therefore, the rock shelter will be essentially blocked from the large-scale land disturbance that will be a part of the proposed project.

It is typical in archaeological preservation plans to fence off archaeological preserve areas to ensure an appropriate buffer is maintained around the site or sites to be protected. For SIHP #50-80-08-6699, based on its geographic situation, fencing only around the specific site will likely serve as more of a detriment that a protective measure. Because of the steep slope from the unimproved access road to the rock shelter, a natural physical barrier already sets apart the access road from the rock shelter. Erecting a buffer fence around the site would not provide a more effective physical barrier than the steep slope itself, but would likely draw attention to the rock shelter location. This attention would only be due to the buffer fence itself because the rock shelter is indistinguishable from other similar rock outcrops in the vicinity, as indicated above.

Rather than placing a buffer fence around the rock shelter, instead it is proposed that a partial buffer fence should be erected along a portion of the up slope margins of the unimproved access road. This fencing would appear associated with the roadway itself, so as not to draw attention to the adjacent rock shelter, but would also serve to inhibit pedestrian access from the access road to the slope in the immediate vicinity of the rock shelter.

Figure 7. Aerial photograph showing location of SIHP #50-80-08-6699, existing water tanks and unimproved road, and proposed fencing (source: USGS Orthoimagery 2005)

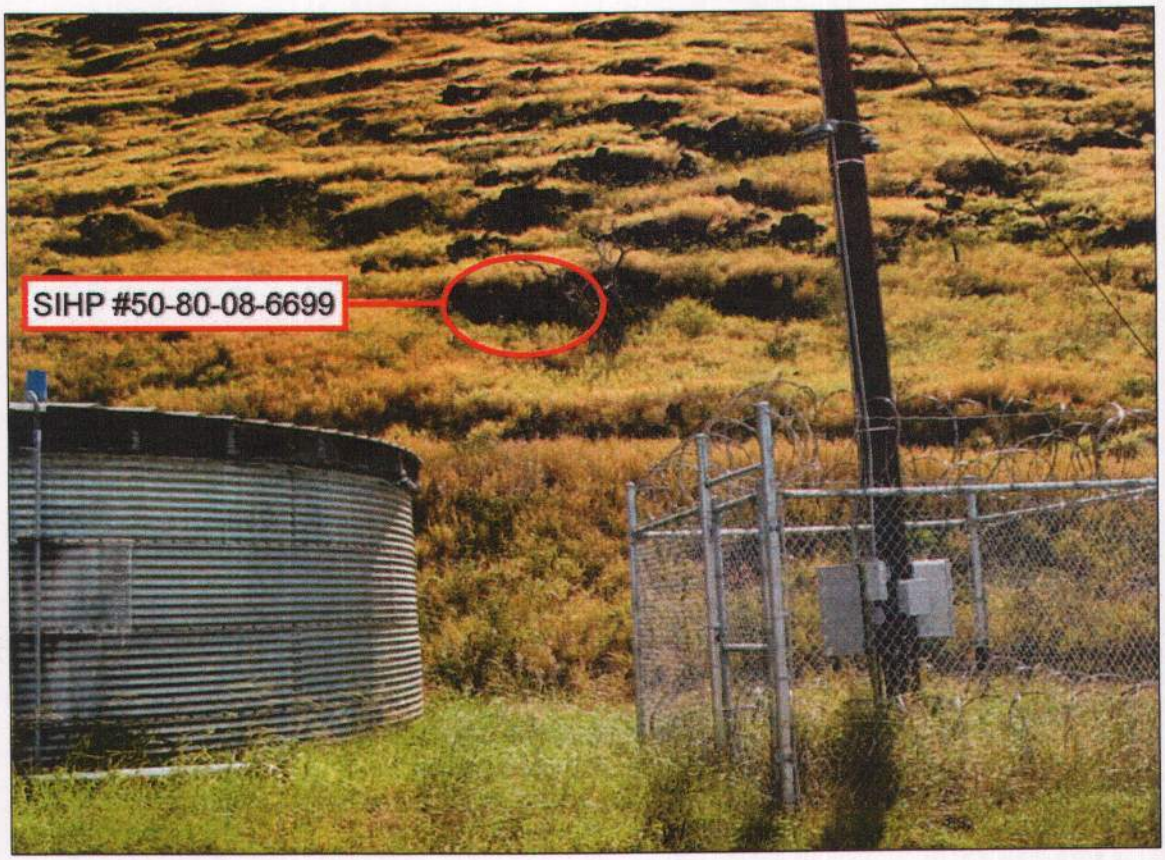

Figure 8. Photograph showing SIHP #50-80-08-6699 obscured by numerous rock outcrops along the slope

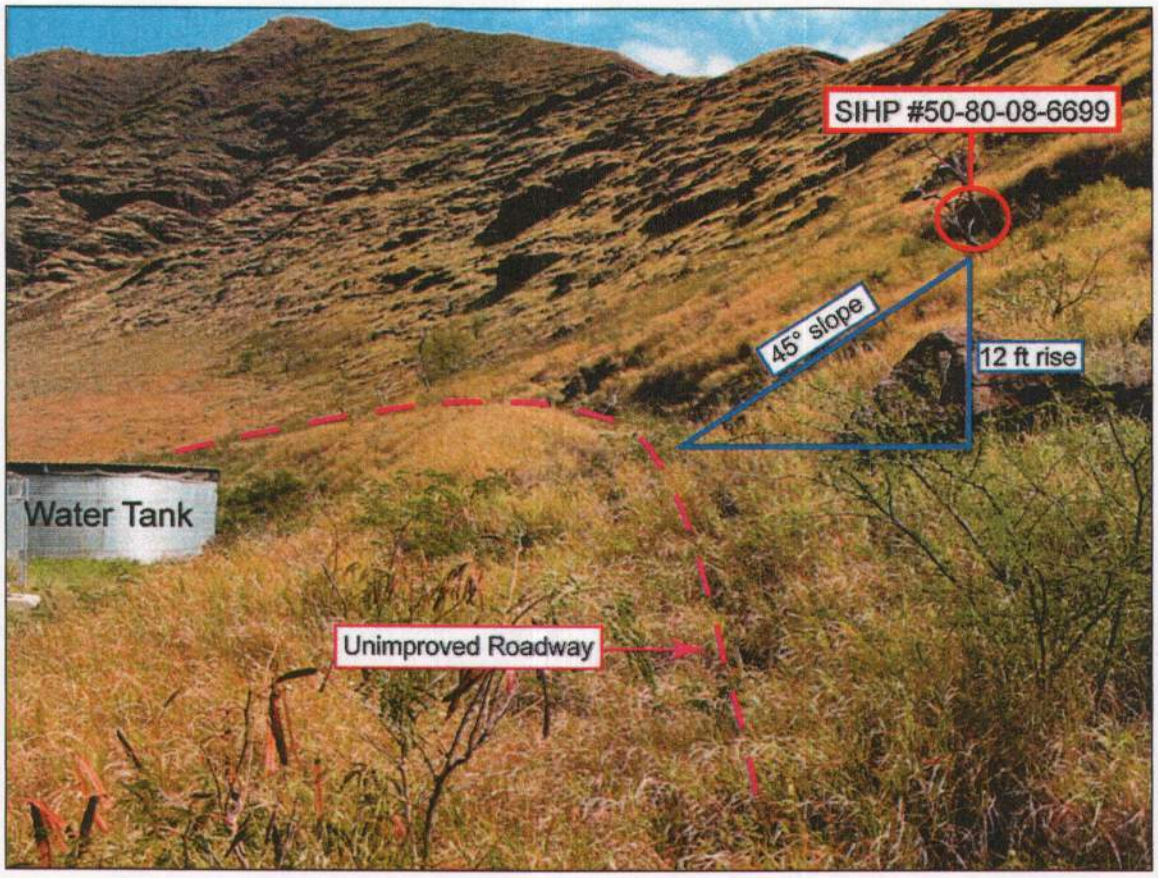

Figure 9. Photograph showing steep and rocky terrain surrounding SIHP #50-80-08-6699

An 8 meter (26 foot) interim and permanent buffer area around the entire rock shelter would be established and placed on all construction drawings. However, as indicated above, the fencing would be installed only along the upper margin of the access road to keep pedestrians outside the buffer area, while at the same time not drawing unneeded attention to the rock shelter. The existing 45-degree slope between the access road and the rock shelter will serve as an effective deterrent to vehicular encroachment within the buffer area.

3.2 Interim Protection Measures

Interim protection measures will include placing an 8 m (26 ft) buffer around the site and plotting the site and the buffer area boundaries on all construction/grading plans. Additionally, a fence consisting of steel posts supporting four-foot high orange mesh, plastic event fencing will be erected and maintained along the margin of the unimproved roadway, 8 m (26 ft) down-slope from the rock shelter. This fencing will run along the up-slope margin of the unimproved road for a length of approximately 35 m (115 ft) (Figure 7). This will ensure that the occasional use of the unimproved road for continued fire management activities will not impact the site. It will also serve as a deterrent to pedestrians.

This approach towards preservation constitutes the best protection for the site and has been developed for the following three reasons:

1. The immediate area will not be impacted by grading or other construction related disturbance due to the need to protect the existing water tanks, located approximately 20 m (66 ft) down-slope of the site, and the unimproved road, located 8 m (26 ft) down-slope from the site. Additionally, proposed project elements, including the landfill and the paved access road to the facility, will be located down slope of the water tanks, approximately 150 feet from the rock shelter, at the closest point. Therefore, the rock shelter will be essentially blocked from the large-scale land disturbance that will be a part of the proposed project.
2. It is believed that if fencing were erected around the specific site itself, it would attract unwanted attention to an otherwise obscure rock shelter that currently blends into the numerous rock outcrops that cover the slope (Figure 8).
3. The steep and rocky terrain on which the site is located would further deter pedestrian inspection of the area and would prevent vehicle access (Figure 9).

The prime contractor will be notified of the site's location, its designation for preservation, and the importance of avoiding work within the buffer area, to ensure the site is not disturbed. However, if construction plans change and construction activities are planned within the 8 meter (26 ft) buffer area around the site, SHPD must be notified immediately and this plan must be revised.

3.3 Long-Term Preservation Plan Provisions

The scope of work for development of a long-term preservation plan is detailed in Hawaii Administrative Rules, Title 13, Sub-Title 13, chapter 277, "Rules Governing Requirements for Archaeological Site Preservation and Development".

In compliance with Hawaii Administrative Rules, the following preservation procedures will be implemented:

3.3.1 Long Term Buffer Zones

The long-term buffer zones would be 8 m (26 ft) from the perimeter of the site designated for preservation. Construction activity within this buffer zone would be prohibited.

3.3.2 Demarcation of Buffer Zone

The buffer zone would be demarcated on all construction/grading plans. Rather than physically marking the buffer perimeter on the ground with fencing, and drawing unwanted attention to the rock shelter, a permanent steel post and wire (such as used along highway right of ways) buffer fence (or a chain link fence) will be constructed along the along the up-slope margin of the unimproved road, 8 m (26 ft) down-slope from the rock shelter, for a length of approximately 35 m (115 ft) (see Figure 8).

The presence of the archaeological preserve area, with its 8 meter (26 foot) radius buffers will be marked on site plans, be recorded with the Bureau of Conveyances, and will accompany deed documents in perpetuity.

3.3.3 Vegetation Clearing Methods

Vegetation clearing is not anticipated in or around the archaeological preserve area. In fact, natural vegetation will be allowed to thrive as a means of obscuring the rock shelter's location and further protecting the site.

3.3.4 Stabilization

No stabilization is anticipated at the site designated for preservation.

3.3.5 Landscaping Plan

There is no landscaping plan anticipated for the archaeological preserve area.

3.3.6 Pathways, Lighting, Other Hard-scape Structures within the Preserve Areas

There is no plan for specific hard-scape construction, pathways, or lighting in the vicinity of the site designated for preservation.

3.3.7 Access to the Site

Public access to the archaeological preserve will be prohibited unless authorized by the landowner and SHPD.

3.3.8 Handling of Litter

As appropriate, the land owner will periodically remove litter from the preserve area.

3.3.9 Approaches to Interpret and Inform the Public

No signage or regular public access is planned at this time.

3.3.10 Future Archaeological Research

Future archaeological research within the preserve sites will be allowed only with the written approval of a research plan by the SHPD and in coordination with the landowner.

3.3.11 Penalty

Non-compliance with the provisions and procedures of this plan once accepted by the SHPD shall result in a directive not to proceed with construction near the site, and may result in a denial or revocation of SHPD's written concurrence or agreement, and shall also be penalized as provided in section 6E-11, HRS and applicable laws.

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Appendix A SHPD Correspondence

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STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
601 KAMOKILA BOULEVARD, ROOM 555
KAPOLEI, HAWAII 96707

January 5, 2006

Mr. Owen O'Leary
Cultural Surveys of Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2007.0053
DOC NO: 0701amj06
Archaeology

Dear Mr. O'Leary:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Revised Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 (portion)

Thank you for submitting the revised report by O'Leary and McDermott (2006), which we received on December 17, 2006. Two historic properties were identified in the project area: SIHP No. 50-80-08-6699, a small pre-Contact rockshelter, and SIHP No. 50-80-08-6681, a World War II concrete bunker. Site 6699 was tested (excavated), yielding basalt and volcanic-glass flakes and debitage, coral, and shell. One radiocarbon sample was dated to 270±50 BP, and calibrated to the pre-Contact period.

In a letter (LOG NO: 2006.3673, DOC NO: 0611amj04) dated November 3, 2006, we reviewed an earlier version of this report. We requested two minor changes and one more substantial revision (*i.e.*, regarding the mitigation of Site 6699). You have made the changes to our satisfaction.

You have assessed both sites (6681 and 6699) as eligible for the Hawai'i Register of Historic Places under criterion D. Site 6681 is also eligible under criterion A. We concur with these significance assessments. You have changed the mitigation recommendation to preservation for Site 6699. We concur with this recommendation, and look forward to receipt of a preservation plan, which will need to be approved and implemented prior to any ground disturbance near the site.

The archaeological inventory survey is accepted in fulfillment of HAR 13-284 and 13-276.

Please contact Mr. Adam Johnson (O'ahu Assistant Archaeologist) at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Melanie Chinen, Administrator
State Historic Preservation Division

amj:

Archaeological Inventory Survey of

200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill

Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i

TMK: [1] 8-7-09: por. 1

Prepared for
URS Corporation
615 Pi'ikoi St., Suite 900
Honolulu, HI 96814-3141

by
Owen L. O'Leary, MA
and
Matt McDermott, MA

Cultural Surveys Hawai'i, Inc. (Job Code: LUAL 6)
December 2006

MANAGEMENT SUMMARY

Reference	Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i. (O'Leary and McDermott 2006)
Date	December 2006
Project Number	Cultural Surveys Hawai'i Inc. (CSH) Job Code: LUAL 6
Permit Number	Fieldwork for this investigation was performed under archaeological fieldwork permit numbers 0404 and 0508, issued by the Hawai'i Department of Land and Natural Resources / State Historic Preservation Division (DLNR / SHPD)
Agencies	SHPD
Location	O'ahu, Wai'anae, Lualualei, TMK 8-7-09 por: 1, 1998 Schofield Barracks USGS 7.5-minute topographic quadrangle
Land Jurisdiction	Leeward Land LLC owns the property and is the project proponent. URS Corporation is the consulting firm assisting Leeward Land LLC with its proposed project.
Project / Survey Acreage and Area of Potential Effect (APE)	The project area is 200.109 acres and the systematic ground survey associated with this investigation covered the entire 200.109-acre project area. For the purposes of this report, the area of potential effect (APE) is defined as a slightly smaller portion of the 200.109-acre project area, measuring approximately 185 acres. This APE has a slightly smaller foot-print than the project area, resulting in a narrow band around the project area's perimeter that is within the project area, and hence the survey area, but outside the project's APE. This narrow band, based on information from the client, will not be affected by the proposed project.
Project Description	The proposed facility is anticipated to accept the wastes currently collected by the Honolulu Disposal Service, Inc. (HDSI), on Oahu. HDSI intends to process so-called "Dirty Materials Recovery Facility" (MRF) at this new facility. It is anticipated that HDSI's MRF will remove up to 50% of the waste stream as recyclables. The remaining, non-recyclable wastes will be delivered to the Nanakuli Facility for processing and disposal. Leeward Land LLC intends to process a significant portion of the wastes delivered to the Nanakuli B Facility, with a particle size reduction and a proprietary volume reduction process. Leeward Land LLC anticipates approximate daily waste disposal rates of 250 tpd to 500 tpd. Leeward Land LLC has indicated that it is possible that it may receive additional significant quantities of solid waste from additional waste sources after the landfill opens for business. For this reason, the proposed waste processing facility (WPF) and landfill will be designed to be capable of accepting an additional 1,000 tons of wastes requiring daily disposal. Based on current estimates, the Nanakuli B Facility should provide Leeward Land LLC with at least 20 years of waste disposal capacity.
Historic Preservation Regulatory Context	This archaeological inventory survey was undertaken to fulfill Hawai'i Administrative Rules (HAR) Title 13 (Department of Land and Natural Resources), Subtitle 13 (State Historic Preservation Division), Chapter 276 (Rules Governing Standards for Archaeological Inventory Surveys and Reports). This inventory survey report will support the project's historic preservation review under HAR Chapter 13-284 (Rules Governing Procedures for Historic Preservation Review to Comment on Section 6E-42, HRS [Hawai'i Revised Statutes], Projects)

Field Effort	Owen L O'Leary, MA, Jesse Yorck, BA, Todd Tulchin, BA, Dominique Cordy, BA, John Tulchin, BA, Guadalupe Ochoa, BA, and David Shideler, MA, acting under the overall supervision of Hallett H. Hammatt, Ph.D (principal investigator), completed the investigation fieldwork between September 20 and October 7, 2004, and on November 16, 2005, requiring a total of ten person days.
Number of Historic Properties[1] Identified	Two (see also Appendix C)
Historic Properties Recommended Eligible to the Hawai'i Register of Historic Places (Hawai'i Register)[2]	• State Inventory of Historic Properties (SIHP) 50-80-08-6699, small prehistoric basalt rock shelter, criterion "D". • SIHP 50-80-08-6681, World War II concrete bunker, criteria "A" and "D" (See also Appendix C)
Historic Properties Recommended Ineligible for the Hawaii Register	None
Effect Recommendation	Based upon the project description, the project area maps provided by the client, and consultation with the client, the proposed project will not affect the significant historic properties located within the project area, but outside the project APE. Accordingly, CSH recommends a project specific effect recommendation of "no historic properties affected".
Mitigation Recommendation	Based upon the information provided by the client at the time of the preparation of this report, the historic properties within the project area are outside the project APE and will be avoided by all construction activities. However, because historic property 50-80-08-6699 is extremely close to the proposed APE, and past experience on a number of projects has shown that sites in this situation have been impacted, we recommend that the site be preserved. If the project design changes in the future and avoidance of historic property 50-80-08-6681 is not possible, CSH recommends data recovery program be developed and implemented. For historic property 50-80-08-6681, World War II concrete bunker, appropriate architectural recordation would include more formal recording of the buildings construction and architectural traits, for example through Historic American Engineering Record (HAER)-type recordation. Following the approval of these recommendations by SHPD, a preservation plan addressing historic property 50-80-08-6699 will be prepared and submitted for review and approval.

[1]Under Hawai'i State historic preservation review legislation, "historic properties" are defined as "any building, structure, object, district, area, or site, including heiau and underwater site, which is over fifty years old" [Hawai'i Administrative Rules (HAR) 13-13-275-2 and 284-2]. Under state law, a project's effect and potential mitigation measures are evaluated based on the project's potential impact to "significant" historic properties (those historic properties determined eligible, based on established significance criteria, for the Hawai'i Register of Historic Places—see footnote 2).

[2]To be considered eligible for listing on the Hawai'i State Register of Historic Places, a historic property must possess integrity of location, design, setting, materials, workmanship, feeling, and association, and meet one or more of the following broad cultural/historic significance criteria: "A" reflects major trends or events in the history of the state or nation; "B" is associated with the lives of persons significant in our past; "C" is an excellent example of a site type/work of a master; "D" has yielded or may be likely to yield information important in prehistory or history; and, "E" has traditional cultural significance to an ethnic group, includes religious structures and/or burials.

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I. INTRODUCTION

A. Investigation Background

This document is an archaeological inventory survey prepared by Cultural Surveys Hawaii Inc. (CSH) for the proposed Nānākuli B Site Materials Recovery Facility and Landfill within 200.109 acres of undeveloped land in Lualualei, Wai'anae, O'ahu. This archaeological inventory survey was conducted to identify, record, and assess the significance of all historic properties with the boundaries of the project area. This investigation was completed at the request of URS Corporation, who represents Leeward Land LLC, the landowner and project developer. This archaeological inventory survey investigation was carried out to fulfill the requirements set forth in the Hawai'i Administrative Rules (HAR) Title 13 (Department of Land and Natural Resources), Subtitle 13 (State Historic Preservation Division), Chapter 276 (Rules Governing Standards for Archaeological Inventory Surveys and Reports). This inventory survey report will support the proposed project's historic preservation review under HAR Chapter 13-284 (Rules Governing Procedures for Historic Preservation Review to Comment on Section 6E-42, HRS [Hawai'i Revised Statutes], Projects).

The project area is located along the southwestern slopes of Pu'u Heleakalā, as depicted on the 1998 Schofield Barracks USGS 7.5-minute topographic quadrangle (Figure 1). The property is located within Tax Map Key: 8-7-9: por. 1 (See Figure 2 and Figure 3). A portion of the project area is shown in Figure 4, a photograph taken during the mid 1970s (Cameron 1977).

The project area is 200.109 acres and the systematic ground survey associated with this investigation covered the entire 200.109-acre project area. For the purposes of this report, the area of potential effect (APE) is defined as a slightly smaller portion of the 200.109-acre project area, measuring approximately 185 acres. This APE has a slightly smaller foot-print than the project area, resulting in a narrow band around the project area's perimeter that is within the project area, and hence the survey area, but outside the project's APE. This narrow band (see Figure 5 and Figure 6), based on information from the client, will not be affected by the proposed project.

Fieldwork was completed between September 20 and October 7, 2004 and on November 16, 2005, by Owen L O'Leary, MA, Jesse Yorck, BA, Todd Tulchin, BA, Dominique Cordy, BA, John Tulchin, AS, Guadalupe Ochoa, BA, David Shideler, MA, and Hallett H. Hammatt, Ph.D. (principal investigator), and required 10 total person-days to complete. Fieldwork for this investigation was performed under archaeological fieldwork permit numbers 0404 and 0508, issued by the Hawai'i Department of Land and Natural Resources / State Historic Preservation Division (DLNR / SHPD). Two historic properties were found, a prehistoric temporary habitation in a rockshelter (State Inventory of Historic Places 50-80-08-6699) and a World War II concrete bunker (SIHP 50-80-08-6681).

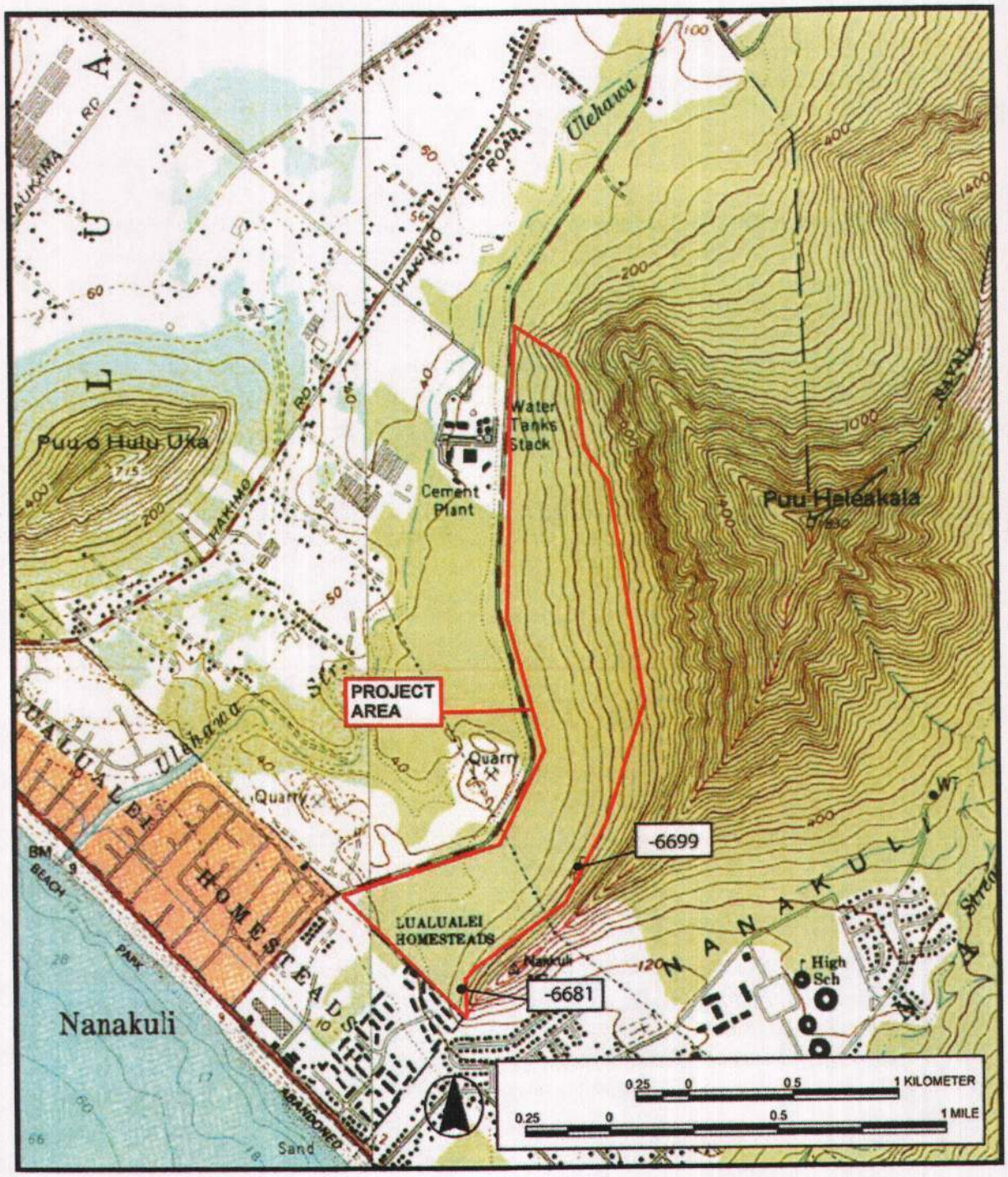

Figure 1. 1998 USGS 7.5 minute topographic map, Wai'anae quadrangle, O'ahu, showing project area location, SIHP 50-80-08-6699, and SIHP 50-80-08-6681

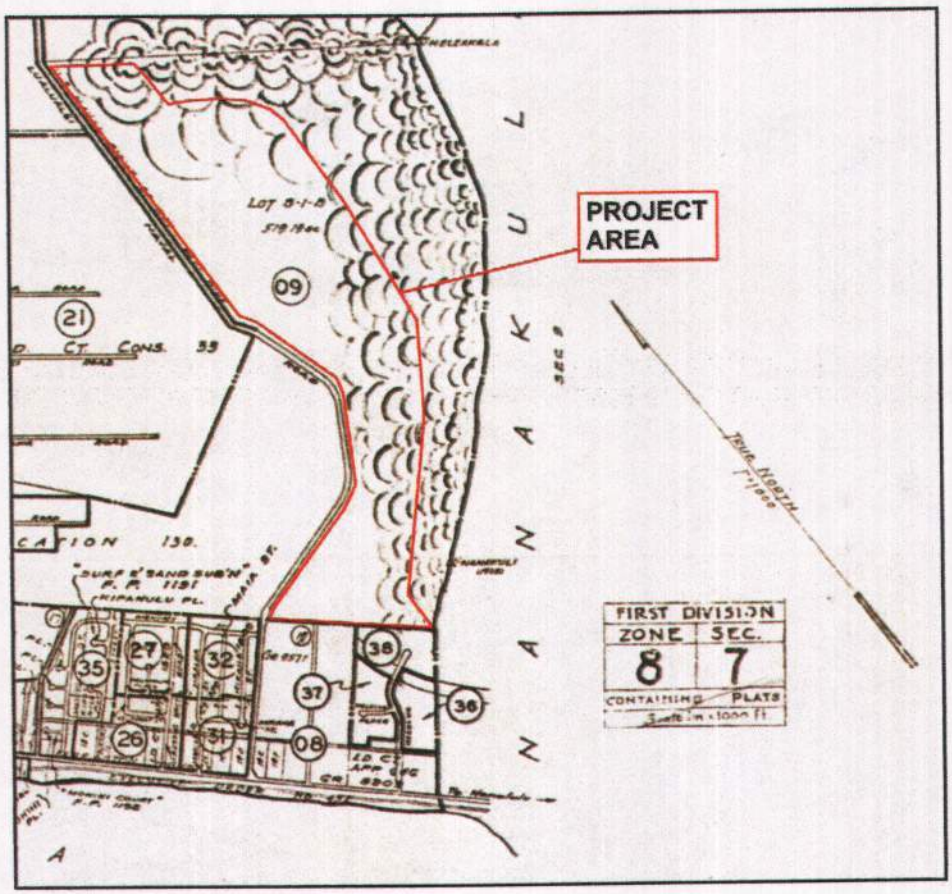

Figure 2. Tax Map Key 8-7-09, section map showing project location (red outlined area)

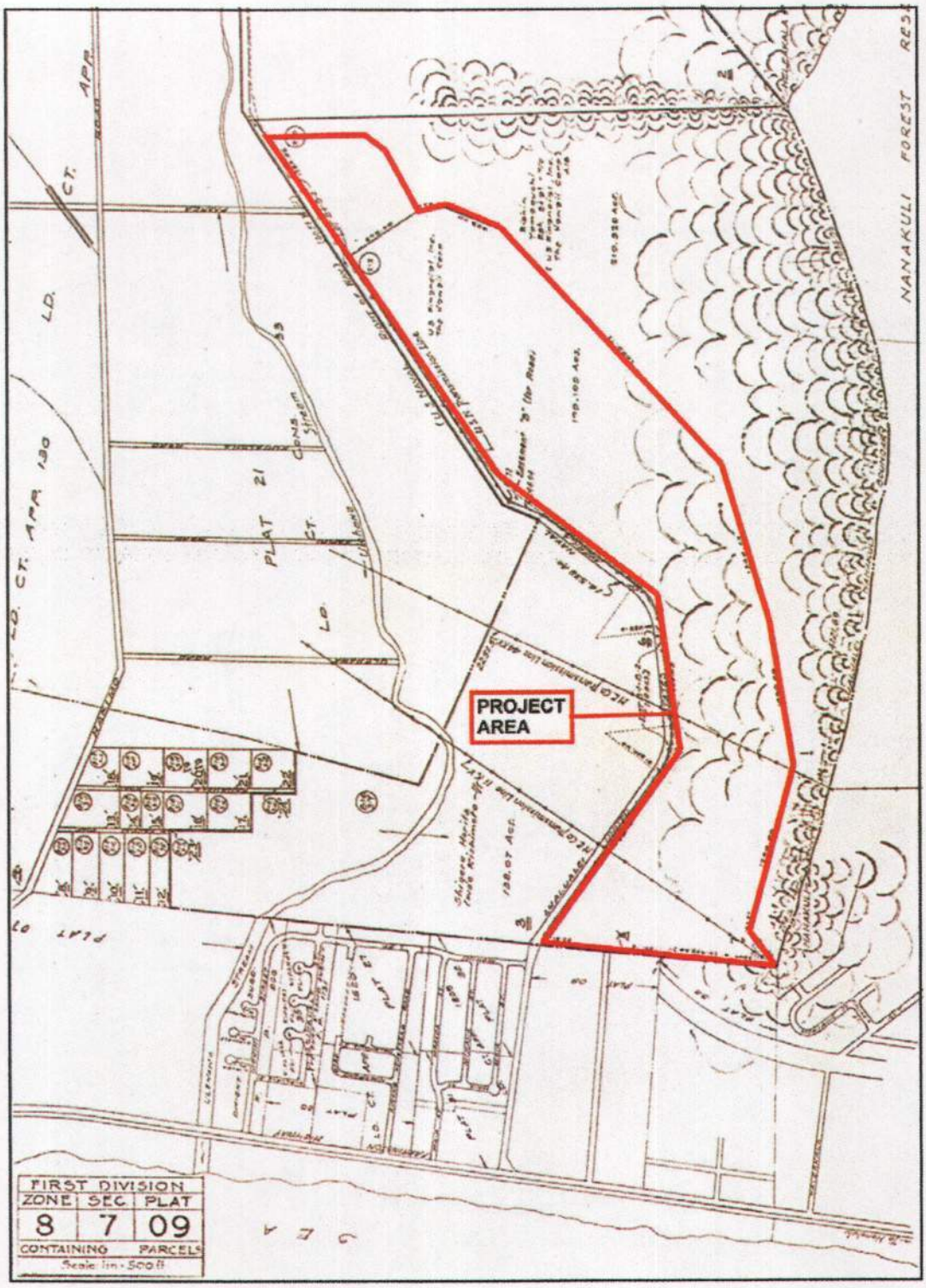

Figure 3. Tax Map Key 8-7, plat map showing project location (red outlined area)

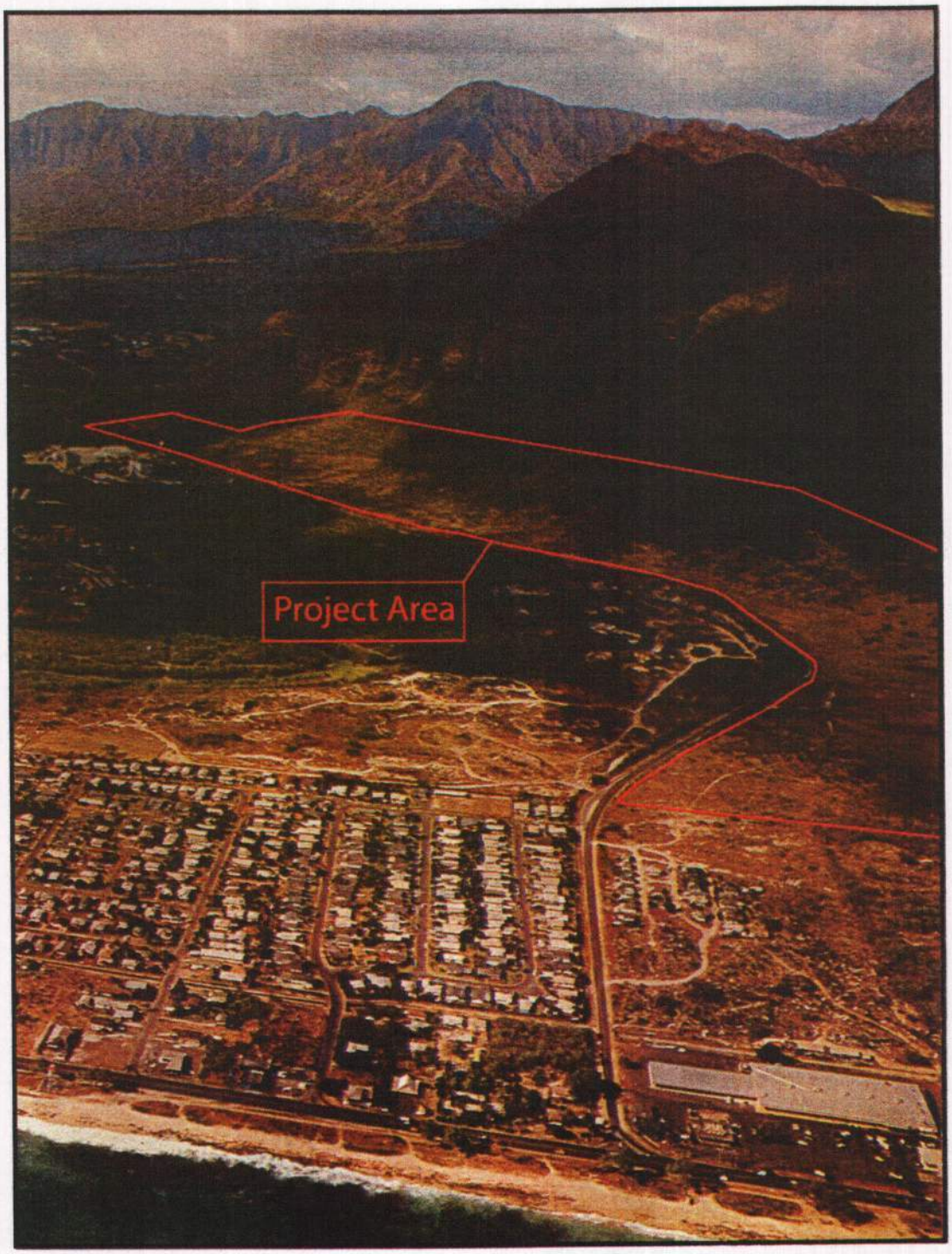

Figure 4. Aerial photograph of Lualualei Valley showing a portion of the project area. Photo was taken some time during the mid to late 1970s (Cameron 1977)

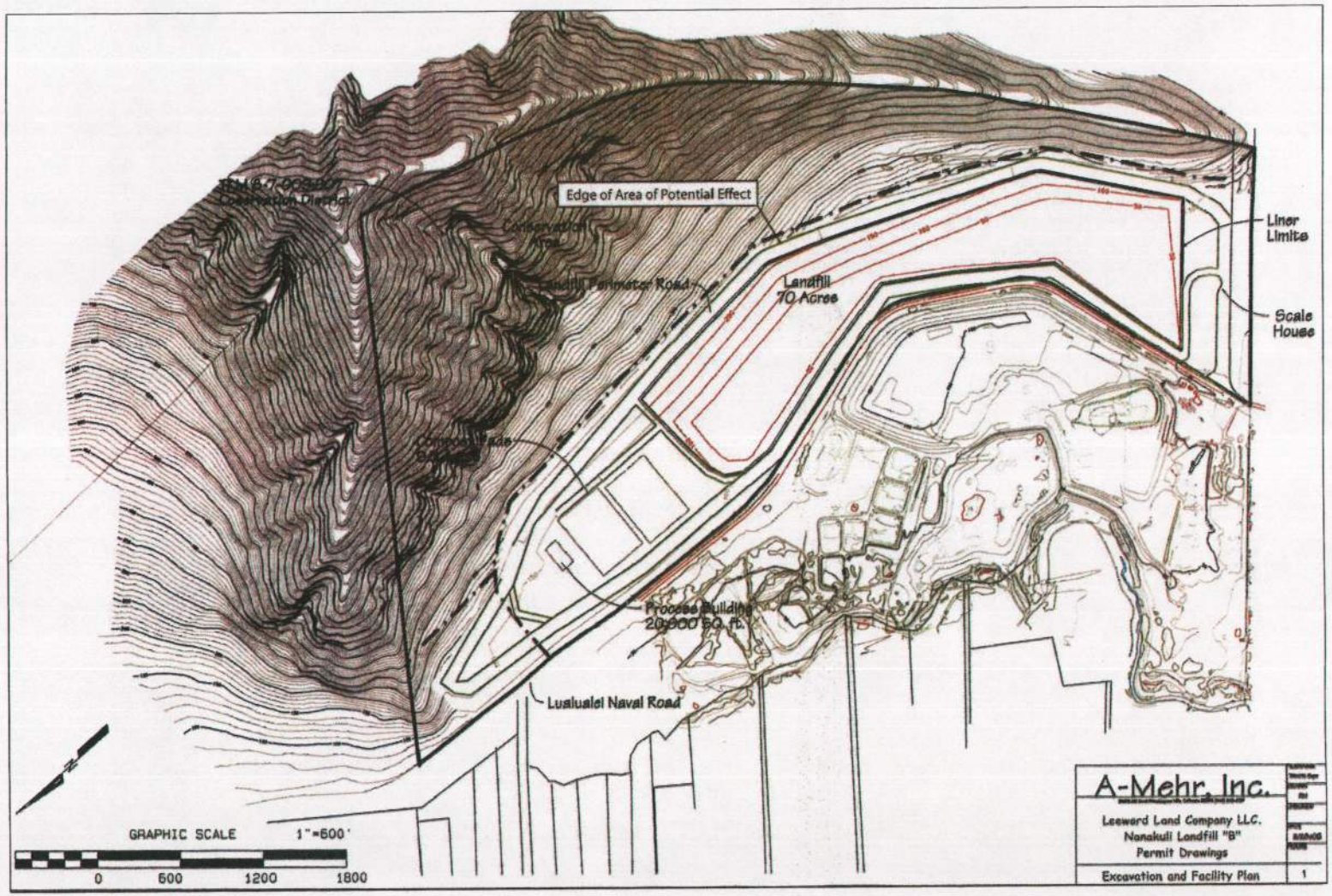

Figure 5. Excavation and Facility Plan Map

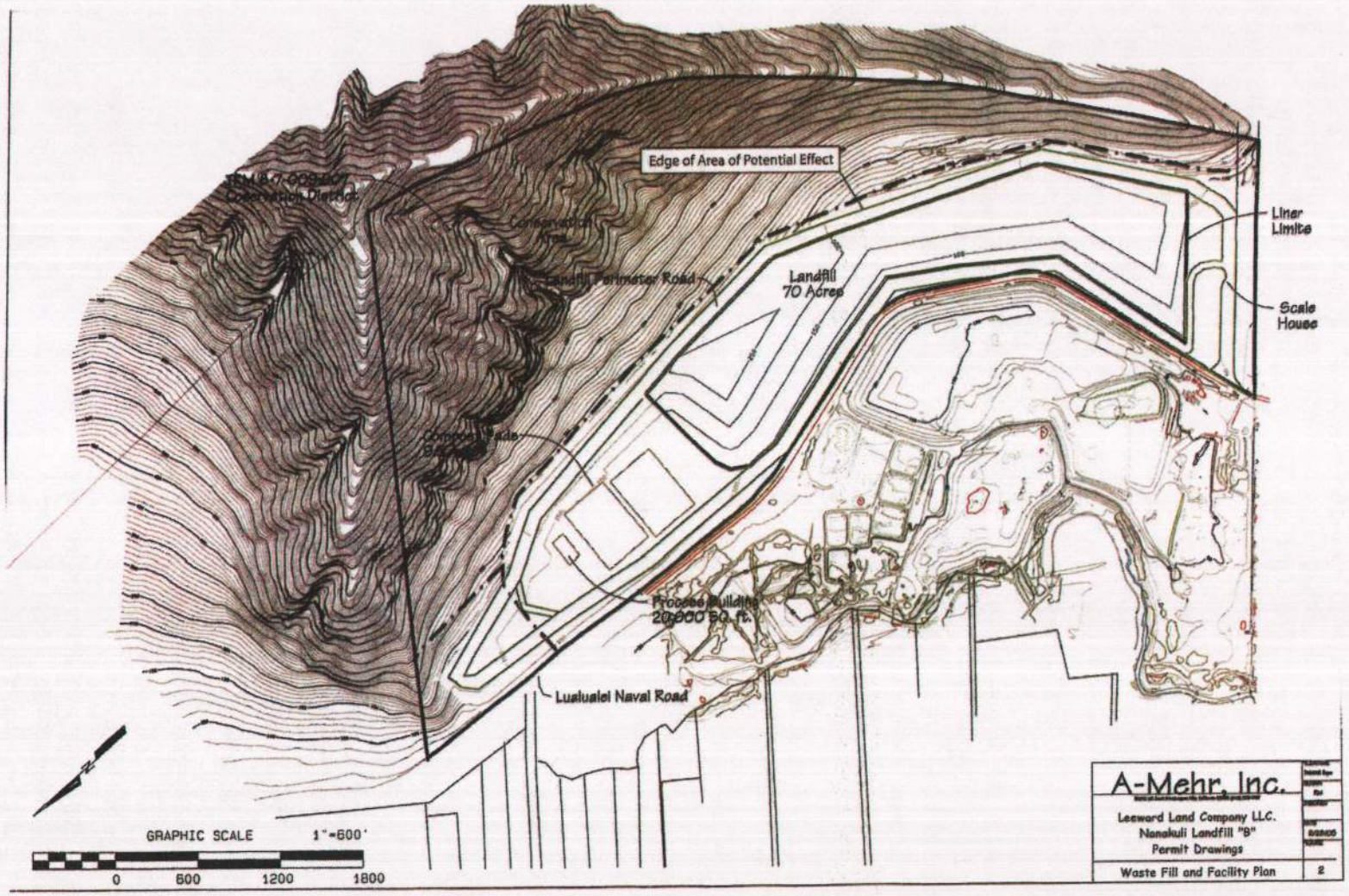

Figure 6. Waste Fill and Facility Plan Map

B. Project Description

The proposed facility is anticipated to accept the wastes currently collected by the Honolulu Disposal Service, Inc. (HDSI), on Oahu. HDSI intends to process so-called "Dirty Materials Recovery Facility" (MRF) at this new facility. It is anticipated that HDSI's MRF will remove up to 50% of the waste stream as recyclables. The remaining, non-recyclable wastes will be delivered to the Nanakuli Facility for processing and disposal. Leeward Land LLC intends to process a significant portion of the wastes delivered to the Nanakuli B Facility, with a particle size reduction and a proprietary volume reduction process. Leeward Land LLC anticipates approximate daily waste disposal rates of 250 tpd to 500 tpd.

Leeward Land LLC has indicated that it is possible that it may receive additional significant quantities of solid waste from additional waste sources after the landfill opens for business. For this reason, the proposed waste processing facility (WPF) and landfill will be designed to be capable of accepting an additional 1,000 tons of wastes requiring daily disposal. Based on current estimates, the Nanakuli B Facility should provide Leeward Land LLC with at least 20 years of waste disposal capacity.

Detailed drawings of the project site including grading, landscaping and building details are not yet available, but a general layout of the "Excavation and Facilities Plan" and the "Waste Fill and Facilities Plan" are included in Figure 5 and Figure 6, respectively. In general, the project will consist of the following elements:

- A minimum 100 foot x 100 foot receiving building for Municipal Solid Waste (MSW) grinding to prepare MSW for aerobic composting operation;
- A 10-acre concrete composting pad will be designed to both deliver air to the MSW for aerobic decomposition and to remove any liquids (leachate) generated by the composting process;
- The leachate will be treated as necessary prior to disposal in a regulatory acceptable manner;
- A landfill excavation and fill plan, including areas for stockpiling of excavated materials. Proposed maximum height of the fill is 250 feet (approximately 180 to 210 feet above local grades);
- A one to two story waste processing and administrative office building of approximately 20,000sqare feet, with associated car parking area;
- Equipment parking and maintenance area;
- Scale house and roads for on-site circulation;
- Storm water drainage facilities.

C. Scope of Work

The following archaeological inventory survey scope of work satisfies the State and County requirements as per Hawai'i Administrative Rules (HAR) Title 13 (Department of Land and Natural Resources), Subtitle 13 (State Historic Preservation Division),

Chapter 276 (Rules Governing Standards for Archaeological Inventory Surveys and Reports):

1. A complete ground survey of the entire project area for the purpose of site inventory. All sites have been located, described, and mapped with evaluation of function, interrelationships, and significance. Documentation includes photographs and scale drawings of all sites, and each site has been assigned a state site numbers.
2. Research on historic and archaeological background, including search of historic maps, written records, and Land Commission Award documents. This research focused on the specific area with general background on the *ahupua'a* and district and emphasizes settlement patterns.
3. Preparation of this survey report, which includes the following:
   a. A topographic map of the survey area showing all recorded historic properties;
   b. Descriptions of all historic properties, including selected photographs, scale drawings, and discussions of age, function, and significance, per the requirements of Hawaii Administrative Rules Title 13, Subtitle 13, Chapter 276 "Rules Governing Standards for Archaeological Inventory Surveys and Reports";
   c. Historical and archaeological background sections summarizing prehistoric and historic land of the project area and its vicinity;
   d. A summary of site categories and site significance based upon the Hawai'i Register of Historic Places (Hawai'i Register) significance criteria;
   e. A project effect determination
   f. Treatment recommendations to mitigate the project's adverse effect on any significant historic properties (properties recommended eligible to the Hawai'i Register) identified in the project area.

This scope of work also includes full coordination with the State Historic Preservation Division (SHPD), and County relating to archaeological matters. This coordination has taken place with the consent of the owner and/or the owner's designated representatives.

D. Methods

1. Background Research

A variety of sources were consulted during the background research for this inventory survey including texts on native Hawaiian oral history of the region, texts on the history of the area, old maps and photographs, Waihona 'Āina, the SHPD library, reports of previous archaeological work in the *ahupua'a*, and texts on the natural history and geography of the area. The books, archaeological reports, and older maps contained within this inventory survey report were contained within the library at CSH.

Sterling and Summers (1978), 'Ī'ī (1959), Kamakau (1991) were used to prepare the Mythological and Tradition Accounts. In addition to 'Ī'ī and Kamakau, McGrath *et al.* (1973) Ellis (1974), Schmitt (1973), Chinen (1958), Cordy et al. (1998), and Bowser (1880) were

utilized for the sections on the history of Lualualei. Land Commission Awards were checked on Waihona 'Āina.

Historical maps within the library of CSH were examined and 1943 USGS maps and 1918 military fire control maps have been included in this inventory survey report. Sterling and Summers (1978) also provided historic maps that show archaeological sites recorded by McAlister (1933). One historic photograph of the area was found in Cameron (1977). In addition to McAllister (1933) numerous previous archaeological studies were checked (e.g. Barrera 1975; Bordner 1977; Chiogioji and Hammatt 1993; Cordy 1975; Hammatt and Shideler 1990; Hammatt *et al.* 1993; Haun 1991; Jimenez, 1994; Jones and Hammatt 2004; Kennedy 1983; Kolb *et al.* 1995; Mayberry and Rosendahl 1994; McDermott and Hammatt 2000; Ogden Environmental and Energy Services Co. Inc. 1997, 1998; O'Hare *et al.* 2003; Souza and Hammatt 2003; Tulchin *et al.* 2003).

To place the project area within environmental context Armstrong (1973), Giambelluca *et* al. (1986), Foote *et al.* (1972), Abbot *et al.* (1983), and Juvik and Juvik (1998) were used.

2. Field Work

CSH personnel covered 100 percent of the project area with systematie pedestrian transects on September 20, 2004 and November 16, 2005. Survey members included Jesse Yorck, BA, Todd Tulchin, BA, Dominique Cordy, BA, Guadalupe Ochoa, and Owen L O'Leary, MA, who served as field supervisor for the archaeological inventory survey. Work began on the uphill property boundary farthest from Lualualei Naval Road and proceeded in successive transect sweeps following the contours of the hill slope until the road was reached. The interval between surveying archaeologists was 10-20 meters depending on the density of the vegetation. Overall the vegetation was relatively open with some dense patches of *koa haole* (*Leucaena leucocephala*) which hampered the survey crew's ability to survey the ground. Sections of the first sweep on the first transect were also hampered by the steep terrain and several water worn gullies towards the north end of the project area. The spacing between personnel was closer together in the areas of denser vegetation. There were also several patches of ground that had been burnt only a few months prior to the survey that allowed for greater visibility of the ground surface. These were inspected in greater detail and no cultural remains were found.

GPS points were taken for both historic sites were taken using a Garmin GPS 5 handheld unit, which were then plotted onto the USGS topographic map using TOPO! Version 3.2.0 by National Geographic Holdings (Figure 1). Two historic properties were found, a prehistoric temporary habitation in a rockshelter (SIHP 50-80-08-6699) and a World War II concrete bunker (50-80-08-6681). Both sites were photographed with a Mini-Rod photo scale. Scale plan maps and profile maps were also drawn of both sites and have been included in this report.

Given the size and location of the parcel, subsurface testing with a backhoe was originally included in the inventory survey scope of work because preliminary background research indicated the potential for subsurface cultural deposits, such as buried cultural layers and/or deposits with significant paleoenvironmental data, that could not be located by surface pedestrian inspection. Subsequent to the completion of project-related historical and cultural background research, and following the completion of the project area's systematic pedestrian inspection, it was determined that backhoe testing was not warranted because of the lack of surface sites and sinkholes within the project area.

Two test units were excavated within SIHP 50-80-08-6699. Before excavation took place the location of both test units were plotted on the plan view site map. Photographs were also taken of the ground surface both before and after excavation. Following the completion of each excavation a stratigraphic profile was drawn to scale of a sidewall of the unit. Excavation of Test Unit #1 was conducted by Owen L. O'Leary and Jesee Yorck on September 21, 2004 and Test Unit #2 by Owen L. O'Leary and John Tulchin on September 23, 2004 using hand trowels following natural stratigraphic layers. Because the dirt floor of the cave was relatively level all the depths of the stratigraphic layers were recorded as centimeters below surface (cmbs).

All excavated sediment was sieved through 1/8-inch mesh screen in the field. Select sediment samples were collected in bulk and returned to the laboratory for wet screening and/or charcoal flotation. All cultural material was collected and labeled by provenience, including test unit, stratum, and depth. The excavations were documented with standard archaeological procedures including the preparation of level records, plan view and profile drawings, photographs, profile records, and sediment descriptions. Sediment descriptions included, Munsell color, texture, consistence, structure, plasticity, cementation, origin of sediments, descriptions of any inclusions such as cultural material and/or roots and rootlets, lower boundary distinctiveness and topography, and other general observations.

3. Laboratory Analytic Methods

Layer three from Test Unit #1 was bagged as a bulk sample in the field because of the high density of remains that were seen by the excavators. This sample was wet sieved in the lab using 1/8-inch mesh screen. This involved placing a box screen across two sawhorses and using a garden hose with moderate water pressure to break up the sediment and push all objects smaller than 1/8 inch through the screen. The recovered materials were then processed in the same fashion as all other remains.

Flotation was conducted by Owen L. O'Leary and Dominique Cordy using five-gallon buckets. A bucket was filled ¾ full with water and then a bulk sample was poured into the water. Sediment sample were the slowly poured into the water. After approximately two minutes the sediment which had settled on the bottom was gently agitated so that the less buoyant particles such as charcoal would be released and float to the surface. The process of settling and agitation was repeated several times. The floating materials were then skimmed off the surface of the water and placed onto newspaper to dry. Samples were eventually bagged, labeled, and weighed following the procedure outlined below.

Cultural remains were sorted by type and individually bagged from each layer within each test unit by John Tulchin. The few recovered artifacts were identified by CSH personal and a catalogue of traditional Hawaiian artifacts has been included with this report (APPENDIX A). CSH staff also identified a small amount of vertebrate faunal remains and the results are also noted below in the results of fieldwork section.

E. Environmental Summary

1. Natural Summary

Lualualei is the largest leeward valley on O'ahu. Comprised of approximately 14,000 acres, Lualualei extends from the Wai'anae Range to the ocean. To the south is the *ahupua'a of*

Nānākuli and to the north is the *ahupua'a* of Wai'anae. Its southern border includes a portion of Pu'u Heleakalā, and its northern boundary includes a portion of Pu'u Pāhe'ehe'e. Lualualei Valley, like the other valleys in the Wai'anae District is characterized by its dry, leeward climate. The prevailing winds in the area are the northeast trades that blow over the Ko'olau mountains, then continue over the Wai'anae range and head out over the southwest potion of the island (Juvik and Juvik 1998: 55). This wind pattern is responsible for the relatively low rainfall averages on the leeward side of the island. The winds cause the rain to hit the Ko'olau Range, first releasing most of their moisture there, and then continuing on over the Wai'anae Rang, releasing what moisture may be left (Abbott *et al.* 1983: 224). Based on data from the Rainfall Atlas of Hawai'i, the mean annual rainfall around the project area is less than 20 inches (Giambelluca *et al.* 1986: 138). The majority of precipitation occurs during the rainy season, October-April, and less precipitation occurs May-September. Temperatures in the area range from 43-88° Fahrenheit in January to 58-95° Fahrenheit in July (Armstrong 1973: 58).

Accoding to Juvik and Juvic (1998: 90) perennial streams are not found in leeward O'ahu. Examination of the Schofield Barracks and Wai'anae USGS Qaudrangle maps shows that Ulehawa Stream is the closest intermittent stream to northwest of the project area and Nānākuli Stream is the closest intermittent stream to the southeast.

Vegetation along this arid coast is sparse. With 20 inches or less of rain annually, only the hardiest plants adapted to the coastal environments can thrive in these zones. The vegetation is typical of dry seashore environments in Hawai'i and is dominated by alien species. Indigenous species include *hau* (*Hibiscus tiliaceous*), *koa* (*Cordia subcordata*), *kamani* (*Calophyllum inophyllum*), *naupaka* or *naupaka kahakai* (*Scaevola sericea*), *pa'u o Hi'iaka* (*Jacquemontia ovalifolia sandwicensis*), the native beach morning glory or *pōhuehue* (*Ipomea pes-caprae*) and the coconut *niu* (*Cocos nucifera*). Introduced species found bordering Farrington Highway include sea grape (*Coccoloba uvifera*), *kiawe* trees (*Prosopis pallida*), Madagascar olive trees (*Noronhia emarginata*), and *koa haole* (*Leucaena leucocephala*) (Foote *et al.* 1972: 93).

The project area lies along the lower slopes of the western slopes of Pu'u Heleakalā. The southern end and southwest corner of the project are comprised of upraised limestone. This is overlain by erosional sediements from the foothills of Pu'u Heleakalā. The majority of the sediments are Lualualei extremely stony clay 3 to 35 percent slopes (LPE). The southwestern corner of the project area is Mamala stony silty clay loam, 0-12 percent slope with some Lualualei clay 2 to 6 percent slopes (LuB) in the vey north corner of the project area long Lualualei Naval Road.

2. Built Environment

The project area is bounded to the north, northeast, and southeast by the ridges of Pu'u Heleakalā. The southwest end of the project area is bordered by Lualualei Homesteads where there are presently small apartment buildings within approximately 50 meters of the edge of the project area boundary. Lualualei Naval Road makes up the entire west side of project area. Across Lualualei Naval Road is a landfill managed by PVT Land Company Ltd. that accepts construction debris, asbestos, and soil for bioremediation. The landfil is located on top of an old quarry which can been seen in both Figure 1 and Figure 4. On the west side of Lualualei Naval Road on the north end of the project there is a cement plant, which can also be seen in Figure 1 and Figure 4.

There has been substantial ground disturbance within the project some time in the past. Lagre portions of the project area shows signs of bulldozer activities. Within the project area pushed up mounds of dirt and raised berms and banks were observed by the field personnel. Several of these appear to have been cut into the hill in order to channel water run off. It is not possible to tell when the bulldozing took place, but almost all of the moved earth has extensive grass growth. Numerous basalt boulders throughout the property have bulldozer scars on them, indicating that their current location is due to modern activities. The project area also has a developed dirt road, which is currently in use that runs from an access gate at the very southwest corner of the property to the two large water tanks along the hill slope. The road is a graded mix of the sediment extending down from the hillside and broken up limestone. There are also several older roads that are overgrown with vegetation, but still visible in various places on the property. Two of these can be seen on the 1943 United States Geological Survey map (Figure 12) and more recent disturbance can be seen in the aerial photograph (Figure 4). This extensive previous modification is likely the reason that no prehistoric or historic cultural remains were found over most of the property.

At several locations within the project area boulders that had been broken by bulldozers were observed to be of relatively fine-grained high quality basalt that could have served as raw material for stone tools. A large dike that crosscuts the regular stratigraphy of Pu'u Hekeakalā is the possible source of these rocks. In a handful of locations within the project area basalt flakes were observed. Unfortunately, it is difficult to determine if these fine-grained basalt flakes are prehistoric lithic reduction debitage or incidentally-fractured stone related to modern bulldozer modifications.

Overall, the extensive evidence of bulldozer activity suggests that any sites that may have been located in the flatter sections of the project area have long since been destroyed. These observations correspond with the fact that the only two SIHP were found along the steeper edge of the project area.

The only other non-natural objects on the landscape are a few scattered rusty barrels, two stripped and rusted out cars and numerous abandoned rusting appliances that have been dumped into the tall *koa haole* along Lualualei Naval Road in the southern end of the project area.

The present state of the project area can be seen in Figure 7 through Figure 10.

Figure 7. Photograph taken looking north showing the northern end of the project area.

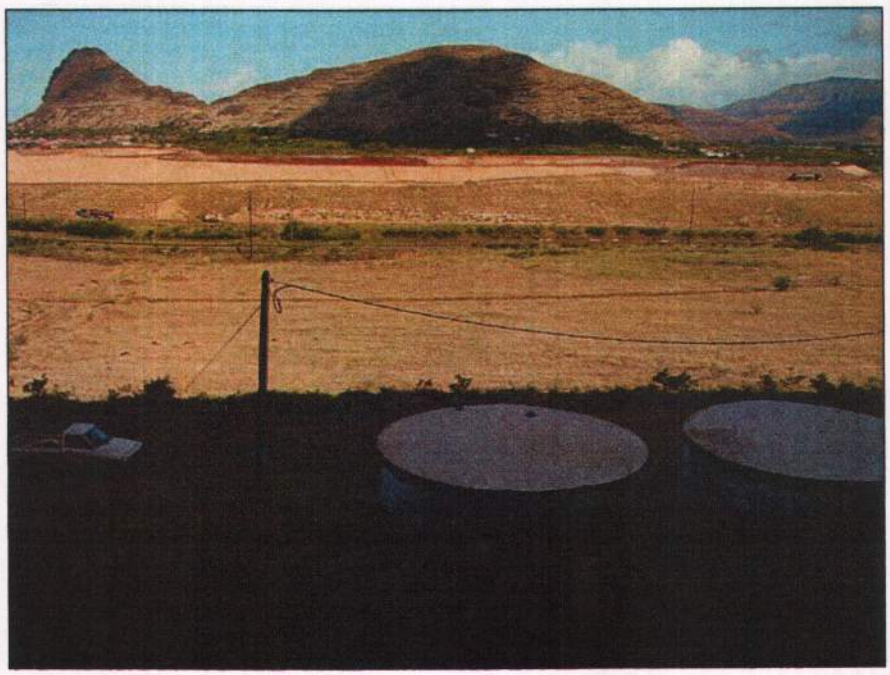

Figure 8. Photograph taken looking west showing the middle portion of the project area and the PVT Land Company Ltd. Landfill across Lualualei Naval Rd.

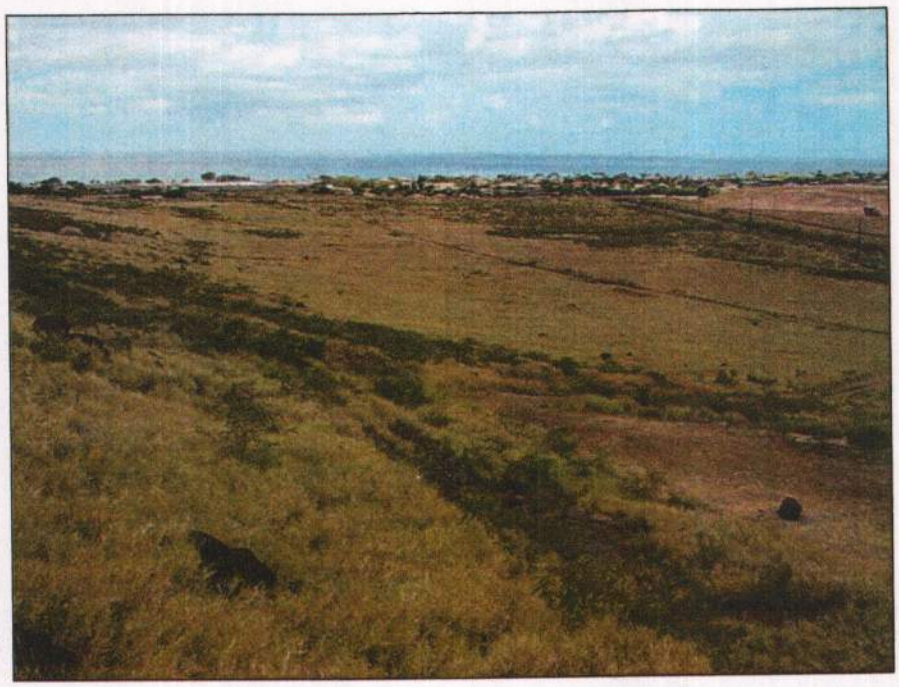

Figure 9. Photograph taken looking southwest to show the southern end of the project area.

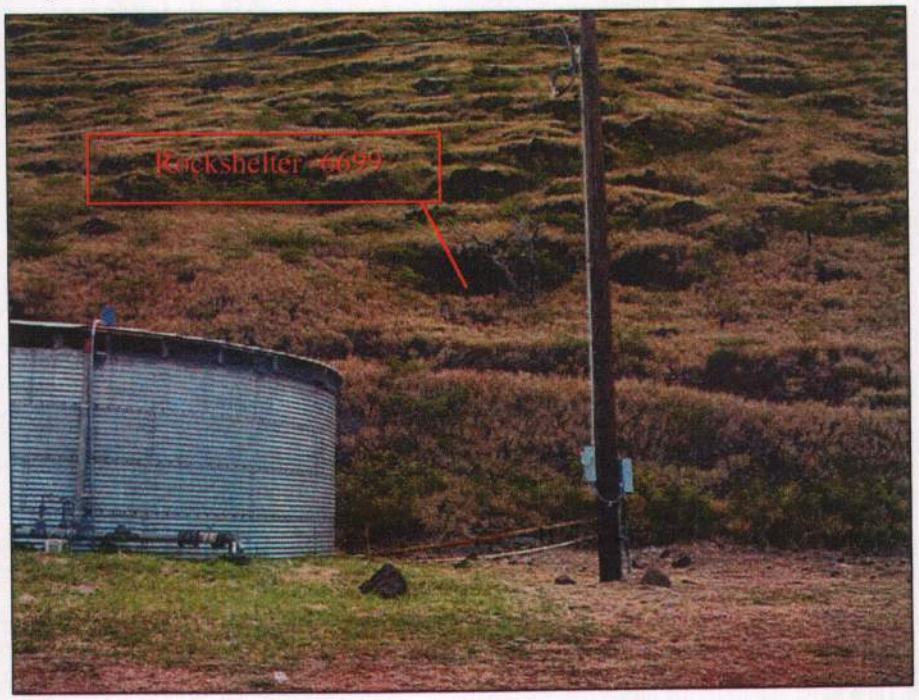

Figure 10. Photograph looking southeast showing the location of SIHP 50-80-08-6699 in relation to the nearby water tank.

II. HISTORICAL SETTING

The District of Wai'anae extends from Nānākuli on the west coast of O'ahu north to Ka'ena Point, and once incorporated eight *ahupua'a*, including Lualualei. In ancient times, the District of Wai'anae was known for its multitude of fish and especially for deep-sea fishing off Ka'ena, where the ocean currents meet. The meaning of Wai'anae (mullet water) also implies an abundance of fish — '*anae*, which is the full-grown mullet (*Mugil cephalus*) (Pukui *et al.* 1974). In 1840, Wilkes made the following comment: "The natives are much occupied in catching and drying fish, which is made a profitable business, by taking them to O'ahu, where they command a ready sale" (Wilkes 1845: 81-82). Handy and Handy (1972) attribute the naming of Wai'anae to a large fresh water pond for mullet called Pueha [sic] (Puehu). Today, Wai'anae is still considered one of the best fishing grounds on O'ahu.

Wai'anae was also known for the independent lifestyle and attitudes of its inhabitants, another trend that continues into the modern day. This independence was a factor in many of the political struggles of the prehistoric and early historic period when the district was the scene of battles and rebellions and often the refuge of dissident and/or contentious factions. This independent spirit is often attributed to the conditioning of generations having to cope with marginal environments, as many areas of Wai'anae, especially Lualualei, were notorious for their inhospitable climate.

A. Mythological and Traditional Accounts

There are two traditional meanings given to the name Lualualei. One meaning, "flexible wreath" is attributed to a battle formation used by Mā'ilikūkahi against four invading armies in the battle of Kīpapa in the early 15th century (Sterling and Summers, 1978: 68). A second, and perhaps more recent meaning, offered by John Papa 'Ī'ī, is "beloved one spared". This meaning relates to a story of a relative who was suspected of wearing the king's *malo* (loincloth). The punishment was death by fire. 'Ī'ī writes:

> The company, somewhat in the nature of prisoners spent a night at Lualualei. There was a fish pond there on the plain and that was where the night was spent . . .
>
> After several days had passed, the proclamation from the king was given by Kula'inamoku, that there was no death and that Kalakua did not wear the king's loin cloth. Thus was the family of Luluku spared a cruel death. For that reason, a child born in the family later was named Lualualei. ('Ī'ī 1959: 23)

Mary Pukui believed the first meaning, "flexible wreath", to be the more appropriate one for Lualualei (Sterling & Summers 1978: 63). According to Kelley (1991: 317), the fish pond on the plain is Puehu fish pond, which is actually located just over the border in Wai'anae. The fish pond no longer exists today and was probably destroyed during the sugar plantation era. Perhaps, a third association to the name Lualualei is an older reference to one of Māui's sisters, who went by the same name.

Numerous Hawaiian legends, in addition to archaeological evidence, reveal the Wai'anae coast and *mauka* (towards the mountains) interior to be an important center of Hawaiian history. It is here, in Wai'anae, that the famous exploits of Māuiakalana (Māui) are said to have

originated. Traditional accounts of Lualualei focus on the mischievous adventures of the demi-god Māui. It was here that Māui learned the secret of making fire for mankind and perfected his fishing skills. Other famous accounts tell of the place where Māui's adzes were made, and of the magic fishhook, Mānaiakalani and the snare for catching the sun, and his kite-flying expedition. Pu'u Heleakalā is the ridge that separates Nānākuli from Lualualei. It was at Pu'u Heleakalā where Hina, Māui's mother, lived in a cave and made her *kapa* (bark cloth) (Sterling and Summers 1978: 62).

Samuel Kamakau tells us that Māui's genealogy can be traced from the 'Ulu line thru Nana'ie:

> Wawena lived with Hina-mahuia, and Akalana, a male, was born; Akalana lived with Hina-kawea, and Maui-mua, Maui-waena, Maui-ki'iki'i, and Maui-akalana, all males, were born.
>
> Ulehawa and Kaolae, on the south side of Waianae, Oahu, was their birthplace. There may be seen the things left by Maui-akalana and other famous things: the tapa-beating cave of Hina, the fishhook called Manai-a-kalani, the snare for catching the sun, and the places where Maui's adzes were made and where he did his deeds. However, Maui-akalana went to Kahiki after the birth of his children in Hawai'i. (Kamakau 1991:135)

B. Early Historic Period

In January of 1778, Captain James Cook sighted Wai'anae from a distance, but chose to continue his journey and landed off Waimea, Kaua'i instead. Fifteen years later, Captain George Vancouver approached the coast of Wai'anae from Pu'uloa and wrote in his log:

> The few inhabitants who visited us [in canoes] from the village earnestly entreated our anchoring . . . And [they] told us that, if we would stay until morning, their chief would be on board with a number of hogs and a great quantity of vegetables; but that he would not visit us then because the day was taboo poory [a *kapu* day]. The face of the country did not however, promise an abundant supply [of water]; the situation was exposed." (Vancouver quoted in McGrath *et al.* 1973:17)

Vancouver was not impressed with what he saw of the Wai'anae coastline, stating in his log that the entire coast was "one barren, rocky, waste nearly destitute of verdure, cultivation or inhabitants."

Vancouver did not anchor at Wai'anae. But had he done so, he would have been pleasantly surprised, at least by portions of the coastline. Even though the dry, arid coast presented a dismal forecast, the ocean provided an abundant supply of fish, the lowlands provided *'uala* (*Ipomoea batatas*) and *niu* (*Cocos nucifera*), and the inland valley areas were planted in *kalo* (*Colocasia esculenta*) and *wauke* (*Broussonetia papyrifera*). The upland forest regions provided various woods needed for weapons and canoes.

By 1811, sandalwood merchants began actively exploiting the Hawai'i market and huge amounts of sandalwood were exported to China. Traditionally, Hawaiians used sandalwood for medicinal purposes and as a scent to perfume their *kapa*. Kamehameha I and a few other chiefs controlled the bulk of the sandalwood trade. Kamakau (1992: 204) writes, "The chiefs also were

ordered to send out their men to cut sandalwood. The chief immediately declared all sandalwood to be the property of the government."

The sandalwood trade greatly impacted Hawaiian culture, and the traditional lifestyle Hawaiians had always pursued was altered drastically. In an effort to acquire western goods, ships, guns and ammunition, the chiefs had acquired massive debts to the American merchants ('Ī'ī 1983:155). These debts were paid off in shiploads of sandalwood. When Kamehameha found out how valuable the sandalwood trees were, he ordered the people not to let the felled trees fall on the young saplings, to ensure their proteetion for future trade (Kamakau 1992:209-210). According to Samuel Kamakau:

> The debts were met by the sale of sandalwood. The chiefs, old and young, went into the mountains with their retainers, accompanied by the king and his officials, to take charge of the cutting, and some of the commoners cut while others carried the wood to the ships at the various landings; none was allowed to remain behind. Many of them suffered for food . . . and many died and were buried there. The land was denuded of sandalwood by this means. (Kamakau 1992:252)

Kamakau comments about the plight of the common people and the general state of the land during this time:

> This rush of labor to the mountains brought about a scarcity of cultivated food throughout the whole group. The people were forced to eat herbs and tree ferns, hence the famine called Hīlaulele, Hāhāpilau, Laulele, Pualele, 'Ama'u, or Hāpu'u, from the wild plants resorted to. (Kamakau 1992:204)

In 1816, Boki Kama'ule'ule was made governor of O'ahu (and ehief of the Wai'anae district) and served in that capacity until 1829, when he sailed to New Hebrides in search of sandalwood. 'Ī'ī writes:

> It was Boki's privilege to assign work, for he had been governor of the island of O'ahu from the time Kamehameha I ordered all the chiefs to O'ahu in 1816 to expel the Russians. ('Ī'ī 1983: 145)

The sandalwood era was short-lived and by 1829, the majority of the sandalwood trees had been harvested, and the bottom fell out of the trade business. It is unclear how extensive Lualaulei's sandalwood resources were, however, the effects of the sandalwood gathering, the population shifts and disruption of traditional lifestyles and subsistence patterns, would undoubtedly have affected the population of Lualualei.

The Reverend William Ellis visited the Hawaiian Islands in 1823. At that time, he estimated the population on the island of O'ahu to be about 20,000 (Ellis 1974:19). The missionaries were the first to gather systematic figures regarding population statistics throughout the various districts on each island. The first census figures were gathered from 1831-1832 and 1835-1836. Population figures for Lualualei were not given, however population numbers given for all of Wai'anae were 1,868 and 1,654 respectively (Schmitt 1973:9).

Following the western encroachment into the Wai'anae Coast, a swift decline in population occurred due to disease and a "tendency to move to the city where there was more excitement" (McGrath *et al.* 1973:25). The *'ōku'u* epidemic of 1804 (thought to be cholera) undoubtedly had

a major effect on the native population, not only in Wai'anae, but throughout the rest of the islands as well. John Papa 'Ī'ī (1983: 16) relates that the *'ōku'u* "broke out, decimating the armies of Kamehameha I" [on O'ahu]. Other diseases also took their toll. In 1835, a missionary census listed 1,654 residents on the Wai'anae Coast. The population of the Wai'anae Coast was decimated by a smallpox epidemic in late 1853. In 1855, the Wai'anae tax collector recorded 183 taxpayers on the leeward coast, which is thought to represent a total population of about 800 people. This catastrophic depopulation facilitated the passing of large tracts of land into the hands of a few landholders, and led to the decline of the traditional economy that once supported the region (Hammatt *et al.* 1993:10-11).

C. Mid-1800's: Land Commission Awards (LCAs)

The Organic Acts of 1845 and 1846 initiated the process of the Māhele - the division of Hawaiian lands - that introduced private property into Hawaiian society. In 1848, the crown and the *ali'i* (royalty) received their land titles. *Kuleana* awards to commoners for individual parcels within the *ahupua'a* were subsequently granted in 1850. At the time of the Māhele, the *ahupua'a* of Wai'anae, which included Lualualei, was listed as Crown lands and was claimed by King Kamehameha III as his personal property (Board of Commissioners 1929: 28). As such, the land was under the direct control of the King. Many of the chiefs had run up huge debts to American merchants throughout the early historic period and continuing up into the mid 1800's. A common practice at the time was to lease (or mortgage) large portions of unused land to other high chiefs and foreigners to generate income and pay off these earlier debts.

Until the passage of the Act of January 3, 1865, which made Crown Lands inalienable, Kamehameha III and his successors did as they pleased with the Crown Lands, selling, leasing, and mortgaging them at will (Chinen 1958:27).

In 1850, the Privy Council passed resolutions that would affirm the rights of the commoners or native tenants. To apply for fee-simple title to their lands, native tenants were required to file their claim with the Land Commission within the specified time period of February 1846 and February 14, 1848. The *Kuleana* Act of 1850 confirmed and protected the rights of native tenants. Under this act, the claimant was required to have two witnesses who could testify they knew the claimant and the boundaries of the land, knew that the claimant had lived on the land for a minimum of two years, and knew that no one had challenged the claim. The land also had to be surveyed.

Not everyone who was eligible to apply for *kuleana* lands did so and, likewise, not all claims were awarded. Some claimants failed to follow through and come before the Land Commission, some did not produce two witnesses, and some did not get their land surveyed. For whatever reason, out of the potential 2,500,000 acres of Crown and Government lands "less than 30,000 acres of land were awarded to the native tenants" (Chinen 1958:31).

A total of twelve land claims were made in Lualualei, however only six were actually awarded. All six awards were located upland in the *'ili* of Pūhāwai, far *mauka* of the current project area. No quiet land titles were claimed near the coast. From the claims, it can be determined that at least eight families were living in Pūhāwai at the time of the Māhele in 1848. Together, they cultivated a minimum of 163 *lo'i* (wetland agriculture). The numerous *lo'i* mentioned in the claims indicate the land was ideal for growing wetland taro and that this

livelihood was actively pursued by the awardees. In addition, dryland crops were grown on the *kula* (plains), *wauke* was being cultivated, and one claimant was making salt.

Information on the occupation at Lualualei at the time of the Mahele, aside from the historical accounts of scattered coastal hamlets, is from archival records indicating there were nine taxpayers at Mā'ili near the coast and 11 taxpayers at Pūhāwai in the upper valley (Cordy 1998: 36). Mā'ili is located along the eastern edge of the *ahupua'a* and Pūhāwai is well *mauka.* Based on these numbers, Cordy estimates a population of 90 people for coastal Lualualei and 55 people for the upper valley in 1855 (Cordy 1998: 36). Regardless of the population estimate, the existence of 20 taxpaying adults in Lualualei indicates that the area was being inhabited and worked. In this case, the Māhele documents are only a partial reflection of the population and actual land use during the time.

D. 1850 - 1900

With strong financial backing from King Kalākaua, Hermann A. Widemann, a German immigrant, was able to initiate the Wai'anae Sugar Plantation in 1879. This plantation would extend into Lualualei. Although it was never a large-scale plantation by modern standards, it was one of the first and last to be served by a plantation railroad. Some 15 miles of 30-inch narrow-gauge railroad delivered harvested cane to the mill. All the sugar was shipped by inter-island vessels to Honolulu departing from Wai'anae Landing, until the O'ahu Railway and Land Company (OR&L) railroad was extended to Wai'anae and beyond in 1889. The OR&L railroad ran along the *makai* (toward the sea) side of Farrington Highway. The J. M. Dowsett Estate sold the plantation to American Factors (now Amfac/JMB-Hawai'i) in 1931, and the OR&L railroad closed in 1947.

The first longhorn cattle were brought to O'ahu from Hawai'i Island in 1809 by John Young and Kamehameha I (Kamakau 1992:268). One of the first areas to be utilized for ranching on the Wai'anae coast was Lualualei. Hawai'i Bureau of Land Conveyances (1845-1869) records show that William Jarrett leased approximately 17,000 acres of land from Kamehameha III in 1851. This was the beginning of Lualualei Ranch. The lease was written for 30 years with a lease fee of $700 per year (DLNR, B.C. Liber 4:616-618.). It seems that Jarrett sold Paul F. Marin, son of Don Francisco de Paula Marin, one-half of his interest in the ranch. Marin lived on the ranch and managed it until 1864, when a dispute arose over the profits of the ranch. Apparently, Marin had never turned over any ranch profits to Jarrett during the time he managed it. After the dispute was settled, Jarrett took on George Galbraith as a new partner (B.C. Liber 18:31).

In 1869, Jarrett sold the remaining years of his son's interest in Lualualei Ranch to James Dowsett (B. C. Liber 29:16-18). James Dowsett was a descendant of a British sea captain and is noted for being the first Anglo-Saxon child born in Honolulu (Nakamura and Pantaleo 1994: 21). Dowsett was an entrepreneur of sorts and dabbled in many different business ventures, such as:

> ...a whaling fleet, a dairy, a salt works, an extensive trade in *awa* (a Hawaiian narcotic drink) and numerous land holdings . . . He also ran cattle at different times in Nānākuli, Mikilua and Lualualei. (McGrath *et al.* 1973:32)

In 1880, George Bowser traveled through Wai'anae and wrote about Lualualei in his journal:

> Leaving Wai'anae, a ride of about two miles brought me to the Lualualei Valley, another romantic place opening to the sea and surrounded in every direction by high mountains. This valley is occupied as a grazing farm by Messrs. Dowsett & Galbraith, who lease some sixteen thousand acres from the Crown. Its dimensions do not differ materially from those of the Wai'anae Valley, except that it is broader – say, two miles in width by a length of six or seven miles. The hills which enclose it, however, are not so precipitous as those at Wai'anae, and have, therefore, more grazing land on their lower slopes, a circumstance which adds greatly to the value of the property as a stock farm. Although only occupied for grazing purposes at present, there is nothing in the nature of the soil to prevent the cultivation of the sugar cane, Indian corn, etc. Arrangements for irrigation, however, will be a necessary preliminary to cultivation. (Bowser 1880:493-494)

Bowser's comments imply that though water was still a problem, Lualualei seemed to have some potential for development.

In 1894, Link McCandless entered the ranching scene:

> ...he and a man named Tom King chartered the brigantine Oakland in Seattle, filled her hole with cattle and the cabins with feed, and sailed for Hawai'i. By the turn of the century, McCandless' ranching empire covered much of the Wai'anae Coast, including land at Nānākuli, 4,000 acres at Lualualei, San Andrews' property in Mākua and pastures toward Ka'ena Point. (McGrath *et al.* 1973:31)

An 1894 description of Lualualei by the Commissioner of Crown Lands described the land as "one of the best and most valuable of the Crown lands on the Island of O'ahu...surpassing any of the other lands for richness and great fertility of the soil" (Commissioner of Crown Lands 1894:36).

The sugar industry came to the Wai'anae coast in 1878 when the first sugar cane was planted in upper Wai'anae Valley. By 1892, at least 300 acres of cane was planted in Lualualei. In addition to the cultivated lands, a railroad, irrigation ditches, and flumes, reservoirs and plantation housing were constructed to support the sugar industry. The cane from the *mauka* areas of Lualualei was loaded onto a railroad and transported to the mill at Wai'anae.

The O'ahu Railway and Land Company (OR&L) signed its charter on February 4, 1889. The Railway was the brainchild of Benjamin Franklin Dillingham. Along with James Castle and others, he had invested in large tracts of land for speculation and resale, but the idea was slow to catch on because "the land lay too far from Honolulu, at least 12 miles." (McGrath *et al.*1973:54) He foresaw an economic opportunity. The railway was a means to provide transportation to the country and promote development of unoccupied lands, as well as connect with the sugar plantations in 'Ewa, Wai'anae, Waialua, and Kahuku. Construction on the railway began in March of 1889. The first length of the railway was completed and opened to the public by January 1, 1890. Five years later, on July 4, 1895 the railway finally reached Wai'anae. The Railway served the Wai'anae coast until 1946 when the Wai'anae Sugar Plantation closed down.

E. Early 1900's to Present

By 1901, the Wai'anae Sugar Company had obtained a five-year lease on 3,332 acres of land at Lualualei to be used for raising cane as well as for ranching (Commissioner of Crown Lands

1902). Sugar and ranching continued to dominate the Lualualei landscape during the early years of the 20th century. The determining factor in the success of Lualualei for sugar production was always the water.

Throughout the first half of the twentieth century, the Wai'anae Sugar Company continued cultivating their sugar lands in Lualualei. By the 1940's, Wai'anae Sugar Company could no longer compete with foreign labor. This, in addition to drought problems, labor unions and land battles, caused the undermining of Wai'anae Sugar Company. In 1946, the Company was liquidated, and the land was sold.

Examination of older maps shows that sugar cultivation did not take place within the area currently encompassed by the project area. This is displayed in Figure 11 and Figure 12.

1. Homesteading

After the overthrow of the Hawaiian monarchy in 1893, the Crown Lands and the Government Lands were combined to become Public Lands. The Crown Lands were no longer indistinguishable and inalienable. In 1895, the Republic of Hawai'i decided to open up lands for homesteading in the hopes of attracting a "desirable class of immigrants" — Americans and those of Caucasian decent (Kuykendall and Day 1961:204). In anticipation of the Dowsett-Galbraith lease expiring in 1901, the Government intended to auction off these lands to the highest bidder.

There were two waves of homesteading on the Wai'anae Coast (McDermott and Hammatt 2000). The first impacted Lualualei and coincided with homesteading occurring at Wai'anae Kai. In 1902, the government ran adds in the local newspapers stating their intent to open up land in Lualualei for homesteads (Kelly 1991:328). Due to the lack of water, the lots were classified as second-class pastoral land, rather than agricultural land. The homesteads were sold in three series between the years 1903 and 1912. In Lualualei, the first series was for *mauka* lots purchased by McCandless, who ranched most of his land until 1929, subletting use rights to the Sandwich Island Honey Company. The second and third series were for lots in the lower valley and along the coast, *mauka* of the government road. By the early 1920's, about forty families had settled on homestead lots in Lualualei (Kelly 1991:331-332). The big-name families that obtained homestead lots at this time were Von Holt, McCandless, and Dowsett.

Despite promises by the government to supply water, there was none, and what little there was, was not enough to go around. Competition between the Wai'anae plantation and the homesteaders for water caused friction within the community. The lack of water placed a hardship on the homesteaders. Water had to be carried in, and many lost their crops. The Wai'anae Sugar Company had a lease with the government to take 2.5 million gallons of water daily from government lands, but even after their lease had expired, the plantation continued to take the water. In 1924, the government made an agreement with the plantation to release 112,000 gallons of water daily for the homesteaders.

2. Military

Another major influence in Lualualei, during the first half of the 20th century, was the military. By 1929, over 8,184 acres of the McCandless Cattle Ranch had been condemned and purchased by the U.S. Navy for the construction of a Naval Ammunition Depot for the ships of Pearl Harbor Naval Base.

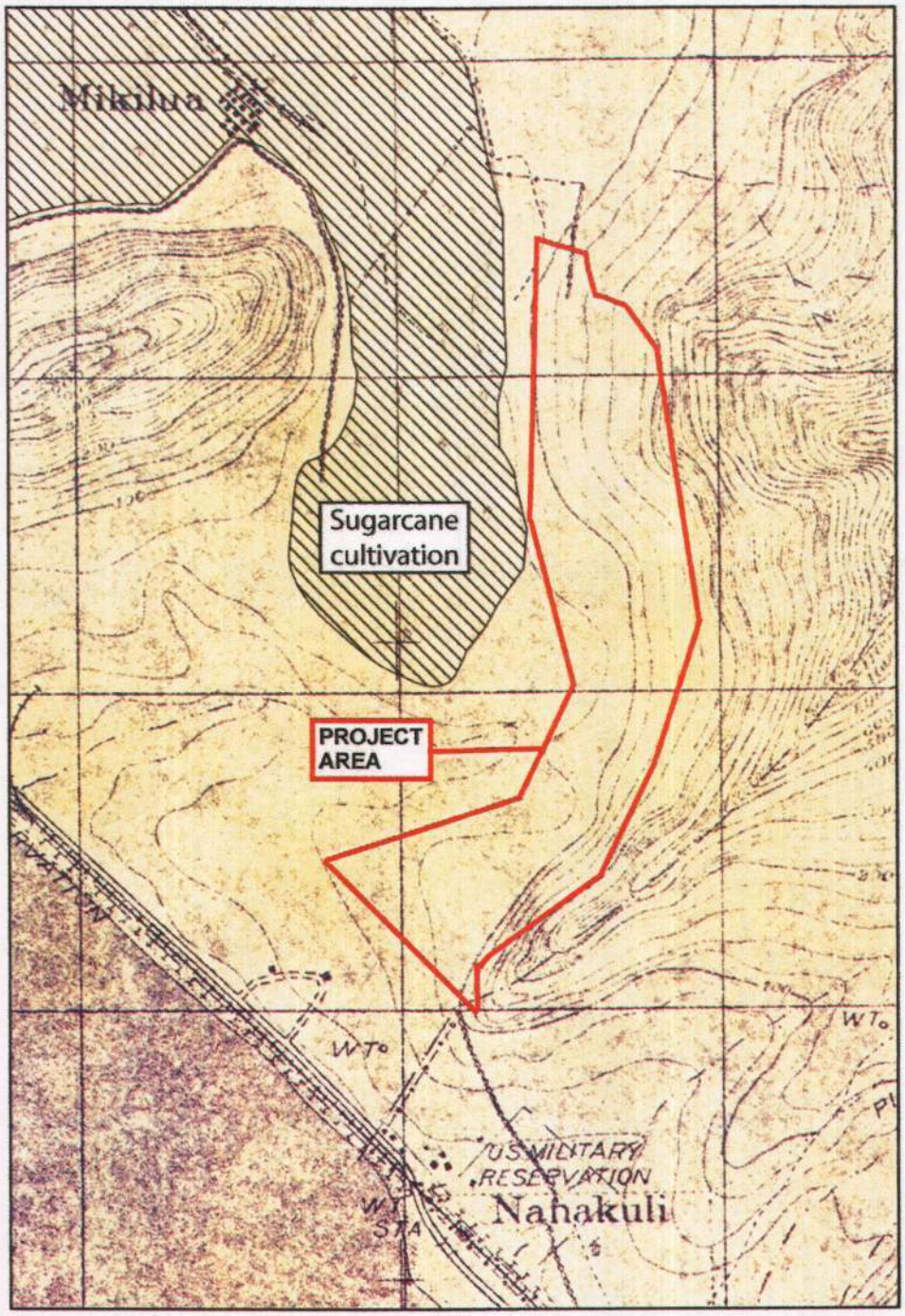

Figure 11. United States Military Fire Control Map from 1918 with the extent of sugar cane cultivation and the current project area overlain

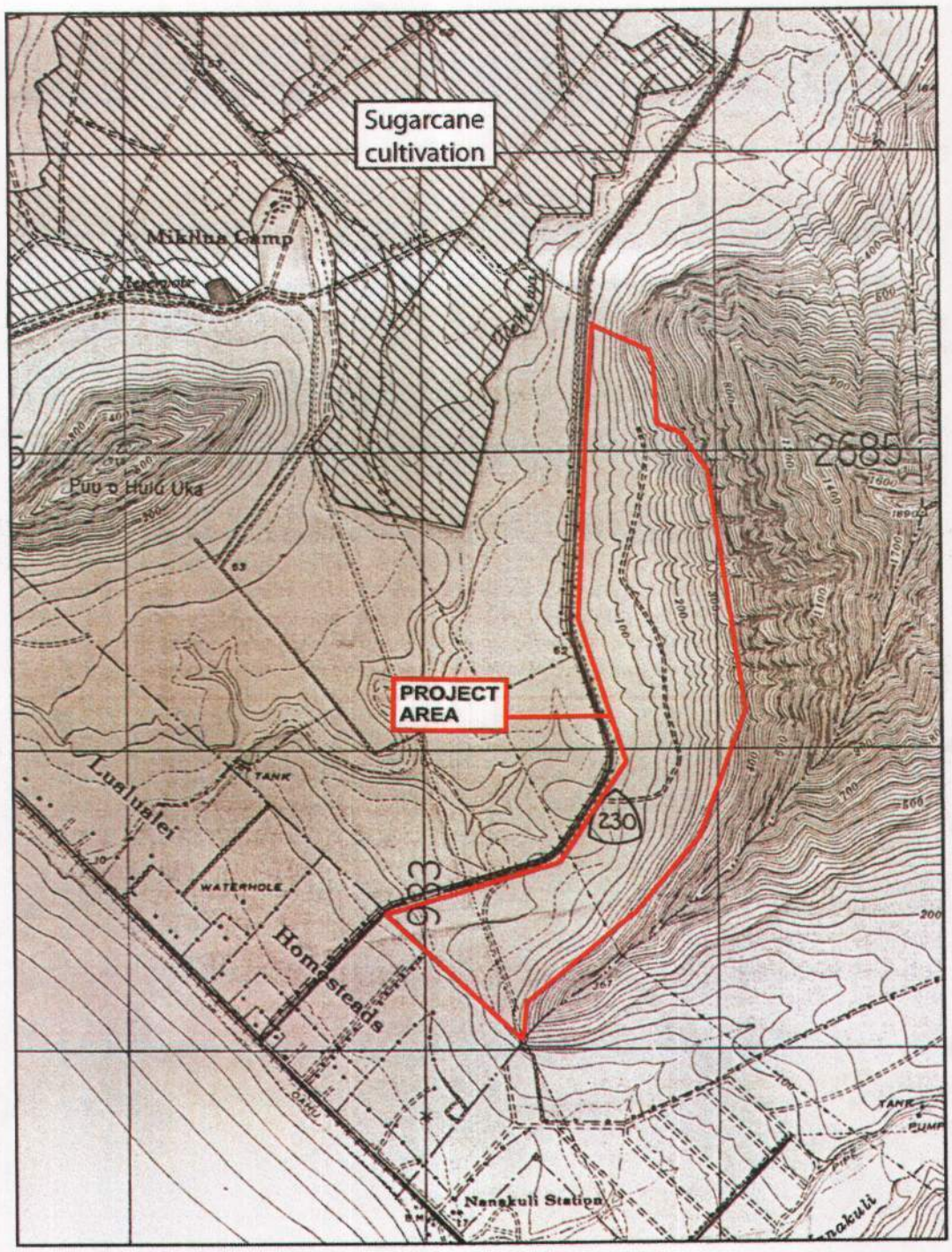

Figure 12. 1943 USGS map showing the previous area of sugarcane cultivation and current project area.

The construction of Naval Magazine LLL and Radio Transmission Facility (RTF) took place in Lualualei between 1930 and 1935 (Kelly 1991:339-341). The number of troops stationed and trained on the Wai'anae Coast during World War II at times reached 15, 000 to 20,000 (McGrath *et al.*1973:136). The beaches were fortified with barbed wire and concrete bunkers--many of which are still visible today. Martial law severely curtailed the movements of the local population. In 1971, the Navy began sub-leasing some of their lands for agricultural uses, mainly for grazing and bee keeping. The presence of the military at Lualualei has boosted the economy of Lualualei by providing jobs to residents over the years. The lower portions of Lualualei Valley were developed into residential lots after WWII. The study area lies outside of military lands.

III. PREVIOUS ARCHEAOLOGICAL RESEARCH

A. Previous Archaeological Studies in Lualualei

Table 1 summarizes the previous archaeological studies conducted in Lualualei (illustrated in Figure 13). The earliest attempt to record archaeological sites in the nearby regions of Lualualei was in the 1930's by J. Gilbert McAllister. McAllister recorded four sites in Lualualei, one site on the border between Lualualei and Nānākuli Ahupua'a, and three sites on the border of Lualualei and Wai'anae *Ahupua'a* (Figure 14). The site on the border with Nānākuli, south of the present project area was 'Ilihune Heiau.

'Ilihune Heiau is destroyed today and its location will not be impacted by activities within the proposed project area. McAllister, however, does provide a small amount of information. The locations of both 'Ilihune Heiau and the Maui Rock can be seen in relation to the project area in Figure 14 and Figure 15.

> Site 147. Approximate site of 'Ilihune Heiau, Nanakuli, of which nothing remains. Thrum notes: "A small walled heiau of *pō'okanaka* class; used about 1860 by Frank Manini as a cattle pen, for which natives prophesized his poverty and death." (McAllister 1933: 110)
>
> Site 148. Large rock said to be named Maui, about 1.1 mile from Nanakuli station toward Pu'u o Hulu
>
> Northeast of the road on the property of E.P. Fogarty is a rock said to be named after the Hawaiian hero, Maui, who is said to have landed here when he first came to the Hawaiians islands from the south. This stone at the time was surrounded by water, and it was here that Maui reposed and sunned himself. In the bluff just northeast of the rock is a shelter in which he lived, and in the vicinity was a spring where he obtained water. The large rock is now split in half and adorned with many small, oddly-shaped rocks. It is said to be bad fortune to build one's house across a line drawn directly from the rock to the shore. (McAllister 1933: 110)

McAllister recorded three sites in the *mauka* portion of Lualualei. Site 149 was Nioiula Heiau, on Hālona Ridge, said to be of the *pō'okanaka* class. Some of the stones were used for a cattle pen on the McCandless property. Site 150 consisted of house sites or *heiau* at the foot of the cliffs in Pāhoa. Cattle destroyed much of the walls and terraces. Site 151 was Kakaio Heiau, located at Pūhāwai. It had a sacred spring where the sound of drums and conches could be heard on the nights of Kāne (McAllister 1933: 110).

McAllister recorded three sites near the boundary of Lualualei and Wai'anae, far north of the project area. Site 152, Pu'u Pāhe'ehe'e Heiau, consisted of a walled *heiau* on the slopes of Pāhe'ehe'e Ridge. In ancient times, the slopes were covered with slippery grass for the purpose of staging sledding contests (McAllister 1933: 112). This site was completely destroyed with the enlargement of the adjacent Oriental Cemetery. At the tip of Kāne'īlio Point was Site 153, Kū'īlioloa Heiau. This *heiau* was surrounded by water on three sides and consisted of three platforms with evidence of terracing (McAllister 1933: 112). Site 162 was a burial cave at Mauna Kūwale. It contained fragments of skeletal material (McAllister 1933: 116).

Table 1: Previous Archaeological Investigations in Lualualei Ahupua'a.

Reference	Location	Description and Results
McAllister 1933	Lualualei Ahupua'a	Island-wide Survey; McAllister recorded eight sites in or near Lualualei: Site 147. 'Ilihune Heiau; Site 148, rock called Maui; Site 149, Nioiula Heiau on Hālona ridge; Site 150, House sites or heiau at Pahoa cliffs; Site 151, Kakioe Heiau at Pūhāwai; Site 152 Pu'u Pāhe'ehe'e Heiau; Site 153, Kū'īlioloa Heiau; and, Site 162, Mauna Kūwale burial cave.
Bordner 1977	Lualualei Ahupua'a TMK 8-7-9	Reconnaissance Survey: Performed on the proposed site for the Nānākuli landfill. The area included land on both sides of Lualualei Naval Road, continuing up the slope to Pu'u Heleakalā. No archaeological sites were found.
Haun 1991	Naval Magazine and Naval Communications Area Transmission Facility TMK 8-6; 8-7; 8-8-01	Archaeological Reconnaissance Survey: Included a 8,184-acre parcel, and a 700-acre parcel encompassing the entire inland portion of Lualualei Valley. A total of 131 sites and 1,004 features were identified. The features included "alignments, C-shapes, L-shapes, U-shapes, walls, terraces, enclosures, mounds, platforms, walled terraces and paved terraces" (Haun 1991; vii). The features are related to habitation, rituals, ceremonies, agriculture, the procurement of lithic material, and the manufacture of stone tools. Historical and recent structures associated with cattle ranching and military use were also identified.
Chiogioji, Hammatt 1993	Lualualei Ahupua'a TMK 8-7-21:17	Archaeological Survey and Testing: (Revised from the 1992 'Archaeological Investigations' report). This five acre parcel, formerly a basil farm, was situated between Pu'u o Hulu to the northwest and 'Ulehawa Stream to the southeast. The results of the survey found an absence of intact archaeological remains.
Hammatt et al. 1993	Lualualei Ahupua'a Lualualei Golf Course TMK 8-7-9:2; 8-7-10:6&10; 8-7-19:1	Archaeological Inventory Survey: Identified eight sites within the project area, two traditional Hawaiian sites that included one habitation complex and the remnants of one wall, and six historic sites that included a cattle wall, a furnace, wells, a house lot, and cement foundation structure. (These findings have also been included in the Final Environmental Impact Statement produced by Hida, Okamoto, & Associates, April 1991)

Reference	Location	Description and Results
Ogden Environ-mental and Energy Services Co., Inc. 1997	Lualualei Ahupua'a Lualualei Navel Magazine	Cultural Resource Review Survey: This survey reviewed existing information on sites in the previously listed locations. Sites reviewed within NAVMAG-LLL included 197 sites with 1020 recorded features and also an additional 400 sites that had been reported but not recorded; in NAVMAG-Waikele five sites with 11 features; in NAVMAG-West Loch two sites; and Kolekole Rock was located near NAVMAG-LLL. Three sites listed in the National Register of Historic Places (NRHP) were located in the project area. They include the Nioiula Heiau, NAVMAG-LLL; 'Oki'okiolepe Fishpond, NAVMAG-West Loch; and the Pearl Harbor National Historic Landmark, NRHP site 50-80-13-9992
Ogden Environ-mental and Energy Services 1998	Lualualei Ahupua'a Radio Transmission Facility	Phase I Archaeology Reconnaissance Survey: This survey was conducted to locate archaeological sites and incorporate them into a Cultural Resource Management Plan. Three sites were located on a 260-acre parcel. Site 5591 is composed of features associated with the sugarcane industry of the 19th and 20th centuries. Sites 1886 and 5592 are considered traditional Hawaiian sites; they include a permanent habitation site and a rock mound.
Tulchin et al. 2003	Lualualei Ahupua'a, Pu'u Mā'ili'ili	Archaeological Inventory Survey: Cultural Surveys Hawai'i recently conducted an inventory survey of the proposed Wai'anae 242 Reservoir and Access Road project area, on the northeast ridge of Pu'u Mā'ili'ili. Two possible field shelters and a cave were investigated, but there was little evidence that these were traditional Hawaiian sites.

Table 2: Previous Archaeological Investigations in Mā'ili, Lualualei Ahupua'a.

Reference	Location	Description and Results
Barrera 1975	Mā'ili, Kaiser Pacific Prop. Corp. Land	Archaeological Site Survey: Six sites were found; a religious structure; C-shaped feature; two house site features; a possible site; and a midden scatter.
Cordy 1975	Mā'ili, Kaiser Pacific Prop. Corp. land	Excavation of Site CH-0A-1: The religious structure in Barrera's (1975) report was excavated. This report found no evidence to confirm the site as being a religious structure, instead it was found to be a modern structure built no earlier than 1930 or 1940.
Kennedy 1983	Mā'ili, TMK 8-7-06:32	Reconnaissance Survey: No archaeological sites were found on or within 50 feet of the proposed Wai'anae Corporation Yard site.
Hammatt Shideler 1990	Mā'ili, Liopolo Street Burial (Site 50-80–08-4244)	Archaeological Monitoring and Osteological Analysis: Seven burials were discovered during the installation of a Board of Water Supply 8-inch water main. The burials were found in calcareous beach sand. Five burials were removed, and two were left in situ.
Jimenez 1994	Mā'ili Kai TMK 8-7-10:2	Additional Inventory Survey: Conducted at four previously inventoried sites in the Mā'ili Kai project area. This inventory identified intact prehistoric and historic cultural deposits at two of the sites. Twenty-five of 26 sites had been considered significant for scientific information content and required no additional data collection, while the remaining site was considered significant and recommended for additional data collection.
Mayberry, Rosendahl 1994	Mā'ili, TMK 8-7-10:2, 14	Reconnaissance Survey: Twenty-six sites were located. Twenty-four of these sites dated to the 20th century. Two of the 24 sites dated to the early to late 20th century, and the other 22 sites dated from 1930 to the present. The remaining two sites presented rock features, possibly pre-dating the 20th century.
McDermott Hammatt 2000	Mā'ili, 'Ulehawa Beach Park, TMK 8-7-05:01, 03 and 05; 8-7-06:03; 8-7-08:01, 8-7-08:26; 8-7-08:26	Archaeological Inventory Survey: Two subsurface cultural layers, designated sites -5762 and 5763, were found during test excavations. Deposits consisted of midden (marine shell, fish bone, etc.) and both indigenous (fish hooks, volcanic and basalt flakes) and historic (glass, metal and concrete fragments) artifacts. Of particular interest was a nearly complete, barb-less pearl shell fish hook with an unusually deep v-bend reminiscent of Marquesan or Tahitian hooks and is atypical for Hawaiian hooks. Both layers appear to date to late pre-Contact or very early post-Contact times.

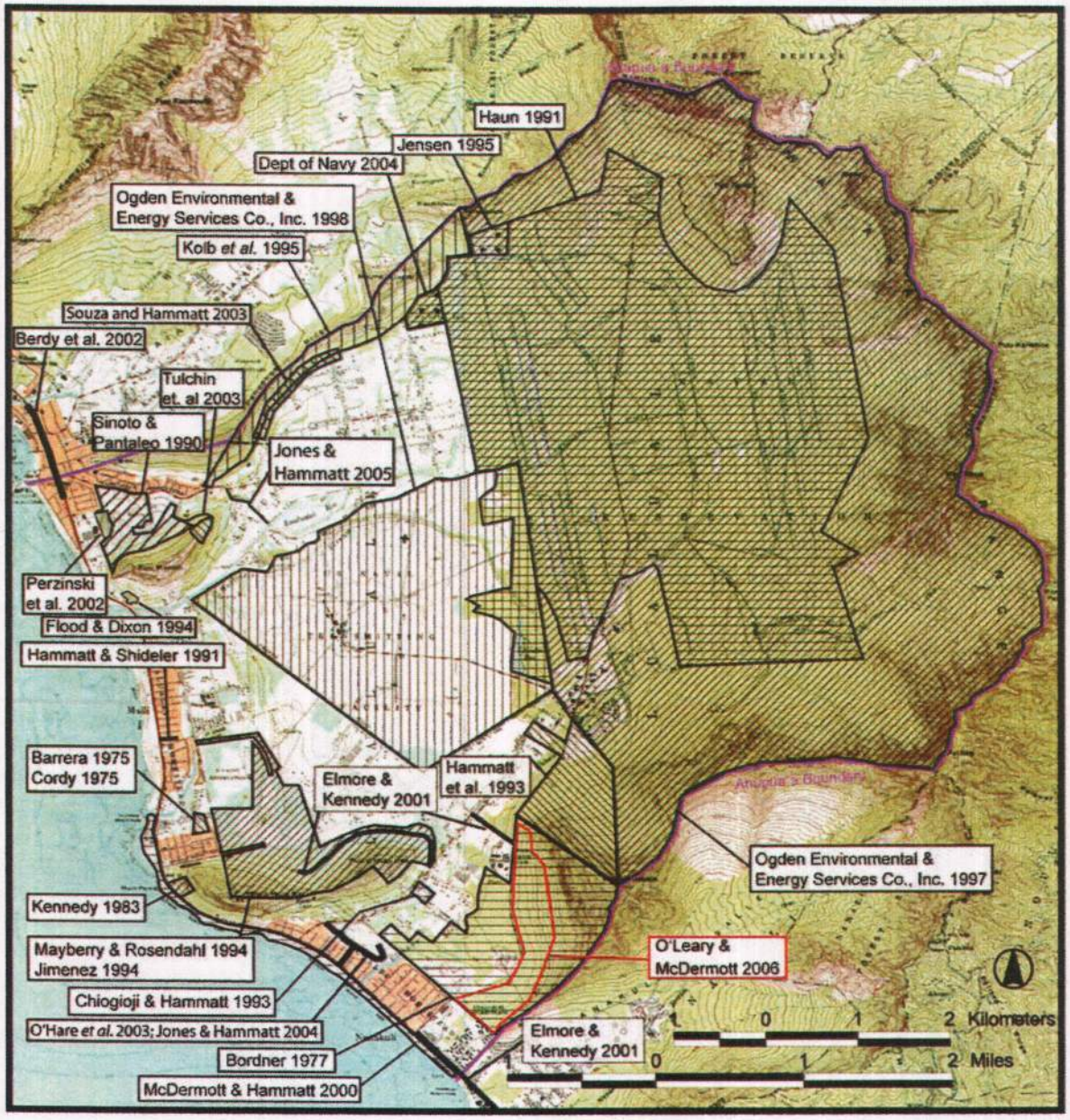

Figure 13. Previous Archaeological Work in the *Ahupua'a* of Lualualei, Wai'anae, O'ahu

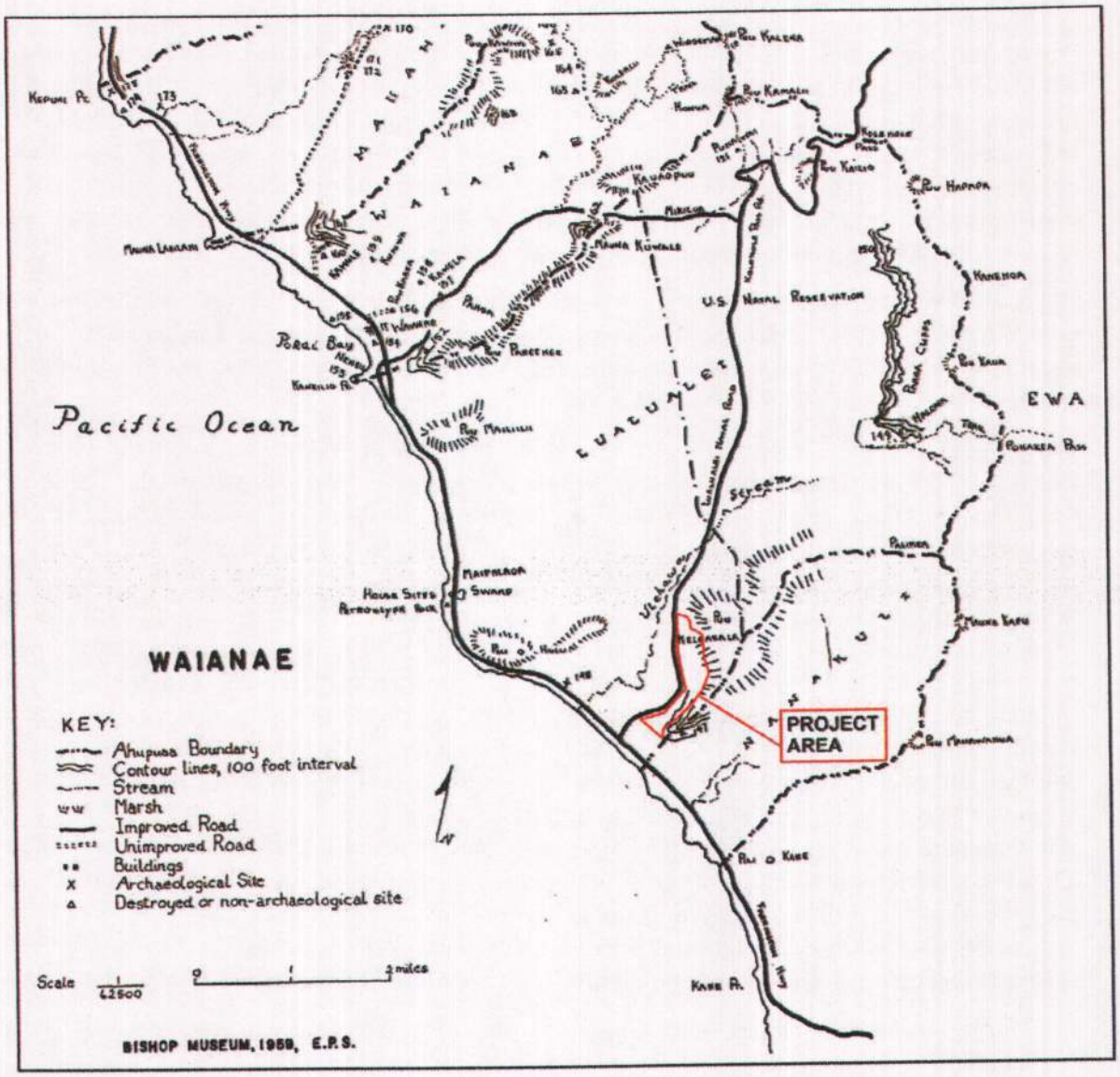

Figure 14. Archaeological sites in Lualualei Ahupua'a, Wai'anae District, showing McAllister's sites 147-153 and 162 (after Sterling and Summers 1978); note the proximity of site 147 to the project area.

McAllister recorded three sites near the boundary of Lualualei and Wai'anae, far north of the project area. Site 152, Pu'u Pāhe'ehe'e Heiau, consisted of a walled *heiau* on the slopes of Pāhe'ehe'e Ridge. In ancient times, the slopes were covered with slippery grass for the purpose of staging sledding contests (McAllister 1933: 112). This site was completely destroyed with the enlargement of the adjacent Oriental Cemetery. At the tip of Kāne'īlio Point was Site 153, Kū'īlioloa Heiau. This *heiau* was surrounded by water on three sides and consisted of three platforms with evidence of terracing (McAllister 1933: 112). Site 162 was a burial cave at Mauna Kūwale. It contained fragments of skeletal material (McAllister 1933: 116).

A 1977 reconnaissance survey for the proposed Nānākuli landfill recorded no archaeological sites (Bordner 1977). The survey area included land on both sides of Lualualei Naval Road, continuing up the slope to Pu'u Heleakalā. This inventory survey recovers the ground originally inspected by Bordner south of Lualualei Naval Road (Figure 13).

An archaeological reconnaissance survey of the "Naval Magazine, Lualualei (NAVMAG LLL) and Naval Communications Area Master Station Eastern Pacific Radio Transmitting Facility, Lualualei (RTF LLL)" was accomplished during the mid-1980's. The survey encompassed more than 9,000 acres, "the entire half of the large amphitheater-shaped valley, and approximately one-third of the coastal half" (Haun 1991:4). A total of 131 sites, consisting of 1,004 features, was identified during the survey. Indigenous Hawaiian feature types recorded include alignments, C-shapes, L-shapes, U-shapes, walls, terraces, enclosures, mounds, platforms, walled terraces and paved terraces. The features recorded relate to activities including habitation, rituals, ceremonies, agriculture, the procurement of lithic raw material, and the manufacture of stone tools. Historical and recent structures associated with cattle ranching and military use of the area were also identified. Fourteen shovel probes provided datable materials (charcoal and volcanic glass), as well as cultural materials (artifacts and midden). Radiocarbon dates range from A.D. 1420 to 1950. It is suggested that the interior of Lualualei Valley was initially occupied on a temporary basis by people cultivating the area. This may have begun as early as the mid 1400's, continuing up to the mid to late 1700's to early 1800's. Permanent habitation sites were occupied, and population of the valley evidently increased quite rapidly, based on the dense distribution of habitation and agricultural features (Haun 1991:vii).

During an archaeological study conducted on a five-acre parcel, formerly a basil farm, no archaeological remains were documented (Chiogioji and Hammatt 1993). The parcel was situated between Pu'u o Hulu and 'Ulehawa, north of the current study area.

An archaeological inventory survey of an approximately 170-acre parcel located southeast of the Naval Magazine was conducted by Cultural Surveys Hawai'i, Inc. (Hammatt *et al.* 1993). The parcel is described as comprising "vacant, unused lands. It is undeveloped and contains several remnant and abandoned historic structures" (Hammatt *et al.* 1993:7). Eight archaeological sites were identified, including "two traditional Hawaiian sites and six historic sites related to ranching and military activities" (Hammatt *et al.* 1993:i). The two traditional Hawaiian sites, 50-80-08-4366 (a site complex) and 50-80-08-4367 (a wall remnant), were interpreted as being attributable to traditional Hawaiian activity, with one site (50-80-08-4366) probably representing prehistoric, recurrent habitation at the foothills of Pu'u Heleakalā. This is primarily evidenced by the presence of a probable hearth feature within the site complex. Site 50-80-08-4367 - a remnant wall section running adjacent to an intermittent streambed - suggests an agricultural usage, possibly constructed to retain or divert water. Given the weathered condition of the structure, this site may be prehistoric (Hammatt *et al.* 1993:28).

The paucity of Hawaiian sites within the study parcel - in comparison to the number located within the large Naval Magazine study area, located to the north and *mauka*, suggests that the parcel may represent, at most, the *makai*-most fringe of the inland settlement. The survey report concludes:

> The few traditional Hawaiian sites identified during the present study suggest that most of the project area was sparsely inhabited during prehistory and early history. This would be due primarily to the lack of fresh water resources in the vicinity...Although surface run-off and intermittent drainage present in the project area would allow some potential for seasonal agriculture, the attraction for settling in the wetter upland valleys would surely have been greater. (Hammatt *et al.* 1993:31)

A cultural resource review survey was conducted by Ogden Environmental and Energy Service Co., Inc. (1997). This survey reviewed existing information on sites in the previously listed locations. Sites reviewed within NAVMAG-LLL included 197 sites with 1020 recorded features and also an additional 400 sites that had been reported but not recorded; in NAVMAG-Waikele five sites with 11 features; in NAVMAG-West Loch two sites; and Kolekole Rock was located near NAVMAG-LLL. Three sites listed in the National Register of Historic Places (NRHP) were located in the project area. They include the Nioiula Heiau, NAVMAG-LLL; 'Oki'okiolepe Fishpond, NAVMAG-West Loch; and the Pearl Harbor National Historic Landmark, NRHP site 50-80-13-9992

An archaeological survey of 260 acres of the Lualualei Ahupua'a Radio Transmission Facility was carried out to locate archaeological sites and incorporate them into a Cultural Resource Management Plan (Ogden Environmental and Energy Services Co., Inc. 1998). Three sites were located, 50-80-08-5591, 50-80-08-5592 and 50-80-08-1886. Site 50-80-08-5591 is composed of features that are associated with the sugarcane industry of the 19th and 20th centuries. Site 50-80-08-5592, a permanent habitation site and Site 50-80-08-1886, a rock mound are considered traditional Hawaiian sites. The report suggests that areas inland from the coast may once have been more heavily settled.

Cultural Surveys Hawai'i recently (Tulchin *et al.* 2003) conducted an inventory survey of the proposed Wai'anae 242 Reservoir and Access Road project area, on the northeast ridge of Pu'u Mā'ili'ili. Two possible field shelters and a cave were investigated, but there was little evidence that these were traditional Hawaiian sites.

Jones and Hammatt (2004) completed a monitoring report for sections of La'ikū, Wai'olu and Princess Kahanu Streets four a water main installation and found no historic or prehistoric cultural materials.

B. Previous Archaeological Studies in Mā'ili

During the 1970's and 1980's, a series of studies was undertaken at Mā'ili on the northeast side of Pu'u o Hulu, north of the present project area. The area encompassed by these studies would ultimately comprise 415 acres. In 1975, William Barrera conducted an archaeological site survey of approximately 80 acres at Mā'ili. The eighty acres were divided into two survey areas. Barrera recorded six sites: five stone configurations and a single midden scatter. Four of the stone structures were deemed by Barrera to be either of modern origin or too amorphous to

assess. However, one, Site Ch-Oa-1, was judged "quite probably an ancient religious structure" (Barrera 1975:9). In October of 1975, Ross Cordy conducted an archaeological excavation of Site Ch-Oa-1. Cordy's report on the excavation noted "no underlying cultural deposits were found" and Cordy concluded that the results of the excavation indicated the structure was not an ancient religious structure, but was rather a quite recent structure (probably built no earlier than 1930-1940) of unknown function (Cordy 1975).

Also in 1975, Cordy conducted an archaeological survey of an additional 130 acres at Mā'ili. Cordy identified nineteen sites including stone walls, mounds, enclosures, platforms, C-shapes, a trench with bridge, and a trail. Two rock platforms were recorded in what is now the proposed Pu'u o Hulu Community Park, Ch-Oa-28 (State Site No. -3757) and Ch-Oa-29 (State Site No. -3758). Site No. -3757 was described as a vertical-sided platform with a flat surface with dimensions of 6.2 m long by 4.9 m wide. Site No. -3758 was described as a rock platform with a C-shaped enclosure with dimensions of 6.0 m long, 5.5 m (meters) wide and 0.8-1.0 m high. In interpreting the platforms, Cordy suggests that the "vertical, high well-made walls are almost always characteristic of recent era sites" (Cordy 1976: 23). Cordy notes that much of the surveyed land had been recently impacted by bulldozing activity for quarrying purposes and concludes: "Most of the sites found in this survey are either walls, highly disturbed sites, or seemingly recent (ca. AD 1890-1970) sites" (Cordy 1976:21). His conclusions are largely based on associated historic or modern surface artifacts. He recommended archaeological test excavations of a C-shape enclosure, five platforms and a rock enclosure.

An archaeological reconnaissance survey for the proposed Wai'anae Corporation Yard was completed in 1983 (Kennedy 1983). No archaeological sites were found in the project area, which was on the coast along Mā'ili Point, north of the present study area.

The areas surveyed by Barrera and Cordy in the 1970's were subsumed in a 415-acre "Mā'ili Kai Property project area" (TMK 8-7-10:2,14) that was the subject of an archaeological reconnaissance survey conducted by Paul H. Rosendahl, Inc. in December of 1987. The survey report (Mayberry and Rosendahl 1988) noted that "large scale ranching, land clearing, and quarrying from 1851 to the present have extensively altered" the project area (Mayberry and Rosendahl 1988:ii). The report also documented 12 new sites and the reinvestigation of 14 sites previously recorded by Barrera and Cordy. The report summarizes:

> Land clearing and quarrying in particular have been destructive to the natural and cultural environments. One result of the destruction is that 24 of the 26 sites in the project area date to the 20th century. Two of the 24 sites date to the early to late 20th century and the other 22 sites date from 1930 to the present. Only two small sites, rock features without associated artifacts, may predate the 20th century. (Mayberry and Rosendahl 1988:ii)

Five sites were recommended for subsurface testing including site 50-80-08-3344, a platform located approximately 2500 ft north of Pu'u o Hulu Community Park, site 50-80-08-3750, a C-shape enclosure located approximately 2500 ft north of the Pu'u o Hulu Park, site 50-80-08-3755, a rock mound/platform located approximately 2000 ft north of Pu'u o Hulu Park, site 50-80-08-3335, a sinkwell and wall located approximately 2000 ft makai of the Pu'u o Hulu Park, site 50-80-08-3339, a stone enclosure and wall located on the northern base of Pu'u o Hulu Mauka. The two platforms (sites 50-80-08-3757 and 50-80-08-3758) recorded earlier by Cordy

were relocated during the Rosendahl survey and were interpreted as sites related to land clearing and ranching of the early twentieth century. Mayberry and Rosendahl (1994: 22) conclude:

> None of the ovoid or rectangular rock mounds and platforms in this group exhibit indications of internal structuring in the form of walls or raised platforms. They are thought to be the result of land clearing and rock-gathering operations... The research potential and cultural significance of this second group of sites is minimal. No further work was recommended for the rock platforms in the study area and these sites are thought to have been destroyed during the initial grading of the development.

Subsurface testing of the sites recommended for further testing during the Rosendahl study was carried out at the end of 1993 (Jimenez 1994). The sinkwell and wall (site 50-80-08-3335) had been destroyed during Phase I of the development, so no further archaeological testing could be done on that site. Of the remaining sites tested, only one produced evidence of pre-contact use, site 50-80-08-3750. This C-shaped enclosure yielded small amounts of lithics, midden, and charcoal. Radiocarbon dates suggest the site was used as a temporary habitation during the late prehistoric period. Further data collection was recommended for this site.

In 1990, several burials were inadvertently discovered during excavation work associated with improvements to the Mā'ili water system (Hammatt and Shideler 1990). In total, the water main work uncovered seven burials found in calcareous beach sand. Five of the burials were removed and two were left *in situ*. The five sets of removed human remains were examined to determine ethnicity and all were found to be Polynesian. The report concludes that the concentration of burials suggests a "specific burial ground for one or more Hawaiian families of the Mā'ili area during prehistoric or early historic times" (Hammatt and Shideler 1990:23).

In 1999, PBR Hawaii completed a Final Environmental Assessment for the recent improvement of 'Ulehawa Beach Park. An extensive cultural horizon, 8 to 10 centimeters thick was recorded within a sand dune cut. The deposit included charcoal flecking and contained bird and fish bones (PBR Hawai'i 1999).

In 1999, McDermott and Hammatt (2000) conducted an inventory survey on a 57.65 acre parcel of 'Ulehawa Beach Park. Two subsurface cultural layers, designated sites 50-80-08-5762 and 50-80-08-5763, were found during test excavations that covered approximately 2% of the project area. The deposits consisted of midden (marine shell, fish bone, etc.) and both indigenous (fish hooks, volcanic and basalt flakes) and historic (glass, metal, and concrete fragments) artifacts. Of particular interest was a nearly complete, barb-less pearl shell fishhook with an unusually deep v-bend reminiscent of Marquesan or Tahitian hooks. This type of fishhook is considered atypical for Hawaiian fishhooks. Both cultural layers appeared to date to late pre-contact or very early post-contact times. The scant midden and artifact assemblages found suggest little evidence of permanent or recurrent habitation along the coastal area and further enforces the consensus that traditional Hawaiian settlement was concentrated inland. Also during 1999, two extensive cultural deposits were identified during an archaeological inventory survey of 'Ulehawa Beach Park (McDermott and Hammatt 2000: 147-149), as State sites 50-80-08-5762 and 50-80-08-5763. Located adjacent to Lualualei Naval Road, south of the current project area, site 50-80-08-5762 contains charcoal enriched sediments, pit features, and a midden associated with prehistoric occupation. Site 50-80-08-5763 is located adjacent to Princess Kahanu Avenue, between the comfort station and 'Ulehawa Stream, and contains charcoal

enriched sediments, pit features, artifacts and midden associated with prehistoric occupation. This deposit is *makai* of the present project area, on the other side of Farrington Highway. According to a local informant, Walter Kamanā, a fishing *ko'a* (shrine) used to stand in this area, but was destroyed by the 1946 tidal wave. Mr. Kamanā also said that this general area was part of a pre-contact/early historic habitation site.

Also noted in this report is an area identified by a local informant to contain burials and cultural deposits (McDermott and Hammatt 2000: 43). This area extends approximately from 'Ulehawa Stream northwest. Mr. Walter Kamanā's comments pertaining to the present project area follow:

> The land from the bathrooms, just north of 'Ulehawa drainage, on around Mā'ili point is all *kapu* (taboo) ground. The night marchers are active at this place. There have been problems associated with that area, including violence and tragedy, including car wrecks. There were lost souls at that place in Hawaiian times. It is likely that you will find Hawaiian remains in the area. There are burials there on the *makai* side of Farrington Highway. A testing crew went in there to test the area, but Mr. Kamana did not know what for. Bones were found, but the public was not informed.
>
> Just beyond Hakimo Road, on the *makai* side of Farrington Highway, is a place called by the Japanese "Takamina", where the Japanese shrine stands today. [a "fishing marker" approximately 500 m north of Hakimo Road]. The Japanese shrine is not only important because of the Japanese culture and beliefs, but because of Hawaiian culture and beliefs as well. It was formerly a shrine area for the Hawaiians, but the shrine area has been largely forgotten by local Hawaiian residents. The shrine area should be respected at all times. Mr. Kamana mentions it as a "Point to Point (?) burial ground". That place must be respected. (McDermott and Hammatt 2000: 43).

The presence of coastal cultural deposits to the south suggest that the area was significant in traditional times, and that the sandy shoreline seaward of Farrington Highway may contain additional, heretofore unidentified burials and cultural deposits (Dega 1998:3, McDermott and Hammatt 2000). A number of historic-era structures, such as concrete World War II bunkers, were also noted in the 'Ulehawa Beach Park studies (Dega, 1998: 5; McDermott and Hammatt 2000:143-147). Two WWII concrete foundations were observed seaward of Farrington Highway.

A recent archaeological study (Hammatt *et al.* 2001) has evaluated the available data on burials in the vicinity of the present project area. This study notes a document in SHPD Burials Program files entitled "Burial Sites and Grave Sites Graveyards and Cemeteries Case Inventory" (page 19) has a line item:

* Ma'ili - Cave Burials / ID (#584)

* human remains re-interred.

It is less than clear whether there are known remains in Mā'ili Cave or where this cave may be. This 2001 study also notes that a few sites in Lualualei Ahupua'a are traditionally associated with human deaths. Nioiula Heiau on Hālona Ridge in Lualualei (Site 149; also known as Hālona Heiau) was said to have been of the *po'okanaka* class (McAllister 1933:110, Westervelt

1915a:122, Westervelt 1915b:178, Thrum 1908:47), which suggests associations with human sacrifice, but this site was located at the south base of the Pāhoa Cliffs of the Wai'anae Range. There are numerous accounts associating Kolekole Pass and vicinity with battles and mortal combat (Sterling and Summers 1978:67), but the area referred to is Pōhākea Pass. 'Ilihune Heiau (site 147, reported as destroyed by 1930), also said to be of *po'okanaka* class (McAllister 1933:110; Thrum 1906:47) lay closer at the tip of the Heleakalā Ridge, southeast of the present project area. This 2001 study also notes that a Lualualei, Wai'anae, O'ahu map by Emerson, dated October 1901 (Registered Map Number 2040), shows an annotation of "Maili Grave" on the seaward side of present day Farrington Highway.

Based upon the survey of the previous archaeological work conducted in Lualualei discussed above Table 3 and Figure 15 display archaeological sites that are within one mile of the project area.

Table 3: Previously Identified Sites Within One Mile of the Nānākuli Municipal Solid Waste Site B Project Area.

SIHP #	Distance and General Location Relative to the Project Area	Nature of Site	Status/ Comments	Source
50-80-08-147	100 yds SE	'Ilihune Heiau	Destroyed	McAllister 1933:110
50-80-08-148	Between 0.5 and 1.0 miles to the S	Maui' Rock	Large boulder	McAllister 1933:110
50-80-08-3337	Between 0.25 and 0.5 mile, to the WNW	Wall	Boundary	Mayberry & Rosendahl 1994:28
50-80-08-3338	Between 0.5 and 1.0 mile, to the WNW	Rock Mounds	Two mounds	Mayberry & Rosendahl 1994:28
50-80-08-3339	Between 0.5 and 1.0 mile, to the WNW	Enclosure & wall	Temporary Habitation	Mayberry & Rosendahl 1994:28
50-80-08-3340	1.0 mile, to the west	C-shape & wall	Possibly Military	Mayberry & Rosendahl 1994:28
50-80-08-4053	Between 0.5 and 1.0 miles to the NE	Ag. Complex	Agriculture	Cordy et al. 1990:13
50-80-08-4054	Between 0.5 and 1.0 miles to the NE	Hab./Ag. Complex	Permanent Habitation & Agriculture	Cordy et al. 1990:13
50-80-08-4055	Between 0.5 and 1.0 miles to the NE	Enclosure	Agriculture?	Cordy et al. 1990:14
50-80-08-4056	Between 0.5 and 1.0 miles to the NE	Hab./Ag. Complex	Permanent Habitation & Agriculture	Cordy et al. 1990:14
50-80-08-4159	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:14
50-80-08-4161	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:15
50-80-08-4163	Between 0.5 and 1.0 miles to the NE	Enclosure	Agriculture?	Cordy et al. 1990:15
50-80-08-4165	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:15
50-80-08-4166	Between 0.5 and 1.0 miles to the NE	Hab./Ag. Complex	Perm.Hab. & Ag.	Cordy et al. 1990:15
50-80-08-4168	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation.	Cordy et al. 1990:16
50-80-	Between 0.5 and 1.0	Wall	Boundary	Cordy et al.

SIHP #	Distance and General Location Relative to the Project Area	Nature of Site	Status/ Comments	Source
08-4171	miles to the NE			1990:16
50-80-08-4172	Between 0.5 and 1.0 miles to the NE	Platform	Unknown function	Cordy et al. 1990:16
50-80-08-4173	Between 0.5 and 1.0 miles to the NE	Hab./Ag. Complex	Perm.Habitation Agriculture	Cordy et al. 1990:16
50-80-08-4175	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:17
50-80-08-4177	Between 0.5 and 1.0 miles to the NE	Rock Shelter	Unknown function	Cordy et al. 1990:17
50-80-08-4178	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:17
50-80-08-4179	Between 0.5 and 1.0 miles to the NE	Wall	Boundary	Cordy et al. 1990:17
50-80-08-4180	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Permanent Habitation	Cordy et al. 1990:17
50-80-08-4182	Between 0.5 and 1.0 miles to the NE	Ag. Complex	Agriculture	Cordy et al. 1990:17
50-80-08-4183	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:17
50-80-08-4210	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Permanent Habitation	Cordy et al. 1990:18
50-80-08-4211	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Perm. Hab.	Cordy et al. 1990:18
50-80-08-4212	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Perm. Hab.	Cordy et al. 1990:18
50-80-08-4213	Between 0.5 and 1.0 miles to the NE	Enclosure	Permanent Habitation	Cordy et al. 1990:18
50-80-08-4214	Between 0.5 and 1.0 miles to the NE	Hab. Complex	Temporary Habitation	Cordy et al. 1990:18
50-80-08-4364	200 yards to north	Wall	Ranching	Hammatt et al. 1993:25
50-80-08-4365	200 yards to north	Shelter	Military	Hammatt et al. 1993:25
50-80-08-4366	Between 0.25 and 0.5 mile, to the NNE	Hab. Complex	Habitation	Hammatt et al. 1993:25
50-80-08-4367	0.5 mile, to the north	Wall	Agriculture	Hammatt et al. 1993:25
50-80-08-4370	Between 0.25 and 0.5 mile, to the north	House Lot	Ranching	Hammatt et al. 1993:25
50-80-08-4371	Between 0.5 and 1.0 mile, to the north	Wells	Ranching	Hammatt et al. 1993:25
50-80-	Between 0.25 and	Foundation	Ranching	Hammatt et

SIHP #	Distance and General Location Relative to the Project Area	Nature of Site	Status/ Comments	Source
08-4372	0.5 mile, to the north			al. 1993:25
50-8008-4373	Between 0.25 and 0.5 mile, to the north	Incinerator	Military/Ranching	Hammatt et al. 1993:25
50-80-08-4398	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4403	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Perm. Hab.	Cordy 1993:7
50-80-08-4404	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Temporary Habitation	Cordy 1993:7
50-80-08-4405	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Permanent Habitation	Cordy 1993:7
50-80-08-4408	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Temporary Habitation	Cordy 1993:7
50-80-08-4408	Between 0.5 and 1.0 mile to the NE	Complex	Permanent Habitation & Agriculture	Cordy 1993:7
50-80-08-4415	Between 0.5 and 1.0 mile to the NE	Poss. Heiau	Ceremonial	Cordy 1993:8
50-80-08-4419	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Permanent Habitation	Cordy 1993:8
50-80-08-4420	Between 0.5 and 1.0 mile to the NE	Enclosure	Ranching	Cordy 1993:8
50-80-08-4421	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Temporary Habitation	Cordy 1993:7
50-80-08-4803	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4804	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4806	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4808	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4808	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation & Agriculture	Cordy 1993:7
50-80-08-4809	Between 0.5 and 1.0 mile to the NE	Hab./Ag. Complex	Temporary Habitation &	Cordy 1993:7

SIHP #	Distance and General Location Relative to the Project Area	Nature of Site	Status/ Comments	Source
			Agriculture	
50-80-08-4810	Between 0.5 and 1.0 mile to the NE	Hab. Complex	Permanent Habitation	Cordy 1993:7
50-80-08-5761	Between 0.5 and 1.0 mile to the NE	Bunkers & Slabs	WWII Military	McDermott & Hammatt 2000:144-147
50-80-08-5762	Between 0.5 and 1.0 mile to the NE	Subsurface Layer	Pre-contact	McDermott & Hammatt 2000:147
50-80-08-5763	Between 0.5 and 1.0 mile to the NE	Subsurface Layer	Pre-contact	McDermott & Hammatt 2000:147-149
50-80-08-5946	Between 0.25 and 0.5 mile, to the south	Camp Andrews	WWII Military	McDermott et al. 2001:40-62
50-80-08-5947	Between 0.25 and 0.5 mile, to the south	17 sinkholes	one sinkhole has a burial	McDermott et al. 2001:62-128
50-80-12-9714	Between 0.25 and 0.5 mile, to the SW along the coast	O.R.&L. Railroad	Railroad Bed	McDermott & Hammatt 2000:149

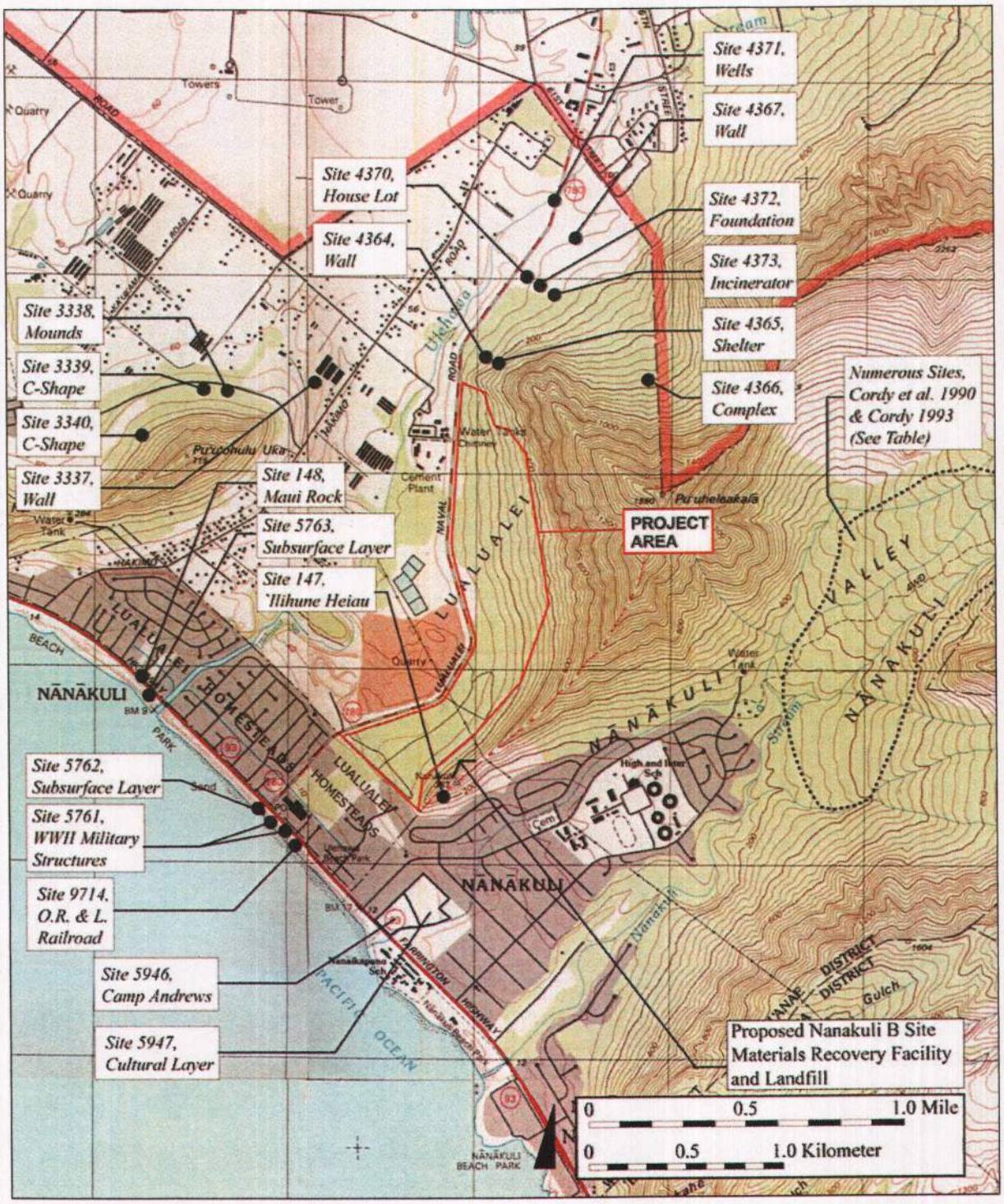

Figure 15. Location of Archaeological Sites in the Vicinity of the Proposed Nānākuli Municipal Solid Waste Site B Project Area.

IV. SETTLEMENT PATTERNS FOR THE STUDY AREA

Cordy (1998) has provided a synthesis of the settlement patterns and prehistory of the Wai'anae District, of which Lualualei is a portion. This study places the settlement of Wai'anae into the wider context of O'ahu settlement as a whole. The proximity of expansive forest resources and well-watered agricultural lands to abundant marine resources made the windward side of O'ahu most appealing to the early O'ahu settlers and their descendants. Foraging trips to the dryer areas of the island would have occurred and were most likely associated with recurrent, temporary habitation used during resource procurement. The rich marine resources of the Wai'anae District, particularly the fishing grounds off-shore, would have been a strong draw for early O'ahu inhabitants. As population in the windward areas increased, permanent settlement began to spill over into the well-watered regions of the leeward side. Eventually, with further population expansion, permanent settlement spread to the less watered regions of the leeward side, which included much of the Wai'anae District and all of the current project area (Cordy 1998:1-6). Settlement would most likely begin as temporary habitation along the coast in association with marine resource procurement. Later, permanent settlement would have developed in response to expanding populations in previously settled, better watered areas.

Prehistorically, land use in Lualualei was greatest at the sea, where marine resources were plentiful, and in the mountainous interior, where there was sufficient rainfall for agriculture and forest resources. The intervening lands between the sea and the mountains were a dry scrubland. Although potentially useful for dryland agriculture in the wet winter months, it is unlikely that this area would have been largely utilized by Native Hawaiians. The settlement pattern prior to Western Contact for this region was likely dispersed residences concentrated at the sea and the mountains. Based on the season and the available resources, the resident population most likely used multiple residences, perhaps one at the seaside and another *mauka*, to reduce resource transport time. It is also possible, as is suggested by the account provided by Pukui (cited in McGrath *et al.* 1973:10), that there existed an informal exchange network where by coastal dwellers traded marine resources for the agricultural and forest resources of the inland dwellers.

Archaeological surveys of the upper portion of Lualualei Valley have located the remains of traditional-Hawaiian habitation, ceremonial, and agricultural structures. The extensive archaeological survey of the *mauka* portions of these valleys is offset by a paucity of archaeological investigation in their coastal portions. However, based on context, information from long time residents of the area, and traditional accounts, it is likely that the coastal areas of Lualualei will contain cultural deposits related to habitation, including human burials.

Available radiocarbon dates indicate that by at least A.D. 600-800, there was at least temporary coastal habitation on the Wai'anae coast. This dated sample comes from the area fronting Pōka'ī Bay, one of the only areas along the Wai'anae Coast to have a perennial stream reach the coast, and undoubtedly one of the more attractive areas for early temporary and, later, permanent settlement (Cordy 1998:6). Radiocarbon dates from inland, apparently permanent habitation contexts, within Nānākuli indicate permanent settlement began by A.D. 1200-1400 (Cordy 1997:9). Extensive archaeological survey of inland Lualualei has yielded radiocarbon dates from permanent habitation contexts dating to A.D. 1620, with earlier dates (mid 1400's) for apparently temporary habitation structures (Haun 1991:237).

The only coastal dates for Lualualei are those reported by McDermott and Hammatt (2000) from the two coastal habitation deposits (Sites 50-80-08-5762 and -5763) found during the inventory survey of the 'Ulehawa Beach Park parcel. The three available dates from this project area span a broad temporal period, from 1460 to 1950. However, considering the early coastal date from Pōka'ī Bay and the *mauka* dates from Lualualei, it is certainly plausible that at least temporary coastal settlement took place within the first half of the 1460-1950 age range. However, if there is inland settlement and resource procurement by circa A.D. 1200-1400, it is likely that initial coastal temporary habitation, associated with marine resource procurement, predated this inland settlement.

The population along the Wai'anae may always have been quite low. The immediate vicinity lacked water for cultivation and was proverbial for its poverty. Vancouver in 1785 noted "few inhabitants" in "the barren, rocky waste." Whitman in 1815 referred to the vicinity as an "uncultivated plain." Oral history accounts emphasize the "crops were always poor and miserable."

By the mid-1800's the traditional Native Hawaiian lifestyle in the valley of Lualualei was in decline. The sandalwood trade, which ended circa 1829, undoubtedly had a negative effect on the Native Hawaiian population. Beginning at this time, Lualualei began its cattle ranching period. The introduction of sugar plantations brought more foreigners and the OR&L railroad, which was linked to Wai'anae in 1895. Based on the paucity of LCA's claimed within the area and the early population figures, it appears that the Native Hawaiian population was quite low in the latter half of the 19th century.

Population numbers slowly increased when homesteading was instituted in the early 1900's. Military use of the land began in 1917. WWII greatly affected the landscape of the Wai'anae coast by placing bunkers, gun emplacements, and barbed wire along the waterfront. As noted by the local informants, tsunamis have also altered the landscape.

V. BACKGROUND SUMMARY AND PREDICTIVE MODEL

In summary, numerous archaeological investigations have taken place with Lualualei Valley on the Leeward side of O'ahu. The studies have demonstrated a pattern of high intensity land use in only the *mauka* and *makai* portions of Lualualei Valley, with a relative gap in archaeological remains in the middle sections.

The studies of the *mauka* portions of the valley (Haun 1991, Ogden Environmental Services 1997) identified more than 500 archaeological sites, which included well over 1,000 features. The identified features included "alignments, C-shapes, L-shapes, U-shapes, walls, terraces, enclosures, mounds, platforms, walled terraces and paved terraces" (Haun 1991; vii). These features related to habitation, agriculture, rituals, ceremonies, and the procurement and manufacture of stone tools.

Extensive evidence of precontact Native Hawaiian activity has also been recorded in *makai* sections of the *ahupua'a*, immediately adjacent to the ocean (Hammatt and Shideler, 1990; McDermott and Hammatt 2000). Hammatt and Shideler (1990) documented 7 Native Hawaiian burials during improvements to the water system. McDermott and Hammatt identified two cultural layers that exhibited charcoal deposits, pit hearts, and midden associated with prehistoric occupation. Fishhooks were also found.

In contrast to the abundance of traditional Hawaiian sites and features encountered during the Bishop Museum survey of the *mauka* half of Lualualei, the surface sites recorded during the studies in the central section of Lualualei Valley at Mā'ili were either post-contact or of equivocal origin. In the one instance where excavation was attempted at a structure originally judged "quite possibly a *heiau*" (Site Ch-Oa-1), the site was established as modern and no subsurface deposits were encountered. The lack of traditional Hawaiian sites in these areas may reflect not only the distortions of modern disturbances (including bulldozing, farming and ranching) but also a general disuse during pre-contact times. Population and activity in Lualualei may have been primarily focused in a narrow band along the coast and farther inland in the *mauka* reaches of this large valley.

Based upon the previous archaeological research conducted within the *ahupua'a*, the land in between the coastal and *mauka* zones are likely to be characterized by fairly an ephemeral archaeological record pointing to the intermittent use of locations such as trails, lithic scatters, and temporary habitation sites.

VI. SURVEY RESULTS

A. SIHP 50-80-08-6699

State SIHP 50-80-08-6699 (Figure 16) is a small *pāhoehoe* basalt rock shelter located approximately 35 meters upslope of the two large water tanks discussed in the Built Environment section. The site's location (589088mE; 2365754mN) is shown in Figure 1. A plan map of the site and the two excavation units is shown in Figure 17 and a cross section of the entrance to the rock shelter is provided in Figure 18. The rock shelter's floor surface consists of loose silty clay with numerous subangular basalt pebbles, cobbles, and boulders. Two basalt flakes were discovered on the surface indicating the potential for subsurface cultural deposits. Two contiguous test units were excavated within the rock shelter to determine the presence or absence and collect appropriate samples from any subsurface cultural deposits. The test units also provided the opportunity to investigate the rock shelter's depositional history.

1. Test Unit #1

Excavation dimensions: 1 m by 1 m

Test Unit #1 was placed centrally within the rock shelter and completely underneath the basalt overhang. A pre-excavation photograph of Test Unit 1 is shown in Figure 19. All surface rocks were inspected to see if they were artifacts, and those which demonstrated evidence of human modification were collected, while the rest were set aside. Figure 20 shows the plan view of Test Unit #1 at the base of stratum III and includes the locations of features 1 and 2. Feature 1 is a small charcoal and ash concentration. Feature 2 was a small seoop hearth measuring 35 cm by 40 cm. When the hearth had originally been created at the time that the rock shelter had been in use the depression was dug down into the culturally sterile stratum IV. The hearth was contained a thick lens (4 cm) of charcoal above a thinner lens of ash (1-2 cm). These features are not shown in the schematic profile of the northeast wall (See Figure 21) beeause both features were completely encompassed by the test unit. A post-excavation photo of Test Unit 1 is shown in Figure 22 and the northeast wall of Test Unit #1 is shown in Figure 23. Table 4 displays the recovered remains from Test Unit #1

Stratum I: 0-4 cmbs	10 YR 2/2, very dark brown; fine to very fine silty clay; structureless, loose dry consistency; plastic; no cementation; clear smooth lower boundary. Very loose aeolian over a much more compact layer II. Contains animal bone, kukui nut, basalt flakes, marine shell, and charcoal.
Stratum II: 4-24 cmbs	A1 Horizon; 10 YR 2/2, very dark brown; fine to very fine silty clay; very coarse, subangular blocky structure; very hard dry consistency; plastic; strong cementation; abrupt wavy lower boundary. Strong soil development with many gravel to cobble size basalt inclusions. Contains charcoal, marine shell, basalt flakes, animal bone, kukui nut, volcanic glass, and a shell preform.

Stratum III: 24-42 cmbs	B Horizon; 10 YR 3/3, dark brown; fine to very fine silty clay; weak, fine, crumb structure; hard dry consistency; plastic; weak cementation; abrupt wavy lower boundary. This layer contained features 1 and 2 (Figure 20), both of which were collected and floated. A charcoal sample from Feature 2 was submitted for radiocarbon dating analysis. The sediment from the entire layer was bagged and wet screened through 1/8 inch mesh in the lab. Charcoal, basalt flakes, volcanic glass, animal bone, and shell were present.
Stratum IV: 42-43/50 cmbs	10 YR 3/4, dark yellowish brown; fine to very fine silty clay; structureless, extremely hard dry consistency; plastic; indurated; very abrupt broken lower boundary. This is a sterile clay layer with a very small amount of silt in it. The layer overlies the bedrock. This stratum is sterile of cultural material.

Figure 16 SIHP 50-80-08-6699 with photo scale. Photograph taken looking east.

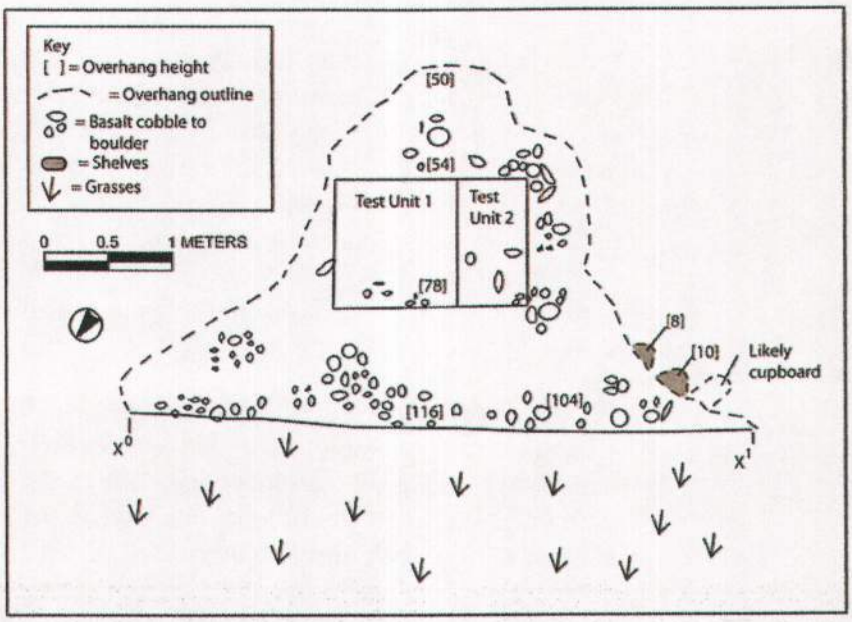

Figure 17. Plan map of state SIHP 50-80-08-6699 with the locations of Test Units 1 and 2.

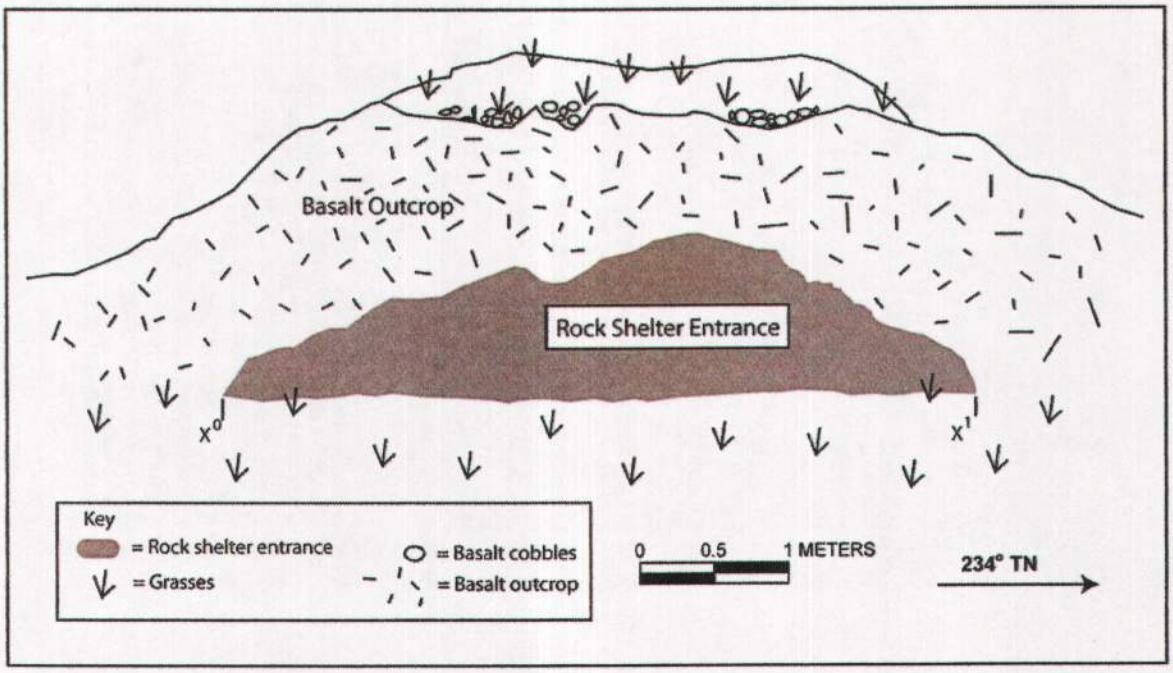

Figure 18. SIHP 50-80-08-6699; cross section map of the entrance to the rock shelter.

Figure 19. Pre-excavation photograph of 1 m by 1 m Test Unit #1 in SIHP 50-80-08-6699 with trowel for scale and direction of north. Photograph taken looking southeast.

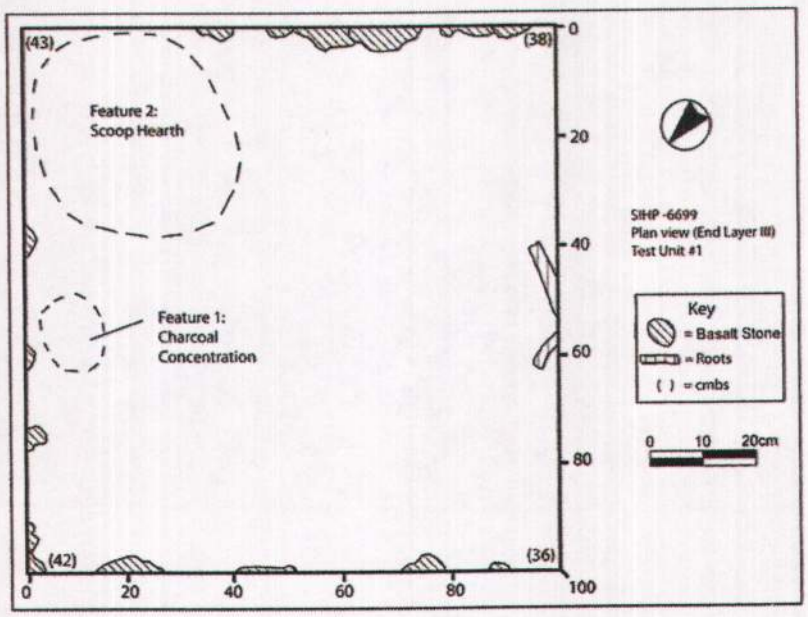

Figure 20. Plan view of the base of Layer III, Test Unit #1, SIHP 50-80-08-6699 showing the location of features 1 and 2.

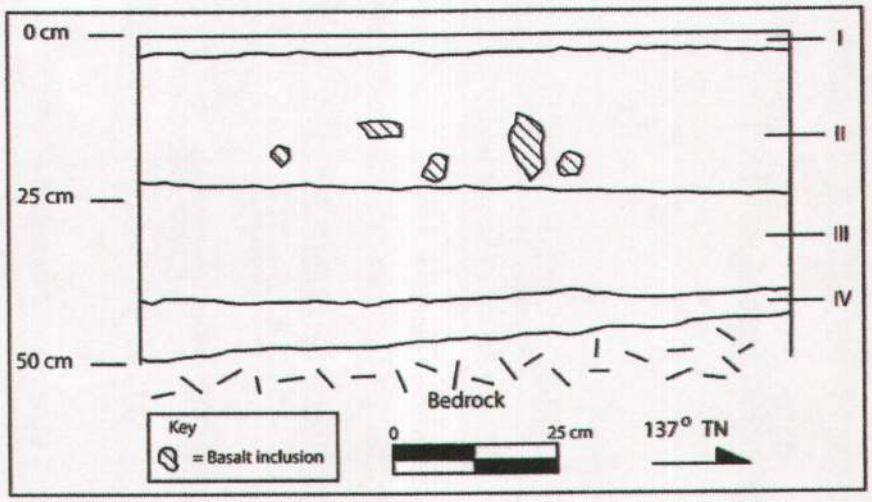

Figure 21. Site 50-80-08–6699, schematic of stratigraphy along the northeast wall Test Unit #1.

Figure 22. Looking southeast at test Unit #1, SIHP 50-80-08-6699, after excavation. Note the bedrock on the floor of the unit.

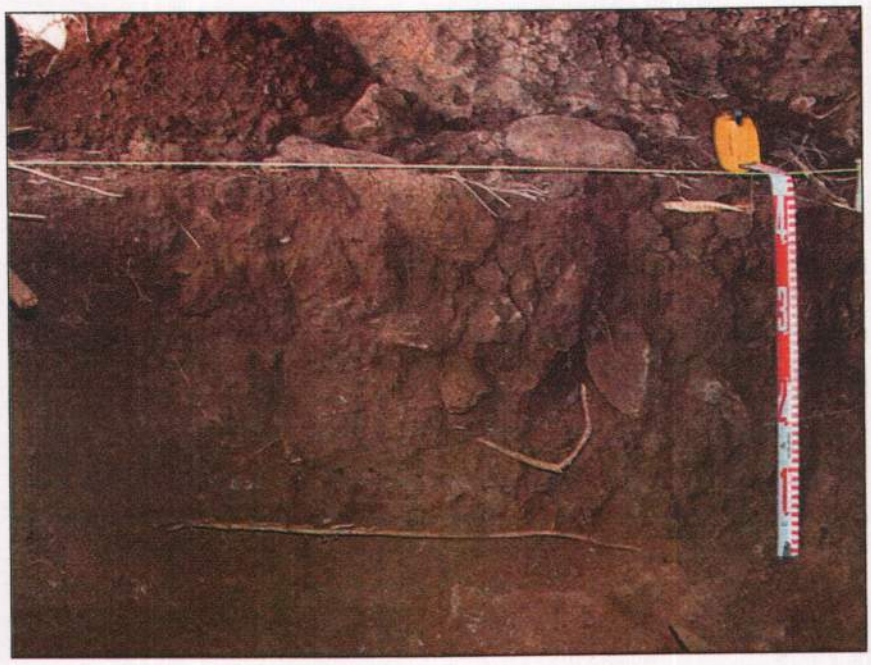

Figure 23. Photograph looking northeast at the northeast wall of Test Unit #1, SIHP 50-80-08-6699.

Table 4: Counts and Weights (in parentheses) of Archaeological Materials Recovered from Test Unit #1 In SIHP 50-80-08-6699.

Recovered Materials	**Surface**	**Stratum I**	**Stratum II**	**Stratum III**	**Strat. III, Feature 1**	**Strat. III Feature 2**
Basalt Flakes	2 (112.7 g)	1 (10.2 g)		7 (14.9 g)		
Charcoal		(0.9 g)	(11.7 g)	(7.3 g)	(3.4 g)	(145.0 g)
Coral			4 (2.2 g)			
Fish Bone			1 (0.1 g)			
Kukuʻi Nut		2 (2.1 g)	5 (1.6 g)			
Rat Bone		3 (0.1 g)	49 (1.8 g)	88 (2.1 g)		
Marine Shell		4 (0.7 g)	6 (1.4)	6 (0.8 g)		
Volcanic Glass Pebbles			3 (44.9 g)	1 (4.0 g)		
Volcanic Glass Flakes			7 (4.0 g)	11 (2.8 g)		

2. Test Unit #2

Excavation dimensions: 1 m by 0.5 m

The unexpectedly successful results of Test Unit #1 prompted the excavation of a second test unit within the rock shelter to recover further archaeological materials. Test Unit #2 is located immediately adjacent to the southwest of Test Unit #1 (See Figure 16). The natural shape of the rock shelter constrained the size of the second test unit. A pre-excavation photo is shown in Figure 24. The stratigraphy in Test Unit #2 exactly matched that of Test Unit #1 except that no hearths were uncovered. The in filled rodent burrow in the south corner of Layers III and IV (See Figure 26) is the only feature of note from Test Unit #2.

Stratum I: 0-4/8 cmbs	10 YR 2/2, very dark brown; fine to very fine silty clay; structureless, loose dry consistency; plastic; no cementation; clear smooth lower boundary. Very loose aeolian sediments over a much more compact layer II. Contains animal bone.
Stratum II: 4/8-28 cmbs	A1 Horizon; 10 YR 2/2, very dark brown; fine to very fine silty clay; very coarse, subangular blocky structure; very hard dry consistency; plastic; strong cementation; abrupt wavy lower boundary. Strong soil development with many gravel to cobble size basalt inclusions. Contains charcoal, marine shell, basalt flakes, animal bone, coral, and volcanic glass.
Stratum III: 28-43 cmbs	B Horizon; 10 YR 3/3, dark brown; fine to very fine silty clay; weak, fine, crumb structure; hard dry consistency; plastic; weak cementation; abrupt wavy lower boundary. This layer contained an infilled rodent burrow (See Figure 17). This stratum contained charcoal, volcanic glass, basalt flake, coral, and animal bone.
Stratum IV: 43/50 cmbs	10 YR 3/4, dark yellowish brown; fine to very fine silty clay; structureless, extremely hard dry consistency; plastic; indurated; very abrupt broken lower boundary. This is a sterile clay layer with a very small amount of silt in it. The layer overlies the bedrock.

Figure 24. Pre-excavation photograph looking south at Test Unit #2, SIHP 50-80-08-6699. Trowel serves as scale and points towards north.

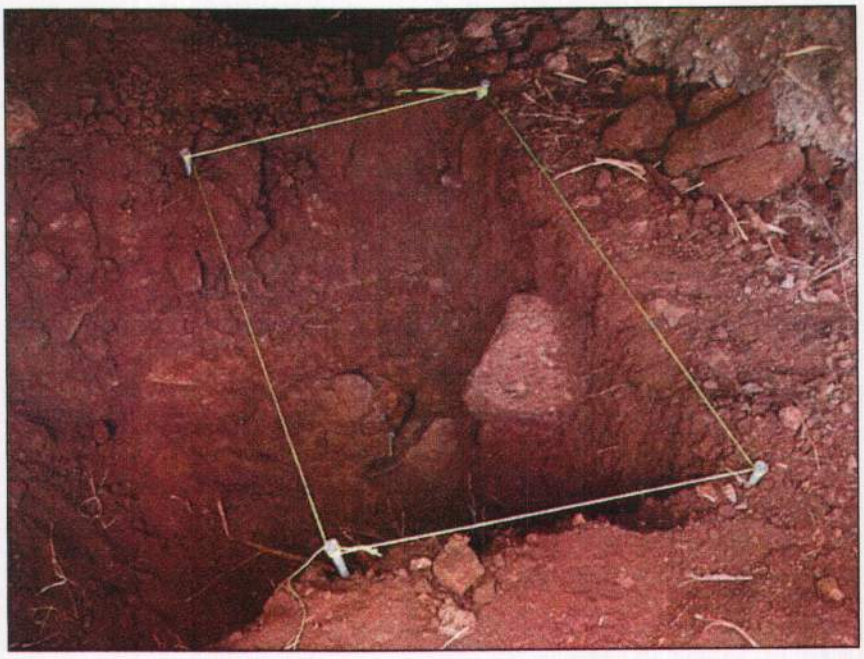

Figure 25. Post excavation photograph looking south at Test Unit #2, SIHP 50-80-08-6699. Ash lenses can be seen in the south corner of the test unit wall.

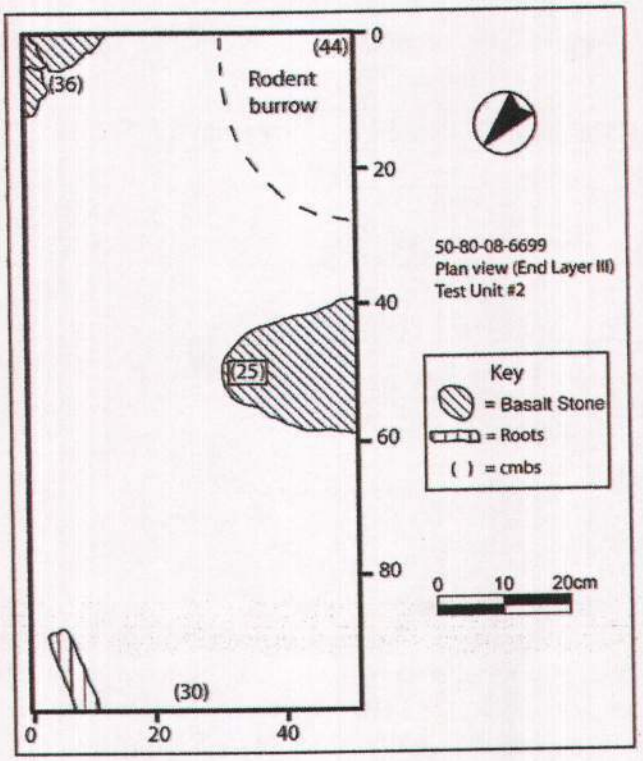

Figure 26. Plan view of the bottom of Layer III, Test Unit #2, SIHP 50-80-08-6699 showing the location of the rodent burrow.

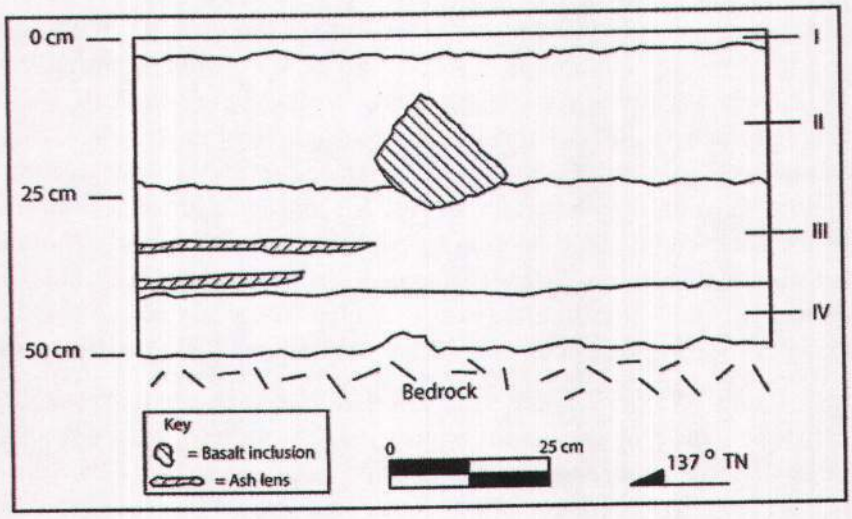

Figure 27. Schematic of stratigraphy along the southwest wall of Test Unit #2, SIHP 50-80-08-6699.

Table 5: Counts and Weights (In Parentheses) of Archaeological Materials Recovered from Test Unit #2 in SIHP 50-80-08-6699.

Recovered Materials	Surface	Stratum I	Stratum II	Stratum III
Basalt Flakes			21 (73.4 g)	1 (0.4 g)
Charcoal			(6.8 g)	(2.0 g)
Coral			1 (9.8 g)	3 (0.2 g)
Kukui Nut				
Pig Bone	1 (1.1 g)			
Rat Bone		3 (0.1 g)	128 (3.8 g)	70 (3.1 g)
Marine Shell			6 (2.3 g)	
Volcanic Glass Pebbles			4 (10.9 g)	
Volcanic Glass Flakes			19 (5.1 g)	1 (0.4 g)

3. Summary of Excavation and Recovered Remains

Prior to human use of the rock shelter a layer of silt-clay (Stratum IV) aecumulated most likely through low energy aeolian mechanisms. At the time of first human use of the site there would have been approximately 1.15 meters between the floor and the ceiling of the rock shelter. On at least one occasion prehistorically a shallow (3-5 cm) depression was excavated down into the sterile sediment to create a small scoop hearth (Feature 2). A fire was burnt, filling the scoop hearth with ash and charcoal. Remnants from the scoop hearth possibly account for the concentration of charcoal that makes up Feature 1. The ash lenses seen in the profile of Test Unit 2 (Figure 27) are also possibly the result of the scoop hearth being cleaned out, but they could also be separate combustion events.

Aeolian sediment (Stratum III) was deposited over time as people continued to periodically use the rock shelter possibly building more small fires. Stratum III shows a small amount of soil formation in the form of fine crumb-like peds. Stratum II is distinguishable from the underlying Stratum III largely because of its large blocky peds, which indicate this sediment remained relatively undisturbed while soil formation occurred. Stratum II's lack of evidence for in situ fires may indicate that burning no longer took place within the cave as Stratum II accumulated, or, more likely based on the charcoal recovered from this layer, that burning took place in other portions of the rock shelter. Sub-angular basalt rocks ranging in size from cobble to boulder are present in Stratum II. Stratum I, which formed the floor of the rock shelter at the time of this inventory survey, is the same fine grained silty clay that made up the matrix of the lower strata. Stratum I is very loosely compacted and has not undergone soil formation processes.

Artifacts found within the site suggest that the rock shelter was used as a temporary habitation on what was probably an infrequent basis. Coral, marine shell, and the single fish bone indicate that materials were being transported approximately 1.25 miles from the nearby Wai'anae coast. The large amount of rat (*Rattus exulans*) bone, none of which is burnt, and the infilled rodent nest indicate that rats were likely scavenging on the remains left behind by humans and later using the rock shelter as home. The numerous rat bones in this site indicate that bioturbation has possibly moved the archaeological materials within and between the deposits.

Small amounts of volcanic glass demonstrates that humans were using and manipulating tools within the cave. The overall small size (< 1.5 cm) of the volcanic glass flakes suggests that tools were being reworked and retouched for further use, and not that tool manufacturing was taking place within the site. In addition, despite noting the current presence of quality basalt for stone tools, very little of this material is was present within the rock shelter.

The charcoal sample submitted to Beta Analytic was returned with a conventional radiocarbon age of 270 ± 50 BP. This date was calibrated using OxCal version 3.5. There is a 68.2% probability that the actual age of the charcoal falls within the single sigma calibrated results. Within that range there is a 35.6% probability that the age is 1520 to 1600 AD, a 27.1% probability that the age is 1620 to 1670 AD, and a 5.5% probability that the age is 1780-1800. There is a 95.4% probability that the age of the charcoal falls within the two sigma range. Within that range there is a 81.4% probability that the age is 1480 to 1680 AD, a 11.8 % probability that the age is 1730 to 1810 AD, and a 2.2% probability that the age is 1930-1960 AD. After calibration using OxCal, and taking into account that no historic materials were found within the excavations, the radiocarbon results indicate that the lower layer of deposition in SIHP 50-80-08-6699 is most likely not modern and dates to the late prehistoric period prior to European contact. The report provided by Beta Analytic is included as Appendix B.

SIHP 50-80-08-6699 is significant under criterion D - historic property has yielded or may be likely to yield information important in prehistory or history - in light of the five broad criteria used by the State of Hawai'i Register of Historic Places. It is also significant because it is located in an area of the leeward side of O'ahu for which there is relatively little information. While many sites have been documented both along the coast and in the *mauka* portions of the *ahupua'a* this is site is located in between those two areas. The intact layers of fine-grained sediments deposited in a low energy environment have left cultural features such as hearths undisturbed within the rockshelter provide detailed information.

B. SIHP 50-80-08-6681

SIHP 50-80-08-6681 is located close to the southern most corner of the project area (588694mE; 2365375mN). While the precise date of the construction of SIHP 50-80-08-6681 is not known, it is likely to have been constructed during the rapid build-up of coastal defensive fortifications during 1942 and 1943 during WWII. The site is a concrete bunker 13 feet square (3.9 m by 3.9 m). The bunker has a solid concrete slab roof approximately 75 cm thick. Built back into the *pāhoehoe* basalt hill, the bunker has a 1.95 m exposed vertical face on the seaward (west) side and 1.1 m on the uphill (east) side. The north, west, and south sides of the bunker have long thin horizontal openings that are 25 cm tall and 3.3 m long. Figure 28 to Figure 37 show both the outside and inside of the historic property.

The exterior of the bunker has been vandalized liberally with spray paint. Modern trash is common around the outside of the bunker. The entrance is located along the east wall near the northeast corner of the bunker. It is 50 cm by 50 cm. There is approximately a one-meter drop from the bottom of the entrance to the dirt floor inside the bunker. The interior measures 3.0 m by 3.0 m and is 1.9 m tall. The inside of the bunker is also covered in spray-paint. Basalt boulders have also been placed within the bunker and there is evidence of modern fires and abundant trash. Metal armament mounting brackets are still in place beneath the bunker's window slits (refer to Figure 37).

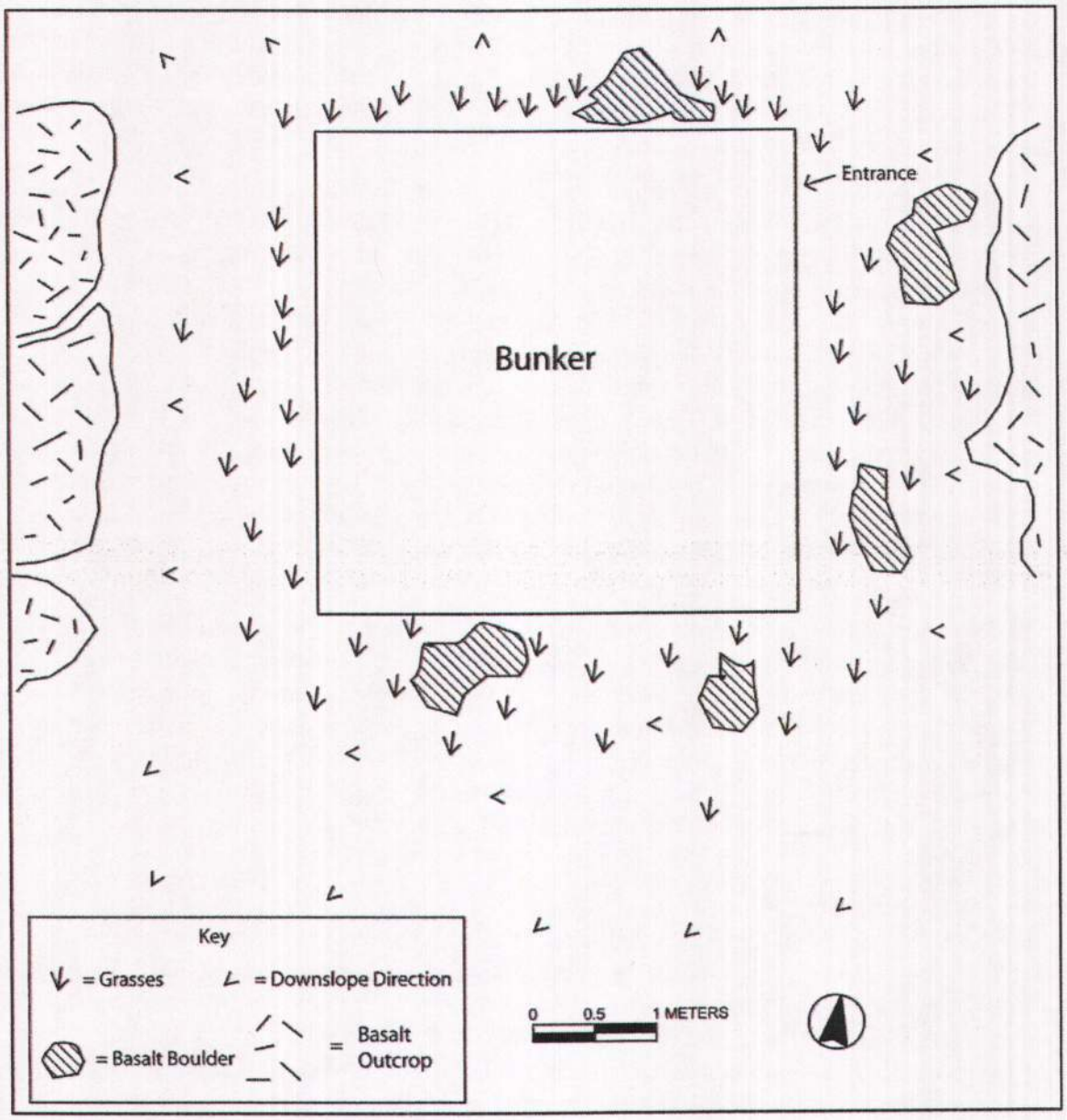

Figure 28. Plan view schematic of SIHP 50-80-08-6681.

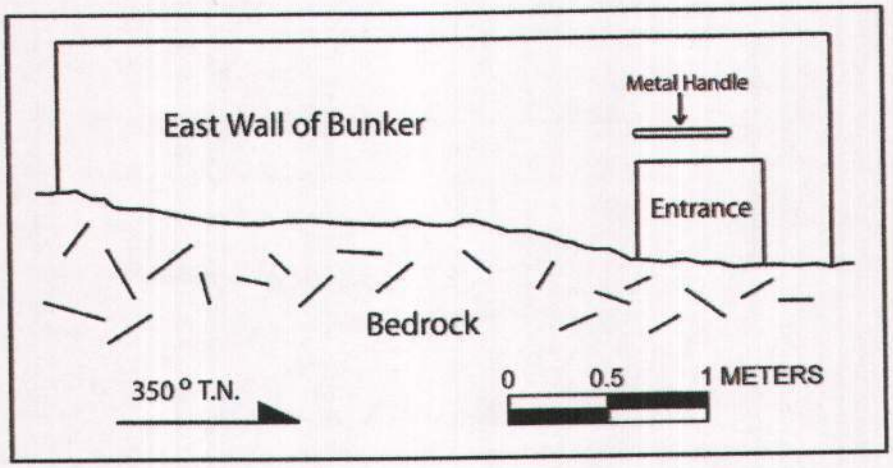

Figure 29. Profile schematic of the east wall of SIHP 50-80-08-6681.

Figure 30. Photograph looking west at the top and the east wall of SIHP 50-80-08-6681.

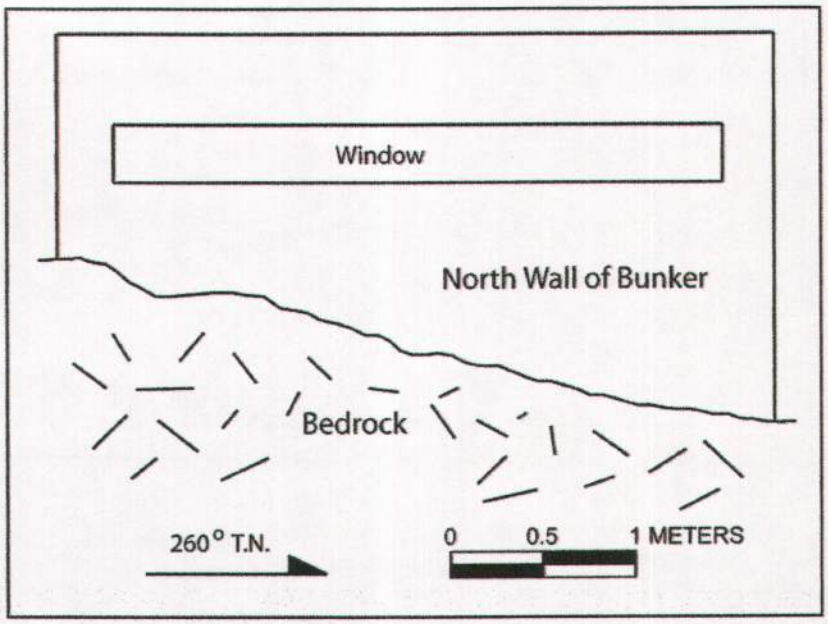

Figure 31. Profile schematic of the north wall of SIHP 50-80-08-6681

Figure 32. Photograph looking south at the north wall of SIHP 50-80-08-6681.

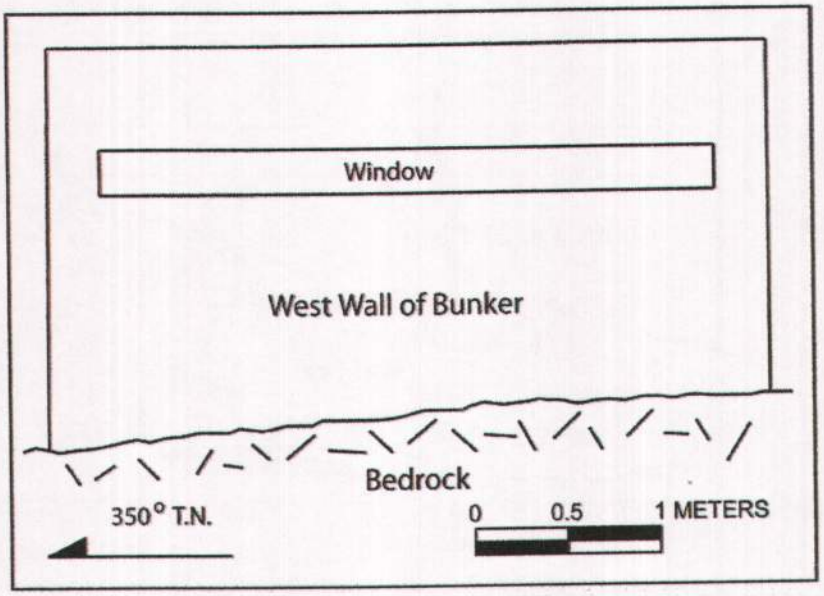

Figure 33. Profile schematic of the west wall of SIHP 50-80-08-6681.

Figure 34. Photograph looking east at the west wall of SIHP 50-80-08-6681.

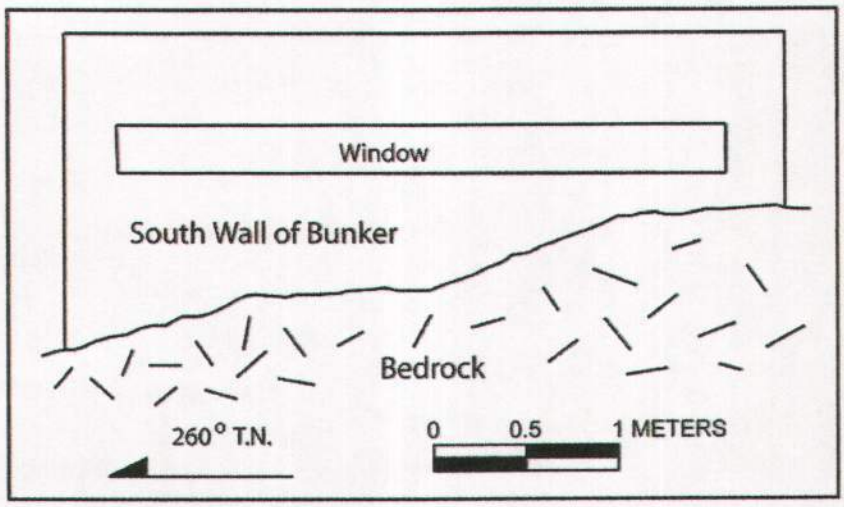

Figure 35. Profile schematic of the south wall of SIHP 50-80-08-6681.

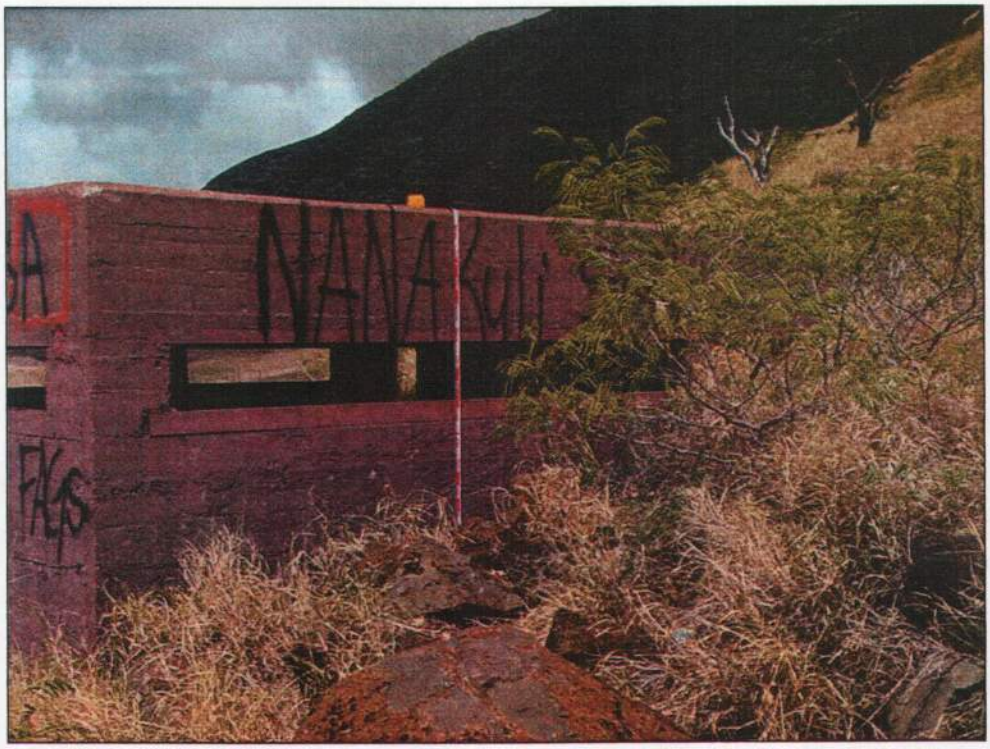

Figure 36. Photograph looking northwest at the south wall of SIHP 50-80-08-6681.

Figure 37. Photograph looking northwest out of the north window of SIHP 50-80-08-6681 showing the mounting brackets.

SIHP 50-80-08-6681 is significant under criterion A - historic property reflects major trends or events in the history of the state or nation - and D - historic property has yielded or may be likely to yield information important in prehistory or history - in light of the five broad criteria used by the State of Hawai'i Register of Historic Places. SIHP 50-80-08-6681, a WWII bunker, is part of a pivotal point in both the history of the state of Hawai'i as well as the United States. Its location is strategically placed, and when examined in the context of broader defensive fortifications such as Battery Arizona, can provide information on the military planning by the United States during the war. And while the bunker has been covered with graffiti and trash, the site has not been structurally damaged and offers information about construction techniques of military defensive fortifications.

C. Community Consultation Summary

In addition to this archaeological inventory survey investigation, a cultural impact assessment to fulfill the requirements of Hawai'i Revised Statutes Chapter 343 (Souza and Hammatt *in prep.*) has been undertaken for the same project. CSH archaeologist/cultural anthropologist Kehaulani Souza, B.A., has been conducting the consultations through e-mail, telephone calls, and group meetings.

CSH has consulted with the following individuals as part of the cultural impact assessment:

- Office of Hawaiian Affairs
- Eric Enos: Local resident
- Analu Josephides: O'ahu Island Burial Council, Wai'anae Representative
- Alice Greenwood: O'ahu Island Burial Council, Wai'anae Representative
- William Ailā: Wai'anae Harbor Master & Hui Malama Chairperson
- Josiah "Black" Ho'ohuli: Cultural Practitioner, Nānākuli Hawaiian Homestead Resource, and Wai'anae Coast Neighborhood Board
- Frenchy Desoto: Wai'anae Coast Archaeological Preservation Committee
- Doreen Lindsey: President Nānāikapono Hawaiian Civic Club
- Patty Teruya: Chair, Wai'anae Coast Neighborhood Board
- Albert H. Silva: Vice Chair, Wai'anae Coast Neighborhood Board
- Karen Awana: Secretary/Treasurer, Wai'anae Coast Neighborhood Board
- Neddie G. Waiamau-Nunuha: Sgt. at Arms, Wai'anae Coast Neighborhood Board
- Adrian Silva Jr.: Wai'anae Coast Neighborhood Board
- Alvin K. Awo: Wai'anae Coast Neighborhood Board
- Georgette "Jo" Jordan: Parks and Rec. I & II Comm. Chair and Wai'anae Coast Neighborhood Board
- Cynthia K.L.: Wai'anae Coast Neighborhood Board
- Suzanna E. Leonida: Wai'anae Coast Neighborhood Board
- James K. Manaku: Wai'anae Coast Neighborhood Board
- Flank D. Slocum: Wai'anae Coast Neighborhood Board
- Walterbea Aldeguer: Local resident
- John Mole: Local resident
- Lucie Gains: Local resident
- Carolyn Holug: Local resident
- Patricia Patterson: Local resident

No additional information was obtained regarding the two historic properties that were identified during the archaeological inventory survey investigation as a result of these consultations. No additional archaeological historic properties have been identified within the current project area as a result of these consultations.

Several individuals contacted by Souza mentioned Hina's Cave. As mentioned above, this cave was the home of the demi-god Maui's mother. The cave is located outside of the current

project area, farther up the slope of Pu'u Heleakala. The current proposed project should not impact this site.

VII. INVENTORY SURVEY SUMMARY

Cultural Surveys Hawaii Inc., at the request of URS Corporation, has completed this archaeological inventory survey of the approximately 200-acre parcel proposed as the site of the Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, District of Wai'anae, O'ahu, Hawai'i.

Cultural and historical background research was undertaken in addition to the archaeological fieldwork. This background research included, but was not limited to, a review of past archaeological studies in the region, oral interviews with knowledgeable local informants, and historic document searches. Document searches included aerial photographs, historic maps extending back to the early 20th century, and Māhele records. Previous historic preservation documentation of the parcel includes Bordner (1977), who reported that there were no historic or prehistoric sites. There are a number of other historical and/or archaeological sources for the Lualualei region including Haun (1991), Ogden Environmental & Energy Services Co., Inc. (1997, 1998), Hammatt *et al.* (1993), McDermott & Hammatt (2000), and Mayberry & Rosendahl (1994).

Traditional Hawaiian accounts reveal Lualualei to have been the location for many of the adventures of the demi-god Māuiakalana (Māui) including fire making, fishing, adze working, and kite flying. Māui's mother, Hina, lived at Pu'u Heleakalā and made her *kapa* (bark cloth) (Sterling and Summers 1978: 62).

Sandalwood harvesting and exportation was the focus of the early historic period on the Wai'anae coast and Lualualei. During the Māhele no claims were submitted within the project area. Cattle ranching began in Lualualei in 1851 when William Jarrett leased approximately 17,000 acres of land from Kamehameha III. The sugar industry was also present in Lualualei, but sugarcane was never grown within the project area itself.

Although large portions have been modified by past bulldozer activity, there has been little actual development of the project area. An over grown, no longer in use road which was used to install SIHP 50-80-08-6681, the WWII bunker, runs the length of the southwest side of the project area. The graded road and power poles that lead to the two large water tanks are the only current development used on the property.

The only prehistoric historic property (50-80-08-6699) found within the project area is a small rockshelter on the slopes of the southwest ridge of Pu'u Heleakalā. Excavation resulted in the recovery of lithic materials, transported marine shell and coral, and numerous rat remains. A small scoop hearth (Feature #2) was also discovered at the bottom of Test Unit #1. Charcoal collected from the feature was submitted for radiocarbon analysis resulting in a date of 270 ± 50 BP. After calibration using OxCal, and taking into account that no historic materials were found within the excavations, the radiocarbon results indicate that the lower layer of deposition in historic property 50-80-08-6699 is most likely not modern and dates to the late prehistoric period prior to European contact.

In summary, historic property 50-80-08-6699 follows the settlement patterns for the study area laid out above. The rock shelter served as a temporary habitation site where native Hawaiians likely took refuge from the mid-day heat or sought shelter while traveling or procuring resources. It is possible that historic property 50-80-08-6699 was used by the

inhabitants of the *mauka* portions of Lualualei when they journeyed to the coast for fishing or shellfish gathering.

Refer to Appendix C for updated information.

VIII. SIGNIFICANCE ASSESSMENTS

The inventory survey investigation and documentation of the project area's two historic properties have provided sufficient information for significance evaluations. Significance is determined after evaluation of each historic property in light of the five broad criteria used by the State of Hawai'i Register of Historic Places. The criteria are the following:

A Historic property reflects major trends or events in the history of the state or nation.

B Historic property is associated with the lives of persons significant in our past.

C Historic property is an excellent example of a site type.

D Historic property has yielded or may be likely to yield information important in prehistory or history.

E Historic property has cultural significance to an ethnic group, including, but not limited to, religious structures, burials, and traditional cultural properties.

Historic property 50-80-08-6699, the rockshelter site that served as a temporary habitation is significant under criterion D for its informational content. During the inventory survey investigation SIHP 50-80-08-6699 yielded general information concerning traditional Hawaiian land use in the project area. The location of this rockshelter – between the coast and *mauka* sections of Lualualei – makes this site significant.

Historic property 50-80-08-6681, the WWII bunker in the south corner of the project area, is significant under criterion A. World War II was a significant and pivotal point in both American history and the history of the state of Hawaii. This site is also significant under criterion D for its informational content. The bunker provided information on both military defensive strategy as well as the architecture of defensive fortifications.

The significance assessments for both historic properties are summarized in Table 6.

Table 6: Significance Assessments of the Two Historic Properties in the Project Area

SIHP #	Description	Significance Criteria
50-80-08-6699	Prehistoric Rockshelter	D
50-80-08-6681	WWII Bunker	A and D

IX. EFFECT RECOMMENDATION

Based upon the project description, the project area maps provided by the client (Figure 38), and consultation with the client, the proposed project will not affect the significant historic properties located within the project area, but outside the project APE. Accordingly, CSH recommends a project specific effect recommendation of "no historic properties affected".

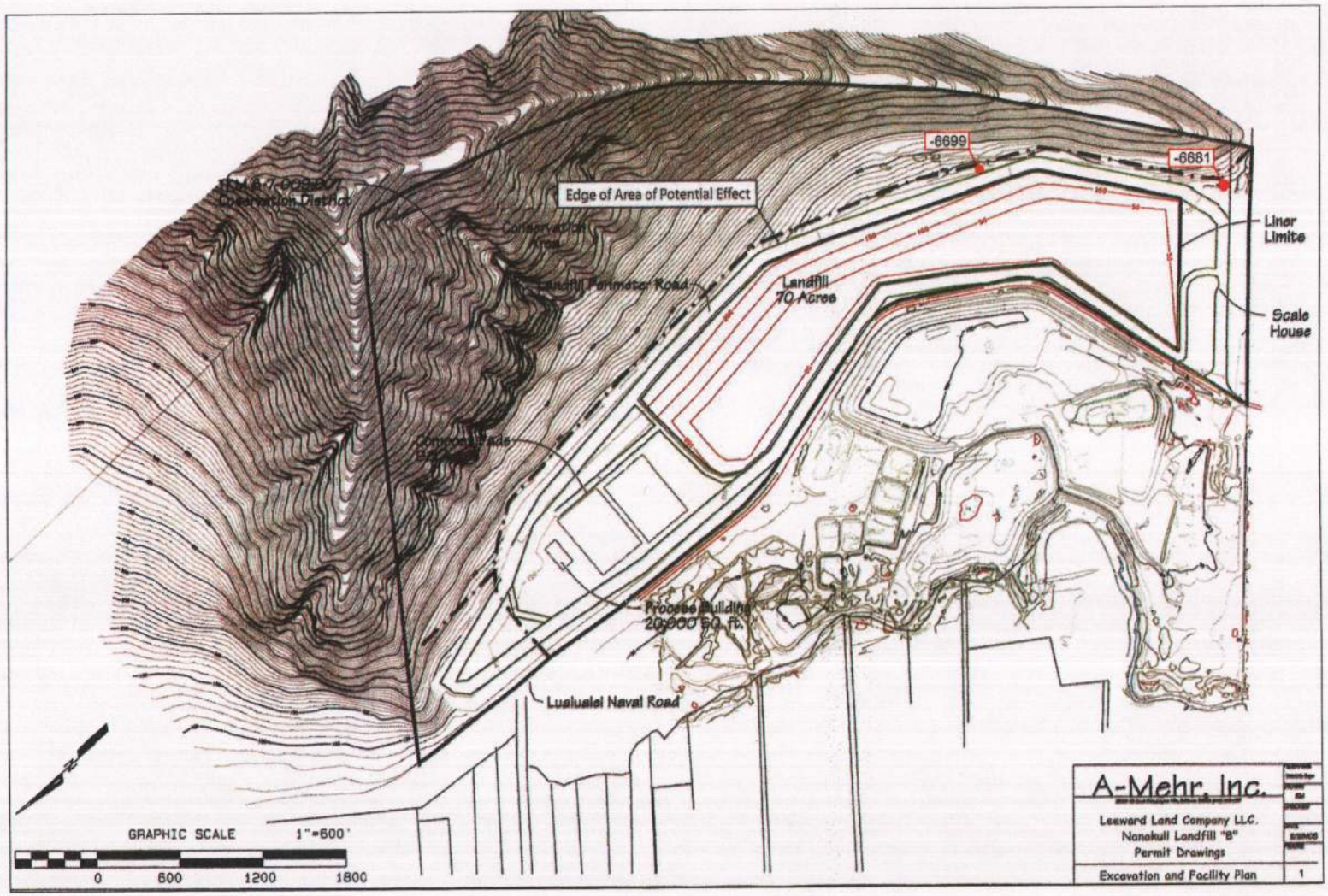

Figure 38. Excavation and Facility Plan Map with the location of the two SIHP (the numbers are prefaced by 50-80-08).

X. MITIGATION RECOMMENDATION

Based upon the information provided by the client at the time of the preparation of this report, the historic properties within the project area are outside the project APE and will be avoided by all construction activities. However, because historic property 50-80-08-6699 is extremely close to the proposed APE, and past experience on a number of projects has shown that sites in this situation have been impacted, we recommend that the site be preserved.

If the project design changes in the future and avoidance of historic property 50-80-08-6681 is not possible, CSH recommends data recovery program be developed and implemented. For historic property 50-80-08-6681, World War II concrete bunker, appropriate architectural recordation would include more formal recording of the buildings construction and architectural traits, for example through Historic American Engineering Record (HAER)-type recordation.

Following the approval of these recommendations by SHPD, a preservation plan addressing historic property 50-80-08-6699 will be prepared and submitted for review and approval.

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APPENDIX A: CATALOG OF INDIGENOUS ARTIFACTS

Bag #	Test Unit	Stratum	Depth (cmbs)	# pieces	Length (cm)	Width (cm)	Weight (g)	Material	Type	Comments
1	1	surface	0	2	4.0/6.5	3.0/5.5	112.7	basalt	flakes	
5	1	I	0-5	2	2.1/3.8	1.2/1.5	10.2	basalt	flakes	
11	1	II	5-23	1	1.9	1.1	0.1	shell	Und. pre-form	
12	1	II	5-23	4	0.5/2.3	0.5/1.3	2.2	coral	manuport	small pebbles
13	1	II	5-23	5	1.3/6.5	1.0/5.9	117.9	basalt	flakes	
14	1	II	5-23	6	0.9/3.4	0.5/2.8	44.9	volcanic glass	manuport	small pebbles
14	1	II	5-23	4	1.0-1.1	0.2/0.7	1.8	volcanic glass	flakes	
20	2	III	28-44	1	1.3	0.5	0.4	basalt	flake	
21	2	III	28-44	1	0.4	1.2	0.9	volcanic glass	flake	
22	2	III	28-44	3	0.3/0.7	0.3/0.4	0.1	coral	manuport	small pebbles
23	2	II	4-28	1	3.5	2.9	9.8	coral	abrader	
26	2	II	4-28	21	0.1-17.2	0.1/3.5	73.4	basalt	flakes	
27	2	II	4-28	4	0.9/1.9	0.7/1.2	10.9	volcanic glass	manuport	small pebbles
27	2	II	4-28	5	1.0/1.3	0.4/0.9	2.1	volcanic glass	flakes	
28	2	II	4-28	14	0.1/0.3	0.1/0.2	1.8	volcanic glass	flakes	
32	1	III	27-42	7	1.4/2.9	0.8/2.5	14.9	basalt	flakes	
33	1	III	27-42	1	1.5	1.5	4.0	volcanic glass	manuport	small pebble
33	1	III	27-42	11	0.5/1.3	0.2/1.1	2.8	volcanic glass	flakes	

APPENDIX B: RADIOCARBON DATING RESULTS

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-5167 FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Hallett H. Hammatt/Owen O'Leary — Report Date: 10/25/2004

Cultural Surveys Hawaii — Material Received: 10/5/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 196317	270 +/- 50 BP	-24.5 o/oo	270 +/- 50 BP

SAMPLE : -6699SCPHRTH
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1490 to 1680 (Cal BP 460 to 270) AND Cal AD 1770 to 1800 (Cal BP 180 to 150)
Cal AD 1940 to 1950 (Cal BP 10 to 0)

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

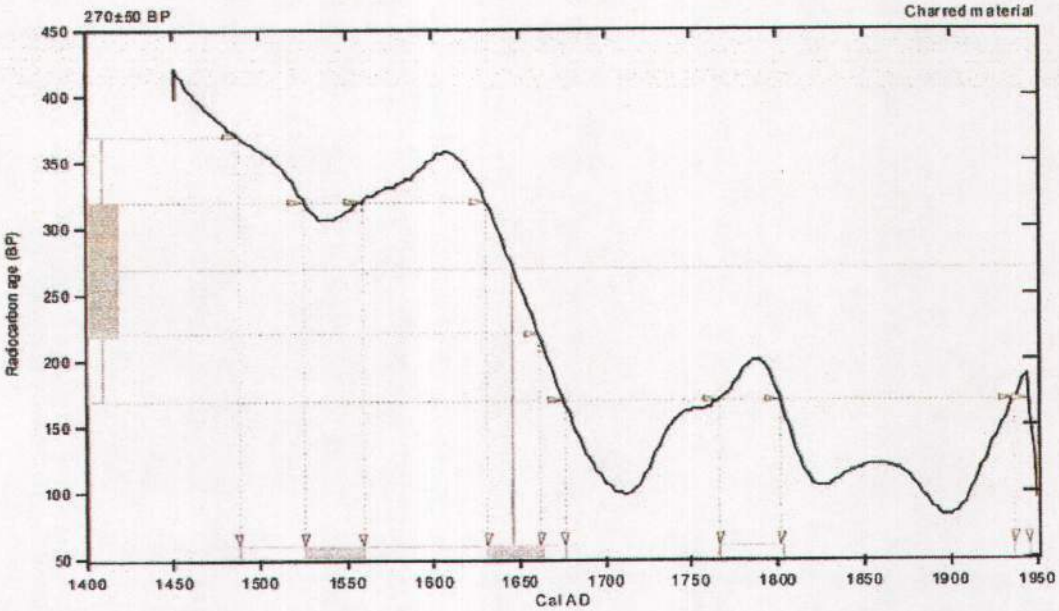
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.5:lab. mult=1)

Laboratory number:	**Beta-196317**
Conventional radiocarbon age:	**270±50 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1490 to 1680 (Cal BP 460 to 270) and Cal AD 1770 to 1800 (Cal BP 180 to 150) and Cal AD 1940 to 1950 (Cal BP 10 to 0)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1650 (Cal BP 300)
1 Sigma calibrated results: (68% probability)	Cal AD 1530 to 1560 (Cal BP 420 to 390) and Cal AD 1630 to 1660 (Cal BP 320 to 290)



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Database used
INTCAL98
Calibration Database
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INTCAL98 Radiocarbon Age Calibration
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Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory
4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

APPENDIX C—ADDITIONAL HISTORIC PROPERTY DESCRIPTION

Addendum To:

"Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i. TMK 8-7-09 por: 1, Cultural Surveys Hawai'i Inc., Waimānalo, Hawaii."

(CSH Job Code: LUAL 6—O'Leary and McDermott 2006)

TMK: [1] 8-7-09: por. 1

Prepared for

USR Corporation

Prepared by

Amy Hammermeister, B.A.

and

Matt McDermott, M.A.

Cultural Surveys Hawai'i, Inc.

Kailua, Hawai'i

(Addendum Job Code: LUALU 5)

May 2007

Appendix C Additional Historic Property Description

Context for this addendum to the AIS report:

In 2006, Cultural Surveys Hawaii, Inc. (CSH) completed an archaeological inventory survey for the then approximately 200-acre proposed Nānākuli B Composting and Solid Waste Landfill Facility, Lualualei Ahupua'a, Waianae District, Island of Oahu [TMK (1) 8-7-009: por. 001]. The State Historic Preservation Division (SHPD) reviewed and approved the archaeological inventory survey report (O'Leary and McDermott 2006[1]) on January 5, 2007 (LOG NO: 2007.0053 DOC NO: 0701amj06).

CSH was also contracted by the project proponents to prepare a cultural impact assessment (CIA) investigation for the proposed Nānākuli B Site project. This investigation was carried out in compliance with the State of Hawaii's Office of Environmental Quality Control's guidelines for assessing cultural impacts. In early February 2007, CSH personnel made a site visit to the project area's environs as part of the CIA research and consultation effort.

During the site visit a stacked stone mound was found on the project area's eastern, upslope boundary. The mound is small and low, measuring approximately two meters square by 0.4 to 0.8 meters high, and largely obscured by vegetation. Based on available evidence, the mound was thought to most likely be older than fifty years, and so eligible as an historic property under Hawaii historic preservation legislation. Based on available information, it was thought potentially to be a traditional Hawaiian feature, clearing mound, marker, or possibly a burial. It was also a potential historic marker--or the foundation of a survey point, for example, the foundation of a survey pole, etc. Based on hand-held GPS location data (accurate to plus or minus 3-5 meters/10-15 feet) CSH could not tell whether this mound was in the project area or not—but it was certainly close enough to the boundary to be a concern.

In consultation with the project proponents, CSH has prepared this addendum to the existing Nānākuli B Site archaeological inventory survey report. Its purpose is to document this stacked-stone mound and provide a record of the available information concerning this historic property. It is submitted to SHPD for review and approval. Based on this information, CSH would like SHPD to supply a State Inventory of Historic Properties (SIHP) number for the historic property. CSH also asks SHPD to review and approve the historic property documentation, significance evaluation, and treatment recommendation. With SHPD's approval, this addendum will be incorporated into the existing Nānākuli B Site archaeological inventory survey report.

This addendum was approved by SHPD July 31st 2007 (LOG NO: 2007.1716 DOC NO: 0707ED32).

Note: Subsequent to SHPD's acceptance of the project's archaeological inventory survey report, the project area was reduced in size from approximately 200 acres to 179 acres. This reduction in the project area's size is shown on Figure 39, below.

[1] O'Leary, Owen and Matt McDermott
2006 Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i. TMK 8-7-09 por: 1, Cultural Surveys Hawai'i Inc., Waimānalo, Hawaii. (CSH Job Code: LUAL 6)

Historic Property Description

SIHP #:	50-80-08-6920
SITE TYPE:	Mound
FUNCTION:	Marker
FEATURES:	1
DIMENSIONS:	2 m N/S x 2 m E/W
CONDITION:	Good
PROBABLE AGE:	Pre-Contact
TAX MAP KEY:	[1] 8-7-09: por. 1
UTM COORDINATES:	589,279 m E, 2,366,680 m N (NAD 83 Zone 4 North)

DESCRIPTION:

SIHP # 6920 consists of a small, roughly circular rock mound located on the lower western slope of Pu'u Heleakalā, near the edge of a natural drainage channel. The site is located approximately 420 m east of Lualualei Naval Road on the eastern boundary of the Nānākuli B Composting and Solid Waste Landfill Facility project area (Figure 39). The elevation is approximately 330 feet above sea level. The surrounding topography slopes steeply (c. 30 to 35 degrees) to the west. The surrounding slope has natural outcrops of basalt bedrock and large basalt rock talus pieces that have tumbled from the upper slopes of Pu'u Heleakalā. Surrounding vegetation consists of fairly dense grass scrub, including exotic grasses and small *koa haole* and *kiawe* shrubs. The adjacent intermittent drainage, located approximately ten meters north of the site, is approximately five meters across, three to four meters deep, and drains Pu'u Heleakalā's upper slopes. The site's location offers a commanding view of Lualualei Valley below.

SIHP# 6920 is composed of basalt boulders and cobbles piled against the sloping hillside. The basalt stones used for the site's construction are locally available from talus and exposures of bedrock along the surrounding eroding slope. Although some of the boulders used in the mounds construction are fairly large, the mound itself does not represent a substantial labor investment because the component boulders and cobbles were locally available.

The mound is roughly circular in plan view, approximately 2 m in diameter, and consists of large basalt boulders (0.6-0.8 m in diameter) forming the periphery, particularly the elevated down slope, western edge, with smaller boulders and cobbles in the center. The upslope, eastern edge is approximately level with the ground surface, while the down slope edge is 0.8 m above the ground surface. A small section of the mound's north side is faced, and its upper surface is gently sloping, roughly following the natural fall line of the surrounding hillside (Figure 40 and Figure 41). The mound does not retain any level soil areas, either within or around it.

No surface artifacts or other cultural material were observed on the mound or its vicinity. Systematic pedestrian inspection in the vicinity of the mound, within a radius of 30 meters, found no additional features. Based on surface appearances, including the mound's construction style and the weathering of the component basalt boulders, the mound appeared to be older than 50 years. In order to better establish the age, function, and significance of this historic property

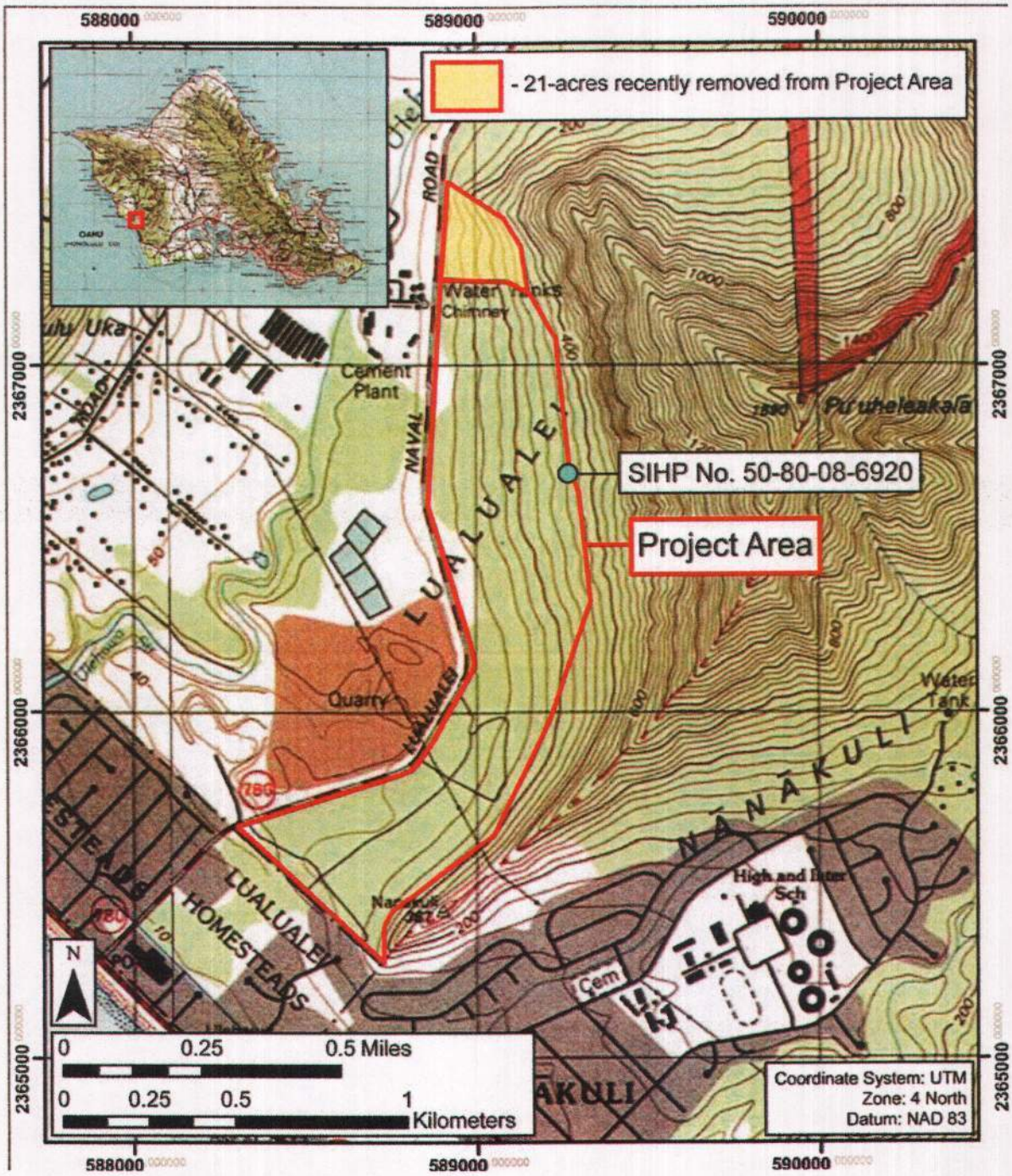

Figure 39 1998 USGS 7.5 minute topographic map, Schofield Barracks Quadrangle, showing the location of the project area and SIHP # 6920

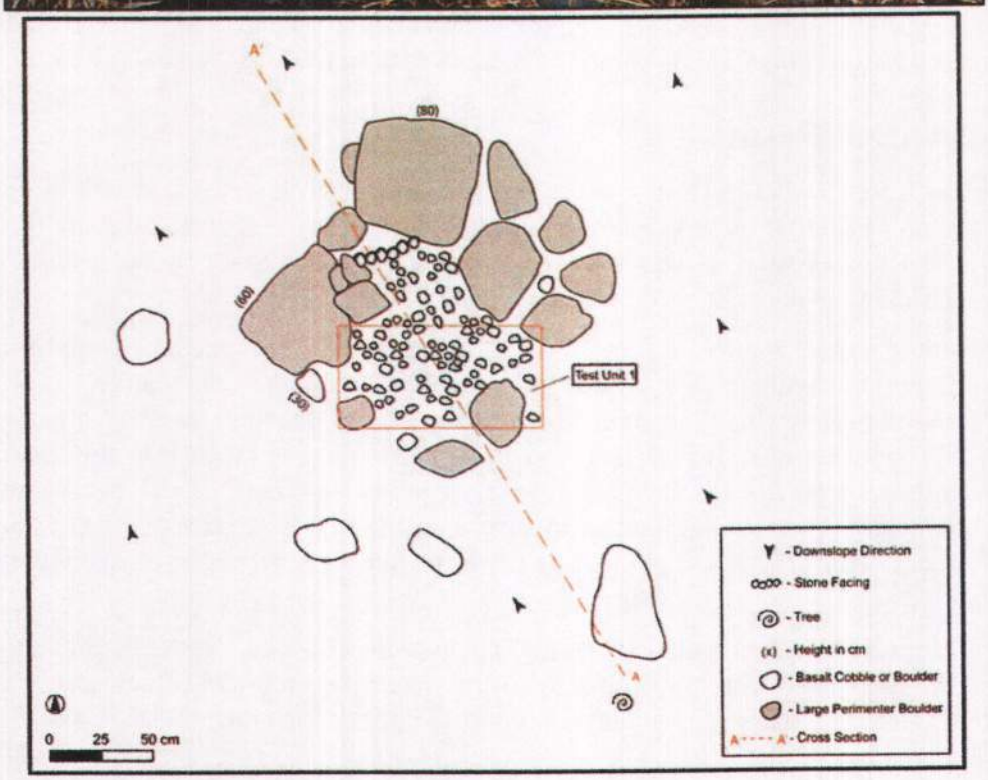

Figure 40 Photograph (above, view SE) and plan view diagram (below) of SIHP # 6920: mound

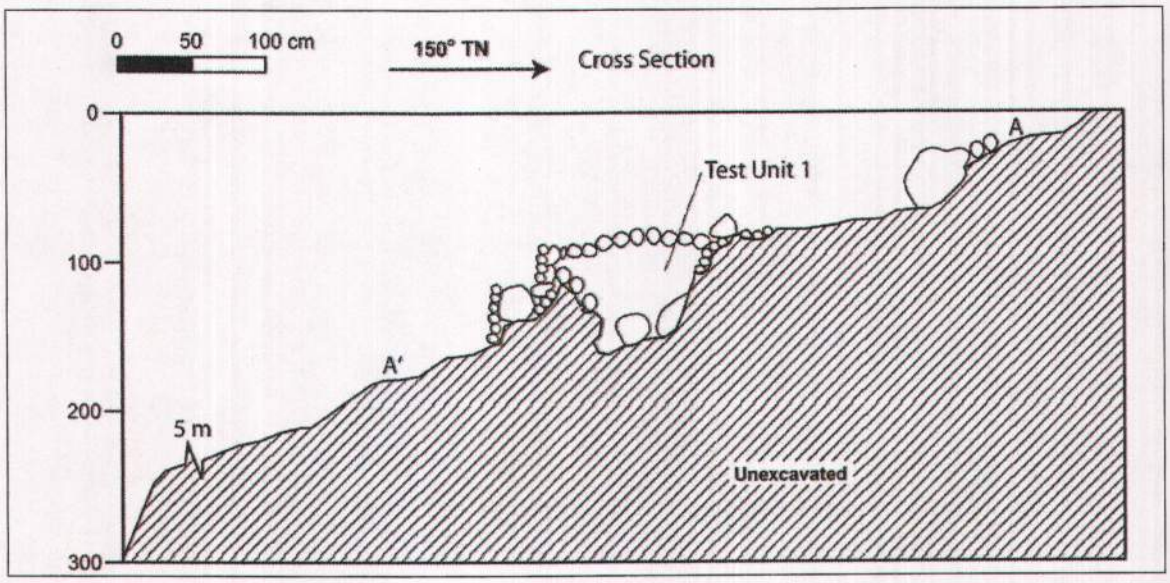

Figure 41 Cross section view diagram of SIHP # 6920: mound

the mound was mapped in plan view and cross section, photographed, and tested for associated subsurface cultural deposits. The mound's location was recorded with a hand-held Garmin GPS unit (horizontal accuracy of three to five meters).

Test Excavation Results

A single 0.5 m by 1.0 m test excavation (Test Unit 1) was excavated within the southern portion of SIHP # 6920 to better determine the age and function of the site (see Figure 40). The test excavation was oriented to minimize disturbance to the feature's support stones and to make post-excavation reconstruction possible.

The stratigraphy within SIHP # 6920 is largely as expected, comprised predominantly of the boulder and cobble fill associated with the construction of the mound feature, with little fine-grained sediments. The natural decomposing bedrock, the C-horizon, was located near the surface and the excavation continued into this basal layer. The following paragraphs provide an overview and summary of the excavation results. For detailed information regarding the test excavation, please refer to the test unit profile, sediment descriptions, and photographs, which follow this more general summary discussion.

The stratigraphy of Test Unit 1 (Figure 42) consisted of: Stratum I, the boulder and cobble rock fill associated with the mound's construction; Stratum II and III, structureless silts; and Stratum IV, the decomposing bedrock C-horizon. (Figure 43 & Table 7).

Figure 42 Pre-excavation (above, view east) and post-excavation (below, view east) photographs of SHIP 6920 with Test Unit 1 marked in blue flagging

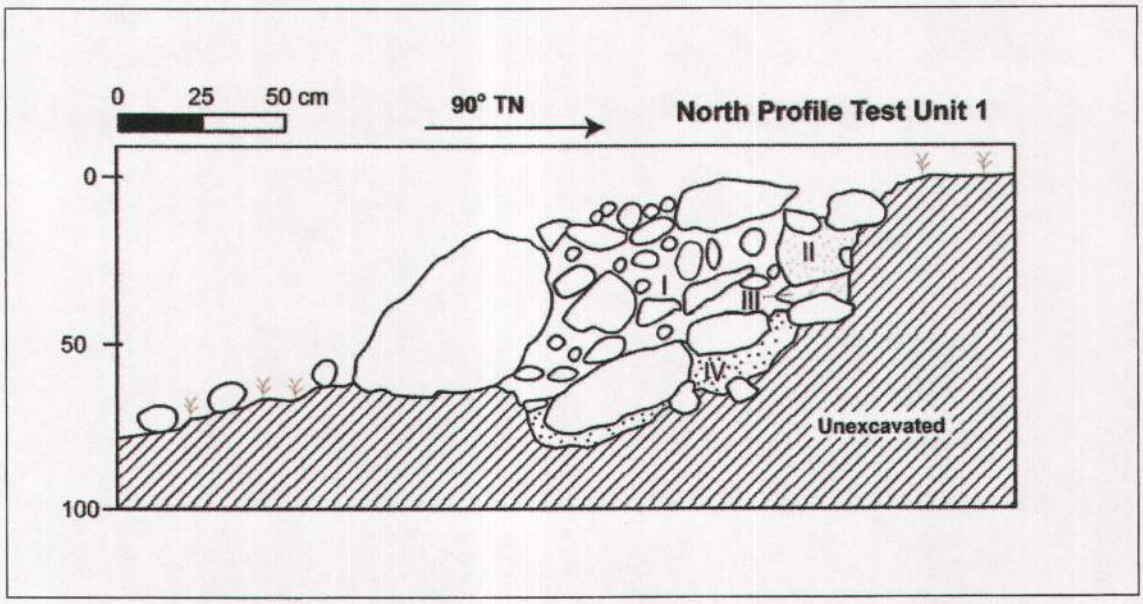

Figure 43 Photograph (above, view north) and stratigraphic profile (below) of the north wall of SIHP # 6920 Test Unit 1

Table 7.Strata Observed at Test Unit 1, SIHP # 6920

Stratum	Depth (cmbs)	Description
I	0-75	7.5YR 3/2 dark brown extremely cobbly and stony silt loam; structureless, single grain; dry, loose consistency; non plastic; no cementation; terrestrial origin; includes small amounts of rootlets and land snail shells; Lower Boundary (LB) is clear, wavy. Rock fill of mound construction with some alluvial and/or eolian deposited finer-grained sediments
II	10-30	2.5YR 3/1 very dark gray silt loam; structureless, single grain; dry, loose consistency; non plastic; no cementation; terrestrial origin; contains burned leaf litter and numerous ash particles; Lower Boundary (LB) is clear, irregular.
III	30-40	7.5YR 3/2 dark brown silt; structureless, single grain; moist, loose consistency; non plastic; no cementation; terrestrial origin; contains few rootlets and some very small land snail shells; Lower Boundary (LB) is diffuse, wavy.
IV	40-80	10YR 3/3 dark brown stony, gravelly, sandy silt, decomposing basalt bedrock; structureless, granular; moist, loose consistency; non plastic; no cementation; terrestrial origin; Lower Boundary (LB) is below base of excavation. C horizon.

All fine-grained sediments were screened through 1/8th inch mesh. No cultural material was observed during the excavation of this test unit. Following excavation, the mound was reconstructed.

The surface of the test excavation consisted of a mixture of small (5 cm diameter), medium (10-30 cm diameter) and large (60^{+} cm diameter), locally available basalt stones. In general the larger stones formed the perimeter of the feature with smaller stones filling the interior.

Four strata were observed through the excavation of Test Unit 1 (Figure 43). Stratum I consisted of plentiful subangular and rounded basalt boulders and cobbles of various sizes and minimal amounts of silt. Stratum II consisted of a dark gray silt loam sediment containing burned and unburned leaf litter as well as ash particles from recent wildfires. Stratum II is likely a remnant portion of the natural A horizon. Stratum III consisted of dark brown silt with few rootlets and few small land snail shells. Stratum III may be a remnant B Horizon. Stratum IV consisted of dark brown stony, gravelly sandy silt decomposing bedrock. Stratum II and III may have been truncated by the construction of the stone mound. The test excavation was terminated at approximately 80 cmbs, where several large bedrock boulders made it impossible to excavate further into the sterile stratum IV (refer to Figure 42, lower photo).

Summary, Significance, and Treatment Recommendation

No cultural material was observed during test excavations at SIHP # xxx. The distinct lack of cultural material in the test excavation did not suggest a specific feature function; however it does help exclude possible functional interpretations. Sediments screened through1/8-inch mesh contained no bone, largely ruling out the possibility that the mound functioned as a human burial. Additionally, the lack of wood, wire, glass, and concrete may be an indication that the feature is pre-Contact, rather than historic or modern. Systematic, intensive survey in the vicinity revealed no other rock mounds, suggesting SIHP # 6920 was not an agricultural feature, which are generally found in clusters rather than in isolation.

While SIHP # 6920's function cannot be determined with certainty based on the available evidence, in the past similar features from similar contexts have often been interpreted as markers, for example of trails, boundaries, view points, or other significant areas. Based on the available evidence, SIHP # 6920 is interpreted as a pre-Contact marker.

SIHP # 6920 has integrity of location, design, materials, and workmanship. SIHP # 6920 is assessed as significant under Criterion D (has yielded, or may yield information important in prehistory or history) of the Hawai'i Register of Historic Places evaluation criteria.

The potential information from SIHP # 6920 has been recorded during the current investigation with detailed plan view and cross-section maps, GPS location data, photographs, a written description, and excavation results. Accordingly, no further historic preservation work is recommended for SIHP # 6920.

Cultural Surveys Hawai'i Inc.
Archaeological and Cultural Impact Studies
Hallett H. Hammatt, Ph.D., President

Providing Excellence in Cultural Resource Management

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3 October 2007

Ms. Ann Sansevero
Senior Environmental Planner
URS Corporation
55 South Market Street, Suite 1500
San Jose, CA 95113
Via Email: Ann_Sansevero@URSCorp.com

CSH Job Code: LUALU 5

Subject: Evolution of the project description for the proposed Nānākuli B Composting and Solid Waste Landfill Facility, Lualualei, Oahu, and its effect on the results and conclusions of the project's archaeological inventory survey report (O`Leary and McDermott 2006)

Ms. Sansevero:

As we have recently discussed in email correspondence, the project description for the proposed Nānākuli B Composting and Solid Waste Landfill Facility project has evolved over the last few years. At the time of the project's archaeological inventory survey (AIS) investigation in 2004 and 2005 (O`Leary and McDermott 2006), the project description was for a "Materials Recovery Facility and Landfill." More recently in 2006 and 2007, as described in the text of CSH's cultural impact assessment (CIA) investigation for the project (Souza and Hammatt 2007), the project is described as a "Composting and Solid Waste Landfill."

Based on our discussion and the project description information that URS has provided to CSH, the changes in the project description between CSH's AIS and CIA investigations are minor and should not change the results and conclusions of CSH's earlier AIS report. The overall size of the project has been reduced by 21 acres. Additionally, the types of ground disturbances and their geographic relationship to the documented historic properties have not changed significantly. Accordingly, the historic property documentation, significance evaluations, project effect determination, and mitigation recommendations of the project's AIS report (O`Leary and McDermott 2006) should remain valid despite the minor changes in the project's description.

As you are aware, the project proponents have committed to the avoidance and/or preservation of two historic properties along the project's southeastern border. If the planned preservation and/or avoidance of these historic properties is in anyway affected by the current project design, or any subsequent design changes, consultation with the State Historic Preservation Division should be carried out as soon as possible.

Sincerely,
Cultural Surveys Hawai'i, Inc.

Matt McDermott
Projects Manager
(mmcdermott@culturalsurveys.com)

O'Leary, Owen and Matt McDermott
2006 Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i. TMK 8-7-09 por: 1, Cultural Surveys Hawai'i Inc., Waimānalo, Hawaii. (CSH Job Code: LUAL 6)

Souza, Kehau and Hallett H. Hammatt
2007 Cultural Impact Assessment of 179 Acres for the Proposed Nānākuli B Composting and Solid Waste Landfill Facility, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu, Hawai'i, Cultural Surveys Hawai'i Inc., Waimānalo, Hawaii. (CSH Job Code: LUALU 1)

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July 31, 2007

Matt McDermott
Cultural Surveys Hawai'i, Inc.
P.O. BOX 1114
Kailua, Hawai'i 96734

LOG NO: 2007.1716
DOC NO: 0707ED32
Archaeology

Dear Mr. McDermott:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Addendum to: "An Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Wai'anae Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 por.

Thank you for submitting the aforementioned report by Hammermeister and McDermott (May 2007), which we received on May 22, 2007. We apologize for the delay in responding. The submitted report is an addendum to a previously accepted archaeological inventory survey (LOG NO: 2007.0053, DOC NO: 0701amj06).

During a site visit for a cultural impact assessment, CSH personnel identified a stacked stone mound, measuring approximately 2 square meters by 0.4 to 0.8 meters high, located in the project area's eastern boundary. Based on surface appearance, weathering of the basalt and the construction of the mound, the mound is believed to be older than 50 years of age. A 0.5 meter by 1 meter test unit was excavated within the mound to possibly determine the function and the age. No cultural materials and/or evidence that the mound functioned as a burial was observed during excavation.

Based on evidence from similar features in similar contexts interpreted as trail or boundary markers, the mound identified during the current survey is interpreted as a pre-contact marker. We concur with your interpretation of the mound as a boundary marker and with your assessment of the mound as significant under Criterion D. Adequate documentation (detailed plan view and cross-sectional maps, GPS location data, photographs, and written description) and excavation has been conducted and we concur with your recommendation of no further work.

We assigned SIHP number 50-80-08-6920 for the stacked stone mound. Please include this addendum with the existing Nānākuli B Site Archaeological Inventory Survey.

Please contact me at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Melanie Chinen, Administrator
State Historic Preservation Division

ED

LINDA LINGLE
GOVERNOR OF HAWAII

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November 3, 2006

Mr. Owen O'Leary
Cultural Surveys of Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2006.3673
DOC NO: 0611amj04
Archaeology

Dear Mr. O'Leary:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 (portion)

Thank you for the opportunity to review the aforementioned report by O'Leary and McDermott (2006), which we received on September 18, 2006. Two historic properties were identified in the project area: SIHP No. 50-80-08-6699, a small pre-Contact rockshelter, and SIHP No. 50-80-08-6681, a World War II concrete bunker. Site 6699 was tested (excavated), yielding basalt and volcanic-glass flakes and debitage, coral, and shell. One radiocarbon sample was dated to 270±50 BP, and calibrated to the pre-Contact period.

The background, methods, and results are generally excellent, and we commend you, in particular, on the overall excellent quality of the photographs, field maps, and graphics. You also provide (pp.62-64) a list of consulted individuals, with the results of these efforts.

Before we can accept the archaeological inventory survey as adequate under HAR 13-284 and 13-276, however, please address the following comments:

(1) In accordance with HAR 13-276-5 (b), please insert "...a section on background research which should be used to predict the kinds and distributions of historic properties that might still be present..." The last sentence on p.44 appears to cover 'expected finds' for the project area, but a clearer statement, summarizing the large amount of studies you have mentioned in the general area, is needed.

(2) The north arrow in Figure 18 (p.47) makes no sense in this context. Please include the view perspective in the caption.

(3) We do not agree with your mitigation recommendation regarding Site 6699. According to your document, the site is within the project area but outside the area of potential effect (APE) for the proposed undertaking, and will be avoided by all construction activities.

However, Figure 38 (p.69) clearly shows Site 6699 is extremely close to the proposed APE, and our recent experience on a number of projects suggests sites in such close proximity must be formally protected and/or preserved in order to prevent contractors, who typically have little or no information about the presence of archaeological sites, from impacting them. We believe mitigation for Site 6699 should include a formal, protective buffer zone during proposed construction. We recommend submission of a mitigation plan to our office that details how Site 6699 will be protected during proposed construction.

We look forward to receipt of a revised version of this report. Please contact Mr. Adam Johnson (O'ahu Assistant Archaeologist) at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Melanie Chinen, Administrator
State Historic Preservation Division

amj:

LINDA LINGLE
GOVERNOR OF HAWAII

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DEPARTMENT OF LAND AND NATURAL RESOURCES

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February 27, 2008

Matt McDermott
Cultural Surveys Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2007.3341
DOC NO: 0802ED31
Archaeology

Dear Mr. McDermott:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Addendum to the Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 por.

Thank you for submitting the aforementioned report (O'Leary and McDermott, December 2006), which we received on September 8, 2007. We apologize for the delay in responding. Submitted to SHPD was the AIS report, accepted on January 5, 2007 (LOG NO: 2007.0053, DCO No: 0701amj06), and the addendum to the AIS report (Hammermeister and McDermott, May 2007).

This addendum adequately addresses the one minor change we requested of the previously submitted addendum. We accept this report as final.

Please contact Teresa Davan at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy McMahon, Acting Archaeology Branch Chief
State Historic Preservation Division

ED

LINDA LINGLE
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December 10, 2007

Matt McDermott
Cultural Surveys Hawai'i, Inc.
P.O. BOX 1114
Honolulu, Hawai'i 96734

LOG NO: 2007.1713
DOC NO: 0712ED11
Archaeology

Dear Mr. McDermott:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Preservation Plan for SIHP No. 50-80-08-6699, Located in the 179-acre Project Area for the Proposed Nānākuli B Composting and Solid Waste Facility
Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 por.

Thank you for the submitting the aforementioned preservation plan by Tulchin and Hammatt (May 2007), which we received on May 22, 2007. We apologize for the delay in responding. The preservation plan outlines the interim and long-term protection measures for SIHP No. 50-80-08-6699, a pre-Contact rockshelter identified during an archaeological inventory survey conducted by CSH in 2006. Conservation (avoidance and protection) is the proposed mitigation measure for SIHP No. -6699.

SIHP No. -6699 is located eight meters upslope of an unimproved road used for fire control activities. According to the plan, construction activities are proposed more than 150 feet from SIHP No. -6699. Interim protection measures include erecting 35 meters of orange construction fencing upslope of the unimproved roadway, notification to the prime contractor of the site's preservation area, and demarcation of site and buffer on construction drawings. Long-term preservation includes installation of a 35-meter wire or chain link fence upslope of the unimproved roadway. It is believed that fencing erected specifically around the site would attract unwanted attention to the rockshelter that otherwise is obscured by the dense vegetation.

We concur with your mitigation recommendations and we accept this preservation plan as fulfilling the requirements of §13-277-3 Hawai'i Administrative Rules (HAR).

Please contact Teresa Davan at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Nancy McMahon, Acting Archaeology Branch Chief
State Historic Preservation Division

ED

LINDA LINGLE
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January 5, 2006

Mr. Owen O'Leary
Cultural Surveys of Hawai'i, Inc.
P.O. Box 1114
Kailua, Hawai'i 96734

LOG NO: 2007.0053
DOC NO: 0701amj06
Archaeology

Dear Mr. O'Leary:

SUBJECT: Chapter 6E-42 Historic Preservation Review –
Revised Archaeological Inventory Survey of 200 Acres for the Proposed Nānākuli B Site Materials Recovery Facility and Landfill
Lualualei Ahupua'a, Wai'anae District, Island of O'ahu
TMK: (1) 8-7-009:001 (portion)

Thank you for submitting the revised report by O'Leary and McDermott (2006), which we received on December 17, 2006. Two historic properties were identified in the project area: SIHP No. 50-80-08-6699, a small pre-Contact rockshelter, and SIHP No. 50-80-08-6681, a World War II concrete bunker. Site 6699 was tested (excavated), yielding basalt and volcanic-glass flakes and debitage, coral, and shell. One radiocarbon sample was dated to 270±50 BP, and calibrated to the pre-Contact period.

In a letter (LOG NO: 2006.3673, DOC NO: 0611amj04) dated November 3, 2006, we reviewed an earlier version of this report. We requested two minor changes and one more substantial revision (*i.e.*, regarding the mitigation of Site 6699). You have made the changes to our satisfaction.

You have assessed both sites (6681 and 6699) as eligible for the Hawai'i Register of Historic Places under criterion D. Site 6681 is also eligible under criterion A. We concur with these significance assessments. You have changed the mitigation recommendation to preservation for Site 6699. We concur with this recommendation, and look forward to receipt of a preservation plan, which will need to be approved and implemented prior to any ground disturbance near the site.

The archaeological inventory survey is accepted in fulfillment of HAR 13-284 and 13-276.

Please contact Mr. Adam Johnson (O'ahu Assistant Archaeologist) at (808) 692-8015 if you have any questions or concerns regarding this letter.

Aloha,

Melanie Chinen, Administrator
State Historic Preservation Division

amj:

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APPENDIX H
Cultural Impact Assessment

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Final
Cultural Impact Assessment for the PVT Integrated Solid Waste Management Facility Relocation Project, Lualualei Ahupuaʻa, Waiʻanae District, Oʻahu TMK: [1] 8-7-009:007

Prepared for
PVT Land Company, Ltd.

Prepared by
Kellen Tanaka, B.A.,
and
Hallett H. Hammatt, Ph.D.

Cultural Surveys Hawaiʻi, Inc.
Kailua, Hawaiʻi
(Job Code: LUALUALEI 33)

July 2019

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Management Summary

Reference	Final Cultural Impact Assessment (CIA) for the Proposed PVT Integrated Solid Waste Management Facility Relocation Project, Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, TMK: [1] 8-6-009:007 (Tanaka and Hammatt 2019)
Date	July 2019
Project Number(s)	Cultural Surveys Hawai‘i, Inc. (CSH) Job Code: LUALUALEI 33
Agencies	State of Hawai‘i, Department of Health, Office of Environmental Quality Control (DOH/OEQC)
Land Jurisdiction	Leeward Land Company, Ltd., affiliate of PVT
Project Proponent	PVT Land Company, Ltd. (PVT)
Project Location	The project site is located on the southwestern slopes of Pu‘u Heleakalā in Lualualei Ahupua‘a, Wai‘anae District, O‘ahu. The project area is depicted on portions of the 1998 Waianae and Schofield Barracks U.S. Geological Survey (USGS) 7.5-minute topographic quadrangles.
Project Description	The proposed project involves the relocation of an existing integrated solid waste management facility (ISWMF) to a parcel owned by a PVT-affiliate, east of the PVT ISWMF and Lualualei Naval Road. The proposed project is intended to facilitate improvements to PVT's operations, and to provide adequate capacity to accept future construction and demolition (C&D) waste generated on O‘ahu. The key components of the proposed action include 1) relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations; 2) upgrading its recycling operations by installing two materials recovery and diversion (MRD) process lines; and 3) installation of renewable energy facilities (one 1000-kilowatt hour [kWh] enclosed gasification unit or anaerobic digestion system and approximately 7 acres of photovoltaic [PV] panels) to power PVT operations. Approximately 75 acres of the 179-acre project site are proposed to be lined for development and operation of a C&D waste landfill. An area of approximately 10 acres at the north end of the project site would accommodate process lines MRD-2 and MRD-3, which are to be developed and operated to increase the processing capacity and minimize landfilling recyclable materials. The gasification unit or anaerobic digestion system would also be located in the MRD area of the project site.
Project Acreage	The current project area includes approximately 179 acres (72.4 hectares).
Document Purpose	This CIA was prepared to comply with the State of Hawai‘i's environmental review process under Hawai‘i Revised Statutes (HRS) Chapter 343, which requires consideration of the proposed project's

	potential effect on cultural beliefs, practices, and resources. Through document research and cultural consultation efforts, this report provides information compiled to date pertinent to the assessment of the proposed project’s potential impacts to cultural beliefs, practices, and resources (pursuant to the Office of Environmental Quality Control’s *Guidelines for Assessing Cultural Impacts*) which may include traditional cultural properties (TCPs). These TCPs may be significant historic properties under State of Hawai‘i significance Criterion e, pursuant to Hawai‘i Administrative Rules (HAR) §13-275-6 and §13-284-6. Significance Criterion e refers to historic properties that “have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity” (HAR §13-275-6 and §13-284-6). The document will likely also support the project’s historic preservation review under HRS §6E and HAR §13-284. The document is intended to support the project’s environmental review and may also serve to support the project’s historic preservation review under HRS §6E-8 and HAR §13-284.
Results of Background Research	Background research for this project yielded the following results (presented in approximate chronological order): 1. Lualualei is the largest leeward valley on O‘ahu. Composed of approximately 14,000 acres, Lualualei extends from the Wai‘anae Range to the ocean. To the south is the *ahupua‘a* (traditional land division usually extending from the mountain to the sea) of Nānākuli and to the north is the *ahupua‘a* of Wai‘anae. Its southern border includes a portion of Pu‘u Heleakalā, and its northern boundary includes a portion of Pu‘u Pāhe‘ehe‘e. 2. Wai‘anae Moku (district) consists of ten *ahupua‘a*: Nānākuli, Lualualei, Wai‘anae Kai, Wai‘anae Uka, Mākaha, Kea‘au, ‘Ōhikilolo, Mākua, Kahanahāiki, and Keawa‘ula. 3. The Hawaiian Islands began exporting sandalwood to Asia shortly after 1800 and the commerce flourished until the supply dwindled in the mid-1830s. Lualualei was a region of importance in the sandalwood trade. The demands put on the *maka‘āinana* to harvest wood for trade caused many agricultural fields to become fallow and unused. 4. At the time of the Māhele, the *ahupua‘a* of Wai‘anae, which included Lualualei, was listed as Crown lands and was claimed by King Kamehameha III as his personal property (Board of Commissioners 1929:28).

	5. Thirteen land claims were made in Lualualei; however, only seven were actually awarded. Most awards were located upland in the *‘ili* (land division smaller than an *ahupua‘a*) of Pūhāwai, approximately 6.5 km northwest of the current project area. From the claims, it can be determined that at least eight families were living in Pūhāwai at the time of the Māhele in 1848. Together, they cultivated a minimum of 163 *lo‘i* (irrigated terraces). The numerous *lo‘i* mentioned in the claims indicate the land was ideal for growing wetland taro and that this livelihood was actively pursued by the awardees. 6. One of the first areas to be utilized for ranching on the Wai‘anae coast was Lualualei. Hawai‘i Bureau of Land Conveyances [B.C.] 1845-1869 (archived at the DLNR) records show William Jarrett leased approximately 17,000 acres of land from Kamehameha III in 1851. This was the beginning of Lualualei Ranch. 7. Hermann A. Widemann was a jack-of-all-trades who dabbled in politics and business (Dorrance and Morgan 2000:43). Widemann had financial backing from Hackfeld & Company as well as George N. Wilcox, a reputable sugar planter from Kaua‘i. In 1879, Widemann leased Wai‘anae Kai for 25 years (McGrath et al.1973:37). Widemann hired 20 Hawaiian workers, 15 *haole* (foreign) technicians, and 60 Chinese laborers. He also built 24 new homes in Wai‘anae to house his employees. 8. In 1901, the Waianae Sugar Company leased 3,332 acres in Lualualei for raising cane as well as for ranching (Commissioner of Crown Lands 1902). Amfac, Inc. purchased the plantation and closed it down in 1947. 9. Land tenure in Lualualei includes Māhele Awards in 1848 and Land Commission Awards in the 1850s; Hawaiian Homelands designations in 1921; U.S. Navy use beginning in 1930 and 1933; and most recently in 1995, the State of Hawai‘i and the U.S. government have been involved in the land ownership changes in Lualualei. 10. During the first half of the twentieth century, another major influence in Lualualei Ahupua‘a was the military. By 1929, over 8,184 acres of the McCandless Cattle Ranch had been condemned and purchased by the U.S. Navy for the construction of a Naval Ammunition Depot for the ships based at Pearl Harbor Naval Base. Extensive evidence of traditional Hawaiian activity is largely confined to the *makai* (seaward) sections of the *ahupua‘a*, immediately adjacent to the ocean. In contrast to the abundance of traditional Hawaiian features known to exist in the *mauka* (inland) half of Lualualei, the

	surface historic properties recorded in the central section of Lualualei Valley, within the region where the current project area is located, were either post-Contact or of equivalent origin. The lack of traditional Hawaiian sites in Lualualei *waena* (central) may reflect not only the distortions of modern disturbances (including bulldozing, farming, and ranching) but also a general disuse during pre-Contact times. Population and activity in Lualualei may have been primarily focused in a narrow band along the coast and farther inland in the *mauka* reaches of this large valley. At the beginning of the twentieth century, Lualualei lands in and around the project area were opened for homesteading. However, due to the lack of water, the lots were classified as second-class pastoral land rather than agricultural land. Simultaneoulsy, the United States federal government expanded its sphere of influence within Lualualei Ahupua‘a, gaining control of the lands surrounding the current project area.
Results of Community Consultation	CSH attempted to contact NHOs, agencies, and community members as well as cultural and lineal descendants in order to identify individuals with cultural expertise and/or knowledge of the project area and vicinity. Community outreach letters were sent to 132 individuals or groups. To date, nine have responded, and one *kupuna* (elder) has submitted written testimony. One community member, representing MA‘O Organic Farms, participated in a formal, sit-down interview. Below is a list of individuals who have shared their *mana‘o* (opinions) and *‘ike* (knowledge) about the project area and Lualualei Ahupua‘a: 1. Shad Kāne, member of the Kapolei Hawaiian Civic Club, Chair of the O‘ahu Council of Hawaiian Civic Clubs Committee on the Preservation of Historic Sites and Cultural Properties, Ali‘i Ai Moku of the Kapuāiwa Chapter of the Royal Order of Kamehameha Ekahi, and ‘Ewa Moku Representative on the State Aha Moku Advisory Committee 2. Kukui Maunakea-Forth, *kama‘āina* (native-born) of Nānākuli and co-founder of MA‘O Organic Farms Community members did not identify specific traditional cultural practices, either past or ongoing, within the project area. As a consequence, CSH was unable to identify evidence of ongoing traditional cultural practices at the project area. Community members also did not identify specific traditional, cultural resources, apart from SIHP #s -6699 and -6920, as existing within the project area. However, interviewees did indicate a potential for subsurface cultural deposits within the project area. Additionally, one *kama‘āina* interviewee articulated a concern about potential impacts to agricultural activity and the environmental welfare of the community. It should be noted that MA‘O Organic Farms intends to expand their agricultural activity within a 236-acre parcel immediately north of the project area.

Impacts and Recommendations	No traditional cultural practices were identified within the project area. Although the proposed project is not anticipated to impact traditional cultural practices in the vicinity of the project area, potential impacts were identified and the following preliminary recommendations made: 1. Impact: Three historic properties were identified within the project area. State Inventory of Historic Places (SIHP) # 50-80-08-6681, a military bunker, was previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places under Criteria A (property reflects major trends or events in the history of the state or nation) and D (historic property has yielded or may be likely to yield information important in prehistory or history) by O'Leary and McDermott (2006). SIHP #s -6699, a rock shelter, and -6920, a rock mound, were previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places solely under Criterion D by O'Leary and McDermott (2006) and Hammermeister and McDermott (2007), respectively. Recommendation: No further historic preservation work has been recommended for SIHP #s -6681 and -6920 (Hammermeister and McDermott 2007). However, due to the proximity of SIHP # -6699 to the project area, it was recommended that interim protection measures be installed to ensure no construction activities adversely affect the historic property. CSH prepared a preservation plan (Tulchin and Hammatt 2007) to protect the historic property from construction activity. The preservation plan recommended demarcation of an 8-m (26-foot [ft]) buffer zone surrounding the historic property for protection from construction activity. The suggested buffer zone would be established using a 35-m (115-ft) long steel post and wire or chain link fence. Additionally, natural vegetation will not be cleared from the historic property, further obscuring the rock shelter's location as an additional means of protection. 2. Impact: It is necessary to note that certain types of historic properties and cultural sites are difficult to recognize by pedestrian survey alone. It is possible subsurface cultural deposits (i.e., *iwi kūpuna* [ancestral remains], *pōhaku* [stones] suitable for traditional construction) may yet exist, and may be encountered during ground disturbing activities. While no human burials have been identified by previous archaeological studies within the project area, historical research indicates that *heiau* (pre-Christian place of worship) of the *po‘okanaka* class (McAllister 1933:110, Thrum 1908:47, Westervelt 1915a:122, Westervelt 1915b:178), were present within Lualualei

	Ahupua‘a. There are also numerous accounts associating upland areas with battles and mortal combat (Sterling and Summers 1978:67). LCA documentation, however, indicates that settlements (and potentially burial sites) were confined to the upland *‘ili* (land section) of Pūhāwai, northwest of the current project area. Recommendation: It is recommended that project construction workers and all other personnel involved in the construction and related activities of the project should be informed of the possibility of inadvertent cultural finds, including human remains. In the event that any potential historic properties are inadvertently discovered within the project area, these discoveries should be reported immediately to the State Historic Preservation Division (SHPD). In the event that *iwi kūpuna* and/or cultural finds are encountered, consultation with lineal and cultural descendants of the area is also recommended. 3. Impact: Interviewee Kukui Maunakea-Forth voiced a concern about potential impacts to cultural resources, practices, and beliefs. Future practices to occur in the vicinity of the project area will include farming. No specific cultural beliefs were identified in connection to the project area, however, brief discussion of the *piko* concept, as well as the cultural associations of Māui and Hina did occur. Mrs. Maunakea-Forth identified potential cultural resources within the vicinity of the proposed project area. These resources include ephemeral ponds and streams, historic *lo‘i kalo* (taro terraces; located on the southeastern side of Ulehawa Stream), Ulehawa Stream, and *pōhaku*. According to Kukui Maunakea-Forth, these *pōhaku* contain a unique quality that makes them suitable for stone masonry work, Additionally, Kukui Maunakea-Forth identified culturally significant sites or *wahi pana* in the vicinity of the project area. These sites include Pu‘u Heleakalā and Ka ‘Ōlae (the 236-acre parcel recently acquired by MA‘O Organic Farms). Recommendation: Currently, Ulehawa Stream and its associated historic *lo‘i kalo* exist outside the current project area. Due to the ephemerality of the ponds and streams, it is difficult to ascertain the full extent of potential impact. It is recommended that a qualified professional provide an assessment of the potential for ephemeral fresh water resources within and near the project area. Additionally, view corridors protecting views of *wahi pana* such as Pu‘u Heleakalā must remain unobstructed.

	4. Impact: There is a concern that the proposed action will have an adverse impact on farming activity to occur immediately north of the project area. Although current farming activity includes the cultivation of both traditional and non-traditional crops, the practice itself is considered to have historical antecedence within Lualualei. Currently, MA‘O Organic Farms produces approximately 75 tons of food every year, and distributes this food to over 26 different restaurants and markets on O‘ahu. Farmers employed through MA‘O are primarily young *kama‘āina* from throughout Wai‘anae Moku; cultivated crops gathered by these farmers (crops that are not distributed to restaurants and markets) are also kept for personal consumption. The availability of crops is especially vital to the health and wellness of farmers and their *‘ohana* (families). Due to understandings of farming as an articulation of Hawaiian identity and manifestation of culture, agricultural activity in the vicinity of the project area may be understood to represent a cultural practice. Recommendation: It is recommended that an environmental scientist or similar qualified professional provide an assessment of the impacts of the proposed action to the surrounding environment and community. Such an assessment will address concerns for potential impacts to future agricultural activity occurring north of the project area. Should stakeholders (i.e., *mahi‘ai* (farmers) and/or community members) observe changes in crop quality or impacts to the environmental welfare of the community, the landowner and/or developer should remain amenable to engaging in *ho‘oponopono* (conflict resolution) to either avoid or minimize impacts or to provide compensatory mitigation.

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Section 1 Introduction

1.1 Project Background

At the request of the PVT Land Company, Ltd. (PVT), Cultural Surveys Hawai‘i, Inc. (CSH) is conducting a cultural impact assessment (CIA) for the proposed PVT Integrated Solid Waste Management Facility Relocation project, Wai‘anae Distict, O‘ahu, TMK: [1] 8-7-009:007. The total project area consists of approximately 179 acres located on a privately owned, vacant parcel adjacent to the PVT Integrated Solid Waste Management Facility (ISWMF). The project site is accessed by Lualualei Naval Road. The project area is depicted on a portion of the 1998 Waianae and Schofield Barracks U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle (Figure 1), a tax map plat (Figure 2), and a 2013 aerial photograph (Figure 3).

The PVT proposes improvements to its operations to provide adequate landfill capacity to accept future construction and demolition (C&D) waste generated on O‘ahu. The key components of the proposed action include relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations; relocation, modernization, and enhancement of recycling operations (e.g., installation of two materials recovery and diversion [MRD] process lines); and installation of renewable energy facilities to power PVT operations (e.g., one 1000-kilowatt hour [kWh] gasification unit or anaerobic digestion system and approximately 7 acres of photovoltaic [PV] panels).

Approximately 75 acres of the 179-acre project site are proposed to be lined for development and operation of a C&D waste landfill. An area of approximately 10 acres at the north end of the project site would accommodate process lines MRD-2 and MRD-3, which are to be developed and operated to increase the processing capacity and minimize landfilling of recyclable materials. The gasification unit or anaerobic digestion system would also be located in the MRD area of the project site.

1.2 Document Purpose

This cultural impact assessment was prepared to comply with the State of Hawai‘i’s environmental review process under Hawai‘i Revised Statutes (HRS) Chapter 343, which requires consideration of the proposed project’s potential effect on cultural beliefs, practices, and resources. Through document research, this report provides information compiled to date pertinent to the assessment of the proposed project’s potential impacts to cultural beliefs, practices, and resources (pursuant to the Office of Environmental Quality Control’s *Guidelines for Assessing Cultural Impacts*) which may include traditional cultural properties (TCPs). These TCPs may be significant historic properties under State of Hawai‘i significance Criterion e, pursuant to Hawai‘i Administrative Rules (HAR) §13-275-6 and §13-284-6. Significance Criterion e refers to historic properties that “have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group’s history and cultural identity” (HAR §13-275-6 and §13-284-6). The document will likely also support the project’s historic preservation review under HRS §6E and HAR §13-284. The document is also intended to support the project’s environmental review.

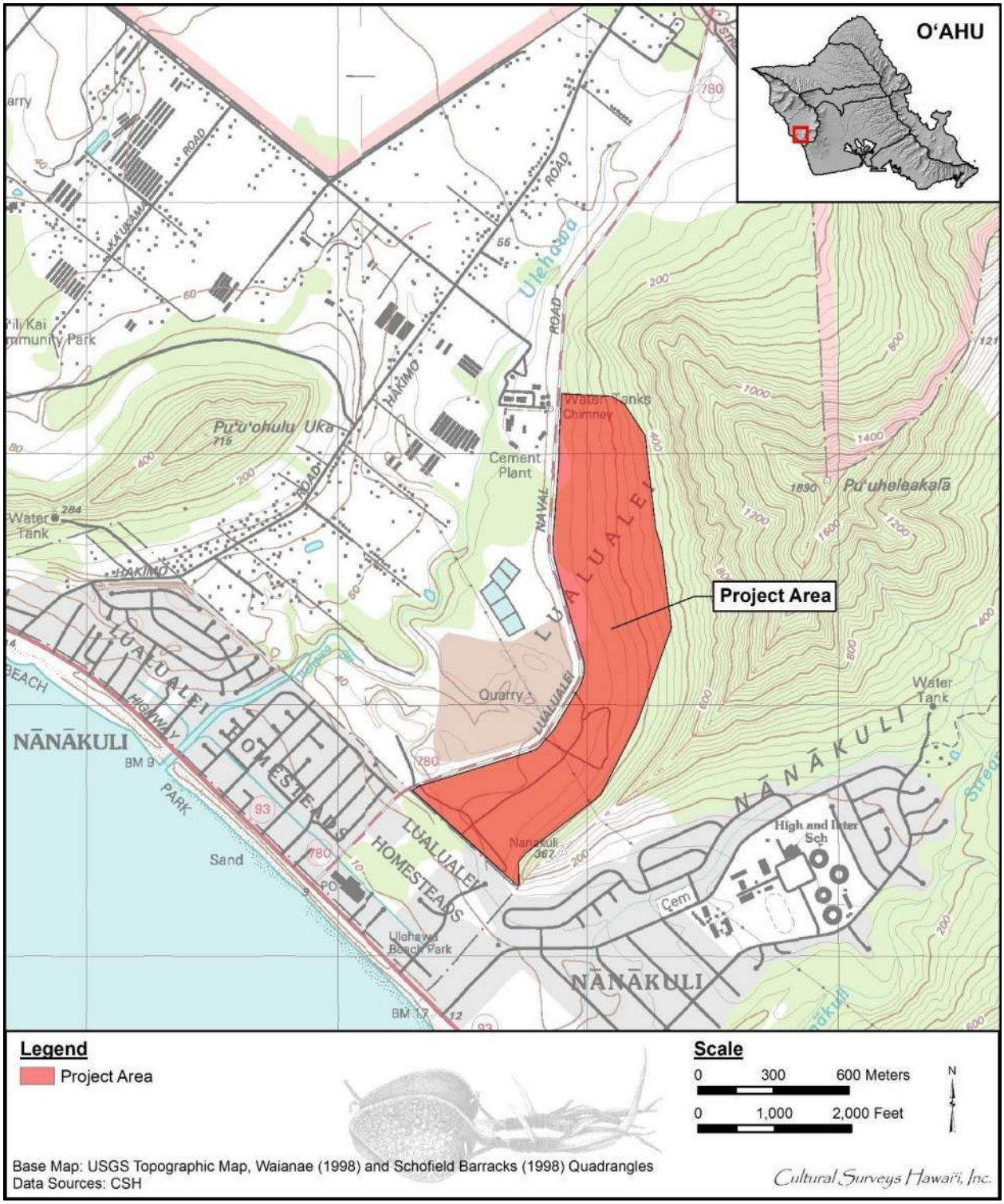

Figure 1. Portion of the 1998 Waianae and Schofield Barracks USGS topographic quadrangles showing the location of the project area

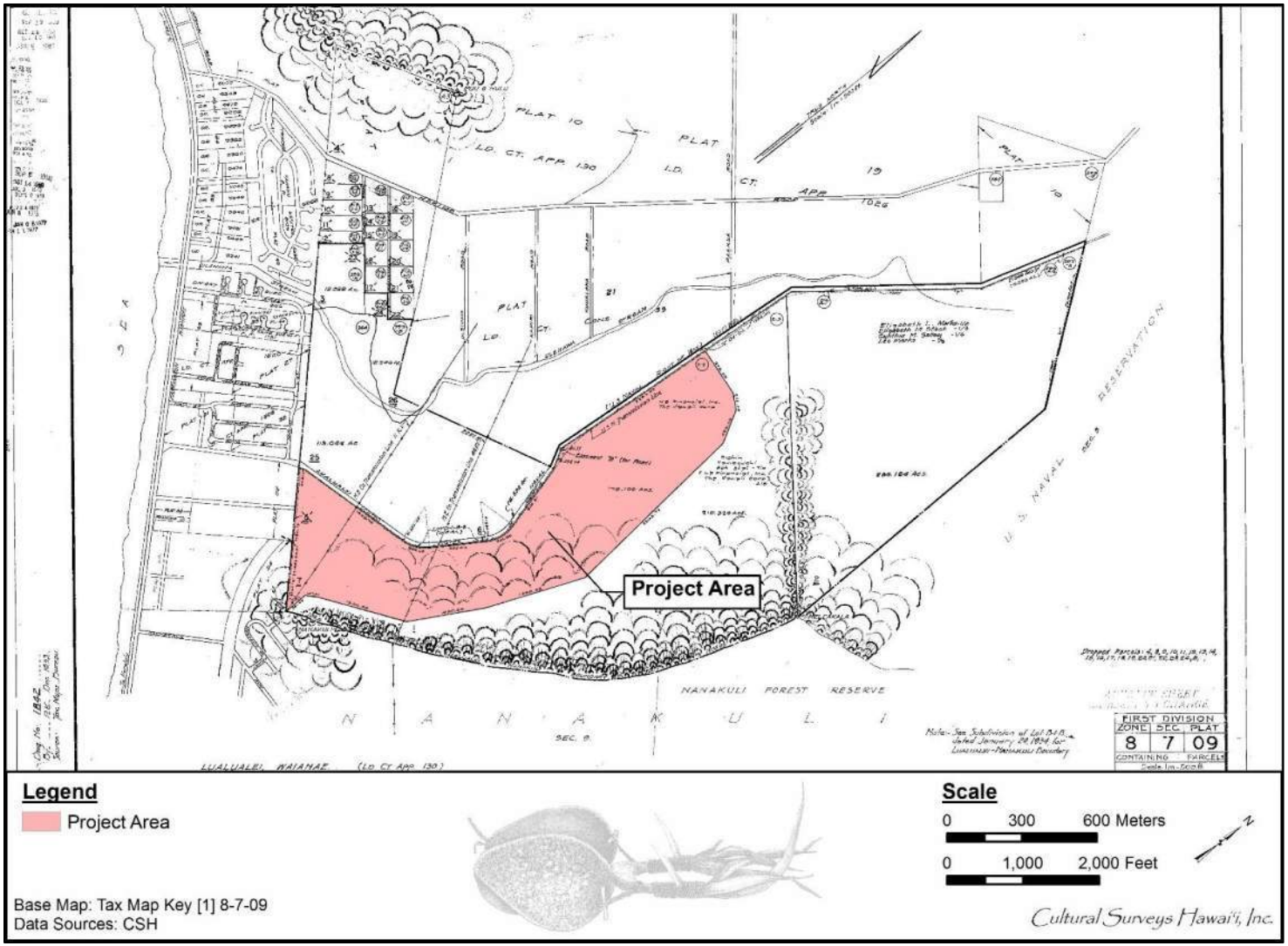

Figure 2. Tax Map Key (TMK) [1] 8-7-09 showing the project area (Hawai‘i TMK Service 2014)

Figure 3. Aerial photograph of the project area (Google Earth 2013)

1.3 Scope of Work

The scope of work for this cultural impact assessment includes the following:

1. Examination of cultural and historical resources, including Land Commission documents, historic maps, and previous research reports, with the specific purpose of identifying traditional Hawaiian activities including gathering of plant, animal, and other resources or agricultural pursuits as may be indicated in the historic record.
2. Review of previous archaeological work at and near the subject parcel that may be relevant to reconstructions of traditional land use activities; and to the identification and description of cultural resources, practices, and beliefs associated with the parcel.
3. Consultation and interviews with knowledgeable parties regarding cultural and natural resources and practices at or near the parcel; present and past uses of the parcel; and/or other practices, uses, or traditions associated with the parcel and environs.
4. Preparation of a report that summarizes the results of these research activities and provides recommendations based on findings.

1.4 Environmental Setting

1.4.1 Natural Environment

Lualualei is the largest leeward valley on O‘ahu. Composed of approximately 14,000 acres, Lualualei extends from the Wai‘anae Range to the ocean. To the south is the *ahupua‘a* (traditional land division) of Nānākuli and to the north is the *ahupua‘a* of Wai‘anae. Its southern border includes a portion of Pu‘u Heleakalā, and its northern boundary includes a portion of Pu‘u Pāhe‘ehe‘e. Lualualei is the largest valley in the Wai‘anae Moku (district) consisting of interior areas including Ulehawa, Hālona, Pāhoa, Mā‘ili, and Pūhāwai. Lualualei Ahupua‘a is bordered by Wai‘anae Ahupua‘a to the west and Nānākuli Ahupua‘a to the east. There are two traditional meanings given to the name Lualualei. Lualualei Valley, like the other valleys in the Wai‘anae District, is characterized by its dry leeward climate. The prevailing winds in the area are the northeast trades that blow over the Ko‘olau mountains, then continue over the Wai‘anae Range and over the southwest portion of the island (Juvik and Juvik 1998:55). This wind pattern is responsible for the relatively low rainfall averages on the leeward side of the island. The winds cause the rain to hit the Ko‘olau Range, releasing most of their moisture there before continuing over the Wai‘anae Range and releasing what moisture may be left (Abbott et al. 1983:224).

1.4.2 *Ka Lepo* (Soils)

Fertile soils are abundant in most of the upper valleys in Wai‘anae. Soil quality in the lower valleys varies based on its location in relation to streams. According to the U.S. Department of Agriculture (USDA) Soil Survey Geographic (SSURGO) database (2001) and soil survey data gathered by Foote et al. (1972), soils within the project area primarily consists of Lualualei extremely stony clay 3 to 35% slopes (LPE). The southwestern corner of the project area is Mamala stony silty clay loam (MnC), 0-12% slope with some Lualualei clay 2 to 6% slopes (LuB) in the very north corner of the project area along Lualualei Naval Road. Figure 4 illustrates the various soil sediments within the vicinity of the project area.

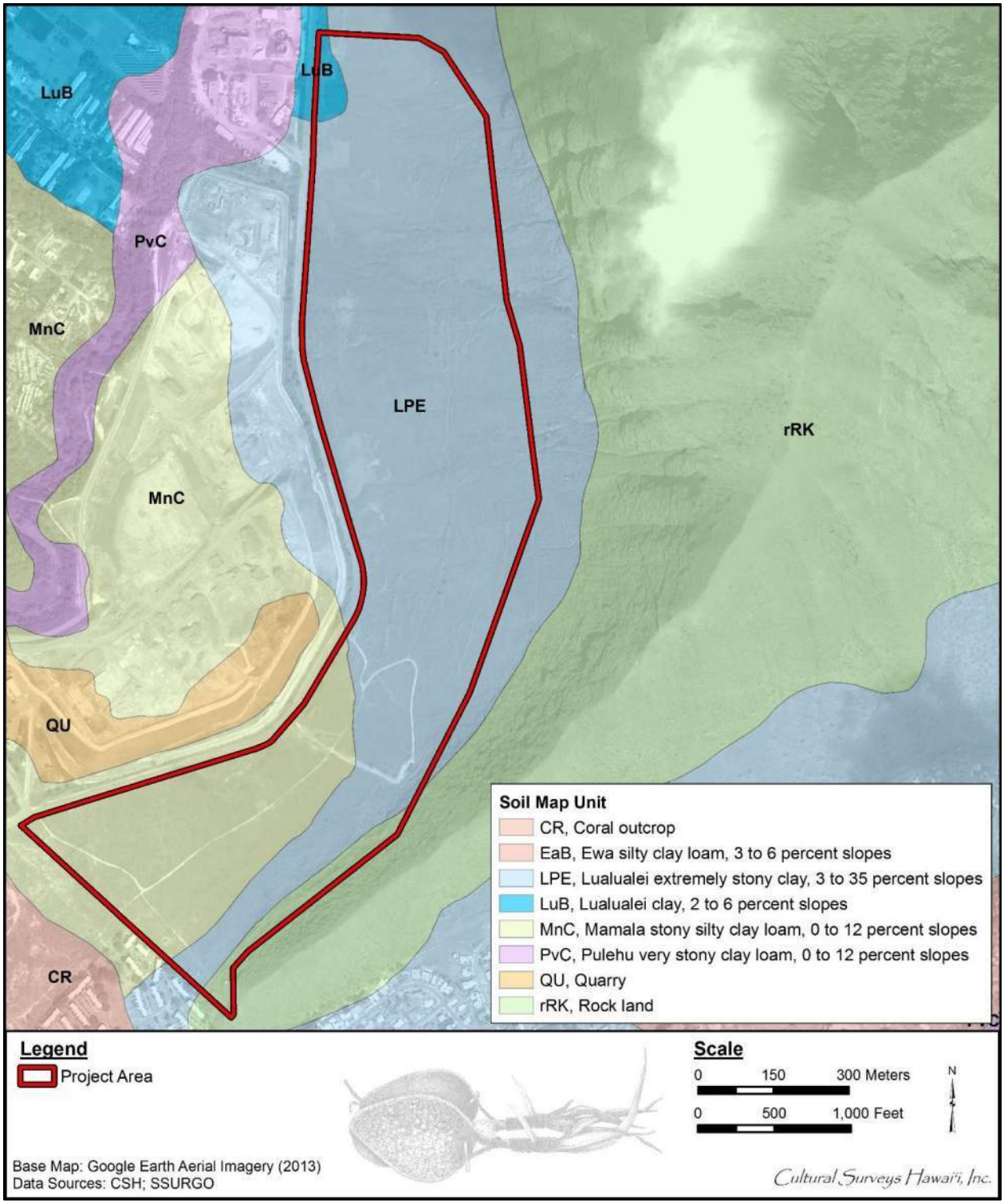

Figure 4. 2013 aerial photograph (Google Earth 2013) with an overlay of the USDA SSURGO database (2001) and soil survey gathered by Foote et al. (1972)

Soils of the Lualualei series are described as follows:

> This series consists of well-drained soils on the coastal plains, alluvial fans, and on 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. […] These soils are used for sugarcane, truck crops, pasture, wildlife habitat, urban development, and military installations. The natural vegetation consists of kiawe, koa haole, bristly foxtail, uhaloa, and fingergrass. [Foote et al. 1972:84]

Soils of the Mamala series are described as follows:

> This series consists of shallow, well-drained soils along the coastal plains on the islands of Oahu and Kauai. These soils formed in alluvium deposited over coral limestone and consolidated calcareous sand. They are nearly level to moderately sloping. Elevations range from nearly sea level to 100 feet on Oahu but extend to 850 feet on Kauai. […] These soils are used for sugarcane, truck crops, orchards, and pasture. The natural vegetation consists of kiawe, koa haole, bristly foxtail, and swollen fingergrass. [Foote et al. 1972:93]

Rock Land is described as follows:

> Rock land (rRK) 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 are mainly basalt and andesite. […] Rock land is used for pasture, wildlife habitat, and water supply. The natural vegetation at the lower elevations consists mainly of kiawe, klu, pili grass, Japanese tea, and koa haole. [Foote et al. 1972:119]

1.4.3 *Ka Makani* (Winds)

Northeasterly trade winds prevail throughout the year, although their frequency varies from 80 to 95% of the time during the summer months, when high-pressure systems tend to be located north and east of Hawai‘i. During the winter months, the high pressure systems are located farther to the south, decreasing the occurrence of the trade winds to about 50 to 80% of the time (WRCC 2010).

Winds were recognized by their characteristic differences and each were named in such a way as to describe the direction, locale, or velocity. *The Wind Gourd of La‘amaomao* tells the story of Pāka‘a and his son Kuāpāka‘a, descendants of the wind goddess La‘amaomao. They are able to control the winds of Hawai‘i which are contained in a gourd and may be called forth by chanting their names. Pāka‘a’s chant traces the winds of O‘ahu in the *moku* of Wai‘anae.

He Kaiaulu ko Waianae,	Kaiāulu is of Wai‘anae,
He Kumumaomao ko Kamaile,	Kumuma‘oma‘o is of Kamaile,
He Kumaipo ko Kualele,	Kumaipo is of Kualele,
He Kopiliehu ko Olopua,	Kopiliehu is of Olopua,
Hulilua na makani o Kaena . . .	The wind of Ka‘ena turns in two directions . . .
[Nakuina 1904:57]	[Nakuina 1992:51]

Pukui and Elbert (1986:299) also mention the Pahelehala (*lit.* pandanus ensnarement) and Pakaiea (Pukui and Elbert 1986:304) winds associated with Wai‘anae.

1.4.4 *Ka Ua* (Rains)

Based on data from the *Rainfall Atlas of Hawai‘i*, the mean annual rainfall around the project area is less than 20 inches (Giambelluca et al. 1986:138). The majority of precipitation occurs during the rainy season, October-April, and less precipitation occurs between May-September. Lower valleys typically receive 20 inches or less of rain per year while upper valleys receive 30-40 inches of rain per year, with some areas, including parts in the upper valleys of Wai‘anae and Makaha, receiving over 40 inches of rain (Cordy 2002a:6).

Similar to the naming of winds, rains were named to show their action on plants or the supposed effects on people or their possessions (Pukui and Elbert 1986:361). Due to the dry conditions of Wai‘anae, not many sources reference particular rains of Lualualei, however, the following sections lists rains in the broader region of Wai‘anae.

1.4.4.1 *Ka Ua Ki‘owao* (Cool Mountain Rain Accompanied by Wind and Fog)

This rain is mentioned briefly in a chant and is associated with Ka‘au in the upper regions of Wai‘anae (Akana and Gonzalez 2015:86):

Ke ‘ū ala ka ua Ki‘owao	The Ki‘owao rain groans
Wai ka nahele o Ka‘au	The forest of Ka‘au is watery
[Akana and Gonzalez 2015:86]	

1.4.4.2 *Ka Ua Nāulu* (Sudden Shower)

The Nāulu rain, associated with many places in Hawai‘i, is also directly linked to Wai‘anae. The follow section is taken from a *mele inoa* or name chant for Kaiona.

Kāhiko i ka pua ko‘olau	Bedecked with the ko‘olau bloom
He ‘ohu kapu no ka wahine	A sacred adornment for the woman
I kui ‘ia mai e Li‘a	Strung into a lei by Li‘a
Ka wahine noho i ka Ulumano	The woman who resides in the Ulumano wind
No Kaiona noho i ka la‘i	For Kaiona who dwells in the calm
O ka ua Nāulu i ke kula	Of the Nāulu rain over the plains
[Akana and Gonzalez 2015:198]	

1.4.5 *Ka Wai* (Water)

1.4.5.1 *Ke Kahawai* (Streams)

According to Juvik and Juvik (1998:90) perennial streams are not found in leeward O‘ahu. Examination of the Schofield Barracks and Wai‘anae USGS quadrangles shows Ulehawa Stream, northwest of the project area, as the closest intermittent stream. Nānākuli Stream is the closest intermittent stream to the southeast.

Ulehawa Stream winds down the valley floor of the *ahupua‘a* in a southwesterly direction before emptying into the ocean. Pu‘u Heleakalā creates a division in the water system, where an intermittent stream pours away from the project area down the southeasterly slope of the mountain and flows into the Nānākuli stream system. Another stream is the Mā‘ili‘ili Stream, an intermittent stream which rises at about 2,000 feet (ft) elevation under Pu‘u Hāpapa, and flows to the sea. Another stream is mentioned in the Land Commission Claims where the water would have originated from Pūhāwai Spring.

The project area is located within the Commission of Water Resource Management (CWRM) Lualualei Aquifer System Area located in the Wai‘anae Aquifer Sector. Lualualei Aquifer System Area has a sustainable yield of 4 million gallons per day. Wai‘anae Aquifer Sector has a sustainable yield of 16 million gallons per day (CWRM 2008).

1.4.5.2 *Ka Punawai me ka Luawai* (Springs and Wells)

Seeps and springs were also present, “emerging from the base of the ridges from dikes and from soil layers between old lava flows.” Seeps and springs occur in most of the upper valleys. Wai‘anae Valley had “30 such springs in the 1,000-2,000 ft elevation” (Cordy 2002a:8–9).

There were eight springs in Lualualei Valley according to geologist Harold Stearns and artesian well engineer Knute N. Vaksvik (1935). The largest one was located in the “northwest corner of the valley at an altitude of 1,630 ft. and is used by the United States Navy” (Stearns and Vaksik 1935:438). The southernmost one, Pōhākea Spring, is at a lower altitude than the other seven. But the most productive spring was Pūhāwai. In the claims for *lo‘i* (irrigated terrace), several *kuleana* (Native land right) parcels included the term *kahawai* (stream). And undoubtedly, the one referred to in these claims was fed by Pūhāwai Spring (Kelly 1991:38).

Besides natural springs, there were approximately 60 wells in Lualualei but the majority are now unused, a few have been lost and some are used for irrigation (Townscape 2009: D3-D14).

1.4.5.3 *Ka Lihikai me ka Moana* (Seashore and Ocean)

The *makai* (seaward) region provided a variety of fish and ocean invertebrates for consumption. Traditionally, the seashore and ocean areas were vitally important for resource extraction in the early days of settlement. Fishermen along the coast maintained a respected status within traditional Hawaiian society; Kanahele asserts that “early Hawaiians regarded fishing as the oldest, and hence the most prestigious of professions” (Kanahele 1995:17). Coastal portions of Lualualei Ahupua‘a are described in depth below.

1.4.5.3.1 Ulehawa Beach Park

Ulehawa Beach Park spans from Ulehawa Stream on the south to Ma‘ipalaoa Stream to the north (Clark 1977:84). Pukui translates Ulehawa as “filthy penis” (Pukui et al. 1974:214–215). Pukui also states that Ulehawa was said to be the birthplace of the demigod Māui and to have been named for a chief (Pukui et al. 1974:215; Sterling and Summers 1978:64). The beach park takes its name from Ulehawa Stream, which empties into the ocean. The beach is considerably long; however, one area frequented most often is centered around a comfort station known as Aupaka. The sandy pocket of beach is between a limestone point on the east and a reef shelf on the west (Clark 1977:85). During the summer months, the area is relatively calm. However, during winter the beach disappears. The freshwater from Ulehawa Stream has created a relatively smooth shelf

compared to the surfaces of the remainder of the area. The Pu‘u o Hulu Kai section of Ulehawa is rocky and no recreational swimming is possible. The area is ideal for fishing and many pole fishermen can be found in this area. A concrete marker on the point warns fishermen of the dangerous, rocky conditions. In 1935, these markers were constructed by the Honolulu Japanese Casting Club (Clark 1977:85). The original markers were printed in Japanese with the word “danger” on both sides and placed at actual spots where fishermen were lost at sea. Pu‘u o Hulu was known to Japanese fishermen as *obake* or ghosts, from a feeling that the area was haunted.

1.4.5.3.2 Mā‘ili Beach Park

Mā‘ili Beach Park is long stretch of shoreline extending from Ma‘ipalaoa Stream to Mā‘ili‘ili Stream. Mā‘ili is a contracted form of the word *mā‘ili‘ili* (“lots of little pebbles”). *‘Ili‘ili* (pebbles) were used for many purposes such as net sinkers, percussion instruments for dances and chanting, as a filler for the construction of house and religious sites, and as jacks by children for the game of *kimo* (a game similar to jacks) (Clark 1977:85). Many residents argue about the name because no *‘ili‘ili* were in fact ever found in this area. The most popular swimming area is in front of the wide sand beach next to the mouth of Mā‘ili‘ili Stream. Surfers once frequented the area for a choice surf spot. However, the construction of a jetty in 1966 to improve the stream channel has affected the break (Clark 1977:86).

1.4.5.3.3 Lualualei Beach Park

Lualualei Beach Park extends from Kalaeokakao to Kāne‘īlio Point. The park is primarily used by picnickers and fishermen. Recreational swimming is almost impossible, due to the entire park being fronted by low cliffs and raised coral reefs. The widest and most popular section of Lualualei Beach Park was once known as Kalaeokakao or “the point of the goats” (Clark 1977:86–87). During the 1800s, numerous wild goats roamed the area. Goats were originally introduced by Captain Cook in 1778. Captain Vancouver brought additional animals to Hawai‘i in 1792. Originally the animals were protected by the *kapu* (taboo, prohibited). Eventually they multiplied so rapidly they began to run rampant, destroying cultivated lands, native plants, watersheds, and forest areas (Clark 1977:87). It became necessary to kill off the introduced animals, resulting in large, organized hunts.

1.4.6 Built Environment

Currently, the project site consists of open land mostly covered by low-growing grasses, shrubs, and trees. The property is largely undeveloped apart from some unpaved roads/paths, two non-potable brackish water industrial supply wells, one PVT groundwater monitoring well, and two 25,000-gallon storage tanks, which are used to supply operational water to the existing ISWMF operation.

There has been substantial ground disturbance within the project area some time in the past. Evidence of past bulldozer activity observed by field personnel within the project area included pushed up mounds of dirt and raised berms and banks (O’Leary and McDermott 2006). Several of these appear to have been cut into the hill in order to channel water run off or could possibly be the eroded remnants of unimproved road segments. It is not possible to tell when the bulldozing took place, but almost all of the moved earth has extensive grass growth. Numerous basalt boulders throughout the property have bulldozer scars on them, indicating that their current location is due to modern activities.

The only other non-natural objects on the landscape are a few scattered rusty barrels, two stripped and rusted out cars and numerous abandoned rusting appliances that have been dumped into the tall *koa haole* along Lualualei Naval Road in the southern end of the project area.

Vegetation along this arid coast is sparse. With 20 inches or less of rain annually, only the hardiest plants adapted to the coastal environments can thrive in these zones. The vegetation is typical of dry seashore environments in Hawai‘i and is dominated by alien species. Indigenous species include *hau* (*Hibiscus tiliaceous*), *koa* (*Cordia subcordata*), *kamani* (*Calophyllum inophyllum*), *naupaka* or *naupaka kahakai* (*Scaevola sericea*), *pa‘u o Hi‘iaka* (*Jacquemontia ovalifolia sandwicensis*), the native beach morning glory or *pōhuehue* (*Ipomea pes-caprae*) and the coconut *niu* (*Cocos nucifera*). Introduced species found bordering Farrington Highway include sea grape (*Coccoloba uvifera*), *kiawe* trees (*Prosopis pallida*), Madagascar olive trees (*Noronhia emarginata*), and *koa haole* (*Leucaena leucocephala*) (Foote et al. 1972:93).

Section 2 Methods

2.1 Archival Research

Research centers on Hawaiian activities including *ka‘ao* (legends), *wahi pana* (storied places), *‘ōlelo no‘eau* (proverbs), *oli* (chants), *mele* (songs), traditional *mo‘olelo* (stories), traditional subsistence and gathering methods, ritual and ceremonial practices, and more. Background research focuses on land transformation, development, and population changes beginning with the early post-Contact era to the present day.

Cultural documents, primary and secondary cultural and historical sources, historic maps, and photographs were reviewed for information pertaining to the study area. Research was primarily conducted at the CSH library. Other archives and libraries including the Hawai‘i State Archives, the Bishop Museum Archives, the University of Hawai‘i at Mānoa’s Hamilton Library, Ulukau, The Hawaiian Electronic Library (Ulukau 2014), the State Historic Preservation Division (SHPD) Library, the State of Hawai‘i Land Survey Division, the Hawaiian Historical Society, and the Hawaiian Mission Houses Historic Site and Archives are also repositories where CSH cultural researchers gather information. Information on Land Commission Awards (LCAs) were accessed via Waihona ‘Aina Corporation’s Māhele database (Waihona ‘Aina 2000), the Office of Hawaiian Affairs (OHA) Papakilo Database (Office of Hawaiian Affairs 2015), and the Ava Konohiki Ancestral Visions of ‘Āina website (Ava Konohiki 2015).

2.2 Community Consultation

2.2.1 Scoping for Participants

We begin our consultation efforts with utilizing our previous contact list to facilitate the interview process. We then review an in-house database of *kūpuna* (elders), *kama‘āina* (native born), cultural practitioners, lineal and cultural descendants, Native Hawaiian Organizations (NHOs; includes Hawaiian Civic Clubs and those listed on the Department of Interior’s NHO list), and community groups. We also contact agencies such as SHPD, OHA, and the appropriate Island Burial Council where the proposed project is located for their response on the project and to identify lineal and cultural descendants, individuals, and/or NHO with cultural expertise and/or knowledge of the study area. CSH is also open to referrals and new contacts.

2.2.2 “Talk Story” Sessions

Prior to the interview, CSH cultural researchers explain the role of a CIA, how the consent process works, the project purpose, the intent of the study, and how their *‘ike* (knowledge) and *mana‘o* (thought, opinion) will be used in the report. The interviewee is given an Authorization and Release Form to read and sign.

“Talk Story” sessions range from the formal (e.g., sit down and *kūkākūkā* [consultation, discussion] in participant’s choice of place over set interview questions) to the informal (e.g., hiking to cultural sites near the study area and asking questions based on findings during the field outing). In some cases, interviews are recorded and transcribed later.

CSH also conducts group interviews, which range in size. Group interviews usually begin with set, formal questions. As the group interview progresses, questions are based on interviewees’

answers. Group interviews are always transcribed and notes taken. Recorded interviews assist the cultural researcher in 1) conveying accurate information for interview summaries, 2) reducing misinterpretation, and 3) missing details to *mo‘olelo*.

CSH seeks *kōkua* (assistance) and guidance on identifying past and current traditional cultural practices of the study area. Those aspects include general history of the *ahupua‘a*; past and present land use of the study area; knowledge of cultural sites (for example, *wahi pana*, archaeological sites, and burials); knowledge of traditional gathering practices (past and present) within the study area; cultural associations (*ka‘ao* and *mo‘olelo*); referrals; and any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the study area.

2.2.3 Completion of Interview

After an interview, CSH cultural researchers transcribe and create an interview summary based on information provided by the interviewee. Cultural researchers give a copy of the transcription and interview summary to the interviewee for review and ask to make any necessary edits. Once the interviewee has made those edits, we incorporate their *‘ike* and *mana‘o* into the report. When the draft report is submitted to the client, cultural researchers then prepare a finalized packet of the participant’s transcription, interview summary, and any photos taken during the interview. We also include a thank you card and honoraria. This is for the interviewee’s records.

It is important to CSH cultural researchers to cultivate and maintain community relationships. The CIA report may be completed, but CSH researchers continuously keep in touch with the community and interviewees throughout the year—such as checking in to say hello via email or by phone, volunteering with past interviewees on community service projects, and sending holiday cards to them and their *‘ohana* (family). CSH researchers feel this is an important component in building relationships and being part of an *‘ohana* and community.

“*I ulu no ka lālā i ke kumu*—the branches grow because of the trunk,” an *‘ōlelo no‘eau* (#1261) shared by Mary Kawena Pukui with the simple explanation: “Without our ancestors we would not be here” (Pukui 1983:137). As cultural researchers, we often lose our *kūpuna* but we do not lose their wisdom and words. We routinely check obituaries and gather information from other informants if we have lost our *kūpuna*. CSH makes it a point to reach out to the *‘ohana* of our fallen *kūpuna* and pay our respects including sending all past transcriptions, interview summaries, and photos for families to have on file for genealogical and historical reference.

Section 3 *Ka‘ao* and *Mo‘olelo*

Hawaiian storytellers of old were greatly honored; they were a major source of entertainment and their stories contained lessons while interweaving elements of Hawaiian lifestyles, genealogy, history, relationships, arts, and the natural environment (Pukui and Green 1995:IX). According to Pukui and Green (1995), storytelling is better heard than read for much becomes lost in the transfer from the spoken to the written word and *ka‘ao* (legends) are often full of *kaona* or double meanings.

Ka‘ao are defined by Pukui and Elbert (1986:108) as a "legend, tale […], romance, [and/or], fiction." *Ka‘ao* may be thought of as oral literature or legends, often fictional or mythic in origin, and have been "consciously composed to tickle the fancy rather than to inform the mind as to supposed events" (Beckwith 1970:1). Conversely, Pukui and Elbert (1986:254) define *mo‘olelo* as a "story, tale, myth, history, [and/or] tradition." The *mo‘olelo* are generally traditional stories about the gods, historic figures or stories that cover historic events and locate the events with known places. *Mo‘olelo* are often intimately connected to a tangible place or space.

In differentiating *ka‘ao* and *mo‘olelo* it may be useful to think of *ka‘ao* as expressly delving into the *wao akua* (realm of the gods), discussing the exploits of *akua* (gods) in a primordial time. *Mo‘olelo* on the other hand, reference a host of characters from *ali‘i* (chiefs) to *akua; kupua* (supernatural beings) to *maka‘āinana* (commoners); and discuss their varied and complex interactions within the *wao kānaka* (realm of man). Beckwith elaborates, "In reality, the distinction between *ka‘ao* as fiction and *mo‘olelo* as fact cannot be pressed too closely. It is rather in the intention than in the fact" (Beckwith 1970:1). Thus a so-called *mo‘olelo*, which may be enlivened by fantastic adventures of *kupua*, "nevertheless corresponds with the Hawaiian view of the relation between nature and man" (Beckwith 1970:1).

Both *ka‘ao* and *mo‘olelo* provide important insight into a specific geographical area, adding to a rich fabric of traditional knowledge. The preservation and passing on of these stories through oration remains a highly valued tradition. Additionally, oral traditions associated with the study area communicate the intrinsic value and meaning of a place, specifically its meaning to both *kama‘āina* as well as others who also value that place.

The following background sections of this study present a broad review of traditional and historical accounts concerning the general area in order to ascertain the specific history of the land within the study area boundaries. Many relate an age of mythical characters whose epic adventures inadvertently lead to the Hawaiian race of *ali‘i* (chiefs) and *maka‘āinana* (commoners). The *ka‘ao* in and around the project area shared below are some of the oldest Hawaiian stories that have survived; they still speak to the characteristics and environment of the area and its people.

3.1 *Ka‘ao*

3.1.1 The Naming of Lualualei

There are two suggestions for meanings of the name Lualualei. One meaning, "flexible wreath," is attributed to a battle formation used by Mā‘ilikūkahi, an *ali‘i kapu* (sacred chief) born at Kukaniloko, Wahiawā around the fourteenth century AD (Pukui et al. 1974:113). This formation was used against four invading armies in the battle of Kīpapa in the early fifteenth century (Sterling

and Summers 1978:68). A second, and perhaps more recent meaning, offered by John Papa ‘Ī‘ī, is “beloved one spared.” This meaning relates to the story of an individual suspected of wearing the king’s *malo* (loincloth). The punishment was death by fire. ‘Ī‘ī writes the following:

> The company, somewhat in the nature of prisoners, spent a night at Lualualei near the fish pond on the plain. The next day they reached the southern side of Kanepuniu, and there they encamped for eight days to await an announcement concerning the death and burning of the wrongdoers. Finally, a proclamation from the king was given by Kaulainamoku, stating that there would be no deaths, for Kalakua had not worn the king’s malo. Thus was the Luluka family spared a cruel fate. A child born in the family later was named Lualualei. [‘Ī‘ī 1959:23]

Mary Kawena Pukui believed the first meaning, “flexible wreath,” to be the more appropriate one for Lualualei (Sterling and Summers 1978:63). A third association of the name Lualualei is an older reference to one of Māui’s sisters, who went by the same name (McGuire and Hammatt 1999:82–83).

3.1.2 Māuiakalana

Numerous traditional accounts of Lualualei focus on mythology of the demi-god Māui. Legends of Māui extend to Micronesia and Melanesia (Luomala 1949:3) but Māui is best known for his mischievous tricks and supernatural powers throughout Polynesia. W.D. Westervelt (1910:vii) writes that “Māui legends form one of the strongest links in the mythological chain of evidence which binds the scattered inhabitants of the Pacific into one nation.” Throughout Polynesia, there are many similarities with only slight variations when discussing Māui’s adventures. Westervelt explains the origin of the meaning of the name Māui:

> The meaning of the word is by no means clear. It may mean ‘to live,’ ‘to subsist.’ It may refer to beauty and strength, or it may have the idea of ‘the left hand’ or ‘turning aside.’ The word is recognized as belonging to remote Polynesian antiquity.
>
> MacDonald, a writer of the New Hebrides Islands, gives the derivation of the name Maui primarily from the Arabic word ‘Mohyi,’ which means ‘causing to live’ or ‘life,’ applied sometimes to the gods and sometimes to chiefs as ‘preservers and sustainers’ of their followers.
>
> The Maui story probably contains a larger number of unique and ancient myths than that of any other legendary character in the mythology of any nation. [Westervelt 1910:vi]

Numerous Hawaiian legends, in addition to archaeological evidence, reveal the Wai‘anae coast and *mauka* (inland, toward the mountains) interior to be an important center of Hawaiian history. It is here in Wai‘anae that the famous exploits of Māuiakalana (Māui) are said to have originated. Ulehawa was the birthplace of Māui and the origin of the Māui legends (Pukui at al. 1974:215). It was in Lualualei that Māui learned the secret of fire-making and perfected his fishing skills. Other famous accounts tell of the place where Māui’s adzes were made and of his magic fishhook, Manaiakalani. Pu‘u Heleakalā is the ridge that separates Nānākuli from Lualualei. It was at Pu‘u Heleakalā where Hina, Māui’s mother, lived in a cave and made her *kapa* (tapa) (Sterling and Summers 1978:62).

3.1.2.1 Māui Genealogy

The Hawaiian concept of genealogy and kinship is a crucial structure for piecing together the similarities in Hawaiian stories. Kamakau (1991) outlines the ‘Ulu genealogy as it leads down to Māui-akalana, the legendary Hawaiian trickster whose exploits are recorded in one of the oldest genealogical and cosmogonic chants, the Kumulipo. In the fifteenth epoch of the Kumulipo, Māui, the youngest of four sons, is born to Akalana and Hinaakeahi. In the sequence of Hawaiian genealogies, Māui is associated with the line of ‘Ulu and the sons of Ki‘i (Westervelt 1910:4). Kamakau articulates the same kinship chart following seven generations of fathers that stretch back to Nana‘ie and his marriage to Kahaumokule‘ia, leading down to the marriage of Hina-kawea and chief Akalana and their four offspring, all with the name Māui: Māui-mua, Māui-waena, Māui-ki‘iki‘i, and Māui-akalana (Kamakau 1991:135). Māui-akalana is the Māui whose stories fill legendary accounts on the island of O‘ahu. From Kamakau’s reading, it’s stated that there are four sons named Māui born to Hina. This is an important concept to understand as each of the four main Hawaiian Islands may have had their very own Māui and each would have been a descendant of Hina with a distinct *wahi pana* associated with them.

Samuel Kamakau tells us that Māui’s genealogy can be traced from the ‘Ulu line through Nana‘ie:

> Nana‘ie lived with Kahaumokule‘ia at Wai‘alua, and Nanaialani, a male was born;
> Nanaialani lived with Hina-kinau, and Waikūlani, a male, was born;
> Waikūlani lived with Kekauilani, and Kūheleimoana, a male, was born;
> Kūheleimoana lived with Mapunaia‘a‘ala, and Konohiki, a male was born;
> Konohiki lived with Hīka‘ululena, and Wawana, a male, was born;
> Wawena lived with Hina-mahuia, and Akalana, a male, was born;
> Akalana lived with Hina-kawea, and Māui-mua, Māui-waena, Māui-ki‘iki‘i, and Māui-akalana, all males, were born. [Kamakau 1991:135]

Furthermore, Kamakau notes that after the birth of his children in Hawai‘i, Māui-akalana went to Kahiki. His children would later become the ancestors of Polynesia (Kamakau 1991:135).

3.1.2.2 Māui Learns the Secret of Fire

According to Pukui, Ulehawa was the birthplace and origin of Māui legends (Pukui et al. 1974:215). It was here in Lualualei that Māui learned the secret of making fire:

> Maui’s first feat is getting fire from the mud hens while they are roasting bananas. Hina teaches him to catch the littlest one. He finds them at Waianae on Oahu. Each time he approaches they scratch out the fire. When he finally succeeds in seizing the littlest mud hen she tries to put him off by naming first the taro stalk, then the ti leaf as the secret of fire. That is why these leaves have hallows today, because Maui rubbed them to try to get fire. At last the mud hen tells him that fire is in the water (wai), meaning the tree called ‘sacred water’ (wai-mea), and shows how to obtain it. So, Maui gets fire, but he first rubs a red streak on the mud hen’s head out of revenge for her trickery before letting the bird escape. [Beckwith 1970:229–230]

3.1.2.3 Māui Catching the Sun

In another legend, Māui slowed the speed of the sun so that his mother, Hina, could finishing pounding and drying her *kapa* before the sun would set:

> He went to the hill Hele-a-ka-la, which means ‘journey of the sun.’ He thought he would catch the sun and make it move slowly. He went up the hill and waited. When the sun began to rise, Maui made himself long, stretching up toward the sky. Soon the shining legs of the sun came up the hillside. He saw Maui and began to run swiftly, but Maui reached out and caught one of the legs, saying: ‘O sun, I will kill you. You are a mischief maker. You make trouble for Hina by going so fast.’ Then he broke the shining leg of the sun. The sufferer said, ‘I will change my way and go slowly—six months slow and six months faster.’ Thus arose the saying, ‘Long shall be the daily journey of the sun and he shall give light for all the people's toil.’ Hina learned that she could pound until she was tired while the farmers could plant and take care of their fields. Thus also this hill received its name Hele-a-ka-la. This is one of the hills of Waianae near the precipice of the hill Puu-ohulu. [Westervelt 1910:122–123]

3.1.2.4 Māui’s Flying Expedition

Māui seeks his grandfather who designs for him a flying apparatus in the shape of a bird. Māui flies to the mythical land of Moanaliha to rescue his wife who had been taken by Pe‘ape‘a-maka-walu (Eight-eyed bat):

> One day Maui and his brothers went fishing again in the sea of Ulehawa. They each let down their hooks but caught only sharks. Maui then let down his famous hook, ma-nai-a-ka-lani and caught a moi and ulua. Maui then gave the order to paddle to shore where he took the fishing tackle gourd and hokeo (his paddle) to his mother Hina. The fish he took to the heiau Luaehu because he had to eat it there.
>
> He began to eat the fish from the head and had reached almost to the tail when he looked towards Pohakea and saw the chief Pea-pea-maka-walu (eight eyed Pea-pea) carrying off his wife Kumu-lama. He left the tail of the fish and pursued Pea-pea. Unable to overtake Pea-pea who had disappeared into the sky beyond the sea he returned mourning to the heiau, where he had left the fish tail, but it had disappeared.
>
> Weeping he returned to his mother Hina who told him to rest first and then to go to the land of Ke-ahu-moa where he would find Ku-olo-kele his grandfather who would further instruct him as to how to recover his wife.
>
> Maui went as directed, not finding his grandfather in the hut he looked in the potato field on the other side of Pohakea but saw no one. Then from a hill he saw coming toward Waipahu a man ‘with a load of potato leaves, one pack of which it is said would cover the whole land of Keahumoa’. When this man, Kuolokele, reached the stream he layed down his bundle and Maui seeing he was hunch backed picked up a stone and threw it at him. The stone hit the old man on the back and immediately his back was straightened. He then picked up the stone and threw it on Waipahu where it is to this day.

> Kuolokele picked up his bundle and went to meet Maui. When they arrived at the hut he asked Maui his errand and on being told he directed Maui to go and catch birds for feathers and gather ki leaves and ie ie vine and fill the house which was near by.
>
> After doing this Kuolokele then told Maui to go home but to return in three days. While Maui was gone Kuolokele fashioned a bird out of the materials gathered by Maui. When Maui returned his grandfather bid him enter this ‘moku-manu’ (bird ship) and gave him the following instructions. Maui must go to the land of Moanaliha which was Pea-pea’s land. There he would find a village and the inhabitants would be down on the beach. Among them would be Pea-pea and Maui’s wife.
>
> Maui was to attract their attention and then fly way out over the ocean. As he returned towards the group Pea-pea will say, ‘Perhaps that is my bird and if so he will fly to and rest on the sacred box.’
>
> Maui listened to his instructions and then flew for two days and two nights until he reached the land of Moanaliha. He did as he was told and when Pea-pea exclaimed about the bird Maui flew to the sacred box and rested there. The chief then returned to the village and commanded the bird to be brought to his sleeping house and fed. This was done and then all retired. But Maui had to wait for Pea-pea’s eyes to close one by one. Since it was almost dawn he called on Hina to hold back the night for a little while. This done Pea-pea’s 8 eyes were finally all closed in sleep. Maui was then able to kill Pea-pea. He cut off Pea-pea’s head and taking this and his wife flew back to his grandfather where they all feasted and rejoiced. [Sterling and Summers 1978:65]

3.1.2.5 Māui and Manai-a-ka-lani

At the sea of Ulehawa, Māui attempted to join the Hawaiian Islands using his magical fishhook, Manai-a-ka-lani:

> Maui-ku-pua lived with his mother Hina. He often wondered why the islands were separated and decided to try and join them. He consulted his mother who sent him to Kaa-lae-nui-a-hina (k). Kaa-lae told him the power to do so belonged to Uniho-kahi who is found at Po-naha-ke-one (a fishing station at Ule-hawa).
>
> Maui returned home and next day told his mother he was going fishing. Maui asked his brothers to go with him and they made ready their fishing gear. Maui got ready his famous hook ma-nai-a-ka-lani. Maui told his brothers to watch for a kaliu (bailer) floating at the bow of the canoe and to catch it. They sailed to the middle of the sea of Ulehawa and Maui took bearings from Hina’s place of drying her kapas. There they saw the kaliu and Maui told his brother Maui-mua to catch it. His brother thinking there was no need for one as the canoe already had one did not do so, so Maui caught it as it floated by him.
>
> The name of this bailer was Hina-a-ke-ka. When the brothers turned around they saw a beautiful woman in the back of the canoe. They all sailed on to Ponahakeone and anchored but when the brothers looked around again the woman was gone.

> Maui knew the bailer (the woman) had dropped into the sea. He called to his brothers to drop a hook to the bottom of the ocean but each time they caught only a fish. Maui then dropped manaiakalani and told his brothers to prepare to paddle. The hook was grasped by Hina-a-ke-ka who took it to Unihokahi. She asked him to open his mouth so she could see if he had one tooth or many. When he did so, she hooked in manaiakalani and jerked the line so Maui would know.
>
> Maui then commanded his brothers to paddle hard but not to look back. Finally becoming exhausted and thinking that it was not a fish they had hooked, they gave up and looked back. They saw the chain of islands following and were surprised. Maui was angry because they didn’t reach shore and the islands were never joined. The hook was loosened from Unihokahi’s mouth and the islands separated and drifted back to their original positions. [Sterling and Summers 1978:65]

3.1.3 Kahalaopuna at Pōhākea Pass

One of the most popular legends of O‘ahu is that of Kahalaopuna (or Kaha) a young woman of Mānoa who is slandered by others and is then killed by her betrothed, Kauhi, a chief from Ko‘olau, O‘ahu. While the numerous accounts (Day 1906:1–11, Fornander 1919:5:188–193, Kalākaua 1888:511–522, Nakuina 1904:41–45, Patton 1932:41–49, Skinner 1971:220–223, Thrum 1907:118–132) vary in details they typically have Kahalaopuna slain and then revived repeatedly with the aid of a protective owl spirit. Kauhi forces her to hike west from Mānoa through the uplands until they get to Pōhākea Pass (just northeast of the project area) through the southern Wai‘anae Range in north Honouliuli. At Pōhākea Pass, Kauhi beats her with a stick until she is dead (“*Ia hahau ana a Kauhi i ka lā‘au, make loa o Kahalaopuna*”). Her spirit (*‘uhane*) flies up into a *lehua* tree and chants for someone to go notify her parents of her fate. Upon hearing the news, her parents fetch Kahalaopuna back to Mānoa and she is restored to life.

3.1.4 Twin Sisters Legend

Northwest of Pu‘u Heleakalā is Pu‘u o Hulu Kai, the hill nearest the ocean which rises to 860 ft in elevation. It is connected to Pu‘u o Hulu Uka by a saddle which drops down to 284 ft in elevation and Pu‘u Mā‘ili‘ili and Pu‘u Pāhe‘ehe‘e are northwest of Pu‘u Hulu. According to legend,

> Pu‘u o Hulu was said to be a chief who was in love with Ma‘ili‘ilii, one of twin sisters, but he could never tell, whenever he saw them, which of the two was his beloved. A *mo‘o* changed them all into mountains so he is still there watching and trying to distinguish his loved one. [V. Holt in Sterling and Summers 1978:67]

3.1.5 The Epic Tale of Hi‘iakaikapoliopele

In *The Epic Tale of Hi‘iakaikapoliopele*, the fire goddess Pele sends her youngest sister, Hi‘iakaikapoliopele, to fetch her lover, Lohi‘au, the *ali‘i* of Kaua‘i, and bring him to her in Hawai‘i. She travels with companions across the islands to find Lohi‘au. In one section of the story, Hi‘iaka and her *aikāne* (close companion), Wahine‘ōma‘o, are looking for a canoe to sail to Kaua‘i. She requests a canoe from her brothers, Kalaeoka‘ena and Pōhakuokaua‘i, so her party can sail from Ka‘ena Point across Moanawaikaio‘o, the sea between O‘ahu and Kaua‘i.

> *Aia i kēlā wahi lā, ‘o ia ho‘i kēlā lae e moe a‘ela, ‘o ka lae ia ‘o Ka‘ena. Huli ma kēlā ‘ao‘ao, ‘o Wai‘anae ia i ka wehe lau niu o ke Kaiāulu, a ‘o kēia huli nō ho‘i*

ma ‘ane‘i nei, ‘o Waialua nō ia i ka ‘ehu kai o Pua‘ena. ‘O kēia moe kīpāpali e kū nei, ‘o Leinahonua ia; aia a hō‘ea aku kāua i kēlā āhua pōhaku e kū maila, ‘o ia kōā ma lalo iho, ‘o leina ia a ka ‘uhane. ‘O Leinahonua ka luna, ‘o Leina‘uhane ko lalo. ‘O kēia moana kai e waiho mai nei, ‘o Moanawaikaio‘o ia. Ua hele nei moana a pā i Kahiki Kū a pā nō ho‘i i Kahiki Moe. Aia a hō‘ea aku kākou i ka lae, ma laila kākou e holo aku ai no Kaua‘i. No laila, e nonoi a‘e au i nā kaikunāne o kākou i wa‘a no kākou e halo ai i Kaua‘i. [Ho‘oulumāhiehie 2008b:175]

Translation:

That point stretching out to there is Ka‘ena. Along the other side is Wai‘anae, where the Kaiāulu breeze stirs the palm fronds, this side here being Waialua, in the sea out there is Ka‘ena. This low rise here is Leinahonua; when we reach that stone mound, the gap underneath it is the leaping place of the spirits. Leinahonua is the upper section, Leina‘uhane is below. This sea here is Moanawaikaio‘o. This sea reaches to Kahiki Ku and to Kahiki Moe. When we reach the point, that is where we will depart for Kauai. So I shall ask our brothers for a canoe for us to sail there. [Ho‘oulumāhiehie 2008a:164]

When Hi‘iaka arrives in Kaua‘i, she learns that Lohi‘au has died. After resurrecting Lohi‘au, Hi‘iaka and Lohi‘au go surfing in Moanawaikeo‘o. While surfing Lohi‘au regains his physical strength.

Eia kāua i ke kai o Hawai‘i nei i kapa ‘ia ‘o Moanawaikeo‘o. ‘O ka hele kēia o nei kai a hō‘ei i O‘ahu, a ne‘e a hō‘ea i Kūkulu o Kahiki Kū, popo‘i i Kahiki Moe. ‘O ko kāua kūlana nalu kēia. No laila, e mākaukau ‘oe, e ke kāne, ua kū ka nalu, ke mahiki mai nei ‘o Ka‘ōnohiokalā. [Ho‘oulumāhiehie 2008b:233]

Translation:

Of the Hawaiian seas, this one we have entered is called Moanawaikeo‘o. This sea stretches out to O‘ahu, reaches the Pillars of Kahiki Kū, and breaks at Kahiki Moe. This is where we will surf. So get ready, husband, for the wave is rising and Ka‘ōnohiokalā, the orb of the sun, is breaking free of the horizon. [Ho‘oulumāhiehie 2008a:218]

When Lohi‘au’s health is restored, he announces to his people that he will be leaving Kaua‘i with Hi‘aka to journey “over the crashing billows of Moanawaikeo‘o” on their voyage to Hawai‘i.

A eia ka ‘ōlelo a ‘oukou e ho‘olohe mai ai i ku‘u alaka‘i nei lā, ku‘u makamaka o kēlā wahi makamaka ‘ole paha auane‘i a‘u e ‘au aku ai i kēia mau kai ‘ewalu, i nā ‘ale huli lua o Moanawaikeo‘o, a hō‘ea i nā kai kuehu o Maui mā a hō‘ea i Hawai‘i. [Ho‘oulumāhiehie 2008b:245]

Translation:

And now, here is a statement, which you should all heed, from my guide here, my friend of what may be a friendless place, where I shall journey across these eight seas, over the clashing billows of Moanawaikeo‘o, to the tempestuous seas of Maui’s isles and on to Hawaii‘i. [Ho‘oulumāhiehie 2008a:230]

Hi‘iaka meets Kaulanaokalā, a traveler who is looking for an answer to a riddle. Kaulanaokalā has travelled to each island but has not yet found the answer. If he fails to answer the riddle, he will be punished by death. Hi‘iaka sends her *kūkini* (trained runners) to fetch some *manini* (*Acanthurus triostegus;* Surgeonfish) from a small pond on the face of Ka‘ena. The fishpond had "all the kinds of ocean fishes, with the exception of the big fishes of Moanawaikeo‘o." Hi‘iaka uses the *manini* to explain the answer of the riddle to Kaulanaokalā.

> *‘Ae, he wahi loko i‘a nō, aia i kea lo o nā pali o Ka‘ane,’ i pane mai ai ke ali‘i wahine o Mākua me ka ho‘omau ‘ana mai ho‘i i ke kama‘ilio ‘ana, ‘Aia i loko o kēia wahi loko i‘a nā ‘ano i‘a a pau o ka moana, koe aku na‘e nā i‘a nunui o Moanawaikeo‘o. (‘O ia kēlā moana kai ma ka ‘ākau o Waialua a hō‘ea i ka lae o Kahuku – Mea Kākau.)* [Ho‘oulumāhiehie 2008b:271]

Translation:

> Yes, there is a small pond, right on the face of the cliffs of Ka‘ena,’ she replied, then went on to say, ‘In this little pond are all of the kinds of ocean fishes, with the exception of the big fishes of Moanawaikeo‘o. (That sea extends from the north of Waialua to Kahuku Point – AUTHOR.) [Ho‘oulumāhiehie 2008a:254]

3.2 Wahi Pana

Wahi pana are legendary or storied places of an area. These legendary or storied places may include a variety of natural or human-made structures. Oftentimes dating to the pre-Contact period, most *wahi pana* are in some way connected to a particular *mo‘olelo*, however, a *wahi pana* may exist without a connection to any particular story. Davianna McGregor outlines the types of natural and human-made structures that may constitute *wahi pana*:

> Natural places have mana, and are sacred because of the presence of the gods, the akua, and the ancestral guardian spirits, the ‘aumakua. Human-made structures for the Hawaiian religion and family religious practices are also sacred. These structures and places include temples, and shrines, or heiau, for war, peace, agriculture, fishing, healing, and the like; pu‘uhonua, places of refuge and sanctuaries for healing and rebirth; agricultural sites and sites of food production such as the lo‘i pond fields and terraces slopes, ‘auwai irrigation ditches, and the fishponds; and special function sites such as trails, salt pans, holua slides, quarries, petroglyphs, gaming sites, and canoe landings. [McGregor 1996:22]

As McGregor makes clear, *wahi pana* can refer to natural geographic locations such as streams, peaks, rock formations, ridges, offshore islands and reefs, or they can refer to Hawaiian land divisions such as *ahupua‘a* or *‘ili* (land division smaller than an *ahupua‘a*), and man-made structures such as fishponds. In this way, the *wahi pana* of Lualualei tangibly link the *kama‘āina* of Lualualei to their past. It is common for places and landscape features to have multiple names, some of which may only be known to certain *‘ohana* or even certain individuals within an *‘ohana*, and many have been lost, forgotten or kept secret through time. Place names also convey *kaona* (hidden meanings) and *huna* (secret) information that may even have political or subversive undertones. Before the introduction of writing to the Hawaiian Islands, cultural information was exclusively preserved and perpetuated orally. Hawaiians gave names to literally everything in their environment, including individual garden plots and *‘auwai* (water courses), house sites, intangible

phenomena such as meteorological and atmospheric effects, *pōhaku* (rock, stone), *pūnāwai* (freshwater springs), and many others. According to Landgraf (1994), Hawaiian *wahi pana* “physically and poetically describes an area while revealing its historical or legendary significance” (Landgraf 1994:v).

The earliest documented research in Lualualei Ahupua‘a was completed by J. Gilbert McAllister (1933) during his survey of O‘ahu. Elspeth P. Sterling and Catherine C. Summers (1978) expanded McAllister’s survey by collecting additional testimonies and archival sources. Below is a compilation of McAllister and Sterling and Summers’ findings. In instances where McAllister and Sterling and Summers do not provide information, a short description is given by Pukui et al. (1974). Figure 5 shows place names of some of the *wahi pana* found within Lualualei.

3.2.1 *Pu‘u* (Hills and Peaks)

3.2.1.1 Pu‘u Heleakalā

Pu‘u Heleakalā is a hill separating Nānākuli and Lualualei Ahupua‘a. The barren *pu‘u* is sometimes called Haleakalā, which Pukui felt was wrong. Pukui translated the words as *hele* (“to snare”), *a* (“belonging to”), and *kalā* (“the sun”) (Sterling and Summers 1978:62). Together, Heleakalā means, “Snare by the sun.” Pukui goes on to define Heleakalā: “This hill faces right into the setting sun and reference is made as to this place being ‘where the sun’s rays are broken.’” Pu‘u Heleakalā is the location where Hina, Māui’s mother, lived in a cave and made her *kapa* (Sterling and Summers 1978:62). An account published in the Hawaiian newspaper, *Kuokoa*, by a *kama‘āina* named Poepoe read: “I saw the cave in which Hina [Maui’s mother] made kapa cloths on the slope of a hill facing a stream [Ulehawa]” (Cordy 2002:91, translation from Sterling and Summers 1978). Figure 6 and Figure 7 depict Hina’s Cave and the view from the cave, respectively.

3.2.1.2 Pu‘u Mā‘ili‘ili

Pu‘u Mā‘ili‘ili is a hill and stream located in Lualualei Ahupua‘a. Pu‘u Mā‘ili‘ili literally translates to “pebbly” (Pukui et al. 1974:139).

3.2.1.3 Palikea

Palikea is a peak located on the borders of Honouliuli, Nānākuli, and Lualualei Ahupua‘a. The peak has an elevation of 3,098 ft. Palikea literally translates to “white cliff” (Pukui et al. 1974:177).

3.2.1.4 Pu‘u Kaua

Pu‘u Kaua is a peak on the Wai‘anae Mountain Range on the Lualualei and Honouliuli Ahupua‘a border. The peak has an elevation of 3,127 ft. Pu‘u Kaua literally translates to “war hill” or “fort hill” (Pukui et al. 1974:199).

3.2.1.5 Pu‘u Kānehoa

Pu‘u Kānehoa is a peak located on the border of Lualualei and Honouliuli Ahupua‘a. The peak has an elevation of 2,728 ft. Pu‘u Kānehoa was named for native shrubs (Pukui et al. 1974:198). The native shrubs and trees include all species and varieties of *pūkiawe* or *maiele* (*Styphelia* [Cyathodes]) and grow to a height of 1-2 m. They consist of narrow leaves, tiny white flowers, and red or white fruits. The leaves were used in the practice of *lā‘au lapa‘au* (Hawaiian healing

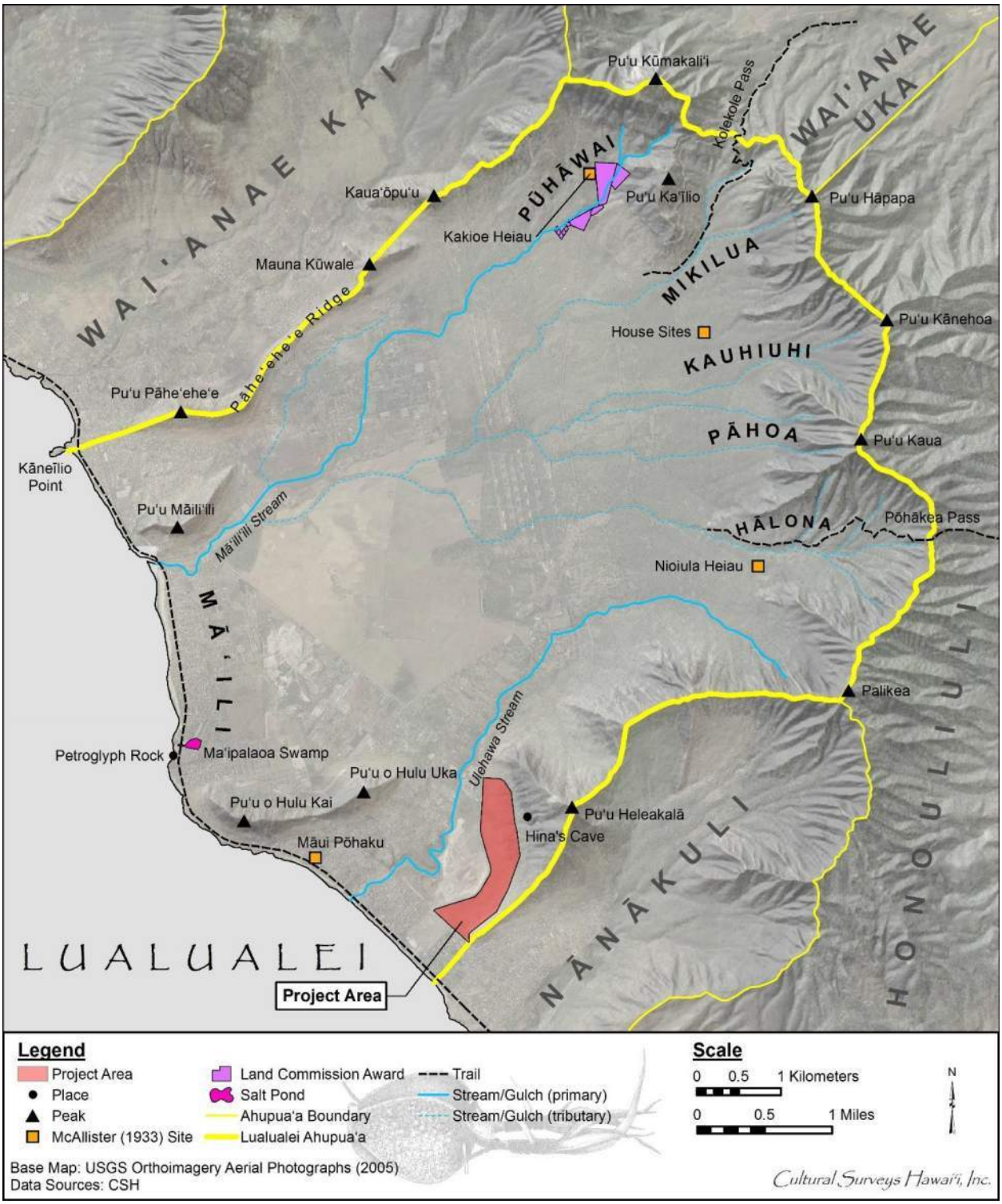

Figure 5. 2005 USGS Orthoimagery aerial photographs depicting *wahi pana*, McAllister sites, LCAs, *loko*, trails, streams, and gulches

Figure 6. Photo of Hina’s Cave located within Pu‘u Heleakalā (CSH 2015)

Figure 7. View of Lualualei Ahupua‘a from Hina’s Cave; note Pu‘u o Hulu Kai in the background (CSH 2015)

medicine) for colds or headaches. A small enclosure said to be a *heiau* (pre-Christian place of worship) is located in a gulch at the foot of Pu‘u Kānehoa (Sterling and Summers 1978:32).

3.2.1.6 Pu‘u Hāpapa

Pu‘u Hāpapa is located on the border of the Honouliuli, Wahiawā, and Wai‘anae districts (Sterling and Summers 1978). Hāpapa literally translates to “rock stratum” (Pukui et al. 1974:42).

3.2.1.7 Pu‘u Ka‘īlio

Pu‘u Ka‘īlio is located in the Wai‘anae Mountain Range prior to reaching Kolekole Pass. The peak has an elevation of approximately 1,965 ft. Ka‘īlio literally translates to “the dog hill” (Pukui et al. 1974:197).

3.2.1.8 Pu‘u Kūmakali‘i

Pu‘u Kūmakali‘i is a peak located on Kolekole Pass in the Wai‘anae Mountain Range. The peak has an elevation of 2,572 ft. Pu‘u Kūmakali‘i literally translates to “rising Pleiades” (Pukui et al. 1974:200).

3.2.1.9 Kaua‘ōpu‘u

Kaua‘ōpu‘u is a hill and stream located in Wai‘anae Ahupua‘a. The hill has an elevation of approximately 1,054 ft (Pukui et al. 1974:91).

3.2.1.10 Mauna Kūwale

Mauna Kūwale is a mountain located on the Lualualei and Wai‘anae Ahupua‘a border as well and is *makai* of Kaua‘ōpu‘u. Mauna Kūwale literally translates to “mountain standing alone” (Pukui et al. 1974:149). A small burial cave is located near the peak of Mauna Kūwale facing Kawiwi in Wai‘anae. Kawiwi was a *pu‘uhonua* (place of refuge) in times of war (Kamakau 1991:18). The cave contains fragments of skeletal material, but none of the objects were buried with the dead (Sterling and Summers 1978:73).

3.2.1.11 Pu‘u Pahe‘ehe‘e

Pāhe‘ehe‘e is a ridge and hill that borders Lualualei and Wai‘anae Ahupua‘a. The ridge has an elevation of 652 ft. Pāhe‘ehe‘e translates to “slippery” (Pukui et al. 1974:174). Pu‘u Pāhe‘ehe‘e Heiau is a located on Pu‘u Pāhe‘ehe‘e Ridge. Pu‘u Pāhe‘ehe‘e Heiau was “completely destroyed with the enlargement of the Oriental cemetary” (Sterling and Summers 1978:68).

Pu‘u Pāhe‘ehe‘e once had an *hōlua* slide. Though the exact location is unknown, it is possible the *hōlua* slide could have been associated with the name Kauhiuhi. Uhiuhi was a type of hard wood used for *hōlua* sleds, weapons, digging sticks, and house construction.

3.2.1.12 Kāne‘īlio Point

Kāne‘īlio Point is also on the Lualualei and Wai‘anae Ahupua‘a border. The point demarcates the most southern point of Pōka‘ī Bay. A *heiau* once stood at the point and was named to Kū‘īlioloa, a legendary giant man dog. The name translates to “dog Kāne [man]” (Pukui et al. 1974:84). In ancient times, Kū‘īlioloa was known as a protector of travelers. Kū‘īlioloa Heiau was partially destroyed by the Army during World War II but still remains visible (Sterling and Summers 1978:69).

3.2.2 Pōhaku (Stones)

3.2.2.1 Māui Pōhaku

Site 148, a large rock said to be Māui, is located approximately 1.1 miles from the Nānākuli Station going toward Pu‘u o Hulu (Sterling and Summers 1978:64). McAllister continues,

> Northeast of the road on the property of E.P. Fogarty is a rock said to be named after the Hawaiians hero, Maui, who is said to have landed here from the south. This stone at the time was surrounded by water, and it was here that Maui reposed and sunned himself. In the bluff just northeast of the rock is a shelter which he lived, and in the vicinity was a spring where he obtained water. The large rock is now split in half and adorned with many small, oddly shaped rocks. It is said to be bad fortune to build one's house across a line drawn directly from the rock to the shore. J.J. Mathews is said to have collected detailed information in regard to this site. [McAllister 1933:110].

The "small, oddly shaped rocks" McAllister speaks of are no longer present. The Māui rock is currently overgrown with young Chinese banyan saplings (*Ficus retusa*), grasses, and weeds.

Figure 8 displays the Māui Pōhaku within the Garden Grove condominium complex in Lualualei. Figure 9 shows the plaque found at the foot of the Māui Pōhaku recalling the *mo‘olelo* by McAllister.

3.2.2.2 Petroglyph Pōhaku

Sterling and Summers noted a rock with petroglyphs in Lualualei Ahupua‘a. Described as being near a dried swamp and adjacent to light pole #152 in a public park near the edge of a beach, former house sites and a petroglyph rock were discovered. The *pōhaku* was reported to the Bishop Museum where it was later removed and housed (Sterling and Summers 1978:67).

3.2.3 Heiau

Heiau are pre-Christian places of worship. Some *heiau* were constructed as elaborate communal structures while others were simple earth terraces or shrines. There are many different kinds of *heiau*, depending on the purpose for which they have been built.

> If it were for peace in the chiefdom, *aupuni*, then a house for peace, a *hale o ka maluhia*, was erected; if for war, then a house for the [war] god in the war *heiau*, *ka heiau kaua* .. if for rebellion, then [a house for the rebel's war god] in his own *heiau*. If it were for blessings to all the land, the well-being of all the people, for 'food' or 'fish,' then the chiefs built *heiaus* all over the land. The people, *maka‘ainana*, erected fishing shrines, *ko‘a ku‘ula*, all around the islands so that the land would be provided with fish. If there were distress because of trouble with the staple plant food, *‘ai*, *heiaus* called *ipu-o-Lono* were raised up all over the land to revive them. [Kamakau 1976:129]

McAllister reported on two known *heiau* in the *ahupua‘a* of Lualualei as well as one other site that could have possibly been a *heiau*.

Figure 8. Photo of the Māui Pōhaku at the Garden Grove condominium complex in Lualualei (CSH 2015)

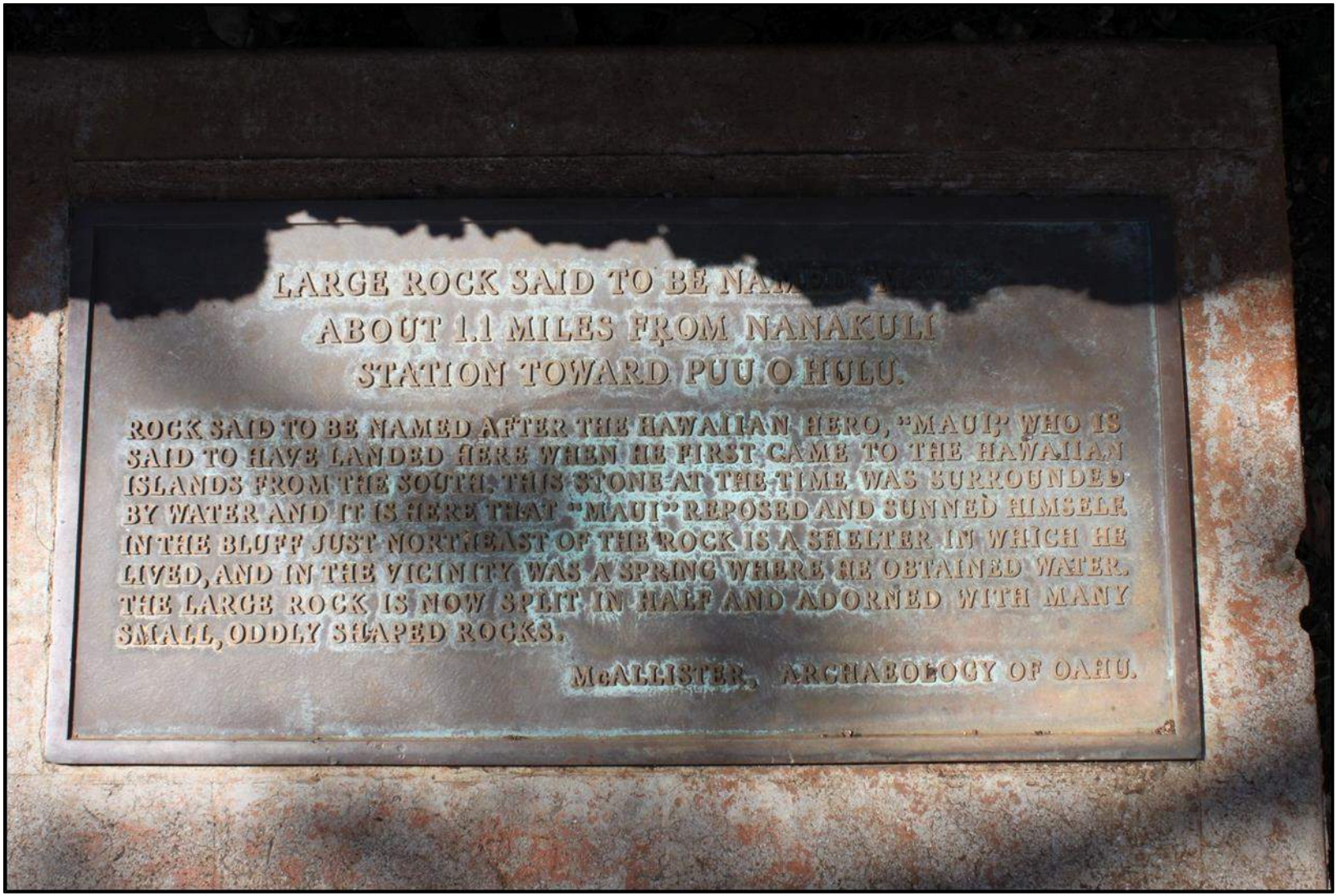

Figure 9. Photo of plaque located at the foot of the Māui Pōhaku at the Garden Grove condominium complex CSH (CSH 2015)

3.2.3.1 Nīoi‘ula Heiau, Site 149

Nīoi‘ula Heiau is located within the Lualualei Naval Preservation on Halona Ridge in Lualualei (McAllister 1933:110). The paved and walled *heiau* was classified as *po‘okanaka* or sacrificial class. The northern portion was nearly completely destroyed and the stones were used for a cattle pen on the McCandless Cattle Ranch. It is said that the cattle in the pen became sick and died, resulting in infrequent use followed by abandonment. McAllister continues,“The heiau probably had three inclosures [*sic*] and three platforms open to the west side, but so little remains of the northern part of the heiau that it is difficult to discern inclosures and terraces” (McAllister 1933:110). Westervelt’s account of the legendary Kawelo also suggests this is the *heiau* where the body of the boxer killed by Kawelo was sacrificed as an offering to the gods. The *heiau* is said to be ancient and belonged to Kakuhihewa (Westervelt 1963:178). Figure 10 depicts the site plan of the *heiau*.

3.2.3.2 Kakioe Heiau, Site 151

Kakioe Heiau was located at Pūhāwai in Lualualei. It was a small *heiau*, however, “nothing remains except the sacred spring, and the sound of its drums and conchs on the nights of Kāne” (McAllister 1933:110). Within McAllister’s description of Kakioe, is a particularly salient reference to ceremonial drumming. Around AD 1250:

> […] the sharkskin drum was brought to Hawai‘i from Tahiti ‘sounding over the oceans’ by La‘amaikahiki. . . The *pahu*, as it is also known in Tahiti and other parts of central Polynesia, was the instrument of ali‘i (chiefs) used in *heiau* (temple) rituals and in *hula kapu* (sacred dance). La‘amaikahiki is credited for the introduction of both the large temple drum, *pahu heiau*, and the smaller dance drums, *pahu hula*. [Smithsonian Institution 1989]

Pahu heiau (drums specifically used at/in *heiau*) were traditionally used by *kahuna* (priests) to “signal the activities of complex ceremonies, significant events such as the births of chiefs, and to accompany the prayers and movements of *kahuna* and *ali‘i*” (Smithsonian Institution 1989). Prayers (identified as “composed, memorized, handed-down chants” by Pukui et al. 1972:123) “for public ceremonies and in high *ali‘i* circles […] were often accompanied by sacrifices to the gods, embellished by ritual, [or] enhanced by the beat of the pahu (prayer drum) […]” (Pukui et al. 1972:123).

3.2.3.3 Pu‘upāhe‘ehe‘e Heiau

Pu‘upāhe‘ehe‘e Heiau is located on Pu‘upāhe‘ehe‘e Ridge. The *heiau* consists of two or three divisions, the upper section being 70 ft across, with a width of 57 ft; the lower sections are not so well defined. The *heiau* has been completely destroyed with the enlargement of the Oriental cemetery (McAllister 1933:112).

3.2.3.4 Kū‘īlioloa Heiau

Kū‘īlioloa Heiau is located at the tip of Kāne‘īlio Point. Kū‘īlioloa Heiau was partially destroyed by the Army during World War II but still remains visible (Sterling and Summers 1978:69). The *heiau* was named after Kū‘īlioloa, a “dog with a human body and supernatural power” and “a great soldier and famous warrior” (Beckwith 1970:347) who was known as a “protector of travelers” (Sterling and Summers 1978:69)

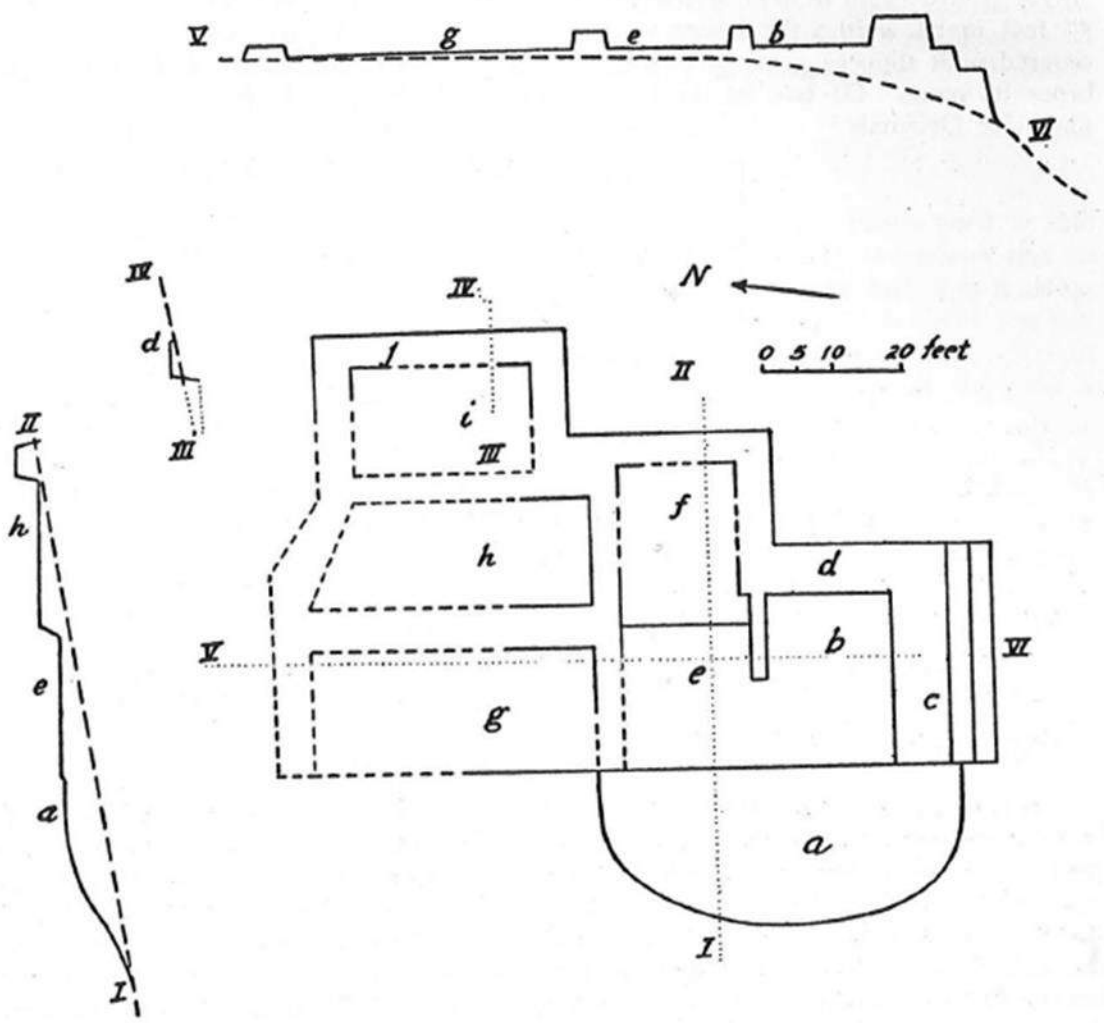

FIGURE 33.—Nioiula heiau, Halona, Lualualei, Site 149: *a*, sloping terrace of large rocks, approximately 20 feet wide, probably built up in form of steps, as slope approximates 10 feet in vertical height; *b*, probable site of house with front lanai 18 by 24 feet, paved with stones 1 foot in width; *c*, wall 4 feet high on inside, 8 feet wide, with two terraces 3 feet wide on outside where ridge that rapidly slopes into deep gully is faced by embankment of stones 14 feet high; *d*, wall 4 feet high inside and outside, 7 feet wide; *e*, open dirt-paved terrace; *f*, terrace 3 feet higher than *e*, paved with stones 1 foot in width, surrounded on three sides by walls but open toward *e*; *g*, stone-paved terrace 46 by 18 feet, probably walled originally on three sides but open to west; *h*, *i*, probably walled inclosures; *j*, wall 26 feet long, 5 feet wide, 4 feet high inside, flush with slope on the outside. Roman numerals indicate cross sections.

Figure 10. Image of Nīoi‘ula Heiau from McAllister's Survey (McAllister 1933:111)

3.2.3.5 Site 150

House sites or possible *heiau* are located at the foot of the cliffs of Pāhoa in the middle of Lualualei. Walls and small terraces reportedly used as house sites or possibly old *heiau* are located near the end of the ridges (McAllister 1933:110).

3.2.4 *Nā Ala Hele* (Trails)

Trails served to connect the various settlements throughout O‘ahu. John Papa ‘Ī‘ī described three trails accessing the Wai‘anae District during the early post-Contact period (‘Ī‘ī, 1959:97–99) (Figure 11). The most popular was the coastal route that circled O‘ahu. The other two trails traversed the Wai‘anae Mountains into Lualualei. The northeast route traversed Kolekole Pass, followed the Pūhāwai Stream Valley down crossing into Wai‘anae Kai through the gap and finally to Pōka‘ī Bay (Green in Robins 1994:22). According to ‘Ī‘ī, the second trail traverses the Wai‘anae Mountains at Pōhākea Pass and descends the stream valley below Pōhākea. On maps, this valley is shown as Halona. There is no indication where the Pōhākea trail continues after Halona. This trail may have passed alongside the northern boundary of the current project. ‘Ī‘ī, goes on to describe the trails:

> From Kunia the trail . . . met with the trails from Wahiawa and Waialua. The trail continued to the west of Mahu, to Mālamanui, and up to Kolekole, from where one can look down to Pōka‘ī and Wai‘anae Uka. There was a long cliff trail called Elou from Kalena and Hale‘au‘au on the east side of Ka‘ala coming down to Wai‘anae . There was also a trail called Kūmaipō which went up and then down Mākaha Uka.
>
> Below Kūmaipō trail in the olden days was a stronghold named Kawīwī . . . [and it] was part of a mountain ridge lying between Wai‘anae and Mākaha and overlooking Kamaile. The trail Kūmaipō, went down to the farms of Mākaha and the homes of that land. A branch trail which led up Mount Ka‘ala and looked down on Waialua and Mokulē‘ia could be used to go down to those level lands. It was customary to have dwelling places along the mountain trails that led downward from here into Kamaile, as well as along the beach trail of Mākaha.
>
> . . . Pu‘u o Kapolei [trail] . . . joined the beach trail from Pu‘uloa and from Waimānalo.
>
> The trail went down to the stream and up again, then went above the taro patches of Waiau, up to a *makai* field, to Waimano, to Manana, and to Waiawa; then to the stream of Kukehi and up to two other *maika* (ancient Hawaiian game suggesting bowling) fields, Pueohulunui and Haupuu. At Pueohulunui was the place where a trail branched off to go to Waialua and down to Honouliuli and on to Waianae. As mentioned before, there were three trails to Waianae, one by way of Pu‘u o Kapolei, another by way of Pohakea, and the third by way of Kolekole. [‘Ī‘ī 1959:97]

Two trails were recorded during the Mā‘ilikai Community Park Archaeological Survey (Cordy 1976:16–17; Jimenez 1994:13). In 1976, Cordy recorded an east-west trail that encompassed the northern base of Pu‘u o Hulu (the site was destroyed before the second archaeological survey was conducted). The trail was described as “1 meter wide with small, hand-sized stones bound on each side by larger stones” with a wooden post set in the middle of the trail (Cordy 1976:17).

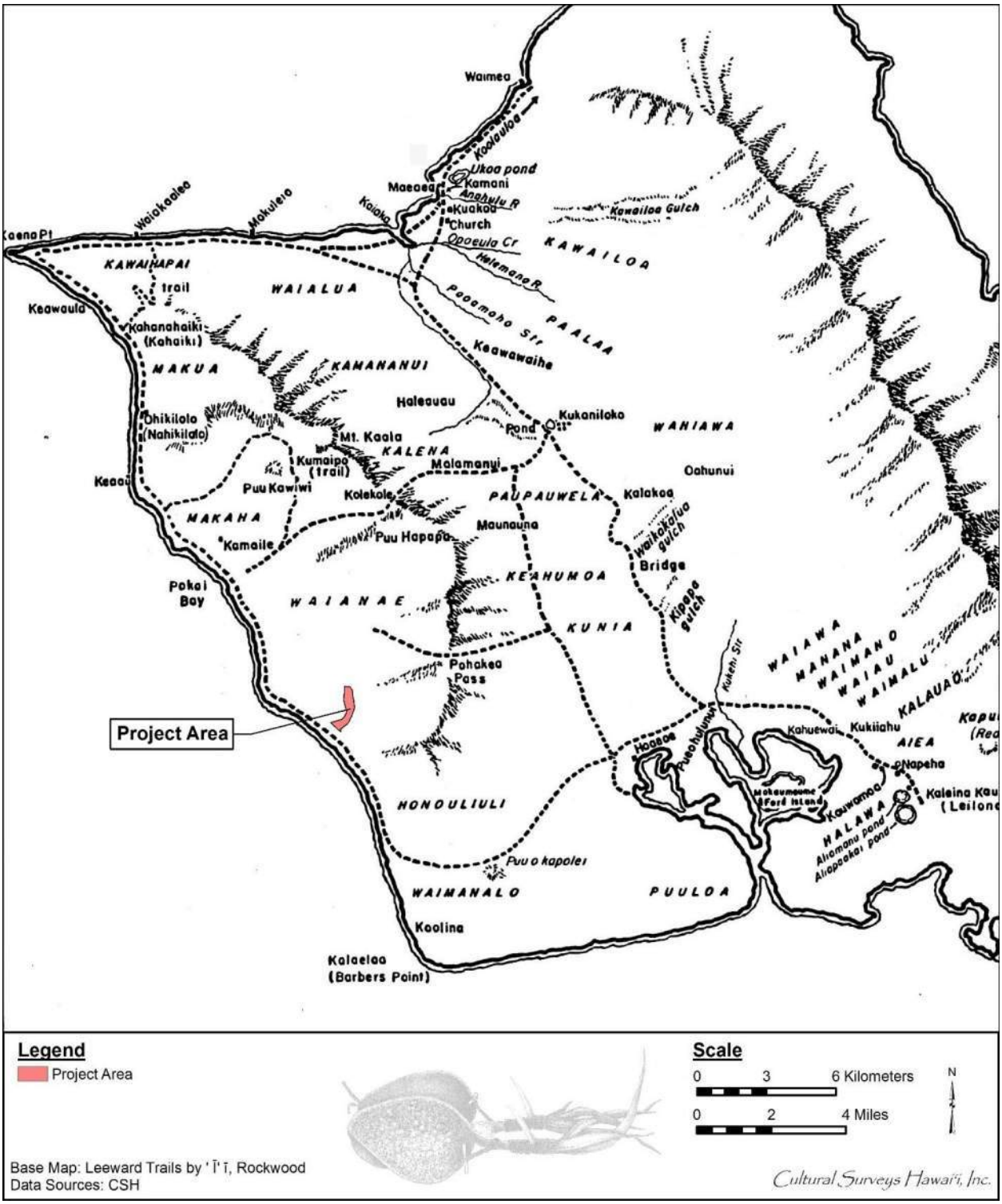

Figure 11. Trails of Leeward O‘ahu as described by ‘Ī‘ī; map by Paul Rockwood (‘Ī‘ī 1959:96)

Although Cordy interprets this east-west running trail as a historic trail based on the associated historic wooden post, the trail may have been a pre-Contact trail. Given its location along the northern base of Pu‘u o Hulu, which is just west of Pu‘u Heleakalā, this trail may have served as a *mauka-makai* pre-Contact trail that many *kūpuna* refer to.

One of the few tested archaeological sites to produce evidence of pre-historic occupation was Site -3750, a C-shape enclosure (Jimenez 1994). During the test excavations of the site, a plan view was drawn which depicts a trail running north-south. However, no physical description of the trail was given in the site description and no mention of the trail was made when the site was originally identified in 1975. There is no documentation that this trail served as a pre-Contact trail, however, its proximity to a known habitation site (6 m) and to potential sources of water (Site -3336, two sinkwells situated approximately 400 m to the north) suggest the trail may be associated with the site. Continuing in a southerly direction on this trail may have led to the east-west trail running along the northern base of Pu‘u o Hulu which is west of the project area.

3.2.4.1 Pōhākea Pass

Pōhākea Pass traverses the Wai‘anae Mountains and descends Hālona Valley below Pōhākea (Figure 12). The peak has an elevation of 2,200 ft. Pōhākea literally translates to “white stone” (Pukui et al. 1974:185). Pōhākea serves as a passage to Honouliuli Ahupua‘a.

Pōhākea Pass is understood as one of the resting places of Pele’s sister Hi‘iaka as she was returning from Kaua‘i with Pele’s lover Lohi‘au (Fornander 1919). A considerable number of *mele* (songs) and *pule* (prayers) are ascribed to Hi‘iaka as she stood at the summit of Pōhākea (*Aluna au a Pōhākea, Kū au, nānā ia Puna* . . .) (Emerson 1915:162–168). This is also the location where Hi‘iaka saw cloud omens that her *lehua* (flower of the *‘ōhi‘a* tree) groves had been burned by her sister Pele and that her friend Hōpoe had been turned into stone.

3.2.4.2 Kolekole Pass

Kolekole is a passage and road from Wai‘anae Uka (Schofield Barracks) through the Wai‘anae Mountain Range in Lualualei (Figure 13). Kolekole Pass was one of the most heavily used mountain trails of O‘ahu (Cordya 2002:65). The trail descends from the Wai‘anae Mountain Range down the valley toward the ocean (Figure 14).

A sacrificial stone is located at Kolekole Pass. This stone was previously identified by McAllister as Site 214. The stone measures from 5 to 8 ft high and about 8 ft wide with a central depression 1.5 ft deep and 2 ft in diameter at the top. The stone has many ridges that rib its sides, one apparently draining the bowl-like depression. On one side, there is a projection which persons were made to stand and lean over when decapitated. This stone is also said to represent a woman by the name of Kolekole, the guardian of the pass, from which the trail takes its name (Sterling and Summers 1978:134).

> In the old days people from Wahiawa side would meet those from Waianae at Kolekole and attempt to cross over. Each would challenge the other for the right to pass. The losing chief would then have to kneel before the big rock and place his head on it and be killed. His skin was then stripped from the flesh and bones (leaving it raw–Kolekole).* The spoils of the battle and the bones were then brought to the heiau in Halona (Site 149) and offered in sacrifice. Below Kolekole and

Figure 12. Photo of Lualualei and Wai‘anae Ahupua‘a from Pōhākea Pass, n.d. (Hawai‘i State Archives)

Figure 13. Photo of the Wai‘anae Mountain Range with Kolekole Pass in left background; Pu‘u o Hulu Uka in the left foreground; downslope of Pu‘u Heleakalā in right foreground, n.d. (Hawai‘i State Archives)

Figure 14. Photo of Kolekole Pass in right background with Pu‘uka‘īlio directly below; Mauna Kūwale in left foreground (CSH 2012)

> beyond Kailio is a hair-pin turn known as Hupe Loa for the retainers of the vanquished chief—because of their weeping and blowing of noses.
>
> *Mrs. Pukui says ‘holehole’ is to strip the flesh. She believes the name Kolekole most likely came because of the battles and the wounds the warriors received, leaving their flesh raw—‘Kolekole’. The idea of the chief kneeling before a rock to be killed seems to be modern. [Sterling and Summers 1978:67]

Kolekole Pass is where Kahekili, the king of Maui, and his army defeated the last of the army of O‘ahu:

> When Kahekili was reigning as king of Maui, and Kahahana was king of Oahu, it was during this period that Kahahawai with a number of warriors came to make war on Oahu. In this battle the people of Oahu were defeated and slaughtered at Niuhelewai, and the waters of the stream were turned back, the stream being dammed by the corpses of the men.
>
> After the battle of Niuhelewai, the chiefs and the men retreated and encamped on the mountains of Kaala. They were well supplied with war implements and other things necessary for the destruction of their enemies. So Kahahawai contrived a means of destroying them, thus: They were a little more than forty men, and Kahahawai told them to prepare torches. When these were ready they went one evening to the top of a hill which was near to the rendezvous of the enemies where they lighted their torches.
>
> After the torches were lit they moved away to a cliff called Kolekole and hid themselves there, leaving their torches burning at the former place until they (the torches) died out. The enemies thought that Kahahawai and his men had gone off to sleep. They therefore made a raid on the men of Kahahawai. But Kahahawai and his men arose and destroyed all the people who were asleep on the hills and the mountains of Kaala. Thus the enemies were annihilated, none escaping. Those who raided the torch encampment were captured, there being no avenue for escape from death and destruction by Kahahawai and his men. [Sterling and Summers 1978:135]

Kolekole Pass is also a place where students praticed *lua* (Hawaiian martial arts) fighting. *Lua* involves breaking bones, dislocating joints, and inflicting pain by pressing on nerve centers. Students would wait along the plains of Leilehua for travelers to pass and practice their *lua* skills on them (Sterling and Summers 1978:135).

In another explanation of the name Kolekole, which literally translates to “raw, scarred,” a woman saw an apparently blind man walking through the pass. Doubting the man’s blindness, the woman exposed herself. The man opened his eyes and exclaimed, *A ‘ula, kolekole!* Red, raw! (Pukui et al. 1974:116).

3.3 *‘Ōlelo No‘eau*

Hawaiian knowledge was shared by way of oral histories. Indeed, one’s *leo* (voice) is oftentimes presented as *ho‘okupu* (“a tribute or gift” given to convey appreciation, to strengthen bonds, and to show honor and respect); the high valuation of the spoken word underscores the importance of

the oral tradition (in this case, Hawaiian sayings or expressions), and its ability to impart traditional Hawaiian "aesthetic, historic, and educational values" (Pukui 1983:vii). Thus, in many ways these expressions may be understood as inspiring growth within reader or between speaker and listener:

> They reveal with each new reading ever deeper layers of meaning, giving understanding not only of Hawai‘i and its people but of all humanity. Since the sayings carry the immediacy of the spoken word, considered to be the highest form of cultural expression in old Hawai‘i, they bring us closer to the everyday thoughts and lives of the Hawaiians who created them. Taken together, the sayings offer a basis for an understanding of the essence and origins of traditional Hawaiian values. The sayings may be categorized, in Western terms, as proverbs, aphorisms, didactic adages, jokes, riddles, epithets, lines from chants, etc., and they present a variety of literary techniques such as metaphor, analogy, allegory, personification, irony, pun, and repetition. It is worth noting, however, that the sayings were spoken, and that their meanings and purposes should not be assessed by the Western concepts of literary types and techniques. [Pukui 1983:vii]

Simply, *‘ōlelo no‘eau* may be understood as proverbs. The Webster dictionary notes it as "a phrase which is often repeated; especially, a sentence which briefly and forcibly expresses some practical truth, or the result of experience and observation." It is a pithy or short form of folk wisdom. Pukui equates proverbs as a treasury of Hawaiian expressions (Pukui 1995:xii). Oftentimes within these Hawaiian expressions or proverbs are references to places. This section draws from the collection of author and historian Mary Kawena Pukui and her knowledge of Hawaiian proverbs describing *‘āina* (land), chiefs, plants, and places. There were no *‘ōlelo no‘eau* found making specific mention of the *ahupua‘a* of Lualualei, the following proverbs concerning the surrounding Wai‘anae Moku come from Mary Kawena Pukui's *‘Ōlelo No‘eau* (Pukui 1983).

3.3.1 *‘Ōlelo No‘eau* #691

The following *‘ōlelo no‘eau* describes the famed mud hen who taught the demi-god Māui the secret of fire.

> *He ke‘u na ka ‘alae a Hina*
>
> A croaking by Hina's mudhen.
>
> A warning of trouble. The cry of a mudhen at night is a warning of distress.
>
> [Pukui 1983:77]

3.3.2 *‘Ōlelo No‘eau* #2830

The following *‘ōlelo no‘eau* describes the cause and effect from the demi-god Māui looking for the secret of fire; the secret of fire was only known to the mudhen who guarded the knowledge from Māui.

> *Ua mo‘a ka mai‘a, he keiki māmā ka Hina.*
>
> The bananas are cooked, [and remember that] Hina has a swift son.
>
> Let's finish this before we are caught. This saying comes from the legend of Māui and the mudhens, for a long time he tried to catch them in order to learn the secret

of making fire. One day he overheard one of them saying these words. He caught them before they could hide and forced them to yield the secret of fire.

[Pukui 1983:310]

3.3.3 *‘Ōlelo No‘eau* #2495

The following *‘ōlelo no‘eau* describes the particular leeward winds that blow across the channel from Kaua‘i.

Ola Wai‘anae i ka makani Kaiaulu.

Wai‘anae is made comfortable by the Kaiaulu breeze.

Chanted by Hi‘iaka at Ka‘ena, O‘ahu, after her return from Kaua‘i.

[Pukui 1986:273]

3.3.4 *‘Ōlelo No‘eau* #363

The following *‘ōlelo no‘eau* describes fate of one priest‘s one under the harsh rule of Kahāhana.

E nui ke aho, e ku‘u keiki, a moe i ke kai, no ke kai loa ho‘i ka ‘āina.

Take a deep breath, my son, and lay yourself in the sea, for then the land shall belong to the sea.

Uttered by the priest Ka‘opulupulu at Wai‘anae. Weary with the cruelty and injustice of Kahāhana, the chief of O‘ahu, Ka‘opulupulu walked with his son to Wai‘anae, where the told his son to throw himself into the sea. The boy obeyed, and there died. Ka‘opulupulu was later slain and taken to Waikīkī where he was laid on the sacrificial altar at Helumoa. [Pukui 1983:64]

3.3.5 *‘Ōlelo No‘eau* #770

The following *‘ōlelo no‘eau* speaks of a goddess who lived in the Wai‘anae Mountains.

He lokomaika‘i ka manu o Kaiona.

Kind is the bird of Kaiona.

Said of one who helps a lost person find his way home. The goddess Kaiona, who lived in the Wai‘anae Mountains of O‘ahu, was said to have pet birds who could guide anyone lost in the forest back to his companions. [Pukui 1983:85]

3.3.6 *‘Ōlelo No‘eau* #1476

The following *‘ōlelo no‘eau* speaks of the famous coconut grove of Pōkā‘ī.

Ka malu niu o Pōkā‘ī.

The coco-palm shade of Pōkā‘ī.

Refers to Wai‘anae, on O‘ahu. At Pōkā‘ī was the largest and best-known coconut grove on O‘ahu, famed in chants and songs. [Pukui 1983:160]

3.3.7 *‘Ōlelo No‘eau* # 1524

The following *‘ōlelo no‘eau* was said by Hi‘iaka in reference to Wai‘anae.

Kapakahi ka lā ma Wai‘anae.

Lopsided is the sun at Wai‘anae.

Used to refer to anything lopsided, crooked, or not right. First uttered by Hi‘iaka in a rebuke to Lohi‘au and Wahine‘ōma‘o for talking when she warned them not to. [Pukui 1983:164]

3.3.8 *‘Ōlelo No‘eau* #1643

The following *‘ōlelo no‘eau* again mentions the goddess Kaiona and her good nature.

Ka wahine hele lā o Kaiona, alualu wai li‘ulā o ke kaha pua ‘ōhai blossoms grow.

The woman, Kaiona, who travels in the sunshine pursuing the mirage of the place where the ‘ōhai blossoms grow.

Kaiona was a goddess of Ka‘ala and the Wai‘anae Mountains. She was a kind person who helped anyone who lost his way in the mountains by sending a bird, an ‘iwa to guide the lost one out of the forest. In modern times Princess Bernice Pauahi Bishop was compared to Kaiona in songs. [Pukui 1983:177]

3.3.9 *‘Ōlelo No‘eau* #2075

The following *‘ōlelo no‘eau* mentions the once famed *maile* of Wai‘anae.

Maile lau li‘i o Ko‘iahi.

Fine-leaved maile of Ko‘iahi.

Often used in chants. The fine-leaved maile of Ko‘iahi, in Wai‘anae, was considered the best on O‘ahu for beauty and fragrance. After the introduction of goats this beautiful and much-liked vine vanished. [Pukui 1983:225-226]

3.3.10 *‘Ōlelo No‘eau* #2495

The following *‘ōlelo no‘eau* mentions the cool breeze, Kaiaulu.

Ola Wai‘anae i ka makani Kaiaulu.

Wai‘anae is made comfortable by the Kaiaulu breeze.

Chanted by Hi‘iaka at Ka‘ena, O‘ahu, after her return from Kaua‘i. [Pukui 1983:273]

3.3.11 *‘Ōlelo No‘eau* #2890

The following *‘ōlelo no‘eau* speaks of the the supernatural tree, Kānepūniu, at Wai‘anae.

Uwē o Kānepūniu i ka wela a ka lā.

Kānepūniu complains of the heat of the sun.

Said when someone complains of the heat. From a chant by Hi‘iaka, who saw Kānepūniu (Kāne-of-the-coconut), a supernatural tree at Wai‘anae, O‘ahu, on a very warm day. [Pukui 1983:315]

3.4 *Oli* (Chants)

Oli, according to Mary Kawena Pukui (Pukui 1995:xvi–xvii), are often grouped according to content. Chants often were imbued with *mana* (spiritual power); such *mana* was made manifest through the use of themes and *kaona*. According to Pukui, chants for the gods (prayers) came first, and chants for the *ali‘i*, “the descendants of the gods,” came second in significance. Chants “concerning the activities of the earth peopled by common humans,” were last in this hierarchy (Pukui 1995:xvi–xvii). Emerson conversely states,

> In its most familiar form the Hawaiians—many of whom [were lyrical masters]—used the oli not only for the songful expression of joy and affection, but as the vehicle of humorous or sarcastic narrative in the entertainment of their comrades. The dividing line, then, between the oli and those other weightier forms of the mele, the inoa, the kanikau (threnody), the pule, and that unnamed variety of mele in which the poet dealt with historic or mythologic subjects, is to be found almost wholly in the mood of the singer. [Emerson 1965:254]

While *oli* may vary thematically, subject to the perspective of the *ho‘opa‘a* (chanter), it was undoubtedly a valued art form used to preserve oral histories, genealogies, and traditions, to recall special places and events, and to offer prayers to *akua* (gods) and *‘aumākua* (family gods) alike. Although *oli* often underpins religious practice, it also “created a mystic beauty . . . confirming the special feeling for the environment among Hawaiians: their *one hānau* (birthplace), their *kula iwi* (land of their ancestors)” (Alameida 1993:26).

3.4.1 *Oli* by Hi‘iaka-i-ka-poli-o-Pele as told by Emerson

A version of the *mo‘olelo* of Hi‘iaka-i-ka-poli-o-Pele by Nathaniel B. Emerson places Hi‘iaka, Lohi‘au, and Wahine‘ōma‘o in a canoe en route to Mokulē‘ia. The party of three land in Mokulē‘ia where Hi‘iaka parts ways and tells Lohi‘au and Wahine‘ōma‘o that she will call for them at a designated place at a later time. Hi‘iaka pays her respects to her *kupuna*, Pōhaku-o-Kaua‘i, then to Ka‘ena (Emerson 1915:156–157). Passing through Ka‘ena, the western cape of O‘ahu, she turns and passes through the slopes of the Wai‘anae Mountain Range and chants the following:

Kunihi Kaena, holo i ka malie;	Kaena’s profile fleets through the calm,
Wela i ka La ke alo o ka pali;	With flanks ablaze in the sunlight—
Auamo mai i ka La o Kilauea;	A furnace-heat like Kilauea;
Ikiiki i ka La na Ke-awa-ula,	Ke-awa-ula swelters in heat;
Ola i ka makani Kai-a-ulu Koholā-lele—	Koholā-lele revives in the breeze,
He makani ia no lalo.	That breath from the sea, Kai-a-ulu.
Haōa ka La i na Makua;	Fierce glows the sun of Makua;
Lili ka La i Ohiki-lolo;	How it quivers at Ohiki-lele [*sic*]

Ha‘a-hula le‘a ke La i ke kula,	This the Sun-god’s dance o’er the plain,
Ka Ha‘a ana o ka La i Makaha;	A riot of dance at Makaha.
Oī ka niho o ka La i Ku-manomano;	The sun-tooth is sharp at Kumano;
Ola Ka-maile i ka hunā na niho;	Life comes again to Maile ridge. When the Sun-god ensheaths his fang.
Mo‘a wela ke kula o Waliō;	The plain Wailiō is sunburned and scorched:
Ola Kua-iwa i ka malama po;	Kua-iwa revives with the nightfall;
Ola Waianae i ka makani Kai-a-ulu, (a)	Waianae is consoled by the breeze
Ke hoa aku la i ka lau o ka niu.	Kai-a-ulu and waves its coco fronds;
Uwē o Kane-pu-niu (b) i ka wela o ka La;	Kane-pu-niu’s fearful of sunstroke; (e)
Alaila ku‘u ka luhi, ka malo‘elo‘e,	A truce, now, to toil and fatigue:
Auaua aku i ka wai i Lua-lua-lei.	We plunge in the Lua-lei water
Aheahe Kona, (c) Aheahe Koolau-wahine, (d)	And fell the kind breeze of Kona, the cooling breath of the goddess
Ahe no i ka lau o ka ilima.	As it stirs the leaves of ilima.
Wela, wela i ka la ka pili i ka umauma,	The radiant heat scorches the breast
I Pu‘u-li‘ili‘i, i Kalawalawa, i Pahe-lona,	While I sidle and slip and climb
A ka pi‘ina i Wai-ko-ne-ne-ne;	Up one steep hill then another;
Hoomaha aku i Ka-moa-ula;	Thus gain I at last Moa-ula,
A ka luna i Poha-kea	The summit of Poha-kea.
Ku au, nana i kai o Hilo:	There stand I and gaze oversea to Hilo,
Ke ho‘omoe a‘e la i ke kehau	Where lie my dewy-cool forest preserves of lehua
O a‘u hale lehua i kai o Puna,	That reach the sea in Puna—

O a‘u hale lehua i kai o Kuki‘i.	My lehuas that enroof Kuki‘i.

(a) *Kai-a-ulu*, a sea-breeze that comforted Wai‘anae.

(b) *Kane-pu-niu*, a form of god Kane, now an uncarved bowlder [boulder]; here used in a tropical sense to mean the head. The Hawaiians, impelled by the same vein of humor as ourselves, often spoke of the human head as a coconut (puniu).

(c) *Kona*, here used as a local name for the sea-breeze.

(d) *Koolau-wahine*, a wind, stronger, but from the same direction as the Kona.

(e) The author begs to remark that sunstroke is unknown in all Hawaii.

[Emerson 1915:157–158]

3.4.2 Oli from *The Epic Tale of Hi‘iakaikapoliopele*

Another version of *The Epic Tale of Hi‘iakaikapoliopele* tells of Hi‘iaka and her companions as they travel on the leeward coast of O‘ahu. Wahine‘ōma‘o and Lohi‘au travel by canoe, Pā‘ūopala‘ā travel the seaside roadway to Wai‘anae, and Hi‘iaka took the mountain road which led up and over Pōhākea. Hi‘iaka came up seaward of the plain called Mā‘ili, and turned and looked inland where she saw the sun sparkling on the plains of Lualualei, at which point she chanted the following chant:

Wela i ka lā ē!	Hot from the sun!
Wela i ka lā ē!	Hot from the sun!
Ua wela i ka lā ke kula o Lualualei	The plain of Lualualei is heated by the sun
Ua nau ‘ia e ka lā, ua okaoka	Gnashed by the sun into bits
Ua hā‘ule ka papa ‘auwae o ka lā	The lower jaw of the sun has fallen
‘O ka lā ē! I nā kūkulu	O the sun, ah! In all directions
Na ka lā nō i kahu a ‘ena‘ena	The sun tended its fire to a blaze
‘A‘ole wahi puka ho‘omaha	With no place of respite
A ka wāwae e ho‘omaha aku ai	Where one‘s foot can find relief
I ka luna o Pōhākea	Up to the top of Pōhākea
E uē ho‘i kāua ē	Let us share our tears.
[Ho‘oulumāhiehie 2008b:279]	[Ho‘oulumāhiehie 2008a:260]

When Hi‘iaka finished chanting, her *aikāne* replied back with annoyance that as they travel in wet and cold conditions, she travels on dry land. Hi‘iaka responds to her *aikāne* by climbing to the hot plain and chants the following:

A Waikonene i ke alanui	At Waikonene on the pathway
Ka pi‘ina i Komoa‘ula	The climb to Komoa‘ula
Ka lā wela i ka umauma	The hot sun on the breast
Waha ka ‘īlio i ke kula o Pūhāmalo‘o	The dog carries me to the plain of Pūhāmalo‘o
Ke ho‘ohaehae maila ka Nāulu	When the Nāulu rains stir their fury
Moku kahawai, miha ka poi o Pūhāwai	The streambanks break lose, but the heart of Pūhāwai is silent
Ua hakakā, kipikipi ke Kaiāulu me ke kanaka	Feisty, the Kaiāulu wind toys with people
Ua ku‘iku‘i wale a hā‘ena nā ihu	Pounding away until faces blaze
Ua kā wale i ka hope	Striking a blow at the back
Ka lā wela o Lualualei ē	Such is the suns heat in Lualualei, ah
He lei aloha no ‘olua ē.	A lei of regard for the two of you.
[Ho‘oulumāhiehie 2008b:279]	[Ho‘oulumāhiehie 2008a:261]

Following the chants by Hi‘iaka to her *aikāne,* Wahine‘ōma‘o, she continued on to the peak of Pōhākea. It was atop of Pōhākea that she looked toward Hawai‘i Island and saw her beloved *aikāne* Hōpoe had been killed by her sister Pele. Multiple versions have been published of when and how Hi‘iaka found out that Hōpoe was killed by Pele’s fire. In another version, it wasn’t until Hi‘iaka returned to Hawai‘i Island at Hilo Palikū that she found Hōpoe to be consumed by her sister’s flames (Ho‘oulumāhiehie 2008a:262).

She chants the following:

I kau Pōhākea i ke ao o ka makani	Pōhākea is perched in the realm of the wind
Makani hāli‘ali‘a aloha ke ‘ala o Puna	Wind that stirs fond memories of Puna’s perfume
E kono mai ana i ku‘u waimaka e hanini	Beckoning my tears to flow
Ke ala huli hele ma ka nahele ē	On the forest path of my quest

I hele ho‘i au e huli i ke aloha nō ho‘i āu ē	That I travel to seek your beloved
Lele kawa ke ao a ka ‘āina, ua kau ma mua	The landscape plummets, laid down before me
E waha ana ka ‘īlio i ke kula o Pūhāmalo‘o	The dog carries me on the back to the plains of Pūhāmalo‘o
Ke ho‘ohaehae a‘ela i ka Nāulu	Raging against the Nāulu rains
Ua mokuhia kahawai, ua nihoa ka pali	The streambanks are breached, the cliffs worn jagged
Ua hakakā ke Kaiāulu me ke kanaka	The Kaiāulu wind an opponent
Ua ku‘iku‘i wale ‘ia, ua hā‘ena nā ihu	Pounded upon, faces ablaze
Ua kā ka ‘ūpē i ke kula loa o Lualualei	Mucus wiped away on the long plain of Lualualei
Ku‘u lei aloha no ‘olua ē	This is my lei of regard for you two.
[Ho‘oulumāhiehie 2008b:280]	[Ho‘oulumāhiehie 2008a:261]

The Kaiāulu wind is the wind of the Wai‘anae district (Nakuina 1992:51). Pukui adds that it is a pleasant and gentle trade-wind breeze (Pukui and Elbert 1986:115). This wind is also mentioned multiple times in *The Epic Tale of Hi‘iakaikapoliopele* during her travels on the Leeward side of O‘ahu.

The Kaiāulu wind unfurls from Kuaiwa to Pōka‘i, in an *oli* from *The Epic Tale of Hi‘iakaikapoliopele*.

Lei kapa ‘ehu kai Ka‘ena na ka makani	Ka‘ena is wreathed in a cloak of sea spray by the wind
Hohola a‘ela i nā uka o Poloea	Spread out in the uplands of Poloea
Kāhiko ihola i ka noe luna o Kamae	The summit of Kamae is adorned by mist
Maika‘i ihola ‘o Waialua ē, i laila	Splendid is Waialua, there
‘O Līhu‘e kekahi, aloha wale	As is Līhu‘e, beloved indeed
‘O ka luna wale o Kamaoha	The highlands of Kamaoha

Nani Malamanui, hui me Kawaikōloa	Malamanui is beautiful, joined with Kawaikōloa
I ka ho‘ohanuhanu ‘ia e ke kupukupu	Suffused with the aroma of ferns
He pua ‘ala nō ka mau‘u maika‘i	Fragrant are the blooms of the fine grasses
I halihali mai a Kokoloea	Carried all the way to Kokoloea
Pua weo i ka nahele o Ka‘au ē, i laila	The red blossom in the forest of Ka‘au, there
Ho‘okā‘au ka mana‘o, ho‘olaka i ke kanaka	Entertaining are the thoughts, taming the man
Ho‘onani i ke kino e noho nei, ‘oe anei ē, i laila	Adorning this body, is it you, there
Noho nō i Kanoenoe ke Kuahine	The Kuahine rain dwells in Kanoenoe
Hele a haiamū ka ua i ke kula	The rains gather in the plains
Me he kanaka maika‘i lā ka ua Ki‘owao	The Ki‘owao rain is like a handsome man
Ka pua ‘ula i ka uka o Kahui ē, i laila	The red blossom in the uplands of Kahui, there
Nani Ka‘ala, hemolele i ka mālie	Beautiful is Ka‘ala, flawless in the calm
He kuahiwi nui ia no Wai‘anae	Grand mountain of Wai‘anae
E wehe ana i ka makani Kaiāulu	The Kaiāulu wind unfurls
Mai Kuaiwa nō a Pōka‘ī ē, i laila	From Kuaiwa to Pōka‘ī, there
Mai loko‘ino ‘oe, e ka makamaka ia‘u	Do not be cruel, my friend, to me
E ‘ike mai nō ka pono kāhea mai	Recognize the need for your welcoming call
‘Oe anei ē	Is it you?
[Ho‘oulumāhiehie 2008b:173]	[Ho‘oulumāhiehie 2008a:162]

3.5 *Mele* (Songs)

There exist several *mele* that concern or mention either Lualualei and/or Wai‘anae Moku. These particular *mele* may also be classified as *mele wahi pana* (songs for legendary or historic places). *Mele wahi pana* such as those presented here may or may not be accompanied by *hula* (dance) or *hula wahi pana* (dance for legendary or historic places). As the Hula Preservation Society notes,

> Hula Wahi Pana comprise a large class of dances that honor places of such emotional, spiritual, historical, or cultural significance that chants were composed for them. Only the composers of the chants could know the deepest meanings, as they would be reflections of their feelings and experiences . . . Since the subjects of Wahi Pana compositions are extremely varied, their implementation through hula are as well. Coupled with the differences from one hula style and tradition to the next, Hula Wahi Pana can be exceptionally diverse. They can be done sitting or standing, with limited body movement or wide free movement; with or without the use of implements or instruments; with the dancers themselves chanting and/or playing an implement or being accompanied by the *ho‘opa‘a* [drummer and *hula* chanter (memorizer)]. Beyond the particular hula tradition, what ultimately determines the manner in which a Hula Wahi Pana is performed are the specific place involved, why it is significant, the story being shared about it, and its importance in the composer’s view. [Hula Preservation Society 2014]

3.5.1 Aloha ‘Ia ‘o Wai‘anae

This mele was written by Abigail Pililā‘au and Rachael Kaleiwahea. Hailama Farden shares this *mana‘o* on the *mele*:

> In a video taped interview given to Hailama by Mrs. Pilila‘au’s remaining two daughters, Agnes Kim & Mercy Garcia, they stated the song was Auntie Rachael Kaleiwahea’s, who took the mele to Auntie Abbie to paka (edit). Since Mrs. Pilila‘au had much to edit, she joined in ownership. Ka‘ala is the highest mountain on O‘ahu. Pōka‘ī means Pō the night of Î and was the name of a no longer existing coconut grove in the area of Kamaile, near the present site of Wai‘anae Intermediate School. The correct name for Pōka‘ī bay is Nene‘u. Ōmalaea or Malaea is not the name of the rock which bears its name, the correct name is Nene‘u. Malaea is the ancient name of the area where the Army Rest Camp is now located. [Huapala, n.d.]

Aloha ‘ia ‘o Wai‘anae	Love for Wai‘anae
He malu i ka ulu niu	The peaceful shady
Ulu niu kaulana ‘o Pōka‘ī	Famous coconut grove of Pōka‘ī Bay
He nani ke ‘ike aku	I see the beauty
Kū kilakila Ka‘ala	Majestic Ka‘ala
Kuahiwi kau i ka hano	The glorious mountain
Uluwehi i ka maile lau li‘ili‘i	Where the small leaf maile grows in profusion
He ‘ala hu‘ihu‘i ē	With its penetrating fragrance
Pā ‘ana ka makani he Kaiāulu	The wind named Kaiāulu
He aheahe mālie	Blows gently
Puīa i ke ‘ala o ka ‘awapuhi	Brings the fragrance of ginger

He pua ‘ala onaona	The sweet smelling flower
Ha‘ina mai ka puana	Tell the refrain
O Wai‘anae ku‘u home	Of my home at Wai‘anae
Home i aloha ‘ia e mākou	The home that we love
Home poina ‘ole	The unforgettable home

[Huapala, n.d.]

3.5.2 Kaula ‘Ili

This *mele* was composed by Eliza Ha‘aheo and translated by Kepā Maly. It is said to be about an innocent man who was hung. The second verse was part of another song that was later incorporated into this song. The third, fourth, and fifth verses are from the collection of Penny Keli‘i. Pu‘uohulu is a twin mountain peak in the *ahupua‘a* of Lualualei.

Ho‘omākaukau ko kaula ‘ili	Make ready your lariat
I luna o ka pu‘u Kanakaleonui	Put it over the throat, of the man with the big voice
Ho‘olohe i ke kani o nā manu	Heed the cry of birds
O never mind ua hina pū ua hiki nō	Never mind, you will fall, it is done
O never mind ua hina pū ua hiki nō	Never mind, you will fall, it is done
O ‘oe ka i huia ihola	You are the one who was met
Ka mana‘o e pua pua‘i ‘ala	My constantly recurring thought
Eia o Pu‘uohulu	Here is a group of special people
Ulu nō wau ua hiki nō	I am inspired, it is done
Ulu nō wau ua hiki nō	I am inspired, it is done
I loko o ka ulu la‘au	There in the forest,
E ki‘i ana i na pipi kuni‘ole	Catching the unbranded cattle
Ho‘olei i hola ke kaula ‘ili	Caught by the throw of the rawhide rope
O never mind a komo ‘oe a komo‘ole	Never mind if you come in or not
O never mind a komo ‘oe a komo‘ole	Never mind if you come in or not

Pa‘a hola ka pipi kuni‘ole	The unbranded steer is held tight
Ho‘opili i ke kumu mamane	Bound to the mamane tree
Pa‘a hola ka lio i ka alu	The horse holds fast to the slack
O never mind a lilo ‘oe pau ela no	Never mind if its lost to you, that's how it is
O never mind a lilo ‘oe pau ela no	Never mind if its lost to you, that's how it is
Kau mai ka hau o Mauna Kea	The snows settle on Mauna Kea
Ka makani hu‘ihu‘i ke kino	The cold wind is upon the body
E huli ho‘i nei kēia	So this one turns to go back
O never mind a ho‘i au a ho‘i‘ole	Never mind if you return or not
O never mind a ho‘i au a ho‘i‘ole	Never mind if you return or not

[Huapala, n.d.]

3.5.3 Nene‘u

This *mele* was composed by Abigail Pilila‘au and translated by Kinni Sulivan. Nene‘u is the proper name for Pōka‘i Bay in Wai‘anae. The *mele* also mentions the Kaiāulu wind which is the wind of the Wai‘anae district. It is a pleasant and gentle trade-wind breeze.

Kaulana ‘oe Nene‘u kou inoa	Famous are you, Nene‘u for your name
I ka ne‘e a ke kai i ka pu‘e one	For the moving of the sea on the sand bar
He nani Ka‘ala kau mai i luna	Beautiful is Ka‘ala that rises above
Kuahiwi kaulana ku kilakila	Famous mountain that stands majestic
‘O ‘oe Wai‘anae noho i ka la‘i	You, Wai‘anae, live in peace
Me na kini lehulehu e po‘ai ana	With the multitude surrounding
‘O ka pa kolonahe a ke Kaiaulu	The gentle blowing of the Kaiaulu wind
Halihali mai ana ke ‘ala lipoa	Is carrying the fragrance of lipoa
Ha‘ina ‘ia mai ana ka puana	The story is told

Kaulana ‘oe Nene‘u i kou inoa	Famous are you, Nene‘u, for your name

[Huapala, n.d.]

Section 4 Traditional and Historical Background

The following section provides a summary of the historical events that transpired in Lualualei Ahupua‘a. Focusing on geographic and temporal scales, this section traces the exploration of the Pacific Ocean and the subsequent discovery, settlement, and expansion into the Hawaiian archipelago. The historical background illustrates the changes to Lualualei Ahupua‘a from the time of the arrival of Captain Cook in 1778, the first Western explorer to visit Hawai‘i, through to the present era.

4.1 Pre-Contact to Early Post-Contact Period

4.1.1 Settlement Patterns

The archaeological record suggests early Hawaiians formed settlements of hamlets along the coasts, interred the deceased, ate domesticated pigs, dogs, and chickens, and began to clear tracts of forest between AD 600–1100 (Kirch 2000:293). Significant advances in radio carbon dating in the past two decades suggest the initial settlement of Hawai‘i came from eastern Polynesia between approximately AD 1000 and 1200 (Kirch 2011:3). The early settlers of the Hawaiian archipelago would have been especially attracted to windward O‘ahu with its coral reefs, bays, and sheltered inlets for fishing, dense basalt dikes for the production of stone adzes and other tools, and amphitheater-headed valleys and broad alluvial floodplains that contained fertile soils, numerous permanently flowing streams, and abundant rainfall for the cultivation of crops (Kirch 1985:69). Archaeological excavation data indicate the settlers’ descendants, like their east Polynesian ancestors, lived in pole-and-thatch dwellings, interred the dead beneath these structures, cooked in small hearths, and manufactured stone tools as well as bone and shell fishhooks, and supported themselves by cultivating inland crops, raising domesticated animals, hunting seabirds on offshore islets, fishing, and gathering shellfish (Kirch 1985:71–74).

As they adapted to local conditions, they invented distinctive Hawaiian artifacts, including two-piece fishhooks and the *lei niho palaoa* (whale tooth pendant), which, in addition to other ornaments interred with individuals, suggests a degree of social stratification among the early Hawaiians (Kirch 1985:71–74).

The rich marine resources of the Wai‘anae District, particularly the fishing grounds off-shore, would have been a strong draw for early O‘ahu inhabitants. As population in the windward areas increased, permanent settlement began to spill over into the well-watered regions of the leeward side. Eventually, with further population expansion, permanent settlement spread to the less watered regions of the leeward side, which included much of the Wai‘anae District and all of the current project area (Cordy 1998:1–6). Settlement would most likely begin as temporary habitation along the coast in association with marine resource procurement. Later, permanent settlement would have developed in response to expanding populations in previously settled, better watered areas.

Prehistorically, land use in Lualualei was greatest near the coastline, where marine resources were plentiful, and in the mountainous interior, where there was sufficient rainfall for agriculture and forest resources. The intervening lands between the sea and the mountains were a dry scrubland. Although potentially useful for dryland agriculture in the wet winter months, it is unlikely that this area would have been largely utilized by Native Hawaiians. The settlement

pattern prior to Western Contact for this region was likely dispersed residences concentrated at the sea and the mountains. Based on the season and the available resources, the resident population most likely used multiple residences, perhaps one at the seaside and another *mauka*, to reduce resource transport time. It is also possible, as suggested by the account provided by Pukui (cited in McGrath et al. 1973:10), that there existed an informal exchange network whereby coastal dwellers traded marine resources for the agricultural and forest resources of the inland dwellers.

4.1.2 *Ahupua‘a* System (Land Divisions)

Prior to the unification of the Hawaiian Islands, each island was independently ruled and the ruling faction, the *ali‘i*, managed the land. The inhabitants of O‘ahu divided the land as it extended from the uplands to the sea; the system is known in Hawaiian as *ahupua‘a*. Chinen describes this land division as follows:

> To a large extent, the Hawaiians made the divisions of the land along rational lines, following a mountain range, the bottom of a ravine, or the center of a stream or river. But oftentimes only the line of growth of a certain type of tree or grass marked a boundary; and sometimes only a stone determined the corner of a division. [Chinen 1958:1]

By approximately AD 1310, Māweke (a priest renowned for his knowledge of black magic and sorcery) partitioned O‘ahu into three main districts: the Kona region; the ‘Ewa, Wai‘anae, and Waialua region; and the windward Ko‘olau region (Kirch 2010:88). This division of land and resources allowed sustainable living within each *moku*.

Later, in approximately 1490 AD, the *‘aha ali‘i* (council of chiefs) chose the *ali‘i* Mā‘ilikūkahi to be the new *ali‘i nui* (paramount chief) (Kirch 2010:89). After Mā‘ilikūkahi’s paramountship was installed at the *heiau* of Kapukapuākea (Site 225; McAllister 1933:140) in central Waialua, Mā‘ilikūkahi instituted an explicit land division and administrative structure. O‘ahu was divided further into six *moku*—Kona, ‘Ewa, Wai‘anae, Waialua, Ko‘olauloa, and Ko‘olaupoko—that were further divided into 86 *ahupua‘a* and smaller territorial units (Kirch 2010:89–90).

This land system divides districts based loosely on natural land formations. The *ahupua‘a* could also be subdivided into *‘ili*, a smaller land section that would be cared for by *konohiki* (land manager). The *mō‘ī* (paramount chief) appointed the *konohiki* (as well as the *ali‘i* who would oversee the *konohiki* in their duties). As Lilikalā Kame‘eleihiwa illuminates,

> . . . a hierarchy of *Ali‘i*, *konohiki*, and *maka‘āinana* (Chiefs, Land stewards, and commoners) administered and cultivated any given piece of *‘Āina*. . . This arrangement ensured coordinated cultivation by the *maka‘āinana*, with each level of people having overlapping rights to, and interests in, the products of that *‘Āina*. [Kame‘eleihiwa 1992:9]

The established *ahupua‘a* system was essential to the functioning of the traditional subsistence economy, one that was predicated upon “communal access to land” and generosity (Kame‘eleihiwa 1992:9-11). .

4.1.2.1 Wai‘anae Moku

Wai‘anae Moku extends for 20 miles from the Ka‘ena Point to Kahe Point area. It stretches from the nearshore waters up to the ridgeline of the Wai‘anae Range. Wai‘anae Moku consists of

ten *ahupua‘a*: Nānākuli, Lualualei, Wai‘anae Kai, Wai‘anae Uka, Mākaha, Kea‘au, ‘Ōhikilolo, Mākua, Kahanahāiki, and Keawa‘ula.

In ancient times, the *moku* of Wai‘anae was renowned for its ocean resources especially for deep sea fishing off Ka‘ena where the ocean currents meet. In 1840, Wilkes stated that “The natives are much occupied in catching and drying fish, which is made a profitable business, by taking them to O‘ahu, where they command a ready sale” (Wilkes 1845:81–82). The meaning of Wai‘anae (“mullet water”) also implies an abundance of fish hence the word *‘anae*, which is the full-grown mullet (*Mugil cephalus*) (Pukui and Elbert 1986). Handy and Handy (1972) attribute the naming of Wai‘anae to a large freshwater pond for mullet called Pueha or Puehu. Today, Wai‘anae is still considered one of the best fishing grounds on O‘ahu.

Wai‘anae was also known for the independent lifestyle and attitudes of its inhabitants, another trend that continues into the modern day. This independence was a factor in many of the political struggles of the pre-Contact and early historic period when the district was the scene of battles and rebellions and often the refuge of dissident and/or contentious factions. This independent spirit is often attributed to the conditioning of generations having to cope with marginal environments. In Wai‘anae, the lack of water for cultivation and consumption was precariously balanced by the productivity of the marine resources available off-shore (Handy and Handy 1972:467).

4.1.3 Observations of Early Explorers and Westerners

In January 1778, Captain James Cook sighted Wai‘anae from a distance, but chose to continue his journey and landed off Waimea, Kaua‘i instead. Fifteen years later, Captain George Vancouver approached the coast of Wai‘anae from Pu‘uloa and wrote in his log:

> The few inhabitants who visited us [in canoes] from the village earnestly entreated our anchoring . . . And [they] told us that, if we would stay until morning, their chief would be on board with a number of hogs and a great quantity of vegetables; but that he would not visit us then because the day was taboo poory [a kapu day]. The face of the country did not however, promise an abundant supply [of water]; the situation was exposed. [Vancouver in McGrath et al. 1973:17]

Vancouver was not impressed with what he saw of the Wai‘anae coastline, stating in his log that the entire coast was “one barren, rocky, waste nearly destitute of verdure, cultivation or inhabitants.”

Vancouver did not anchor at Wai‘anae. But had he done so, he would have been pleasantly surprised, at least by portions of the coastline. Even though the dry, arid coast presented a dismal aspect, the ocean provided an abundant supply of fish, the lowlands provided *‘uala* (*Ipomoea batatas*; sweet potato) and *niu* (*Cocos nucifera*; coconut), and the inland valley areas were planted in *kalo* (*Colocasia esculenta*; taro) and *wauke* (*Broussonetia papyrifera*; paper mulberry). These crops not only underpinned the local subsistence economy, but also figured prominently within traditional Hawaiian cosmologies (Kagawa-Viviani et al. 2018:1). The crops that were selected and developed proved,

> . . . unique to the complex geographies of place and culture, evolving multi-layered, inseparable biocultural relationships between plants and people, woven together through cosmologies and genealogies that name core crop plants as ancestors and gods. . . [e.g. Hāloa as the elder sibling of the Hawaiian people] . . .Within this

> ethno-biological context, intricate agricultural systems emerged, hefted and slipped into ecological flows and topographical and geological boundaries. . . [Kagawa-Viviani et al. 2018:1-2]

The environmental characteristics (or limitations) of particular localities would have dictated the ways in which agricultural production was facilitated, either through an irrigated wetland system or a rain-fed dryland system. According to “models for the distribution of intensive agricultural systems” (Ladefoged et al. 2009:5), Wai‘anae Valley, immediately northwest of Pāhe‘ehe‘e Ridge and Mauna Kūwale, as well as Mākaha Valley and Mākua Valley presented the highest potential for irrigated agriculture within Wai‘anae Moku. Coastal portions of Mākua and Keawa‘ula would have had the highest potential for rain-fed dryland agriculture within Wai‘anae Moku (Ladefoged et al. 2009:5). The upland forest regions also provided various woods needed for weapons and canoes. By the 1790s, there was probably a good variety of introduced vegetables being planted in the valley as well.

4.1.4 Sandalwood Trade

The Hawaiian Islands began exporting sandalwood to Asia shortly after 1800 and the commerce flourished until the supply dwindled in the mid-1830s. Lualualei was a region of importance in the sandalwood trade. The demands put on the *maka‘āinana* to harvest wood for trade caused many agricultural fields to become fallow and unused.

By 1811, sandalwood merchants began actively exploiting the Hawai‘i market and huge amounts of sandalwood were shipped to China. Traditionally, Hawaiians used sandalwood for medicinal purposes and as a scent to perfume their *kapa*. Kamehameha I and a few other chiefs controlled the bulk of the sandalwood trade. Kamakau writes, “The chiefs also were ordered to send out their men to cut sandalwood. The chief immediately declared all sandalwood to be the property of the government” (Kamakau 1992:204).

The sandalwood trade greatly impacted Hawaiian culture and drastically altered the traditional lifestyle Hawaiians pursued. In an effort to acquire western goods, ships, guns and ammunition, the chiefs had acquired massive debts to the American merchants (‘Ī‘ī 1959:155). Chiefs including Boki Kama‘ule‘ule were in debt 15,000 piculs (one picul equals 133.33 pounds) of sandalwood worth approximately $200,000 (McGrath et al. 1973:24). When Kamehameha found out how valuable the sandalwood trees were, he ordered the people not to let the felled trees fall on the young saplings, to ensure their protection for future trade (Kamakau 1992:209–210). According to Samuel Kamakau:

> The debts were met by the sale of sandalwood. The chiefs, old and young, went into the mountains with their retainers, accompanied by the king and his officials, to take charge of the cutting, and some of the commoners cut while others carried the wood to the ships at the various landings; none was allowed to remain behind. Many of them suffered for food . . . and many died and were buried there. The land was denuded of sandalwood by this means. [Kamakau 1992:252]

Kamakau comments about the plight of the common people and the general state of the land during this time:

> This rush of labor to the mountains brought about a scarcity of cultivated food throughout the whole group. The people were forced to eat herbs and tree ferns,

> hence the famine called Hīlaulele, Hāhāpilau, Laulele, Pualele, ‘Ama‘u, or Hāpu‘u, from the wild plants resorted to. [Kamakau 1992:204]

In 1816, Boki was made governor of O‘ahu (and chief of the Wai‘anae district) and served in that capacity until 1829, when he sailed to New Hebrides in search of sandalwood. Boki assembled a group of people to join him on his sandalwood expedition and set out with two ships to help pay off his debts. Boki was never seen again in the Hawaiian Islands and it was reported that his ship was wrecked (McGrath et al. 1973:24).

After Kamehameha’s death in 1819, Liholiho allowed his chiefs to share in the trade, resulting in an unrestrained demand on the stocks of wood and upon the energies of the *maka‘āinana* who did the harvesting. Already by October 1817, a Russian visitor noted on O‘ahu, “There are now many fields left uncultivated, since the natives are obliged to be cutting sandalwood” (Barratt 1988:218).

The sandalwood era was short-lived and by 1829, the majority of the sandalwood trees had been harvested, and the bottom fell out of the trade business. It is unclear how extensive Lualaulei’s sandalwood resources were; however, the effects of the sandalwood gathering, the population shifts and disruption of traditional lifestyles and subsistence patterns, would undoubtedly have affected the population of Lualualei.

4.1.5 Missionaries

The Reverend William Ellis visited the Hawaiian Islands in 1823. At that time, he estimated the population on the island of O‘ahu to be about 20,000 (Ellis 1974:19). The missionaries were the first to gather systematic figures regarding population statistics throughout the various districts on each island. The first census figures were gathered from 1831-1832 and 1835-1836. Population figures for Lualualei were not given, however, population numbers given for all of Wai‘anae were 1,868 and 1,654 respectively (Schmitt 1973:9).

4.1.6 Population Decline

Following the western encroachment into the Wai‘anae Coast, a swift decline in population occurred due to disease and a tendency to move to the city where there was more excitement (McGrath et al. 1973:25). The *‘ōku‘u* epidemic of 1804 (thought to be cholera) undoubtedly had some effect on the native population. John Papa ‘Ī‘ī (1959:16) relates that the *‘ōku‘u* “broke out, decimating the armies of Kamehameha I” [on O‘ahu]. Other diseases also took their toll. In 1835, a missionary census listed 1,654 residents on the Wai‘anae Coast. The population of the Wai‘anae Coast was decimated by a smallpox epidemic in late 1853. In 1855, the Wai‘anae tax collector recorded 183 taxpayers on the leeward coast, which is thought to represent a total population of about 800 people. This catastrophic depopulation facilitated the passing of large tracts of land into the hands of a few landholders and led to the decline of the traditional economy that once supported the region (Hammatt et al. 1993:10–11).

4.2 Mid- to Late 1800s

4.2.1 Life in Lualualei During the Mid-Nineteenth Century

In 1855, a Wai‘anae tax collector named J.W. Makalena listed the taxpayers and their contributions into the Ewa & Wai‘anae Tax Assessment (McGrath et al. 1973:29). This gave insight into the area’s population during that time. By the mid-nineteenth century there were fewer

than 800 people left in Wai‘anae, which is less than one-fourth of the estimated number of people living there in 1778 (McGrath 1973:28). This is attributed to the series of epidemics brought by foreigners that overran the Hawaiian population. Even with its distance from the densely populated areas of Honolulu, Wai‘anae was also gravely affected by the fatal diseases.

Although the population declined considerably, those that remained kept to a traditional lifestyle of living in grass houses and farming about 100 acres of taro. For the few that could afford to, frame homes were built on stilts and livestock were kept beneath (McGrath et al. 1973:29). By this time the people of the area started to veer away from bartering fish and taro and began to use money instead. Makalena’s record of taxes also gave insight into how the Hawaiian people of this place obtained money. Among the 116 adult males who were taxed, there were over 200 horses and 13 mules and donkeys accounted for from Wai‘anae Valley, Kamaile, and Nānākuli (McGrath et al. 1973:29). An account by Mark Twain who visited the Islands in the 1860s talks about how excellent the Hawaiians were at horse trading and that a steed could be purchased for $2.50 to $40 (McGrath et al. 1973:31).

4.2.2 The Māhele (1848)

The Organic Acts of 1845 and 1846 initiated the process of the Māhele—the division of Hawaiian lands—that introduced private property into Hawaiian society. In 1848, the crown and the *ali‘i* received their land titles. *Kuleana* awards to commoners for individual parcels within the *ahupua‘a* were subsequently granted in 1850. At the time of the Māhele, the *ahupua‘a* of Wai‘anae, which included Lualualei, was listed as Crown lands claimed by King Kamehameha III as his personal property (Board of Commissioners 1929:28). As such, the land was under the direct control of the King. Many of the chiefs had run up huge debts to American merchants throughout the early historic period and continuing up into the mid-1800s. A common practice at the time was to lease (or mortgage) large portions of unused land to other high chiefs and foreigners to generate income to pay off these earlier debts.

Until the passage of the Act of 3 January 1865, which made Crown Lands inalienable, Kamehameha III and his successors did as they pleased with the Crown Lands, selling, leasing, and mortgaging them at will (Chinen 1958:27).

In 1850, the Privy Council passed resolutions that affirmed the rights of the commoners or native tenants. To apply for fee-simple title to their lands, native tenants were required to file their claim with the Land Commission within the specified time period of February 1846 to 14 February 1848. The Kuleana Act of 1850 confirmed and protected the rights of native tenants. Under this act, the claimant was required to have two witnesses who could testify they knew the claimant and the boundaries of the land, knew that the claimant had lived on the land for a minimum of two years, and knew that no one had challenged the claim. The *kuleana* parcels also had to be surveyed.

Not everyone who was eligible to apply for *kuleana* lands did so and, likewise, not all claims were awarded. Some claimants failed to follow through and come before the Land Commission, some did not produce two witnesses, and some did not get their land surveyed. For many reasons, out of the potential 2,500,000 acres of Crown and Government lands “less than 30,000 acres of land were awarded to the native tenants” (Chinen 1958:31).

Thirteen land claims were made in Lualualei; however, only seven were actually awarded. Most awards were located upland in the *‘ili* of Pūhāwai, northwest of the current project area. From

the claims, it can be determined that at least eight families were living in Pūhāwai at the time of the Māhele in 1848. Together, they cultivated a minimum of 163 *lo‘i*. The numerous *lo‘i* mentioned in the claims indicate the land was ideal for growing wetland taro and that this livelihood was actively pursued by the awardees. In addition, dryland crops were grown on the *kula* (plains), *wauke* (paper mulberry; *Broussonetia papyrifera*) was being cultivated, and one claimant was making salt. Land Commission Awards (LCA) are listed in Table 1; the locations of these LCAs are identified in Figure 5.

Information on the occupations at Lualualei at the time of the Māhele, aside from the historical accounts of scattered coastal hamlets, is from archival records indicating there were nine taxpayers at Mā‘ili near the coast and 11 taxpayers at Pūhāwai in the upper valley (Cordy et al. 1998:36). Mā‘ili is located along the eastern edge of the *ahupua‘a* and Pūhāwai is *mauka*. Based on these numbers, Cordy estimates a population of 90 people for coastal Lualualei and 55 people for the upper valley in 1855 (Cordy et al.1998:36). Regardless of the population estimate, the existence of 20 taxpaying adults in Lualualei indicates the area was inhabited and worked. In this case, the Māhele documents are only a partial reflection of the population and actual land use during the time.

4.2.3 Lualualei Ranch

The first longhorn cattle were brought to O‘ahu from Hawai‘i Island in 1809 by John Young and Kamehameha I (Kamakau 1992:268). One of the first areas to be utilized for ranching on the Wai‘anae coast was Lualualei. Hawai‘i Bureau of Land Conveyances [B.C.], 1845-1869, (archived at the DLNR) records show that William Jarrett leased approximately 17,000 acres of land from Kamehameha III in 1851. This was the beginning of Lualualei Ranch. The lease was written for 30 years with a lease fee of $700 per year (DLNR, B.C. Liber 4:616–618). It seems that Jarrett sold Paul F. Marin, son of Don Francisco de Paula Marin, one-half of his interest in the ranch. Marin lived on the ranch and managed it until 1864, when a dispute arose over the profits of the ranch. Apparently, Marin had never turned over any ranch profits to Jarrett during the time he

Table 1. Land Commision Awards (LCA) in Lualualei Ahupua‘a

LCA number	Claimant and ‘ili	Property description (measurements omitted)	Original LCA transcription in Hawaiian
7334	Kulepe: located in Lehanoiki, Moomuku	Parcel of land 1: A narrow strip of cultivated land within Lehanoiki, Waianae Oahu. Commencing at the southern corner and moving northeast on the farmed boundary. Thence moving southwest at the boundary of Akaloa. Moving south at the boundary of Pooloa and going to the beginning of the square. Parcel of land 2: An agricultural field and house in Lehanoiki. Commencing at the western corner and moving northeast to the field boundary of the land manager. Thence moving southeast to the road, thence moving southwest of the land manager’s field, thence going northwest at the bulrush (Scirpus validus) of Lehanoiki. Going northeast, then moving northwest, going back to the beginning square. In total 2 acres, (or) 9 23/100 links. Parcel of land 3: A narrow strip of land in Ana, Waianae. Commencing at the northeastern corner going southeast at the boundary of Paupau. Going southwest at the field boundary. Thence going northeast at the field boundary. Then continuing going northeast. Then going northeast at the boundary of Keauhee. Then going southeast at the farm to the beginning square. In total 4 acres, (or) 7 18/100 links. A. Bishop	Apana 1. He mookalo iloko o Lehanoiki, Waianae Oahu. E hoomaka ma ke kihi Hema, e hele ana. Ak. 61º Hik.i 1.00 k.h. maka palena koele. Malaila aku. Ak. 32º Kom. i 4.66 k.h. ma ka palena no Akaloa. Malailaaku. Hem. 51 1/2º Kom. i 1.44 k.h. ma ka palena no Kekee. Malaila aku. Hem. 34 1/2º Hik.i 4.50 k.h. ma ka palena no Pooloa. a hiki i ka hoomaka ana. He 5 59/100 k.h huinaha. Apana 2. He kula mahiai, me ka pahale, ma Lehanoiki. E hoomaka ma ke kihi Komohana, e hele ana. Ak. 68º Hik. i 3.00 k.h. maka palena kula o Konohiki. Malaila aku. Hem. 18º Hik. i 7.95 k.h. ma ka alanui. Malailaaku. Hem. 62º Kom. i 3.50 k.h. ma kula o Kon. Malaila aku. Ak. 20º Kom. i 4.00 k.h. ma ke akaakai o Lehanoiki. Malaila aku. Ak. 73º Hik. i 0.98 k.h. Malaila aku. Ak. 20ºKom. i 3.90 k.h. a hiki i ka hoomaka ana. 2 Eka. 9 23/100 k.h. huinaha. Apana 3. He mooaina ilo o Ana, Waianae.E hoomaka ma ke kihi Hik. Akau, e hele ana. Hem. 7º Hik. i 2.60 k.h. maka palena no Paupau. Malaila aku. Hem. 48º Kom. i 5.50 k.h. ma ka palena kula. Malaila aku. Ak. 6º Hik. i 2.92 k.h. ma ka palena kula. Malaila aku. Ak. 51º Hik.i 2.40 k.h. Malaila aku. Ak. 16 1/2º Hik. i 3.50 k.h. ma ka palena no Keauhee. Malaila aku Hem. 11º Hik. i 1.98 k.h. Malaila aku. Hem. 80º Hik. i 0.28 k.h. ma ka palena koele, a hiki i ka hoomaka ana. 1 Eka. 2.95 k.h. huinaha. Pau loa 4 Eka. 7 18/100 k.h. huinaha. A. Bishop. Mea Ana

LCA number	Claimant and ‘ili	Property description (measurements omitted)	Original LCA transcription in Hawaiian
7436	Kahi: located in Puhawai	Parcel of land 1: A narrow strip of land belonging to Kalimako. In Puhawai, Waianae. Oahu. Commencing at the southern corner, moving northeast at the boundary of the land manager. Continuing northeast along the gulch. Then moving northwest at the boundary of Apiki. Continuing northwest, then going southwesterly, then going southeast at the boundary of Maui, then finishing at the beginning. In total 24 acres, (or) 2.21 links. Parcel of land 2: House platform [Hanapili] in Puhawai. At the house boundary of Kailianu. The three other sides are bound by the land manager. In total there are 24 acres (or) .56 links. A. Bishop	Apana 1. He mooaina Kalimako. Puhawai. Waianae. Oahu. E hoomaka ma ke kihi He. e hele ana. A. 81º Hi. i 3.50 kh.ma ka palena i Konohiki. Malaila aku. A. 41º Hi. i 2.06 kh. ma kahawai. Malaila aku. A. 2 Ko. i 11.79 kh. ma ka palena no Apiki. Malaila aku. A. 3º Ko. i 13.63 kh. Malaila aku. He. 7(?)º Ko. i 13.40 kh. Malaila aku. He. 20 ½º Hi. i 25.80 kh. ma ka palena aina no Maui. a hiki i ka hoomaka ana. He.24 Eka. 2.21 kh. huinaha. Apana 2. Kahuahale. Hanapili. Puhawai. He. 34 ½º Ko. i 2.12 kh. ma ka palena hale o Kailianu. He. 50º Hi. i 2.95 kh. ma kula o Konohiki. A. 34º Hi. i 2.12 kh. ma kula o Konohiki. A. 50º Ko. i 2.95 kh. ma kula o Konohiki. He. 6.35 kh. huinaha Pau loa 24 Eka. (?).56 kh. huinaha. A. Bishop. Mea Ana
7451	Kailianu: located in Puhawai, Mookumu	Parcel of land: 1 A house lot at Keakahiki in the section of Puhawai, Waianae, Oahu. Commencing at the eastern corner and moving southwest at the boundary house lot of Kami. Thence north thence northeast thence southeast, then finishing at the beginning. In total there are 3.34 links. Parcel of land 2: A taro field of Kumukukui, in the section of Moomuku, Waianae. Commencing at the southern corner and moving northeast at the boundary of Kaina. Thence northwest. Thence southwest. Thence southeast, and finishing at the beginning. In total there are 1.91 links. Parcel of land 3: Narrow strip of land, in the section of Moomuku, Waianae. Commencing at	Ap. 1. He Pahale ma Keakahiki, ili o Puhawai. Waianae. Oahu. E hoomaka ma ke kihi Hi, e hele ana. He. 34 ½º Ko. i 2.12 kh. ma ka palena pahale o Kami. Malaila aku. A 5º1.58 kh. Malaila aku. A. 3(?)º Hi. i 2.12 kh. Malaila aku. He. 50º Hi. i 1.50 kh. a hiki i ka hoomaka ana He. 3.34 kh. huinaha. Ap. 2. He loi o Kumukukui, ili o Moomuku. Waianae.E hoomaka ma ke kihi. He. e hele ana. A. 68º Hi. i 1.20 kh.ma ka palena no Kaina. Malaila aku. A. 24º Ko. i 1.80 kh.Malaila aku. He. 66º Ko. 1.10 kh. Malaila aku. He. 20º Hi. i 1.71 kh. a hiki i ka hoomaka ana. He. 1.91 kh. huinaha. Ap. 3. Mooaina Kanaikoele. ili o Moomuku. Waianae. E hoomaka ma ke kihi. A. Ko. e hele ana. He. 31 ½ º

LCA number	Claimant and ‘ili	Property description (measurements omitted)	Original LCA transcription in Hawaiian
		the northwestern corner, moving southwest at the land boundary of Hulupu. Thence southeast then northeast at the farm boundary. Thence northeast then southeast again at the land managers boundary. Thence north, then west back to the beginning quadrangle. In total there are 2 acres (or) 2.25 links. Final payment for 2 acres 7.5 links total. A. Bishop	Ko. i 4.80 kh. ma ka palena aina no Hulupu. Malaila aku. He. 56º Hi.i 1.86 kh. Malaila aku. A. 55º Hi. i 1.76 kh. ma ka palena koele. Malaila aku. A. 81º Hi. i 2.24 kh. Malaila aku. He. 5 ½ º Hi. I 3.85 kh. Malaila aku. A. (?)2º Hi. i 1.11 kh. ma ka palena no Konohiki. Malaila aku. A. i 4.00 kh. Malaila aku. Ko. i 3.90 kh. a hikiika hoomaka ana. He. 2 Eka me 2.25 kh. huinaha. Pau loa. 2 Eka 7 ½ kh. huinaha. A. Bishop. Mea Ana
7452	Kaahia: located in Puhawai	Parcel of land 1: A narrow strip of [Ohia grove]. Puhawai. Waianae, Oahu. Commencing at the western corner going southeast at the farm boundary, thence northeast thence northwest thence southwest at the land boundary of Kahi. Then going to the beginning quadrangle. One acre. Parcel of land 2: House lot at Keakapili in Puhawai. Commencing at the western corner and moving southeast at the house lot of Apiki. Thence northwest, thence southeast, then going back to the beginning quadrangle. It total there are 2 acres .80 links. A. Bishop	Ap. 1. Mooaina, Kumuohia. Puhawai. Waianae. Oahu. E hoomaka ma ke kihi. Ko. e hele ana He. 44º Hi. i 3.60 kh.ma ka palena koele. Malaila aku. A. 35º Hi. i 6.16 kh. Malailaaku. A. 40º Ko. i 2.00 kh. Malaila aku. He. 49º Ko. i 5.70 kh. ma ka palena aina no Kahi. a hiki i ka hoomaka ana. 1 Eka me (???)4 Ap. 2. Pahale ma Keakapili. Puhawai. E hoomaka ma ke kihi Ko. e hele ana. He. 50º Hi. i 2.00 kh.ma ka pahale o Apiki. Malaila aku. A. 30ºHi. i 2.12 kh. Malaila aku. A. 50º Ko. i 2.00 kh. Malaila aku. He. 30º Hi. i 2.12 kh.a hiki i ka hoomaka ana. He 4.24 kh. huinaha. Pau loa. 2 Eka 0.80 kh. huinaha. A. Bishop. Mea Ana.
7454	Kanahele: located in Puhawai	Parcel of land 1: A narrow strip of land, in Waianae, Oahu. Commencing at the western corner, moving north then south along the land manages boundary. Thence southeast thence southwest at the cliff boundary. Thence northwest at the boundary of Kailaa. Going back to the	Ap. 1. Mooaina. (??) (??) Waianae. Oahu. E hoomaka ana ke kihi. Ko. e hele ana. A. 20º He. i 2.70 kh.ma ka palena o Konohiki. Malaila aku.He.44º Hi. i 3.60 kh. Malailaaku. He. 52º Ko. i 2.64 kh. ma ka aoao pali. Malaila aku. A. 42 ½º Ko. i 2.10 kh. ma ka palena no Kailaa. a hiki ika hoomakaana He. 7 09/100 kh. huinaha.

LCA number	Claimant and ‘ili	Property description (measurements omitted)	Original LCA transcription in Hawaiian
		beginning quadrangle. In total there are 7 9/100 links. Parcel of land 2: The house lot of Keakapili located in Puhawai. Commencing at the southern corner and moving northeast at the land manager’s field. Thence northwest at the fence of Kailaa. Thence southwest thence south at the house site of Kaahia, then going back to the beginning eastern quadrangle. A. Bishop	Ap. 2. Pahale no Keakapili. Puhawai. E hoomaka ma ke kihi He. e hele ana A. 30º Hi. i 2.86 kh. ma kulao Konohiki. Malaila aku. A. 50º Ko. i 7.86 kh. ma ka paaina o Kailaa. Malaila aku. He. 30º Ko. i 2.86 kh. Malaila aku. He. 50º(??) (??) kh. ma ke kahuahale o Kaahia. a hiki i ka hoomaka ana. Hi. 4.42 kh. huinaha. A. Bishop. Mea Ana.
7456	Kailaa: located in Puhawai	Parcel of land 1: A narrow strip of land, within Keakapili, in Puhawai, Waianae, Oahu. Commencing at the western corner and moving east at the house lot of Kailaa. Thence East at the field boundary. Thence northwest at the base of the cliff. Thence northeast, thence northwest at the gulch. Thence southwest beside the gulch, then going back to the beginning. Parcel of land 2: The home site at Keakapili. Commencing at the northern corner of the property, moving southeast at the fence of Kailaa. Thence southwest thence northwest thence north then south to the beginning quadrangle. There are 6 acres with 7.42 links total. A. Bishop	Ap. 1. Mooaina. Keakapili. Puhawai. Waianae. Oahu. E hoomaka ma ke kihi Ko. e hele ana. Hi. 55 ½º HI. i 3.06 kh. ma ka pahale no Kailaa. Malaila aku. Hi. i 6.70 kh.ma ka palena kula. Malaila aku. A. 6º Ko. i 3.95 kh.ma kumu pali. Malaila aku. A. 4 ½º Hi. i 3.15 kh. Malaila aku. A. 13º Hi.i 3.57 kh. Malaila aku. A. 43º Ko. i 3.10 kh. a ke kahawai. Malaila aku. He. 39º Ko. i 13.55 kh. ma kahawai. a hiki i kahi.(?) hoomaka (??) (??) Eka, a he okoa na koele. Ehia mawaena. Ap. 2. He kahuahale ma Keakapili. E hoomaka ma ke kihi A. e hele ana. He. 55 ½º Hi. i 2.90 kh.mano paaina no Kailaa. Malaila aku. He. 53º Ko. i 2.65 kh. Malaila aku. A. 55 ½º Ko. i 2.90 kh. Malaila aku. A. 53ºA (?) 2.65 kh. He 7.42 kh. huinaha. Pau loa. 6 Eka me 7.42 kh. huinaha. A. Bishop. Mea Ana
8005	Apiki: located in Puhawai	Parcel of land 1: Commencing at the eastern corner and going southwest beside the gulch. Thence northwest thence northwest at the land	Ap. 1. E hoomaka ma ke kihi. Hi. e hele ana. He. 28º Ko. i 13.00 kh ma kahawai. Malailaaku. A. 53º Ko. i 3.62 kh. Malaila aku.A. 3º Ko. i 13.63 kh. ka

LCA number	Claimant and ‘ili	Property description (measurements omitted)	Original LCA transcription in Hawaiian
		boundary of Mahi. Thence southeast and going back to the beginning quadrangle. Parcel of land 2: The home at Kealahili. Commencing at the northern corner and going southwest at the boundary marker of Kahi. Thence southeast, thence south again. Thence northwest at the boundary marker of K(??)ahai, then finishing back at the beginning quadrangle. Total 7 acres. A. Bishop	palenaaina no Mahi. Malaila aku. He. 68º Hi. i 11.00 kh. a hiki i ka hoomaka ana, (????)(?) (?) me 5.82 kh. huinaha. Ap. 2. Ko Kahuahale ma Keakahili. Puhawai. E hoomaka ma ke kihi A. e hele ana. He. 34º Ko.ma (?) palena pa o Kahi. Malaila aku. He. 50º Hi. i 2.00 kh. Malailaaku. 4.34º He. i 2.12 kh. Malaila aku. A.50º Ko. 2.00 kh. ma ka palena pa o K(??)ahia, a hiki i ka hoomaka ana. He. 4.24 kh. huinaha. Pau loa 1(7) Eka. A. Bishop. Mea Ana

managed it. After the dispute was settled, Jarrett took on George Galbraith as a new partner (DLNR, B.C. Liber 18:31).

In 1869, Jarrett sold the remaining years of his son’s interest in Lualualei Ranch to James Dowsett (DLNR, B. C. Liber 29:16–18). James Dowsett was a descendant of a British sea captain and is noted for being the first Anglo-Saxon child born in Honolulu (Nakamura and Pantaleo 1994:21). Dowsett was an entrepreneur of sorts and dabbled in many different business ventures, such as “a whaling fleet, a dairy, a salt works, an extensive trade in awa (a Hawaiian narcotic drink) and numerous land holdings . . . He also ran cattle at different times in Nānākuli, Mikilua and Lualualei” (McGrath et al. 1973:32).

In 1880, George Bowser traveled through Wai‘anae and wrote about Lualualei in his journal:

> Leaving Wai‘anae, a ride of about two miles brought me to the Lualualei Valley, another romantic place opening to the sea and surrounded in every direction by high mountains. This valley is occupied as a grazing farm by Messrs. Dowsett & Galbraith, who lease some sixteen thousand acres from the Crown. Its dimensions do not differ materially from those of the Wai‘anae Valley, except that it is broader—say, two miles in width by a length of six or seven miles. The hills which enclose it, however, are not so precipitous as those at Wai‘anae, and have, therefore, more grazing land on their lower slopes, a circumstance which adds greatly to the value of the property as a stock farm. Although only occupied for grazing purposes at present, there is nothing in the nature of the soil to prevent the cultivation of the sugar cane, Indian corn, etc. Arrangements for irrigation, however, will be a necessary preliminary to cultivation. [Bowser 1880:493–494]

Bowser’s comments imply that though water was still a problem, Lualualei seemed to have some potential for development.

In 1894, Link McCandless entered the ranching scene:

> . . . he and a man named Tom King chartered the brigantine Oakland in Seattle, filled her hole with cattle and the cabins with feed, and sailed for Hawai‘i. By the turn of the century, McCandless’ ranching empire covered much of the Wai‘anae Coast, including land at Nānākuli, 4,000 acres at Lualualei, San Andrews’ property in Mākua and pastures toward Ka‘ena Point. [McGrath et al. 1973:31]

4.2.4 Oahu Railway and Land Company (OR&L)

The Oahu Railway and Land Company (OR&L) signed its charter on 4 February 1889. The Railway was the brainchild of Benjamin Franklin Dillingham. Along with James Castle and others, he had invested in large tracts of land for speculation and resale, but the idea was slow to catch on because “the land lay too far from Honolulu, at least 12 miles” (McGrath et al.1973:54). He foresaw an economic opportunity. The railway was a means to provide transportation to the country and promote development of unoccupied lands, as well as connect with the sugar plantations in ‘Ewa, Wai‘anae, Waialua, and Kahuku. Construction on the railway began in March 1889. The first length of the railway was completed and opened to the public by 1 January 1890. Five years later, on 4 July 1895, the railway finally reached Wai‘anae. The Railway served the Wai‘anae coast until 1946 when the Waianae Sugar Plantation closed down.

4.2.5 Lualualei in Hawaiian Language Newspapers

Hawaiian language newspapers were printed from as early as 1834 up until 1980. A general search of Lualualei on the Ulukau database presented a list of random articles with mention of this *ahupua‘a.* Reading through these articles, one can begin to formulate a sense of environment and means of living in Lualualei. The articles are presented below with translations provided by CSH staff.

4.2.5.1 *Ka Hae Hawai‘i*, 13 Ianuali 1858

OLELO HOOLAHA.

E IKE auanei na kanaka a pau ma keia palapala. Ke hoomalu nei ka mea nona ka inoa malalo i kona aina hoolimalima, o ke Kula o Lualualei i Waianae, o na mea holoholona e hele ana maia wahi, a me ka poe i Kuleana ma ko lakou wahi, e lawe aku i ko lakou mau holoholona ma ko lakou wahi ponoi, ke loaa ole aku ka Palapala Ae i ka hele ana oia mau holoholona ma ke Kula.
PAULO F. MANINI LAPAULA.
*Ianuari 9, 1858. 42-1t**

Translation:

Announcement

Be aware now, all people, by means of this document. The person whose name is below is protecting their rental lands, the Kula of Lualualei in Waianae. Concerning the animals that are moving upon that place and the people who have a responsibility to that place, bring your animals to their proper place if there is no document of agreement that states that those animals can walk upon the *Kula*, plain.

Paulo F. Manini Lapaula.

January 9, 1858

4.2.5.2 *Ka Nupepa Kuokoa*, 16 ‘Apelila 1864

KA HIHIA JARRETT - MANINI, Ua hoopuka ia mai ka olelo hooholo hope loa a ka Aha Kiekie no ka hihia waiwai iwaena o W. Jarrett ame P. F. Manini, i hana loihi iho nei iloko o na makahiki i kaahope ae, a o ke ano nui o ka olelo hooholo penei: E uku aku o Paulo F. Manini, i na dala he 3,844.34 ia Paulo Jarrett, (Lapaula opio) me $721.36 no ke koina o ka Aha. Eia nae, e mahele like ia no ka waiwai o Lualualei, ame na bi- bi, ame na mea a pau e pili ana i ka waiwai nona ke kumu hoopaapaa; a na W. Jarrett, makuakane o Paulo Jarrett e hooponopono i na mea e pili ana i ua waiwai nei ma Hono- lulu, a na P. F. Manini e hooponopono ka waiwai ma Waianae, a e mahele like ia no na loaa mai, ame na pomaikai a pau i uluhia mai noloko o ua waiwai la, a e hoike aku a e hoike mai i kekahi i kekahi i na mea i pili i ka waiwai, iloko o kela ame keia hapalua makahiki, a pela e malamaia'i, a hiki i ka wa e kanakamakua‘i o Lapaula opio. Ua hoike ia mai no ke kope o ka olelo hooholo, a no ka loihi loa, nolaila, aole makou i pai holookoa ia mea.

Translation:

The involvement of Jarrett and Manini. The settlement that was worked on extensively last year concerning the entanglement of the estates between W. Jarrett and P.F. Manini has been released from the Supreme Court, and the major aspects of the settlement are as follows: Paul F. Marin payed 3,844.34 dollars to William Jarrett and 721.36 dollars for the court. Furthermore, the estate of Lualualei, the cattle and all other things connected to their estate being disputed will be divided equally. William Jarrett, the father of Paulo Jarrett will correct the things of the estate connected to Honolulu, and P.F. Marin will oversee the estate at Waianae. The earnings will be divided equally, as will all of the important things possessed within the estate. Each will demonstrate to one another the things connected to the estate within this half year, and that is how it will be taken care of until the time when Paulo becomes an adult. The copy of the settlement has been shown, but because of its length, we did not print the entire thing.

4.2.5.3 *Ka Makaainana*, 20 Ianuari 1896

HOOLAHA KAI LAWAIA.

E ike auanei na mea a pau loa, o maua o na mea no laua na inoa malalo iho, ke papa a hookapu loa aku nei maua i na kanaka o kela a me keia ano i loaa ole ke kuleana mai a maua aku, aole e hele wale e lawaia ma na kai lawaia o ka aina o Nanakuli a me Lualualei a me na Nukuwai, iloko o ua mau aina la. O ka mea kue a hoolohe ole i keia, e hanaia no ia e like me na kanawai o ka aina.
D.N. POINALO,
M.K. LELEO,
Na ona o ke kai lawaia o Nanakuli a me Lualualei.
Waianae, Oahu, Ianuari 8, 1896.

Translation:

Everyone understand this here now. Us two, whose two names are here below are forbidding and placing a restriction on all types of people who have not received the authority from us. Do not just go and fish where there are places to fish in the ocean and all other locations within the lands Nānākuli, Lualualei, and Nukuwai. For those that do not follow this order, it will be dealt with according to the law of the land.

D.N. Poinalo,

M.K. Leleo,

The owner of the fishing ocean of Nānākuli and Lualualei.

Waianae, Oahu, 8 January 1896.

4.2.5.4 *Ka Nupepa Kuokoa*, 23 ‘Okakopa 1924

NA KULANA O LUALUALEI I

UHIIA E KA UHIWAI O

KAALA.

I ka Lunahooponopono o ka Nupepa Kuokoa, Mr. Solomon Hanohano; Aloha pumehana kaua:—E Oluolu mai oe i ka'u mau hooheno o ka aina puuhonua i pohaiia e ke kiawe a'u e luala'i nei me ko'u, mau hoa, uhai-aholo i ke alualu i ka aina, o ia hoi o Lualualei.

Ma ka auwina la o ka Poaha, la 9 i haule iho ai kekahi ua nui koikoi ma Lualualei, nona ka ma-u hookahi kapuai me ka hapa, nolaila, e hoolale mai ana ia'u e liuliu e mahi i ka aina, i kanu na anoano i ka lepo, a oili mai, a ulu.

Mahele elua, eia na paipuwai o ke aupuni ua hiki mai, eia ke waiho nei; i ke aipo o Waianae i hakalia a lilo i ka mea koho haahaa nana e hookele ahiki i ka paa ana, a kahe ka wai iluna o ka lepo o Lualualei, a inu ka lehulehu, a i ae inu i ka wai ono o Kaala, huihui ke moni aku; hauoli pu hoi me ko'u mau hoa i hoho hoomanawanui iluna o keia aina panoa, aia no a ua, alaila, kanu, pau no ka ua, hoomaha, a pela iho la,

E ike mai oukou e ko'u mau makamaka, o ka la no ka mea paamau, aia no a kokoke i na mahina hope, alaila hooma-u liilii iho la, i ae la ke kanaka, mahiai, ola ia kini ke a mai la ke ahi; he oiaio a o ia Kana i i mai ai penei: Owau no ke kumu waina oiaio.

O ko‘u makua no ka mahi waina, o ka lala hua iloko o'u kana e hoomaemae, o ka lala hua ole, na oukou ia e na makamaka e kaana iho, a hoiliili, a pehea aku la.

Mahele Ekolu—Huliamahi na ele-mau, me ka lakou mau mama na keiki pu no, i ka ohi kiawe a piha ke eke he hapaha, nui ka Likana Eliwai e hoonee mai ai ia oe, nana no ke eke, o kau wale no, o ka ohi, a hoopiha iloko o ke eke a piha maikai, he mau haneri eke au e ohi ai, me ka hooikaika no e pono ai i nui kau mau hapaha.

Nolaila ola na keiki o ia aina i uhi paa ia e ke kiawe, he nui hoi kela.

Oiai, ua puka o Pilipo Laiki, keiki hanau o ka aina, no Kauai Manokalanipo.

Hui hou au me ka‘u moopuna mai Molokai mai, Kalaupapa a eia oia ke noho nei i ke kaona nei, ka Kapitala i onaia e ka poe waiwai, a hanohano a haahaa, ka home hoo-nanea o na malihini, mai na aina mamao mai, i hui pu hoi me a'u a huli hoi aku i ko'u aina home hookupono, a ili aku i na keiki a moopuna kuakahi a kualua.

Ua lawa iho la keia, e haawi nei au i ko'u mahalo nui i ka wiliki nui o keia keena pa'i, me na keiki wili ani peahi o ka mikini uwila hooholo hua.

Owau iho no keia, ke kiu hanu meahou.

W. K. APUAKEHAU,
Lualualei, Oct. 14, 1924.

Translation:

The condition of Lualualei that was covered by the heavy fog of Ka‘ala.

Dear Mr. Solomon Hanohano, editer of the Nupepa Kuokoa, warm greetings between us:

Show kindndess as I express cherished thoughts of the land of refuge encircled by kiawe, Prosopis pallida, where I am currently at leisure with my friends, and time swiftly passes because of the softness of the land. This place is also known as Lualualei. On Thursday afternoon the 9th, a heavy rain fell at Lualualei. The rain was a foot and a half and damp, thus, I got ready in no time at all to farm the land and plant the seeds in the soil to sprout and grow.

Part two. Here are the water pipes of the government that have arrived and here is their placement-from the summit swamp of Waianae where the water flows slowly to the thing that gathers it downward until it is contained, and then the water flows upon the dirt of Lualualei. The people drink it as well as the delicious water of Ka‘ala. The drinking water is chilly. My friends and I who breathe and endure upon this dry land are very happy. When it rains, then we plant. When the rain is finished, there is rest and that is how it is.

Understand you all, my friends, the sun is the thing that is regular and when the moon follows shortly after, it becomes a little damp. The people agree and farm and live when the fire burns brightly. It is truth when Kana proclaims like this: I am the the source of the wine of truth.

My parents are the wine farmers. The branches of fruit are mine to clean, the branches without fruit are for you to gather, and it is like that.

Part three. People (nā ele mau) join together in great numbers, and the children are with their mothers, to harvest the kiawe, Prosopis pallida, and fill a quarter of bags. There is a lot that Likana Eliwai will move along to you. The bags are for him and for me is the harvesting and correct filling of the bags. There are several hundred bags from my harvesting and with strength it is correct to increase my quarter.

Thus, the children of that land covered in kiawe, Prosopis pallida, flourish and it is an important thing.

Meanwhile, Pilipo Laiki, a child of the earth, was born in Kaua‘i Manokalanipō.

I am meeting again with my grandchild from Kalaupapa, Moloka‘i and we are staying now in town, the capital that is made to be intoxicted by rich people and is praised and made famous by the interested foreigners from far away places…

This is sufficient and so I provide my thanks to the engineer of this printing office and the children who keep the printing machine spinning.

This is me here, *ke kiu hanu mea hou.*

W.K. Apuakehau

Lualualei, 14 Oct. 1924.

4.2.5.5 *Ka Nupepa Kuokoa*, 9 Kekemapa 1926

E HOOMAHU‘I MA KA HANA HANAI MOA.

Aole he hana i nele i na pono ame na pomaikai, ke lawelaweia kela mau hana, maluna o na kahua kupono; pela no auanei ka oiaio loa, no ka lilo o ka oihana hanai moa, i oihana holomua loa.

Ma ka hoomahu'i ana i ka hana hanai moa, aole no e ikeia ka pomaikai o kela hana, ina he uuku na moa e hanai ai, a i ole, hanai paha ma na welo moa maikai ole, e laa ka hanau nui ole i ka hua, a liilii paha o ke kino; a iloko no hoi o ia manawa hookahi, e loaa pu he ike me kekahi makaukau kupono no ka malama ana i na moa.

O keia kekahi o na hana kupono loa, e lawelaweia maluna b na aina hookuonoono apuni o Hawaii nei, no ke kumu, he hikiwawe loa ka hoopomaikai mai i ka poe e komo ana ma kela hana, me ke kakali ole no kekahi mau makahiki loihi, alaila ike aku i na pomaikai o ka hooikaika ana, ina ma kekahi mau hana e ae i hoohanaia aku ai kela mau aina hookuonoono.

He mau mahina kakaikahi wale ae nei no i hala, ua lawe mai la o Mr. Dan K. Pokipala i kekahi aina hookuonoono o Lualualei, Waianae, i haaleleia e ka mea mua nana i lawe i kela aina, no ka ike ole ia o kekahi pomaikai. Me na haneri moawahine i loaa iaia, ua hoihoi aku la oia e hanai i keia mau moa maluna o kona aina hookuonoono, a i keia la, ke ohi mau nei oia ma kekahi o ke kanaha ame ke kanalima kakini huamoa no ka pule hookahi; ua like ia me kanaha ame kanalima dala kona loaa no na huamoa wale no i ka pule, me ka helu ole ia o na dala e loaa ana iaia, mai na moa e hooliloia aku ana ma ke kuai.

O ka malama i na moa i ikeia ka hanau i na hua, o ka nui no hoi o na moa e malama ai, a hui pu me ka ike i ke ano o ka malama ana, o na kahua nui iho la no ia o ka holomua ma keia oihana.

Ua makaukau mau na makeke no na huamoa ame na moa, me ka hiki ole no ke hoolawa aku i na wahi i makemake mai i na huamoa ame na moa; nolaila ina e hoomahu'i ana na Hawaii, ma keia oihana, me ke kanalua ole ke olelo ae, aole no e loihi ka manawa e hoohana aku ai, e ohi koke ana no i na pomaikai o ka luhi ana, ka mea nana e hapai ae i kekahi heluna nui o ka poe hookuonoono a kau ma na anuu kiekie e hookupono ana i ko lakou noho ana o keia mua aku.

Translation:

Duplicate the process of raising chickens.

Raising chickens is not work that is lacking in prosperity when it is being tended to upon the correct foundations. This here is the great truth for the transition of the profession of raising chickens to a profession that is enduring.

When following the process of raising chickens, the prosperity of this work will not be seen if the chickens being raised are small, the incorrect breed is raised, the eggs are doomed to not hatch, or the bodies of the chickens are small. However, it was seen one time that someone was correctly prepared for raising of chickens.

Here is one of the correct processes to follow that was conducted upon the homestead lands of Hawai‘i here, having the foundation of bringing prosperity

> quickly to the people who entered upon this work without having to wait several years. Thus, understand the correctness of the strong work if there are other kinds of work being done upon the homestead lands.
>
> There are only a few months that passed since Mr. Dan K. Pokipala accepted the homestead lands of Lualualei, Waianae because the person who bore those lands before left due to not being prosperous. With one hundred hens that he obtained, he was interested in raising these hens upon his homestead land, and at this time he is collecting around 40 to 50 dozen eggs per week. He is earning the same amount, 40 to 50 dollars per week, for the eggs without counting the chickens that are purchased/spent money on.
>
> The raising of chickens is seen in the hatching of the eggs, which is an important thing for the chickens being cared for. It coincides with the knowledge of the process of raising chickens, and is a major foundation of how this profession progresses.
>
> The market is ready for the eggs and the chicken because of other areas being unable to have them where eggs and chickens are desired. So, if Hawai‘i duplicates this process of raising chickens, upon this profession without doubt, the time will not be long until the prosperous harvest of the labor being carried by a number of the people developing homesteads and who stand upon the high reaching stairs, will make righteous their lives for the future.

4.3 Twentieth Century to Present

4.3.1 Homesteading

After the overthrow of the Hawaiian monarchy in 1893, the Crown Lands and the Government Lands were combined to become Public Lands. The Crown Lands were no longer indistinguishable and inalienable. In 1895, the Republic of Hawaii decided to open up lands for homesteading in the hopes of attracting a “desirable class of immigrants”—Americans and those of Caucasian descent (Kuykendall and Day 1961:204). In anticipation of the Dowsett-Galbraith lease expiring in 1901, the Government intended to auction off these lands to the highest bidder.

There were two waves of homesteading on the Wai‘anae Coast (McDermott and Hammatt 2000). The first impacted Lualualei and coincided with homesteading occurring at Wai‘anae Kai (Figure 15). In 1902, the government ran advertisements in the local newspapers stating their intent to open up land in Lualualei for homesteads (Kelly 1991:328). Due to the lack of water, the lots were classified as second-class pastoral land rather than agricultural land. The homesteads were sold in three series between the years 1903 and 1912. In Lualualei, the first series was for *mauka* lots purchased by McCandless, who ranched most of his land until 1929, subletting use rights to the Sandwich Island Honey Company. The second and third series were for lots in the lower valley and along the coast, *mauka* of the government road. By the early 1920s, about 40 families had settled on homestead lots in Lualualei (Kelly 1991:331–332). The well-known families that obtained homestead lots at this time were Von Holt, McCandless, and Dowsett (Figure 16).

Despite promises by the government to supply water, there was none, and what little there was, was not enough to go around. Competition between the Wai‘anae plantation and the homesteaders

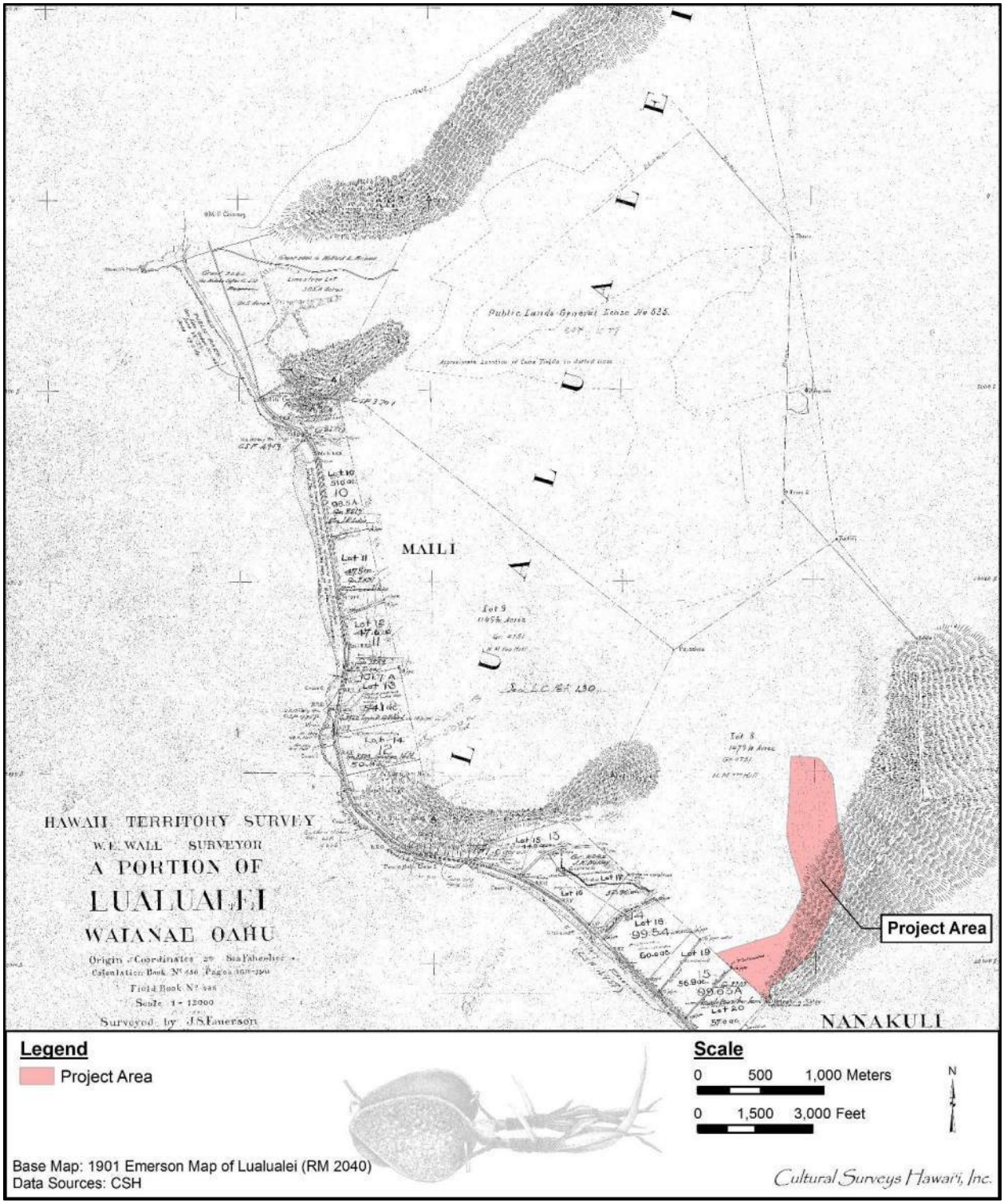

Figure 15. Portion of 1901 Emerson map of Lualualei showing location of project area

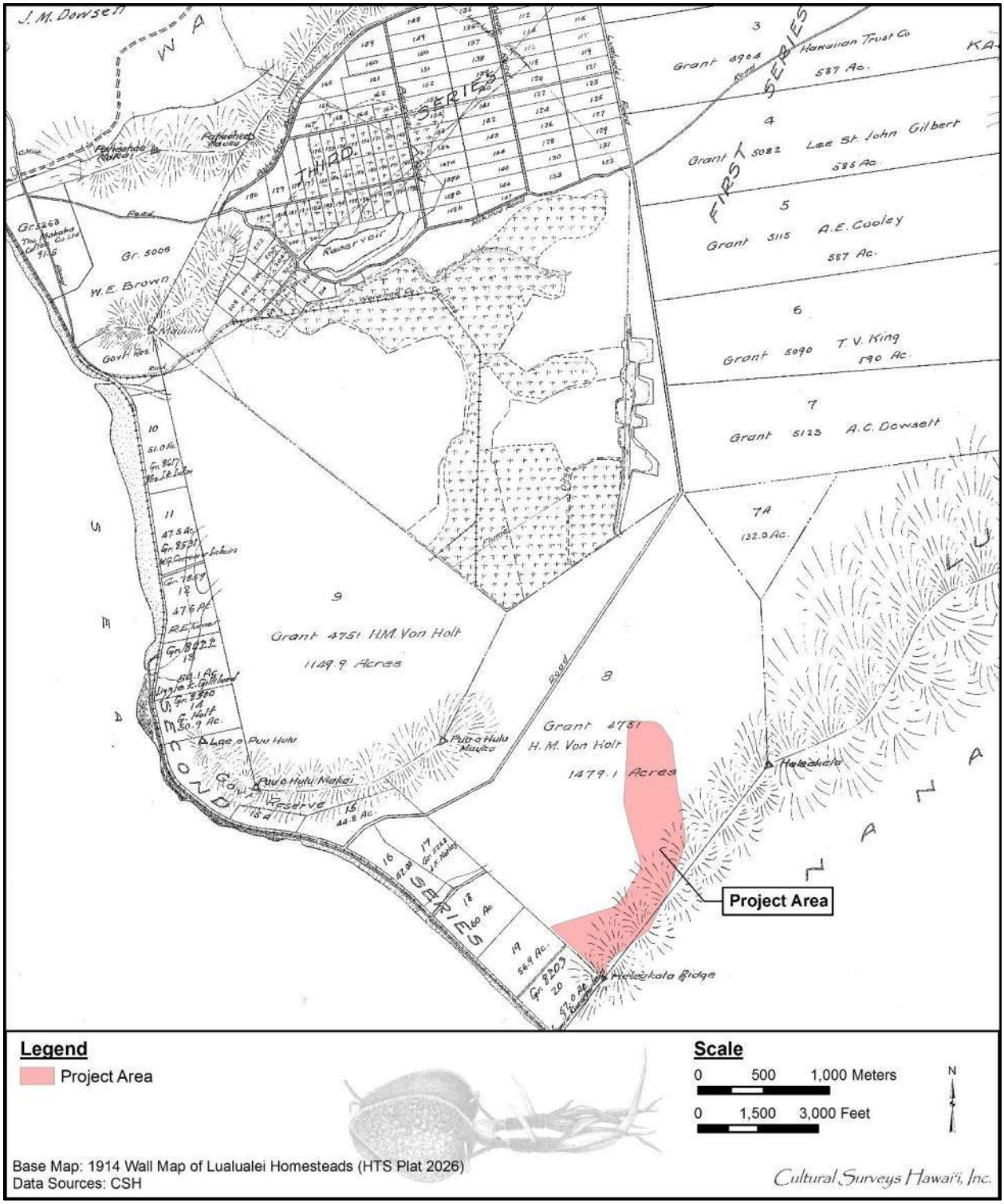

Figure 16. Portion of 1914 Wall map of Lualualei Homesteads, showing location of project area

placed a hardship on the homesteaders. Water had to be carried in, and many lost their crops. The Waianae Sugar Company had a lease with the government to take 2.5 million gallons of water daily from government lands, but even after their lease had expired, the plantation continued to take the water. In 1924, the government made an agreement with the plantation to release 112,000 gallons of water daily for the homesteaders.

4.3.2 Sugar Industry

The sugar industry in the Hawaiian Islands first began in the 1830s. Between 1837 and 1868, sugar industry production in Hawai‘i increased from 4,286 pounds to 17,127,161 pounds creating a demand for labor recruitment (Chun-Hoon 2010:61). American sugar planters recruited a range of immigrant workers. To keep wages low, planters used a “divide and rule” strategy—hiring recent immigrant groups at lower wages and keeping them in separate work camps. In 1868, Japanese laborers began working on contracts paying $4.00/month and within a couple of decades a large portion of the workforce was made up of Japanese laborers. In the early twentieth century, the Hawaiian Sugar Planters’ Association (HSPA) recruited Filipinos, Puerto Ricans, and other recent immigrant groups at lower wages. Promoting ethnic resentment worked to the HSPA’s advantage by keeping labor costs minimal and by discouraging strike activity. Laborers were constantly reminded that they could be easily replaced by another ethnic group willing to work for lower wages (Rosa 2010:55-56).

In 1863, a discouraged missionary wrote that the Wai‘anae Coast had “little prospect of the population’s increasing for years to come, but the opposite, as no part of the district is suitable for an extensive sugar plantation” (McGrath et al. 1973:35). Hermann A. Widemann was a jack-of-all-trades who dabbled in politics and business (Dorrance and Morgan 2000:43). Widemann had financial backing from Hackfeld & Company as well as George N. Wilcox, a reputable sugar planter from Kaua‘i. In 1879, Widemann leased Wai‘anae Kai for 25 years (McGrath et al.1973:37). Widemann hired 20 Hawaiian workers, 15 *haole* (foreign) technicians, and 60 Chinese laborers. He also built 24 new homes in Wai‘anae to house his employees.

By 1901, the Waianae Sugar Company had obtained a five-year lease on 3,332 acres of land at Lualualei to be used for raising cane as well as for ranching (Figure 17). The small plantation was unique in the sense that it had its own 30-inch narrow gauge railroad (Dorrance and Morgan 2000:43). The plantation boasted 12 miles of railroad, three locomotives, and 350 laborers (McGrath et al. 1973:48). The Waianae Sugar Company had smooth labor relations due to its isolated location and careful attention to employees. Hardship has often been a centralizing theme in histories of plantation labor and life in Hawai‘i. However, rather than be defined by oppression and hardship, many plantation workers and their descendants found strength in their shared values. These values were centered on family, loyalty, filial piety, industry, frugality, and equality. Whilst the Waianae Sugar Company was typified by smooth labor relations, elsewhere throughout the islands, plantation laborers fought to build “a labor movement based on family . . . community organizing and multi-ethnic solidarity” (Center for Labor Education and Research n.d.); from their struggles was borne Hawai‘i’s unique *kama‘āina* culture. This unique culture remains visible throughout the Wai‘anae Coast.

Production increased dramatically during the plantation’s early years due to the construction of several tunnels, which were used to collect mountain water. Wells were also constructed at

Figure 17. Photo of sugarcane in Lualualei Valley with flume to the right, Kolekole Pass in center background, n.d. (Hawai‘i State Archives)

Kamaile, the site of an early Native Hawaiian village and spring, to tap ground water for irrigation (McGrath et al. 1973:49). Prior to the construction of the tunnels and wells, sugar yielded 5.24 tons per acre (Dorrance and Morgan 2000:44). In 1930, after the construction of the tunnels and wells, sugar yield increased to 8.57 tons per acre. Five years later, the yield had increased again to 13.79 tons per acre. By the 1940s, Waianae Sugar Company could no longer compete against foreign companies with cheaper labor. This, in addition to drought problems, labor unions, and land battles, caused the undermining of Waianae Sugar Company. In 1947, Amfac, Inc. purchased the plantation and closed it down.

4.3.3 Military

Soon after the annexation of Hawai‘i in 1898, the first U.S. military garrison arrived. Military expansion in the early twentieth century continued due to the need for increased military personnel and changing technologies. Forts DeRussey, Ruger, Shafter, and Armstrong were established in the first decade of the twentieth century to provide coastal defense and infantry units. Bellows, Hickam, and Kāne‘ohe airfields were established in the 1930s to accommodate the increasing use of aircraft. During the Cold War, the Barking Sands missile facility on Kaua‘i was established reflecting the expanding missile technologies (Ferguson and Turnbull 2010:48).

During the first half of the twentieth century, the United States federal government had a major influence in Lualualei Ahupua‘a. The influence of the federal government, and by extension, the U.S. military within Lualualei is evidenced within a portion of 1906 Donn Hawaii Territory Survey map of O‘ahu (Figure 18). The current project area is depicted as existing within “Federal Reservations,” wherein the federal government had “reserved” lands as the property of the United States. By 1929, over 8,184 acres of the McCandless Cattle Ranch had been condemned and purchased by the U.S. Navy for the construction of a Naval Ammunition Depot for the ships based at Pearl Harbor Naval Base.

In 1921, Congress designated approximately 2,000 acres in Lualualei as Hawaiian home lands. However, in 1930 and 1933 Territory of Hawaii Governor Lawrence Judd signed an executive order granting 1,525 acres of land in Lualualei to the United States Navy for an ammunition depot and radio station (*Honolulu Star-Bulletin* 5 October 1998).

The construction of the Naval Magazine LLL (NAVMAG) and Radio Transmission Facility (RTF) took place in Lualualei between 1930 and 1935 (Figure 19 through Figure 21; Kelly 1991:339–341).

The mission of NAVMAG Lualualei is to receive, renovate, maintain, store, and issue ammunition, explosives, expendable ordnance items and weapons, and technical ordnance material for the Navy, Air Force, Army, and other activities and units as designated by the Chief of Naval Operations (CNO). The Naval Communication Area Master Station, Eastern Pacific, Radio Transmission Facility (NCTAMS EASTPAC, RTF) Lualualei facility operates on another 1,720 acres in Lualualei, which is used for high and low frequency radio signal transmissions for the navigation of Navy vessels throughout the Pacific Ocean (Townscape 2009:2-48).

In 1986, the State of Hawai‘i filed a lawsuit to recover land in Lualualei. However, two years later, Judge Harold Fong threw out the lawsuit stating that the statute of limitations had run out (*Honolulu Star-Bulletin* 5 October 1998). In 1995, President Bill Clinton signed the Hawaiian Home Lands Recovery Act, which was authored by Senator Daniel Akaka and set a dollar value

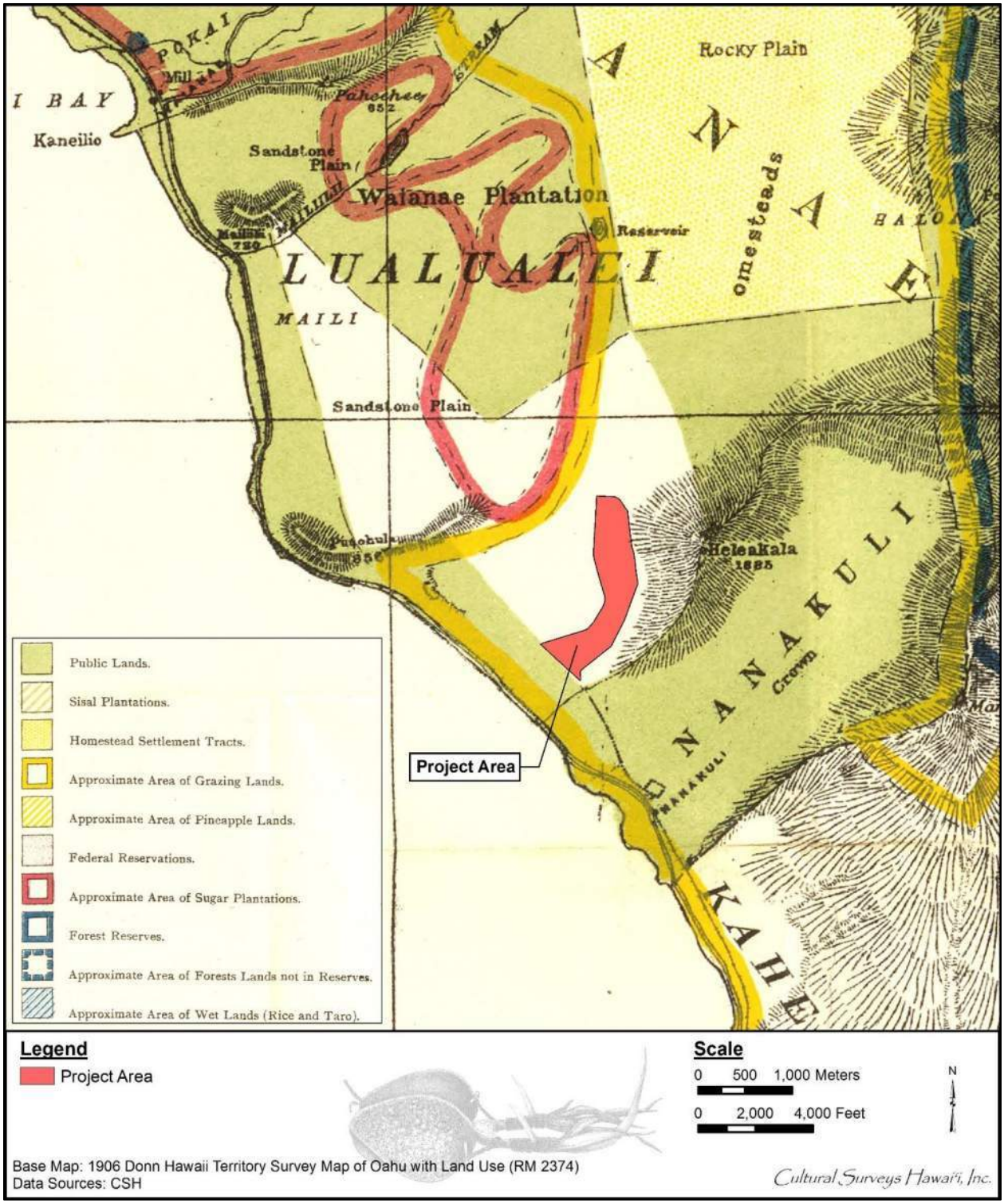

Figure 18. Portion of 1906 Donn Hawaii Territory Survey map of O‘ahu with land use showing project area

Figure 19. Photo of the Lualualei Naval Base area (Hawai‘i State Archives n.d.)

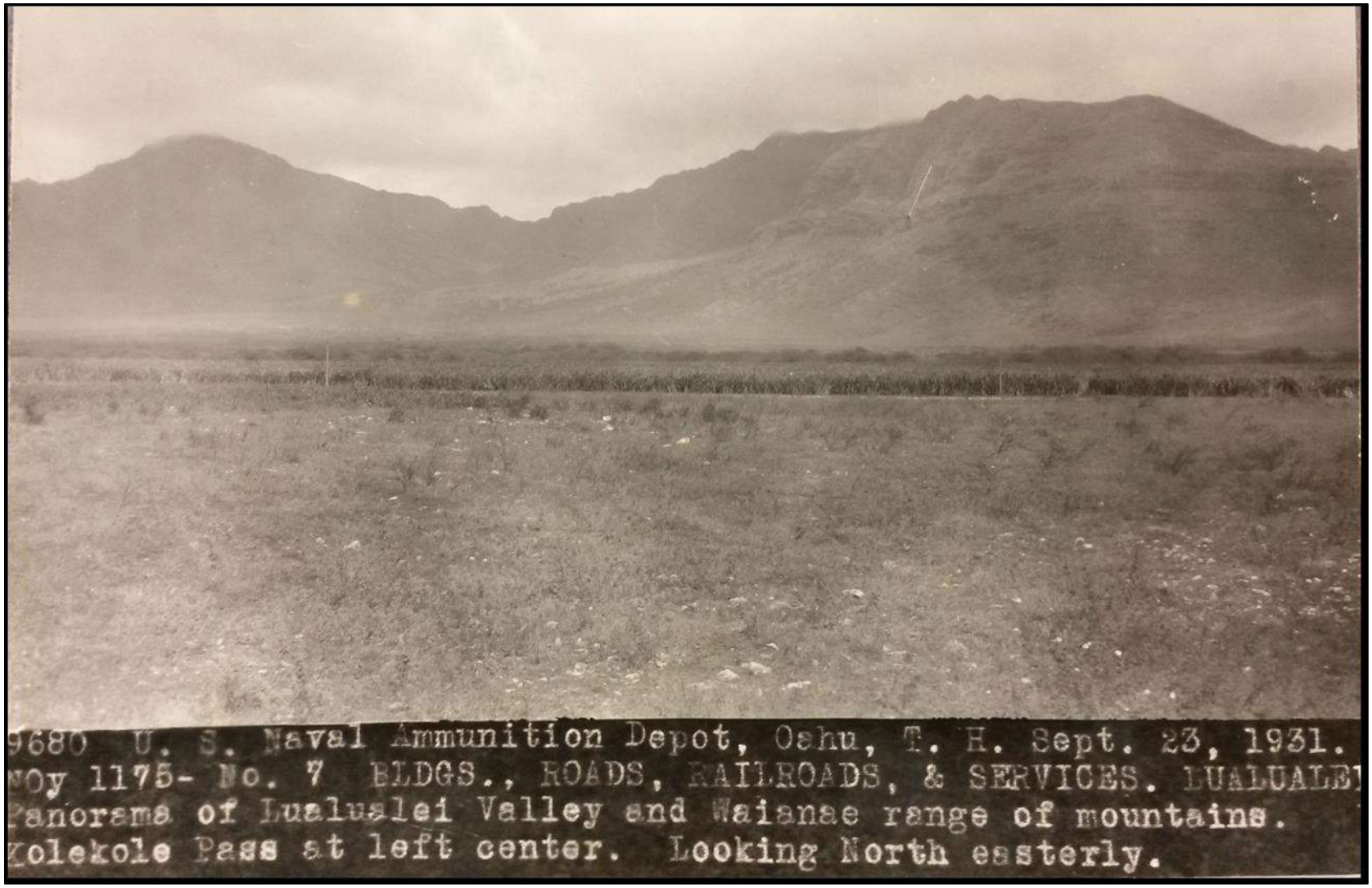

Figure 20. Photo of the Lualualei Naval Ammunition Depot taken on 23 September 1931 showing the valley and Wai‘anae Mountain Range; Kolekole Pass lies in the middle background (Hawai‘i State Archives)

Figure 21. Photo of the Lualualei Naval Ammunition Depot taken on 28 October 1931; Pu‘u Heleakalā in the center background; government offices in the foreground (Hawai‘i State Archives)

on the confiscated lands in Lualualei. In 1998, the Department of Hawaiian Home Lands was awarded 894 acres of surplus federal land under the Hawaiian Home Lands Recovery Act. However, the Navy was still granted continued use of the Lualualei facilities. Today, two antennas of the Navy’s communication systems at Lualualei stand at 1,503 ft, the State of Hawai‘i’s highest structure (Figure 22).

The number of troops stationed and trained on the Wai‘anae Coast during World War II at times reached 15,000 to 20,000 (McGrath et al. 1973:136). The beaches were fortified with barbed wire and concrete bunkers—many of which are still visible today. Martial law severely curtailed the movements of the local population. In 1971, the Navy began sub-leasing some of its land for agricultural use, mainly for grazing and bee keeping. The presence of the military boosted the economy of Lualualei by providing jobs to residents over the years. The lower portions of Lualualei Valley were developed into residential lots after World War II. The project area lies outside military lands.

The transformation of the Second Brigade of the Twenty-fifth Infantry Division (Light) into a Stryker Brigade Combat Team brought 291 Stryker urban assault vehicles to Hawai‘i, requiring 25,663 acres of land on the islands of O‘ahu and Hawai‘i. The army considered the possibility of locating Stryker facilities on Naval Magazine Lualualei, which occupies 8,105 acres in central O‘ahu, however, the location was rejected due to “a possible hazardous material spill site” which would pose very high “potential cleanup costs.” Lualualei has been rendered unsuitable for the Stryker Brigade due to past military use (Ferguson and Turnbull 2010:48).

Various historic maps and aerial photographs show the progression of development in the vicinity of the project area. A 1919 U.S. Army War Department fire control map (Figure 23) shows no apparent development of the area, with the exception of the railroad line extending along the coast. Lands south of the project area are labelled as “U.S. Military Reservation”. A 1936 U.S. War Department terrain map (Figure 24) shows the beginning of the Lualualei Homesteads indicating sparse settlement, as well as Mikilua Camp northwest of the project area. The 1943 U.S. Army War Department terrain map (Figure 25) shows additional development of access roads inside and northwest of the project area but the remainder of the area appears largely unchanged.

The 1953 and 1954 USGS topographic map (Figure 26) shows greater density of residences in the Lualualei Homesteads and along Lualualei Road and surrounding areas, though the project area and areas immediately surrounding remain undeveloped. The 1963 and 1969 USGS topographic maps (Figure 27) depict increasing development throughout the region, with additional infrastructure features labelled, including water tanks, quarries, and a cement plant. A 1965 aerial photograph (Figure 28) depicts the residential development of the area, in which housing density southwest of the project area appears to have increased slightly. A 1977 aerial photograph (Figure 29) depicts a dramatic increase in cleared and developed land south and southeast of the project area. A 1993 aerial photograph (Figure 30) depicts the project area and surrounding areas as similar to their current condition, with residential and commercial development spanning much of the landscape west and south of the mountain ridgeline.

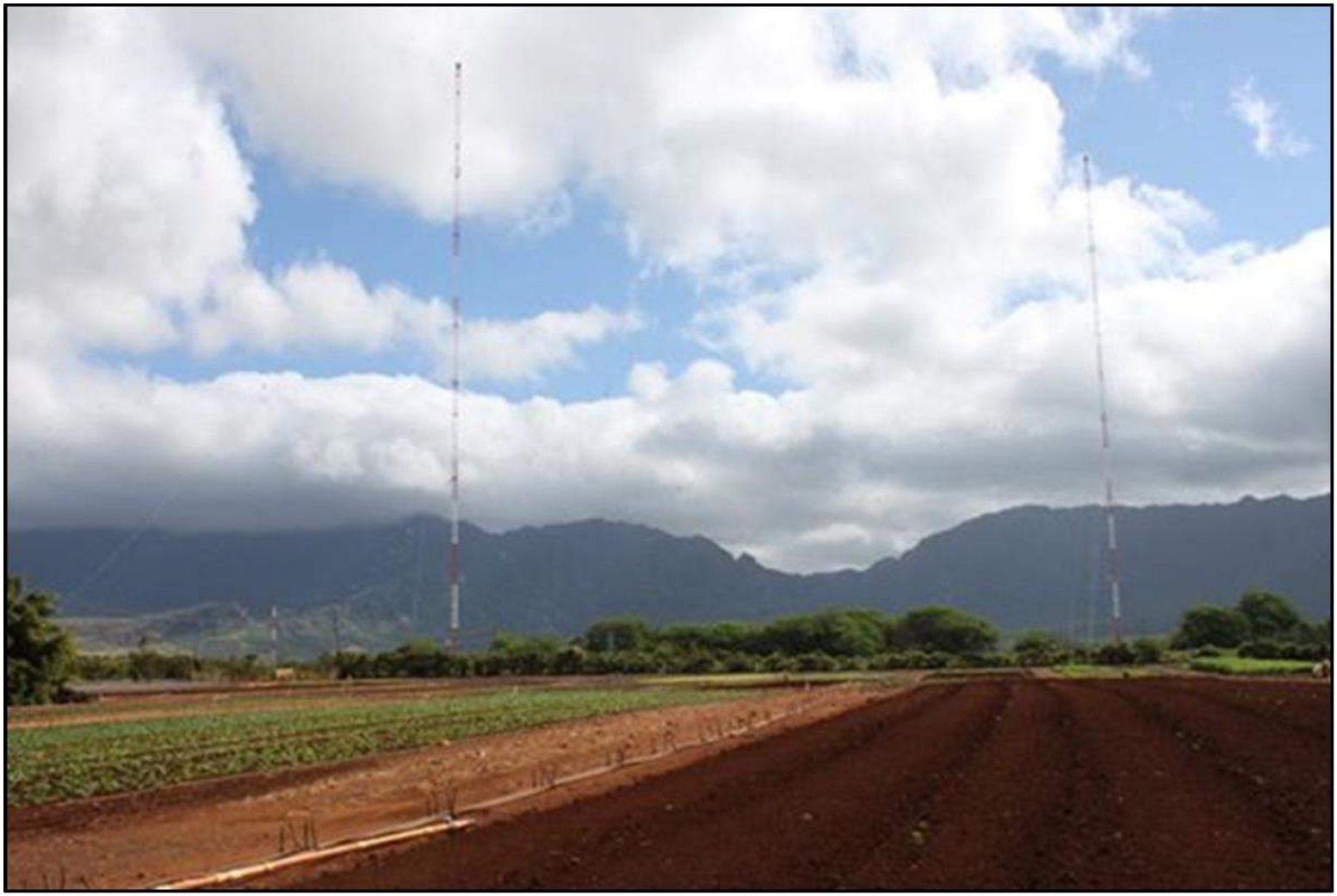

Figure 22. Photo of the two antennas used for the Navy’s communication systems at Lualualei; the two antennas stand at 1,503 ft, the highest structures in the State of Hawai‘i (CSH 2012)

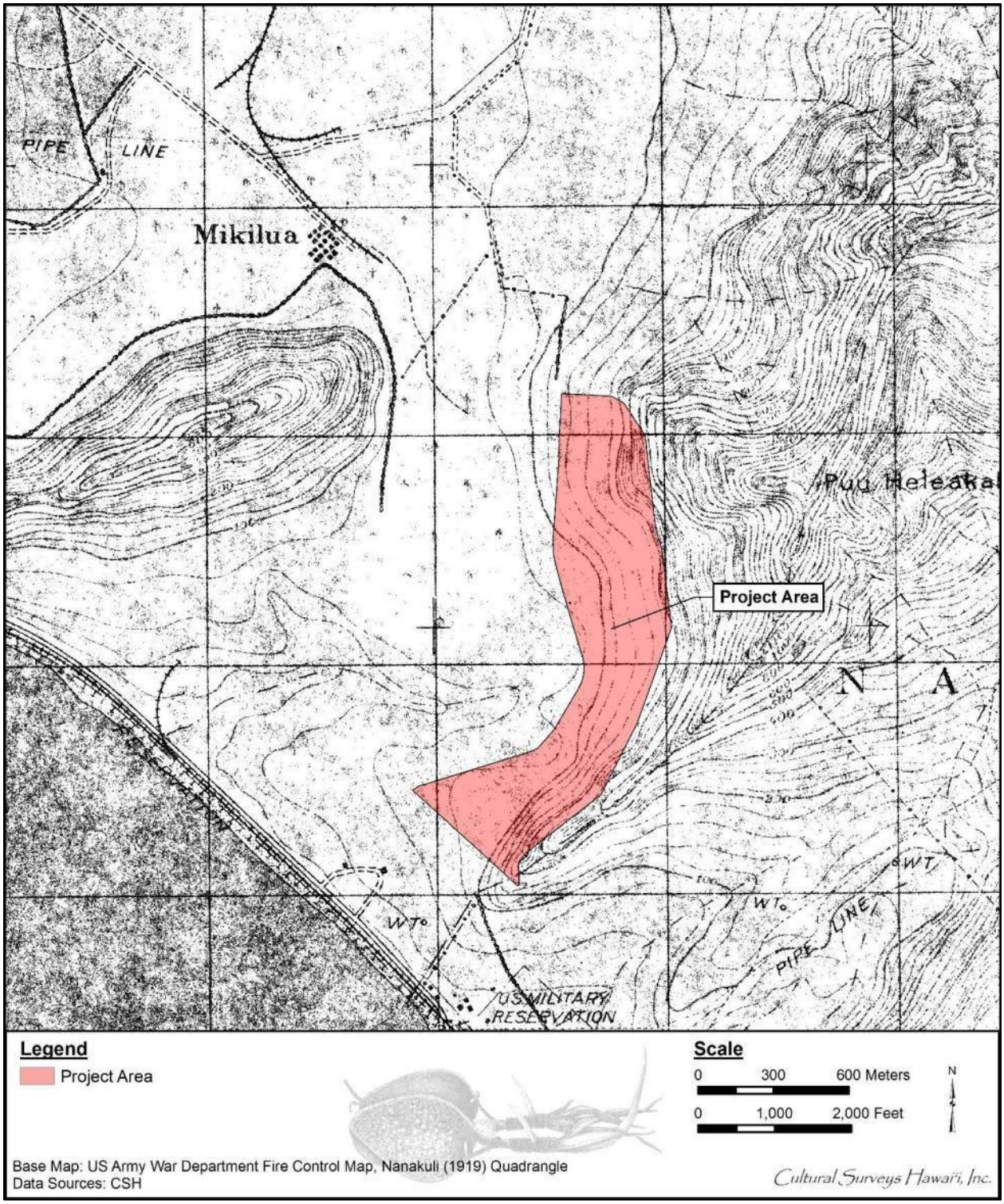

Figure 23. Portion of the 1919 U.S. Army War Department fire control map, Nanakuli quadrangle showing the location of the project area

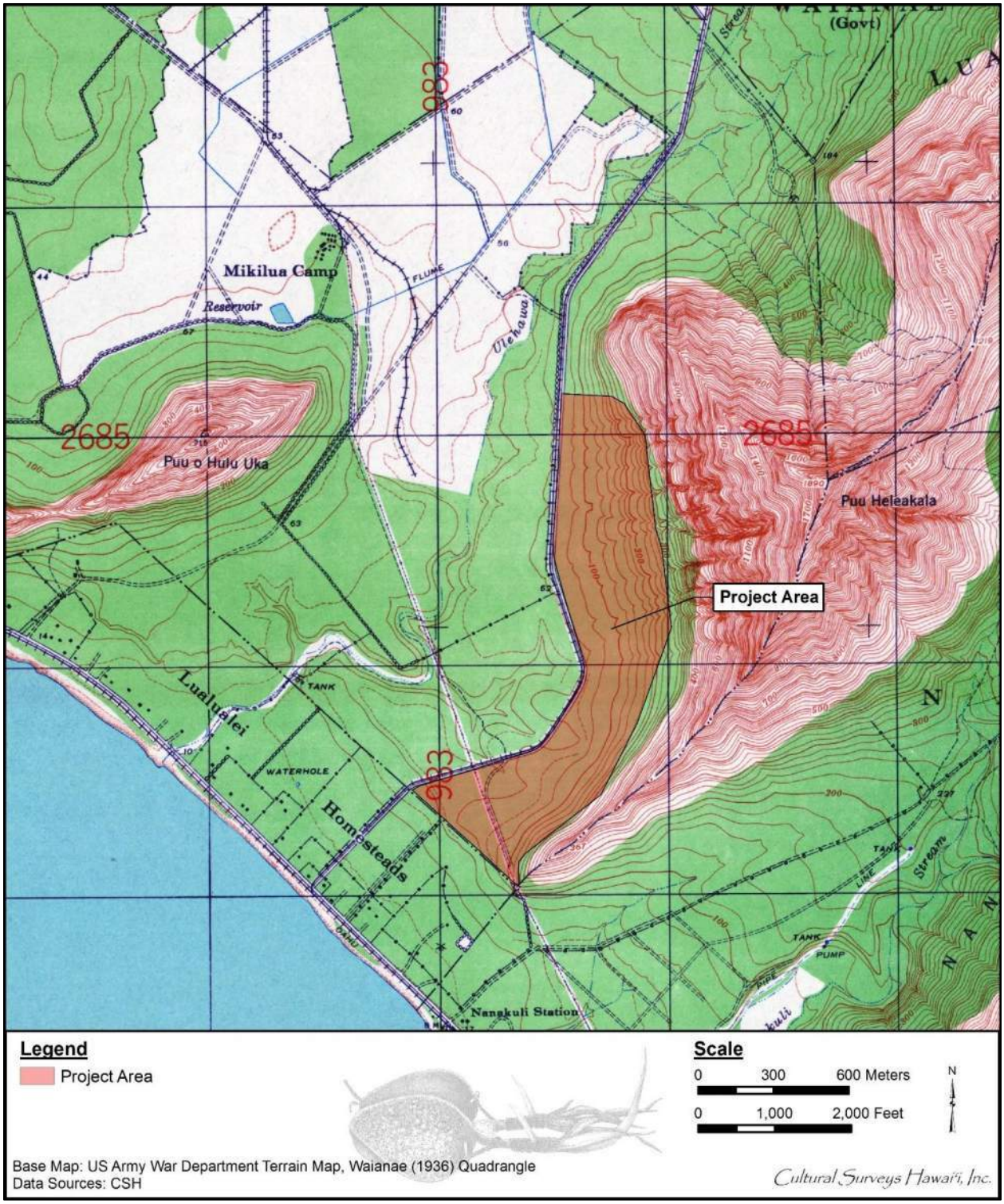

Figure 24. Portion of the 1936 U.S. Army War Department terrain map, Waianae quadrangle, showing location of the project area

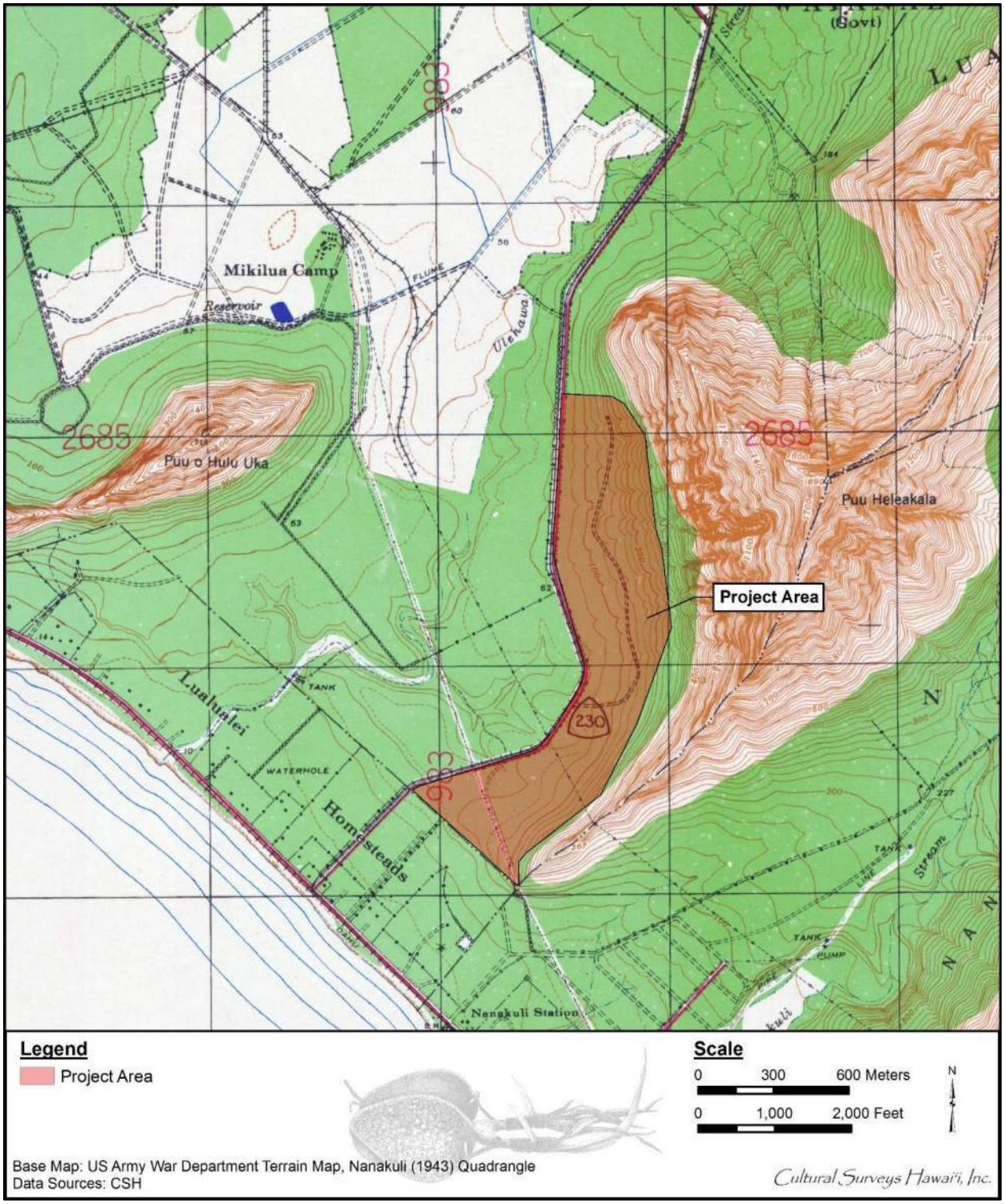

Figure 25. 1943 U.S. Army War Department terrain map, Waianae (1943) and Nanakuli (1943) quadrangles, with project area highlighted in red

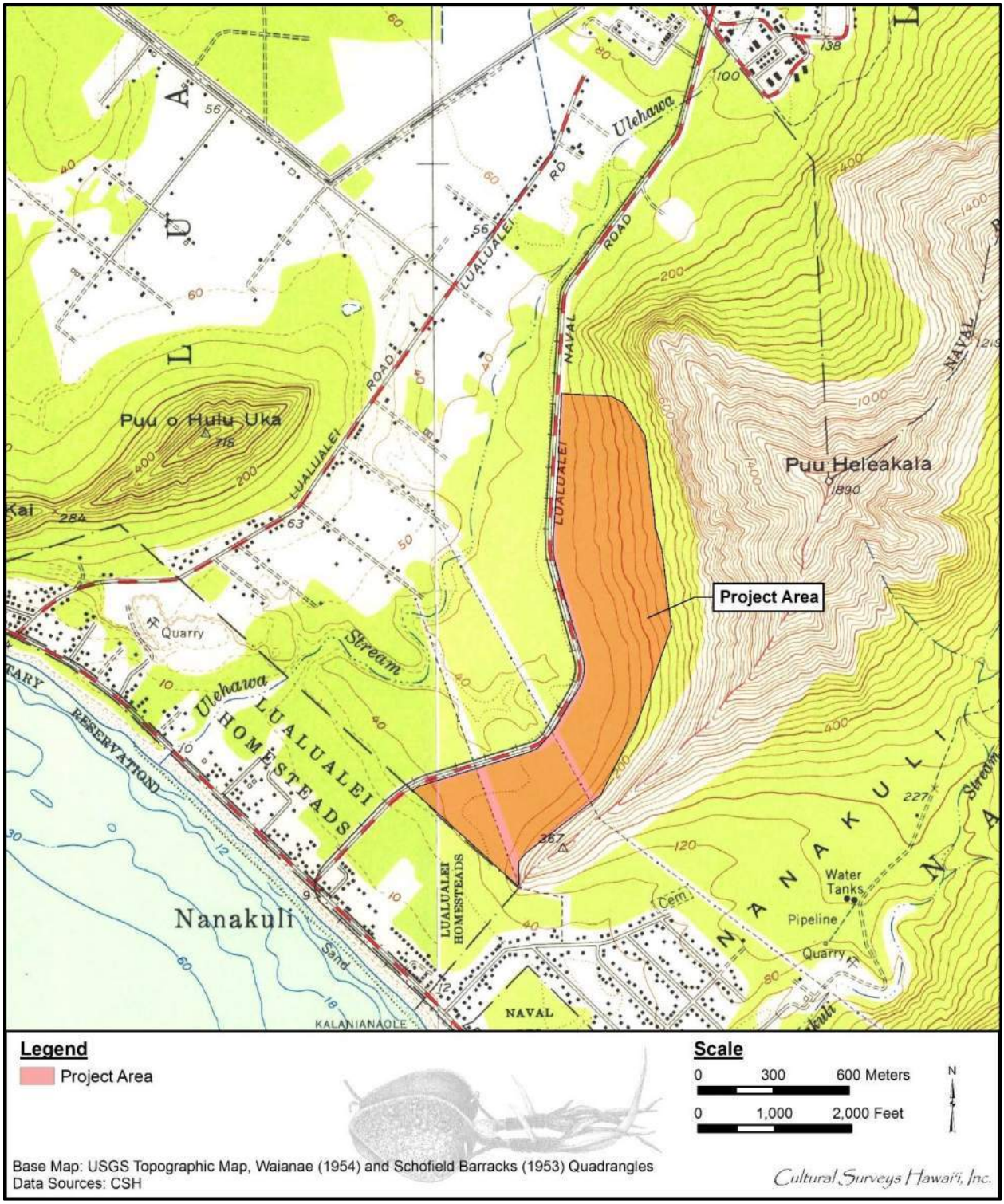

Figure 26. Portion of 1954 Waianae and 1953 Schofield Barracks USGS topographic quadrangles showing location of project area

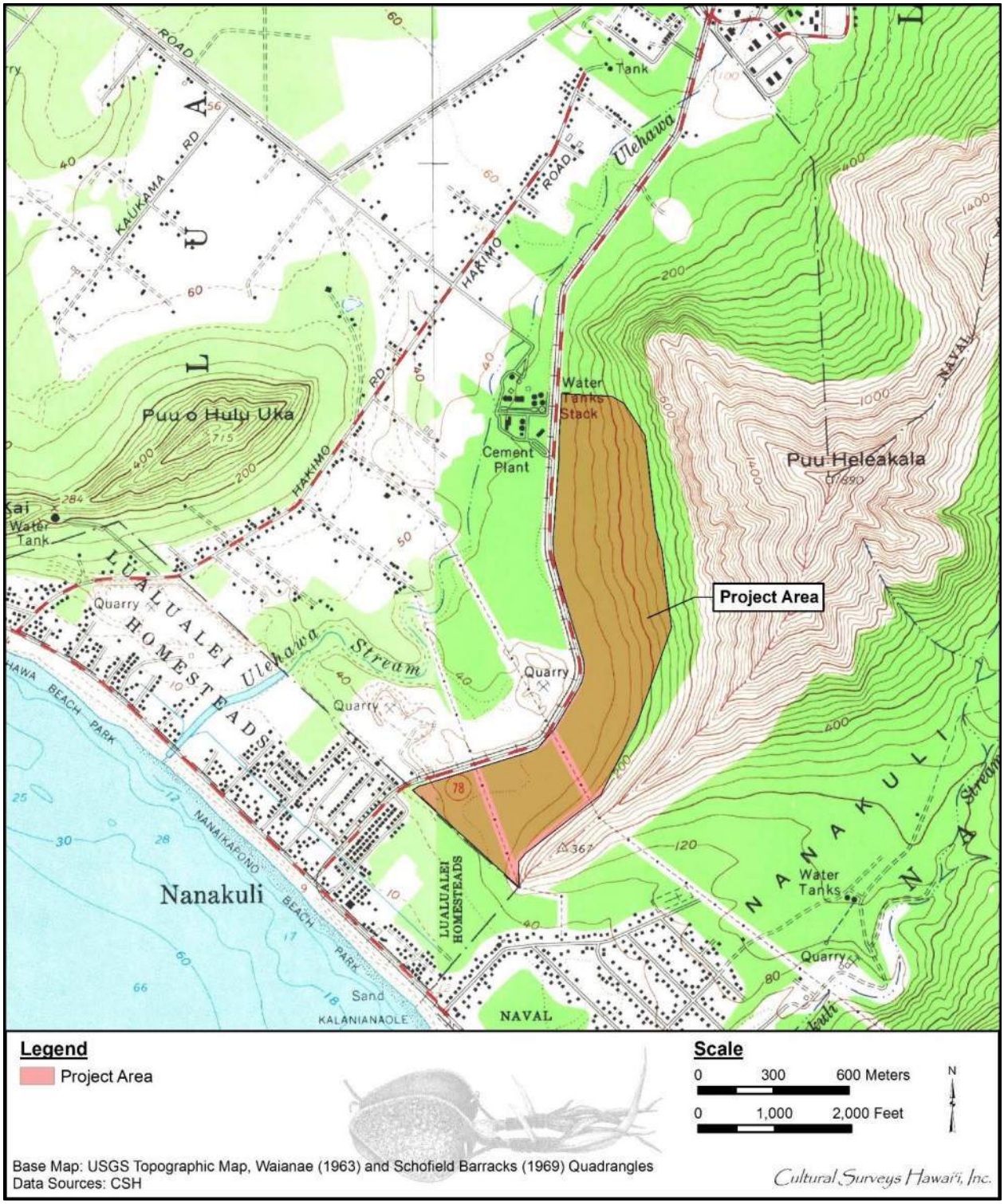

Figure 27. Portion of 1963 Waianae and 1969 Schofield Barracks USGS topographic quadrangles showing location of the project area

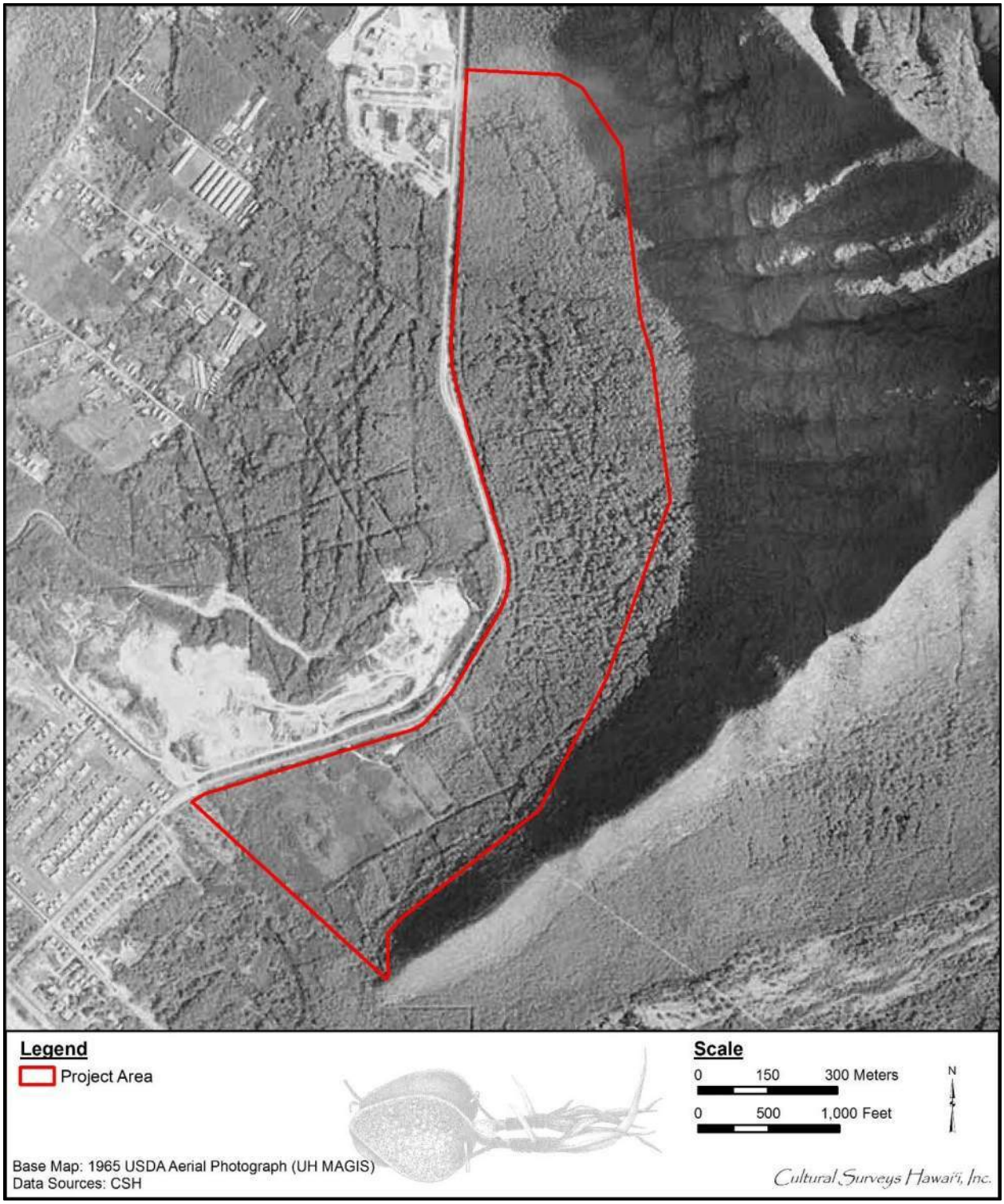

Figure 28. 1965 USDA aerial photograph (UH MAGIS) showing location of project area

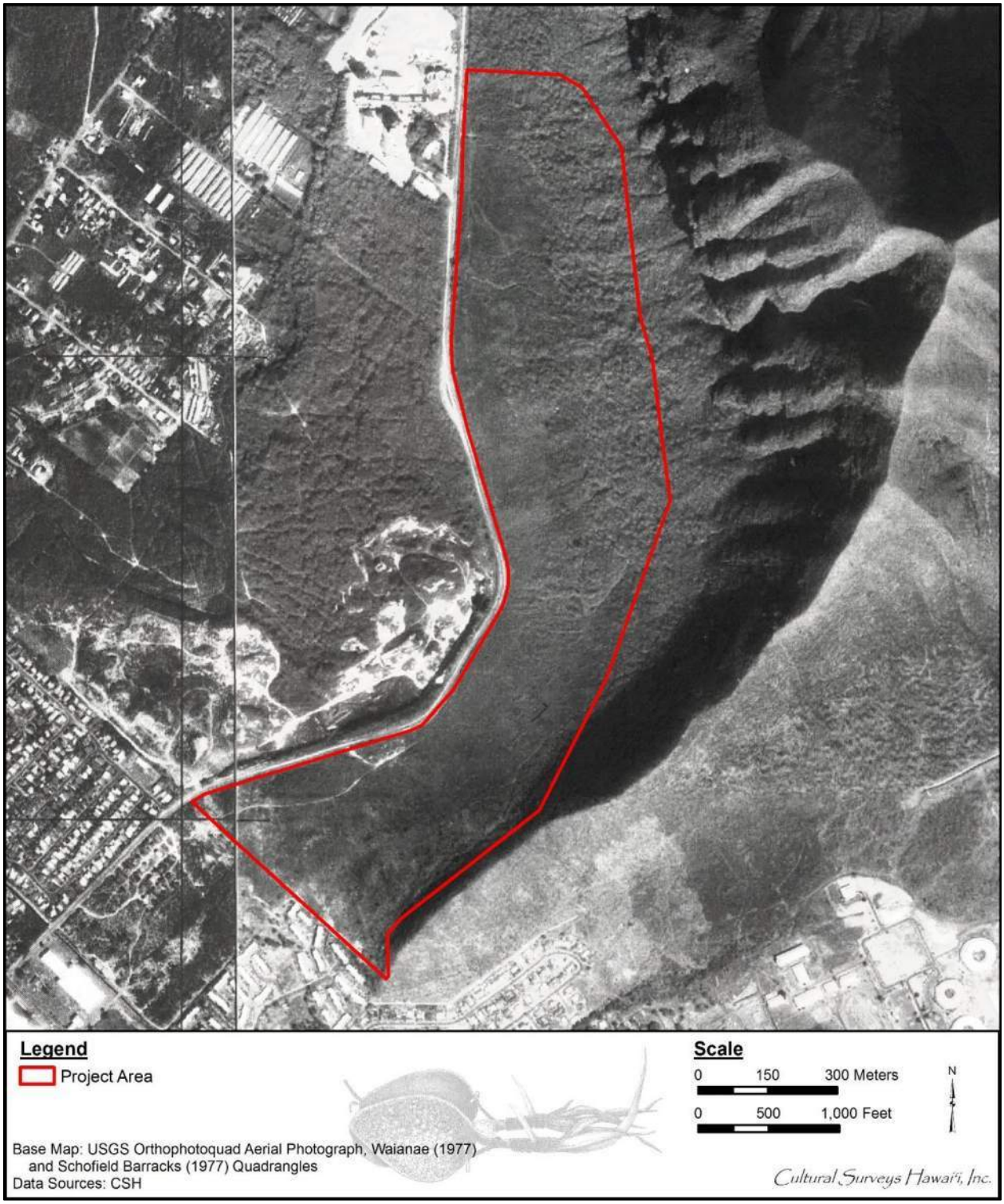

Figure 29. 1977 USGS Orthophotoquad aerial photograph, Waianae and Schofield Barracks quadrangles showing location of project area

Figure 30. 1993 National Oceanic and Atmospheric Administration (NOAA) aerial photograph (UH MAGIS) showing location of project area

Section 5 Previous Archaeological Research

Table 2 summarizes the previous archaeological studies conducted in Lualualei Ahupua‘a, and (illustrated in Figure 31). Previously identified historic properties in the vicinity of the project area are summarized in Table 3 and illustrated in Figure 32.

5.1.1 McAllister 1933

The earliest attempt to record archaeological historic properties in the nearby regions of Lualualei was in the 1930s by J. Gilbert McAllister. Surveying sites on O‘ahu in 1930, McAllister (1933) recorded eight historic properties (Sites 147–153 and 162) in or near Lualualei.

‘Ilihune Heiau, Site 147, was on the border with Nānākuli, south of the present project area. ‘Ilihune Heiau was destroyed by the time of McAllister’s (1933) survey. The locations of ‘Ilihune Heiau (Site 147) and the Māui Rock (Site 148) can be seen in relation to the present project area in Figure 32. McAllister’s (1933) descriptions of Sites 147 and 148 are presented below:

> Site 147. Approximate site of ‘Ilihune Heiau, Nanakuli, of which nothing remains. Thrum notes: ‘A small walled heiau of *pō ‘okanaka* class; used about 1860 by Frank Manini as a cattle pen, for which natives prophesized his poverty and death.’
>
> Site 148. Large rock said to be named Maui, about 1.1 mile from Nanakuli station toward Pu‘u o Hulu.
>
> Northeast of the road on the property of E.P. Fogarty is a rock said to be named after the Hawaiian hero, Maui, who is said to have landed here when he first came to the Hawaiians islands from the south. This stone at the time was surrounded by water, and it was here that Maui reposed and sunned himself. In the bluff just northeast of the rock is a shelter in which he lived, and in the vicinity was a spring where he obtained water. The large rock is now split in half and adorned with many small, oddly-shaped rocks. It is said to be bad fortune to build one’s house across a line drawn directly from the rock to the shore. [McAllister 1933:110]

McAllister (1933) recorded three sites (Sites 149–151) in the *mauka* portion of Lualualei. Site 149 was Nioiula Heiau on Hālona Ridge, said to be of the *pō ‘okanaka* class. Site 150 consisted of house sites or *heiau* at the foot of the cliffs in Pāhoa. Site 151 was Kakaio Heiau at Pūhāwai, which had a sacred spring where the sound of drums and conches could be heard on the nights of Kāne. McAllister’s (1933) descriptions of Sites 149–151 are presented below:

> Site 149. Nioliula heiau, Halona Ridge in Lualualei, just southwest of the Forest Reserve line.
>
> A paved and walled heiau said to have been of *pookanaka* class. The northern portion has been almost completely destroyed, the stones having been used for a cattle pen on the McCandless property. Since cattle put into the pen sickened and died, it was seldom used and is now abandoned. The heiau probably had three inclosures and three platforms open to the west side, but so little remains of the northern part of the heiau that it is difficult to discern inclosures and terraces. This is probably the heiau on which was placed the body of the boxer killed by Kewalo

Table 2. Previous archaeological investigations in Lualualei Ahupua‘a

Reference	Nature of Study	Location	Results (SIHP # 50-80-08)
McAllister 1933	Island-wide reconnaissance survey	Lualualei Ahupua‘a	Recorded eight sites in or near Lualualei: Site 147, ‘Ilihune Heiau; Site 148, Māui Rock; Site 149, Nioiula Heiau on Hālona ridge; Site 150, House sites or *heiau* at Pahoa cliffs; Site 151, Kakioe Heiau at Pūhāwai; Site 152, Pu‘u Pāhe‘ehe‘e Heiau; Site 153, Kū‘īlioloa Heiau; and Site 162, Mauna Kūwale burial cave
Bordner 1977	Reconnaissance survey	TMK: [1] 8-7-009	No historic properties identified
Chiogioji and Hammatt 1993	Archaeological survey and testing	TMK: [1] 8-7-021:017	No historic properties identified
Hammatt et al. 1993	Archaeological inventory survey	Lualualei Golf Course, TMKs: [1] 8-7-009:002; 8-7-010:006, 010; and 8-7-019:001	Identified eight historic properties: two traditional Hawaiian (habitation complex and remnants of a wall) and six post-Contact (cattle wall, furnace, wells, house lot, and cement foundation structure)
Sinoto and Pantaleo 1994a	Reconnaissance survey	TMKs: [1] 8-7-007, 8-7-008, 8-7-009, 8-7-021, and 8-70-22	No historic properties identified
Sinoto and Pantaleo 1994b	Reconnaissance survey	TMKs: [1] 8-7-006, 8-7-008, 8-7-033, and 8-9-002	No historic properties identified
Dega 1998	Reconnaissance survey	TMKs: [1] 8-7-006 and 8-7-007	Observed subsurface cultural layer and WWII-era bunkers (no SIHP #s designated)
McDermott and Hammatt 2000	Archaeological inventory survey	‘Ulehawa Beach Park, TMKs: [1] 8-7-005:001, 003, and 005; 8-7-006:003; and 8-7-008:001, 026	Two subsurface cultural layers designated SIHP #s -5762 and -5763, consisting of midden (marine shell, fishbone) and traditional Hawaiian (fishhooks, volcanic and basalt flakes) and post-Contact (glass, metal, and concrete fragments) artifacts; layers likely date to late pre- or early post-Contact period

Reference	Nature of Study	Location	Results (SIHP # 50-80-08)
Elmore and Kennedy 2001	Archaeological inventory survey	Mahina‘au Rd from Maiu‘u Rd to Kaulawaha Rd	Documented two historic properties: SIHP # 50-80-07-5949, subsurface cultural layer with associated features (including human remains), and SIHP # -5950, a portion of sugar plantation camp and associated infrastructure features (water pumping station, foundations, and well)
Kennedy 2003	Addendum archaeological inventory survey	TMKs: [1] 8-7-008:076 and 077	No historic properties identified; documented three sinkholes, none determined to be significant
Ostroff and Desilets 2005	Archaeological monitoring	Farrington Hwy between Hakimo Rd and Haleakala Ave	Documented charcoal-enriched sand deposits possibly associated with SIHP # -5763 (subsurface cultural deposit)
Jones and Hammatt 2006	Archaeological monitoring	La‘ikū, Wai‘olu and Princess Kahanu streets	No historic properties identified
O’Leary and McDermott 2006	Archaeological inventory survey	Proposed Nānākuli B Site Materials Recovery Facility and Landfill	Identified two historic properties: SIHP #s -6681, WWII-era concrete bunker, and -6699, likely pre-Contact basalt rock shelter
Souza and Hammatt 2006	Archaeological monitoring	Farrington Hwy between Nānākuli Ave and Hakimo Rd	No historic properties identified
Hammermeister and McDermott 2007	Addendum archaeological inventory survey	Proposed Nānākuli B Site Materials Recovery Facility and Landfill	Investigated a stacked stone mound, designated as SIHP # -6920
Hammatt and Shideler 2010	Supplemental archaeological inventory survey and interim protection measures implementation	TMK: [1] 8-7-009:002 por.	Further documentation and implemented preservation measures for SIHP # -4366, terrace remnants
Dagher and Spear 2011	Literature review and field inspection	Pacific Mall, TMK: [1] 8-7-008:012	No historic properties identified

Reference	Nature of Study	Location	Results (SIHP # 50-80-08)
Mierzejewski and Hammatt 2014	Archaeological monitoring	Ulehawa Beach Park	No historic properties identified
Hammatt and Shideler 2015	Literature review and field inspection	TMK: [1] 8-7-007:005	No historic properties identified
Stark et al. 2015	Literature review and field inspection	TMKs: [1] 8-7-009:025 and 8-7-021:026	Two potential historic properties: CSH 1, dry-stacked historic (ca. 1936) rock wall, and CSH 2, linear pile of boulders
DeMaio Starr et al. 2016	Archaeological inventory survey	TMK: [1] 8-7-007:001	No historic properties identified
Hammatt and Shideler 2018	Reconnaissance survey	TMKs: [1] 8-7-033:001 and 027	No historic properties identified
Hammatt et al. 2018	Reconnaissance survey	TMK: [1] 8-7-033:001	No historic properties identified

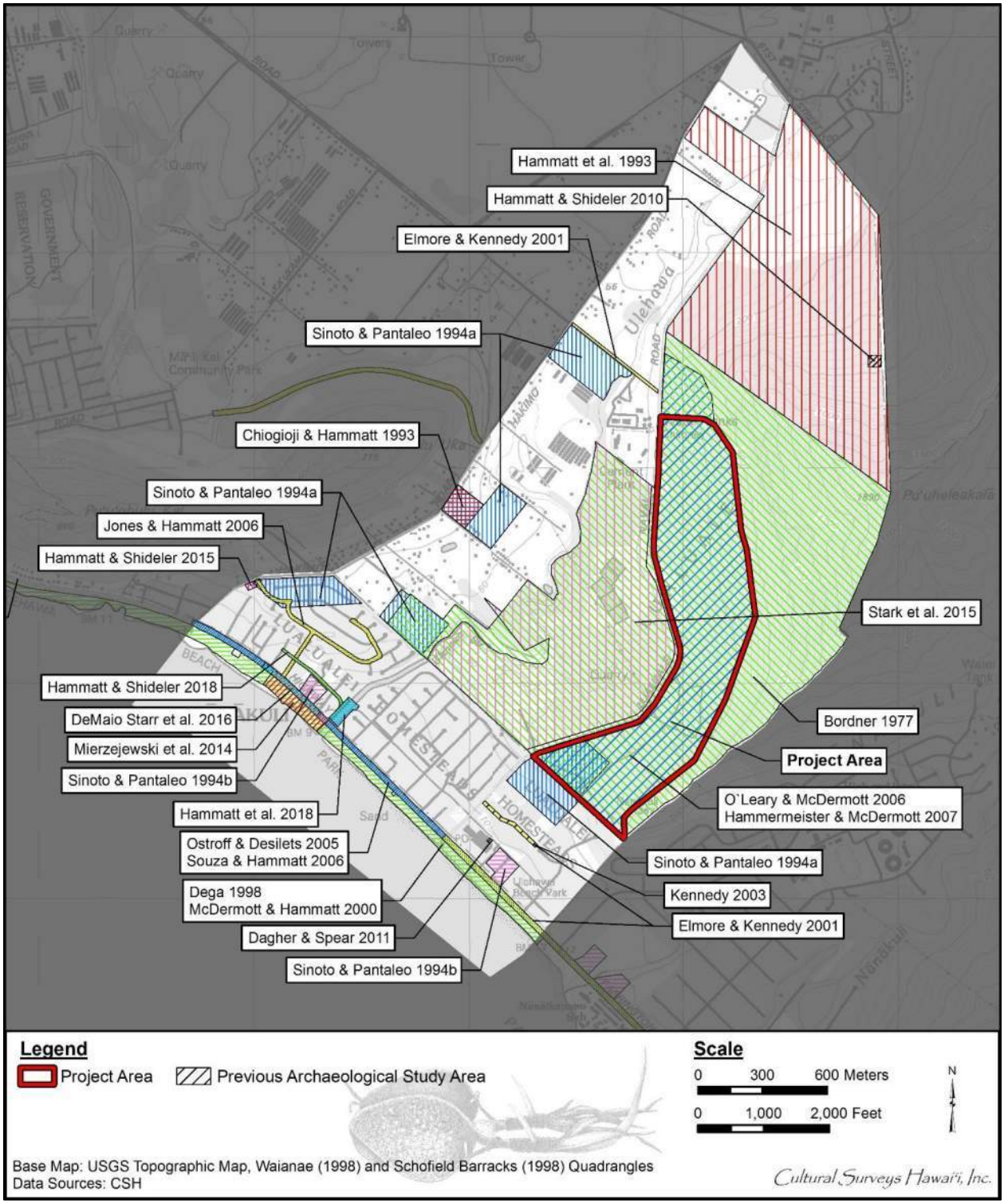

Figure 31. Portions of the 1998 Waianae and Schofield Barracks USGS 7.5-minute topographic quadrangles showing previous archaeological studies in the vicinity of the project area.

Table 3. Previously identified historic properties in the vicinity of the project area.

SIHP # 50-80-08	Formal Type	Description	Source
-148	Māui Rock	Large boulder	McAllister 1933:110
-4364	Wall	Associated with ranching	Hammatt et al. 1993:25
-4365	Shelter	Military	Hammatt et al. 1993:25
-4366	Habitation complex	–	Hammatt et al. 1993:25
-4367	Wall	Agricultural	Hammatt et al. 1993:25
-4370	House lot	Associated with ranching	Hammatt et al. 1993:25
-4371	Wells	Associated with ranching	Hammatt et al. 1993:25
-4372	Foundation	Associated with ranching	Hammatt et al. 1993:25
-4373	Incinerator	Associated with military/ranching	Hammatt et al. 1993:25
-5761	Bunkers and slabs	WWII-era military	McDermott and Hammatt 2000:144–147
-5762	Subsurface cultural layer	Pre- and/or early post-Contact	McDermott and Hammatt 2000:147
-5763	Subsurface cultural layer	Pre- and/or early post-Contact	McDermott and Hammatt 2000:147–149
-6681	Military infrastructure	WWII-era concrete bunker	O’Leary and McDermott 2006
-6699	Rock shelter	Small pre-Contact basalt rock shelter	O’Leary and McDermott 2006
-6920	Stone mound	Stacked stone mound interpreted as a traditional Hawaiian marker	Hammermeister and McDermott 2007
-9714	OR&L railroad	Railroad bed	McDermott and Hammatt 2000:149
CSH 1	Wall	Dry-stacked historic (ca. 1936) rock wall	Stark et al. 2015
CSH 2	Linear pile of boulders	Possibly a result of mechanical bulldozer push	Stark et al. 2015

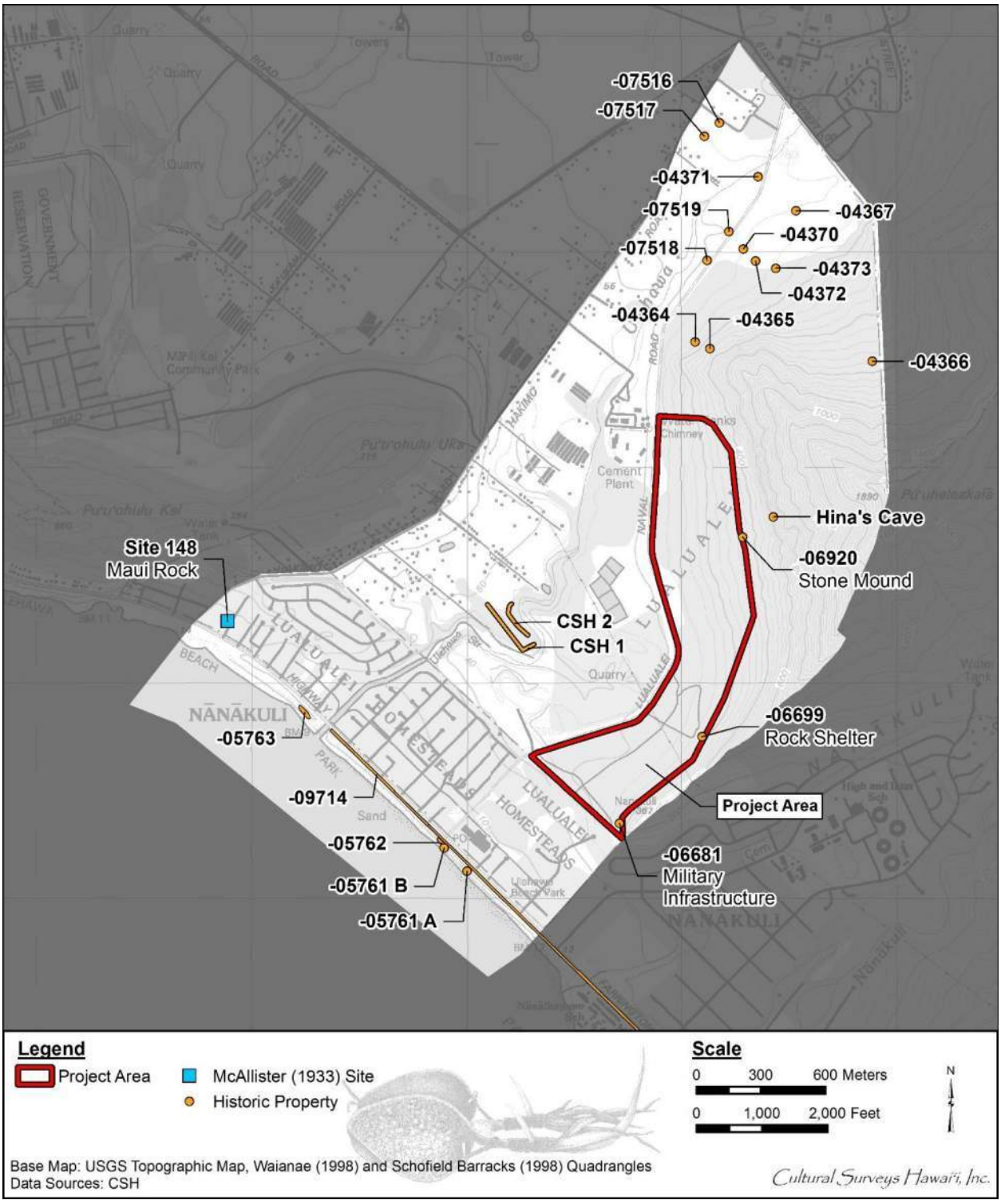

Figure 32. Portions of the 1998 Waianae and Schofield Barracks USGS 7.5-minute topographic quadrangles showing previously identified properties in the vicinity of the project area

> and offered as a sacrifice to the gods. The temple is said to have been very ancient, belonging to the chief, Kakuihewa.
>
> Site 150. House sites or heiaus, middle of Lualualei at the foot of cliffs, Pahoa.
>
> Innumerable walls and small terraces that have been house sites or possibly very old heiaus whose sites have long since been forgotten by the natives are located on the ends of small ridges, the sea sides of most of which are covered with rough lava rocks. These small prominences have been leveled off and some have been walled and paved with smooth stones. None of the sites are sufficiently preserved to indicate a plan, for this has been a cattle range almost since the coming of Europeans, and the cattle have scattered many a wall and terrace in grazing.
>
> Site 151. Kakioe heiau was located at Puhawai, Lualualei. Thrum notes: ‘A small heiau of which nothing now remains but its sacred spring, and the sound of its drums and conchs on the nights of Kane.’ [McAllister 1933:110]

McAllister recorded three sites near the boundary of Lualualei and Wai‘anae, far north of the present project area. Site 152, Pu‘u Pāhe‘ehe‘e Heiau, consisted of a walled *heiau* on the slopes of Pāhe‘ehe‘e Ridge. It was destroyed by the time of McAllister’s (1933) survey. At the tip of Kāne‘īlio Point was Site 153, Kū‘īlioloa Heiau, which was surrounded by water on three sides and consisted of three platforms with evidence of terracing. Site 162 was a burial cave at Mauna Kūwale, which contained fragments of skeletal material. McAllister’s (1933) descriptions of Sites 152, 153, and 162 are presented below:

> Site 152. Puupaheehee heiau, on the sea end of Puupaheehee Ridge. Completely destroyed with the enlargement of the Oriental cemetery. According to Thrum it was of *luakini* class. Thrum adds:
>
> A walled heiau of two or three divisions, the upper section being 70 feet across, by 57 feet in its width; the lower ones not so well defined. Its slopes in ancient time, covered with slippery grass strewn for the purpose, was the scene of sledding contests, hence its name. Of late its north and western slopes have been assigned as a burial place for Orientals.
>
> Site 153. Kuilioloa heiau, on the extreme tip of Kaneilio Point.
>
> The heiau is surrounded on three sides by water. It has three platforms, with evidence of terracing. The most important platform, evidently is at the end of the point. It is the highest, and terraces once marked the three sides toward the sea. Sand and dirt have been filled in between large stones. The second platform is lower than the first and is slightly wider. The pavement is similar to the first and, like the first, the walls were made by standing large pieces of lava on end and filling in. The walls have a flat, even facing. The third platform is lower than the second and can only be distinguished from the ground to the north and west by a row of stones in the grass. It is evenly paved with sand and may possibly have been used for house sites, as suggested by Thrum. [McAllister 1933:112]

5.1.2 Bordner 1977

A 1977 reconnaissance survey for the proposed Nānākuli landfill recorded no archaeological historic properties (Bordner 1977). The survey area included land on both sides of Lualualei Naval Road, continuing up the slope to Pu‘u Heleakalā.

5.1.3 Chiogioji and Hammatt 1993

During an archaeological study conducted on a 5-acre parcel, formerly a basil farm, no archaeological historic properties were documented (Chiogioji and Hammatt 1993). The parcel is between Pu‘u o Hulu and ‘Ulehawa, north of the current study area.

5.1.4 Hammatt et al. 1993

An archaeological inventory survey (AIS) of an approximately 170-acre parcel southeast of the Naval Magazine was conducted by CSH (Hammatt et al. 1993). The parcel is described as comprising “vacant, unused lands. It is undeveloped and contains several remnant and abandoned historic structures” (Hammatt et al. 1993:7). Eight archaeological historic properties were identified, including “two traditional Hawaiian sites and six historic sites related to ranching and military activities” (Hammatt et al. 1993:i). The two traditional Hawaiian sites are SIHP #s 50-80-08-4366, site complex, and -4367, wall remnant. SIHP # -4366 likely represents pre-Contact, recurrent habitation at the foothills of Pu‘u Heleakalā. This is primarily evidenced by the presence of a probable hearth feature within the site complex. The location of SIHP # -4367, adjacent to an intermittent streambed, suggests an agricultural usage; Hammatt et al. (1993) suggest it was constructed to retain or divert water. Given the weathered condition of the structure, SIHP # -4367 may be also be pre-Contact (Hammatt et al. 1993:28).

The paucity of Hawaiian sites within the study parcel, in comparison to the number within the large Naval Magazine study area to the north and *mauka*, suggested to Hammatt et al. (1993) that the parcel may represent, at most, the *makai*-most fringe of the inland settlement. The survey report concludes the following:

> The few traditional Hawaiian sites identified during the present study suggest that most of the project area was sparsely inhabited during prehistory and early history. This would be due primarily to the lack of fresh water resources in the vicinity . . . Although surface run-off and intermittent drainage present in the project area would allow some potential for seasonal agriculture, the attraction for settling in the wetter upland valleys would surely have been greater. [Hammatt et al. 1993:31]

5.1.5 Sinoto and Pantaleo 1994a

Aki Sinoto Consulting completed a reconnaissance level archaeological survey for six potential sites for the Nanakuli III Elementary School project. No historic properties were identified within the six candidate sites.

5.1.6 Sinoto and Pantaleo 1994b

Aki Sinoto Consulting completed a reconnaissance level archaeological survey for five potential sites for the Nanakuli Public Library project. No historic properties were identified within the five candidate sites.

5.1.7 Dega 1998

In 1998 Scientific Consulting Services, Inc. (SCS) provided a review of archival research and results of a reconnaissance survey completed within Ulehawa Beach Park. The author noted that SIHP # 50-80-12-9714 (OR&L Railroad line remnants) have been identified within the study area. During the reconnaissance survey, SCS documented a subsurface cultural layer with extensive charcoal flecking and faunal osseous remains, as well as three World War II-era bunkers. The features were noted briefly, though no SIHP # designations were provided.

5.1.8 McDermott and Hammatt 2000

In 1999, CSH (McDermott and Hammatt 2000) conducted an AIS on a 57.65-acre parcel of ‘Ulehawa Beach Park. Two subsurface cultural layers, designated as SIHP #s 50-80-08-5762 and -5763, were found during test excavations that covered approximately 2% of the project area. The deposits consisted of midden (marine shell, fish bone) and both traditional Hawaiian (fishhooks, volcanic and basalt flakes) and post-Contact (glass, metal, and concrete fragments) artifacts. Of particular interest was a nearly complete, barb-less pearl shell fishhook with an unusually deep V-bend reminiscent of Marquesan or Tahitian hooks. This type of fishhook is considered atypical for Hawaiian fishhooks. Both cultural layers appeared to date to the late pre-Contact or very early post-Contact period.

Also noted in this report is an area identified by a local informant to contain burials and cultural deposits (McDermott and Hammatt 2000:43). This area extends approximately from ‘Ulehawa Stream northwest. Mr. Walter Kamanā’s comments pertaining to the present project area follow:

> The land from the bathrooms, just north of ‘Ulehawa drainage, on around Mā‘ili point is all *kapu* (taboo) ground. The night marchers are active at this place. There have been problems associated with that area, including violence and tragedy, including car wrecks. There were lost souls at that place in Hawaiian times. It is likely that you will find Hawaiian remains in the area. There are burials there on the *makai* side of Farrington Highway. A testing crew went in there to test the area, but Mr. Kamana did not know what for. Bones were found, but the public was not informed.
>
> Just beyond Hakimo Road, on the *makai* side of Farrington Highway, is a place called by the Japanese ‘Takamina’, where the Japanese shrine stands today. [a “fishing marker” approximately 500 m north of Hakimo Road]. The Japanese shrine is not only important because of the Japanese culture and beliefs, but because of Hawaiian culture and beliefs as well. It was formerly a shrine area for the Hawaiians, but the shrine area has been largely forgotten by local Hawaiian residents. The shrine area should be respected at all times. Mr. Kamana mentions it as a ‘Point to Point (?) burial ground’. That place must be respected. [McDermott and Hammatt 2000:43]

A number of historic-era structures, such as concrete World War II bunkers, were also noted in the ‘Ulehawa Beach Park studies (Dega 1998:5; McDermott and Hammatt 2000:143–147). Two World War II-era concrete foundations were observed seaward of Farrington Highway.

5.1.9 Elmore and Kennedy 2001

Archaeological Consultants of the Pacific, Inc. completed an AIS along Mahina‘au Road from Maiu‘u Road to Kaulawaha Road. The survey included 100% pedestrian inspection and 36 test excavations. The AIS identified two historic properties: SIHP # 50-80-07-5949, subsurface cultural layer and associated features, including one human burial, and -5950, a portion of a sugar plantation camp and pumping station, including the water pumping station, foundations, and a well.

5.1.10 Kennedy 2003

Archaeological Consultants of the Pacific, Inc. completed an addendum AIS for the Wai‘anae Coast Emergency Access Road project. During the initial AIS investigation three potential cultural features were documented, all three possible sinkholes. The addendum AIS report determined the sinkholes not to be significant historic properties, and no additional historic properties were documented during the addendum investigation.

5.1.11 Ostroff and Desilets 2005

Garcia and Associates conducted archaeological monitoring for water line replacements along Farrington Highway between Hakimo Road and Halekala Avenue. The monitoring program documented five areas of charcoal-enriched sand deposits, one of which was suggested to be associated with SIHP # 50-80-07-5763 (subsurface cultural deposit). No additional historic properties were identified during the archaeological monitoring program.

5.1.12 Souza and Hammatt 2006

CSH conducted archaeological monitoring for the Fiber Optic Line project along Farrington Highway between the streets of Nānākuli Avenue and Hakimo Road. Documented stratigraphy was entirely composed of fill, and no historic properties were identified during the archaeological monitoring program.

5.1.13 Jones and Hammatt 2006

Jones and Hammatt (2006) completed a monitoring report for sections of La‘ikū, Wai‘olu and Princess Kahanu Streets for a water main installation. No historic properties were identified during monitoring.

5.1.14 O’Leary and McDermott 2006

CSH (O’Leary and McDermott 2006) conducted an AIS of 200 acres for the proposed Nānākuli B Site Materials Recovery Facility and Landfill, Lualualei Ahupua‘a; note this area largely overlaps with the current project area (it extended slightly farther north). Two historic properties were identified, both within the current project area:

- SIHP # 50-80-08-6699, small pre-Contact basalt rock shelter
- SIHP # -6681, World War II concrete bunker

Full historic property descriptions are presented in Section 8 of the current report.

O’Leary and McDermott (2006) describe the project area, which includes the present project area, as follows:

> There has been substantial ground disturbance within the project area at some point in the past, as large portions of the project area show signs of bulldozer activities. Within the project area, pushed up mounds of dirt and raised berms and banks were observed by the field personnel. Several of these appeared to have been cut into the hill in order to channel water run-off. It was not possible to tell when the bulldozing took place, but almost all of the moved earth had extensive grass growth. Numerous basalt boulders throughout the property have bulldozer scars on them, indicating that their current location is due to modern activities. The project area also has a developed dirt road, which is currently in use, that runs from an access gate at the very southwest corner of the property to the two large water tanks along the hill slope. The road is a graded mix of the sediment extending down from the hillside and broken up limestone. There are also several older roads that are overgrown with vegetation but are still visible in various places on the property . . . This extensive previous modification is likely the reason that surface archaeological remains were not found over most of the property.
>
> At several locations within the project area, boulders that had been broken by bulldozers were observed to be of relatively fine-grained high quality basalt that could have served as raw material for stone tools. A large dike that crosscuts the regular stratigraphy of Pu‘u Hekeakalā is the possible source of these rocks. In a handful of locations within the project area, basalt flakes were observed during the AIS. Unfortunately, it is difficult to determine if these fine-grained basalt flakes are pre- and/or early post-Contact lithic reduction debitage or incidentally fractured stone related to modern bulldozer modifications.
>
> Overall, the extensive evidence of bulldozer activity suggests that any sites that may have been in the flatter sections of the project area have long since been destroyed. These observations correspond with the fact that the only two SIHP were found along the steeper edge of the project area.
>
> The only other non-natural objects observed on the landscape were a few scattered rusty barrels, two stripped and rusted cars, and numerous abandoned rusting appliances that have been dumped into the tall *koa haole* along Lualualei Naval Road at the southern end of the project area. [O’Leary and McDermott 2006:13]

5.1.15 Hammermeister and McDermott 2007

CSH (Hammermeister and McDermott 2007) returned to the proposed Nānākuli B Site Materials Recovery Facility and Landfill (see O’Leary and McDermott 2006 above) to investigate a stacked stone mound found on the project’s eastern upslope boundary. The feature was excavated and interpreted as a traditional Hawaiian marker. It is within the current project area and was assigned SIHP # 50-80-08-6920.

5.1.16 Hammatt and Shideler 2010

In 2010, CSH documented the condition of SIHP # 50-80-08-4366, which consists of a terrace, attached enclosure, and adjacent modified outcrop. Condition of the historic property appeared to be largely the same as when it was originally documented. CSH erected a continuous line of 4-ft

tall plastic orange fencing around the site as a protective measure. The study did not document any additional historic properties.

5.1.17 Dagher and Spear 2011

SCS conducted a literature review and field inspection for AT&T telecommunications at the Pacific Mall (Dagher and Spear 2011). The field inspection noted no historic properties in close proximity to the cell tower in question.

5.1.18 Mierzejewski et al. 2014

From 2013 to 2014, CSH conducted archaeological monitoring for the Ulehawa Beach Park Wastewater Treatment Reconstruction project. Documented stratigraphy largely consisted of fills overlying natural alluvial deposits and natural marine sand. No historic properties were identified during the archaeological monitoring program.

5.1.19 Hammatt and Shideler 2015

In 2015, CSH conducted an archaeological literature review and field inspection for the Lualualei Line Booster System Improvements project. No surface historic properties were identified during the field inspection, and potential for subsurface historic properties was evaluated as low.

5.1.20 Stark et al. 2015

CSH (Stark et al. 2015) prepared an archaeological literature review and field inspection report for the PVT Integrated Solid Waste Management Facility (ISWMF)–Expanded Recycling, Landfill Grading and Renewable Energy project in Lualualei Ahupua‘a (TMKs: [1] 8-7-009:025 and 8-7-021:026). Two potential historic properties were described with temporary site designations:

- CSH 1 is a dry-stacked historic (ca. 1936) rock wall, 125 cm high by 80 cm wide and approximately 400 m long, extending beyond the project area to the northwest for several kilometers. CSH 1 is composed of dry-stacked coral limestone. The wall is bi-faced with in-fill and with a rectilinear cross section.
- CSH 2 is a linear pile of boulders meandering along the top margin of a break in slope so as to form a terrace and appears to have in-filling on the high side of the terrace. The pile of stones in CSH 2 is substantial (approximately 220 m long by 1.5 m wide) and appears to have been created either as a result of a mechanized bulldozer push and/or hand-piling along the top of the break in slope.

5.1.21 DeMaio Starr et al. 2016

In 2016, CSH conducted an AIS for the Farrington Highway Drainage Improvements project. No historic properties were identified within the project area.

5.1.22 Hammatt and Shideler 2018

In 2017, CSH completed an archaeological literature review and field inspection of a 0.34-acre area within the Waianae Flood Control Right-of-Way (U-1), for the proposed repair of a portion of the U-1 channel. Aside from the U-1 channel itself, no additional historic properties were documented.

5.1.23 Hammatt et al. 2018

In 2018, CSH completed an archaeological literature review and field inspection for the Ulehawa U-1 Channel Improvements project. Aside from the U-1 drainage ditch itself and the channelization of Ulehawa Stream, no additional historic properties were observed.

5.1.24 Shideler and Hammatt 2018 (not depicted in Figure 31)

In 2018, CSH conducted a field inspection within the proposed PVT Relocation of Integrated Solid Waste Management Facility project area. The fieldwork, which included pedestrian inspection and GPS data collection, focused on relocating three historic properties (SIHP #s 50-80-08-6681, -6699, and -6920) identified during previous studies within the project area in order to assess their current conditions. SIHP #s -6681, World War II-era military bunker, and -6699, traditional Hawaiian rock shelter, were documented during a 2006 AIS by O’Leary and McDermott. SIHP # -6920, rock mound interpreted as a traditional Hawaiian marker, was documented during an addendum AIS by Hammermeister and McDermott the following year (2007). In addition, one historic property (Māui Rock, SIHP # 50-80-07-0148) and a *wahi pana* (Hina’s Cave, no SIHP number) outside the present project area were also investigated and documented during the field inspection.

The Māui Rock (SIHP # 50-80-07-0148) and Hina’s Cave were found to be free of recent disturbance, with no rubbish or offerings (e.g., *lei*) observed. The view from Hina’s Cave southwest toward the Māui Rock was found to be relatively clear, as the cave is sufficiently elevated above the filled land in between to maintain an unbroken view (Figure 33). However, the view from the rock northeast toward the cave is blocked by a residential duplex subdivision (Figure 34).

5.1.25 Other Relevant Studies

An archaeological study by Hammatt et al. (2001) evaluated the available data on burials in the vicinity of the present project area. The study notes that a document in SHPD Burials Program files entitled “Burial Sites and Grave Sites Graveyards and Cemeteries Case Inventory” (page 19) has the following line item:

* Ma‘ili - Cave Burials / ID (#584)

* human remains re-interred.

It is less than clear whether there are known remains in Mā‘ili Cave, or where this cave may be. This 2001 study also notes that a few historic properties in Lualualei are traditionally associated with human deaths. Nioiula Heiau on Hālona Ridge (Site 149; also known as Hālona Heiau) was said to have been of the *po‘okanaka* class (McAllister 1933:110, Westervelt 1915a:122, Westervelt 1915b:178, Thrum 1908:47), which suggests associations with human sacrifice; however, this site was at the south base of the Pāhoa Cliffs of the Wai‘anae Range. There are numerous accounts associating Kolekole Pass and vicinity with battles and mortal combat (Sterling and Summers 1978:67), but the area referred to is Pōhākea Pass. ‘Ilihune Heiau (Site 147, reported as destroyed by 1930), also said to be of *po‘okanaka* class (McAllister 1933:110, Thrum 1906:47), lay closer at the tip of the Heleakalā Ridge, southeast of the present project area. This 2001 study also notes that a Lualualei map by Emerson, dated October 1901 (Registered Map 2040), shows an annotation of “Maili Grave” on the seaward side of present-day Farrington Highway.

Figure 33. View from Hina’s Cave looking toward SIHP # 50-80-07-0148, Māui Rock, view to southwest (Shideler and Hammatt 2018)

Figure 34. View from SIHP # 50-80-07-0148, Māui Rock (on right), looking toward Hina’s Cave, view to northeast (Shideler and Hammatt 2018)

Section 6 Community Consultation

6.1 Introduction

Throughout the course of this assessment, an effort was made to contact and consult with NHOs, agencies, and community members including descendants of the area, in order to identify individuals with cultural expertise and/or knowledge of the *ahupua‘a* of Lualualei. CSH initiated its outreach effort in January 2019 through letters and emails. CSH concluded its outreach effort in April 2019.

6.2 Community Contact Letter

Letters (Figure 35 and Figure 36) along with a map, aerial photograph, and site development plan of the project were mailed with the following text:

> At the request of PVT Land Company Ltd (PVT), Cultural Surveys Hawai‘i, Inc. (CSH) is conducting a cultural impact assessment (CIA) for the proposed PVT Integrated Solid Waste Management Facility Relocation project, Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, Hawai‘i, TMK: [1] 8-7-009:007. The total project area consists of approximately 179 acres along the southwestern slopes of Pu‘u Heleakalā, and is accessed via Lualualei Naval Road. The project area is depicted on portions of the 1998 Wai‘anae and Schofield Barracks USGS 7.5-minute topographic quadrangles (Figure 1) and on a 2011 aerial photograph (Figure 2).
>
> The proposed project involves the relocation of an existing integrated solid waste management facility (ISWMF) to a parcel owned by a PVT-affiliate, east of the PVT ISWMF and Lualualei Naval Road. The proposed project is intended to facilitate improvements to PVT’s operations, and to provide adequate capacity to accept future construction and demolition (C&D) waste generated on O‘ahu. The key components of the proposed action include: (1) relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations; (2) upgrading its recycling operations by installing two materials recovery and diversion (MRD) process lines; and (3) installation of renewable energy facilities (one 1000-kilowatt hour [kWh] enclosed gasification unit and approximately seven acres of photovoltaic [PV] panels) to power PVT operations.
>
> Approximately 75 acres of the 179-acre project site are proposed to be lined for development and operation of a C&D waste landfill. An area of approximately 10 acres at the north end of the project site would accommodate process lines MRD-2 and MRD-3, which are to be developed and operated to increase the processing capacity and minimize landfilling of recyclable materials. The gasification unit would also be located in the MRD area of the project site. Please refer to Figure 3 for the site development plan.
>
> The purpose of this CIA is to gather information about the project area and its surroundings through research and interviews with individuals knowledgeable about this area in order to assess potential impacts to the cultural resources, cultural

Cultural Surveys Hawai‘i, Inc.
Archaeological and Cultural Impact Studies
Hallett H. Hammatt, Ph.D., President

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Job code: LUALUALEI 33 bbeauchan@culturalsurveys.com www.culturalsurveys.com

January 28, 2019

Aloha,

At the request of PVT Land Company Ltd (PVT), Cultural Surveys Hawai‘i, Inc. (CSH) is conducting a cultural impact assessment (CIA) for the proposed PVT Integrated Solid Waste Management Facility Relocation project, Lualualei Ahupua‘a, Wai‘anae District, O‘ahu, Hawai‘i, TMK: [1] 8-7-009:007. The total project area consists of approximately 179 acres along the southwestern slopes of Pu‘u Heleakalā, and is accessed via Lualualei Naval Road. The project area is depicted on portions of the 1998 Wai‘anae and Schofield Barracks USGS 7.5-minute topographic quadrangles (Figure 1) and on a 2011 aerial photograph (Figure 2).

The proposed project involves the relocation of an existing integrated solid waste management facility (ISWMF) to a parcel owned by a PVT-affiliate, east of the PVT ISWMF and Lualualei Naval Road. The proposed project is intended to facilitate improvements to PVT's operations, and to provide adequate capacity to accept future construction and demolition (C&D) waste generated on O‘ahu. The key components of the proposed action include: (1) relocation of C&D waste receiving, materials sorting/recycling, and C&D disposal operations; (2) upgrading its recycling operations by installing two materials recovery and diversion (MRD) process lines; and (3) installation of renewable energy facilities (one 1000-kilowatt hour [kWh] enclosed gasification unit and approximately seven acres of photovoltaic [PV] panels) to power PVT operations.

Approximately 75 acres of the 179-acre project site are proposed to be lined for development and operation of a C&D waste landfill. An area of approximately 10 acres at the north end of the project site would accommodate process lines MRD-2 and MRD-3, which are to be developed and operated to increase the processing capacity and minimize landfilling of recyclable materials. The gasification unit would also be located in the MRD area of the project site. Please refer to Figure 3 for the site development plan.

The purpose of this CIA is to gather information about the project area and its surroundings through research and interviews with individuals knowledgeable about this area in order to assess potential impacts to the cultural resources, cultural practices, and beliefs identified as a result of the planned project. We are seeking your *kōkua* and guidance regarding the following aspects of our study:

- **General history as well as present and past land use of the project area.**
- **Knowledge of cultural sites which may be impacted by future development of the project area—for example, historic and archaeological sites, as well as burials.**
- **Knowledge of traditional gathering practices in the project area, both past and ongoing.**
- **Cultural associations of the project area, such as *mo‘olelo* and traditional uses.**

Figure 35. Community consultation letter page one

LUALUALEI 33 – CIA for the Proposed PVT Integrated Solid Waste Management Facility Relocation

Page 2

- **Referrals of *kūpuna* or elders and *kama‘āina* who might be willing to share their cultural knowledge of the project area and the surrounding *ahupua‘a* lands.**
- **Any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the project area.**

In advance, we appreciate your assistance in our research effort. If you are interested in participating in this study, please contact Brittany Beauchan at bbeauchan@culturalsurveys.com. I am also available by phone at (808) 262-9972. **We kindly ask for your response by, February 14, 2019.**

Me ka ha‘aha‘a,

Brittany Beauchan
Cultural Researcher

Figure 36. Community consultation letter page two

practices, and beliefs identified as a result of the planned project. We are seeking your *kōkua* and guidance regarding the following aspects of our study:

• General history as well as present and past land use of the project area

• Knowledge of cultural sites which may be impacted by future development of the project area—for example, historic and archaeological sites, as well as burials.

• Knowledge of traditional gathering practices in the project area, both past and ongoing.

• Cultural associations of the project area, such as *mo‘olelo* and traditional uses.

• Referrals of *kūpuna* or elders and *kama‘āina* who might be willing to share their cultural knowledge of the project area and the surrounding ahupua‘a lands.

• Any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the project area.

Community outreach letters were sent to 132 individuals or groups. The organizations consulted include OHA, the O‘ahu Island Burial Council (OIBC), the SHPD (Burial Sites Specialist and History and Culture Branch), the Hui ‘Ōiwi Hawaiian Club, the Lualualei Hawaiian Civic Club, the Nānāikapono Hawaiian Civic Club of Nānākuli, the Tulipa Hawaiian Civic Club, the Wai‘anae Hawaiian Civic Club, and community members of Wai‘anae Moku. Nine have responded and one *kupuna* has submitted written testimony. One community member, representing MA‘O Organic Farms, participated in a formal, sit-down interview.

6.3 Community Contact Table

The table below contains the names, affiliations, dates of contact, and comments from NHOs, individuals, organizations, and agencies contacted for this project. Results are presented in alphabetical order.

Table 4. Community contact table

Name (Individual, Organization)	Affiliation	Comments
Aila, Ivan	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Aila, Manuel	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; new address located, and letter and figures resent via USPS on 17 January 2019;

		letter and figures returned on 25 January 2019
Aila, William Jr.	Deputy to the Chair, Department of Hawaiian Homelands	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 Letter and figures sent via email on 7 February 2019
Aila, William and Ruby	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Ainoa, Abbey	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Aipoalani, Hanalei	Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Aldeguer, Walterbea	Leeward Community College (LCC) Wai‘anae Moku	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
AuHoon, Ann	Manager, Hale Makana O Nanakuli	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Awana, Karen	Treasurer, Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Barber, Paige Kapiolani	Executive Director, Nanakuli Housing Corporation	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Battle, Cherie Kahealani Keohokalole	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Burns, Genevieve	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019

		Letter and figures sent via USPS on 31 January 2019
Caceres, Mana and Caceres ‘Ohana	‘Ewa Moku Representative, O‘ahu Island Burial Council (OIBC)	Letter and figures sent via email on 31 January 2019
Cachola Jr., Fred	Former Principal of Nānāikapono Elementary School and founder of the Nānāikapono Museum	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Choy, Harry	Mikilua Valley Community Association	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Concerned Elders of Wai‘anae		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 On 2 February 2019 CSH notified that attempt to deliver email failed
Cowles, James A.	Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Crabbe, Dr. Kamana‘opono	Office of Hawaiian Affairs (OHA)	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
De Troye, Butch	Ka‘ala Learning Center	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 14 January 2019; new address located, and letter and figures resent via USPS on 17 January 2019; letter and figures returned on 21 January 2019
Dodge, Fred	Retired doctor from Waianae Coast Comprehensive Health Center (WCCHC); long time resident of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Eli, Stacelynn	Representative for House District 43; Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019

Enos, Eric	Founder, Ka‘ala Farms, cultural practitioner	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Enos, Kamuela	MA‘O Organic Farms	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Flores, Paul Kalani	Hui ‘Ōiwi Hawaiian Club; referred by Mr. Aulii Mitchell	Letter and figures sent via email on 31 January 2019
Fujikane, Candace	Professor, University of Hawai‘i at Mānoa; Kahea – The Hawaiian-Environmental Alliance	Letter and figures sent via email on 31 January 2019
Gates, Cedric Asuega	Representative, House District 44	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Gay, Lucy	Kahea – The Hawaiian-Environmental Alliance; Concerned Elders of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Upon the recommendation of Ms. Cynthia Rezentes, CSH followed up with Ms. Gay via email on 7 February 2019; Ms. Gay replied via email on 8 February 2019: *Our group of Concerned Elders of Waianae will be meeting on the 12th to discuss the proposed PVT project and we will be able to get back to you with our concerns and interest soon after that.* CSH replied via email on 8 February 2019: *Mahalo for your response. I look forward to hearing from you and the Concerned Elders of Waianae sometime after the 12th.* CSH reached out via email on 22 March 2019: *I am just following up with you about the proposed PVT project and any concerns or comments that may have been generated during the Concerned Elders of Wai‘anae meeting.*
Gomes, Domingo	*Kama‘āina* and fisherman	Letter and figures sent via USPS on 4 January 2019

		Letter and figures sent via USPS on 31 January 2019
Grace, Polly “Granny”	President, Waianae Community Outreach	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 5 January 2019; new address located and letter and figures resent via USPS on 17 January 2019; letter and figures returned on 23 January 2019
Hawai‘i Farmers Union United – Wai‘anae Chapter		CSH presented about the CIA and provided letters and figures to meeting attendees during the Hawai‘i Farmers Union United – Wai‘anae Chapter meeting at Kahumana Farms on 1 April 2019
Hawaiian Railway Society		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 4 February 2019
Higa, C. Pono	Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Higa, Lisa	Principal, Nānākuli Elementary	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Hilo, Regina	Burial Sites Specialist, SHPD	Letter and figures sent via email on 31 January 2019
Honolulu Community Action Program (HCAP)		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Ho, Shirleen	President of Lualualei Hawaiian Civic Club	Letter and figures sent via USPS on 4 January 2019 Letter and figures returned 28 January 2019; unable to locate correct address
Ho‘oluli, Josiah “Black”	Ahupua‘a O Nānākuli Homestead Association	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Hope Chapel Nanakuli		Letter and figures sent via USPS on 4 January 2019. Letter and figures returned on 8 January 2019. CSH reached out to Hope Chapel via email on 17 January 2019:

		A letter was sent to your church on 1/4/19 but returned to us as not deliverable at P.O. Box 2865. If you would like to read and comment on the Cultural Impact Statement for Lualualei, please let me know where I might e-mail you the letter or send it. Mahalo. Vicki Creed, researcher, Cultural Surveys Hawai‘i Letter and figures sent via email on 31 January 2019; delivery failed due to Domain Name System (DNS) error
Hopfe, Hanale	Wai‘anae Representative, Aha Moku Advisory Council; lineal and cultural descendant; cultural practitioner; Native Hawaiian artist	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Hui Huliau	Adrian Silva, Chairman	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Jellings, Carl	Wai‘anae Moku Representative, Aha Moku Advisory Council	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Kahakalau, Dr. Kū	Cultural Specialist, Kupu Ola, INPEACE	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email and care of Ms. Sanoe Marfil on 31 January 2019
Kahanamoku-Teruya, Patty	Secretary, Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Kahumana Farm		CSH presented about the CIA and provided letters and figures to meeting attendees during the Hawai‘i Farmers Union United – Wai‘anae Chapter meeting at Kahumana Farms on 1 April 2019.
Kaleikini, Ali‘ikaua	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, Haloa	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019

		Letter and figures sent via USPS on 31 January 2019
Kaleikini, Kala	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, Mahiamoku	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, Moehonua	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, No‘eau	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, Paulette Ka‘anohi	Cultural descendant, *kama‘āina* of Wai‘anae, Cultural Monitor and practitioner, owner of ‘Ōiwi Cultural Resources	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini, Tuahine	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kaleikini Soares, Moani	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kamealoha, Thomas	*Kama‘āina* of Waianae and Cultural Monitor	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Kanahele, Kamaki	Department of Hawaiian Homelands (DHHL) Nānākuli, State Council of Hawaiian Homestead Associations; Director, Native Voices Center; *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Kāne, Shad	‘Ewa Moku Representative, Aha Moku Advisory Council	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 Mr. Kane replied via email on 31 January 2019: *Although I haven’t been on the property for a while I can share a little of what I know. I am sure you will be able to find Waianae Kupuna who know more than I.* ***General history and present and past land use of the project are**:* *As all other areas around the island it has an ancient history. However, like most other areas it has been largely disturbed. During most of the 1900s it has been used for cattle grazing. During the 1980s I did volunteer work for Ed Keliikoa and Wayne Silva roping, rounding up and branding cattle. In that region we used to gather the cattle in the higher elevations and bring them down into pens where the roping and branding took place. I cannot remember seeing any cultural structures while riding my horse on those properties.* ***Knowledge of cultural sites- for example, historic sites, archaeological sites, and burials.*** *I rode my horse over most of that property and do not recall seeing any historic sites, archaeological sites and burials.* ***Knowledge of traditional gathering practices in the project area, both past and ongoing.*** *During the time I spent in the area I am not aware of anyone or saw anyone conducting traditional gathering practices. Most of that region had foreign weeds. During the time I spent riding in that area I do not recall even seeing uhaloa growing.* ***Cultural associations of the project area, such as legends and traditional uses.*** *I am not aware of any.* ***Referrals of kūpuna or elders and kama‘āina who might be willing to share***

		their cultural knowledge of the project area and the surrounding ahupua‘a lands. *In that particular area I know not of any.* ***Any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the project area.*** *I know not of any.* CSH replied via email on 12 February 2019, thanking him for sharing his *mana‘o*.
Kawamura, Dorothy	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Ke Ali‘i O Ka Malu	*Hālau hula*	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; unable to locate correct address
Keamo, Maylene	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; new address located, and letter and figures resent via USPS on 12 February 2019
Ke Kai O Kahiki	*Hālau hula*	Letter and figures sent via email on 31 January 2019
Keli‘inoi, Kalahikiola	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Keli‘inoi, Kilinahe	Cultural descendant and *kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Kila, Glen	Program Director, Koa Ike; Program Director, Marae Ha‘a Koa	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019 Letter and figures sent via email on 7 February 2019
Kini-Lopes, Puahone	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Koethe, Frankie	Ma‘ili‘ili Project Coordinator, Conservation Specialist,	Letter and figures sent via email on 31 January 2019

	O‘ahu Resource Conservation & Development Council	Ms. Koethe replied via email on 19 February 2019: *If you are needing more input, you can announce at the Hawaii Farmers Union United meeting Waianae Chapter, first Mondays 6:30 PM at Kahumana Organic Farms Cafe.* *Additionally, have you spoken to Ka‘eha Lenchanko? He works at Ka‘ala Cultural Center and has a lot of mana‘o of the area. Let me know if not or timing is still good, I can provide an email.* CSH replied via email on 28 February 2019, thanking Ms. Koethe for her *mana‘o* On 1 March 2019, Ms. Koethe provided CSH with the contact information for Mr. Ka‘eha Lenchanko. CSH replied via email on 1 March 2019, thanking Ms. Koethe for her assistance. CSH reached out to Ms. Koethe via email on 4 March 2019 to inform her that due to scheduling conflicts, CSH would be unable to attend the Hawai‘i Farmers Union United - Waianae Chapter meeting scheduled at Kahumana Farms for 4 March 2019. Ms. Koethe replied via email on 5 March 2019 to acknowledge scheduling conflict. CSH reached out to Ms. Koethe on 1 April 2019 regarding Hawai‘i Farmers Union United - Waianae Chapter meeting scheduled at Kahumana Farms for 1 April 2019. Ms. Koethe confirmed meeting time via email on 1 April 2019. CSH attended Hawai‘i Farmers Union United - Waianae Chapter meeting at Kahumana Farms on 1 April 2019.
Lacaden, Charlie	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Lankford-Faborito, Lu Ann Mahiki	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Lenchanko, Anthony	*Kumu Hula*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Lenchanko, Ka‘eha	Ka‘ala Cultural Center; referred by Ms. Frankie Koethe	Letter and figures sent via email on 1 March 2019
Lenchanko, Tom	Aha Moku	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Lopes, Kamahao	Cultural descendant	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Lualualei Hawaiian Civic Club		Letter and figures sent via USPS on 4 January 2019; letter and figures returned 14 January 2019; letter and figures sent via email on 31 January 2019
Mahi, Ann. A.	Superintendent, Nānākuli-Wai‘anae Complex	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Mahoe, Harriet	Council for Native Hawaiian Advancement; Waianae Valley Homestead Community Association	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Mālama Learning Center		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 Letter and figures returned to CSH on 25 March 2019
Manansala, Sophie Flores	Mikilua Valley Community Association	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Manaku, James K. Sr.	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019; letter and figures returned 9 January 2019; address was corrected and letter and figures resent via USPS on 31 January 2019

Maneafaiga, Jan	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
MA‘O Organic Farms		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019 On 28 February 2019, J. Kukui Maunkea-Forth, on behalf of MA‘O Organic Farms, replied via email: *We are going to be farming neighbors from the proposed expansion. Although it is past the deadline, are you still interviewing people for further information?* CSH replied via email on 28 February 2019 to attempt to schedule an in-person interview. CSH reached out via email about scheduling an interview on 22 March 2019. CSH reached out via telephone to schedule an interview on 1 April 2019. Ms. J. Kukui Maunakea-Forth was unavailable, CSH left a message. CSH reached out via telephone on 4 April 2019 to schedule an interview. During the telephone call, Ms. Maunakea-Forth noted a concern about potential impacts to “future [agricultural] practice.” Interview scheduled for 22 April 2019. Interview completed on 22 April 2019.
Medeiros, Richard	Vice Chair, Nānākuli-Mā‘ili Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019. Mr. Medeiros replied via email on 4 February 2019: *Mahalo, I’ll review and get back to you shortly.* CSH replied via email on 5 February 2019 to thank him for his response.
Mello, Christy	Assistant Professor of Anthropology at University of Hawai‘i West O‘ahu	CSH reached out via email on 4 April 2019: *It was great getting to meet you Monday night! I really enjoyed learning about the work that you all are doing in Lualualei Valley as part of ‘Aha ‘Imi Na‘auao. I wanted*

		to attach an outreach letter for your records and was hoping to learn more about your mapping project. Dr. Christy Mello replied via email on 8 April 2019: *It was great to meet you! Thank you for sharing this. Here is the link to the maps and I'm happy to discuss if you'd like to meet. . .* CSH replied via email on 8 April 2019: *Mahalo for the link to the maps. The maps are great! I took a scroll through and the data is really interesting. It looks like quite a bit of stores and restaurants in Honolulu and portions of East O‘ahu are being supplied by Wai‘anae farms. I wish the stores or restaurants did a bit more advertisement of these farms – I think it would help us residents, who live outside of those ahupua‘a, really feel connected and committed to supporting both the farmers and residents (making sure they also have equal access to whole foods). I think sometimes we forget where our food comes from and consequently overlook many of the obstacles local farmers face. . . Mahalo for your invitation to meet up and discuss the mapping project. . . hopefully we can also discuss aspects of the CIA and the proposed PVT project. . .* CSH did not receive a reply back in regard to scheduling a meeting.
Meyers, Germaine K.	Nānākuli-Maile Neighborhood Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Mitchell, Aulii	Wai‘anae Representative, OIBC	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 1 February 2019.
Mole, John Piimauna	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Momoa, Joseph	*Kama‘āina*, member of Nā Keiki O Kamo‘i Canoe Club and local artist	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nahulu, Analika	Ke Ola Mamo	Letter and figures sent via USPS on 4 January 2019; letter returned 9 January 2019; CSH reached out to Ke Ola Mamo via email to locate a correct mailing address
Nahulu, Eli	*Kama‘āina*, cultural practitioner	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Naiwi, Dolly	Nānāikapono	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nānāikapono Hawaiian Civic Club of Nānākuli		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nānāikapono Protestant Church		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nānākuli Housing Corporation		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nānākuli Public Library		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nānākuli Ranch		Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; new address located, and letter and figures resent via USPS on 17 January 2019; letter and figures returned on 25 January 2019
Nānākuli-Maili Neighborhood Board No. 36		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Native Hawaiian Church		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nunes, Keoni	*Kama‘āina* of Wai‘anae	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Nu‘uanu, David	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Oliveira, Chris	Executive Director, Koa Ike Project Director, Marae Ha‘a Koa; cultural practitioner; life-long resident of the Wai‘anae coast	Letter and figures sent via email on 31 January 2019 Mr. Oliveira responded via email on 6 February 2019: *I will go over the documents today. Please contact Glen Kila as well as Gale Sale whom are kupuna familiar with the area. I'll follow up after reviewing.* CSH forwarded letters and figures to the *kūpuna* recommended by Mr. Oliveira. CSH replied via email on 7 February 2019: *Mahalo for your response. I went ahead and sent a copy of the documents over to Mr. Kila via email. Unfortunately, I don't have an email address for Gale Sale, but was able to locate a physical address. . . I will be forwarding along documents to this address.* CSH followed up via email on 1 April 2019.
Ornellas, Landis	Owner, Mahana Enterprise	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Our Lady of Kea‘au		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Pa‘aluhi, Marc	Vice-Chair, Wai‘anae Coast Neighborhood Board No. 24	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Pacific Justice & Reconciliation Center		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Parker, Alvin N.	Principal, Kawaihona Public Charter School	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Patterson, Patricia	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Perkins, Leialoha Apo	Author and publisher	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Pieper, Michelle	Hawaiian Language Teacher, Nānākuli High School	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Pilialoha, Darin	Principal, Nānākuli High School	Letter and figures sent via USPS on 4 January 2019
Pine, Kymberly Marcos	Councilmember, Honolulu City Council District 1	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 Councilmember Pine replied via email on 1 February 2019: *Thank you for the invitation. I will let the elders of the community and the Hawaiian civic clubs speak on my behalf of this. They have so much more knowledge than I have on this subject.* CSH replied via email on 1 February 2019 to thank Councilmember Pine for sharing her *mana‘o*.
Poe, Sharlette	Chair, Wai‘anae Coast Neighborhood Board No. 24	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019

Princess Kahanu Estates Association		Letter and figures sent via email on 31 January 2019
Pūnana Leo o Wai‘anae		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Pu‘u Heleakala Community Association		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Queen Lili‘uokalani Trust Wai‘anae Unit		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Quitevis, Leimaile	*Kama‘āina* of Wai‘anae; former member of the OIBC	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Rezentes, Cynthia	Chair, Nānākuli-Mā‘ili Neighborhood Board; Wai‘anae Community Board Member	Letter and figures sent via USPS on 4 January 2019 Ms. Rezentes replied via email on 9 January 2019: *My personal experience with the parcel of land being considered (Nanakuli B owned by PVT on the Honolulu side of Lualualei Naval Road) is that during my lifetime it has been vacant land. Mauka of this parcel (near the JBPHH Lualualei Entry Gate was a farming area that has been documented by the community during the disagreement with the nearby property owner's desire to establish a light industrial park. In addition, there have been identified other historic sites along that mountain scape by a kupuna, Alice Greenwood. Unfortunately, Alice's passing has left a void for some of that information. I would recommend that you speak with Lucy Gay from LCC-Waianae Moku who helped guide the Elders of Wai‘anae to see if she has the specific information or may access the information for you. I have copied Lucy on this email as an introduction that hopefully*

		you will make contact with. In addition, I hope that you have also asked William Aila, another local community leader for his knowledge of the area to enrich the information that you gather regarding the property under question. CSH replied via email on 7 February 2019: *Mahalo nunui for your patience and mahalo for sharing your mana‘o and recollections of the project area. I went ahead and looked up historic sites along the western slope of Pu‘u Heleakalā and saw that only three sites have been recorded within the project area. These sites were assigned State Inventory of Historic Places (SIHP) numbers; these site numbers are SIHP # 50-80-08-6681, SIHP # 50-80-08-6699, and SIHP # 50-80-08-6920. SIHP # -6681 is a WWII-era bunker, SIHP # -6699 is a likely late pre-Contact rock shelter, and SIHP # -6920 is a likely pre-Contact rock mound. The rock mound is believed to be a marker, but to date, it doesn’t appear that there has been much interpretation within published studies. I will certainly reach out to the community members that you have referred us to, especially so that we may learn more about these wahi pana.*
Sale, Gale	*Kupuna*; referred by Mr. Christopher Oliveira	Letter and figures sent via USPS on 7 February 2019 Letter and figures returned on 10 February 2019; new address was located, and letter and figures resent via USPS on 5 March 2019.
Salmon, Pākē	*Kama‘āina*; photographer and water woman	CSH hand delivered letter and figures on 8 March 2019. Ms. Salmon noted her knowledge of the project, but did not offer any concerns or recommendations.
Savini, Kumu Leato	President, Tulipa Hawaiian Civic Club	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Shimabukuro, Maile S.L.	Senator, Senatorial District 21	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019

Silva, Adrian	Chairman, Hui Huiliau	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Silva, Albert	‘Ōhikilolo Ranch	Letter and figures sent via USPS on 4 January 2019
Silva, Alika	*Kama‘āina* of Wai‘anae; Koa Mana	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019
Solis, Kaahiki	Cultural Historian, SHPD	Letter and figures sent via email on 31 January 2019 Ms. Solis replied via email on 4 February 2019: *. . . For Lualualei you already have my list of Civic Clubs. Nānākuli Hawaiian Homes Association* *Uncle William Aila DHHL* *Leeward Community College Wai‘anae has an Environmental Bus Tour it speaks directly about Lualualei and the mo‘olelo all about the aina. You whole crew should ride it and take notes! A good mix of mo‘olelo and kupa ‘āina. All the Hawaiian Clubs and Immersion Schools within the APE.* *High School Hawaiian Clubs Nānākuli, Wai‘anae many of the students are very connected to the land.* *Ma‘o Farms Kamu Enos* *Ka‘ala Farms Learning Center-Uncle Butch/Uncle Eric Enos* *Princess Kahanu Estates Hawaiian Homestead may have an association. Check into it.* *Mā‘ili Homestead* *Wai‘anae Valley Homestead Community Association-if you look into the minutes of the various associations you will find contact information for people with specific interests. You can find the same information in the OIBC meeting minutes for the particular moku you are interested in. It is all public information when folks offer their emails in the meeting minutes.*

		Lualualei may also have a homestead association. Look into this for sure. *The Environmental Bus Tour given by LCC Wai‘anae is usually a community grant that is associated with LCC Wai‘anae I am not sure if they are the direct contact though.* *If you speak with these people they will lead you to others.* CSH researched and requested to be placed on mailing list for the Environmental Justice Bus Tour on 4 February 2019; CSH replied via email on 12 February 2019
Tanahy, Dalani	*Kapa* maker	Letter and figures sent via email on 31 January 2019
Taylor, Vernon	*Kama‘āina*	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Tupua, Kekoa	Clubhouse Director, NFL YET (Boys & Girls Club of Hawaii)	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Wai‘anae Ahupua‘a Council		Letter and figures sent via USPS on 4 January 2019 Letter and figures returned 20 January 2019; unable to locate correct address
Wai‘anae Coast Coalition		Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; unable to locate correct address
Wai‘anae Coast Culture & Arts Society		Letter and figures sent via USPS on 4 January 2019; letter and figures returned 8 January 2019; unable to locate correct address
Waianae Coast Neighborhood Board No. 24		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Wai‘anae Community Outreach		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019

Wai‘anae Hawaiian Civic Club		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Wai‘anae Kai Hawaiian Homestead Association		Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via USPS on 31 January 2019
Watson, Kali	President & CEO, Hawaiian Community Development Board	Letter and figures sent via USPS on 4 January 2019 Letter and figures sent via email on 31 January 2019 Mr. Watson replied via email on 1 February 2019: *PVT has always been very supportive of the community, especially helping the homesteaders with the disposal of construction debris when we were doing the Kauhalepono Replacement homes project. Therefore, I support their proposed development. Let me know how I can help. I don't know anything about the cultural stuff, but can testify of their positive community involvement.* CSH replied via email on 12 February 2019: *Mahalo for sharing your mana‘o with me. Although, we are particularly focused on potential impacts to cultural resources, practices, and beliefs, we will welcome any testimony that you have to offer. Once again, mahalo for your kokua and consideration.*
Wong-Kalu, Hinaleimoana	Chair, OIBC	Letter and figures sent via email on 31 January 2019
Worthington, Mele	President, Wai‘anae Hawaiian Civic Club	Letter and figures sent via email on 31 January 2019

6.4 Written Testimony from Shad Kāne

Mr. Shad Kane, member of the Kapolei Hawaiian Civic Club, Chair of the O‘ahu Council of the Association of Hawaiian Civic Clubs Committee on the Preservation of Historic Sites and Cultural Properties, Ali‘i Ai Moku of the Kapuaiwa Chapter of the Royal Order of Kamehameha Ekahi, and ‘Ewa Moku Representative on the State Aha Moku Advisory Committee, replied by email to CSH on 31 January 2019 with the following statement:

Although I haven’t been on the property for a while I can share a little of what I know. I am sure you will be able to find Waianae Kupuna who know more than I.

General history and present and past land use of the project are:

As all other areas around the island it has an ancient history. However, like most other areas it has been largely disturbed. During most of the 1900s it has been used for cattle grazing. During the 1980s I did volunteer work for Ed Keliikoa and Wayne Silva roping, rounding up and branding cattle. In that region we used to gather the cattle in the higher elevations and bring them down into pens where the roping and branding took place. I cannot remember seeing any cultural structures while riding my horse on those properties.

Knowledge of cultural sites- for example, historic sites, archaeological sites, and burials.

I rode my horse over most of that property and do not recall seeing any historic sites, archaeological sites and burials.

Knowledge of traditional gathering practices in the project area, both past and ongoing.

During the time I spent in the area I am not aware of anyone or saw anyone conducting traditional gathering practices. Most of that region had foreign weeds. During the time I spent riding in that area I do not recall even seeing uhaloa growing.

Cultural associations of the project area, such as legends and traditional uses.

I am not aware of any.

Referrals of kūpuna or elders and kama‘āina who might be willing to share their cultural knowledge of the project area and the surrounding ahupua‘a lands.

In that particular area I know not of any.

Any other cultural concerns the community might have related to Hawaiian cultural practices within or in the vicinity of the project area.

I know not of any.

6.5 *Kama‘āina* Interviews

The authors and researchers of this report extend our deep appreciation to everyone who took time to speak and share their *mana‘o* and *‘ike* with CSH whether in interviews or brief consultations. If this interview is to be used in future documents, we request that the words of contributors are reproduced accurately and in no way altered, and that if large excerpts from interviews are used, report preparers obtain the express written consent of the interviewee/s.

The interview was conducted in accordance with federal and state laws and guidelines with individuals knowledgable of the general history, present and past land use, traditional gathering practices (both past and ongoing), and cultural sites of the project area and its environs. In some

instances, discussion of neighboring Nānākuli Ahupua‘a also occurred. The following summary is intended to facilitate the identification of potential impacts to cultural resources, ongoing cultural practices, and/or cultural sites within the project area or its immediate vicinity. As the current CIA involves the study of Lualualei Ahupua‘a in its entirety, CSH recognizes the importance of discussing cultural resources, cultural practices, and cultural sites that may exist outside of the project area.

6.5.1 Summary of Kukui Maunakea-Forth (MA‘O Organic Farms) Interview

CSH interviewed Mrs. Kukui Maunakea-Forth on the lands currently managed and cultivated by MA‘O Organic Farms on 22 April 2019 for the Proposed PVT Integrated Solid Waste Management Facility Relocation project (Figure 37). MA‘O Organic Farms currently cultivates approximately 23 acres within Lualualei Ahupua‘a. MA‘O was founded in the late ‘90s by

> . . . a group of residents, traditional practitioners, teachers, and business experts to . . . create the Wai’anae Community Re-Development Corporation (WCRC), a federally recognized 501 (c) (3) nonprofit organization designed to. . . address the challenges of our youth and community. [MA‘O Organic Farms n.d.]

Mrs. Maunakea-Forth co-founded WCRC and MA‘O Organic Farms alongside her husband, Mr. Gary Maunakea-Forth. Together they answered the *kāhea* (call) set forth by the community, to reaffirm traditional values, values centered on both *‘āina* (land) and *nā ‘ōpio* (youth). In speaking with Mrs. Maunakea-Forth, it was made abundantly clear that the children or youth of Wai‘anae remain a symbol of “hope and redemption for the future” (Stahl 1986:83). In discussing both pedagogy and the need to empower youth, she revealed,

> We teach by mentoring. . . For us, it was a MA‘O. For us, it was because our children were not thriving in schools. It was such a shame, and all of our kids were different. How could you not address the beauty of our *keiki*. Of all *keiki*. Don’t they deserve that? So that’s why MA‘O exists. Literally.

The values held by Mrs. Maunakea-Forth, to leave a sustainable legacy for the children of the area whilst encouraging education and healthy living, are exemplified by the *‘ōlelo no‘eau*, “*E mālama ‘ia nā pono o ka ‘āina e nā ‘ōpio*” (“the traditions of the land are preserved by the youth”). These values, in turn, have played a critical role in shaping MA‘O Farms’ mission statement. As part of their mission, they have identified land and youth as two assets critical to the future of modern-day Hawai‘i:

> MA‘O is the acronym for mala ‘ai ‘opio which translates as the youth food garden. MA‘O connects two of our most precious assets, our ‘āina—that which feeds and our ‘opio, our youth to create a movement that will build a comprehensive and living local food system—educate and empower youth, fight hunger and injustice, improve our health and nutrition, and grow a local, organic and fair agriculture industry—all connected to empower our community to move towards self-sufficiency. [MA‘O Organic Farms n.d.]

Mrs. Maunakea-Forth also discussed the ways in which farming, as an educational activity, has supported leadership development. In nurturing future leaders, the transfer of knowledge and skills remains of the utmost importance. Traditionally, the passing on of knowledge and skills upon the land itself was one of the most effective means of connecting children to both their culture and

Figure 37. General overview of interview location at MA‘O Organic Farms; farmlands extend beyond (view to southeast)

natural resources, while simultaneously assuring “that a people’s cultural legacy continues” (Chun 2011:2). Mrs. Maunakea-Forth introduced CSH to many of MA‘O’s youth leaders. One of these leaders, Kiana Tector, explained her role at the farm as well as her focus on improving health and nutrition within the community. Kiana and her *‘ohana* are *kama‘āina* of Nānākuli; as *kama‘āina*, Kiana’s deep connection to, as well as her concern for the health and well-being of her community was especially evident.

As a nutrition and dietetics major at the University of Hawai‘i as well as a Ho‘owaiwai Youth Leadership Training intern, Kiana has been able to contribute to the Mauli Ola study while working at the farm. The study, enabled by a partnership between the University of Hawai‘i at Mānoa and MA‘O Organic Farms, “collect[s] data to capture the relationship between ‘āina (land/environment) and ola (health/life) within social networks from individuals living in Wai‘anae. This information includes demographics, health, behaviors and social networks” (Mauli Ola Network 2017). Due to the potential environmental impacts associated with the proposed project, Kiana’s specialized knowledge of health, wellness, Hawaiian culture, and the Nānākuli community proves particularly salient. Kiana highlighted the ways in which environmental health shapes and/or influences human health:

> . . . It contextualizes in a way where people cannot doubt what we already knew. We already knew that connecting people back to the land and just having peers that they count on [can] affect a whole bunch of things, mental health, just the way their eating habits are, [etc.]. Everything just connects, contextualizing it in a way where people cannot doubt us. So, the study is a two-year study since the internship is two years.

She explained in detail the ways in which data was collected for the study,

> Upon entering the program, the interns take a survey and then they take health metrics. So, the survey gathers socio-economic status, mental health, eating habits, and family information. Then to go further out from that, they listed family members and close friends [social networks] that they think influenced their habits, their eating habits. Then we also took surveys and health metrics from them. This study is focused towards diabetes, but we know that it affects more than that. The health metrics we took was A1c, and that’s how we get the whole . . . their risk of contracting type 2 diabetes, because A1c is the blood proteins instead of the blood sugar. So, it’s compiled over the last two months, so gauging their habits over the past two months, if they continue on that path, we can tell they are at risk of developing type 2 diabetes. We also do BMI [body mass index] and blood pressure. So then after that, they stay in the internship, then after one year of being [in the] internship, they do the exact same survey and health metrics again, just so we have some sort of comparative data. From entering the program, most of the interns are coming up on their two-year mark. So, after the two year they will be able to publish the data. But the preliminary data that we got so far showed that after being in the internship for one year, participants reduced their risk of contracting type 2 diabetes by 60%. And social networks, what I mentioned earlier, the family and friends, they reduced their risk of contracting type 2 diabetes by 15%, and then there’s the economics part of this whole study. They show health care providers, like HMSA,

> how we're actually saving money by reducing these risks. So, it's $32,000 per cohort and then $120,000 if you count their social networks per year. That's cost avoidance just from diabetes management. So, it's not the whole care, just the management of diabetes.

Throughout this discussion on emphasis was placed on the need to centralize health and *‘āina*, with the implication that the proposed action may be antithetical to not only the mission of MA‘O, but to the needs of the community as well. As a future neighbor to PVT, it is essential that the needs of both the property owner (PVT) and the *hoa‘āina* (MA‘O) are assessed and in balance (Forman and Serrano 2012:12).

CSH then inquired into the ways that the aforementioned study was influenced by traditional Hawaiian belief and practice regarding the human body and health. Kiana discussed the ways in which the study actively connected students to traditional Hawaiian beliefs and practices. Of particular importance was the connection of *piko* (crown of head, navel, and genitals). Mary Kawena Pukui eloquently describes the importance of self (and by extension one's physical, emotional, and mental health) in relation to the *piko* concept:

> There was a physical and mystic linking of the body with forebearers of old and descendants to come; this was placed in the *piko* of head, of navel and umbilical cord, and of genitals. The genitals (*piko*) linked the living person with offspring, present and yet unborn. The navel and umbilical cord (*piko*) tied one equally to one's parents and one's children. But the *piko* of the head—the crown or posterior fontanel—symbolized the bonds between the living individual and his never known and long departed ancestors. These, once mortal, were now god-spirits. These were the *‘aumākua*. [Pukui et at. 1972:294]

When touching upon the *piko* concept, Kiana expressed the following:

> I think that was a really important thing to get connected to first, and I'm glad that was one of the first things brought back to me when I started here. Bringing back aspects of culture, we also have *hula* every Wednesday after check out, we like to incorporate the language. We just changed our 'No Panic, Go Organic' into 'Mai Hopohopo E 'Ai Pono.' I think people are starting to be more familiar and come back to their culture. I've been thinking a lot about the roles culture plays on your identity, people are lost without their culture, without their language. So, to bring it back I think, they kinda get a sense of who they are again.

Mrs. Maunakea-Forth also built upon Kiana's comments, noting that emotional and mental health is also emphasized within the study as well as within the daily work at the farm. Touching upon the linkages between traditional Hawaiian culture and health, Mrs. Maunakea-Forth also referenced the work of Dr. Alika Maunakea. Dr. Maunakea's research into epigenetics has shown that

> Inherent in the traditional Native Hawaiian concept of health (*mauli ola*) is the understanding that environmental factors, including nutrition and social behaviors, trans-generationally impact health outcomes in individuals and communities. [Institute for Biogenesis Research n.d.]

Indeed, environmental and socio-economic changes during the post-Contact period had profound impacts on health and lifestyle of *kama‘āina* (native-born). Historical documentation by early explorers, in general, comments on the excellent health of the Hawaiian people and their ability to bear “great fatigue” (Shintani 1993:10). As the nineteenth century progressed, a series of political events, including the forced signing of the Bayonet Constitution and the overthrow of the Hawaiian monarchy, resulted in the political and economic disenfranchisement of the Hawaiian people. Invariably, these events impacted the health of the Hawaiian people. In a program manual put forth by the Wai‘anae Coast Comprehensive Health Center in 1993, the Wai‘anae Coast is identified as having the largest concentration of Hawaiians; additionally, Hawai‘i is identified as among the healthiest states in the union. The manual continues to point out that in sharp contrast, the Hawaiian people are identified as having the worst health in the nation. Such decline, over a nearly 200-year period, indexes more systemic issues at play. These systemic issues have also influenced the nature of education in Hawai‘i, both in a traditional and ecological sense. Within indigenous communities, an ecological education,

> . . . revolves around the issues that are essentially ethical, religious, and sacred. Ecological education provides the foundation that enables human beings to resonate individual and communal ‘inscapes’ with the natural landscape. This is in direct opposition to the orientation permeating modern education; an orientation that emphasizes extreme profaneness and materialism. This leads to conditioning that engenders a radical destructiveness at the individual, spiritual, communal, and environmental levels of being. [Cajete 1994:76]

Mrs. Maunkea-Forth was particularly concerned about impacts to the social and emotional (SEL) learning skills of Wai‘anae youth as precipitated by the severance of these youth from *‘āina*. Mrs. Maunkea-Forth often made direct reference to the surrounding Lualualei landscape, of how the natural landscape can shape the “individual and communal ‘inscapes’” of local *keiki*. As the Kaiāulu wind cut through the *hālau* (meeting house), it became abundantly clear that Mrs. Maunakea-Forth was advocating for culturally relevant or responsive pedagogy, “a student-centered approach to teaching in which the students’ unique cultural strengths are identified and nurtured to promote student achievement and a sense of well-being about the student’s cultural place in the world” (Lynch 2012).

Social influences coupled with the interactions of an individual with their environment (via an ecological education) can effectively shape one’s identity (the way one sees oneself in relation to the world) or habitus. Habitus can be understood as including the habits, perceptions, dispositions, and actions of an individual (Bourdieu 1977 and Bourdieu 2000). The development of these habits, attitudes, and/or values has a direct influence on the types of choices an individual is to make, especially in regard to well-being; it is essential to condition certain habits and/or values wherein *‘āina* and *ola* (health) are given primacy. In essence, one’s environment or visible landscape profoundly shapes one’s identity. With the verdant valley walls of Lualualei and the cultivated lands of MA‘O Farms clearly in sight, Mrs. Maunkea-Forth underscored the importance of maintaining a visibly thriving landscape.

Maintenance of a thriving landscape or ecosystem requires a shared vision and bold plan to address systemic issues. In order to address systemic issues, Mrs. Maunakea-Forth argued for a reconceptualization or re-centering of *‘āina*:

> For me, the PVT, that's systemic. The issues are systemic, it's not just PVT alone. It's the way that we regard *‘āina*. Period. I think that's important to get into a study or into a report, about what that means. We are only now discovering that it is really, that human health is connected to the environment. If we don't *mālama* [care for] that, how are we going to *mālama* our own health? If we see PVTs everywhere, how does that impact community [their perceptions, habits, and actions]? People think they can trash because somebody else makes it disappear.

Furthermore, a reconceptualization would involve understanding the area not as "undifferentiated acreage" (Charlot 1983:56), or a refuse deposit, but as a spiritually and culturally significant place. Mrs. Maunakea-Forth underscored the importance of Lualualei, especially in the vicinity of Pu‘u Heleakalā, as a rich and meaningful *wahi pana* for the people of Wai‘anae. Such sacredness stems not just from the connections of an area to the gods (Māui and Hina), but also arises out of the connections of *lāhui* (nation, race, tribe, people) to their *one hānau* (birth sands) and *kula iwi* (land of their ancestors). "The respectable person was bound affectionately to the land by which he was sustained" (Charlot 1983:55).

Mrs. Maunakea-Forth maintains a longstanding and familial relationship with Lualualei and Nānākuli. Indeed, she remains affectionately bound to the *ahupua‘a* of Nānākuli, conscious of and deferent to the *‘āina* that has sustained her and her *‘ohana*. Her connection to Nānākuli was established through her *kūpuna*, Edwin and Katherine Maunakea. Moving from Honolulu, her grandparents were among the first to receive their homestead in Nānākuli. Heading west, the Maunakea Family "brought their five children and . . . settled on 3/4ths of an acre." There was limited infrastructure at the time, thus the family was required to be self-sufficient and raise their own food crops. Mrs. Maunakea-Forth fondly remembered her grandmother as a community activist and advocate,

> . . . she belonged to every single club or organization that you could think of that had anything to say in the community and the way it developed, including schools, churches, civic clubs, and associations. At one point, she was even a part of the University Mother's Club. It's an extension of the University that was there to bring resources for new moms in the community that needed more skills. So, through that, I actually, our home became a community hub in and of itself, so many of the activities around language, sewing, cooking, all those things, all those community things, happened from my home. So, I was able to grow up in that environment of community.

The values she learned from her grandmother, "to be inclusive [and] to know aloha had a role to play in human relationships and in our relationship with the land," have undoubtedly influenced her career and her work in the community. Within the MA‘O community, her grandmother's influence is especially visible. Predominately displayed in their office is an *‘ōlelo no‘eau* from Kupuna Katherine Maunakea, *Ne huli ka lima iluna, pololoi ka opu. Ne huli ka lima ilalo, piha ka opu* ("When your hands are turned up, you will be hungry. When your hands are turned to the soil, you will be full"). In addition to learning important values, Mrs. Maunakea-Forth was exposed to many cultural practices. She watched her grandmother grow food crops and flowers, make *lei* (garland), and weave *lauhala* (pandanus leaves). Her father was also an extraordinary *mahi‘ai* (farmer):

> . . . he and my grandmother, but in different eras, when we were in my grandmother's home, she grew food everywhere in that homestead. For him, when he finished work and clocked out of work, he would just go next door and the owner of Tsunada Trucking had given him land, and so he grew food for all of the workers that wanted or needed. Papaya, watercress, eggplant, *bok choy*. . . it was like a small farm, like two and a half acres, something like that.

Additionally, her grandmother was a native speaker and the Hawaiian language was regularly used within their household. In summarizing her family's relationship to the area, Mrs. Maunakea-Forth noted that their "roots are long but not as long as some of the community members that actually came from this community,"

> So, we came in the '30s or something, our family. I was born in the home that we live in now and raised there. So, I feel that this is definitely my genealogy, and where my *one hānau* [birth place] starts.

As noted by the geographer Edward Relph (1976), "there is a deep association with and consciousness of the places of birth and childhood. This association . . .[is] a vital source of individual identity, cultural identity, and security" (Relph 1976:231 in Andrade 2014:7). Mrs. Maunakea-Forth's attachment to Wai‘anae Moku is evident in her personal *mo‘olelo* (stories); these *mo‘olelo* act as anchors, drawing her to the *‘āina* and filling her with love for it (Andrade 2014:8–9).

CSH continued the interview by inquiring into specific *mo‘olelo* or cultural practices associated with Lualualei and/or the project area. Mrs. Maunakea-Forth noted the potential to uncover additional information about the cultural history of the project area and its environs. During this discussion, Mrs. Maunakea-Forth shared that MA‘O Organic Farms had recently acquired a 236-acre parcel adjacent to the proposed project area. With this addition, MA‘O Organic Farms hopes to "minimize the urbanization of Wai‘anae" and to help end a "cycle of poverty" through educational equity (Gomes 2019) (Figure 38). Traditionally, the area within the parcel was known as Ka ‘Ōlae. The "*lae*" or point references Kahe Point. Explaining the meaning of Ka ‘Ōlae, Mrs. Maunakea-Forth shared the following,

> So, the Ka ‘Ōlae is like the movement, the action, the inclusiveness, the 'Ka,' the going to 'Lae,' to that place. So, you look at the orientation, right, it's going that way. Whereas you have the Ulehawa stories of Hina and Māui that is going out to that side, which is the *mo‘o*, and the areas of 'Ewa, kind of like that pathway.

When describing this parcel (Ka ‘Ōlae), Mrs. Maunakea-Forth recalled the many *kūpuna* once associated with the area as well as those who would know of specific *mo‘olelo* or cultural traditions,

> Yeah so, I think that's one of the things I can't quite remember. I remember a lot of stories and a lot of people that were attached to those places, now those folks are no longer here unfortunately. Like Aunty Aggie Cope, she was one of the kupuna that were friends with my grandma. . . Aunty Sarah Kawailima was also really good, she knew her Nānākuli history. The Kānes, right there on Haleakalā Avenue, she was known to be a *mea huna*, not *kahuna*, but somebody who knew a little bit

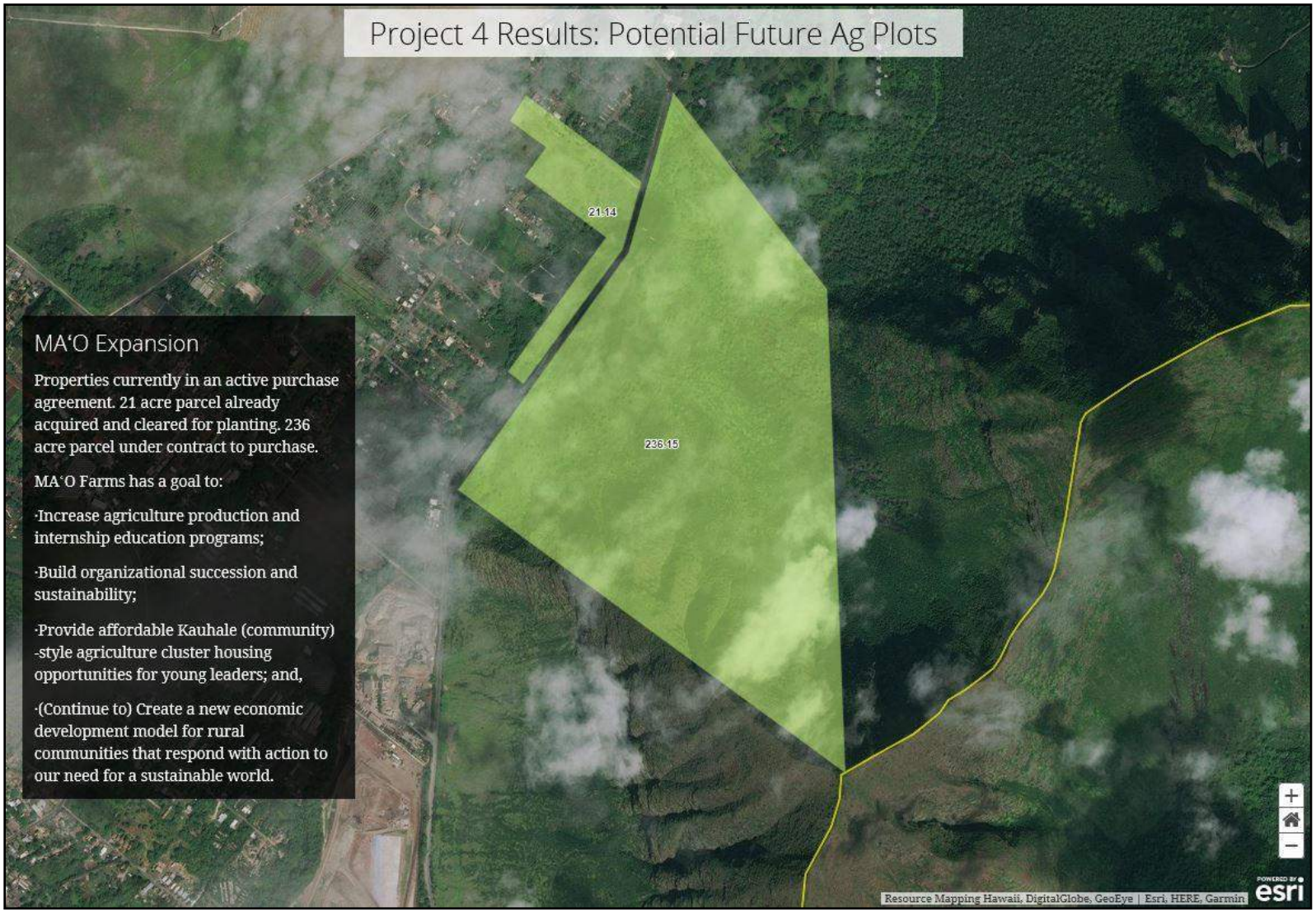

Figure 38. Depiction of MA‘O Expansion adjacent to the Proposed PVT Integrated Solid Waste Management Facility Relocation project area (‘Imi Na‘auao Mapping Project 2018; link to maps provided by Dr. Christy Mello)

> about the spiritual aspects of Nānākuli. I don't know if her daughter is still alive, but her eldest daughter knows a lot about the stories of Nānākuli. Because we live right on the side of that *pu‘u* yeah, Pu‘u Heleakalā. So, we live right there. And my brothers were all pig hunters, so they know all the areas, specifically more on the Nānākuli side. But this family, they always went towards Lualualei, and they weren't supposed to, but because they had connections, they were part military. . . so we didn't do any *mālama ‘āina* there. . .

Mrs. Maunakea-Forth also explained why the area was not accessed:

> No on this side of the hill we just didn't go because that was Māui and Hina's [area]. Not just the back which is, so as you are coming up Lualualei Naval Road, across from PVT, you just didn't go there. The story was, it's just a sacred space, a sacred place. You don't go *hana ‘ino* (abuse, mistreat) over there. In the old days they used to have it fenced off. You literally couldn't go over there. But we would be on the top of the mountain, we could easily go down. But you just don't go *maha ‘oi* (impertinent, bold), you just don't go. So now, we're [MA‘O Farms is] on the other side. But some things are triggering. Some things in my mind's eye are triggering. We weren't told that we couldn't go there, we were just told it was a sacred place. You see what I'm saying, which is different. There [are] *kūpuna*, Tom Lenchanko. Uncle Glen Kila. Now I know our history, now I know we're tied to this place genealogically, not just Wai‘anae Moku . . . once they made the connection. So now, I'm having memories from when we were kids. We used to go to the base a lot. Because all my uncles were military. So, we had access, so they could go all the time. My Uncle Mana, he was a sergeant in the Army. . . he would take us inside all the roads, all the bunkers and stuff like that. It was no big deal. We used to go where there was water. There was water back there.

While discussing the project area and its environs, Mrs. Maunakea-Forth recalled potential cultural resources. Most notably, she recalled the presence of fresh water as well as *lo‘i kalo* (irrigated taro patches). CSH inquired into whether these fresh water resources were springs; Mrs. Maunakea-Forth, however, clarified that fresh water occurred as ponds, runoff from springs located *mauka*:

> Not springs, it was where the springs came down . . . so they would pond up at certain times in the year, so we would go down there and pick crawfish. Then I remember on the left-hand side of the valley, this side of the valley, get choke *kalo* terraces. Get choke *lo‘i kalo* terraces. So, on the right-hand side you had streams but they weren't running all the time. On this side, you had streams that was kind of running. But we had access through Nānākuli. Not from this side of the valley, but from that side of the valley, all because of my uncle. Then I remembered that this woman, Betty Sellers, I don't know if you guys talked with her yet. But she worked a long time up at Lualualei Naval. Up in the Commander's office. She had access to all the different things that they have there, including some of the archaeological stuff they were removing from sites . . . they were removing things from house sites, from farming sites, maybe others. But she talked about implements, adzes, things like that. . .

Soils and *pōhaku* (stones) were also identified as potential cultural resources located in the vicinity of the project area. Soils within the project area consist of Lualualei extremely stony clay, Lualualei clay, and Mamala stony silty clay loam. Mrs. Maunakea-Forth noted that soils around the base of the *pu‘u* (Lualualei extremely stony clay and Lualualei clay) are believed to be good soils, however, they often contain large stones. These stones or *pōhaku* are extremely dense and particularly good for building or dry-stack stone masonry.

Mrs. Maunakea-Forth also underscored the importance of *wahi pana* and the potential stories or *mo‘olelo* connected to place. Due to the historic severance of *kama‘āina* from the land, many of the unique stories intimately tied to place have been either forgotten or pushed from the conscious mind. As alluded to by Mrs. Maunakea-Forth, *wahi pana* or cultural sites serve as signs of identity and signs of memory, they are “markers and makers of cultural identity” (Cipolla 2008:196). Only when *kūpuna* and *kama‘āina* are able to connect fully with *‘āina* again, will the unique stories and memories of Lualualei and Nānākuli be unearthed:

> I think if I’m on the land. Now that we have access to the land, it’s going to all come back. I’m going to start to remember and start to know the people who remember. Get to know all those guys and their stories. Once you get older, you have no reason to hold on to information. What you knew is kinda obsolete now, so I’m really interested in that time and hearing about how things are known. Because at my age, I wasn’t meant to know, I shouldn’t know, but now, those *kūpuna* will share freely with me. I feel very honored about that. The other person is Aunty Lucy Gay and Aunty Polly Grace and all the Nānākuli aunties, they hear stories, hear stories, hear stories, but I think once they get on the land, like when Aunty Alice them went visiting where Hina’s Cave is and all of that, like then they started to remember stuff. I think that’s the problem with being severed from that land, that you literally are disconnected, like physically, and then you lose track of those stories.

CSH concluded the interview by inquiring into whether Mrs. Maunakea-Forth had any particular concerns about impacts to cultural resources, practices, and/or beliefs due to the proposed action. She shared,

> So, unfortunately, we owned a home in this subdivision area here. The quality of life was horribly poor, because of the original PVT footprint. Because there’s technology, it’s been a little bit mitigated, right? They’ve been able to manage the dust, the actual leaching, all those things. But that’s a very static way to look at this because that dump will be there forever. So, when we came into the picture to look at this land, yes there was a whole thing about, ‘we don’t want a golf course. The community doesn’t want agriculture.’ But one, this was the biggest land that we could find, because our scaling plan puts us at reversing the grant dependence. We’re reversing it. In terms of a long-term plan that’s looking at our sustainability in that way, in terms of a non-profit. But the other reason, is because you know, if not us, then who? If we aren’t going to address what the alternatives are to development, this kind of land into these kinds of projects, we’re not facing the fact that we are putting our garbage where we could be possibly growing our food. I agree that this is rocky. It is part of the watershed there, there’s a purpose to that,

> there’s a purpose. Re-purposing it into a development that’s going to take care of trash that just seems so short-sighted to me. But that’s not the idea. The idea is all our kids see us as a dump. When they can see us in our power, as a community that can grow our own food. You know, we’re looking at all these areas, all these areas are the same soil that they say you can’t grow food on. But that’s not true, you saw. You can grow food here and you can grow it organically. . . so that to me is the bigger issue. You have to look long-term, I believe there are other solutions to dealing with our waste. But this is not about opinion, this is about, I think what we know to be true. That our land was not meant to do this to. So, whatever we create, we need to take care of ourselves. . . I have concerns about all of that [cultural resources, practices, and beliefs]. Yeah, of access, of sites, of potential sites. I’m looking more future, and what impact that place has, not just its physical self, its organizational self. There are people there that are working because they are feeding their families. But, honestly the profit is not staying in our community and it far outweighs the good it could be doing for our community. If the community was involved and we could see more transparently, where those profits were going. Because they have their people telling us it’s the margins, the margins, nobody is getting rich in this venture . . . somebody is certainly profiting from this venture. So, I’m concerned about sustainable, livable wages, the quality life of those employees, and maybe later on, they’ll start to talk about the community benefits. But, everything that we processed for them, and sort of gave them our list of like, ‘this is [what is required to be] good neighbors’ kind of thing. Every single one of them, they shot it down, or they had some sort of justification . . .

Although articulating concerns, Mrs. Maunakea-Forth ended the interview incredibly hopeful and eager to care for MA‘O Organic Farm’s newly acquired lands. She concluded by sharing wisdom from her grandmother, a fitting allegory for the work and mission of MA‘O:

> My grandma always said that there’s always seeds. Even though it looks bare, there’s always seeds inside the land that once you pay attention to them and they’re nourished, then they come forth. Nobody has been there for a long time. So, I’m expecting we know more as we do more on the land.

Section 7 Traditional Cultural Practices

Timothy R. Pauketat succinctly describes the importance of traditions, especially in regards to the active manifestation of one’s culture or aspects thereof. According to Pauketat,

> People have always had traditions, practiced traditions, resisted traditions, or created traditions . . . Power, plurality, and human agency are all a part of how traditions come about. Traditions do not simply exist without people and their struggles involved every step of the way. [Pauketat 2001:1]

It is understood that traditional practices are developed within the group, in this case, within the Hawaiian culture. These traditions are meant to mark or represent aspects of Hawaiian culture that have been practiced since ancient times. As with most human constructs, traditions are evolving and prone to change resulting from multiple influences, including modernization as well as other cultures. It is well known that within Hawai‘i, a “broader ‘local’ multicultural perspective exists” (Kawelu 2015:3) While this “local” mixed culture is deservedly celebrated, it must be noted that it has often come into contact with “traditional Hawaiian culture.” This contact between cultures and traditions has undoubtedly resulted in numerous cultural entanglements. These cultural entanglements have prompted questions regarding the legitimacy of newly evolved traditional practices. The influences of “local” culture are well noted throughout this section, and understood to represent survivance or “the active sense of presence, the continuance of native stories, not a mere reaction, or a survivable name. Native survivance stories are renunciations of dominance, tragedy and victimry” (Vizenor 1999:vii). Acknowledgement of these “local” influences help to inform nuanced understandings of entanglement and of a “living [Hawaiian] contemporary culture” (Kawelu 2015:3). This section strives to articulate traditional Hawaiian cultural practices as were practiced within the *ahupua‘a* in ancient times, and the aspects of these traditional practices that continue to be practiced today; however, this section also challenges “tropes of authenticity” (Cipolla 2013) and acknowledges the multicultural influences and entanglements that may “change” or “create” a tradition.

This section integrates information from Section 1.4 and Sections 3–6 to further examine cultural resources and practices, both past and ongoing, identified within or in proximity to the project area. Such an analysis is conducted in order to determine whether the proposed undertaking will potentially affect or physically alter cultural resources, practices, or beliefs, isolate cultural resources, practices, or beliefs from their setting, and/or introduce elements which may alter the setting in which cultural practices take place (OEQC 2012:13). Although this analysis is designed to identify and describe cultural resources, practices, and beliefs located within the “potentially affected area” (OEQC 2012:12), community members did not identify specific traditional cultural practices, either past or ongoing, within the project area. As consequence, CSH was unable to identify evidence of ongoing traditional cultural practices at the project area. Community members also did not identify specific traditional, cultural resources, other than SIHP # -6699 (a likely late pre-Contact rock shelter) and SIHP # -6920 (a likely pre-Contact rock mound), as existing within the project area. However, interviewees did indicate a potential for subsurface cultural deposits within the project area. Additionally, one *kama‘āina* interviewee articulated a concern about potential impacts to the local environment, which could in turn negatively impact agricultural, and by extension, cultural practices. It should be noted that MA‘O Organic Farms intends to expand

their agricultural activity within a 236-acre parcel immediately north of the project area. However, concerns related to agricultural activity and the environmental welfare of the community lay beyond the purview of the current CIA. The results of studies evaluating potential air and water quality impacts in addition to mitigative measures should be included in the Final Environmental Impact Statement (FEIS).

7.1 Subsistence and Gathering of Plant and Aquatic Resources

According to traditional and historical research, Wai‘anae was known for its ocean resources and especially its deep sea fishing. It was observed that residents of the area would often catch and dry fish then take them to be sold. The name of the *moku* itself, Wai‘anae (“mullet water”), would suggest an area where the mullet is plentiful.

An AIS (McDermott and Hammatt 2000) at Ulehawa Beach Park uncovered traditional fishhooks and fish bone midden. One particular fishhook was found and seemed to have been made in the Marquesan or Tahitian style. The project area, however, is not located on the coast and was not used for the gathering of aquatic resources.

Mauka, within the upper valleys of Wai‘anae Moku, soils are considered well suited to sustaining agricultural activity. Soil fertility, however, varies in the lower valleys and is influenced by the location of streams. The streams closest to the proposed project area include the Ulehawa and Nānākuli streams. As the Ulehawa cuts a path *makai*, it comes within 287 m of the proposed project area. The location of this intermittent freshwater source appears to influence soils in the vicinity of the project area. The project area itself consists of soils associated with the Lualualei and Mamala series. These soils are typically used for sugarcane, truck crops, orchards, wildlife habitat, and pasture. Traditionally, however, Hawaiian agricultural production would have been focused on crops such as *kalo*, *‘uala*, *uhi* (yams), *mai‘a*, and *kō* (sugarcane) and would have been facilitated in one of two ways, either through an irrigated wetland system or a rain-fed dryland system.

The irrigated system was based entirely on *kalo*, the revered staple food believed to have derived from the first-born son of Wakea and Papa. This irrigated or *lo‘i* system can still be observed within certain valleys on O‘ahu Island, including Wai‘anae. For many involved in *‘āina*-based education, restoration and maintenance of *lo‘i kalo* has become “a core vehicle for communication and education regarding Hawaiian culture” (Lincoln et al. 2018:1). Conversely, the rain-fed dryland system was based largely on *‘uala* and “to a lesser extent dryland taro. . . banana. . . sugar cane. . . and other crops” (Ladefoged et al. 2009:2). Western encroachment into the Wai‘anae Coast and subsequent population decline during the early nineteenth century had an adverse impact upon agricultural practice and the traditional economy. As Ladefoged et al. (2009) documents,

> Most rain-fed systems were abandoned early in the 19th century, following the decimation of the Hawaiian population by introduced diseases. Hence, in contrast to the pond field systems that continue to operate in valley localities into modern times (albeit in restricted scale), the rain-fed systems were no longer operating and were not described in detail during early ethnographic archipelago-wide surveys of the early 20th century (Handy, 1940; Handy and Handy, 1972). [Ladefoged et al. 2009:2]

Europeans visiting the islands in the early nineteenth century also documented the abandonment of fields, attributing such action to the demands of the sandalwood trade upon *maka‘āinana*.

Journal entries from early European explorers, in addition to census data and Māhele records have aided in the reconstruction of the agricultural landscape during the historic period. At the time of Western Contact, the coastal lowlands of Lualualei and Wai‘anae Moku would have been cultivated with *‘uala* and *niu*, while valley areas would have been planted in *kalo* and *wauke*. Additionally, introduced vegetables would have been also found within the *māla* (gardens) of Wai‘anae. CSH did not identify evidence of ongoing subsistence farming or gathering within the project area. Historic maps provided within the report indicate the project area was not historically used for grazing or crop production.

Following the overturning of the *‘ai kapu* (literally “sacred eating;” under this code of conduct men and women could not share meals together and certain foods were forbidden to women), the types of food sources, and the ways in which they were prepared and consumed (and by whom) was significantly altered. Western-style hunting of introduced game animals was adopted during the early nineteenth century. Over the next century and a half, western-style hunting would become increasingly relied upon as a means to supplement diets, especially for low-income or working class *kama‘āina* families. Kukui Maunakea-Forth recalled that her brothers used to go pig-hunting in the *mauka* portions of Lualualei Valley, approaching from the neighboring *ahupua‘a* of Nānākuli. Although, pig hunting is not considered a traditional Hawaiian cultural practice, it is a respected practice within *kama‘āina* culture. Additionally, *kupuna* Shad Kāne recalled cattle ranching occurring within and in the vicinity of the project area. According to Mr. Kāne, cattle were brought from areas at higher elevations (where they were grazing) to the project area for roping and branding during the mid- to late twentieth century. He shared that,

> During the 1980s I did volunteer work for Ed Keliikoa and Wayne Silva roping, rounding up and branding cattle. In that region we used to gather the cattle in the higher elevations and bring them down into pens where the roping and branding took place. I cannot remember seeing any cultural structures [i.e. former religious, agricultural, and/or habitation sites] while riding my horse on those properties.

Despite several land use changes, agricultural practice continues today within Lualualei Valley. MA‘O Organic Farms currently cultivates approximately 23 acres within Lualualei Ahupua‘a. MA‘O was founded in the late ‘90s by

> . . . a group of residents, traditional practitioners, teachers, and business experts to . . . create the Wai’anae Community Re-Development Corporation (WCRC), a federally recognized 501 (c) (3) nonprofit organization designed to. . . address the challenges of our youth and community. [MA‘O Organic Farms n.d.]

Although early Hawaiians may have cultivated only small areas compared to the total acreage of each major island, in actuality utilizing larger land areas through gathering (Forman and Serrano 2012:5), farming has become an important means of reconnecting to *‘āina*. This association to *‘āina* has become a “vital source of individual identity, cultural identity, and security” (Andrade 2014:7). Additionally, both small-scale and large-scale farming may be considered a *kama‘āina* practice borne from the self-sufficency demanded of early plantation workers. The self-sufficiency of workers, or rather their ability to supplement “their own subsistence needs” was encouraged by plantations, allowing them “to minimize both wages and production costs” (Takaki 1983:9). For

working class *kama‘āina*, the ability to supplement one’s diet with small-scale farming was critical. The vitality of such farming practice was made evident by Mrs. Kukui Maunakea-Forth.

For MA‘O Organic Farms, who will become the future neighbor to the PVT Integrated Solid Waste Management Facility project, the cultivation of food crops has not only provided a sustainable local food system to the Wai‘anae Coast community, but has also allowed for the

> Educat[ion] and empower[ment of] youth, [reduction in] hunger and injustice, improve[ment of] our health and nutrition, and [the development of] a local, organic and fair agriculture industry—all connected to empower [the] community to move towards self-sufficiency. [MA‘O Organic Farms n.d.]

The crops currently cultivated by MA‘O Organic Farms also support communities outside Wai‘anae Moku. Recent research conducted by the ‘Imi Na‘auao Mapping Project indicates that MA‘O Organic Farms produces approximately 75 tons of food every year, and distributes this food to over 26 different restaurants and markets on O‘ahu (including central Honolulu and Kailua) (‘Imi Na‘auao Mapping Project 2018).

7.2 Trails

A map by Paul Rockwood details the trails described by ‘Ī‘ī mentioned in Section 3.2.4. Three distinct trails give access to the Wai‘anae District, the most popular of these trails was the coastal route that circled the entire island of O‘ahu. Site -3750, a C-shape enclosure was discovered near a trail running north-south. Though no documentation further describes the trail, its proximity to known habitation sites and potential sourcs of water suggests it may be associated with the C-shaped enclosure.

As a very arid environment, these trails likely served as a means of commute from lower, coastal areas to upper, inland resources. Several streams are found in the valleys and connect to empty out at either Mā‘ili‘ili or Ulehawa Stream. It is possible that the trails may have provided the opportunity for trade between coastal residents who fished and inland residents who cultivated. No traditional Hawaiian trails were identified within the project area. According to the Rockwood map, the nearest trail to the project area was the coastal path that linked the *moku* of ‘Ewa, Wai‘anae, and Waialua. However, ephemeral footpaths associated with modern-era ground-disturbing activity may still exist within the project area.

7.3 *Wahi Pana*

Cultural sites, or Hawaiian *wahi pana* effectively contribute to the ways in which *kama‘āina* remember and identify (Basso 1996; Holtorf and Williams 2006), and thus continue to manifest and perpetuate culture. Although no *wahi pana* were identified within the project area, several *wahi pana* were identified within the immediate vicinity of the project area. Prominent *wahi pana* are Pu‘u Heleakalā, Hina’s Cave, Ulehawa Stream, and Māui Pōhaku. These *wahi pana*, due to their ability “to manifest and perpetuate culture,” function as cultural resources. As Cipolla (2008) makes clear,

> . . . people inherit the places that they inhabit (from the past), connections between memory, identity and landscape are usually quite strong. In this sense, space, as configured in the past (which could be the recent past) by either natural or cultural

> processes, ties reflexively to social relations in the present (see Bourdieu 1977; Lefevbre 1991) and, in turn, to social memories. [Cipolla 2008:199]

These social memories, in turn, work to inform world views and everyday practices. Counted among these practices, and largely subsumed under a “living contemporary culture” (Kawelu 2015:3), is the care or management of natural resources, including cultural sites.

One aspect of modern-era care includes the management of scenic resources (view planes and/or view corridors). In order to carry out management, which at its core, is dedicated to “protecting those views held most sacred by the populace,” a site must be understood in its natural meaning and environmental role; additionally, human behavioral values ascribed to the site must also be identified (Chappell 2003; Minerbi 1975:8). Human behavioral values can be evaluated alongside the concept of habitus as these values relate to:

> -what people see;
>
> -what people appreciate;
>
> -what people actually use;
>
> -what people remember of their experiences;
>
> -what people associate with [a] site
>
> [Minerbi 1975:8]

In essence, the values that one ascribes to their environment and visible landscape can in turn, shape their identity (or cultural identity).

As cultural sites, several *pu‘u* figure prominently within the Lualualei cultural landscape. *Pu‘u* are important first for their view planes, and also, perhaps their inaccessibility. *Pu‘u*, in general, are landmarks, especially useful in discerning one’s location or routes. The naming of *pu‘u*, and the stories behind the name, contribute to the integrity of the place.

There are many *pu‘u* in Lualualei but some have more traditional importance than others. Pu‘u Heleakalā separates Nānākuli and Lualualei. This *pu‘u* is mentioned in a story of Māui and his mother Hina. Hina lived in a cave within Pu‘u Heleakalā where she would make her *kapa.* In the story, Māui reached up toward the sky and caught one of the legs of the sun, breaking it. In doing so, the sun vowed to change and travel slower during the day to allow people appropriate time to work. An account in the Hawaiian newspaper, *Kuokoa,* by a man named Poepoe confirms the location of this cave that faces Ulehawa Stream. Ulehawa, itself, is also often understood to be the birthplace of Māui and the Māui legends.

The influence of the Māui and Hina tale, as it relates to both *wahi pana* and traditional cultural practice, is also visible within the historic record. Around 1790, Captain Vancouver sailed pass the Wai‘anae coast where he noticed *‘uala*, *niu*, *kalo*, and *wauke* in the inland valleys. Land Commission Awards indicated numerous *lo‘i* and dryland crops of *wauke.* This would suggest that the *ahupua‘a* of Lualualei was utilizing its dry, leeward environment to manufacture *kapa.* The production of such cultural material indexes a tradition tied to a mythic past, a mythic past still visible within the landscape. In a recent field inspection for the proposed project, archaeologists visited Hina’s Cave. As part of their inspection, they noted that Hina’s Cave appeared free of recent disturbance, with no rubbish or offerings (e.g., *lei*) observed (Shideler and Hammatt 2018:46).

Northeast of Hina’s Cave are several more *pu‘u*, including Pu‘u Kaua, Pu‘u Hapapa, and Pu‘u Kānehoa. Pu‘u Kānehoa was named for native shrubs that include all species and varieties of *pūkiawe* and *maiele*. The leaves of these plants were used in the practice of *lā‘au lapa‘au* for colds or headaches. A *heiau* is believed to be at the foot of this *pu‘u.* Mauna Kūwale on the border of Lualualei and Wai‘anae is home to a small burial cave near its peak. Pu‘u Pāhe‘ehe‘e is a ridge and hill and also the name of a *heiau* on the same ridge. The *heiau*, however, was completely destroyed in an effort to enlarge an “oriental” cemetery (Sterling and Summers 1978:68). Pu‘u Pāhe‘ehe‘e which translates to “slippery” (Pukui et al. 1974:174) once had a *hōlua* slide though its exact location is unknown. Lastly, Kāne‘īlio Point demarcates the most southern point of Pōka‘i Bay. A *heiau* once stood at the point and was named after Kū‘īlioloa, a *kupua* who took shape as a dog-man. He was known as a protector of travelers. The *heiau* was partially destroyed though some parts are still visible.

McAllister identified two known *heiau* of Lualualei and a separate site that could have possibly been a *heiau*. Other resources bring the total of known *heiau* to five. These *heiau* include Nīoi‘ula, Kakioe, Pu‘upāhe‘ehe‘e, Kū‘īlioloa and a possible *heiau* at the foot of Pāhoa in the middle of Lualualei.

McAllister describes a *pōhaku* called the Māui Pōhaku. Believed to be named after the demi-god Māui, this rock was once surrounded by water and was said to be the place where Māui sun-bathed. He lived in a shelter just northeast of the rock and gathered water from a nearby spring. The rock is now split in half and currently overgrown with young Chinese banyan saplings, grasses, and weeds. In addition to inspecting Hina’s Cave, archaeologists also documented the Māui Pōhaku (Shideler and Hammatt 2018). Within their field documentation they noted that the Māui Rock (SIHP # 50-80-07-0148) was found to be free of recent disturbance, with no rubbish or *ho‘okupu* (offerings) observed. The lack of *ho‘okupu* is perhaps explained by way of testimony provide by Kukui Maunakea-Forth. In recalling this area (both Hina’s Cave and Pu‘u Heleakalā), she noted that it was a sacred space, *wahi kapu*; as she explained, one did not go *hana ‘ino* or be *maha ‘oi*, these spaces were left to *akua*.

In an effort to account for view planes, archaeologists noted that the view from Hina’s Cave southwest toward the Māui Rock was relatively clear, as the cave remains sufficiently elevated above the filled land in between to maintain an unbroken view. However, the view from the rock northeast toward the cave is blocked by a residential duplex subdivision.

7.4 Religious Practice and Burials

Traditionally, prior to any undertaking, prayers were offered to the multitude of ancestor gods and spirits, to *akua*, *‘aumākua*, and *kupua* alike. As Mary Kawena Pukui notes, “Long before the missionaries came, Hawaiians were *haipule*, religious. Everything they did, they did with prayer” (Pukui et al. 1972:121). The offering of prayer is especially evident by the relatively large number of *pule* ascribed to Hi‘iaka as she stood at the summit of Pōhākea (*Aluna au a Pōhākea, Kū au, nānā ia Puna* . . .) (Emerson 1915:162–168). Pōhākea Pass traverses the Wai‘anae Mountains and descends Hālona Valley below Pōhākea. Pōhākea serves as a passage to Honouliuli Ahupua‘a.

Formal prayers consisting of “composed, memorized, handed-down chants” were often associated with public ceremonies involving both the *ali‘i* and the priestly class. Those belonging to the royal and priestly classes prayed before *kuahu* (altars) and *heiau* (Pukui et al. 1972:123).

According to Pukui et al. (1972:123), “these prayers were often accompanied by sacrifices to the gods, [and] embellished by ritual. . .” Such prayers would have been heard at *heiau* like Kakioe, located at Pūhāwai in Lualualei. Kakioe Heiau was a *pahu heiau* whereby drums would have been utilized to “signal the activities of complex ceremonies, significant events such as the births of chiefs, and to accompany the prayers and movements of *kahuna* and *ali‘i*” (Smithsonian Institution 1989).

Sacred or religious sites such as *heiau* are often seen as a sacred link to the past. Sacred linkages to the past are also represented within one’s *mo‘okū‘auhau*. In understanding the term, it is useful to look at word structure, in this case the root word “*mo‘o*.” Mary Kawena Pukui defines *mo‘o* as a dragon or lizard, as well as a succession or series, especially a genealogical line (Pukui and Elbert 1986:253). Hence *mo‘okū‘auhau*, indexes an understanding of the lizard or dragon’s “interlocking bones as symbolic of their own sacred lineage” (Wianecki 2012):

> The dragon is a major force of life. . . Its head peers into the future, the white dawn yet to come. Its front feet are the ‘opio (youth), reaching, touching, examining. Next come the makua (parents), the stable hind legs of the dragon, and beyond them, the kupuna (elders). The kupuna form the spine, the collective song of all that came before. They tell how other dawns were and how this dawn will be. [Sam Ka‘ai cited by Wianecki 2012]

Beliefs related to lineage are also articulated through the *piko* concept. During the interview with Kukui Maunakea-Forth, CSH was introduced to a youth leader by the name of Kiana Tector. As a *kama‘āina* of Nānākuli, Kiana reflected on the traditional Hawaiian beliefs that had had a profound impact on her work, influencing her relationship to *‘āina*. Kiana identified the connection of *piko* as a belief of particular importance. This cultural belief has been discussed with the young leaders who work at MA‘O Farms and continues to inform their practices within Lualualei Valley. Mary Kawena Pukui describes this connection:

> There was a physical and mystic linking of the body with forebearers of old and descendants to come; this was placed in the *piko* of head, of navel and umbilical cord, and of genitals. The genitals (*piko*) linked the living person with offspring, present and yet unborn. The navel and umbilical cord (*piko*) tied one equally to one’s parents and one’s children. But the *piko* of the head—the crown or posterior fontanel—symbolized the bonds between the living individual and his never known and long departed ancestors. These, once mortal, were now god-spirits. These were the *‘aumākua*. [Pukui et at. 1972:294]

The *‘aumākua* was a revered intercessor, providing the “closest man-with-god relationship” (Pukui et al. 1972:123). As Pukui (1972) also notes:

> For these deities had once been living beings; they were long departed ancestors become gods. From the long corridors of time the *‘aumākua* watched their descendants. And though they judged and punished, they were also special advocates and protectors. For *‘ohana* (family) loyalty continued into eternity. [Pukui 1972:123]

Upon death, the spirit of the recently deceased was said to leave the body and then proceed toward a leaping place (Handy and Pukui 1977:146). It was in fact the *‘aumākua* that guided the

spirit to and over the *leina* (Leinahonua and Leina‘uhane at Ka‘ena) for its leap into Pō, the world of the “unseen” (Handy and Pukui 1977:146). The body of the deceased, however, was attended to by the living. Burial was done at night, “. . . so that by morning the burial was accomplished” (Malo 1951:97).

Previous archaeological studies indicate burials near the project area, but no burials have yet been identified within the project area. McAllister (1933) mentions the burial cave (Site 162) at the peak of Mauna Kūwale. In 1999, CSH (McDermott and Hammatt 2000) conducted an AIS on a parcel at ‘Ulehawa Beach Park. A local informant identified an area that contains burials and cultural deposits. The informant reported that burials would be found *makai* of Farrington Highway and in proximity to ‘Takamina,’ the Japanese shrine, north of Hakimo Road. SIHP #50-80-07-5949 was identified by Elmore and Kennedy (2001) during test excavations and included one human burial.

7.5 *‘Āina* and Hawaiian Cultural Education Systems

Cultural practices of late have been inspired by traditional understandings of caring for natural and cultural resources. Many organizations have adopted practices wherein the community can *mālama ‘āina*, and in turn benefit from the knowledge inherent in it. Many community organizations across the Islands have become dedicated to an *‘āina*-based education or Hawaiian cultural education system. In learning traditional Hawaiian values, *kama‘āina* children acquire the “social and emotional learning (SEL) skills and academic mindsets to succeed in college, careers and communities locally and globally” (Department of Education 2015). Many organizations have adopted the belief that each child deserves access to an excellent education, as well as opportunities to improve health and nutrition and fight hunger and injustice. Mrs. Maunakea-Forth co-founded WCRC and MA‘O Organic Farms alongside her husband, Mr. Gary Maunakea-Forth, in order to effect systemic change within their communities of Wai‘anae and Nānākuli. MA‘O Organic Farms is actively promulgating practices committed to collective and individual empowerment. Of primacy is mentorship and reconnecting back to *‘āina*. In this way, Mrs. Maunakea-Forth and MA‘O Organic Farms promote a culturally-relevant and values-based pedagogy or education system. These values are expressed and made visible through the agricultural work (or practices) of MA‘O Organic Farms and the mentorship of their youth leaders.

Section 8 Summary and Recommendations

CSH undertook this CIA at the request of PVT Land Company Ltd (PVT). The research broadly covered the *ahupua‘a* of Lualualei, including the 179-acre project area.

8.1 Results of Background Research

Background research for this project yielded the following results (presented in approximate chronological order):

1. Lualualei is the largest leeward valley on O‘ahu. Composed of approximately 14,000 acres, Lualualei extends from the Wai‘anae Range to the ocean. To the south is the *ahupua‘a* of Nānākuli and to the north is the *ahupua‘a* of Wai‘anae. Its southern border includes a portion of Pu‘u Heleakalā, and its northern boundary includes a portion of Pu‘u Pāhe‘ehe‘e.
2. Wai‘anae Moku consists of ten *ahupua‘a*: Nānākuli, Lualualei, Wai‘anae Kai, Wai‘anae Uka, Mākaha, Kea‘au, ‘Ōhikilolo, Mākua, Kahanahāiki, and Keawa‘ula.
3. The Hawaiian Islands began exporting sandalwood to Asia shortly after 1800 and the commerce flourished until the supply dwindled in the mid-1830s. Lualualei was a region of importance in the sandalwood trade. The demands put on the *maka‘āinana* to harvest wood for trade caused many agricultural fields to become fallow and unused.
4. At the time of the Māhele, the *ahupua‘a* of Wai‘anae, which included Lualualei, was listed as Crown lands and was claimed by King Kamehameha III as his personal property (Board of Commissioners 1929:28).
5. Thirteen land claims were made in Lualualei; however, only seven were actually awarded. Most awards were located upland in the *‘ili* of Pūhāwai, approximately 6.5 km northwest of the current project area. From the claims, it can be determined that at least eight families were living in Pūhāwai at the time of the Māhele in 1848. Together, they cultivated a minimum of 163 *lo‘i*. The numerous *lo‘i* mentioned in the claims indicate the land was ideal for growing wetland taro and that this livelihood was actively pursued by the awardees.
6. One of the first areas to be utilized for ranching on the Wai‘anae coast was Lualualei. Hawai‘i Bureau of Land Conveyances [B.C.], 1845-1869 (archived at the DLNR) records show that William Jarrett leased approximately 17,000 acres of land from Kamehameha III in 1851. This was the beginning of Lualualei Ranch.
7. Hermann A. Widemann was a jack-of-all-trades who dabbled in politics and business (Dorrance and Morgan 2000:43). Widemann had financial backing from Hackfeld & Company as well as George N. Wilcox, a reputable sugar planter from Kaua‘i. In 1879, Widemann leased Wai‘anae Kai for 25 years (McGrath et al.1973:37). Widemann hired 20 Hawaiian workers, 15 *haole* technicians, and 60 Chinese laborers. He also built 24 new homes in Wai‘anae to house his employees.
8. In 1901, the Waianae Sugar Company leased 3,332 acres in Lualualei for raising cane as well as for ranching (Commissioner of Crown Lands 1902). Amfac, Inc. purchased the plantation and closed it down in 1947.
9. Land tenure includes Māhele Awards in 1848 and Land Commission Awards in the 1850s; Hawaiian homelands designations in 1921; U.S. Navy use beginning in 1930 and

1933; and most recently in 1995, the State of Hawai‘i and the U.S. government have been involved in the land ownership changes in Lualualei.

10. During the first half of the twentieth century, another major influence in Lualualei Ahupua‘a was the military. By 1929, over 8,184 acres of the McCandless Cattle Ranch had been condemned and purchased by the U.S. Navy for the construction of a Naval Ammunition Depot for the ships based at Pearl Harbor Naval Base.

Extensive evidence of traditional Hawaiian activity is largely confined to the *makai* sections of the *ahupua‘a*, immediately adjacent to the ocean. In contrast to the abundance of traditional Hawaiian features known to exist in the *mauka* half of Lualualei, the surface historic properties recorded in the central section of Lualualei Valley, within the region where the current project area is located, were either post-Contact or of equivalent origin. The lack of traditional Hawaiian sites in Lualualei *waena* may reflect not only the distortions of modern disturbances (including bulldozing, farming, and ranching) but also a general disuse during pre-Contact times. Population and activity in Lualualei may have been primarily focused in a narrow band along the coast and farther inland in the *mauka* reaches of this large valley. At the beginning of the twentieth century, Lualualei lands in and around the project area were opened for homesteading. However, due to the lack of water, the lots were classified as second-class pastoral land rather than agricultural land. Simultaneoulsy, the United States federal government expanded its sphere of influence within Lualualei Ahupua‘a, gaining control of the lands surrounding the current project area.

8.2 Results of Community Consultation

CSH attempted to contact NHOs, agencies, and community members as well as cultural and lineal descendants in order to identify individuals with cultural expertise and/or knowledge of the project area and vicinity. Community outreach letters were sent to 132 individuals or groups. To date, nine have responded, and one *kupuna* has submitted written testimony. One community member, representing MA‘O Organic Farms, participated in a formal, sit-down interview. Below is a list of individuals who have shared their *mana‘o* and *‘ike* about the project area and Lualualei Ahupua‘a:

1. Shad Kāne, member of the Kapolei Hawaiian Civic Club, Chair of the O‘ahu Council of Hawaiian Civic Clubs Committee on the Preservation of Historic Sites and Cultural Properties, Ali‘i Ai Moku of the Kapuāiwa Chapter of the Royal Order of Kamehameha Ekahi, and ‘Ewa Moku Representative on the State Aha Moku Advisory Committee
2. Kukui Maunakea-Forth, *kama‘āina* of Nānākuli and co-founder of MA‘O Organic Farms

Community members did not identify specific traditional cultural practices, either past or ongoing, within the project area. As consequence, CSH was unable to identify evidence of ongoing traditional cultural practices at the project area. Community members also did not identify specific traditional cultural resources, apart from SIHP #s -6699 and -6920, as existing within the project area. However, interviewees did indicate a potential for subsurface cultural deposits within the project area. Additionally, one *kama‘āina* interviewee articulated a concern about potential impacts to agricultural activity and the environmental welfare of the community. It should be noted that MA‘O Organic Farms intends to expand their agricultural activity within a 236-acre parcel immediately north of the project area.

8.3 Impacts and Recommendations

No traditional cultural practices were identified within the project area. Although the proposed project is not anticipated to impact traditional cultural practices in the vicinity of the project area, potential impacts were identified, and the following preliminary recommendations made:

1. Impact: Three historic properties were identified within the project area. SIHP # -6681, a military bunker, was previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places under Criteria A (property reflects major trends or events in the history of the state or nation) and D (historic property has yielded or may be likely to yield information important in prehistory or history) by O’Leary and McDermott (2006). SIHP #s -6699, a rock shelter, and -6920, a rock mound, were previously evaluated as eligible for listing on the State of Hawai‘i Register of Historic Places solely under Criterion D by O’Leary and McDermott (2006) and Hammermeister and McDermott (2007), respectively.

   Recommendation: No further historic preservation work has been recommended for SIHP #s -6681 and -6920 (Hammermeister and McDermott 2007). However, due to the proximity of SIHP # -6699 to the project area, it was recommended that interim protection measures be installed to ensure no construction activities adversely affect the historic property. CSH prepared a preservation plan (Tulchin and Hammatt 2007) to protect the historic property from construction activity. The preservation plan recommended demarcation of an 8-m (26-ft) buffer zone surrounding the historic property for protection from construction activity. The suggested buffer zone would be established using a 35-m (115-ft) long steel post and wire or chain link fence. Additionally, natural vegetation will not be cleared from the historic property, further obscuring the rock shelter’s location as an additional means of protection.

2. Impact: It is necessary to note that certain types of historic properties and cultural sites are difficult to recognize by pedestrian survey alone. It is possible subsurface cultural deposits (i.e., *iwi kūpuna*, *pōhaku* suitable for traditional construction) may yet exist, and may be encountered during ground disturbing activities. While no human burials have been identified by previous archaeological studies within the project area, historical research indicates that *heiau* of the *po‘okanaka* class (McAllister 1933:110, Thrum 1908:47, Westervelt 1915a:122, Westervelt 1915b:178), were present within Lualualei Ahupua‘a. There are also numerous accounts associating upland areas with battles and mortal combat (Sterling and Summers 1978:67). LCA documentation, however, indicates that settlements (and potentially burial sites) were confined to the upland *‘ili* (land section) of Pūhāwai, northwest of the current project area.

   Recommendation: It is recommended that project construction workers and all other personnel involved in the construction and related activities of the project should be informed of the possibility of inadvertent cultural finds, including human remains. In the event that any potential historic properties are inadvertently discovered within the project area, these discoveries should be reported immediately to the State Historic Preservation Division (SHPD). In the event that *iwi kūpuna* and/or cultural finds are encountered, consultation with lineal and cultural descendants of the area is also recommended.

5. Impact: Interviewee Kukui Maunakea-Forth voiced a concern about potential impacts to cultural resources, practices, and beliefs. Future practices to occur in the vicinity of the project area will include farming. No specific cultural beliefs were identified in connection to the project area, however, brief discussion of the *piko* concept, as well as the cultural associations of Māui and Hina did occur. Mrs. Maunakea-Forth identified potential cultural resources within the vicinity of the proposed project area. These resources include ephemeral ponds and streams, historic *lo‘i kalo* (taro terraces; located on the southeastern side of Ulehawa Stream), Ulehawa Stream, and *pōhaku*. According to Kukui Maunakea-Forth, these *pōhaku* contain a unique quality that makes them suitable for stone masonry work, Additionally, Kukui Maunakea-Forth identified culturally significant sites or *wahi pana* in the vicinity of the project area. These sites include Pu‘u Heleakalā and Ka ‘Ōlae (the 236-acre parcel recently acquired by MA‘O Organic Farms).

   Recommendation: Currently, Ulehawa Stream and its associated historic *lo‘i kalo* exist outside the current project area. Due to the ephemerality of the ponds and streams, it is difficult to ascertain the full extent of potential impact. It is recommended that a qualified professional provide an assessment of the potential for ephemeral fresh water resources within and near the project area. Additionally, view corridors protecting views of *wahi pana* such as Pu‘u Heleakalā must remain unobstructed.

3. Impact: There is a concern that the proposed action will have an adverse impact on farming activity to occur immediately north of the project area. Although current farming activity includes the cultivation of both traditional and non-traditional crops, the practice itself is considered to have historical antecedence within Lualualei. Currently, MA‘O Organic Farms produces approximately 75 tons of food every year, and distributes this food to over 26 different restaurants and markets on O‘ahu. Farmers employed through MA‘O are primarily young *kama‘āina* from throughout Wai‘anae Moku; cultivated crops gathered by these farmers (crops that are not distributed to restaurants and markets) are also kept for personal consumption. The availability of crops is especially vital to the health and wellness of farmers and their *‘ohana*. Due to understandings of farming as an articulation of Hawaiian identity and manifestation of culture, agricultural activity in the vicinity of the project area may be understood to represent a cultural practice.

   Recommendation: It is recommended that an environmental scientist or similar qualified professional provide an assessment of the impacts of the proposed action to the surrounding environment and community. Although, the project area is downwind and down gradient from the MA‘O Farm parcel, an assessment will aid in addressing concerns about potential impacts to future agricultural activity occurring north of the project area. Should stakeholders (i.e., *mahi‘ai* and/or community members) observe changes in crop quality or impacts to the environmental welfare of the community, the landowner and/or developer should remain amenable to engaging in *ho‘oponopono* (conflict resolution) to either avoid or minimize impacts or to provide compensatory mitigation.

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n.d. Photo of sugarcane in Lualualei Valley with flume to the right; Kolekole Pass in center background. Hawai‘i State Archives, Honolulu.

n.d. Photo of Lualualei Naval Base area. Hawai‘i State Archives, Honolulu.

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Appendix A Authorization and Release Forms

A.1 Kukui Maunakea-Forth

22 April 2019

Cultural Surveys Hawai‘i, Inc.
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AUTHORIZATION AND RELEASE FORM

Cultural Surveys Hawai‘i (CSH) appreciates the generosity of the *kūpuna* and *kama‘āina* who are sharing their knowledge of cultural and historic places, and experiences of past and present cultural practices. At the request of PVT Land Company Ltd (PVT), Cultural Surveys Hawai‘i (CSH) is conducting a Cultural Impact Assessment (CIA) for the proposed PVT Integrated Solid Waste Management Facility Relocation project, Lualualei Ahupua‘a, Wai‘anae Distict, O‘ahu, Hawai‘i, TMK: [1] 8-7-009:007.

We understand our responsibility in respecting the wishes and concerns of the interviewees participating in our study. Here are the procedures we promise to follow:

1. The interview will not be tape-recorded without your knowledge and explicit permission.
2. You will have the opportunity to review the written transcript or notes of our interview with you. At that time you may make any additions, deletions or corrections you wish.
3. You will be given a copy of the interview transcript or notes for your records.
4. You will be given a copy of this release form for your records.

For your protection, we need your written confirmation that:

1. You consent to the use of the complete transcript and/or interview quotes for reports on cultural sites and practices, historic documentation, and/or academic purposes.
2. You agree that the interview shall be made available to the public.
3. If a photograph is taken during the interview, you consent to the photograph being included in any report/s or publication/s generated by this cultural study.

I, J. KUKUI MAUNAKEA FORTH (Please print your name here), agree to the procedures outlined above and, by my signature, give my consent and release for this interview and/or photograph to be used as specified.

K Maunakea Forth (Signature)

4/22/19 (Date)

A.2 Kiana Tector

22 April 2019

Cultural Surveys Hawai‘i, Inc.
Archaeological and Cultural Impact Studies
Hallett H. Hammatt, Ph.D., President

P.O. Box 1114 Kailua, Hawai‘i 96734 Ph: (808) 262-9972 Fax: (808) 262-4950

Job code: LUALUALEI 33 bbeauchan@culturalsurveys.com www.culturalsurveys.com

AUTHORIZATION AND RELEASE FORM

Cultural Surveys Hawai‘i (CSH) appreciates the generosity of the *kūpuna* and *kama‘āina* who are sharing their knowledge of cultural and historic places, and experiences of past and present cultural practices. At the request of PVT Land Company Ltd (PVT), Cultural Surveys Hawai‘i (CSH) is conducting a Cultural Impact Assessment (CIA) for the proposed PVT Integrated Solid Waste Management Facility Relocation project, Lualualei Ahupua‘a, Wai‘anae Distict, O‘ahu, Hawai‘i, TMK: [1] 8-7-009:007.

We understand our responsibility in respecting the wishes and concerns of the interviewees participating in our study. Here are the procedures we promise to follow:

1. The interview will not be tape-recorded without your knowledge and explicit permission.
2. You will have the opportunity to review the written transcript or notes of our interview with you. At that time you may make any additions, deletions or corrections you wish.
3. You will be given a copy of the interview transcript or notes for your records.
4. You will be given a copy of this release form for your records.

For your protection, we need your written confirmation that:

1. You consent to the use of the complete transcript and/or interview quotes for reports on cultural sites and practices, historic documentation, and/or academic purposes.
2. You agree that the interview shall be made available to the public.
3. If a photograph is taken during the interview, you consent to the photograph being included in any report/s or publication/s generated by this cultural study.

I, Kiana Tector, agree to the procedures outlined above and, by my
(Please print your name here)
signature, give my consent and release for this interview and/or photograph to be used as specified.

Kiana Tector
(Signature)

04/22/19
(Date)

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APPENDIX I
Landscaping Plan

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BROWNLIE & LEE

LANDSCAPE ARCHITECTURE
SITE PLANNING
IRRIGATION CONSULTANTS

City Financial Tower
201 Merchant St.
Suite 1930
Honolulu, Hawaii 96813
Tel: (808) 528-4363
Fax: (808) 531-8191

PVT ISWMF RELOCATION

SHEET LIST	
L-001	TITLE SHEET AND SHEET LIST
L-100	OVERALL LANDSCAPE PLAN
L-101	LANDSCAPE PLAN - 1
L-102	LANDSCAPE PLAN - 2
L-103	LANDSCAPE PLAN - 3
L-104	LANDSCAPE PLAN - 4
L-105	LANDSCAPE PLAN - 5
L-200	OVERALL IRRIGATION PLAN
L-201	IRRIGATION PLAN - 1
L-202	IRRIGATION PLAN - 2
L-203	IRRIGATION PLAN - 3
L-204	IRRIGATION PLAN - 4
L-205	IRRIGATION PLAN - 5
L-206	IRRIGATION DETAILS
L-207	IRRIGATION DETAILS

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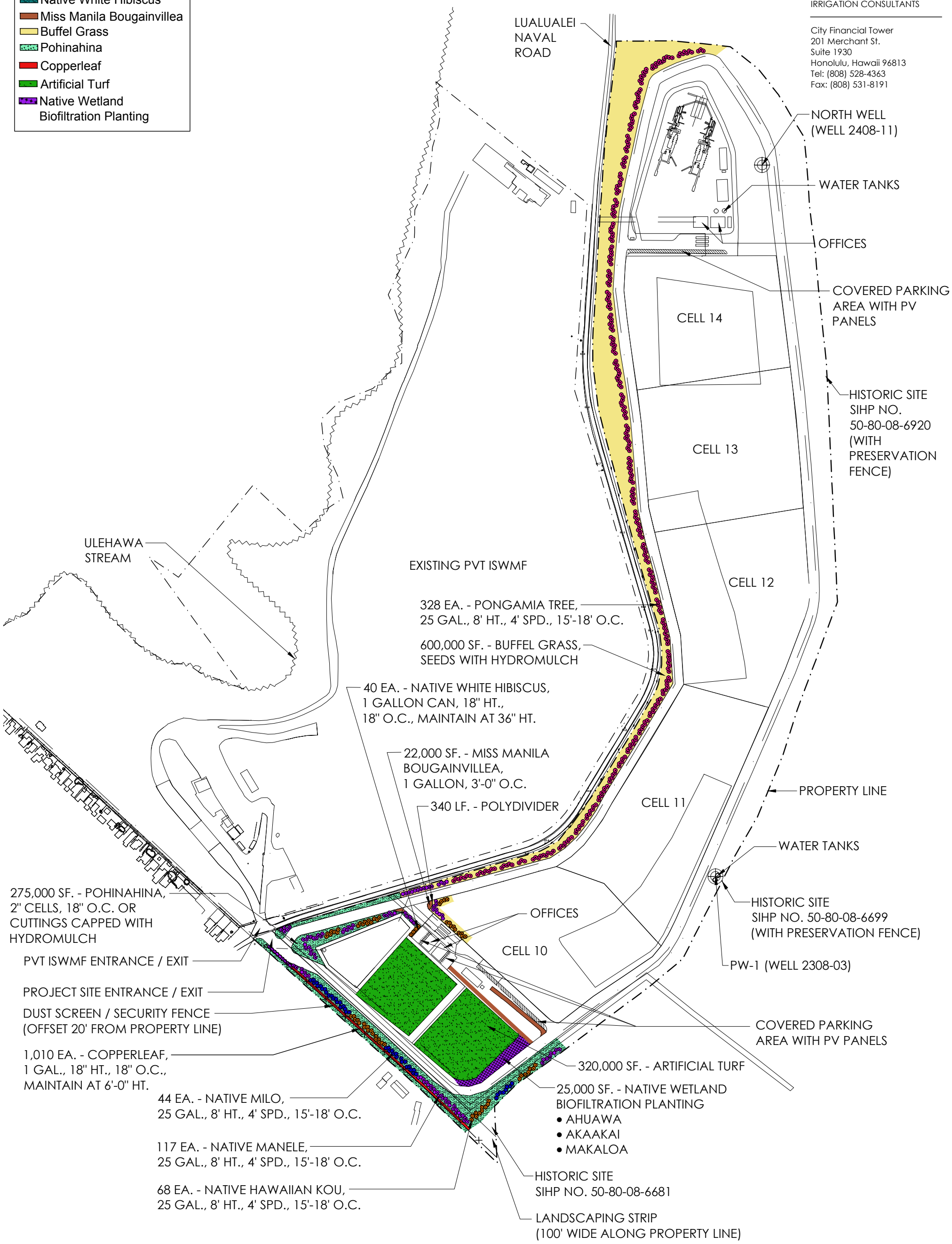
Legend
- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting



NORTH

OVERALL LANDSCAPE PLAN

SCALE: 1" = 500'

0 250 500 1,000 1,500

SCALE: 1" = 500'

L-100

Legend
- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting

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NORTH

LANDSCAPE PLAN - 1

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

L-101

Legend

- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting

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NORTH

LANDSCAPE PLAN - 2

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

Legend

- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting

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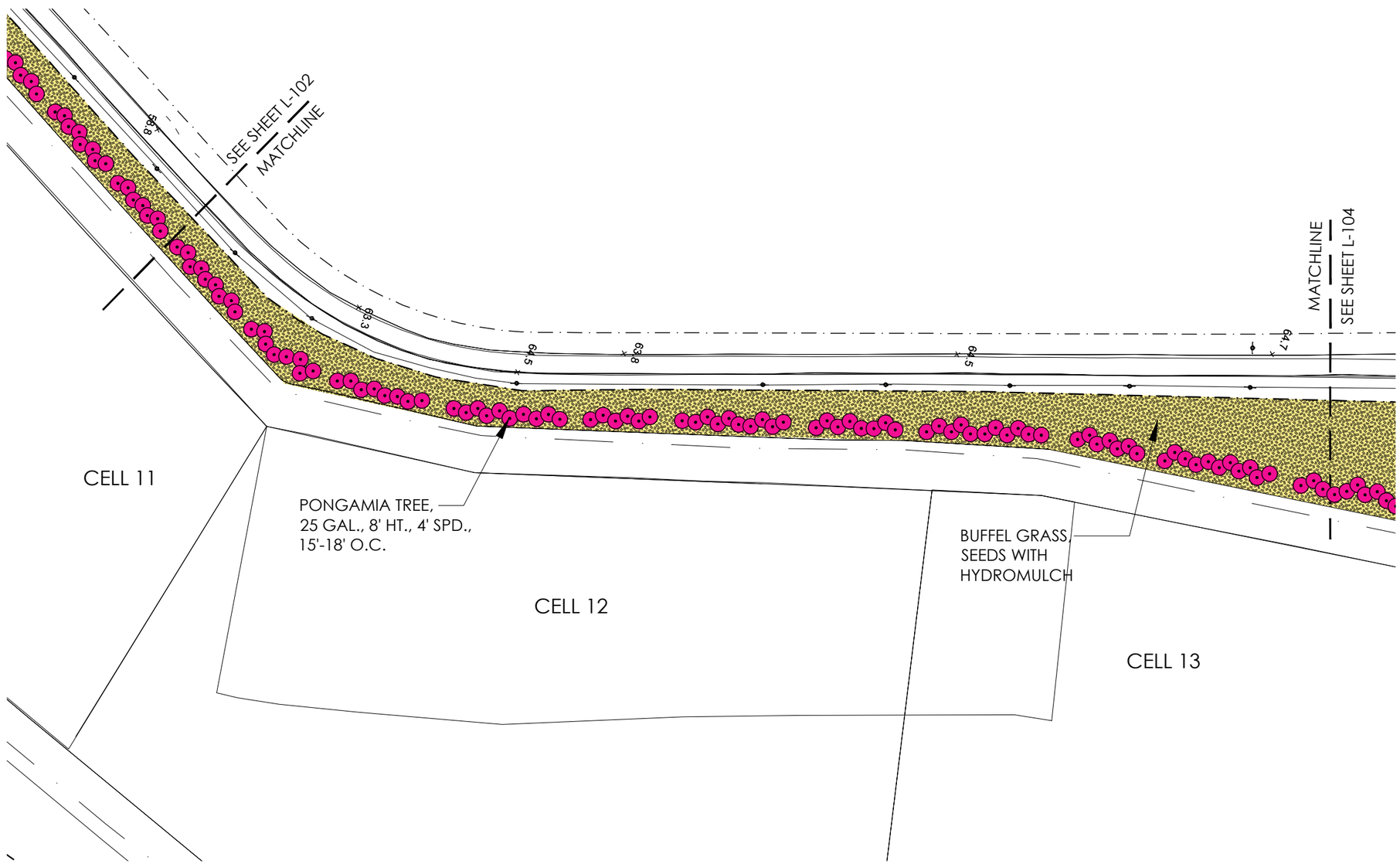

NORTH

LANDSCAPE PLAN - 3

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

Legend

- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting

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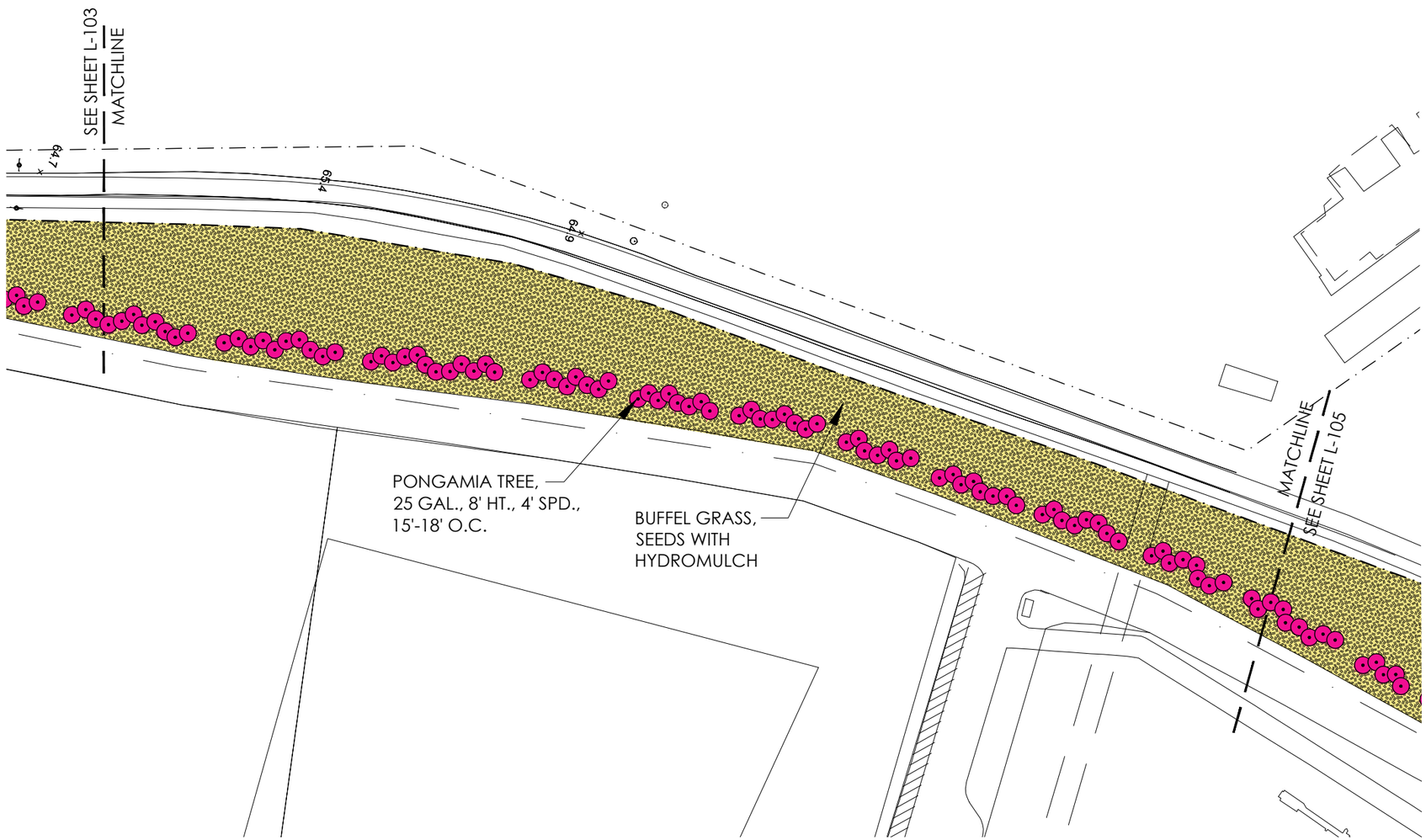


NORTH

LANDSCAPE PLAN - 4

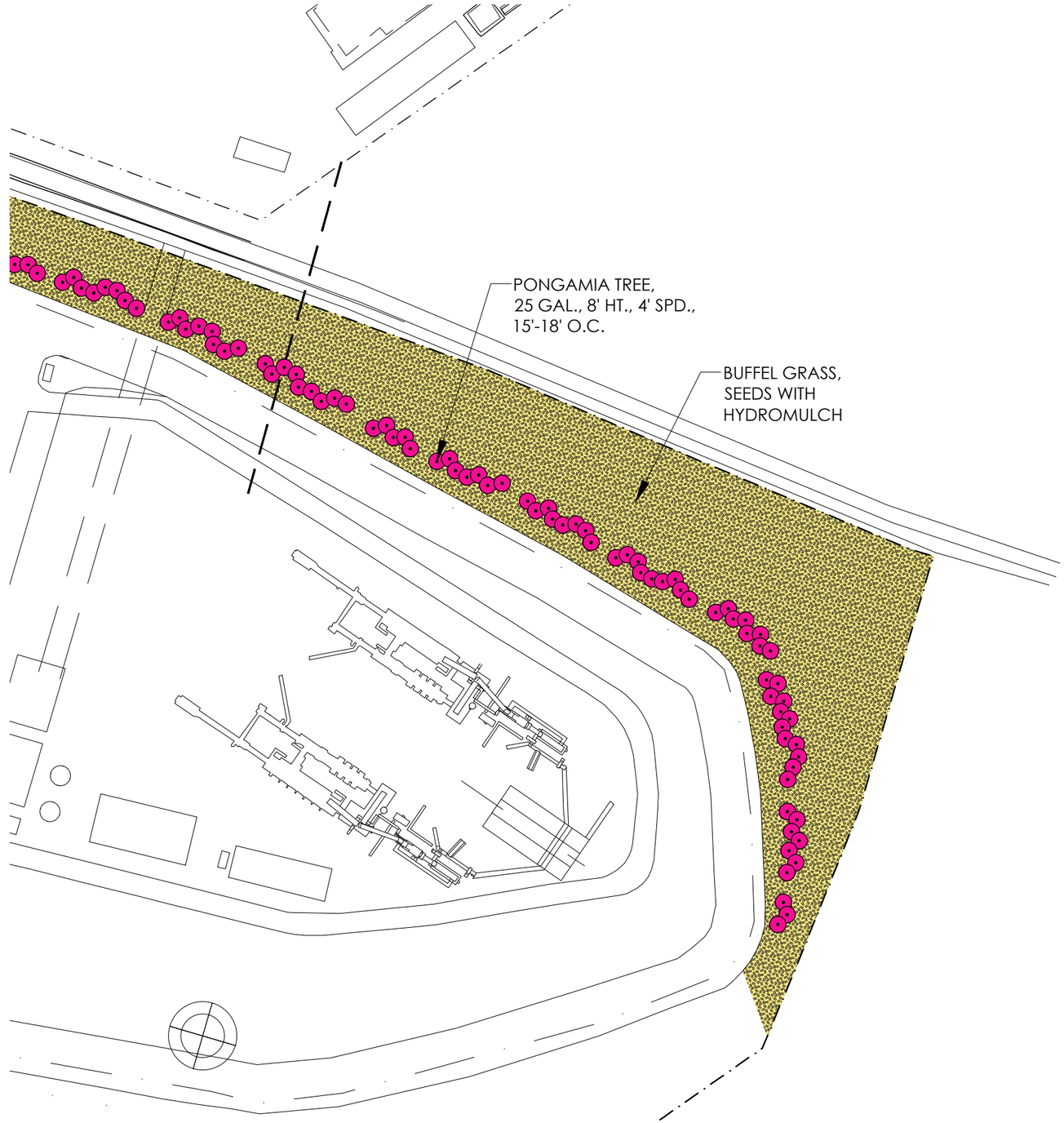
SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

Legend

- Pongomia Tree
- Native Hawaiian Kou
- Native Manele
- Native Milo
- Native White Hibiscus
- Miss Manila Bougainvillea
- Buffel Grass
- Pohinahina
- Copperleaf
- Artificial Turf
- Native Wetland Biofiltration Planting



NORTH

LANDSCAPE PLAN - 5

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

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LANDSCAPE ARCHITECTURE
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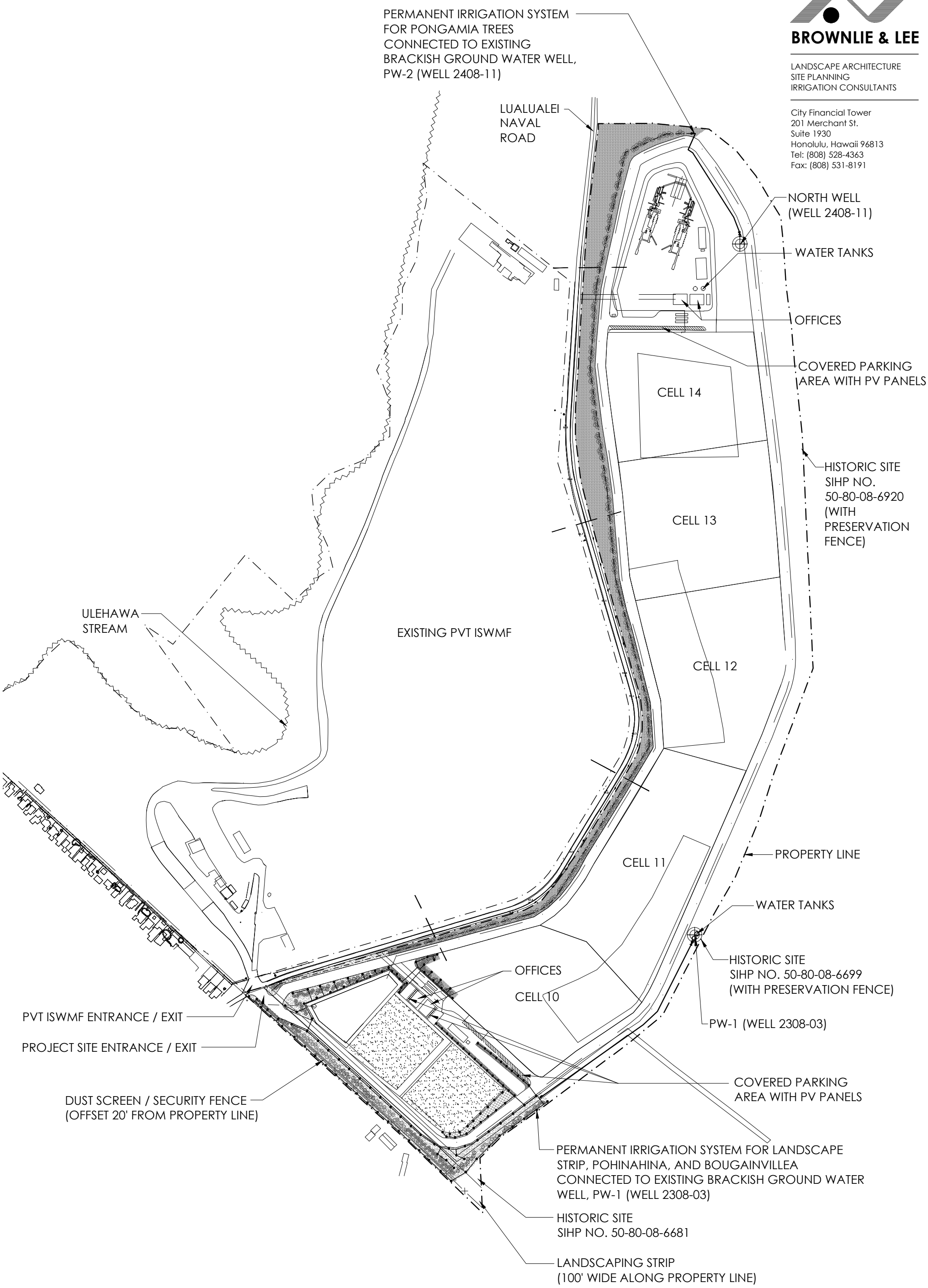

NORTH

OVERALL IRRIGATION PLAN

SCALE: 1" = 500'

0 250 500 1,000 1,500

SCALE: 1" = 500'

L-200

BROWNLIE & LEE

LANDSCAPE ARCHITECTURE
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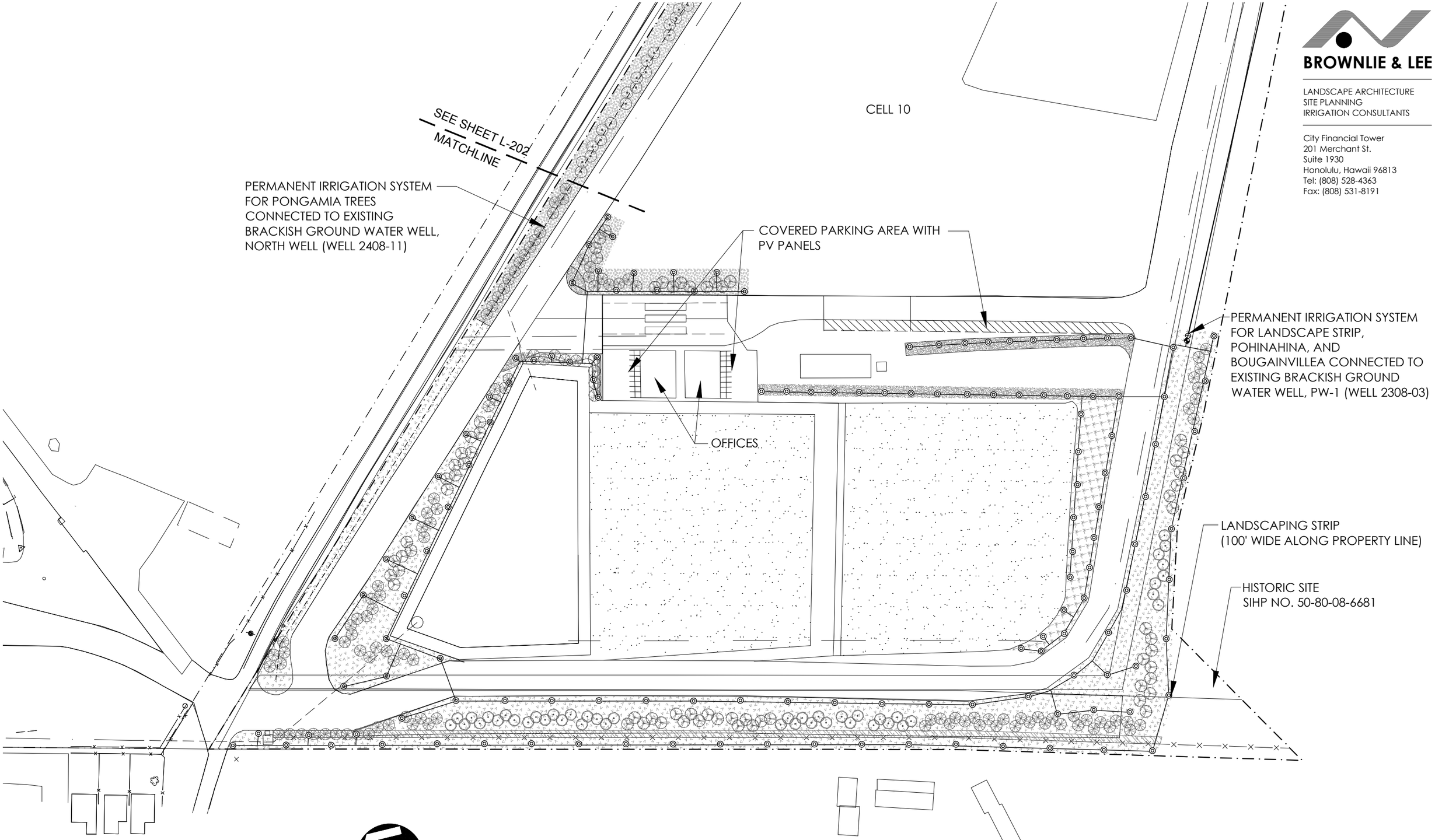
Fax: (808) 531-8191



NORTH

IRRIGATION PLAN - 1

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

L-201

BROWNLIE & LEE

LANDSCAPE ARCHITECTURE
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City Financial Tower
201 Merchant St.
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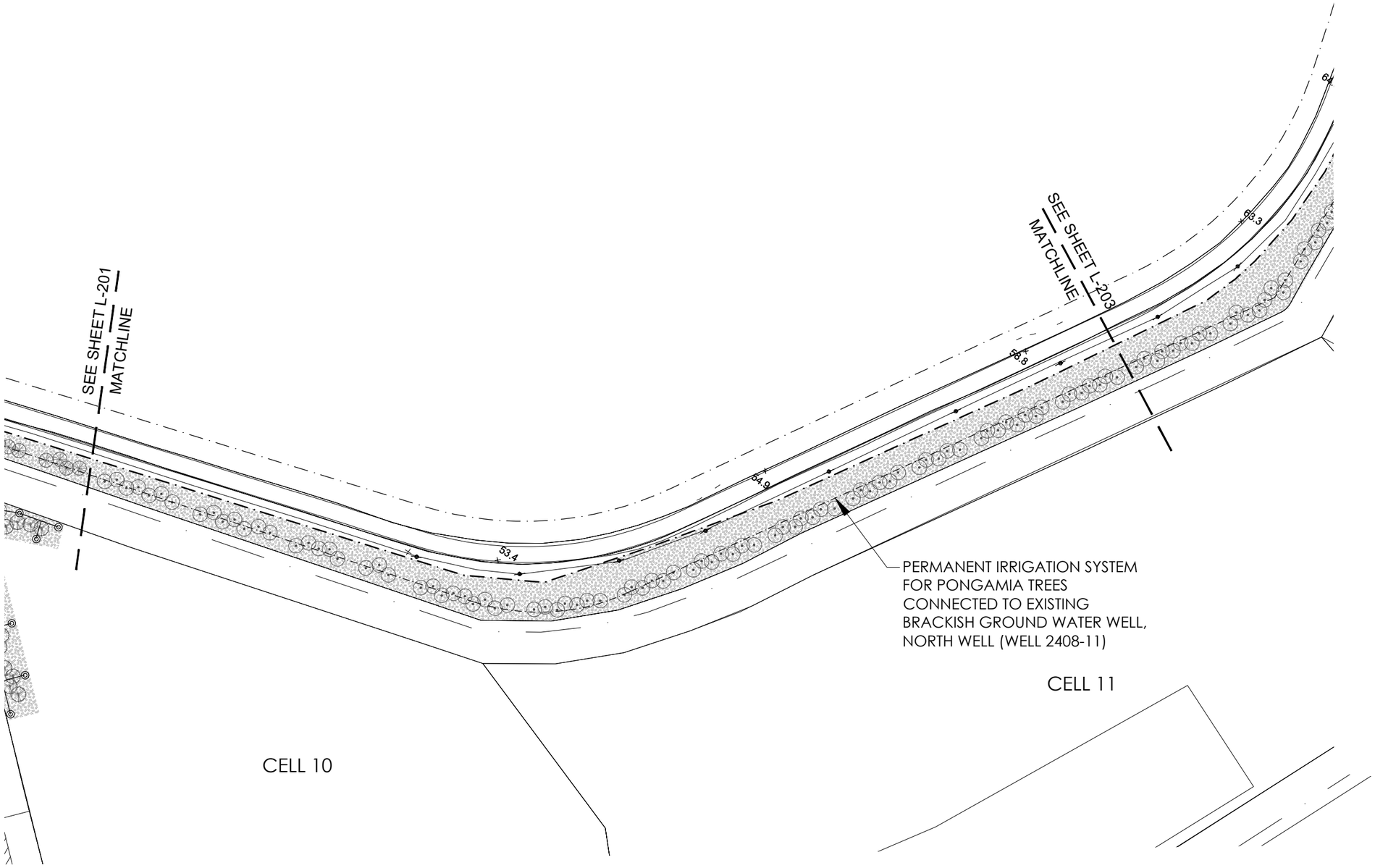
Tel: (808) 528-4363
Fax: (808) 531-8191



NORTH

IRRIGATION PLAN - 2

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

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SITE PLANNING
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City Financial Tower
201 Merchant St.
Suite 1930
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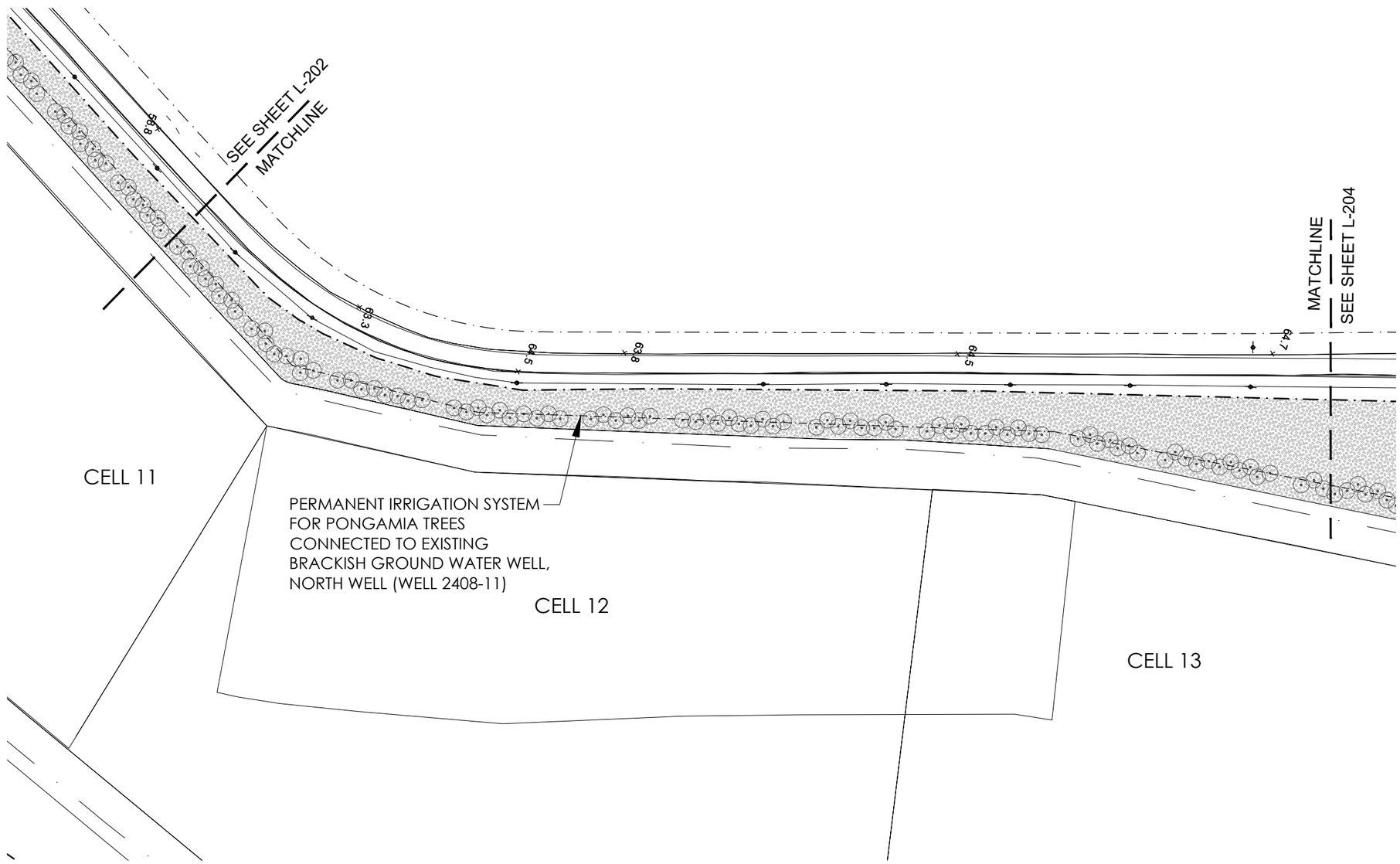
Fax: (808) 531-8191



NORTH

IRRIGATION PLAN - 3

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

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SITE PLANNING
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City Financial Tower
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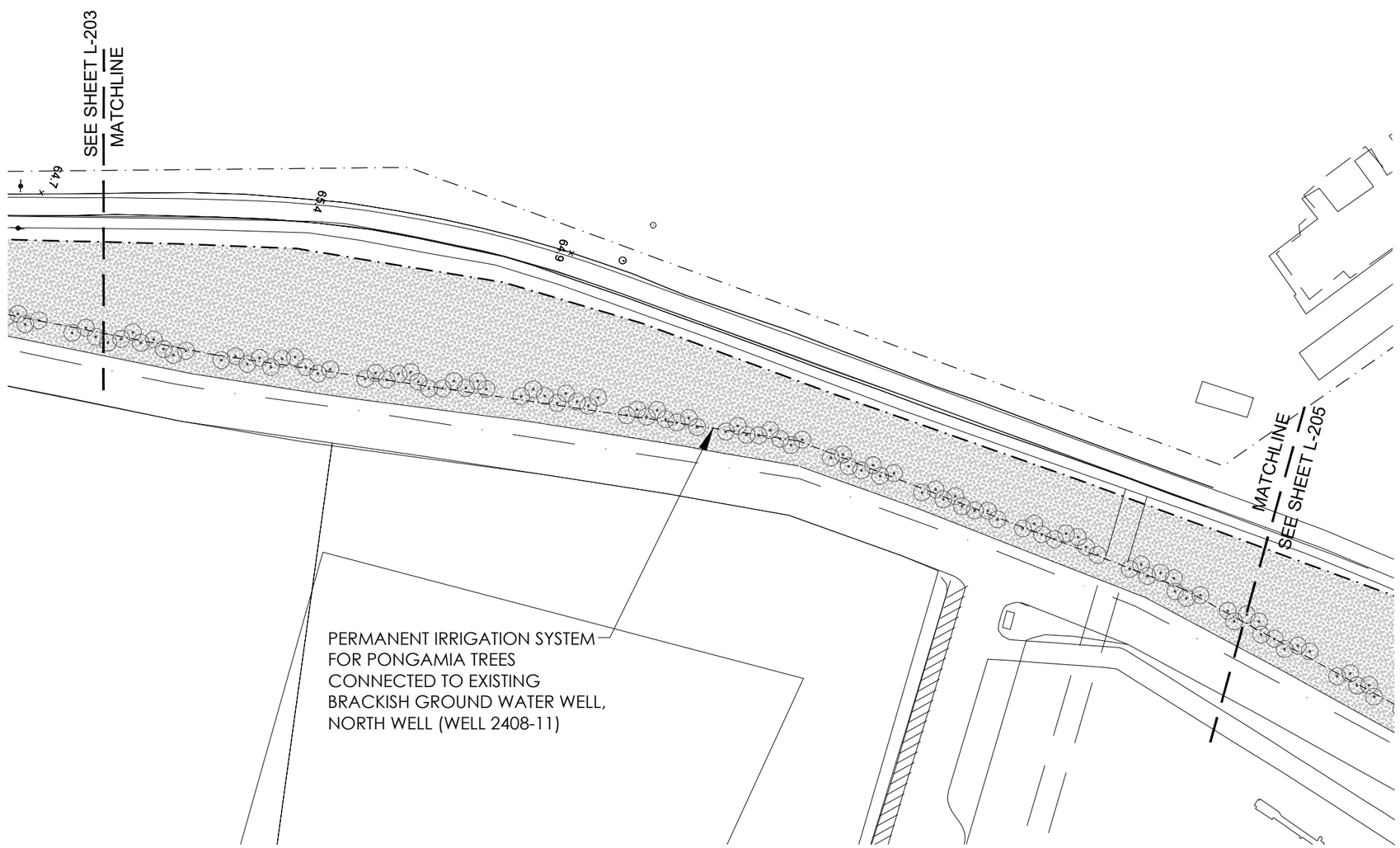
Fax: (808) 531-8191



NORTH

IRRIGATION PLAN - 4

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

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SITE PLANNING
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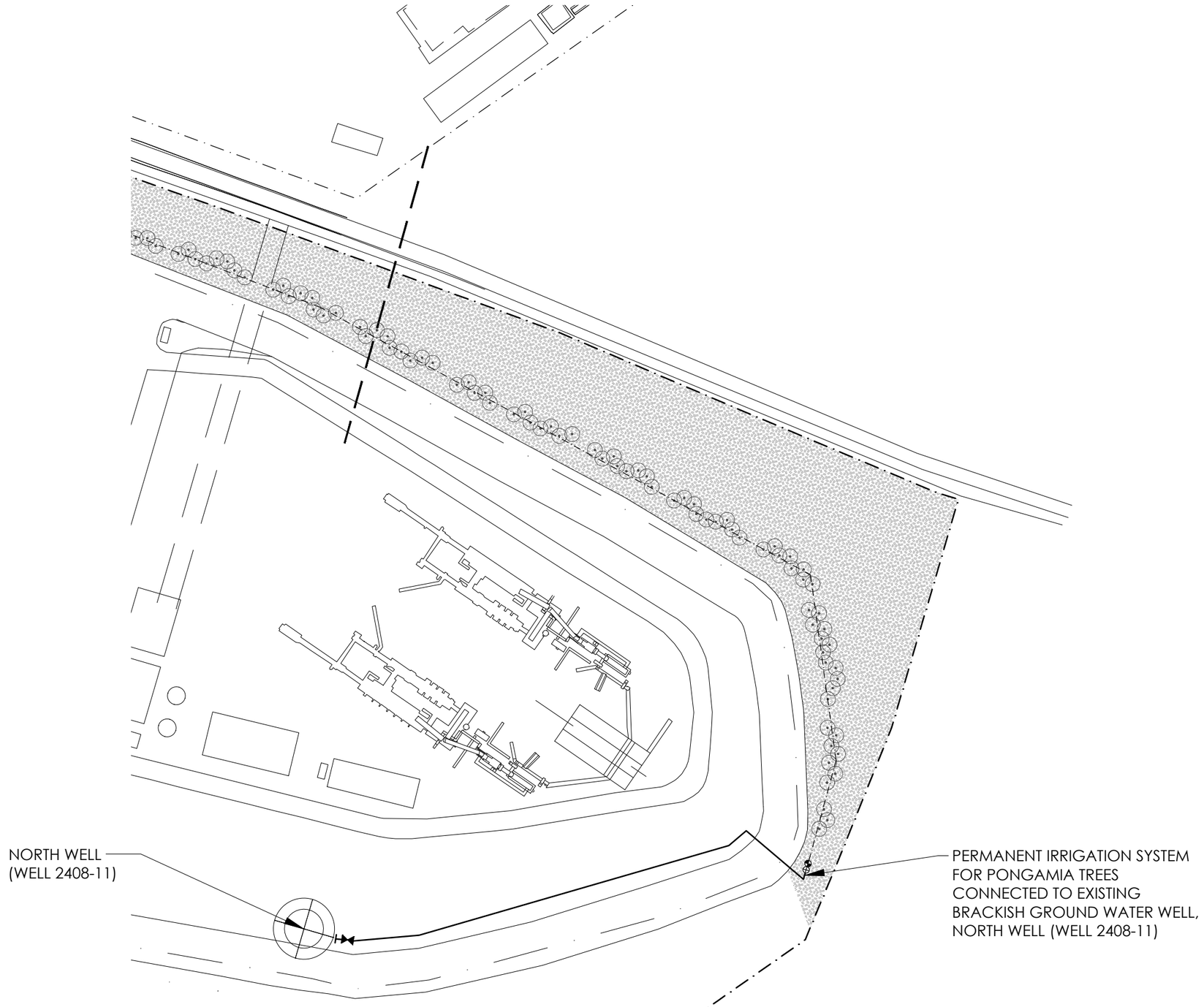

NORTH

IRRIGATION PLAN - 5

SCALE: 1" = 150'

0 75 150 300 450

SCALE: 1" = 150'

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LANDSCAPE ARCHITECTURE
SITE PLANNING
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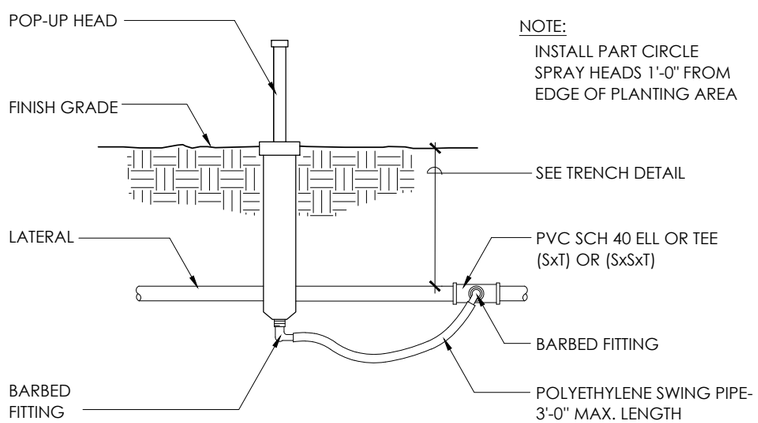
City Financial Tower
201 Merchant St.
Suite 1930
Honolulu, Hawaii 96813
Tel: (808) 528-4363
Fax: (808) 531-8191

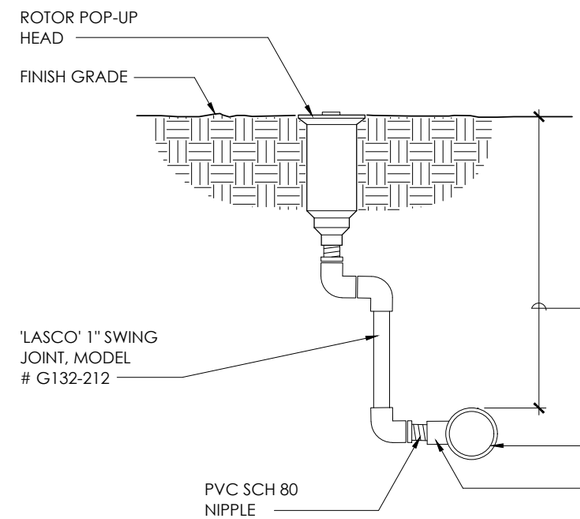


NOTE:
INSTALL PART CIRCLE SPRAY HEADS 1'-0" FROM EDGE OF PLANTING AREA

SPRAY HEAD POP-UP

NOT TO SCALE

IH-001
12/30/98



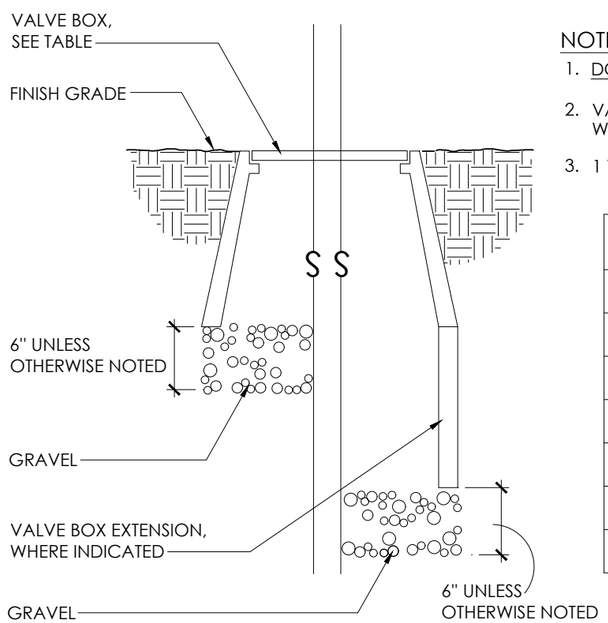
NOTE:

1. DO NOT INSTALL HEAD IN DRAINAGE SWALE.
2. INSTALL PART CIRCLE ROTOR HEADS 1'-0" FROM EDGE OF PLANTING AREA

ROTOR HEAD - POP-UP

NOT TO SCALE

IH-006A
5/5/15



NOTES:

1. DO NOT INSTALL VALVE BOX IN DRAINAGE SWALE
2. VALVE BOX EXTENSIONS SHALL BE COMPATIBLE WITH CORRESPONDING VALVE BOX
3. 1 VALVE PER VALVE BOX UNLESS OTHERWISE NOTED

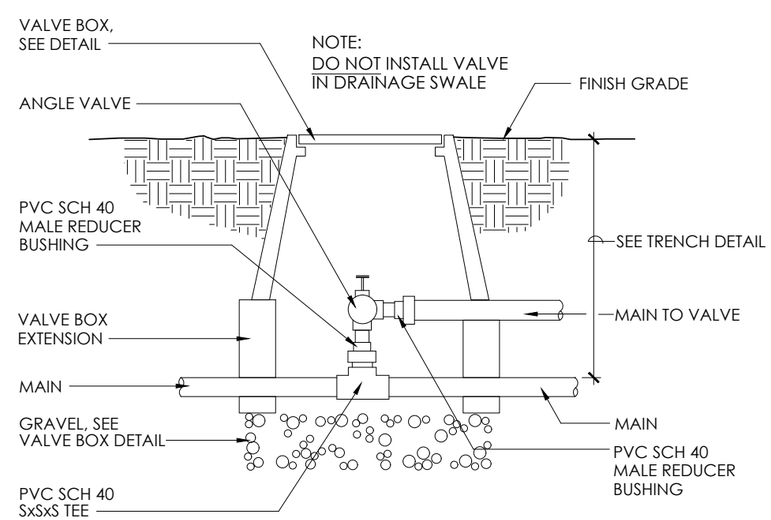
VALVE BOX CONTENTS	VALVE BOX MODEL NO. (OR APPROVED EQUAL)
GATE VALVE	RAINBIRD VB 10" ROUND
ANGLE VALVE	RAINBIRD VB 10" ROUND
ELECTRIC VALVE	RAINBIRD VB STANDARD
QUICK COUPLER	RAINBIRD VB 10" ROUND
IRRIGATION WIRES	RAINBIRD VB STANDARD
WATER METER	RAINBIRD VB STANDARD
PRESSURE REDUCING VALVE	RAINBIRD VB STANDARD

VALVE BOX TABLE

VALVE BOX

NOT TO SCALE

IV-021A
12/30/98



NOTE:
DO NOT INSTALL VALVE IN DRAINAGE SWALE

ANGLE VALVE

NOT TO SCALE

IV-016
12/30/98

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Honolulu, Hawaii 96813
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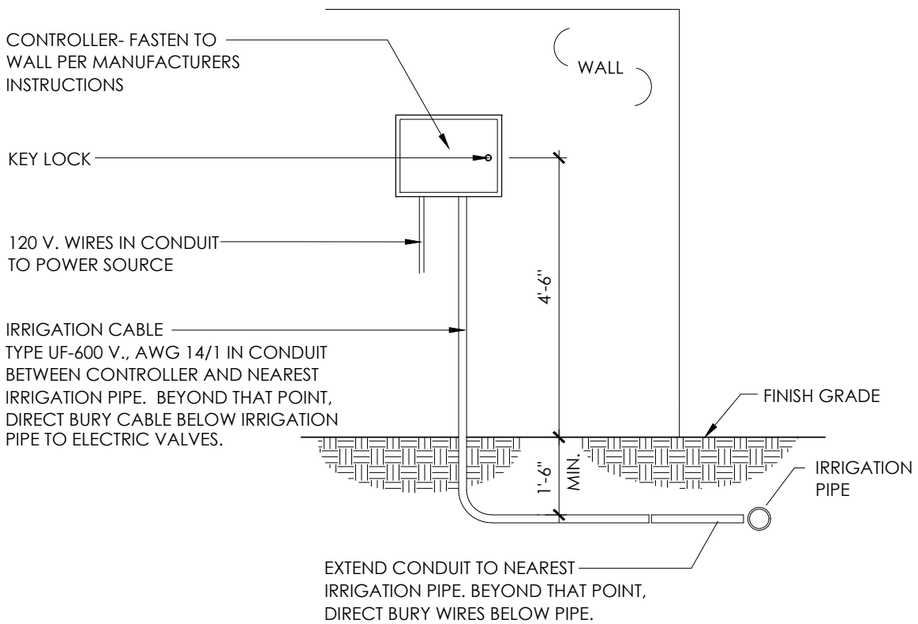
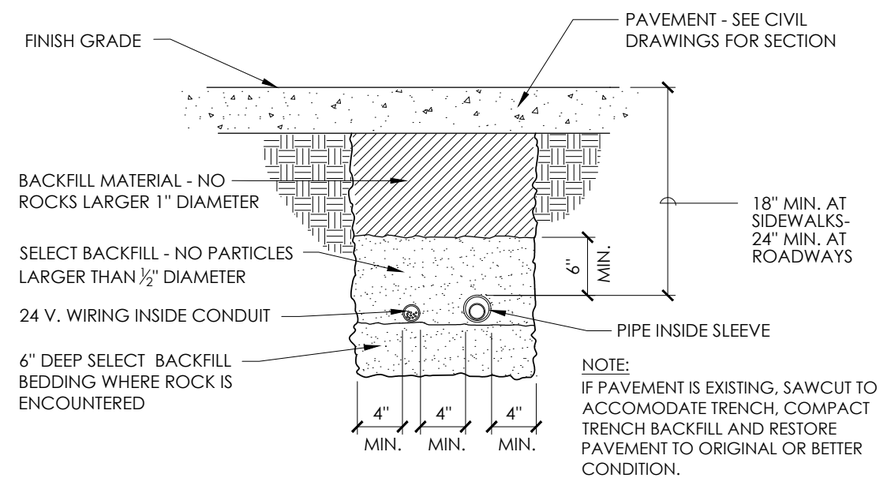
Fax: (808) 531-8191



CONTROLLER-EXTERIOR WALL MOUNTED

NOT TO SCALE

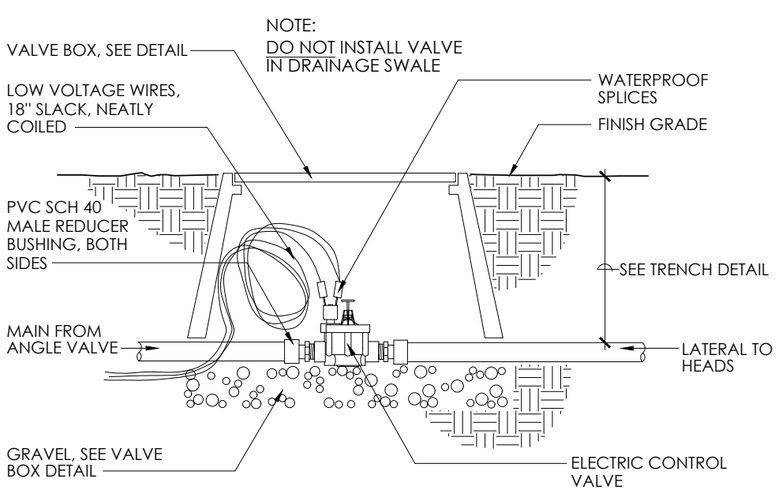
IC-006
12/10/02



PIPE TRENCH - PAVED AREAS WITH CONDUIT

NOT TO SCALE

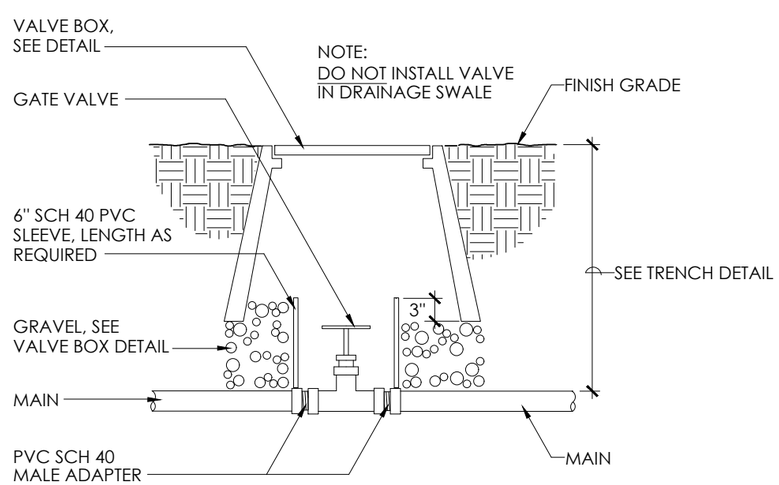
IT-003B
9/23/15



ELECTRIC VALVE

NOT TO SCALE

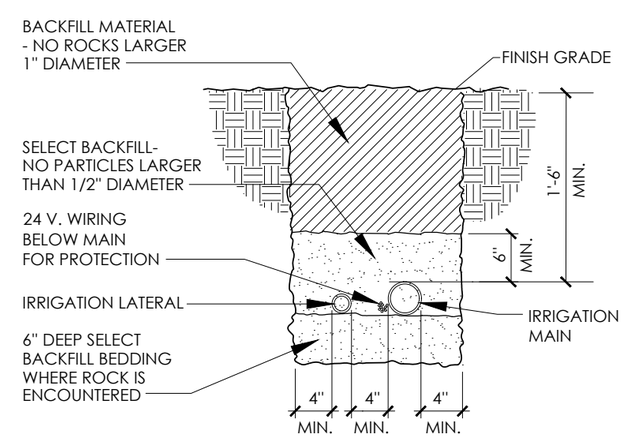
IV-004
12/30/98



GATE VALVE (3" AND SMALLER)

NOT TO SCALE

IV-011
12/30/98



PIPE TRENCH - PLANTING AREAS

NOT TO SCALE

IT-001A
8/3/12

PVT ISWMF Relocation – Plant Photos

Kou

Manele

Milo

Pongamia

Copperleaf

Hibiscus, Native White

Miss Manila Bougainvillea

Ahuawa

Akaakai

Makaloa

Pohinahina

Buffel Grass

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APPENDIX J
EISPN Distribution List

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Appendix J - EISPN Distribution List

City and County of Honolulu

#	Agency / Company
1	Board of Water Supply
2	DFM: Facilities Maintenance
3	DEM: Department of Emergency Management
4	Office of Climate Change, Sustainability, and Resiliency
5	HES: Honolulu Emergency Services Department
6	Fire Department
7	Police Department
8	DDC: Design and Construction
9	DPR: Parks and Recreation
10	DTS: Transportation Services
11	DPP: Planning Division
12	DPP: Site Development Division, Traffic Review
13	DPP: Site Development Division, Wastewater
14	DPP: Land Use Permits Division
15	ENV: Department of Environmental Services
16	Office of the Mayor
17	Managing Director
18	Waianae Library
19	Nanakuli Library
20	Neighborhood Commission (NB)
21	Neighborhood Bd. No. 24 (Waianae Coast)
22	Neighborhood Bd. No. 36 (Nanakuli-Maili)
23	Satellite City Hall No. 10 (Waianae Coast)
24	Honolulu City Council (CCL)
25	City Council - Kymberly Pine
26	Municipal Reference and Records Center

State of Hawaii

#	Agency / Company
27	DNLR: Department of Land and Natural Resources
28	DLNR: State Historic Preservation Division
29	DBEDT: Dept of Business, Economic Dev't &Tourism
30	DOA: Department of Agriculture,- Board of Agriculture
31	DOH : Department of Health
32	DOT: Deaprtment of Transportation
33	Oahu Metropolitan Planning Organization
34	Director of Emergency Management State Civil Defense/Hawaii Emergency Management Agency
35	Land Use Commission
36	DHHL: Department of Hawaiian Homelands
37	Office of Hawaiian Affairs
38	Office of Planning
39	Office of the Governor
40	Senator - Maile Shimabukuro
41	Representative - Stacelynn Eli
42	Representative - Cedric Gates

Federal	
#	**Agency / Company**
43	U. S. Army Corps of Engineers, Honolulu Engineering District
44	DOI US Fish and Wildlife
45	Department of the Navy, Naval Facilities Engineering Command
46	Federal Aviation Administration (FAA), Airport District Office

Other Interested Parties	
#	**Agency / Company**
47	HECO
48	The Outdoor Circle
49	Bishop Trust Estates
50	Honolulu Star Advertiser
51	Sierra Club
52	Life of the Land
53	UH Environmental Center
54	Hawaii's Thousand Friends
55	Historic Hawaii Foundation
56	The Nature Conservancy
57	Land Use Research Foundation of Hawaii
58	Concerned Elders of Waianae
59	Farmers of Maile
60	Kahea: The Hawaiian-Enviornmental Aliiance

APPENDIX K
DEIS Distribution List

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Appendix K - Draft EIS Distribution List

GOVERNMENT OF THE STATE OF HAWAII

AGENCY	MAILING ADDRESS	WEB ADDRESS	PHONE	EMAIL
Department of Agriculture	1428 S. King St. Honolulu, HI 96814	http://hdoa.hawaii.gov/contact/	(808) 973-9560	hdoa.info@hawaii.gov
Department of Accounting and General Services	P.O. Box 2359 Honolulu, Hawaii 96804	http://ags.hawaii.gov/contact/	(808) 586-0400	dags@hawaii.gov
Department of Accounting and General Services Archives Division	P.O. Box 2359 Honolulu, Hawaii 96804	http://ags.hawaii.gov/archives/	(808) 586-0329	archives@hawaii.gov
Department of Business Economic Development and Tourism (DBEDT)	P.O. Box 2359 Honolulu, Hawaii 96804	http://hawaii.gov/dbedt/main/about/about-dbedt	(808) 586-2355	webmaster@dbedt.hawaii.gov
DBEDT Research and Economic Analysis Division	P.O. Box 2359 Honolulu, Hawaii 96804	http://hawaii.gov/dbedt/info/economic	(808) 586-2466	webmaster@dbedt.hawaii.gov
DBEDT Strategic Industries Division	P.O. Box 2359 Honolulu, Hawaii 96804	http://hawaii.gov/dbedt/info/energy	(808) 587-3807	energyoffice@dbedt.hawaii.gov
DBEDT Office of Planning	235 S Beretania St., 6th Floor, Honolulu, HI 96813	http://hawaii.gov/dbedt/op/	(808) 587-2846	webmaster@dbedt.hawaii.gov
DBEDT Library	No. 1 Capitol District Building, 250 S. Hotel Street, 4th floor Honolulu, Hawaii 96813			
Department of Defense	3949 Diamond Head Road Honolulu, HI 96816	http://hawaii.gov/dod	(808) 733-4246	hi.dod.pa@icloud.com
Department of Education	P.O. Box 2360 Honolulu, HI 96804	http://doe.k12.hi.us/	(808) 586-3230	doe_info@hawaiidoe.org
Hawaii State Library Hawai'i Documents Center	478 S. King Street Honolulu, HI 96813	http://www.librarieshawaii.org/locations/index.htm	(808) 586-3555	
Department of Hawaiian Home Lands	P.O. Box 1879 Honolulu, HI 96805	http://hawaii.gov/dhhl/contact-info	(808) 620-9501	webmaster@hawaiianhomelands.org
Department of Health Environmental Health Administration	P.O. Box 3378 Honolulu, HI 96801	http://hawaii.gov/health	(808) 586-4424	webmail@doh.hawaii.gov
Department of Land and Natural Resources	P.O. Box 621 Honolulu, HI 96809	http://hawaii.gov/dlnr	(808) 587-0400	dlnr@hawaii.gov
Department of Land and Natural Resources, State Historic Preservation Division	601 Kamokila Blvd., Rm. 555 Kapolei, HI 96707	http://dlnr.hawaii.gov/shpd/	(808) 692-8015	
Department of Transportation	869 Punchbowl Street Honolulu, HI 96813	http://hawaii.gov/dot	(808) 587-2160	dotpao@hawaii.gov
University of Hawai'i Office of Capital Improvement	1960 East-West Road, Biomed B-102 Honolulu, HI 96822	http://www.hawaii.edu/oci	(808) 956-7935	oci-help@lists.hawaii.edu
University of Hawai'i Water Resources Research Center	2540 Dole Street, Room 283 Honolulu, HI 96822	http://www.wrrc.hawaii.edu/	(808) 956-7847	wrrc@hawaii.edu
University of Hawai'i Environmental Center	2500 Dole Street Krauss Annex 19 Honolulu, HI 96822	http://www.hawaii.edu/envctr/evs/index.html	(808) 956-7362	jcusick@hawaii.edu
University of Hawai'i Marine Program	2450 Campus Road Dean Hall 105A Honolulu, HI 96822	http://www.hawaii.edu/mop/	(808) 956-8433	mop@hawaii.edu
University of Hawai'i Thomas H. Hamilton Library	2550 McCarthy Mall Honolulu, HI 96822	http://library.manoa.hawaii.edu/departments/hp/	(808) 956-7205	library@hawaii.edu
University of Hawai'i at Hilo Edwin H. Mo'okini Library	200 W. Kawili Street Hilo, HI 96720	http://library.uhh.hawaii.edu/index.html	(808) 974-7346	
University of Hawai'i Maui College Library	310 Ka'ahumanu Avenue Kahului, HI 96732	http://www.maui.hawaii.edu/library/	(808) 984-3233	
University of Hawai'i Kaua'i Community College Library	3-1901 Kaumualii Highway Lihu'e, HI 96766	http://info.kauaicc.hawaii.edu/library/	(808) 245-8233	
Office of Hawaiian Affairs	560 N. Nimitz Hwy., Suite 200, Honolulu, HI 96817	http://www.oha.org/	(808) 594-1835	info@oha.org
Legislative Reference Bureau Library	State Capitol 415 S. Beretania St., Rm. 5 Honolulu, HI 96813	http://lrbhawaii.org/	(808) 587-0690	lrb@capitol.hawaii.gov
Director of Emergency Management State Civil Defense/Hawaii Emergency Management Agency	3949 Diamond Head Road Honolulu, Hawai'i 96816-4495	http://dod.hawaii.gov/hiema/contact-us/	(808) 733-4300	HawaiiEMA@hawaii.gov
State Land Use Commission	235 S Beretania St # 406, Honolulu, HI 96813	http://luc.hawaii.gov/	(808) 587-3822	dbedt.luc.web@hawaii.gov

GOVERNMENT OF THE CITY AND COUNTY OF HONOLULU

AGENCY	MAILING ADDRESS	WEB ADDRESS	PHONE	EMAIL
Board of Water Supply	630 S. Beretania Street Honolulu, HI 96813		(808) 748-5000	contactus@hbws.org
Department of Customer Services Municipal Library	558 S. King Street City Hall Annex Honolulu, HI 96813-3006	http://www.honolulu.gov/csd/mrc.html	(808) 768-3765	csdaccess@honolulu.gov
Department of Design and Construction	650 S. King St., 11th Floor Honolulu, HI 96813	http://www.honolulu.gov/ddc/aboutus.htm	(808) 768-8480	
Department of Environmental Services	1000 ʻUluʻohiʻa St., Ste. 308 Kapolei, HI 96707	http://www.honolulu.gov/env	(808) 768-3486	
Department of Facility Maintenance	1000 ʻUluʻohiʻa St., Ste. 215 Kapolei, HI 96707	http://www.honolulu.gov/dfm/	(808) 768-3343	
Honolulu Fire Department	636 South Street Honolulu, HI 96813-5007	http://www.honolulu.gov/hfd/	(808) 723-7139	
Department of Community Services	925 Dillingham Boulevard, Suite 200, Honolulu HI 96817	http://www.honolulu.gov/dcs/	(808) 768-7762	
Department of Planning and Permitting	650 S. King St. 7th Floor Honolulu, HI 96813	http://www.honoluludpp.org/	(808) 768-8000	info@honoluludpp.org
Department of Parks and Recreation	1000 ʻUluʻohiʻa St., Ste. 309 Kapolei, HI 96707	http://www.honolulu.gov/parks/	(808) 768-3003	parks@honolulu.gov
Police Department	801 S. Beretania Street Honolulu, HI 96813	http://www.honolulupd.org/	(808) 529-3111	
Department of Transportation Services	650 S. King St., 3rd Floor Honolulu, HI 96813	http://www.honolulu.gov/dts/	(808) 768-8303	
Waianae Satellite City Hall	Waianae Neighborhood Community Center 85-670 Farrington Hwy. Waianae, HI 96792	http://www.yelp.com/biz/satellite-city-hall-waianae	(808) 768-3798	csd@honolulu.gov
DEM: Department of Emergency Management	650 South King Street, Basement Honolulu, Hawaii 96813-3078	http://www.honolulu.gov/dem	(808) 723-8960	dem@honolulu.gov
Office of Climate Change, Sustainability, and Resiliency	Kapalama Hale 925 Dillingham Boulevard, Suite 257 Honolulu, Hawaii 96817	https://www.resilientoahu.org/contact-us	(808) 768-2277	resilientoahu@honolulu.gov
HES: Honolulu Emergency Services Department	3375 Koapaka Street, Suite H450 Honolulu, Hawaii 96819	http://www.co.honolulu.hi.us/esd	(808) 723-7800	
Oahu Metropolitan Planning Organization	707 Richards Street, Suite 200 Honolulu, Hawaii 96813	https://www.oahumpo.org/about-mpo/overview/	(808) 587-2015	OahuMPO@OahuMPO.org
Municipal Reference and Records Center	558 S King St, Honolulu, HI 96813		(808) 768-8911	

GOVERNMENT OF THE USA

FEDERAL AGENCY	MAILING ADDRESS	WEB ADDRESS	PHONE	EMAIL
Department of the Interior Geological Survey Pacific Islands Water Science Center	677 Ala Moana Boulevard Ste. 415 Honolulu, HI 96813	http://hi.water.usgs.gov/	(808) 587-2400	
Department of the Interior Fish and Wildlife Service	300 Ala Moana Boulevard Room 3-122 Honolulu, HI 96850-0056	http://www.fws.gov/pacificislands/	(808) 792-9400	
Department of Commerce National Marine Fisheries Service Pacific Islands Regional Office	1845 Wasp Blvd, Honolulu, HI 96818	http://www.fpir.noaa.gov/	(808) 725-5000	pirohonolulu@noaa.gov
Department of the Interior National Parks Service Pacific Islands Support Office	300 Ala Moana Blvd Rm 6-226, Honolulu, HI 96850	http://www.nps.gov/pwro/piso/	(808) 541-2693	
Department of Agriculture National Resources Conservation Service, Pacific Islands Area Office	P.O. Box 50004 Honolulu, HI 96850	http://www.pia.nrcs.usda.gov/	(808) 541-2600	
Department of the Army Army Corps of Engineers Pacific Ocean Division	Building 230 Fort Shafter, HI 96858- 5440	http://www.pod.usace.army.mil/	(808) 835-4715	pod-pao@usace.army.mil
Department of the Navy Pacific Division Naval Facilities Engineering Command	400 Marshall Road Pearl Harbor, Hawaii 96860-3139		(808) 472-1000	
Department of Transportation Federal Aviation Administration	300 Ala Moana Boulevard Room 7-128 Honolulu, HI 96850-7128	http://www.faa.gov/airports/western_pacific/regional/honolulu/	(808) 541-1232	
Department of Transportation Federal Transit Administration	201 Mission St., Ste. 1650 San Francisco, CA 94105-1839	http://www.fta.dot.gov/about/region9.html	(415) 744-3133	
Department of Transportation Federal Highways Administration Hawaii Division	Box 50206 300 Ala Moana Boulevard Room 3-306 Honolulu, HI 96850	http://www.fhwa.dot.gov/hidiv/	(808) 541-2700	
Department of Homeland Security Coast Guard Commander 14th Coast Guard District	300 Ala Moana Boulevard, Room 9-204, Honolulu, HI 96850-4982	http://www.uscg.mil/d14/	(808) 842-2600	
Environmental Protection Agency Region IX, Pacific Islands Contact Office	P.O. Box 50003 Honolulu, HI 96850	http://www.epa.gov/region9/islands/pico.html	(808) 541-2710	higuchi.dean@epa.gov

LIBRARY AND DEPOSITORY

LIBRARY AND DEPOSITORY	MAILING ADDRESS	WEB ADDRESS	PHONE	EMAIL	CONTACT/DIRECTOR
Waianae Public Library	85-625 Farrington Hwy, Waianae, HI 96792		(808) 697-7868		
Nanakuli Public Library	89-070 Farrington Hwy, Waianae, HI 96792		(808) 668-5844		

NEWS MEDIA

ORGANIZATION	MAILING ADDRESS	WEB	PHONE	EMAIL
Honolulu Star Advertiser	Restaurant Row 7, Waterfront Plaza, Suite	http://www.staradvertiser.com/	(808) 529-4747	citydesk@staradvertiser.com
Hawaii Tribue Herald	P.O. Box 767, Hilo, HI 96721	http://www.hawaiitribune-herald.com/	(808) 930-7324	http://www.hawaiitribune-herald.com/share/submit_news/
West Hawai'I Today	P.O. Box 789, Kailua-Kona, HI 96745-0789	http://www.westhawaiitoday.com/	(808) 329-9311	http://www.westhawaiitoday.com/content/
The Garden Island	P.O. Box 231, Lihu'e, HI 96766	http://thegardenisland.com/	(808) 245-3681	neagle@thegardenisland.com
Maui News	100 Mahalani Street, Wailuku, HI 96793	http://www.mauinews.com/	(808) 244-3981	citydesk@mauinews.com
Moloka'I Dispatch	P.O. Box 482219, Kaunakakai, HI 96748	https://themolokaidispatch.com/	(808) 552-2781	editor@themolokaidispatch.com
Honolulu Civil Beat		http://www.civilbeat.com/		becivil@civilbeat.com

ELECTED AND OTHER OFFICALS

OFFICAL	MAILING ADDRESS	WEB	PHONE	EMAIL
U.S. Senator Mazie Hirono	Honolulu Office: 300 Ala Moana Blvd., Rm. 3-106, Honolulu, HI 96850	http://www.hirono.senate.gov/	(808) 522-8970	http://www.hirono.senate.gov/contact
	Washington Location: 722 Hart Senate Office Building, Washington, DC 20510		(202) 224-6361	
U.S. Senator Brian Schatz	Honolulu Location: 300 Ala Moana Blvd., Rm. 7-212, Honolulu, HI 96850	http://www.schatz.senate.gov/	(808) 523-2061	http://www.schatz.senate.gov/contact
	Washington Location: 722 Hart Senate Office Building, Washington, DC 20510		(202) 224-3934	
U.S. Representative Tulsi Gabbard	Honolulu Office: 300 Ala Moana Blvd., Rm. 5-104 , Honolulu, HI 96850	http://gabbard.house.gov/	(808) 541-1986	http://gabbard.house.gov/index.php?option=com_content&view=article&id=120&Itemid=127#
	Washington Location: 1433 Longworth House Office Building, Washington, DC 20515		(202) 225-4906	
U.S. Representative Ed Case	Honolulu Office: 1132 Bishop Street Suite 1910, Honolulu, HI 96813	https://case.house.gov/contact/offices	(808) 650-6688	
	Washington Location: 2443 Rayburn House Office Building, Washington, DC 20515		(202) 225-2726	
Office of the Governor	The Honorable David Y. Ige Governor, State of Hawaii Executive Chambers, State Capitol Honolulu, Hawaii 96813	gov@gov.state.hi.us	(808) 586-0034	gov@gov.state.hi.us
State of Hawaii Senator Maile S. L. Shimabukuro	Hawaii State Capitol, Room 222		(808) 586-7793	senshimabukuro@capitol.hawaii.gov
State of Hawaii Senator Mike Gabbard	Hawaii State Capitol, Room 201		(808) 586-6830	sengabbard@capitol.hawaii.gov
State of Hawaii Representative Cedric Gates	Hawaii State Capitol, Room 311		(808) 586-8460	repgates@Capitol.hawaii.gov
State of Hawaii Representative Stacelynn Eli	Hawaii State Capitol, Room 324		(808) 586-8465	repeli@Capitol.hawaii.gov
Office of the Mayor Kirk Caldwell	530 S King St #300, Honolulu, HI 96813		(808) 768-4141	mayor@honolulu.gov
Managing Director			(808) 768-6634	ramemiya@honolulu.gov
Honolulu City Council (CCL)	CITY COUNCIL, CITY AND COUNTY OF HONOLULU, HONOLULU HALE, HONOLULU, HAWAII 96813-3077			
Council Member Kymberly Marcos Pine	Honolulu Hale, Room 203 Honolulu, HI 96813		808-768-5001	kmpine@honolulu.gov
Neighborhood Commission Office	Kapalama Hale, 925 Dillingham Boulevard, Suite 160 Honolulu, Hawaii 96817		(808) 768-3710	nco@honolulu.gov
Waianae Coast Neighborhood Board No. 24	c/o Neighborhood Commission 925 Dillingham Boulevard Suite 160 Honolulu, Hawaii 96817			waianaenb24@yahoo.com
Nanakuli-Maili Neighborhood Board No. 36	c/o Neighborhood Commission 925 Dillingham Boulevard Suite 160 Honolulu, Hawaii 96817		(C) 808-497-1432	rezentesc@aol.com

OTHER INTERESTED PARTIES

AGENCY	MAILING ADDRESS	WEB ADDRESS	PHONE	EMAIL	CONTACT / DIRECTOR
Hawaiian Electric Company (HECO)	Hawaiian Electric Company P.O. Box 2750 Honolulu, HI 96840	http://www.hawaiianelectric.com/	808-543-7245	ROUEN.LIU@HAWAIIANELECTRIC.COM kerstan.wong@hawaiianelectric.com	Rouen Liu, Permits Engineer
The Outdoor Circle	The Outdoor Circle 1314 South King St, #306 Honolulu, HI 96814	http://www.outdoorcircle.org/	808-593-0300	mail@outdoorcircle.org	
Bishop Trust Estates	B.P. Bishop Trust Estates 567 South King St, #200 Honolulu, HI 96813	http://www.charlesreedbishop.org/		stclayto@ksbe.edu	
Sierra Club	Sierra Club P.O. Box 2577 Honolulu, HI 96803	http://sierraclubhawaii.org/	808-234-9779	abaalto@gmail.com	
Life of the Land	P.O. Box 37158 Honolulu, HI 96837		808-533-3454		
Hawaii's Thousand Friends	300 Kuulei Road, Unit A #281 Kailua, Hawaii 96734	www.hawaiis1000friends.org	808-262-0682	htf@lava.net	
Historic Hawaii Foundation	680 Iwilei Road, Suite 690 Honolulu, Hawaii 96817				
The Nature Conservancy	923 Nuuanu Avenue Honolulu, Hawaii 96817				
Land Use Research Foundation of Hawaii	1100 Alakea Street, Suite 468 Honolulu, Hawaii 96813				
Joint Base Pearl Harbor-Hickam Facility Board			808-448-2711	Victor.m.flint@navy.mil	Victor M. Flint, Community Planning & Liaison Officer
Concerned Elders of Waianae	Lucy Gay		808-228-8557	maninibeach2@yahoo.com	Lucy Gay
Famers of Maile					
KAHEA: The Hawaiian-Environmental Alliance	P.O. Box 37368 Honolulu, Hawaii 96837		(877) 585-2432	kahea-alliance@hawaii.rr.com; fujikane@hawaii.edu	Candace Fujikane, Board Member
Joy Inada				Joyst1babe@msn.com	
Joseph Simpliciano				Jks75@icloud.com	
Cynthia K.L. Rezentes				rezentesc@aol.com	
Jasmine Torres				kahelelanidreams@gmail.com	
Shad Kane				shadskane@gmail.com	
MAO Organic Farms	86-148 Puhawai Rd, Waianae, HI 96792				Kukui Maunakea-Forth, Executive Director

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